Deutsche Akkreditierungsstelle

Annex to Partial Accreditation Certificate D-K-15019-01-01 according to DIN EN ISO/IEC 17025:2018

Valid from: 30.08.2022

Date of issue: 30.08.2022

This certificate annex is part of the accreditation certificate D-K-15019-01-00 holder of the

partial accreditation certificate:

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

The calibration laboratory meets the minimal requirements of DIN EN ISO/IEC 17025:2018 and, if applicable, additional legal and normative requirements, including those in relevant sectoral schemes, in order to carry out the conformity assessment activities listed below.

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

This certificate annex is only valid together with the written accreditation certificate and reflects the status as indicated by the date of issue. The current status of any given scope of accreditation can be found in the directory of accredited bodies maintained by Deutsche Akkreditierungsstelle GmbH at https://www.dakks.de.

Calibrations in the following areas:

Electrical quantities

DC and low frequency

- **DC and AC voltage** [a)]
- **DC and AC voltage** [a)]
- **Voltage ratio** [a)]
- **High-voltage quantities** [a)]
- **DC and AC resistance** [(a)]
- **Charge** [a)]
- **Electrical power** [a)]
- **Electrical energy** [a)]
- **Inductance and capacitance** [a)]

Time and Frequency

- **Time interval** [a)]
- **Frequency and rotational speed** [a)]

Dimensional quantities

Length Measurements

- **Diameter** [a)]
- **Thread** [a)]
- **Gauge blocks** [b)]
- **Handheld instruments** [a)]
- **Line standards, distances** [a)]

Angle

- **Inclination** [b)]

High-frequency and radiation quantities

High-frequency quantities

- **HF voltage** [a)]
- **HF current** [a)]
- **HF impedance (reflection factor)** [a)]
- **HF power** [a)]
- **HF attenuation** [a)]
- **Waveform quantities** [a)]
- **Oscilloscope quantities** [a)]
- **Rise time** [a)]
- **Bandwidth** [a)]

Optical quantities

- **Radiometry** [a)]
- **Photometry** [a)]

[a)] **also as on-site calibration**

[b)] **as an on-site calibration only**

Within the measured variables/Calibration items marked with [c)], the calibration laboratory is permitted to use the standards/calibration guidelines listed here with different versions without requiring prior information and approval from the DAkkS. The calibration laboratory has an up-to-date list of all standards/calibration guidelines in the flexible accreditation scope.

Electrical Quantities- DC and Low Frequency Quantities, DC and AC Voltage

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range		Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC voltage	0 V			35 nV	Short circuit bridge
	0 V to	200 mV	Calibration with the Josephson voltage standard	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	
	> 0 mV to	< 2 V		0.12 µV	Calibration of the deviation of voltmeters
	2 V to	10 V		0.27 µV	
	> 10 V to	100 V	linear step-up/down	$0.28 \cdot 10^{-6} \cdot U$ - 0.34 µV	U = measured value
	> 100 V to	1050 V		$0.24 \cdot 10^{-6} \cdot U$ + 64 µV	
High voltage	1 kV to	10 kV		$7.9 \cdot 10^{-6} \cdot U$ + 17 mV	
	> 10 kV to	60 kV		$46\ 10^{-6} \cdot U$ + 0.95 V	
AC voltage	2 mV to	10 mV	10 Hz; 12.5 Hz	$26 \cdot 10^{-6} \cdot U$ + 0.11 µV	U = Measured value calibration with the Josephson voltmeter. When calibrating measuring instruments, the influence of the load impedance and the 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	$28 \cdot 10^{-6} \cdot U$ + 23 nV	
			48 Hz; 60 Hz; 62.5 Hz	$19 \cdot 10^{-6} \cdot U$ + 0.11 µV	
			625 Hz; 937.5 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot U$ + 0.12 µV	
	> 10 mV to	60 mV	10 Hz; 12.5 Hz	$13 \cdot 10^{-6} \cdot U$ + 0.19 µV	
			20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$8.6 \cdot 10^{-6} \cdot U$ + 0.16 µV	
			48 Hz; 60 Hz; 62.5 Hz	$10 \cdot 10^{-6} \cdot U$ + 0.16 µV	
			625 Hz; 937.5 Hz; 1 kHz	$9.1 \cdot 10^{-6} \cdot U$ + 0.16 µV	
	60 mV to	7.2 V	10 Hz; 12.5 Hz	$10 \cdot 10^{-6} \cdot U$ + 0.14 µV	
			20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz	$2.2 \cdot 10^{-6} \cdot U$ + 0.16 µV	
			48 Hz; 60 Hz; 62.5 Hz	$4.2 \cdot 10^{-6} \cdot U$ + 0.14 µV	
			625 Hz; 937.5 Hz; 1 kHz	$1.4 \cdot 10^{-6} \cdot U$ + 0.16 µV	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	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	$0.29 \cdot 10^{-3} \cdot U$	*U* = measured value Calibration with AC/DC transfer standard. When calibrating measuring instruments, the influence of the load impedance/ impedance of the connectors and the repeatability must be taken into account. Intermediate values increase the measurement uncertainty.
		500 kHz	$0.32 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.43 \cdot 10^{-3} \cdot U$	
	6 mV	10 Hz	$0.16 \cdot 10^{-3} \cdot U$	
		20 Hz	$0.14 \cdot 10^{-3} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$0.13 \cdot 10^{-3} \cdot U$	
		300 kHz	$0.15 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.17 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.22 \cdot 10^{-3} \cdot U$	
	10 mV	10 Hz	$0.13 \cdot 10^{-3} \cdot U$	
		20 Hz	$0.12 \cdot 10^{-3} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$0.10 \cdot 10^{-3} \cdot U$	
		300 kHz	$0.12 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.16 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.21 \cdot 10^{-3} \cdot U$	
	20 mV	10 Hz	$0.12 \cdot 10^{-3} \cdot U$	
		20 Hz	$0.11 \cdot 10^{-3} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$86 \cdot 10^{-6} \cdot U$	
		300 kHz	$0.11 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.13 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.17 \cdot 10^{-3} \cdot U$	
	60 mV	10 Hz	$54 \cdot {}^{10-6} \cdot U$	
		20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz;	$32 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$46 \cdot 10^{-6} \cdot U$	
		500 kHz	$60 \cdot 10^{-6} \cdot U$	
		1 MHz	$95 \cdot 10^{-6} \cdot U$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage Ranges	100 mV	10 Hz	$22 \cdot 10^{-6} \cdot U$	*U* = measured value Calibration with AC/DC transfer standard. When calibrating measuring instruments, the influence of the load impedance/ impedance of the connectors and the repeatability must be taken into account. Intermediate values increase the measurement uncertainty.
		20 Hz; 40 Hz	$20 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$17 \cdot 10^{-6} \cdot U$	
		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	$25 \cdot 10^{-6} \cdot U$	
		500 kHz	$34 \cdot 10^{-6} \cdot U$	
		1 MHz	$53 \cdot 10^{-6} \cdot U$	
	200 mV	10 Hz	$37 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$18 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$15 \cdot 10^{-6} \cdot U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$12 \cdot 10^{-6} \cdot U$	
		100 kHz	$13 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$23 \cdot 10^{-6} \cdot U$	
		500 kHz	$33 \cdot 10^{-6} \cdot U$	
		1 MHz	$49 \cdot 10^{-6} \cdot U$	
	600 mV	10 Hz	$31 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$13 \cdot 10^{-6} \cdot U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$10 \cdot 10^{-6} \cdot U$	
		100 kHz	$11 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \cdot 10^{-6} \cdot U$	
		500 kHz	$33 \cdot 10^{-6} \cdot U$	
		1 MHz	$50 \cdot 10^{-6} \cdot U$	
	1 V	10 Hz	$17 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$11 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \cdot 10^{-6} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$13 \cdot 10^{-6} \cdot U$	
		500 kHz	$17 \cdot 10^{-6} \cdot U$	
		1 MHz	$30 \cdot 10^{-6} \cdot U$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage Ranges	2 V	10 Hz	$38 \cdot 10^{-6} \cdot U$	U = measured value Calibration with AC/DC transfer standard. When calibrating measuring instruments, the influence of the load impedance/ impedance of the connectors and the repeatability must be taken into account. Intermediate values increase the measurement uncertainty.
		20 Hz; 40 Hz	$12 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \cdot 10^{-6} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$11 \cdot 10^{-6} \cdot U$	
		500 kHz	$16 \cdot 10^{-6} \cdot U$	
		1 MHz	$29 \cdot 10^{-6} \cdot U$	
	4 V; 6 V	10 Hz	$32 \cdot 10^{-6} \cdot U$	
		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	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \cdot 10^{-6} \cdot U$	
		500 kHz	$32 \cdot 10^{-6} \cdot U$	
		1 MHz	$35 \cdot 10^{-6} \cdot U$	
	8V; 10V	10 Hz	$19 \cdot 10^{-6} \cdot U$	
		20 Hz	$13 \cdot 10^{-6} \cdot U$	
		40 Hz	$10 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz 100 kHz	$8 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$15 \cdot 10^{-6} \cdot U$	
		500 kHz	$30 \cdot 10^{-6} \cdot U$	
		1 MHz	$47 \cdot 10^{-6} \cdot U$	
	20 V	10 Hz	$29 \cdot 10^{-6} \cdot U$	
		20 Hz	$14 \cdot 10^{-6} \cdot U$	
		40 Hz	$11 \cdot 10^{-6} \cdot U$	
		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	$10 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$16 \cdot 10^{-6} \cdot U$	
		500 kHz	$32 \cdot 10^{-6} \cdot U$	
		1 MHz	$49 \cdot 10^{-6} \cdot U$	
	12V; 15V; 19V	1 kHz; 10 kHz; 100 kHz	$10 \cdot 10^{-6} \cdot U$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage Ranges	> 22 V to 70 V 60 V	10 Hz to 300 kHz 10 Hz	 $23 \cdot 10^{-6} \cdot U$	*U* = measured value Calibration with AC/DC transfer standard. When calibrating measuring instruments, the influence of the load impedance/ impedance of the connectors and the repeatability must be taken into account. Intermediate values increase the measurement uncertainty.
		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;	$9 \cdot 10^{-6} \cdot U$	
		70 kHz	$10 \cdot 10^{-6} \cdot U$	
		100 kHz	$14 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$22 \cdot 10^{-6} \cdot U$	
	> 70 V to 110 V 100 V	10 Hz to 200 kHz 10 Hz; 20 Hz	 $19 \cdot 10^{-6} \cdot U$	
		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	$20 \cdot 10^{-6} \cdot U$	
		100 kHz	$32 \cdot 10^{-6} \cdot U$	
		200 kHz	$37 \cdot 10^{-6} \cdot U$	
	> 110 V to 700 V 200 V	10 Hz to 100 kHz 10 Hz	 $27 \cdot 10^{-6} \cdot U$	
		20 Hz	$21 \cdot 10^{-6} \cdot U$	
		40 Hz	$16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$15 \cdot 10^{-6} \cdot U$	
		400 Hz; 500 Hz; 1 kHz;	$13 \cdot 10^{-6} \cdot U$	
		10 kHz; 20 kHz; 50 kHz;	$17 \cdot 10^{-6} \cdot U$	
		70 kHz	$20 \cdot 10^{-6} \cdot U$	
		100 kHz	$31 \cdot 10^{-6} \cdot U$	
	600 V	40 Hz	$17 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$14 \cdot 10^{-6} \cdot U$	
		1 kHz; 10 kHz; 20 kHz; 50 kHz	$16 \cdot 10^{-6} \cdot U$	
		70 kHz	$25 \cdot 10^{-6} \cdot U$	
		100 kHz	$37 \cdot 10^{-6} \cdot U$	
	> 700 V to 1000 V 1000 V	10 Hz to 100 kHz 40 Hz	 $16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz	$14 \cdot 10^{-6} \cdot U$	
		50 kHz	$25 \cdot 10^{-6} \cdot U$	
		70 kHz	$32 \cdot 10^{-6} \cdot U$	
		100 kHz	$42 \cdot 10^{-6} \cdot U$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
High voltage Sources	1 kV to 10 kV	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$50 \cdot 10^{-6} \cdot U + 2$ V $0.34 \cdot 10^{-3} \cdot U + 1.6$ V $1.6 \cdot 10^{-3} \cdot U + 0.9$ V	U = measured value
	> 10 kV to 40 kV	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.10 \cdot 10^{-3} \cdot U + 3.7$ V $0.43 \cdot 10^{-3} \cdot U + 2.1$ V $1.7 \cdot 10^{-3} \cdot U + 0.7$ 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		$0.10 \cdot 10^{-3} \cdot U + 3.7$ V	
Square wave voltage	5 mV to 220 mV	1 Hz to 10 kHz	$10 \cdot 10^{-6} \cdot U + 0.36$ µV $+ 6.4 \cdot 10^{-9}$ V/Hz · f	Sampling method at 10 MΩ load range indication in peak-peak amplitude U = Peak value of the voltage f = Frequency The additional influence of different load conditions (such as e.g. 50 Ω or 1 MΩ must be taken into account)
	> 220 mV to 2.2 V		$9.3 \cdot 10^{-6} \cdot U + 0.35$ µV $+ 7.0 \cdot 10^{-9}$ V/Hz · f	
	> 2.2 V to 22 V		$9.3 \cdot 10^{-6} \cdot U + 0.58$ µV $+ 14 \cdot 10^{-9}$ V/Hz · f	
	> 22 V to 220 V		$12 \cdot 10^{-6} \cdot U + 35$ µV $+ 75 \cdot 10^{-9}$ V/Hz · 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	$25 \cdot 10^{-3} \cdot U + 0.2$ µV $37 \cdot 10^{-3} \cdot U + 0.5$ µV $44 \cdot 10^{-3} \cdot U + 0.4$ µV $70 \cdot 10^{-3} \cdot U$	With oscilloscope U = measured value
	> 5 V to 50 V	DC up to 2 kHz > 2 kHz to 10 MHz	$12 \cdot 10^{-3} \cdot U + 0.7$ µV $25 \cdot 10^{-3} \cdot U + 0.7$ µV	

DC and AC current

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current Measuring instruments, Calibrators of the model series Fluke 57x0A		Calibration with Josephson quantum calibrator according to QMH Chap. VIa Vers. 5.0 10 Hz to 1 kHz	2.2 nA to 61 µA	*I* = measured value *f* = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
	100 µA; 200 µA; 500 µA	10 Hz; 12.5 Hz; 20 Hz	$62 \cdot 10^{-6} \cdot I$	
		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	$22 \cdot 10^{-6} \cdot I$	
	1 mA	10 Hz; 12.5 Hz	$25 \cdot {}^{10-6} \cdot I$	
		20 Hz	$22 \cdot 10^{-6} \cdot I$	
		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	$18 \cdot 10^{-6} \cdot I$	
	2 mA	10 Hz; 12.5 Hz	$23 \cdot 10^{-6} \cdot I$	
		20 Hz	$20 \cdot 10^{-6} \cdot I$	
		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	$15 \cdot 10^{-6} \cdot I$	
	5 mA; 10 mA; 20 mA	10 Hz; 12.5 Hz	$22 \cdot 10^{-6} \cdot I$	
		20 Hz	$20 \cdot 10^{-6} \cdot I$	
		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	$14 \cdot 10^{-6} \cdot I$	
	50 mA	10 Hz; 12.5 Hz	$23 \cdot 10^{-6} \cdot I$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \cdot 10^{-6} \cdot I$	
		48 Hz; 60 Hz; 62.5 Hz	$16 \cdot 10^{-6} \cdot I$	
		75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz; 625 Hz; 937.5 Hz; 1 kHz	$15 \cdot 10^{-6} \cdot I$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current Measuring instruments, Calibrators of the model series Fluke 57x0A	100 mA; 200 mA	10 Hz; 12.5 Hz	$25 \cdot 10^{-6} \cdot I$	I = measured value f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \cdot 10^{-6} \cdot I$	
		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	$23 \cdot 10^{-6} \cdot I$	
		48 Hz; 60 Hz; 62.5 Hz	$24 \cdot 10^{-6} \cdot I$	
	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	$45 \cdot 10^{-6} \cdot I$	
AC current	100 µA to 100 A	QMH, Chap. VIa Vers. 5.0 10 Hz to 10 kHz	4.4 nA to 6.5 mA	
	100 µA	10 Hz; 20 Hz	$76 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$44 \cdot 10^{-6} \cdot I$	
		10 kHz	$47 \cdot 10^{-6} \cdot I$	
	200 µA	10 Hz; 20 Hz	$68 \cdot 10^{-6} \cdot I$	
		40 Hz	$39 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$36 \cdot 10^{-6} \cdot I$	
		10 kHz	$39 \cdot 10^{-6} \cdot I$	
	0.5 mA	10 Hz; 20 Hz	$64 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz	$28 \cdot 10^{-6} \cdot I$	
		400 Hz; 500 Hz; 1 kHz	$27 \cdot 10^{-6} \cdot I$	
		10 kHz	$32 \cdot 10^{-6} \cdot I$	
	1 mA	10 Hz	$33 \cdot 10^{-6} \cdot I$	
		20 Hz	$30 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz	$26 \cdot 10^{-6} \cdot I$	
		120 Hz; 400 Hz; 500 Hz; 1 kHz	$25 \cdot 10^{-6} \cdot I$	
		10 kHz	$27 \cdot 10^{-6} \cdot I$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current	2 mA	10 Hz	$32 \cdot 10^{-6} \cdot I$	I = measured value f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$29 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \cdot 10^{-6} \cdot I$	
	5 mA	10 Hz	$32 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$29 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz 10 kHz	$24 \cdot 10^{-6} \cdot I$	
	10 mA	10 Hz	$26 \cdot 10^{-6} \cdot I$	
		20 Hz	$24 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \cdot 10^{-6} \cdot I$	
		10 kHz	$22 \cdot 10^{-6} \cdot I$	
	20 mA	10 Hz	$25 \cdot {}^{10-6} \cdot I$	
		20 Hz	$23 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot I$	
		10 kHz	$19 \cdot 10^{-6} \cdot I$	
	50 mA	10 Hz	$25 \cdot {}^{10-6} \cdot I$	
		20 Hz; 40 Hz	$23 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot I$	
		10 kHz	$19 \cdot 10^{-6} \cdot I$	
	100 mA	10 Hz	$26 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$24 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$18 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$20 \cdot 10^{-6} \cdot I$	
	200 mA	10 Hz	$27 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$24 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$18 \cdot 10^{-6} \cdot I$	
		10 kHz	$20 \cdot 10^{-6} \cdot I$	
	500 mA	10 Hz	$36 \cdot 10^{-6} \cdot I$	
		20 Hz	$34 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$31 \cdot 10^{-6} \cdot I$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current	1 A	10 Hz	$32 \cdot 10^{-6} \cdot I$	I = measured value f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$29 \cdot 10^{-6} \cdot I$	
		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	$40 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$34 \cdot 10^{-6} \cdot I$	
	5 A; 10 A	10 Hz	$39 \cdot 10^{-6} \cdot I$	
		20 Hz	$37 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$32 \cdot 10^{-6} \cdot I$	
	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	$53 \cdot 10^{-6} \cdot I$	
	50 A	10 Hz; 20 Hz	$64 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$59 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$68 \cdot 10^{-6} \cdot I$	
	100 A	10 Hz; 20 Hz	$75 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$65 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$75 \cdot 10^{-6} \cdot I$	
	100 A to 200 A	QMH, Chap. VIb.1.1 Vers. 5.0	12 mA to 24 mA	
		10 Hz to 10 kHz	$0.13 \cdot 10^{-3} \cdot I$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current Sources	200 A to 300 A	10 Hz to 1 kHz	$0.30 \cdot 10^{-3} \cdot I - 0.53$ mA	I = measured value f = Frequency
	300 A to 495 A	10 Hz to 65 Hz	$0.48 \cdot 10^{-3} \cdot I + 11$ mA	
		65 Hz to 100 Hz	$0.49 \cdot 10^{-3} \cdot I + 11$ mA	
		100 Hz to 400 Hz	$0.74 \cdot 10^{-3} \cdot I + 7.7$ mA	
		400 Hz to 1 kHz	$1.5 \cdot 10^{-3} \cdot I + 4.0$ mA	
AC current Clamps and clamp current transformers	10 µA 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 $90 \cdot 10^{-6} \cdot I$ 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 conductor.
Equivalent leakage current	0.2 µA to 200 mA	to R_N up to 1 GΩ	$10 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ See matrix M.1	Overall uncertainty U is dependent on the rel. Uncertainty U (R_N)/R_N of the calibration resistor R_N.

