

Accreditation



The German Accreditation Body hereby confirms, by means of this **accreditation certificate**, that the

Testo Industrial Services GmbH
Gewerbestraße 3, 79199 Kirchzarten

operates a calibration laboratory that meets the requirements set out in DIN EN ISO/IEC 17025:2018 for the conformity assessment activities specified in more detail in the facilities listed below. This also includes existing statutory and regulatory requirements applicable to the calibration laboratory, including those set out in relevant sectoral programmes, provided that these are expressly confirmed in the annexes listed below.

D-K-15070-01-01	Valid from: 12
D-K-15070-01-02	February 2026
	Valid from: 5 March
	2026

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

This accreditation was granted in accordance with Article 5(1), second sentence, of Regulation (EC) No 765/2008, following the completion of an accreditation procedure in compliance with the minimum requirements of the DIN EN ISO/IEC 17011 and issued on the basis of an assessment and decision by the relevant accreditation committees.

This accreditation certificate is valid only in conjunction with the decision dated 5 March 2026. It consists of this cover sheet, the back of the cover sheet and the accompanying appendices.

Registration number of the accreditation certificate: **D-K-15070-01-00**

Berlin, 5 March 2026 On behalf of
Dr Florian Witt | Head of Department

German Accreditation Body Ltd

Berlin branch:
Spittelmarkt10,
10117 Berlin

Deutsche Akkreditierungsstelle GmbH (DAkKS) is the designated national accreditation body of the Federal Republic of Germany pursuant to Section 8(1) of the AkkStelleG in conjunction with Section 1(1) of the AkkStelleGBV.

DAkKS is the national accreditation body in accordance with Article 4(4) of Regulation (EC) No 765/2008 and paragraph 4.7 DIN EN ISO/IEC 17000, designated by Germany.

In accordance with Article 11(2) of Regulation (EC) No 765/2008, the accreditation certificate must be recognised as equivalent by the national authorities within the scope of this Regulation, as well as by the

WTO member states which have undertaken, under bilateral or multilateral reciprocal agreements, to recognise as equivalent the certificates issued by accreditation bodies that are members of ILAC or IAF.

DAkKS is a signatory to the multilateral agreements on mutual recognition of the European co-operation for Accreditation (EA), the International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC).

The current membership figures can be found on the following websites: EA:

www.european-accreditation.org

ILAC: www.ilac.org

IAF: www.iaf.nu

German Accreditation Body

Appendix to Accreditation Certificate D-K-15070-01-01 in accordance with DIN EN ISO/IEC 17025:2018

Valid from:

12.02/2026

Date of issue: 25 February 2026

This appendix to the certificate forms part of accreditation certificate D-K-15070-01-00.

The German original version „Anlage zur Akkreditierungsurkunde D-K-15070-01-01 nach DIN EN ISO/IEC 17025:2018“ is valid.

Holder of the accreditation certificate:

**Testo Industrial Services GmbH
Gewerbestraße 3, 79199 Kirchzarten**

with the locations

**Testo Industrial Services GmbH
Calibration Laboratory, Kirchzarten,
Gewerbestraße 3, 79199 Kirchzarten**

**Testo Industrial Services
GmbH, Kirchzarten Calibration
Laboratory
Erich-Rieder-Straße 4, 79199 Kirchzarten**

**Testo Industrial Services GmbH
Calibration Laboratory, Munich
Nikolaus-Otto-Straße 2, 85221 Dachau**

**Testo Industrial Services GmbH
Calibration Laboratory, Essen
Hermann-Drescher-Weg 4 a–d, 45329 Essen**

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

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

Appendix to Accreditation Certificate D-K-15070-01-01

**Testo Industrial Services GmbH
Calibration Laboratory,
Hamburg
Meiendorfer Straße 205, 22145 Hamburg**

**Testo Industrial Services GmbH
Calibration Laboratory,
Mörfelden-Walldorf
Kurfürstenstraße 11, 64546 Mörfelden-Walldorf**

**Testo Industrial Services GmbH
Calibration Laboratory, Winsen
Tönnhäuser Weg 100–106, 21423 Winsen (Luhe)**

**Testo Industrial Services GmbH
Calibration Laboratory,
Heidenheim
18 Alexanderstraße, 89522 Heidenheim an der Brenz**

The calibration laboratory meets the requirements set out in DIN EN ISO/IEC 17025:2018 for carrying out the conformity assessment activities listed in this annex. The calibration laboratory complies with any additional statutory and regulatory requirements, including those set out in relevant sectoral programmes, provided that these are expressly confirmed below.