Matrix M.1 "Equivalent leakage current"

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	10	6 mA	10	600 µA	13	60 µA	19	6 µA	70	600 nA	0.6	60 nA	5.8
110V	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	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC current Sources, measuring instruments	0 pA to 10 nA		0.85 fA to 51 fA	I = measured value
	0 pA		12 fA	
	1 pA		$0.85 \cdot 10^{-3} \cdot I$	Intermediate values increase the measurement uncertainty.
	10 pA		$0.53 \cdot 10^{-3} \cdot I$	
	100 pA		$75 \cdot 10^{-6} \cdot I$	
	1 nA		$10 \cdot 10^{-6} \cdot I$	
	10 nA		$5.1 \cdot 10^{-6} \cdot I$	
	> 10 nA to 100 nA		$4.1 \cdot 10^{-6} \cdot I$ + 10 fA	
	> 100 nA to < 1 µA		$1.4 \cdot 10^{-6} \cdot I$ + 0.21 pA	
	1 µA to 10 µA		$1.4 \cdot 10^{-6} \cdot I$ + 0.19 pA	
	> 10 µA to 100 µA		$1.4 \cdot 10^{-6} \cdot I$ + 1.8 pA	
	> 100 µA to 500 µA		$1.1 \cdot 10^{-6} \cdot I$ + 72 pA	
	20 µA to 200 µA	QMH, Chap. VIa Vers. 5.0	$1.4 \cdot 10^{-6} \cdot I$ + 14 pA	
	200 µA to 2 mA		$0.54 \cdot 10^{-6} \cdot I$ + 0.23 nA	
	2 mA to 10 mA		$1.1 \cdot 10^{-6} \cdot I$ + 2.4 nA	
	10 mA to 50 mA		$0.90 \cdot 10^{-6} \cdot I$ + 25 nA	
	50 mA to 200 mA		$0.33 \cdot 10^{-6} \cdot I$ + 0.26 µA	
	200 mA to 1 A		$12 \cdot 10^{-6} \cdot I$	
	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	QMH, Chap. VIb.1.1 Vers. 5.0	$37 \cdot 10^{-6} \cdot I$	
DC power Sources	300 A to 700 A		$27 \cdot 10^{-6} \cdot I$ + 2.3 mA	
DC current Calibrators of the model series Fluke 57x0A	20 µA to 2 mA	Calibration with Josephson-Quantum Calibrator in accordance with QMH Chap. VIa Vers. 5.0	$0.48 \cdot 10^{-6} \cdot I$ + 19 pA	
	2 mA to 20 mA		$1.1 \cdot 10^{-6} \cdot I$ + 1.0 nA	
	20 mA to 200 mA		$0.26 \cdot 10^{-6} \cdot I$ + 24 nA	
	200 mA to 2 A		$12 \cdot 10^{-6} \cdot I$	
DC 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 strength of the single winding. $WDUT$ is the relative uncertainty of the Measuring object in the stray field of the current-carrying conductor.

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage Harmonics	2.2 V to 22 V	40 Hz to 4 kHz	$65 \cdot 10^{-6} \cdot U_n + 60$ µV	U_n = voltage of the nth harmonic or the 1st harmonic U_{peak} < 1.4 kV
	> 22 V to 220 V		$70 \cdot 10^{-6} \cdot U_n + 0.8$ mV	
	> 220 V to 700 V	40 Hz to 1 kHz	$80 \cdot 10^{-6} \cdot U_n + 4$ mV	
		> 1 kHz to 4 kHz	$0.13 \cdot 10^{-3} \cdot U_n + 6$ mV	
AC voltage Harmonics	1st harmonic 0.1 A to 16 A	40 Hz to 65 Hz 0.15 A to 30 A, peak	$0.68 \cdot 10^{-3} \cdot I$	I_n = Current of the nth harmonic eff.= effective value limit n of the distorted signal When using current clamps, measurement uncertainty and range limits increase at least by the factor of the number of turns *N* used
	Harmonic 0.022 A to 0.22 A	80 Hz to 1 kHz 0.15 A to 1.4 A, peak	$0.12 \cdot 10^{-3} \cdot I_n + 3.5$ µA	
	> 0.22 A to 0.8 A		$0.55 \cdot 10^{-3} \cdot I_n + 35$ µA	
	0.22 A to 1.2 A	> 1.4 A to < 1.8 A, peak		
	0.22 A to 2.2 A	1.8 A to < 7 A, peak		
	> 2.2 A to 4 A		$0.34 \cdot 10^{-3} \cdot I_n$	
	1 A to 8 A	7 A to 14 A, peak	$0.68 \cdot 10^{-3} \cdot I_n$	
	2 A to 15 A	> 14 A to 30 A, peak		
	Harmonic 0.022 A to 0.22 A	> 1 kHz to 4 kHz 0.15 A to 1.4 A, peak	$0.50 \cdot 10^{-3} \cdot I_n + 40$ µA	
	> 0.22 A to 0.8 A		$0.65 \cdot 10^{-3} \cdot I_n + 80$ µA	
	0.22 A to 1.2 A	> 1.4 A to < 1.8 A, peak		
	0.22 A to 2.2 A	1.8 A to < 7 A, peak		
	> 2.2 A to 4 A		$0.34 \cdot 10^{-3} \cdot I_n$	
	1 A to 8 A	7 A to 14 A, peak	$0.68 \cdot 10^{-3} \cdot I_n$	
	2 A to 15 A	> 14 A to 30 A, peak		
Flicker Modulation depth $\Delta U/U$ Sources Measuring instruments	0.4% to 3.2%	DIN EN 61000-4-15:2011[c], Table 5	$1.6 \cdot 10^{-3}$ % $25 \cdot 10^{-3}$ %	Values at $\Delta U/U$ expressed in $\Delta U/U$ Rectangular flicker
Frequency	8.3 mHz to 40 Hz		$0.14 \cdot 10^{-3} \cdot f$	
P_{st}-value	only $P_{st} = 1$		$2.5 \cdot 10^{-3}$	
AC voltage Total harmonic distortion *k*	0% to 30%	45 Hz to 5 kHz > 5 kHz to 30 kHz	$0.5 \cdot 10^{-3} \cdot k + 0.012$ % $0.8 \cdot 10^{-3} \cdot k + 0.012$ %	Values expressed in % of total harmonic distortion

DC and AC resistance

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC resistance Sources, measuring instruments	0 Ω	2-wire short	0.5 mΩ	R = measured value
		4-wire short	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; 10kΩ 100 kΩ; 1 MΩ; 10 MΩ; 100 MΩ	QMH, Chap. VIIa.3 Vers. 5.0 I = 100 A I = 50 A I = 10 A	1.6 nΩ to 49 Ω $0.16 \cdot 10^{-3} \cdot R$ $34 \cdot 10^{-6} \cdot R$ $23 \cdot 10^{-6} \cdot R$ $20 \cdot 10^{-6} \cdot R$ $5.6 \cdot 10^{-6} \cdot R$ $0.32 \cdot 10^{-6} \cdot R$ $1.0 \cdot 10^{-6} \cdot R$ $0.59 \cdot 10^{-6} \cdot R$ $0.56 \cdot 10^{-6} \cdot R$ $1.4 \cdot 10^{-6} \cdot R$ $4.1 \cdot 10^{-6} \cdot R$ $4.9 \cdot 10^{-6} \cdot R$	Calibration of measuring instruments at the nominal values of the standards Intermediate values and different measurement conditions increase the measurement uncertainty.
	1 GΩ to 1 TΩ 1 GΩ; 10 GΩ; 100 GΩ; 1 TΩ	Measuring voltage 100 V or 1000 V	67 kΩ to 72 MΩ $67 \cdot 10^{-6} \cdot R$ $72 \cdot 10^{-6} \cdot R$	
	> 1 TΩ to 120 TΩ 10 TΩ; 100 TΩ	Measuring voltage 1000 V	0.13 GΩ to 23 GΩ $0.13 \cdot 10^{-3} \cdot R$ $0.23 \cdot 10^{-3} \cdot R$	
	100 mΩ to 2 Ω	Calibration with Josephson quantum calibrator in accordance with QMH Chap. VIIa.4 Vers. 5.0 3 µA ≤ I ≤ 50 mA	$0.39 \cdot 10^{-6} \cdot R + 0.25$ µΩ	R = measured value Different measurement conditions increase the measurement uncertainty.
	2 Ω to 10 Ω		$0.43 \cdot 10^{-6} \cdot R + 1.0$ µΩ	
	10 Ω to 100 Ω		$1.2 \cdot 10^{-6} \cdot R - 0.50$ µΩ	
	100 Ω to 500 Ω		$0.52 \cdot 10^{-6} \cdot R - 2.5$ µΩ	
	500 Ω to 10 kΩ		$0.47 \cdot 10^{-6} \cdot R + 20$ µΩ	
	10 kΩ to 100 kΩ		$0.73 \cdot 10^{-6} \cdot R - 0.13$ mΩ	
	100 kΩ to 1.9 MΩ		$0.83 \cdot 10^{-6} \cdot R + 90$ µΩ	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	1 Ω to 10 kΩ	Calibration with Josephson quantum calibrator according to QMH Chap. VIIa.4 Vers. 5.0 10 µA ≤ *I* ≤ 50 mA 10 Hz to 1 kHz	20 µΩ to 0.77 Ω	*R* = measured value *I* = current *f* = frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
	1 Ω	10 Hz; 12.5 Hz	$30 \cdot 10^{-6} \cdot R$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$24 \cdot 10^{-6} \cdot R$	
		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	$21 \cdot 10^{-6} \cdot R$	
	2 Ω	10 Hz; 12.5 Hz	$26 \cdot 10^{-6} \cdot R$	
		20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz	$21 \cdot 10^{-6} \cdot R$	
		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	$16 \cdot 10^{-6} \cdot R$	
	5 Ω	10 Hz; 12.5 Hz	$25 \cdot 10^{-6} \cdot R$	
		20 Hz	$20 \cdot 10^{-6} \cdot R$	
		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	$15 \cdot 10^{-6} \cdot R$	
	10 Ω	10 Hz; 12.5 Hz	$24 \cdot 10^{-6} \cdot R$	
		20 Hz	$19 \cdot 10^{-6} \cdot R$	
		25 Hz; 30 Hz; 37.5 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 quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	20 Ω; 50 Ω; 100Ω	10 Hz; 12.5 Hz	$59 \cdot 10^{-6} \cdot R$	R = measured value I = current f = frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$19 \cdot 10^{-6} \cdot R$	
		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	$12 \cdot 10^{-6} \cdot R$	
	1 kΩ	10 Hz; 12.5 Hz; 20 Hz	$59 \cdot 10^{-6} \cdot R$	
		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; 625 Hz; 937.5 Hz; 1 kHz	$56 \cdot 10^{-6} \cdot R$	
	10kΩ	10 Hz; 12.5 Hz; 20 Hz	$81 \cdot 10^{-6} \cdot R$	
		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	$78 \cdot 10^{-6} \cdot R$	
	100 µΩ to 100 Ω	QMH, Chap. VIIa.3 Vers. 5.0 100 µA ≤ I ≤ 100 A 10 Hz - 10 kHz	13 nΩ to 1.7 mΩ	
	100 µΩ	10 Hz; 20 Hz	$0.17 \cdot 10^{-3} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$0.14 \cdot 10^{-3} \cdot R$	
		1 kHz; 10 kHz	$0.15 \cdot 10^{-3} \cdot R$	
	1 mΩ	10 Hz	$65 \cdot 10^{-6} \cdot R$	
		20 Hz	$63 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$58 \cdot 10^{-6} \cdot R$	
		1 kHz	$61 \cdot 10^{-6} \cdot R$	
		10 kHz	$64 \cdot 10^{-6} \cdot R$	
	10 MΩ	10 Hz	$46 \cdot 10^{-6} \cdot R$	
		20 Hz	$43 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$37 \cdot 10^{-6} \cdot R$	
		1 kHz; 10 kHz	$35 \cdot 10^{-6} \cdot R$	
	20 mΩ	10 Hz	$45 \cdot 10^{-6} \cdot R$	
		20 Hz	$42 \cdot 10^{-6} \cdot R$	
		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 item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	50 mΩ	10 Hz	$45 \cdot 10^{-6} \cdot R$	R = measured value I = current f = frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$42 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$36 \cdot 10^{-6} \cdot R$	
	100 mΩ; 200 mΩ	10 Hz	$39 \cdot 10^{-6} \cdot R$	
		20 Hz	$35 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$30 \cdot 10^{-6} \cdot R$	
	0.5 Ω	10 Hz	$36 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$31 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz;	$26 \cdot 10^{-6} \cdot R$	
	1Ω	10 Hz	$34 \cdot 10^{-6} \cdot R$	
		20 Hz	$30 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \cdot 10^{-6} \cdot R$	
	2 Ω; 5 Ω	10 Hz	$31 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$26 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$20 \cdot 10^{-6} \cdot R$	
		10 kHz	$23 \cdot 10^{-6} \cdot R$	
	10 Ω	10 Hz	$30 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$26 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$21 \cdot 10^{-6} \cdot R$	
		10 kHz	$23 \cdot 10^{-6} \cdot R$	
	20 Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$25 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \cdot 10^{-6} \cdot R$	
		10 kHz	$22 \cdot 10^{-6} \cdot R$	
	50 Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	
		20 Hz	$25 \cdot 10^{-6} \cdot R$	
		40 Hz	$20 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$19 \cdot 10^{-6} \cdot R$	
		1 kHz	$21 \cdot 10^{-6} \cdot R$	
		10 kHz	$25 \cdot 10^{-6} \cdot R$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	100Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	
		20 Hz	$25 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz	$19 \cdot 10^{-6} \cdot R$	
		120 Hz; 400 Hz;	$18 \cdot 10^{-6} \cdot R$	
		500 Hz	$20 \cdot 10^{-6} \cdot R$	
		1 kHz	$31 \cdot 10^{-6} \cdot R$	
		10 kHz	$75 \cdot 10^{-6} \cdot R$	
	100 µΩ to 10 kΩ	10 Hz - 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 on resistor R
	1 Ω to 10 kΩ	20 Hz to 50 Hz	$2.5 \cdot 10^{-3} \cdot R + 3.1$ mΩ	R = Measured value direct measurement method
	> 10 kΩ to 110 MΩ		$2.3 \cdot 10^{-9} \cdot R^2/\Omega + 2.5 \cdot 10^{-3} \cdot R$	
	0 Ω to 20 kΩ	> 50 Hz to 100 Hz	$1.0 \cdot 10^{-3} \cdot R + 2.6$ mΩ	
	> 20 kΩ to 110 MΩ		$2.3 \cdot 10^{-9} \cdot R^2/\Omega + 1.3 \cdot 10^{-3} \cdot R$	
	0 Ω to 50 kΩ	> 100 Hz to 1 kHz	$0.5 \cdot 10^{-3} \cdot R + 1.3$ mΩ	
	> 50 kΩ to 110 MΩ		$1.1 \cdot 10^{-9} \cdot R^2/\Omega + 1.2 \cdot 10^{-3} \cdot R$	
	0 Ω to < 50 Ω	> 1 kHz to 30 kHz	$1.1 \cdot 10^{-3} \cdot R + 1.2$ mΩ	
	50 Ω to 20 kΩ		$0.5 \cdot 10^{-3} \cdot R$	
	> 20 kΩ to 110 MΩ		$1.1 \cdot 10^{-9} \cdot R^2/\Omega + 0.79 \cdot 10^{-3} \cdot R$	
	0 Ω to 20 Ω	> 30 kHz to 100 kHz	$1.1 \cdot 10^{-3} \cdot R + 1.2$ mΩ	
	> 20 Ω to 20 kΩ		$0.5 \cdot 10^{-3} \cdot R$	
	> 20 kΩ to 110 MΩ		$1.3 \cdot 10^{-9} \cdot R^2/\Omega + 1.0 \cdot 10^{-3} \cdot R$	
	0 Ω to 100 Ω	> 100 kHz to 300 kHz	$1.1 \cdot 10^{-3} \cdot R + 2.2$ mΩ	
	> 100 Ω to 2 kΩ		$0.5 \cdot 10^{-3} \cdot R$	
	> 2 kΩ to 110 MΩ		$4.5 \cdot 10^{-9} \cdot R^2/\Omega + 0.9 \cdot 10^{-3} \cdot R$	
	0 Ω to 50 Ω	> 300 kHz to 1 MHz	$1.3 \cdot 10^{-3} \cdot R + 3.2$ mΩ	
	> 50 Ω to 2 kΩ		$0.7 \cdot 10^{-3} \cdot R$	
	> 2 kΩ to 22 MΩ		$15 \cdot 10^{-9} \cdot R^2/\Omega + 1.1 \cdot 10^{-3} \cdot R$	

Electrical performance

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC power	0 W to 110 kW	0 mV to 1100 V 0 µA to 100 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ however, not less than $44 \cdot 10^{-6} \cdot P + 5$ fW	P = measured value
AC current active power Fixed values		45 Hz to 65 Hz 50 V or 200 V 30 mA; 0.3 A; 2 A; or 10 A;		P = measured value PF = Power factor (capacitive or inductive)
	1.5W; 6W; 15W; 60W; 100 W; 400 W;	$PF = 1$	$0.15 \cdot 10^{-3} \cdot P$	
	500W; 2000W		$0.33 \cdot 10^{-3} \cdot P$	
		45 Hz to 65 Hz 220 V; 1 A		
	220 W	$PF = 1$	$0.14 \cdot 10^{-3} \cdot P$	
	198 W	$PF = 0.9$	$0.15 \cdot 10^{-3} \cdot P$	
	110 W	$PF = 0.5$	$0.21 \cdot 10^{-3} \cdot P$	
	22 W	$PF = 0.1$	$0.91 \cdot 10^{-3} \cdot P$	
	11W	$PF = 0.05$	$1.8 \cdot 10^{-3} \cdot P$	
AC current active power Ranges		33 V to 330 V 45 Hz to 65 Hz, $PF = 1$		P = measured value PF = Power factor (capacitive or inductive)
	0.33 W to 0.73 kW	10 mA to 2.2 A	$0.30 \cdot 10^{-3} \cdot P$	
	> 0.73 kW to 3.6 kW	> 2.2 A to 11 A	$0.42 \cdot 10^{-3} \cdot P$	
	0.5 W to 0.73 kW	33 V to 330 V 330 mA to 2.2 A 45 Hz to 65 Hz $0.05 \le PF \le 1$ capacitive	$(0.33 \cdot 10^{-3} \cdot PF^{-0.98}) \cdot P$	
		inductive	$(0.98 \cdot 10^{-3} \cdot PF^{-0.99}) \cdot P$	
	0.11 mW to 21 kW	33 mV to 1020 V 3.3 mA to 20.5 A 45 Hz to 65 Hz, $PF = 1$	$1.4 \cdot 10^{-3} \cdot P$	
Measuring devices with current clamps	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \le PF \le 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.30 \cdot 10^{-3} \cdot P$	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 measuring circuit and in the stray field of the current conductor is to be considered.

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Power factor	0 to 1 0; 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.8; 1	33 V to 330 V 330 mA to 2.2 A 45 Hz to 65 Hz 53 Hz 1 A; 90 V	$0.12 \cdot 10^{-3}$	Interpolated intermediate values increase the measurement uncertainty.
AC reactive power	0 var to 3.6 kvar	45 Hz to 65 Hz	$U_P \cdot$ var/W	U_P is the uncertainty of the active power
Energy *E* Defibrillator analyzer	5 J to 150 J	QMH Chapter XXXV Version 2.0	$2.3 \cdot 10^{-3} \cdot E + 49$ mJ	*E* = Energy Monophasic or Biphasic
	> 150 J to 360 J		$1.1 \cdot 10^{-3} \cdot E + 0.27$ J	
Voltage ratio of bridge standards and measuring instruments	0 mV/V to 100 mV/V	Bridge excitation voltage: 1 V to 10 V AA0386 Version 2.0	0.1 µV/V to 1.6 µV/V see matrix M.2	Intermediate values increase the measurement uncertainty.

Matrix M.2 "Voltage ratio"

Bridge excitation voltage / Measurement 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	0.35µV/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

Time and Frequency

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Frequency f	1 MHz to 10 MHz in steps of 1 MHz	Phase time difference measurements over measuring times > 1 h	$2.0 \cdot 10^{-12} \cdot f$	f: Measured value U_{Tf}: Trigger uncertainty
	0.01 Hz to 350 MHz > 350 MHz to 26.5 GHz > 26.5GHz to 40 GHz		$2.6 \cdot 10^{-12} \cdot f + U_{Tf}$ $11 \cdot 10^{-12} \cdot f + U_{Tf}$ 0.6 Hz + U_{Tf}	
Time interval Δt	0 ns to 0.7 ms 0 ns to 200 s 1 µs to 100 h 1 s to 100 h		1.3 ns $1.5 \cdot 10^{-6} \cdot \Delta t$ + 50 ps $10 \cdot 10^{-9} \cdot \Delta t$ + 1 µs $13 \cdot 10^{-6} \cdot \Delta t$ + 0.82 s	
Clock deviation	0 s/d to 100 s/d		$1.3 \cdot 10^{-7}$ = 0.011 s/d	Electronic and mechanical clocks
Rotational speed	0.02 s^{-1} to 3500 s^{-1}		$3.7 \cdot 10^{-6} \cdot f$	f: Measured value

Inductance and Capacitance

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Inductance	0 µH		0.03 µH	2-wire short
	0 H to 1.1 H			L = measured value
	100 µH	100 Hz	$0.63 \cdot 10^{-3} \cdot L$	Intermediate values increase the measurement uncertainty.
		1 kHz	$0.17 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.22 \cdot 10^{-3} \cdot L$	
	1 mH	100 Hz	$0.14 \cdot 10^{-3} \cdot L$	Absolute value of impedance
		1 kHz	$0.12 \cdot 10^{-3} \cdot L$	50 mΩ ≤ | Z | ≤ 11 kΩ
		10 kHz	$0.17 \cdot 10^{-3} \cdot L$	
	10 mH	100 Hz; 1 kHz	$0.11 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.16 \cdot 10^{-3} \cdot L$	Smallest measurement uncertainties are applicable in the case of direct measurement or substitution on GR 1482 or similar model
	100 mH	100 Hz; 1 kHz	$0.11 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.25 \cdot 10^{-3} \cdot L$	
	1 H	100 Hz; 1 kHz	$0.13 \cdot 10^{-3} \cdot L$	
Capacitance	0 pF		0.2 pF	Open
	0 pF to 10 µF			C = Measured value
	1 pF	1 kHz	$0.21 \cdot 10^{-3} \cdot C$	Intermediate values increase the measurement uncertainty.
		10 kHz	$0.31 \cdot 10^{-3} \cdot C$	
	10 pF	1 kHz	$19 \cdot 10^{-6} \cdot C$	Absolut valvue of impedance 1 Ω ≤ | Z | ≤ 110 MΩ Smallest specifiable fixed value. Smallest measurement uncertainties are applicable in the case of direct measurement or substitution on GR 1403 / 1404 / 1409 or similar model
		10 kHz; 100 kHz	$62 \cdot 10^{-6} \cdot C$	
		1 MHz	$0.10 \cdot 10^{-3} \cdot C$	
	100 pF	1 kHz	$26 \cdot 10^{-6} \cdot C$	
	1 nF	1 kHz	$31 \cdot 10^{-6} \cdot C$	
		100 kHz	$0.10 \cdot 10^{-3} \cdot C$	
	10 nF	100 Hz	$0.20 \cdot 10^{-3} \cdot C$	
		1 kHz	$0.12 \cdot 10^{-3} \cdot C$	
		10 kHz	$0.11 \cdot 10^{-3} \cdot C$	
	100 nF	100 Hz; 1 kHz; 10 kHz	$0.15 \cdot 10^{-3} \cdot C$	
	1 µF	100 Hz; 1 kHz	$0.10 \cdot 10^{-3} \cdot C$	
		10 kHz	$0.20 \cdot 10^{-3} \cdot C$	

High-frequency and radiation quantities

High-frequency quantities

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Vertical oscilloscopes	1 mV to 5 V 5 mV to 200 V	DC up to 10 kHz	$1.2 \cdot 10^{-3} \cdot U + 12\ \mu V$	U: Measured value 50 Ω 1 MΩ
Oscilloscope horizontal	25 ps to 40 s		$0.12 \cdot 10^{-6} \cdot T + 0.1$ ps	T: Measured value
Bandwidth f (Frequency Response)	40 Hz to 6 GHz	EURAMET cg-7 v1	$6.3 \cdot 10^{-3} \cdot f^2$/GHz $+ 20 \cdot 10^{-3} \cdot f$	f: Measured value
	> 6 GHz to 40 GHz		$75 \cdot 10^{-3} \cdot f$	
Rise time	30 ps to 45 ps > 45 ps to 1 ms	0.1 V to 3 V	5 ps $10 \cdot 10^{-3} \cdot T + 3$ 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	$78 \cdot 10^{-3} \cdot T$ $67 \cdot 10^{-3} \cdot T$ $58 \cdot 10^{-3} \cdot T$ $56 \cdot 10^{-3} \cdot T$	calculated from the 3 dB bandwidth T: measured value
Frequency f Time Base	10 MHz		$0.2 \cdot 10^{-6} \cdot f$	
Waveform quantities Rise time (e.g. oscilloscope calibrator)	15 ps to 10 ns	0.1 V to 2 V in 50 Ω	$10 \cdot 10^{-3} \cdot T + 3$ ps	Tektronix CSA8000/80E01 ext. trigger signal required
	160 ps to 10 ms	0.1 V to 40 V in 50 Ω	$30 \cdot 10^{-3} \cdot T + 30$ ps	Agilent 54854
Burst generator Output voltage Peak value U_p	100 V to 4 kV	less than 50 Ω or 1 kΩ load	$48 \cdot 10^{-3} \cdot U_p$	
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		$1 \cdot 10^{-3} \cdot f$	
ESD generator Rise time t_r of current peak	300 ps to 3 ns		3 % · t_r + 15 ps	
Discharge current I	1.5 A to 35 A		4.3 % · I + 0.15 A	Measuring range related to the current peak I_P
Surge voltage generator Front time t_{r,U_p} of open circuit voltage	15 ns to 100 ms		3 % · $t_{r,Us}$ + 1 ns	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Front time $t_{r,Is}$ of short-circuit current	100 ns to 100 ms		3 % · $t_{r,Is}$ + 2 ns	
Half width t_H of the waveform	0.5 µs to 100 ms		5 % · t_H	
Peak value of the open circuit voltage U_P	0.1 kV to 7 kV		2.5 % · U_p	
Peak value of the short-circuit current I_P	10 A to 5 kA		3.5 % · I_p	
	> 5 kA to 10 kA		3.8 % · I_p	
Pulse quantities Measuring receiver		EN 55016-1-1:2015 c)		
Display response to pulses Amplitude relationship (absolute calibration)				
	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 of the display with the pulse frequency (relative calibration)	Pulse Repetition Frequency		0.30 dB	
	0.1 Hz to 2 kHz			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 item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF power Input power and calibration factor of RF power meters	100 pW to < 10 nW	DC up to 2 GHz	$17 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 2 GHz $\lvert\Gamma_L\rvert \leq 0.1$ 2 GHz ≤ f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 12 GHz ≤ f < 18 GHz R&S NRVC with (cascaded) attenuator **) Explanation: see penultimate page
		> 2 GHz to 4 GHz	$18 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$25 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$36 \cdot 10^{-3} \cdot P$	
	10 nW to <1 µW	DC up to 50 MHz	$14 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$33 \cdot 10^{-3} \cdot P$	
	100 nW to < 10 µW	DC up to 50 MHz	$12 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$53 \cdot 10^{-3} \cdot P$	
	1 µW to < 0.1 W	DC up to 50 MHz	$12 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$26 \cdot 10^{-3} \cdot P$	
	0.1 µW to 0.1 mW	DC up to 50 MHz	$16 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz NRV- Z15 ***)
		> 50 MHz to 4 GHz	$17 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$33 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$43 \cdot 10^{-3} \cdot P$	
		> 26.5 GHz to 32 GHz	$45 \cdot 10^{-3} \cdot P$	
		> 32 GHz to 40 GHz	$55 \cdot 10^{-3} \cdot P$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF power Input power and calibration factor of RF power meters	0.1 µW to 0.1 mW	DC up to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5 GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $32 \cdot 10^{-3} \cdot P$ $54 \cdot 10^{-3} \cdot P$ $67 \cdot 10^{-3} \cdot P$ $90 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz R&S NRV- Z55 with attenuator ***)
	0.1 mW to 80 mW	DC up to 50 MHz > 50 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 18 GHz	$7 \cdot 10^{-3} \cdot P$ $8 \cdot 10^{-3} \cdot P$ $9 \cdot 10^{-3} \cdot P$ $12 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_{L,DUT}\rvert \leq 0.07$ DC < f < 2 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.10$ 2 GHz < f ≤ 4 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.13$ 4 GHz < f ≤ 18 GHz R&S NRV-Z51 **) R&S NRVC **)
	1 µW to 10 mW	DC to 12 GHz	$(0.59 \cdot 10^{-3} \cdot f/\text{GHz} + 8.0 \cdot 10^{-3}) \cdot P$	$\lvert\Gamma_{L,DUT}\rvert \leq 0.02\sqrt{f/\text{GHz}}$
		> 12 GHz to 40 GHz	$(0.73 \cdot 10^{-3} \cdot f/\text{GHz} + 15 \cdot 10^{-3}) \cdot P$	R&S NRPC40 ***)
	0.1 mW to 80 mW	DC up to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5 GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$ $45 \cdot 10^{-3} \cdot P$ $52 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz R&S NRV- Z55 ***)

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF power Input power and calibration factor of RF power meters	10 fW to < 1 pW	DC up to 50 MHz	$20 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 2 GHz $\lvert\Gamma_L\rvert \leq 0.1$ 2 GHz ≤ f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 12 GHz ≤ f < 18 GHz R&S NRV-Z51 **) with (cascaded) attenuator **) Explanation: see penultimate page
		> 50 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$22 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$33 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$68 \cdot 10^{-3} \cdot P$	
	1 pW to < 100 pW	DC up to 50 MHz	$19 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$30 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$67 \cdot 10^{-3} \cdot P$	
	100 pW to < 10 nW	DC up to 50 MHz	$18 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$19 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$28 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$39 \cdot 10^{-3} \cdot P$	
	10 nW to < 1 µW	DC up to 50 MHz	$15 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$16 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$17 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$24 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$36 \cdot 10^{-3} \cdot P$	
	100 nW to < 10 µW	DC up to 50 MHz	$13 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$17 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$26 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$66 \cdot 10^{-3} \cdot P$	
	0.1 µW to 0.1 mW	DC up to 50 MHz	$13 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$16 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$23 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$30 \cdot 10^{-3} \cdot P$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Power Output Power and calibration factor of HF sources	0.1 pW to < 10 pW	50 MHz	$27 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $f <$ 18 GHz selective measuring system Agilent N5531S-518 **) Explanation: see penultimate page
		10 MHz to 2 GHz	$30 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 3 GHz	$36 \cdot 10^{-3} \cdot P$	
	10 pW to < 1 nW	50 MHz	$21 \cdot 10^{-3} \cdot P$	
		10 MHz to 2 GHz	$25 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 3 GHz	$32 \cdot 10^{-3} \cdot P$	
	1 nW to 80 mW	50 MHz	$17 \cdot 10^{-3} \cdot P$	
		10 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$29 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$50 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$71 \cdot 10^{-3} \cdot P$	
	0.1 pW to < 10 pW	50 MHz	$29 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 4 GHz $\le f <$ 26,5 GHz Agilent N5531S-526 ***)
		30 MHz to 3 GHz	$35 \cdot 10^{-3} \cdot P$	
	10 pW to < 1 nW	50 MHz	$24 \cdot 10^{-3} \cdot P$	
		30 MHz to 3 GHz	$31 \cdot 10^{-3} \cdot P$	
	1 nW to 80 mW	50 MHz	$19 \cdot 10^{-3} \cdot P$	
		30 MHz to 4 GHz	$25 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$38 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$93 \cdot 10^{-3} \cdot P$	
	1mW	50 MHz	$5 \cdot 10^{-3} \cdot P$	Substitution
	0.1 µW to < 0.1 mW	10 MHz to 50 MHz	$20 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 18 GHz R&S NRV- Z1 **)
		> 50 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$35 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$50 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$75 \cdot 10^{-3} \cdot P$	
	0.1 µW to < 0.1 mW	10 MHz to 50 MHz	$13 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 40 GHz NRV- Z15 ***)
		> 50 MHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$32 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$54 \cdot 10^{-3} \cdot P$	
		> 26.5 GHz to 32 GHz	$67 \cdot 10^{-3} \cdot P$	
		> 32 GHz to 40 GHz	$90 \cdot 10^{-3} \cdot P$	
	0.1 mW to < 80 mW	DC up to 50 MHz	$9 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 18 GHz R&S NRV- Z51 **)
		> 50 MHz to 2 GHz	$12 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$19 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$29 \cdot 10^{-3} \cdot P$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Power Output Power and calibration factor of HF sources	0.1 mW to < 80 mW	DC up to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5 GHz > 26.5GHz to 32GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $53 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 40 GHz R&S NRV- Z55 ***)
	10 mW to < 1 W	DC up to 50 MHz > 50 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 18 GHz	$11 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 18 GHz R&S NRV- Z51 **) with (cascaded) attenuator Explanation: see last page
	> 1 W to 70 W	DC to 3 GHz	$38 \cdot 10^{-3} \cdot P$	
	>70 W to 250 W	DC up to 500 MHz	$37 \cdot 10^{-3} \cdot P$	
HF voltage U_{HF} sources with HF voltage display with respect to 50 Ω	2.2 µV 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 to 7 V	DC up to 18 GHz		
	2.2 µV to 220 µV	DC to 3 GHz		***)
	2.2 mV to 2 V	DC up to 40 GHz		
HF voltage U_{HF} measurement devices and receivers with HF voltage display with respect to 50 Ω	0.7 µV to 2 V	DC up to 18 GHz	$W(U_{HF}) = \frac{W(P_{inc})}{2}$	$W(P_{inc})$ is the relative uncertainty of the irradiated power with respect to $Z_0 = 50\ \Omega$
	2.2 mV to 2 V	DC up to 40 GHz		**) ***)
HF Power Noise display of receivers	DC up to 40 GHz		1.6 dB	Power > -170 dB (1 mW) based on 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
Bandwidth Filter	1 Hz to 10 MHz		0.5 %	Signal to noise ratio SNR ≥ 70 dB
Form factor	> 1:1 to 5:1 > 5:1 to 10:1 > 10:1 to 20:1		3 % 6 % 12 %	Signal to noise ratio SNR ≥ 15 dB
Switching deviation			0.02 dB	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Display linearity	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB > 80 dB to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1dB 0.2 dB	SNR ≥ 50 dB $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ $f \leq 500$ MHz
Input attenuator or IF amplifier	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB > 80 dB to 100 dB > 100 dB to 110 dB	100 kHz to 500 MHz	0.06 dB 0.07 dB 0.09 dB 0.1dB 0.2 dB	Comparison with external step attenuator $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ $f \leq 500$ MHz
	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB	100 kHz to 500 MHz	0.04 dB 0.06 dB 0.08 dB	step down display comparison SNR ≥ 50 dB, Receiver linearity < (0.01 dB + 0.005 dB/10 dB)
HF gain Amplifier	0 dB to 70 dB	DC up 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 to 70 dB	DC up 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
HF current intensity current clamps	100 µA to 50 mA	40 Hz to 10 MHz > 10 MHz to 30 MHz > 30 MHz to 65 MHz	$14 \cdot 10^{-3} \cdot I$ $18 \cdot 10^{-3} \cdot I$ $20 \cdot 10^{-6} f^2 \cdot I$	Tektronix 015-0601-50. Combined with an oscilloscope I = measured value f: frequency in MHz
Non-linearity of HF power meters	10 nW to 1 W	50 MHz	$5.5 \cdot 10^{-3}$ (0.024 dB)	R&S NRVC-B2 60 dB max.

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Reflection Factor Absolute value $\lvert\Gamma\rvert$	0 to 1	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.003 to 0.013 See matrix M.3	N connector, 50 Ω, other connectors increase the measurement uncertainty. Measurement uncertainty in units of absolute value of the reflection factor
	0 to 1	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	0.003 to 0.016 See matrix M.4	3.5mm connector Measurement uncertainty in units of absolute value of the reflection factor
	0 to 1	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0) c)	0.004 to 0.017 See matrix M.5	2.92 mm connector Measurement uncertainty in units of absolute value of the reflection factor
HF Reflection Factor Phase Angle ϕ	-180° to 180°	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.2° to 4.7° See matrix M.6	N connector, 50 Ω, other connectors increase measurement uncertainty
	-180° to 180°	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	0.3° to 5.8° See matrix M.7	3.5 mm connector
	-180° to 180°	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0) c)	0.3° to 6.3° See matrix M.8	2.92 mm connector
HF attenuation attenuators	0 dB 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, ****) $\lvert\Gamma_{DUT}\rvert \leq 0.01$ $f \leq 500$ MHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ 500 MHz < $f \leq$ 10 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.08$ 10 GHz < $f \leq$ 18 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.1$ 18 GHz < $f \leq$ 40 GHz
	> 30 dB 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	0.001 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	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF attenuation attenuators	> 60 dB to 70 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.07 dB 0.10 dB	$\lvert\Gamma_{L,DUT}\rvert \leq 0.01$ $f \leq 500$ MHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ 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	0.1dB 0.3 dB	
HF attenuation	0 dB to 60 dB	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.01 dB to 0.09 dB See matrix M.9	N connector, 50 Ω, other connectors increase measurement uncertainty
	0 dB to 60 dB	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	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 cg-12 (Version 3.0) c)	0.01 dB to 0.32 dB See matrix M.11	2.92 mm connector
HF attenuation Phase Angle ϕ	-180° to 180°	9 kHz to 18 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0) c)	0.2° to 0.8° See matrix M.12	N connector, 50 Ω, other connectors increase measurement uncertainty
	-180° to 180°	9 kHz to 33 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0) c)	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 cg-12 (Version 3.0) c)	0.2° to 2.5° See matrix M.14	2.92 mm connector

Matrix M.3 "HF reflection factor, absolute value|Γ|; N connector 50 Ω"

Measuring uncertainty in units of the absolute value of the reflection factor.

Reflection factor |Γ|	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 "HF reflection factor, absolute value |Γ|; 3.5 mm connector"

Measuring uncertainty in units of the absolute value of the reflection factor.

Reflection factor |Γ|	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

Matrix M.5 "HF reflection factor, absolute value |Γ|; 2.92 mm connector"

Measuring uncertainty in units of the absolute value of the reflection factor.

Reflection factor |Γ|	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 "HF reflection factor, phase angle ϕ; N connector 50 Ω"

Reflection factor |Γ|	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 "HF reflection factor, phase angle ϕ; 3.5 mm connector"

Reflection factor |Γ|	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°

Matrix M.8 "HF reflection factor, phase angle ϕ; 2.92 mm connector"

Reflection factor |Γ|	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	0.01dB	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	0.01dB	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

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	0.01dB	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 "HF 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°

Matrix M.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°

High-frequency and radiation measured variables - Optical measured

Radiometry

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Optical radiometric power fibre optic power meters	1 µW to 0.5 mW	1310 nm, 1550 nm 850 nm 654 nm	1.3 % 2.2% 2.2%	Connector FC, ST, SC, SMA, HMS-10 or adaptable other wavelengths (780 nm, 635 nm, 1625 nm) interpolated
Nonlinearity fibre optic radiation detectors	10 nW to 160 µW	1310 nm, 1550 nm, 850 nm	$1.8 \cdot 10^{-3}$ (0.008 dB)	Addition methods
	0.1 nW to < 0.32 nW		$20 \cdot 10^{-3}$ (0.085 dB)	Comparison methods
	0.32 nW to < 3.2 nW		$7.1 \cdot 10^{-3}$ (0.031 dB)	
	3.2 nW to 0.5 µW		$6.0 \cdot 10^{-3}$ (0.026 dB)	
Attenuation or amplification of fibre optic components	0 dB to 50 dB	Wavelengths: 1310 nm, 1550 nm, 850 nm Reference power: approx. 0.5 mW	$6.0 \cdot 10^{-3}$ (0.026 dB)	
	> 50 dB to 60 dB		$7.1 \cdot 10^{-3}$ (0.031 dB)	
	> 60 dB to 70 dB		$20 \cdot 10^{-3}$ (0.085 dB)	
Central wavelength λ	350 nm to < 700 nm		0.5 nm	
	700 nm to < 1250 nm		2.5 pm	
	1250 nm to1700 nm		2 pm	

High Frequency and Radiation Quantities- Optical Quantities

Photometry

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Transmission filter Transmission *T*	16% to 60% > 60% to 76% > 76% to < 100 %	QMH Chapter XXXIV v4.0 Nominal values in the opacity values of the standards	0.65% 0.70% 0.80 %	
Opacity level *N*	> 0% to < 24% > 24% to < 40% 40% to 84%		0.80 % 0.70% 0.65%	
Opacity coefficient *k*	Measuring chamber length 0.43 m > 0m-1 to $^{4.3m-1}$		0.020 m^{-1} to 0.050 m^{-1}	Opacity coefficient *k* calculated from the opacity level *N*. Uncertainty interval *U(k)* is calculated from the uncertainty interval of the opacity level *U(N)*. Other measurement chamber lengths increase the measurement uncertainty.
Illuminance level *E*	0 lx	QMH XXXI	0.01 lx	Reference zero
	900 lx to 2000 lx		1.7% · *E*	Standard light
	≥ 5 lx to < 10 klx		1.9% · *E*	LED Light
	≥ 10 klx to 110 klx		$9.0 \cdot 10^{-8} \cdot E^2$/lx + 0.02 ·*E* – 13 lx	

Dimensional Quantities

Length and Angle

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Callipers for external, internal and depth dimensions [c)]	to 500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	20 µm + 15 · 10^{-6} · *l*	*l*: Measured value
Micrometers [(c)]	to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	2 µm + 6 · 10^{-6} · *l*	
Dial gauge with scale indicator[c)]	to 100 mm	VDI/VDE/DGQ 2618 Sheet 11.1:2014	1.5 µm + 10 · 10^{-6} · *l*	
Dial gauge with digital display [c)]	to 100 mm	VDI/VDE/DGQ 2618 Sheet 11.4:2020	1.5 µm + 10 · 10^{-6} · *l*	
Dial indicators for linear measurement [c)]	to 3 mm	VDI/VDE/DGQ 2618 Sheet 11.2:2002	0.9 µm	
Lever gauges [c)]	to 1.6 mm	VDI/VDE/DGQ 2618 Sheet 11.3:2002		
Gauges block made of steel or ceramic according to DIN ISO 3650 [c)]	0.5 mm to 100 mm	VDI/VDE/DGQ 2618 Sheet 3.1:2004 Measurement of the deviation l_c from Nominal dimension *ln* by difference measurement	0.1 µm + 0.8 · 10^{-6} · *l*	
	in the nominal dimensions of the standards	Measurement of deviations f_o and f_u from the central length by 5-point differential measurement	0.08 µm	

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Cylindrical gauges Rings gauges Diameter [c]	3 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3	0.7 µm + 0.8 · 10^{-6} · *d*	*d* is the measured diameter
	> 125 mm to 300 mm		0.6 µm + 2.1 · 10^{-6} · *d*	
Plug gauges diameter [c]	1 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3	0.5 µm + 1.2 · 10^{-6} · *d*	
	> 125 mm to 300 mm		0.3 µm + 2.8 · 10^{-6} · *d*	
Cylindrical measuring pins Diameter [c]	1 mm to 20 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 1	0.5 µm + 1.2 · 10^{-6} · *d*	
Thread gauge (single and multiple cylindrical external and internal threads with straight flanks, symmetrical profile, nominal lead and nominal thread angle) External thread [c] Simple pitch 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 µm + 0.2 · 10^{-6} · *d*	*d* is the measured flank diameter
	> 125 mm to 500 mm		2.7 µm + 1.0 · 10^{-6} · *d*	
Internal thread [c] Simple pitch diameter	3 mm to 125 mm	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Option 1 Two-sphere method (perpendicular to the thread axis)	2.5 µm + 0.3 · 10^{-6} · *d*	
Lever systems for force application on brake testers	to 600 mm	Work instruction AA0364 Version 8.0	52 µm	*l*: Measured value
	600 mm to 2500 mm		23 · 10^{-6} · *l* + 0.12 mm	

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Leveling scales for interval measurements	to 100 mm	AA0265-4 Version 8.0	40 µm	Measuring range based on the interval between any two graduation marks on the scale
Tape measures	0.1 m to 25 m	AA0265-2.2.1 Version 8.0	2.4 mm + 45 · 10^{-6} · l	l = measured length tape measures for the characterisation of headlight alignment test systems
Steel circumference tape measures		AA0265-3 Version 8.0		Calibration at the nominal values of the standards
Diameter	150 mm to 300 mm		62 µm	
Circumference	470 mm to 950 mm		190 µm	
Electronic perimeters	-55° to -30°	AA0206 Version 1.0	42·10^{-6}·|α|+ 0.00034°	max. Base length 100 mm α= Angle in °
	-30° to 30°		0.0016°	
	30° to 55°		42·10^{-6}·|α|+ 0.00034°	
Point and line laser inclination deviation	0 mm/m to 2 mm/m	AA0356 Version 9.0		
horizontal			0.080 mm/m	
vertical			0.10 mm/m	
Position Sensitive Detector / PSD Diodes X- and Y-axis deviation	to 5 mm	AA0356 Version 9.0	18 µm	

DC current and low frequency quantities

DC and AC voltage

On-site calibration

Calibration and Measurement Capabilities (CMC)

Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
0 V		35 nV	Short brigde
0 V to 1 V	linear step-up/down	$0.46 \cdot 10^{-6} \cdot U + 0.18$ µV	U = measured value
> 1 to 10 V		$0.18 \cdot 10^{-6} \cdot U + 0.67$ µV	
> 10 V to 100 V		$0.28 \cdot 10^{-6} \cdot U - 0.34$ µV	
> 100 V to 1050 V		$0.24 \cdot 10^{-6} \cdot U + 64$ µV	
1 kV to 10 kV		$7.9 \cdot 10^{-6} \cdot U + 17$ mV	U = measured value
> 10 kV to 60 kV		$46 \cdot 10^{-6} \cdot U + 0.95$ V	
2 mV to 10 mV	10 Hz; 12.5 Hz	$26 \cdot 10^{-6} \cdot U + 0.11$ µV	U = measured value Calibration with the Josephson voltmeter. When calibrating measuring instruments, the influence of the load impedance and the 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;	$28 \cdot 10^{-6} \cdot U + 23$ nV	
	48 Hz; 60 Hz; 62.5 Hz	$19 \cdot 10^{-6} \cdot U + 0.11$ µV	
	625 Hz; 937.5 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot U + 0.12$ µV	
> 10 mV to 60 mV	10 Hz; 12.5 Hz	$13 \cdot 10^{-6} \cdot U + 0.19$ µV	
	20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz;	$8.6 \cdot 10^{-6} \cdot U + 0.16$ µV	
	48 Hz; 60 Hz; 62.5 Hz	$10 \cdot 10^{-6} \cdot U + 0.16$ µV	
	625 Hz; 937.5 Hz; 1 kHz	$9.1 \cdot 10^{-6} \cdot U + 0.16$ µV	
> 60 mV to 7.2 V	10 Hz; 12.5 Hz	$10 \cdot 10^{-6} \cdot U + 0.14$ µV	
	20 Hz; 25 Hz; 30 Hz; 37.5 Hz; 40 Hz; 75 Hz; 80 Hz; 125 Hz; 312.5 Hz; 375 Hz;	$2.2 \cdot 10^{-6} \cdot U + 0.16$ µV	
	48 Hz; 60 Hz; 62.5 Hz	$4.2 \cdot 10^{-6} \cdot U + 0.14$ µV	
	625 Hz; 937.5 Hz; 1 kHz	$1.4 \cdot 10^{-6} \cdot U + 0.16$ µV	
2 mV to < 22 V	10 Hz to 1 MHz		U = measured value
2 mV	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	$0.29 \cdot 10^{-3} \cdot U$	
	500 kHz	$0.32 \cdot 10^{-3} \cdot U$	
	1 MHz	$0.43 \cdot 10^{-3} \cdot U$	
6 mV	10 Hz	$0.16 \cdot 10^{-3} \cdot U$	
	20 Hz	$0.14 \cdot 10^{-3} \cdot U$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
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	$0.13 \cdot 10^{-3} \cdot U$	U = measured value Intermediate values increase the measurement uncertainty. Calibration with AC/DC transfer-standard. When calibrating measuring instruments, the influence of the load impedance, the impedance of the connectors and the repeatability must be taken into account.
		300 kHz	$0.15 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.17 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.22 \cdot 10^{-3} \cdot U$	
	10 mV	10 Hz	$0.13 \cdot 10^{-3} \cdot U$	
		20 Hz	$0.12 \cdot 10^{-3} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$0.10 \cdot 10^{-3} \cdot U$	
		300 kHz	$0.12 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.16 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.21 \cdot 10^{-3} \cdot U$	
	20 mV	10 Hz	$0.12 \cdot 10^{-3} \cdot U$	
		20 Hz	$0.11 \cdot 10^{-3} \cdot U$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz	$86 \cdot 10^{-6} \cdot U$	
		300 kHz	$0.11 \cdot 10^{-3} \cdot U$	
		500 kHz	$0.13 \cdot 10^{-3} \cdot U$	
		1 MHz	$0.17 \cdot 10^{-3} \cdot U$	
	60 mV	10 Hz	$54 \cdot {}^{10-6} \cdot U$	
		20 Hz; 40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$32 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$46 \cdot 10^{-6} \cdot U$	
		500 kHz	$60 \cdot 10^{-6} \cdot U$	
		1 MHz	$95 \cdot 10^{-6} \cdot U$	
	100 mV	10 Hz	$22 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$20 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$17 \cdot 10^{-6} \cdot U$	
		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	$25 \cdot 10^{-6} \cdot U$	
		500 kHz	$34 \cdot 10^{-6} \cdot U$	
		1 MHz	$53 \cdot 10^{-6} \cdot U$	
	200 mV	10 Hz	$37 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$18 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$15 \cdot 10^{-6} \cdot U$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage	200 mV	400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$12 \cdot 10^{-6} \cdot U$	U = measured value Intermediate values increase the measurement uncertainty. Calibration with AC/DC transfer-standard. When calibrating measuring instruments, the influence of the load impedance, the impedance of the connectors and the repeatability must be taken into account.
		100 kHz	$13 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$23 \cdot 10^{-6} \cdot U$	
		500 kHz	$33 \cdot 10^{-6} \cdot U$	
		1 MHz	$49 \cdot 10^{-6} \cdot U$	
	600 mV	10 Hz	$31 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$13 \cdot 10^{-6} \cdot U$	
		400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$10 \cdot 10^{-6} \cdot U$	
		100 kHz	$11 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \cdot 10^{-6} \cdot U$	
		500 kHz	$33 \cdot 10^{-6} \cdot U$	
		1 MHz	$50 \cdot 10^{-6} \cdot U$	
	1 V	10 Hz	$17 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$11 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \cdot 10^{-6} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$13 \cdot 10^{-6} \cdot U$	
		500 kHz	$17 \cdot 10^{-6} \cdot U$	
		1 MHz	$30 \cdot 10^{-6} \cdot U$	
	2 V	10 Hz	$38 \cdot 10^{-6} \cdot U$	
		20 Hz; 40 Hz	$12 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz	$7 \cdot 10^{-6} \cdot U$	
		100 kHz	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$11 \cdot 10^{-6} \cdot U$	
		500 kHz	$16 \cdot 10^{-6} \cdot U$	
		1 MHz	$29 \cdot 10^{-6} \cdot U$	
	4 V; 6 V	10 Hz	$32 \cdot 10^{-6} \cdot U$	
		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	$9 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$21 \cdot 10^{-6} \cdot U$	
		500 kHz	$32 \cdot 10^{-6} \cdot U$	
		1 MHz	$35 \cdot 10^{-6} \cdot U$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage	8V; 10V	10 Hz	$19 \cdot 10^{-6} \cdot U$	U = measured value Intermediate values increase the measurement uncertainty. Calibration with AC/DC transfer-standard. When calibrating measuring instruments, the influence of the load impedance, the impedance of the connectors and the repeatability must be taken into account.
		20 Hz	$13 \cdot 10^{-6} \cdot U$	
		40 Hz	$10 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz; 50 kHz; 70 kHz; 100 kHz	$8 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$15 \cdot 10^{-6} \cdot U$	
		500 kHz	$30 \cdot 10^{-6} \cdot U$	
		1 MHz	$47 \cdot 10^{-6} \cdot U$	
	20 V	10 Hz	$29 \cdot 10^{-6} \cdot U$	
		20 Hz	$14 \cdot 10^{-6} \cdot U$	
		40 Hz	$11 \cdot 10^{-6} \cdot U$	
		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	$10 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$16 \cdot 10^{-6} \cdot U$	
		500 kHz	$32 \cdot 10^{-6} \cdot U$	
		1 MHz	$49 \cdot 10^{-6} \cdot U$	
	12V; 15V; 19V	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	$23 \cdot 10^{-6} \cdot U$	
		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	$9 \cdot 10^{-6} \cdot U$	
		70 kHz	$10 \cdot 10^{-6} \cdot U$	
		100 kHz	$14 \cdot 10^{-6} \cdot U$	
		200 kHz; 300 kHz	$22 \cdot 10^{-6} \cdot U$	
	> 70 V to 110 V 100 V	10 Hz to 200 kHz 10 Hz; 20 Hz	$19 \cdot 10^{-6} \cdot U$	
		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	$20 \cdot 10^{-6} \cdot U$	
		100 kHz	$32 \cdot 10^{-6} \cdot U$	
		200 kHz	$37 \cdot 10^{-6} \cdot U$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage	> 110 V to 700 V 200 V	10 Hz to 100 kHz 10 Hz	$27 \cdot 10^{-6} \cdot U$	U = measured value Intermediate values increase the measurement uncertainty. Calibration with AC/DC transfer-standard. When calibrating measuring instruments, the influence of the load impedance, the impedance of the connectors and the repeatability must be taken into account.
		20 Hz	$21 \cdot 10^{-6} \cdot U$	
		40 Hz	$16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz	$15 \cdot 10^{-6} \cdot U$	
		400 Hz; 500 Hz; 1 kHz;	$13 \cdot 10^{-6} \cdot U$	
		10 kHz; 20 kHz; 50 kHz;	$17 \cdot 10^{-6} \cdot U$	
		70 kHz	$20 \cdot 10^{-6} \cdot U$	
		100 kHz	$31 \cdot 10^{-6} \cdot U$	
	600 V	40 Hz	$17 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$14 \cdot 10^{-6} \cdot U$	
		1 kHz; 10 kHz; 20 kHz; 50 kHz	$16 \cdot 10^{-6} \cdot U$	
		70 kHz	$25 \cdot 10^{-6} \cdot U$	
		100 kHz	$37 \cdot 10^{-6} \cdot U$	
	> 700 V to 1000 V 1000 V	10 Hz to 100 kHz 40 Hz	$16 \cdot 10^{-6} \cdot U$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz; 20 kHz	$14 \cdot 10^{-6} \cdot U$	
		50 kHz	$25 \cdot 10^{-6} \cdot U$	
		70 kHz	$32 \cdot 10^{-6} \cdot U$	
		100 kHz	$42 \cdot 10^{-6} \cdot U$	
High voltage Sources	1 kV to 10 kV	10 Hz to 20 kHz	$50 \cdot 10^{-6} \cdot U + 2$ V	
		> 20 kHz to 50 kHz	$0.34 \cdot 10^{-3} \cdot U + 1.6$ V	
		> 50 kHz to 100 kHz	$1.6 \cdot 10^{-3} \cdot U + 0.9$ V	
	> 10 kV to 40 kV	10 Hz to 20 kHz	$0.10 \cdot 10^{-3} \cdot U + 3.7$ V	
		> 20 kHz to 50 kHz	$0.43 \cdot 10^{-3} \cdot U + 2.1$ V	
		> 50 kHz to 100 kHz	$1.7 \cdot 10^{-3} \cdot U + 0.7$ 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		$0.10 \cdot 10^{-3} \cdot U + 3.7$ V	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Square-wave voltage	5 mV to 220 mV	1 Hz to 10 kHz	$10 \cdot 10^{-6} \cdot U + 0.36\ \mu V + 6.4 \cdot 10^{-9}\ V/Hz \cdot f$	Sampling method at 10 MΩ load. Range indication in peak-to-peak amplitude. U = Peak value of the voltage f = Frequency The additional influence of different load conditions (such as e.g. 50 Ω or 1 MΩ must be taken into account).
	> 220mV to 2.2V		$9.3 \cdot 10^{-6} \cdot U + 0.35\ \mu V + 7.0 \cdot 10^{-9}\ V/Hz \cdot f$	
	> 2.2 V to 22 V		$9.3 \cdot 10^{-6} \cdot U + 0.58\ \mu V + 14 \cdot 10^{-9}\ V/Hz \cdot f$	
	> 22 V to 220 V		$12 \cdot 10^{-6} \cdot U + 35\ \mu V + 75 \cdot 10^{-9}\ V/Hz \cdot f$	
AC voltage Amplitude parameter	5 mV to 5 V	DC to 10 MHz > 10 MHz to 100 MHz > 100 MHz to 300 MHz > 300 MHz to 1 GHz	$25 \cdot 10^{-3} \cdot U + 0.2\ \mu V$ $37 \cdot 10^{-3} \cdot U + 0.5\ \mu V$ $44 \cdot 10^{-3} \cdot U + 0.4\ \mu V$ $70 \cdot 10^{-3} \cdot U$	With oscilloscope U = measured value
	> 5 V to 50 V	DC up to 2 kHz > 2 kHz to 10 MHz	$12 \cdot 10^{-3} \cdot U + 0.7\ \mu V$ $25 \cdot 10^{-3} \cdot U + 0.7\ \mu V$	
AC voltage Harmonics	2.2 V to 22 V	40 Hz to 4 kHz	$65 \cdot 10^{-6} \cdot U_n + 60\ \mu V$	U_n = voltage of the nth harmonic or 1st harmonic $U_{peak} < 1.4$ kV
	> 22 V to 220 V		$70 \cdot 10^{-6} \cdot U_n + 0.8$ mV	
	> 220 V to 700 V	40 Hz to 1 kHz	$80 \cdot 10^{-6} \cdot U_n + 4$ mV	
		> 1 kHz to 4 kHz	$0.13 \cdot 10^{-3} \cdot U_n + 6$ mV	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage Harmonics	1st harmonic 0.1 A to 16 A	40 Hz to 65 Hz 0.15 A to 30 A, peak	$0.68 \cdot 10^{-3} \cdot I$	I_n = Current of the nth harmonic eff.= effective value limit n of the distorted signal When using current clamps, measurement uncertainty and range limits increase at least by the factor of N of turns used
	Harmonic 0.022 A to 0.22 A	80 Hz to 1 kHz 0.15 A to 1.4 A, peak	$0.12 \cdot 10^{-3} \cdot I_n + 3.5\ \mu A$	
	> 0.22 A to 0.8 A		$0.55 \cdot 10^{-3} \cdot I_n + 35\ \mu A$	
	0.22 A to 1.2 A	> 1.4 A to < 1.8 A, peak		
	0.22 A to 2.2 A	1.8 A to < 7 A, peak		
	> 2.2 A to 4 A		$0.34 \cdot 10^{-3} \cdot I_n$	
	1 A to 8 A	7 A to 14 A, peak	$0.68 \cdot 10^{-3} \cdot I_n$	
	2 A to 15 A	> 14 A to 30 A, peak		
	Harmonic 0.022 A to 0.22 A	> 1 kHz to 4 kHz 0.15 A to 1.4 A, peak	$0.50 \cdot 10^{-3} \cdot I_n + 40\ \mu A$	
	> 0.22 A to 0.8 A		$0.65 \cdot 10^{-3} \cdot I_n + 80\ \mu A$	
	0.22 A to 1.2 A	> 1.4 A to < 1.8 A, peak		
	0.22 A to 2.2 A	1.8 A to < 7 A, peak		
	> 2.2 A to 4 A		$0.34 \cdot 10^{-3} \cdot I_n$	
	1 A to 8 A	7 A to 14 A, peak	$0.68 \cdot 10^{-3} \cdot I_n$	
	2 A to 15 A	> 14 A to 30 A, peak		
Flicker Modulation depth $\Delta U/U$	0.4% to 3.2%	DIN EN 61000-4-15:2011[c], Table 5	$1.6 \cdot 10^{-3}$ %	Values at $\Delta U/U$ expressed in $\Delta U/U$ Rectangular flicker
Sources Measuring instruments			$25 \cdot 10^{-3}$ %	
Frequency	8.3 mHz to 40 Hz		$0.14 \cdot 10^{-3} \cdot f$	
P_{st}-value	only $P_{st} = 1$		$2.5 \cdot 10^{-3}$	
AC voltage Total harmonic distortion k	0% to 30%	45 Hz to 5 kHz > 5 kHz to 30 kHz	$0.5 \cdot 10^{-3} \cdot k + 0.012$ % $0.8 \cdot 10^{-3} \cdot k + 0.012$ %	Values expressed in % of total harmonic distortion

DC and AC current

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC current	0 pA to 10 nA 0 pA 1 pA 10 pA 100 pA 1 nA 10 nA		0.85 fA to 51 fA 12 fA $0.85 \cdot 10^{-3} \cdot I$ $0.53 \cdot 10^{-3} \cdot I$ $75 \cdot 10^{-6} \cdot I$ $10 \cdot 10^{-6} \cdot I$ $5.1 \cdot 10^{-6} \cdot I$	I = measured value Intermediate values and different measurement conditions increase the measurement uncertainty.
	> 10 nA to 100 nA		$4.1 \cdot 10^{-6} \cdot I + 10$ fA	
	> 100 nA to < 1 µA		$1.4 \cdot 10^{-6} \cdot I + 0.21$ pA	
	1 µA to 10 µA		$1.4 \cdot 10^{-6} \cdot I + 0.19$ pA	
	> 10 µA to 20 µA		$1.4 \cdot 10^{-6} \cdot I + 1.8$ pA	
	20 µA to 200 µA	QMH, Chap. VIa Vers. 5.0 T = (23 ± 2) °C	$1.4 \cdot 10^{-6} \cdot I + 14$ pA	
	200 µA to 2 mA		$0.54 \cdot 10^{-6} \cdot I + 0.23$ nA	
	2 mA to 10 mA		$1.1 \cdot 10^{-6} \cdot I + 2.4$ nA	
	10 mA to 50 mA		$0.90 \cdot 10^{-6} \cdot I + 25$ nA	
	50 mA to 200 mA		$0.33 \cdot 10^{-6} \cdot I + 0.26$ µA	
	200 mA to 1 A		$12 \cdot 10^{-6} \cdot I$	
	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	QMH, Chap. VIb.1.1 Vers. 5.0 T = (23 ± 2) °C	$37 \cdot 10^{-6} \cdot I$	
DC power Sources	300 A to 700 A		$27 \cdot 10^{-6} \cdot I + 2.3$ mA	
DC current Current clamps and clamp transformer	0 A to 3000 A	1 to N windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot I$ but not less than 8 $\cdot 10^{-6} \cdot I$ or 6 nA	W_{in} is the relative uncertainty of the current of the single winding. W_{DUT} is the relative uncertainty of the measurement object in the stray field of the current-carrying conductor.

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current	100 µA to 100 A	QMH, Chap. VIa Vers. 5.0 10 Hz to 10 kHz	4.4 nA to 6.5 mA	
	100 µA	10 Hz; 20 Hz	$76 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$44 \cdot 10^{-6} \cdot I$	
		10 kHz	$47 \cdot 10^{-6} \cdot I$	
	200 µA	10 Hz; 20 Hz	$68 \cdot 10^{-6} \cdot I$	
		40 Hz	$39 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$36 \cdot 10^{-6} \cdot I$	
		10 kHz	$39 \cdot 10^{-6} \cdot I$	
	0.5 mA	10 Hz; 20 Hz	$64 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz	$28 \cdot 10^{-6} \cdot I$	
		400 Hz; 500 Hz; 1 kHz	$27 \cdot 10^{-6} \cdot I$	
		10 kHz	$32 \cdot 10^{-6} \cdot I$	
	1 mA	10 Hz	$33 \cdot 10^{-6} \cdot I$	
		20 Hz	$30 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz	$26 \cdot 10^{-6} \cdot I$	
		120 Hz; 400 Hz; 500 Hz; 1 kHz	$25 \cdot 10^{-6} \cdot I$	
		10 kHz	$27 \cdot 10^{-6} \cdot I$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current	2 mA	10 Hz	$32 \cdot 10^{-6} \cdot I$	I = measured value f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$29 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$24 \cdot 10^{-6} \cdot I$	
	5 mA	10 Hz	$32 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$29 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz 10 kHz	$24 \cdot 10^{-6} \cdot I$	
	10 mA	10 Hz	$26 \cdot 10^{-6} \cdot I$	
		20 Hz	$24 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \cdot 10^{-6} \cdot I$	
		10 kHz	$22 \cdot 10^{-6} \cdot I$	
	20 mA	10 Hz	$25 \cdot 10^{-6} \cdot I$	
		20 Hz	$23 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot I$	
		10 kHz	$19 \cdot 10^{-6} \cdot I$	
	50 mA	10 Hz	$25 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$23 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$17 \cdot 10^{-6} \cdot I$	
		10 kHz	$19 \cdot 10^{-6} \cdot I$	
	100 mA	10 Hz	$26 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$24 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$18 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$20 \cdot 10^{-6} \cdot I$	
	200 mA	10 Hz	$27 \cdot 10^{-6} \cdot I$	
		20 Hz; 40 Hz	$24 \cdot 10^{-6} \cdot I$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$18 \cdot 10^{-6} \cdot I$	
		10 kHz	$20 \cdot 10^{-6} \cdot I$	
	500 mA	10 Hz	$36 \cdot 10^{-6} \cdot I$	
		20 Hz	$34 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$31 \cdot 10^{-6} \cdot I$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC current	1 A	10 Hz	$32 \cdot 10^{-6} \cdot I$	I = measured value f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$29 \cdot 10^{-6} \cdot I$	
		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	$40 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$34 \cdot 10^{-6} \cdot I$	
	5 A; 10 A	10 Hz	$39 \cdot 10^{-6} \cdot I$	
		20 Hz	$37 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$32 \cdot 10^{-6} \cdot I$	
	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	$53 \cdot 10^{-6} \cdot I$	
	50 A	10 Hz; 20 Hz	$64 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$59 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$68 \cdot 10^{-6} \cdot I$	
	100 A	10 Hz; 20 Hz	$75 \cdot 10^{-6} \cdot I$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$65 \cdot 10^{-6} \cdot I$	
		1 kHz; 10 kHz	$75 \cdot 10^{-6} \cdot I$	
	100 A to 200 A	QMH, Chap. VIb.1.1 Vers. 5.0	12 mA to 24 mA	
		10 Hz to 10 kHz	$0.13 \cdot 10^{-3} \cdot I$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC voltage	200 A to 300 A	10 Hz to 1 kHz	$0.30 \cdot 10^{-3} \cdot I - 0.53$ mA	I = measured value f = Frequency
Sources	300 A to 495 A	10 Hz to 65 Hz	$0.48 \cdot 10^{-3} \cdot I + 11$ mA	
		65 Hz to 100 Hz	$0.49 \cdot 10^{-3} \cdot I + 11$ mA	
		100 Hz to 400 Hz	$0.74 \cdot 10^{-3} \cdot I + 7.7$ mA	
		400 Hz to 1 kHz	$1.5 \cdot 10^{-3} \cdot I + 4.0$ mA	
Current clamps and clamp current transformers	10 µA 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 $90 \cdot 10^{-6} \cdot I$ 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 conductor.
Equivalent leakage current	0.2 µA to 200 mA	to R_N up to 1 GΩ	$10 \cdot 10^{-6} \cdot I$ to $5.8 \cdot 10^{-3} \cdot I$ see matrix M.2	Overall uncertainty U is dependent on the rel. uncertainty $U(R_N)/R_N$ of the calibration resistor R_N
Charge Q	20 pC to 200 pC		$0.50 \cdot 10^{-3} \cdot Q + 0.025$ pC	Rectangular current pulses ≥ 1 s, duration t and rise times ≤ 10 µs as product Q = I · t; total uncertainty calculated from the rel. uncertainty W(lin) of the calibration current.
	> 200 pC to 2 nC		$0.33 \cdot 10^{-3} \cdot Q + 0.05$ pC	
	> 2 nC to 11 C		$60 \cdot 10^{-3} \cdot Q + 0.5$ pC	

Matrix M.3 “Equivivalent leakage current, on-site calibration”

Normal resistance *RN*	1 kΩ		10 kΩ		100 kΩ		1 MΩ		10 MΩ		100 MΩ		1 GΩ			
Nominal voltage	**Current intensity | Extended measurement uncertainty *U* in µA/A**										**Current | *U* in mA/A**					
60 V	60 mA	10	6 mA	10	600 µA	13	60 µA	19	6 µA	70	600 nA	0.6	60 nA	5.8		
110V	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			

DC and AC resistance

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC resistance	0 Ω	2-wire short	0.5 mΩ	R = measured value Calibration of measuring instruments at the nominal values of the standards Intermediate values or different measurement conditions increase the measurement uncertainty.
		4-wire short	0.35 µΩ	
	10 µΩ to < 1 GΩ	QMH, Chap. VIIa.3 Vers. 5.0 T = (23 ± 2) °C	1.6 nΩ to 110 Ω	
	10 µΩ 100 µΩ 1 mΩ 10 MΩ 100 MΩ 1 Ω; 10 Ω; 100 Ω; 1 kΩ; 10kΩ 100 kΩ 1 MΩ; 10 MΩ; 100 MΩ	 I = 100 A I = 50 A I = 10 A	$0.16 \cdot 10^{-3} \cdot R$ $34 \cdot 10^{-6} \cdot R$ $23 \cdot 10^{-6} \cdot R$ $20 \cdot 10^{-6} \cdot R$ $5.6 \cdot 10^{-6} \cdot R$ $0.43 \cdot 10^{-6} \cdot R$ $1.0 \cdot 10^{-6} \cdot R$ $0.60 \cdot 10^{-6} \cdot R$ $0.57 \cdot 10^{-6} \cdot R$ $1.4 \cdot 10^{-6} \cdot R$ $1.5 \cdot 10^{-6} \cdot R$ $4.2 \cdot 10^{-6} \cdot R$ $11.2 \cdot 10^{-6} \cdot R$	
	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 $88 \cdot 10^{-6} \cdot R$ $0.13 \cdot 10^{-3} \cdot R$ $0.24 \cdot 10^{-3} \cdot R$	
	> 1 TΩ to 120 TΩ 10 TΩ; 100 TΩ	Measuring voltage 1000 V	0.48 GΩ to 187 GΩ $0.48 \cdot 10^{-3} \cdot R$ $1.87 \cdot 10^{-3} \cdot R$	
AC resistance (Absolut value of impedance)	100 µΩ to 100Ω	QMH, Chap. VIIa.3 Vers. 5.0 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 Intermediate values and different measurement conditions increase the measurement uncertainty.
	100 µΩ	10 Hz; 20 Hz	$0.17 \cdot 10^{-3} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$0.14 \cdot 10^{-3} \cdot R$	
		1 kHz; 10 kHz	$0.15 \cdot 10^{-3} \cdot R$	
	1 mΩ	10 Hz	$65 \cdot 10^{-6} \cdot R$	
		20 Hz	$63 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$58 \cdot 10^{-6} \cdot R$	
		1 kHz	$61 \cdot 10^{-6} \cdot R$	
		10 kHz	$64 \cdot 10^{-6} \cdot R$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	10 MΩ	10 Hz	$46 \cdot 10^{-6} \cdot R$	R = measured value I = current f = Frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$43 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz	$37 \cdot 10^{-6} \cdot R$	
		1 kHz; 10 kHz	$35 \cdot 10^{-6} \cdot R$	
	20 mΩ	10 Hz	$45 \cdot 10^{-6} \cdot R$	
		20 Hz	$42 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$36 \cdot 10^{-6} \cdot R$	
	50 mΩ	10 Hz	$45 \cdot 10^{-6} \cdot R$	
		20 Hz	$42 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; kHz	$36 \cdot 10^{-6} \cdot R$	
	100 mΩ; 200 mΩ	10 Hz	$39 \cdot 10^{-6} \cdot R$	
		20 Hz	$35 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$30 \cdot 10^{-6} \cdot R$	
	0.5 Ω	10 Hz	$36 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$31 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz;	$26 \cdot 10^{-6} \cdot R$	
	1Ω	10 Hz	$34 \cdot 10^{-6} \cdot R$	
		20 Hz	$30 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz; 10 kHz	$25 \cdot 10^{-6} \cdot R$	
	2 Ω; 5 Ω	10 Hz	$31 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$26 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$20 \cdot 10^{-6} \cdot R$	
		10 kHz	$23 \cdot 10^{-6} \cdot R$	
	10 Ω	10 Hz	$30 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$26 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$21 \cdot 10^{-6} \cdot R$	
		10 kHz	$23 \cdot 10^{-6} \cdot R$	
	20 Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	
		20 Hz; 40 Hz	$25 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz; 1 kHz	$19 \cdot 10^{-6} \cdot R$	
		10 kHz	$22 \cdot 10^{-6} \cdot R$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	50 Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	R = measured value I = current f = frequency Intermediate values and different measurement conditions increase measurement uncertainty.
		20 Hz	$25 \cdot 10^{-6} \cdot R$	
		40 Hz	$20 \cdot 10^{-6} \cdot R$	
		55 Hz; 120 Hz; 400 Hz; 500 Hz	$19 \cdot 10^{-6} \cdot R$	
		1 kHz	$21 \cdot 10^{-6} \cdot R$	
		10 kHz	$25 \cdot 10^{-6} \cdot R$	
AC resistance (Absolut value of impedance)	100Ω	10 Hz	$29 \cdot 10^{-6} \cdot R$	R = measured value I = current f = frequency Intermediate values and different measurement conditions increase the measurement uncertainty.
		20 Hz	$25 \cdot 10^{-6} \cdot R$	
		40 Hz; 55 Hz	$19 \cdot 10^{-6} \cdot R$	
		120 Hz; 400 Hz;	$18 \cdot 10^{-6} \cdot R$	
		500 Hz	$20 \cdot 10^{-6} \cdot R$	
		1 kHz	$31 \cdot 10^{-6} \cdot R$	
		10 kHz	$75 \cdot 10^{-6} \cdot R$	
	100 µΩ to 10 kΩ	10 Hz - 10 kHz	$\sqrt{U_I{}^2 + U_U{}^2} \cdot R$	R = measured value Constant current method U_I is the relative uncertainty of the calibration current U_U is the relative uncertainty of the measured voltage On resistor R
	1 Ω to 10 kΩ	20 Hz to 50 Hz	$2.5 \cdot 10^{-3} \cdot R + 3.1$ mΩ	R = measured value direct measurement method
	> 10 kΩ to 110 MΩ		$2.3 \cdot 10^{-9} \cdot R^2/\Omega + 2.5 \cdot 10^{-3} \cdot R$	
	0 Ω to 20 kΩ	> 50 Hz to 100 Hz	$1.0 \cdot 10^{-3} \cdot R + 2.6$ mΩ	
	> 20 kΩ to 110 MΩ		$2.3 \cdot 10^{-9} \cdot R^2/\Omega + 1.3 \cdot 10^{-3} \cdot R$	
	0 Ω to 50 kΩ	> 100 Hz to 1 kHz	$0.5 \cdot 10^{-3} \cdot R + 1.3$ mΩ	
	> 50 kΩ to 110 MΩ		$1.1 \cdot 10^{-9} \cdot R^2/\Omega + 1.2 \cdot 10^{-3} \cdot R$	
	0 Ω to < 50 Ω	> 1 kHz to 30 kHz	$1.1 \cdot 10^{-3} \cdot R + 1.2$ mΩ	
	50 Ω to 20 kΩ		$0.5 \cdot 10^{-3} \cdot R$	
	> 20 kΩ to 110 MΩ		$1.1 \cdot 10^{-9} \cdot R^2/\Omega + 0.79 \cdot 10^{-3} \cdot R$	
	0 Ω to 20 Ω	> 30 kHz to 100 kHz	$1.1 \cdot 10^{-3} \cdot R + 1.2$ mΩ	
	> 20 Ω to 20 kΩ		$0.5 \cdot 10^{-3} \cdot R$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
AC resistance (Absolut value of impedance)	> 20 kΩ to 110 MΩ		$1.3 \cdot 10^{-9} \cdot R^2/\Omega + 1.0 \cdot 10^{-3} \cdot R$	R = measured value direct measurement method
	0 Ω to 100 Ω	> 100 kHz to 300 kHz	$1.1 \cdot 10^{-3} \cdot R + 2.2$ mΩ	
	> 100 Ω to 2 kΩ		$0.5 \cdot 10^{-3} \cdot R$	
	> 2 kΩ to 110 MΩ		$4.5 \cdot 10^{-9} \cdot R^2/\Omega + 0.9 \cdot 10^{-3} \cdot R$	
	0 Ω to 50 Ω	> 300 kHz to 1 MHz	$1.3 \cdot 10^{-3} \cdot R + 3.2$ mΩ	
	> 50 Ω to 2 kΩ		$0.7 \cdot 10^{-3} \cdot R$	
	> 2 kΩ to 22 MΩ		$15 \cdot 10^{-9} \cdot R^2/\Omega + 1.1 \cdot 10^{-3} \cdot R$	
Energy E Defibrillator analyzer	5 J to 150 J	QMH Chapter XXXV Version 2.0	$2.3 \cdot 10^{-3} \cdot E + 49$ mJ	E = energy Monophasic or Biphasic
	> 150 J to 360 J		$1.1 \cdot 10^{-3} \cdot E + 0.27$ J	
Voltage ratio of bridge calibration untis and measuring instruments	0 mV/V to 100 mV/V	Bridge excitation voltage: 1 V to 10 V AA0386 Version 2.0	0.1 µV/V to 1.6 µV/V see matrix M.2	Intermediate values increase the measurement uncertainty.

Matrix M.4 “Voltage ratio”

Bridge excitation voltage / Measurement 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	0.35µV/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

Electrical performance

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
DC power	0 W to 110 kW	0 mV to 1100 V 0 µA to 100 A	$\sqrt{W_U^2 + W_I^2} \cdot P$ however, not less than $44 \cdot 10^{-6} \cdot P + 5$ fW	P = measured value
AC voltage active power Fixed values		45 Hz to 65 Hz 50 V or 200 V 30 mA; 0.3 A; 2 A; or 10 A;		P = measured value PF = power factor (capacitive or inductive)
	1.5W; 6W; 15W; 60W; 100 W; 400 W;	PF = 1	$0.15 \cdot 10^{-3} \cdot P$	
	500W; 2000W		$0.33 \cdot 10^{-3} \cdot P$	
	220 W 198 W 110 W 22 W 11W	45 Hz to 65 Hz 220 V; 1 A PF = 1 PF = 0.9 PF = 0.5 PF = 0.1 PF = 0.05	 $0.14 \cdot 10^{-3} \cdot P$ $0.15 \cdot 10^{-3} \cdot P$ $0.21 \cdot 10^{-3} \cdot P$ $0.91 \cdot 10^{-3} \cdot P$ $1.8 \cdot 10^{-3} \cdot P$	
AC active power Ranges		33 V to 330 V 45 Hz to 65 Hz, PF = 1		PF = power factor P = measured value
	0.33 W to 0.73 kW	10 mA to 2.2 A	$0.30 \cdot 10^{-3} \cdot P$	
	> 0.73 kW to 3.6 kW	> 2.2 A to 11 A	$0.42 \cdot 10^{-3} \cdot P$	
	0.5 W to 0.73 kW	33 V to 330 V 330 mA to 2.2 A 45 Hz to 65 Hz $0.05 \le PF \le 1$ capacitive	$(0.33 \cdot 10^{-3} \cdot PF^{-0.98}) \cdot P$	
		inductive	$(0.98 \cdot 10^{-3} \cdot PF^{-0.99}) \cdot P$	
	0.11 mW to 21 kW	33 mV to 1020 V 3.3 mA to 20.5 A 45 Hz to 65 Hz, PF = 1	$1.4 \cdot 10^{-3} \cdot P$	
Measuring devices with current clamps	0.5 W to 218 kW	33 V to 330 V 10 mA to 660 A 45 Hz to 65 Hz $0.05 \le PF \le 1$ 1 to 60 windings	$\sqrt{W_{in}^2 + W_{DUT}^2} \cdot P$ but not less than $0.30 \cdot 10^{-3} \cdot P$	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 measuring circuit and in the Stray field of the current conductor is to be considered.
Power factor	0 to 1	33 V to 330 V 330 mA to 2.2 A 45 Hz to 65 Hz		Intermediate values increase the measurement uncertainty.
	0; 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.8; 1	53 Hz 1 A; 90 V	$0.12 \cdot 10^{-3}$	
AC voltage Reactive power	0 var to 3.6 kvar	45 Hz to 65 Hz	$U_P \cdot$ var/W	U_P is the uncertainty of the active power

Time and Frequency

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Frequency f Measurement and Synthesis	0.01 Hz to 40 GHz		$0.5 \cdot 10^{-9} \cdot f + U_{Tf}$	f: measured value U_{Tf}: trigger uncertainty
Time interval Δt	0 ns to 0.7 ms 0 ns to 200 s 1 µs to 100 h		1.3 ns $1.5 \cdot 10^{-6} \cdot \Delta t + 50$ ps $10 \cdot 10^{-9} \cdot \Delta t + 1$ µs	
	1 s to 100 h		$13 \cdot 10^{-6} \cdot \Delta t + 0.82$ s	
Clock deviation	0 s/d to 100 s/d		$1.3 \cdot 10^{-7} = 0.011$ s/d	Electronic and mechanical clocks
Rotational speed	0.02 s^{-1} to 3500 s^{-1}		$3.7 \cdot 10^{-6} \cdot f$	f: measured value

Inductance and capacitance

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Inductance	0 µH		0.03 µH	2-wire short
	0 µH to 1.1 H	100 Hz to 10 kHz		L = Measured value Intermediate values increase the measurement uncertainty. Absolute value of impedance 50 mΩ ≤ | Z | ≤ 11 kΩ. Smallest measurement uncertainties are applicable in the case of direct measurement or substitution on GR 1482 or similar model.
	100 µH	100 Hz	$0.65 \cdot 10^{-3} \cdot L$	
		1 kHz	$0.24 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.27 \cdot 10^{-3} \cdot L$	
	1 mH	100 Hz	$0.14 \cdot 10^{-3} \cdot L$	
		1 kHz	$0.13 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.17 \cdot 10^{-3} \cdot L$	
	10 mH	100 Hz; 1 kHz	$0.11 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.16 \cdot 10^{-3} \cdot L$	
	100 mH	100 Hz; 1 kHz	$0.12 \cdot 10^{-3} \cdot L$	
		10 kHz	$0.26 \cdot 10^{-3} \cdot L$	
	1 H	100 Hz; 1 kHz	$0.20 \cdot 10^{-3} \cdot L$	
Capacitance	0 pF		0.2 pF	Open
	0 pF to 10 µF	100 Hz to 1 MHz		C = measured value Intermediate values increase the measurement uncertainty. Absolute value of impedance 1 Ω ≤ | Z | ≤ 110 MΩ. Smallest measurement uncertainties are applicable in the case of direct measurement or substitution to HP 16381A or GR 1404 / 1409 or identical.
	1 pF	1 kHz	$0.47 \cdot 10^{-3} \cdot C$	
		10 kHz	$0.31 \cdot 10^{-3} \cdot C$	
	10 pF	1 kHz	$84 \cdot 10^{-6} \cdot C$	
		10 kHz; 100 kHz	$0.10 \cdot 10^{-3} \cdot C$	
		1 MHz	$0.13 \cdot 10^{-3} \cdot C$	
	100 pF	1 kHz	$56 \cdot 10^{-6} \cdot C$	
	1 nF	1 kHz	$58 \cdot 10^{-6} \cdot C$	
		100 kHz	$0.11 \cdot 10^{-3} \cdot C$	
	10 nF	100 Hz	$0.21 \cdot 10^{-3} \cdot C$	
		1 kHz	$0.14 \cdot 10^{-3} \cdot C$	
		10 kHz	$0.13 \cdot 10^{-3} \cdot C$	
	100 nF	100 Hz; 1 kHz; 10 kHz	$0.16 \cdot 10^{-3} \cdot C$	
	1 µF	100 Hz; 1 kHz	$0.12 \cdot 10^{-3} \cdot C$	
		10 kHz	$0.21 \cdot 10^{-3} \cdot C$	

High-frequency and radiation quantities

High-frequency quantities

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Vertical oscilloscopes	1 mV to 5 V 5 mV to 200 V	DC up to 10 kHz	$1.2 \cdot 10^{-3} \cdot U + 12\ \mu V$	U: measured value 50 Ω 1 MΩ
Oscilloscope horizontal	25 ps to 40 s		$0.12 \cdot 10^{-6} \cdot T + 0.1$ ps	T: measured value
Bandwidth f (Frequency Response)	40 Hz to 6 GHz	EURAMET cg-7 v1	$6{,}3 \cdot 10^{-3} \cdot f^2$/GHz $+ 20 \cdot 10^{-3} \cdot f$	f: measured value
	> 6 GHz to 40 GHz		$75 \cdot 10^{-3} \cdot f$	
Rise time	30 ps to 45 ps > 45 ps to 1 ms	0.1 V to 3 V	5 ps $10 \cdot 10^{-3} \cdot T + 3$ 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	$78 \cdot 10^{-3} \cdot T$ $67 \cdot 10^{-3} \cdot T$ $58 \cdot 10^{-3} \cdot T$ $56 \cdot 10^{-3} \cdot T$	calculated from the 3 dB bandwidth T: measured value
Frequency f Time Base	10 MHz		$0.2 \cdot 10^{-6} \cdot f$	
Burst generator Output voltage Peak value U_p	100 V to 4 kV	less than 50 Ω or 1 kΩ load	$48 \cdot 10^{-3} \cdot U_p$	
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_P of no load voltage	15 ns to 100 ms		3 % · $t_{r,Us}$ + 1 ns	
Duration time t_r, U_p of open-circuit voltage	100 ns to 100 ms		3 % · $t_{r,Is}$ + 2 ns	
Return stroke half-life t_H of the curve shape	0.5 µs to 100 ms		5 % · t_H	
Peak value of the open circuit voltage U_{sp}	0.1 kV to 7 kV		2.5 % · U_{sp}	
Peak value of the short-circuit current I_S	10 A to 5 kA		3.5 % · I_S	
	> 5 kA to 10 kA		3.8 % · I_S	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Waveform quantities		EN 55016-1-1:2015 [c)]		
Measuring receiver Display response to pulses amplitude relation (absolute calibration)				
	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 of the display with the pulse frequency (relative calibration)	Pulse Repetition Frequency		0.30 dB	
	0.1 Hz to 2 kHz			Band A
	0.1 Hz to 50 kHz		0.35 dB	Band B
	0.1 Hz to 1 MHz			Band C and Band D
HF power input power and calibration factor of RF power meters	100 pW to < 10 nW	DC up to 2 GHz	$17 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 2 GHz
		> 2 GHz to 4 GHz	$18 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$25 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.1$ 2 GHz ≤ f < 4 GHz
		> 12 GHz to 18 GHz	$36 \cdot 10^{-3} \cdot P$	
	10 nW to < 1 µW	DC up to 50 MHz	$14 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$14 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.11$ 4 GHz ≤ f < 12 GHz
		> 2 GHz to 4 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.13$ 12 GHz ≤ f < 18 GHz
		> 12 GHz to 18 GHz	$33 \cdot 10^{-3} \cdot P$	
	100 nW to < 10 µW	DC up to 50 MHz	$12 \cdot 10^{-3} \cdot P$	R&S NRVC with (cascaded) attenuator **)
		> 50 MHz to 2 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$53 \cdot 10^{-3} \cdot P$	
	1 µW to < 0.1 W	DC up to 50 MHz	$12 \cdot 10^{-3} \cdot P$	Explanation: see penultimate page
		> 50 MHz to 2 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$26 \cdot 10^{-3} \cdot P$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF power Input power and calibration factor of RF power meters	0.1 µW to 0.1 mW	DC to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$16 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$ $45 \cdot 10^{-3} \cdot P$ $55 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz NRV- Z15 ***)
	0.1 µW to 0.1 mW	DC to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $32 \cdot 10^{-3} \cdot P$ $54 \cdot 10^{-3} \cdot P$ $67 \cdot 10^{-3} \cdot P$ $90 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz R&S NRV- Z55 with attenuator ***)
	0.1 mW to 80 mW	DC to 50 MHz > 50 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 18 GHz to	$7 \cdot 10^{-3} \cdot P$ $8 \cdot 10^{-3} \cdot P$ $9 \cdot 10^{-3} \cdot P$ $12 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_{L,DUT}\rvert \leq 0.07$ DC < f < 2 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.10$ 2 GHz < f ≤ 4 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.13$ 4 GHz < f ≤ 18 GHz R&S NRV-Z51 **) R&S NRVC **)
	1 µW to 10 mW	DC to 12 GHz	$(0.59 \cdot 10^{-3} \cdot f/\text{GHz} + 8.0 \cdot 10^{-3}) \cdot P$	$\lvert\Gamma_{L,DUT}\rvert \leq 0.02 \sqrt{f/\text{GHz}}$
		> 12 GHz to 40 GHz	$(0.73 \cdot 10^{-3} \cdot f/\text{GHz} + 15 \cdot 10^{-3}) \cdot P$	R&S NRPC40 ***)

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF power Input power and calibration factor of RF power meters	0.1 mW to 80 mW	DC up to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5 GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$ $45 \cdot 10^{-3} \cdot P$ $52 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.09$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 12 GHz ≤ f < 26.5 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 26.5 GHz ≤ f < 40 GHz R&S NRV- Z55 ***)
	10 fW to < 1 pW	DC up to 50 MHz	$20 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_L\rvert \leq 0.07$ DC < f < 2 GHz $\lvert\Gamma_L\rvert \leq 0.1$ 2 GHz ≤ f < 4 GHz $\lvert\Gamma_L\rvert \leq 0.11$ 4 GHz ≤ f < 12 GHz $\lvert\Gamma_L\rvert \leq 0.13$ 12 GHz ≤ f < 18 GHz R&S NRV-Z51 **) with (cascaded) attenuator **) Explanation: see penultimate page
		> 50 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$22 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$33 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$68 \cdot 10^{-3} \cdot P$	
	1 pW to < 100 pW	DC up to 50 MHz	$19 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$30 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$67 \cdot 10^{-3} \cdot P$	
	100 pW to < 10 nW	DC up to 50 MHz	$18 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$19 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$20 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$28 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$39 \cdot 10^{-3} \cdot P$	
	10 nW to < 1 µW	DC up to 50 MHz	$15 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$16 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$17 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$24 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$36 \cdot 10^{-3} \cdot P$	
	100 nW to < 10 µW	DC up to 50 MHz	$13 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$17 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$26 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$66 \cdot 10^{-3} \cdot P$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Power Output Power and calibration factor of HF sources	0.1 µW to 0.1 mW	DC up to 50 MHz	$13 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 2 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$16 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$23 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$30 \cdot 10^{-3} \cdot P$	
	0.1 pW to < 10 pW	50 MHz	$27 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \leq 0.1$ $f \leq 2$ GHz $\lvert\Gamma_G\rvert \leq 0.2$ 2 GHz $\leq f <$ 12 GHz $\lvert\Gamma_G\rvert \leq 0.3$ 12 GHz $f <$ 18 GHz selective measuring system Agilent N5531S-518 **) Explanation: see last page
		10 MHz to 2 GHz	$30 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 3 GHz	$36 \cdot 10^{-3} \cdot P$	
	10 pW to < 1 nW	50 MHz	$21 \cdot 10^{-3} \cdot P$	
		10 MHz to 2 GHz	$25 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 3 GHz	$32 \cdot 10^{-3} \cdot P$	
	1 nW to 80 mW	50 MHz	$17 \cdot 10^{-3} \cdot P$	
		10 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$29 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$50 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$71 \cdot 10^{-3} \cdot P$	
	0.1 pW to < 10 pW	50 MHz	$29 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \leq 0.1$ $f \leq 2$ GHz $\lvert\Gamma_G\rvert \leq 0.2$ 2 GHz $\leq f <$ 12 GHz $\lvert\Gamma_G\rvert \leq 0.3$ 4 GHz $\leq f <$ 26,5 GHz Agilent N5531S-526 ***)
		30 MHz to 3 GHz	$35 \cdot 10^{-3} \cdot P$	
	10 pW to < 1 nW	50 MHz	$24 \cdot 10^{-3} \cdot P$	
		30 MHz to 3 GHz	$31 \cdot 10^{-3} \cdot P$	
	1 nW to 80 mW	50 MHz	$19 \cdot 10^{-3} \cdot P$	
		30 MHz to 4 GHz	$25 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$38 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$93 \cdot 10^{-3} \cdot P$	
	1mW	50 MHz	$5 \cdot 10^{-3} \cdot P$	Substitution
	0.1 µW to < 0.1 mW	10 MHz to 50 MHz	$20 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \leq 0.1$ $f \leq 2$ GHz $\lvert\Gamma_G\rvert \leq 0.2$ 2 GHz $\leq f <$ 12 GHz $\lvert\Gamma_G\rvert \leq 0.3$ 12 GHz $\leq f <$ 18 GHz R&S NRV- Z1 **)
		> 50 MHz to 2 GHz	$21 \cdot 10^{-3} \cdot P$	
		> 2 GHz to 4 GHz	$35 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$50 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 18 GHz	$75 \cdot 10^{-3} \cdot P$	
	0.1 µW to < 0.1 mW	10 MHz to 50 MHz	$13 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \leq 0.1$ $f \leq 2$ GHz $\lvert\Gamma_G\rvert \leq 0.2$ 2 GHz $\leq f <$ 12 GHz $\lvert\Gamma_G\rvert \leq 0.3$ 12 GHz $\leq f <$ 40 GHz NRV- Z15 ***)
		> 50 MHz to 4 GHz	$14 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 12 GHz	$32 \cdot 10^{-3} \cdot P$	
		> 12 GHz to 26.5 GHz	$54 \cdot 10^{-3} \cdot P$	
		> 26.5 GHz to 32 GHz	$67 \cdot 10^{-3} \cdot P$	
		> 32 GHz to 40 GHz	$90 \cdot 10^{-3} \cdot P$	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Power Output Power and calibration factor of HF sources	0.1 mW to < 80 mW	DC up to 50 MHz > 50 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 18 GHz	$9 \cdot 10^{-3} \cdot P$ $12 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $29 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 18 GHz R&S NRV- Z51 **)
	0.1 mW to 80 mW	DC up to 50 MHz > 50 MHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 26.5 GHz > 26.5 GHz to 32 GHz > 32 GHz to 40 GHz	$13 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $36 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $53 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 40 GHz R&S NRV- Z55 ***)
	10 mW to < 1 W	DC up to 50 MHz > 50 MHz to 2 GHz > 2 GHz to 4 GHz > 4 GHz to 12 GHz > 12 GHz to 18 GHz	$11 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$	$\lvert\Gamma_G\rvert \le 0.1$ $f \le 2$ GHz $\lvert\Gamma_G\rvert \le 0.2$ 2 GHz $\le f <$ 12 GHz $\lvert\Gamma_G\rvert \le 0.3$ 12 GHz $\le f <$ 18 GHz R&S NRV- Z51 **)
HF voltage U_{HF} sources with HF voltage display with respect to 50 Ω	2.2 µV 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 $Z_0 = 50$ Ω **)
	220 µV to 7 V	DC up to 18 GHz		
	2.2 µV to 220 µV	DC to 3 GHz		***)
	2.2 mV to 2 V	DC up to 40 GHz		
HF voltage U_{HF} measurement devices and receivers with HF voltage display with respect to 50 Ω	0.7 µV to 2 V	DC up to 18 GHz	$W(U_{HF}) = \frac{W(P_{inc})}{2}$	$W(P_{inc})$ is the relative uncertainty of the irradiated power with respect to $Z_0 = 50$ Ω **)
	2.2 mV to 2 V	DC up to 40 GHz		***)
HF power noise indication of receivers	DC up to 40 GHz		1.6 dB	Power > -170 dB (1 mW) based on 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

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Bandwidth Filter	1 Hz to 10 MHz		0.5 %	Signal to noise ratio SNR ≥ 70 dB
Form factor	> 1:1 to 5:1 > 5:1 to 10:1 > 10:1 to 20:1		3 % 6 % 12 %	Signal to noise ratio SNR ≥ 15 dB
Switching deviation			0.02 dB	
Display linearity	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB > 80 dB 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 $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ $f \leq 500$ MHz
Input attenuator or IF amplifier	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB > 80 dB 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 $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ $f \leq 500$ MHz
	0 dB to 30 dB > 30 dB to 60 dB > 60 dB to 80 dB	100 kHz to 500 MHz	0.04 dB 0.06 dB 0.08 dB	gradual display comparison SNR ≥ 50 dB, Receiver linearity < (0.01 dB + 0.005 dB/10 dB)
HF gain Amplifier	0 dB to 70 dB	DC up 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 to 70 dB	DC up 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
HF current Current clamps	100 µA to 50 mA	40 Hz to 10 MHz > 10 MHz to 30 MHz > 30 MHz to 65 MHz	$14 \cdot 10^{-3} \cdot I$ $18 \cdot 10^{-3} \cdot I$ $20 \cdot 10^{-6} f^2 \cdot I$	Tektronix 015-0601-50. Combined with an oscilloscope I = measured value f: frequency in MHz
Non-linearity of HF power measuring instruments	10 nW to 1 W	50 MHz	$5.5 \cdot 10^{-3}$ (0.024 dB)	R&S NRVC-B2 60 dB max.

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Reflection factor Absolute value $\lvert\Gamma\rvert$	0 to 1	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.003 to 0.013 See matrix M.3	N connector, 50 Ω, other connectors increase measurement uncertainty Measuring uncertainty in units of absolute value of the reflection factor
	0 to 1	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	0.003 to 0.016 See matrix M.4	3.5 mm connector Measuring uncertainty in units of absolute value of the reflection factor
	0 to 1	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0) c)	0.004 to 0.017 See matrix M.5	2.92 mm connector Measuring uncertainty in units of absolute of the reflection factor
HF Reflection factor Phase angle ϕ	-180° to +180°	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.2° to 4.7° See matrix M.6	N connector, 50 Ω, other connectors increase measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	0.3° to 5.8° See matrix M.7	3.5mm connector
	-180° to +180°	45 MHz to 45 GHz EURAMET cg-12 (Version 3.0) c)	0.3° to 6.3° See matrix M.8	2.92 mm connector
HF Attenuation attenuators	0 dB 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, ****) $\lvert\Gamma_{DUT}\rvert \leq 0.01$ $f \leq 500$ MHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ 500 MHz < $f \leq$ 10 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.08$ 10 GHz < $f \leq$ 18 GHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.1$ 18 GHz < $f \leq$ 40 GHz
	> 30 dB 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	0.001 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	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
HF Attenuation attenuators	> 60 dB to 70 dB	100 kHz to 500 MHz > 500 MHz to 3 GHz	0.07 dB 0.10 dB	$\lvert\Gamma_{L,DUT}\rvert \leq 0.01$ $f \leq 500$ MHz $\lvert\Gamma_{L,DUT}\rvert \leq 0.05$ 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	0.1dB 0.3 dB	
HF Attenuation	0 dB to 60 dB	9 kHz to 18 GHz EURAMET cg-12 (Version 3.0) c)	0.01 dB to 0.09 dB See matrix M.9	N connector, 50 Ω, other connectors increase measurement uncertainty
	0 dB to 60 dB	9 kHz to 33 GHz EURAMET cg-12 (Version 3.0) c)	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 cg-12 (Version 3.0) c)	0.01 dB to 0.32 dB See matrix M.11	2.92 mm connector
HF Attenuation Phase angle ϕ	-180° to +180°	9 kHz to 18 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0) c)	0.2° to 0.8° See matrix M.12	N connector, 50 Ω, other connectors increase measurement uncertainty
	-180° to +180°	9 kHz to 33 GHz 0 dB to 60 dB EURAMET cg-12 (Version 3.0) c)	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 cg-12 (Version 3.0) c)	0.2° to 2.5° See matrix M.14	2.92 mm connector

Matrix M.3 "HF reflection factor, absolute value|Γ|; N connector 50 Ω"

Measuring uncertainty in units of the amount of the reflection factor.

Reflection factor |Γ|	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 "HF reflection factor, absolute value |Γ|; 3.5 mm connector"

Measuring uncertainty in units of the amount of the reflection factor.

Reflection factor |Γ|	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

Matrix M.5 “HF reflection factor, absolute value |Γ|; 2.92 mm connector”

Measuring uncertainty in units of the amount of the reflection factor.

Reflection factor |Γ|	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 “HF reflection factor, phase angle ϕ; N connector 50 Ω”

Reflection factor |Γ|	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 “HF reflection factor, phase angle ϕ; 3.5 mm connector”

Reflection factor |Γ|	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°

Matrix M.8 "HF reflection factor, phase angle ϕ; 2.92 mm connector"

Reflection factor |Γ|	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	0.01dB	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	0.01dB	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

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	0.01dB	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 “HF 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°

Matrix M.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°

High-frequency and radiation quantities - Optical quantities,

Radiometry

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Optical Radiation output Fibre optic Power meters	1 µW to 0.5 mW	1310 nm, 1550 nm	1.3 %	Connector FC, ST, SC, SMA, HMS-10 or adaptable
		850 nm	2.2%	
		654 nm	2.2%	different wavelengths (780 nm, 635 nm, 1625 nm) interpolated
Nonlinearity fibre optic radiation detectors	10 nW to 160 µW	Wavelengths: 1310 nm, 1550 nm, 850 nm	$1.8 \cdot 10^{-3}$ (0.008 dB)	Addition methods
	0.1 nW to < 0.32 nW		$20 \cdot 10^{-3}$ (0.085 dB)	Comparison methods
	0.32 nW to < 3.2 nW		$7.1 \cdot 10^{-3}$ (0.031 dB)	
	3.2 n to 0.5 µW		$6.0 \cdot 10^{-3}$ (0.026 dB)	
Attenuation or Gain Fibre optic components	0 dB to 50 dB	Wavelengths: 1310 nm, 1550 nm, 850 nm	$6.0 \cdot 10^{-3}$ (0.026 dB)	
	> 50 dB to 60 dB		$7.1 \cdot 10^{-3}$ (0.031 dB)	
	> 60 dB to 70 dB		$20 \cdot 10^{-3}$ (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	

Photometry

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range			Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Transmission filter	16 %	to	60 %	QMH Chapter XXXIV V 4.0 Nominal values in the opacity values of the standards	0.65 %	
Transmission *T*	> 60 %	to	76 %		0.70 %	
	> 76 %	to	< 100 %		0.80 %	
Opacity level *N*	> 0 %	to	< 24 %		0.80 %	
	24 %	to	< 40 %		0.70 %	
	40 %	to	84 %		0.65 %	
Opacity 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}	Opacity coefficient *k* calculated from the opacity level *N* Uncertainty interval *U(k)* calculated from the uncertainty interval of the degree of opacity *U(N).* Other measuring 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

Dimensional

Measurements Length

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range			Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Callipers for external, internal and depth dimensions [c)]	0 mm	to	500 mm	VDI/VDE/DGQ 2618 Sheet 9.1:2006	20 µm + 15 · 10^{-6} · *l*	*l*: Measured value
Micrometers [(c)]		to	300 mm	VDI/VDE/DGQ 2618 Sheet 10.1:2001	2 µm + 6 · 10^{-6} · *l*	
Indicator gauge with scale display [c)]		to	100 mm	VDI/VDE/DGQ 2618 Sheet 11.1:2014	1.5 µm + 10 · 10^{-6} · *l*	
Indicator gauge with digital display [c)]		to	100 mm	VDI/VDE/DGQ 2618 Sheet 11.4:2020	1.5 µm + 10 · 10^{-6} · *l*	
Peripheral tape measures of steel				AA0265-3 Version 8.0		Calibration to the nominal values of the standards
Diameter	150 mm	to	300 mm		71 µm	
Circumference	470 mm	to	950 mm		220 µm	
Cylindrical Gauges				VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3		*d* is the measured diameter
Rings Diameter [c)]	1 mm	to	90 mm		0.9 µm + 10 · 10^{-6} · *d*	
Plug gauges Diameter [c)]	1 mm	to	120 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 3	0.6 µm + 1.8 · 10^{-6} · *d*	
Cylindrical masuring pins Diameter [c)]	1 mm	to	20 mm	VDI/VDE/DGQ 2618 Sheet 4.1:2006 Option 1	0.6 µm + 1.8 · 10^{-6} ·*d*	

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity/ Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Thread gauges [c)] (single and multiple cylindrical external and internal threads with straight flanks, symmetrical profile, nominal lead and nominal thread angle) External thread [c)] Simple pitch diameter	1 mm to 120 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Option 1 Three-wire method (perpendicular to thread axis)	$2.9\ \mu m + 7.7 \cdot 10^{-6} \cdot d$	*d* is the measured flank diameter
Internal thread [c)] Simple pitch Diameter	3 mm to 90 mm	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Option 1 Two-sphere method (perpendicular to the thread axis)	$2.6\ \mu m + 5.5 \cdot 10^{-6} \cdot d$	

Abbreviations used:

AA	work instruction (self-developed procedure) of esz AG
CMC	Calibration and measurement capabilities
DIN	Deutsches Institut für Normung e.V.
DKD-R	Guideline of the German Calibration Service (DKD), published by the Physikalisch-Technischen Bundesanstalt
EN	European Norm
EURAMET	European Association of National Metrology Institutes
QMH	Quality Management Handbook (self-developed procedure) of esz AG

Deutsche Akkreditierungsstelle

Annex to Partial Accreditation Certificate D-K-15019-01-01 according to DIN EN ISO/IEC 17025:2018

Valid from: 30.08.2022

Date of issue: 30.08.2022

This certificate annex is part of the accreditation certificate D-K-15019-01-00 holder of the

partial accreditation certificate:

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

The calibration laboratory meets the minimal requirements of DIN EN ISO/IEC 17025:2018 and, if applicable, additional legal and normative requirements, including those in relevant sectoral schemes, in order to carry out the conformity assessment activities listed below.

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

This certificate annex is only valid together with the written accreditation certificate and reflects the status as indicated by the date of issue. The current status of any given scope of accreditation can be found in the directory of accredited bodies maintained by Deutsche Akkreditierungsstelle GmbH at https://www.dakks.de

Calibrations in the following areas:

Thermodynamic quantities

Temperature quantities

- **Resistance thermometer** [a)]
- **Thermocouples, thermoelements**[a)]
- **Direct reading thermometers** [a)]
- **Temperature indicators and simulators** [a)]
- **Climatic chambers (temperature)** [a)]
- **Block calibrators** [a)]

Humidity quantities

- **Climate chambers (humidity)** [a)]
- **Measuring instruments for relative humidity** [a)]
- **Devices for absolute humidity** [a)]

Mechanical Quantities

- **Pressure** [a)]
- **Force** [a)]
- **Torque** [a)]
- **Balance** [a)]
- **Mass** [b)]

Fluid quantities

- **Gas flow rate** [a)]

a) **also as on-site calibration**
b) **as an on-site calibration only;**

Within the quantities/calibration objects marked with [c)], the calibration laboratory is permitted to use the standards/calibration guidelines listed here with different output statuses without requiring prior information and approval from the DAkkS. The calibration laboratory has an up-to-date list of all standards/calibration guidelines in the flexible accreditation area.

This document annex is only valid together with the document issued in writing and reflects the status at the time of issue. The current status of the valid and monitored accreditation can be found in the database of accredited bodies of the German Accreditation Body (www.dakks.de)

Abbreviations used: see last page

Mechanical Quantities – Pressure

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Pressure Absolute pressure p_{abs}	> 0 bar to 3.0 bar > 3.0 bar to 21 bar > 21 bar to 101 bar > 101 bar to 251 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$2.9 \cdot 10^{-5} \cdot p_{abs} + 15$ µbar $3.4 \cdot 10^{-5} \cdot p_{abs} + 0.19$ mbar $3.9 \cdot 10^{-5} \cdot p_{abs} + 0.44$ mbar + U_{baro} $5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar + U_{baro}	Pressure medium: gas The measurement uncertainty of the barometer U_{baro} has to be taken into account. .
Absolute pressure p_{abs}	900 mbar to 1000 mbar	esz QMH XXIII.4.2 v5.0	$2.9 \cdot 10^{-5} \cdot p_{abs} + 15$ µbar	Reference value ($pabs$ = pamb) Single-point measurement at current ambient pressure
Absolute pressure p_{abs}	1 bar; 2 bar to 71 bar > 71 bar to 701 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$7.8 \cdot 10^{-5} \cdot p_{abs} + 0.36$ mbar + Ubaro $8.2 \cdot 10^{-5} \cdot p_{abs} + 0.72$ mbar + U_{baro}	Reference value ($p_{abs} = p_{amb}$) Pressure medium: Oil The measurement uncertainty of the barometer U_{baro} has to be taken into account.
Absolute pressure p_{abs}	> 0 bar to 301 bar > 301 bar to 1001 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar + U_{baro} $7.4 \cdot 10^{-5} \cdot p_{abs} + 40$ mbar + U_{baro}	Pressure medium: water The measurement uncertainty of the barometer U_{baro} has to be taken into account.
Positive and negative gauge pressure p_e	-200 mbar to 200 mbar > -1 bar to 2 bar > 2 bar to 20 bar > 20 bar to 100 bar > 150 bar to 250 bar	DKD-R 6-1:2014 c) Calibration methods: $p_e = p_{abs} - p_{amb}$	25 µbar $2.3 \cdot 10^{-5} \cdot p_e + 55$ µbar + U_{baro} $3.7 \cdot 10^{-5} \cdot p_e + 0.19$ mbar + U_{baro} $3.9 \cdot 10^{-5} \cdot p_e + 0.44$ mbar $5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar	Pressure medium: gas The measurement uncertainty of the barometer U_{baro} has to be taken into account.

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Gauge pressure p_e	0 bar; 1 bar to 70 bar > 70 bar to 700 bar	DKD-R 6-1:2014 c)	$7.8 \cdot 10^{-5} \cdot p_e + 0.36$ mbar $8.2 \cdot 10^{-5} \cdot pe + 0.72$ mbar	Reference value ($_{pe}$ = 0 bar) Pressure medium: Oil
Gauge pressure p_e	> 0 bar to 300 bar > 300 bar to 1001 bar	DKD-R 6-1:2014 c)	$5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar $7.4 \cdot 10^{-5} \cdot p_{abs} + 40$ mbar	Pressure medium: water

Mechanical Quantities – Flow Quantities

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Volume flow rate Q of flowing gases	5 ml/min to 50 l/min	Volumeter as reference	0.3 % · Q + 0.02 ml/min	Q = Measured value
Flow meters or - controllers with a display or measuring transducer with electronic Interface	10 ml/min to 200 ml/min > 0.2 l/min to 3.2 l/min > 3.2 l/min to 40 l/min > 40 l/min to 620 l/min	Laminar flow Elements as referenc	0.5 % · Q + 0.02 ml/min 0.5 % · Q + 0.32 ml/min 0.5 % · Q + 4 ml/min 0.5 % · Q + 0.06 l/min	Calibration medium dry air (rel. humidity <10%) Measuring ranges related to dry air from 0 °C, 1013.25 mbar

Mechanical Measurements – Force

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Force Measuring instruments and transducer	50 N to 50 kN	Tensile and compressive force according to DKD-R 3-3:2018 c)	0.05 %	

Mechanical Measurements – Torque

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Torque	0.2Nm to < 1 N·m	DIN EN ISO 6789-2:2017 c)	0.9%	Torque-Spanner
Hand torque tools	1 N·m to 10 N·m		0.5 %	
Torque-Spanner tools	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

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Mass or conventional mass	10 mg 20 mg 50 mg	OIML R111-1:2004 [c)]	0.025 mg 0.03 mg 0.04 mg	for weights according to OIML R 111-1:2004 according to Class F2
	100 mg 200 mg 500 mg 1 g 2 g 5 g 10 g 20 g 50 g 100 g 200 g		0.016 mg 0.020 mg 0.025 mg 0.03 mg 0.04 mg 0.05 mg 0.06 mg 0.08 mg 0.10 mg 0.16 mg 0.3 mg	for weights according to OIML R 111-1:2004 according to Class F2
	500 g 1 kg		2.5 mg 5.0 mg	for weights according to OIML R 111-1:2004 according to Class F2
	2 kg		30 mg	for weights according to OIML R 111-1:2004 according to Class F2
	5 kg		25 mg	for weights according to OIML R 111-1:2004 according to Class F2
	10 kg		0.5 g	for weights according to OIML R 111-1:2004 according to Class F2
	20 kg 50 kg		0.3 g 0.8 g	for weights according to OIML R 111-1:2004 according to Class F2
	≥ 10 mg to 20 mg	OIML R111-1:2004 [c)]	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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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
	> 200 mg to 500 mg		0.025 mg	
	> 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 Measurements – Scales

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Balance Non-automatic Weighing instruments	≤ 2 kg	EURAMET cg-18:2015 c) DKD-R-7-2:2018 c)	$7 \cdot 10^{-7}$	With weights Accuracy class E2 according to OIML R111-1:2004
	≤ 50 kg		$1 \cdot 10^{-6}$	With weights Accuracy class E2 according to OIML R111-1:2004
	≤ 150 kg		$1 \cdot 10^{-5}$	With weights Accuracy class E2 according to OIML R111-1:2004

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Thermodynamic quantities - Temperature quantities

Permanent Laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range			Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Resistance thermometer, also directly reading			0.01 °C	DKD-R 5-1:2018 [c] Triple point of water	15 mK	
	-80 °C	to	< -40 °C	DKD-R 5-1:2018 [c] Ethanol bath	45 mK	Comparison with standard resistance thermometers
	-40°C	to	< 0°C		25 mK	
	0 °C	to	100 °C	DKD-R 5-1:2018 [c] Silicone oil baths	20 mK	
	> 100 °C	to	180 °C		25 mK	
	> 180 °C	to	200 °C		35 mK	
	> 200 °C	to	300 °C		$0.23 \cdot 10^{-3} \cdot T + 5$ mK	
	> 300 °C	to	400 °C	DKD-R 5-1:2018 [c] Metal block calibrator	80 mK	
	> 400 °C	to	570 °C		$1.6 \cdot 10^{-3} \cdot T - 0.56$ K	
	> 570 °C	to	700 °C		350 mK	
Base metal thermocouples, also directly indicating	-80 °C	to	< -35 °C	DKD-R 5-3: 2018 [c] Ethanol bath	$1.2 \cdot 10^{-3} \cdot \lvert T \rvert + 0.13$ K	Comparison with standard resistance thermometers
	-35 °C	to	< 0 °C		$1.2 \cdot 10^{-3} \cdot \lvert T \rvert + 0.09$ K	
	0 °C	to	35 °C	DKD-R 5-3: 2018 Silicone oil baths	0.09 K	
	> 35 °C	to	300 °C		$0.5 \cdot 10^{-3} \cdot T + 0.072$ K	
	> 300 °C	to	700 °C	DKD-R 5-3: 2018 [c] Metal block calibrator	$0.6 \cdot 10^{-3} \cdot T + 0.07$ K	
	> 700 °C	to	1210 °C	DKD-R 5-3: 2018 [c] Ceramic block calibrator	$1.4 \cdot 10^{-3} \cdot T + 1.3$ K	Comparison with standard TC
Noble metal thermocouples, also directly indicating	0 °C	to	35 °C	DKD-R 5-3: 2018 [c] Silicone oil baths	0.21 K	Comparison with standard resistance thermometers
	> 35 °C	to	300 °C		$0.3 \cdot 10^{-3} \cdot T + 0.2$ K	
	> 300 °C	to	400 °C	DKD-R 5-3: 2018 [c] Metal block calibrator		
	> 400 °C	to	700 °C		$0.7 \cdot 10^{-3} \cdot T + 0.25$ K	
	> 700 °C	to	1210 °C	DKD-R 5-3: 2018 [c] Ceramic block calibrator	$1.4 \cdot 10^{-3} \cdot T + 1.3$ K	Comparison with standard TC
Temperature indicators and simulators for resistance thermometers Pt100			-199 °C	DKD-R 5-5: 2018 [c] Artifact calibration	1.0 mK	
			0 °C		2.4 mK	
			237 °C		4.8 mK	
	-200 °C	to	800 °C	DKD-R 5-5: 2018 [c]	$12 \cdot 10^{-6} \cdot \lvert T \rvert + 4$ mK	
Pt25	-200 °C	to	-150 °C		2.3 mK	
	> -150 °C	to	800 °C		$19 \cdot 10^{-6} \cdot \lvert T \rvert + 10$ mK	
Pt500	200 °C	to	300 °C		$13 \cdot 10^{-6} \cdot \lvert T \rvert + 3.5$ mK	
	> 300 °C	to	800 °C		$18 \cdot 10^{-6} \cdot \lvert T \rvert + 5.4$mK	
Pt1000	-200 °C	to	800 °C		$17 \cdot 10^{-6} \cdot \lvert T \rvert + 3.8$ mK	
for base metal TC (without reference junction compensation) Type K	-200 °C	to	< 0 °C	DKD-R 5-5: 2018 [c]	$85 \cdot 10^{-6} \cdot \lvert T \rvert + 11$ mK	
	0 °C	to	1300 °C		$5.7 \cdot 10^{-9} \cdot T^2 + 0.17 \cdot 10^{-6} \cdot T + 11$ mK	
Type J	-200 °C	to	< 0 °C		$61 \cdot 10^{-6} \cdot \lvert T \rvert + 8$ mK	
	0 °C	to	1200 °C		$5.6 \cdot 10^{-6} \cdot T + 8$ mK	
Type T	-200 °C	to	< 0 °C		$80 \cdot 10^{-6} \cdot \lvert T \rvert + 11$ mK	
	0 °C	to	400 °C		11 mK	
Type E	-200 °C	to	< 0 °C		$56 \cdot 10^{-6} \cdot \lvert T \rvert$ 7 mK	
	0 °C	to	1000 °C		$4.4 \cdot 10^{-6} \cdot T + 7$ mK	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range		Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Type N	-200 °C to	< 0 °C		$0.12 \cdot 10^{-3} \cdot \lvert T \rvert + 16$ mK	
	0 °C to	1300 °C		$12 \cdot 10^{-9} \cdot T^2 + 10 \cdot 10^{-6} \cdot T + 16$ mK	
Nobel metal-TCs (without reference junction compensation) Type R / S	0 °C to	500 °C	DKD-R 5-5: 2018 c)	$-64 \cdot 10^{-6} \cdot T + 75$ mK	
	> 500 °C to	1768 °C		45 mK	
Type B	0 °C to	1200 °C		$26 \cdot T^{-0.85}$	
	> 1200 °C to	1820 °C		60 mK	
Temperature display devices and simulators for thermocouples (with reference junction compensation)	-200 °C to	1500 °C	DKD-R 5-5: 2018 c)	$\sqrt{U_{TC}^2 + (0.06K)^2}$	U_{TC}=uncertainty of the thermocouple temperature without reference junction compensation
Measuring locations in Climatic chambers with circulating air in the empty or defined loading, temperature	-80 °C to	180 °C	DKD-R 5-7:2018 c) Method C	0.50 K	When loading, the type and arrangement of the loading is to be specified in the calibration certificate precisely
	> 180 °C to	300 °C		0.70 K	
Climatic chambers with air circulation in the empty or defined loaded Usable space, temperature	-80 °C to	100 °C	DKD-R 5-7:2018 c) Method A or B	0.55 K	Inhomogeneity and stability of the measurement object can increase the measurement uncertainty. When loading, the type and arrangement of the loading is to be specified in the calibration certificate precisely.
	> 100 °C to	180 °C		0.75 K	
	> 180 °C to	300 °C		1.0 K	
Block calibrators	-80 °C to	0 °C	DKD-R 5-4:2018 c)	0.10 K	Comparison with standard resistance thermometer Inhomogeneity, stability etc. of the measurement object can increase the measurement uncertainty.
	> 0 °C to	50 °C		0.056 K	
	> 50 °C to	700 °C		$0.21 \cdot 10^{-3} \cdot T + 0.036$ K	

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Thermodynamic Quantities - Humidity Quantities

Permanent laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Dew point temperature Dew level-hygrometer	- 28 °C to 24.8 °C	QMH XIV.5 Version 5.0 Air temperature: 10 °C to 25 °C Relative humidity: 5 % to 98 %	0.080 K	Comparison with dew point mirror in climatic generator or climatic chamber
	- 17 °C to 44.8 °C	QMH XIV.5 Version 5.0 Air temperature: > 25 °C to 45 °C Relative humidity: 5 % to 98 %	0.10 K	
	-3°C to 59.8°C	QMH XIV.5 Version 5.0 Air temperature: > 45 °C to 60 °C Relative humidity: 5 % to 98 %	0.15 K	
	17°C to 89.8°C	QMH XIV.5 Version 5.0 Air temperature: > 60 °C to 90 °C Relative humidity: 10 % to 98 %	0.3 K	Comparison with dew point mirror in climatic chamber
Relative humidity Hygrometers and transmitters	5 % to 20 %	QMH XIV.5 Version 5.0 Air temperature: 10 °C to 25 °C Dew point temperature - 28 °C to 24.8 °C	0.25 %	Measurement uncertainty expressed in relative humidity Comparison with dew point mirror in climatic chamber
	> 20 % to 40 %		0.50 %	
	> 40 % to 60 %		0.75 %	
	> 60 % to 80 %		1.0 %	
	> 80 % to 98 %		1.2 %	
	5 % to 20 %	QMH XIV.5 Version 5.0 Airflow temperature: > 25°C to 45°C Dew point temperature - 17 °C to 44.8 °C	0.65 %	
	> 20 % to 40 %		0.90 %	
	> 40 % to 60 %		1.2 %	
	> 60 % to 80 %		1.4 %	
	> 80 % to 98 %		1.6 %	
	5 % to 20 %	QMH XIV.5 Version 5.0 Air temperature: > 45 °C to 60 °C Dew point temperature -3°C to 59.8°C	0.85 %	
	> 20 % to 40 %		1.1 %	
	> 40 % to 60%		1.4 %	
	> 60 % to 80 %		1.6 %	
	> 80 % to 98 %		1.8 %	
	10 % to 20 %	QMH XIV.5 Version 5.0 Air temperature: > 60 °C to 90 °C Dew point temperature 17 °C to 89.8 °C	1.7 %	Measurement uncertainty expressed in Comparison with dew point mirror in climatic chamber
	> 20 % to 40 %		1.9 %	
	> 40 % to 60 %		2.1 %	
	> 60 % to 80 %		2.3 %	
	> 80 % to 98 %		2.5 %	

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Permanent laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Measuring locations in climatic chambers with air circulation in the empty or defined working space, relative humidity [c)]	5 % to 30 %	Air flow temperature: 10 °C to 90 °C Dew point temperature t_d: -28 °C to 89.8 °C DKD-R 5-7:2018 [c)] Method C	1.0 %	Measurement uncertainty expressed in relative humidity Humidity reference value is calculated from dew point temperature and air temperature at the measuring location. Inhomogeneity and stability of the measurement object can increase the measurement uncertainty. When loading, the type and arrangement of the loading is to be specified in the calibration certificate precisely.
	> 30 % to 60 %		1.5 %	
	> 60 % to 80 %		2.0 %	
	> 80 % to 98 %		2.5 %	

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Permanent laboratory

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Climatic chambers with air circulation in the empty or defined working space, relative humidity	5 % to 30 %	Air temperature: 10 °C to 90 °C Dew point temperature t_d: 28 °C to 89.8 °C DKD-R 5-7:2018 [c)] Method A or B	1.5 %	Measurement uncertainty expressed in relative humidity Humidity reference value is calculated from dew point temperature and air temperature at the measuring location. Inhomogeneity and stability of the measurement object can increase the measurement uncertainty. When loading, the type and arrangement of the loading is to be specified in the calibration certificate precisely.
	> 30 % to 60 %		2.0 %	
	> 60 % to 80 %		2.5 %	
	> 80 % to 98 %		3.0 %	

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Thermodynamic quantities Temperature quantities

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range			Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Resistance thermometer, also directly indicating			0 °C	DKD-R 5-1:2018 c) Ice Point	20 mK	Comparison with standard resistance thermometers
	-40 °C	to	100 °C	DKD-R 5-1:2018 c) Metal block calibrator	50 mK	
	> 100 °C	to	200 °C		75 mK	
	> 200 °C	to	400 °C		80 mK	
	> 400 °C	to	570 °C		$1.6 \cdot 10^{-3} \cdot T$ - 0.56 K	
	> 570 °C	to	700 °C		350 mK	
Base metal thermocouples, also directly indicating	-40 °C	to	200 °C	DKD-R 5-3: 2018 c) Metal block calibrator	$0.8 \cdot 10^{-3} \cdot \lvert T \rvert + 0.1$ K	Comparison with standard resistance thermometers
	> 200 °C	to	400 °C		$1.0 \cdot 10^{-3} \cdot T + 0.08$ K	
	> 400 °C	to	700 °C		$0.6 \cdot 10^{-3} \cdot T + 0.07$ K	
	> 700 °C	to	1210 °C	DKD-R 5-3: 2018 c) Ceramic block calibrator	$1.4 \cdot 10^{-3} \cdot T + 1.3$ K	Comparison with standard TC
Noble metal thermocouples, also directly indicating	0 °C	to	100 °C	DKD-R 5-3: 2018 c) Metal block calibrator	0.22 K	Comparison with standard resistance thermometers
	> 100 °C	to	200 °C		0.25 K	
	> 200 °C	to	400 °C		$0.3 \cdot 10^{-3} \cdot T + 0.2$ K	
	> 400 °C	to	700 °C		$0.7 \cdot 10^{-3} \cdot T + 0.25$ K	
	> 700 °C	to	1210 °C	DKD-R 5-3: 2018 c) Ceramic block calibrator	$1.4 \cdot 10^{-3} \cdot T + 1.3$ K	Comparison with standard TC
Temperature indicators and simulators Resistance thermometer Pt100			-199 °C	DKD-R 5-5: 2018 c) Artifact calibration	1.0 mK	
			0 °C		2.4 mK	
			237 °C		4.8 mK	
	-200 °C	to	800 °C	DKD-R 5-5: 2018 c)	$12 \cdot 10^{-6} \cdot \lvert T \rvert + 4$ mK	
Pt25	-200 °C	to	-150 °C		2.3 mK	
	> -150 °C	to	800 °C		$19 \cdot 10^{-6} \cdot \lvert T \rvert + 10$ mK	
Pt500	200 °C	to	300 °C		$13 \cdot 10^{-6} \cdot \lvert T \rvert + 3.5$ mK	
	> 300 °C	to	800 °C		$18 \cdot 10^{-6} \cdot \lvert T \rvert + 5.4$ mK	
Pt1000	-200 °C	to	800 °C		$17 \cdot 10^{-6} \cdot \lvert T \rvert + 3.8$ mK	
for base metal TE (without reference junction compensation) Type K	-200 °C	to	< 0 °C		$85 \cdot 10^{-6} \cdot \lvert T \rvert + 11$ mK	
	0 °C	to	1300 °C		$5.7 \cdot 10^{-9} \cdot T^2 + 0.17 \cdot 10^{-6} \cdot T + 11$ mK	
Type J	-200 °C	to	< 0 °C		$61 \cdot 10^{-6} \cdot \lvert T \rvert + 8$ mK	
	0 °C	to	1200 °C		$5.6 \cdot 10^{-6} \cdot T + 8$ mK	
Type T	-200 °C	to	< 0 °C		$80 \cdot 10^{-6} \cdot \lvert T \rvert + 11$ mK	
	0 °C	to	400 °C		11 mK	
Type E	-200 °C	to	< 0 °C		$56 \cdot 10^{-6} \cdot \lvert T \rvert + 7$ mK	
	0 °C	to	1000 °C		$4.4 \cdot 10^{-6} \cdot T + 7$ mK	
Type N	-200 °C	to	< 0 °C		$0.12 \cdot 10^{-3} \cdot \lvert T \rvert + 16$ mK	
	0 °C	to	1300 °C		$12 \cdot 10^{-9} \cdot T^2 + 10 \cdot 10^{-6} \cdot T + 16$ mK	

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On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range			Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Nobel metal TC (without reference junction compensation Type R / S	0 °C	to	500 °C	DKD-R 5-5: 2018 c)	$-64 \cdot 10^{-6} \cdot T + 75$ mK	
	> 500 °C	to	1768 °C		45 mK	
Type B	0 °C	to	1200 °C		$26 \cdot T^{-0.85}$	
	> 1200 °	to	1820 °C		60 mK	
Temperature display devices and simulators for thermocouples (with reference junction compensation)	- 200 °C	to	1500 °C		$\sqrt{U_{TC}^2 + (0.06K)^2}$	U_{TC} = uncertainty of the thermocouple temperature without reference junction compensation
Measuring locations in climatic chambers with air circulation in the empty or loaded working space, temperature	-80 °C	to	180 °C	DKD-R 5-7:2018 c) Method C	0.50 K	When loading, the type and arrangement of the loading is to be specified in the calibration certificate precisely.
	> 180 °C	to	300 °C		0.70 K	
Climate chambers with air circulation in the empty or defined loaded usable space, temperature	-80 °C	to	100 °C	DKD-R 5-7:2018 c) Method A or B	0.55 K	
	> 100 °C	to	180 °C		0.75 K	
	> 180 °C	to	300 °C		1.0 K	
Block calibrators	-80 °C	to	0 °C	DKD-R 5-4:2018 c)	0.10 K	Comparison with standard resistance thermometer Inhomogeneity, stability etc. of the measurement object can increase the measurement.
	> 0 °C	to	50 °C		0.056 K	
	> 50 °C	to	700 °C		$0.21 \cdot 10^{-3} \cdot T + 0.036$ K	

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Thermodynamic Quantities - Humidity Quantities

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Dew point temperature Dew level hygrometer	-28 °C to 24.5 °C	QMH XIV.5 Version 5.0 Air temperature: 10 °C to 25 °C Relative humidity: 5 % to 95 %	0.080 K	Comparison with dew point mirror in climate generator
	- 17 °C to 44 °C	QMH XIV.5 Version 5.0 Air flow temperature: > 25°C to 45°C Relative humidity: 5 % to 95 %	0.10 K	
	-3 °C to 58 °C	QMH XIV.5 Version 5.0 Air flow temperature: > 45 °C to 60 °C Relative humidity: 5% to 90%	0.15 K	
Relative humidity Hygrometers and transmitters	5 % to 20 %	QMH XIV.5 Version 5.0 Air temperature: 10°C to 25°C Dew point temperature *td*: -28 °C to 24.5 °C	0.25 %	Measurement expressed in relative humidity Comparison with dew point mirror in climate generator
	> 20 % to 40 %		0.50 %	
	> 40 % to 60 %		0.75 %	
	> 60 % to 80 %		1.0 %	
	> 80 % to 95 %		1.2 %	
	5 % to 20 %	QMH XIV.5 Version 5.0 Air temperature: > 25 °C to 45 °C Dew point temperature -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 5.0 Air temperature: > 45 °C to 60 °C Dew point temperature -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 item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Measuring locations in climate chambers with air circulation in empty or defined loaded working space, relative humidity	5 % to 30 %	Air temperature: 10 °C to 90 °C Dew point temperature t_d: -28 °C to 89.8 °C DKD-R 5-7:2018 [c)] Method C	1.0 %	Measurement uncertainty expressed in relative humidity Humidity reference value is calculated from dew point temperature and air temperature at the measuring location Inhomogeneity and stability of the object can increase measurement uncertainty. When loading, the type and arrangement of the loading has to be specified in calibration certificate.
	> 30 % to 60 %		1.5 %	
	> 60 % to 80 %		2.0 %	
	> 80 % to 98 %		2.5 %	
Climate chambers with air circulation in the empty or defined loaded working space, relative humidity	5 % to 30 %	Air flow temperature: 10 °C to 90 °C Dew point temperature t_d: -28 °C to 89.8 °C DKD-R 5-7:2018 [c)] Method A or B	1.5 %	Measurement uncertainty expressed in relative humidity. Humidity reference value is calculated from dew point temperature and air temperature at the measuring location. Inhomogeneity and stability of the object can increase measurement uncertainty. When loading, the type and arrangement of the loading has to be specified in calibration certificate.
	> 30 % to 60 %		2.0 %	
	> 60 % to 80 %		2.5 %	
	> 80 % to 98 %		3.0 %	

Mechanical Quantities – Pressure

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Pressure Absolute pressure $_{pabs}$	> 0 bar to 21 bar > 21 bar to 251 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$5.0 \cdot 10^{-5} \cdot p_{abs} + 1.2$ mbar + U_{baro} $5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar + U_{baro}	Pressure medium: gas The measurement uncertainty of the barometer U_{baro} has to be taken into account.
Absolute pressure p_{abs}	1 bar; 2 bar to 71 bar > 71 bar to 701 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$7.8 \cdot 10^{-5} \cdot p_{abs} + 0.36$ mbar + U_{baro} $8.2 \cdot 10^{-5} \cdot p_{abs} + 0.72$ mbar + U_{baro}	Reference value ($p_{abs} = p_{amb}$) Pressure medium: Oil The measurement uncertainty of the barometer U_{baro} has to be taken into account.
Absolute pressure p_{abs}	900 mbar to 1100 mbar	esz QMH XXIII.4.2 v5.0	$2.9 \cdot 10^{-5} \cdot p_{abs} + 15$ µbar	Reference *value* ($p_{abs} = p_{amb}$) Single-point measurement at current ambient pressure
Absolute pressure p_{abs}	> 0 bar to 301 bar > 301 bar to 1001 bar	DKD-R 6-1:2014 c) Calibration methods: $p_{abs} = p_e + p_{amb}$	$5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar $7.4 \cdot 10^{-5} \cdot p_{abs} + 40$ mbar	Pressure medium: water The measurement uncertainty of the barometer U_{baro} has to be taken into account.
Positive and negative gauge pressure p_e	-200 mbar to 200 mbar -1 bar to 2 bar > 2 bar to 20 bar > 20 bar to 100 bar > 100 bar to 300 bar	DKD-R 6-1:2014 c)	25 µbar $3.3 \cdot 10^{-5} \cdot p_e + 0.25$ mbar $4.3 \cdot 10^{-5} \cdot p_e + 0.61$ mbar $9.0 \cdot 10^{-5} \cdot p_e + 3.7$ mbar $5.1 \cdot 10^{-5} \cdot p_e + 30$ mbar	Pressure medium: gas
Gauge pressure p_e	0 bar; 1 bar to 70 bar > 70 bar to 700 bar		$7.8 \cdot 10^{-5} \cdot p_e + 0.36$ mbar $8.2 \cdot 10^{-5} \cdot p_e + 0.72$ mbar	Reference value ($pe = 0$ bar) Pressure medium: Oil
Gauge pressure p_e	> 0 bar to 300 bar > 300 bar to 1000 bar	DKD-R 6-1:2014 c)	$5.1 \cdot 10^{-5} \cdot p_{abs} + 30$ mbar $7.4 \cdot 10^{-5} \cdot p_{abs} + 40$ mbar	Pressure medium: water

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Mechanical Quantities – Flow Quantities

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Volume flow rate Q of flowing gases Flow meters or - controllers with a display or measuring transducer with electronic Interface	0.005 l/min to 0.03 l/min > 0.03 l/min to 200 l/min > 200 l/min to 500 l/min	Laminar flow Elements as reference	0.3 ml/min 1 % · Q	Q = Measured value calibration medium dry air (relative humidity < 10%) Measuring ranges related to dry air of 0 °C, 1013.25 mbar
		MFC as reference	$0.89 \cdot 10^{-2} \cdot Q + 0.52$ l/min	

Mechanical Quantities – Force

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Force Measuring instruments and sensors	50 N to 50 kN	Tensile and compressive force according to DKD-R 3-3:2018 c)	0.05 %	

Mechanical Quantities – Torque

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Torque Manually operated Torque - Screwdriving tools c)	0.2Nm to < 1 N·m	DIN EN ISO 6789-2:2017 c)	0.9%	Torque-Spanner
	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 %	

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Mechanical Quantities - Scales

On-site calibration

Calibration and Measurement Capabilities (CMC)

Measurement quantity /Calibration item	Range	Measurement conditions / procedures	Expanded uncertainty of measurement	Remarks
Scales Non-autonomous Electronic Scales	≤ 2 kg	EURAMET cg-18:2015 DKD-R-7-2:2018 c)	$7 \cdot 10^{-7}$	With weights Accuracy class E2 according to OIML R111-1:2004
	≤ 50 kg		$1 \cdot 10^{-6}$	With weights Accuracy class F2 according to OIML R111-1:2004
	≤ 150 kg		$1 \cdot 10^{-5}$	With weights Accuracy class M1 according to OIML R111-1:2004

Abbreviations used:

AA	Work instruction (self-developed procedure) of esz AG
CMC	Calibration and measurement capabilities DIN (Deutsches Institut für Normung e.V.)
DKD-R	Guideline of the German Calibration Service (DKD), published by the Physikalisch-Technischen Bundesanstalt
EN	European Norm
EURAMET	European Association of National Metrology Institutes
OIML	International Organization of Legal Metrology
QMH	Quality Management Handbook (self-developed procedure) of esz AG

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