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

Appendix to Accreditation Certificate D-K-15070-01-01

Electrical quantities

Direct current and low-frequency measured quantities

- Direct current a), b)
- AC voltage a), b)
- Direct current a), b)
- Alternating current strength a), b)
- AC/DC transfer
- Electrical power a), b)
- Phase angle
- DC resistance a), b)
- Alternating current resistance b)
- Capacitance a), b)
- Inductance
- Voltage ratio a), b)
- High-voltage measurement parameters a)

Time and frequency

- Time interval a), b)
- Frequency and rotational speed a), b)

High-frequency measurement parameters

- HF impedance (reflection coefficient) a), b)
- HF power a), b)
- HF attenuation a), b)
- HF noise
- Modulation parameters
- Oscilloscope measurement parameters a), b)
- rise time a), b)
- Bandwidth a), b)
- Pulsed measurement quantities a), b)

Dimensional quantities: length

- Diameter a), b)
- Thread a), b)
- Parallel end dimensions
- Length measuring instruments a), b)
- Measuring instruments for length
- Line dimensions, clearances, angles
- Inclination meters
- Rotation angle

Coordinate measuring technology

- Applications for coordinate measuring machines

a) including on-site calibration

b) Mobile laboratory

Within the parameters marked with *, for the quantities/calibration objects, the calibration laboratory is permitted to apply the standards/calibration guidelines listed here in different editions without the need for prior notification to or approval from DAkkS. The calibration laboratory maintains an up-to-date list of all standards and calibration guidelines within its scope of accreditation.

Appendix to Accreditation Certificate D-K-15070-01-01

Kalibrierlabor Kirchzarten site, Erich-Rieder Straße 4, 79199 Kirchzarten

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC voltage meters	0 V 1 μ V to 220 mV > 220 mV up to 2.2 V > 2.2 V up to 11V > 11 V up to 22V > 22 V up to 220V > 220 V up to 1000 V		0.1 μ V $7.5 \cdot 10^{-6} U + 0.5 \mu$ V $5 \cdot 10^{-6} U + 0.7 \mu$ V $3.5 \cdot 10^{-6} U + 2.5 \mu$ V $3.5 \cdot 10^{-6} U + 4 \mu$ V $5 \cdot 10^{-6} U + 40 \mu$ V $6.5 \cdot 10^{-6} U + 0.4$ mV	U = measured value
Sources	0 V 1 μ V up to 200mV > 200 mV to 2 V > 2 V up to 20V > 20 V to 200 V > 200 V up to 1000 V		0.1 μ V $5.8 \cdot 10^{-6} U + 0.2 \mu$ V $2.9 \cdot 10^{-6} U + 0.3 \mu$ V $2.9 \cdot 10^{-6} U + 0.55 \mu$ V $4 \cdot 10^{-6} U + 35 \mu$ V $4.5 \cdot 10^{-6} U + 0.55$ mV	
High voltage	> 1 kV up to 50 kV		$0.4 \cdot 10^{-3} U$	
Direct current sources and measuring instruments	0 A 0.1 μ A up to < 1 μ A 1 μ A to <10 μ A 10 μ A up to < 100 μ A 100 μ A to 320mA > 320 mA up to 1A > 1 A up to 10A > 10 A up to 1000 A		0.2 nA $35 \cdot 10^{-6} I + 21$ pA $50 \cdot 10^{-6} I + 6$ pA $15 \cdot 10^{-6} I + 0.4$ nA $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \cdot 10^{-3} I$	I = measured value
Current clamps	1 mA up to 2.2A > 2.2 A to 20 A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	
Current transformer	1 A to 120 A > 120 A to 1000 A		$0.22 \cdot 10^{-3} I$ $0.25 \cdot 10^{-3} I$	
Direct current resistance	0 to < 1 m 1 m to 10 m > 10 m up to 10 M > 10 M up to 100 M > 100 M up to 10 G > 10 G to 100 G > 100 g up to 1 T > 1 T up to 10 T > 10 T to 100 T		$1.3 \mu 7 \cdot 10^{-6} R 4 \cdot 10^{-6} R 8 \cdot 10^{-6} R$ $0.17 \cdot 10^{-3} R$ $0.21 \cdot 10^{-3} R$ $0.35 \cdot 10^{-3} R$ $0.6 \cdot 10^{-3} R$ $29 \cdot 10^{-3} R$	R = measured value

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Direct current power measuring instruments	1 mW up to < 220 W	1 mV to 0.22 V 1 A to 1000 A	$0.6 \cdot 10^{-3} P$	
	1 mW up to 320 W	0.22 V to 1000 V 0.1 mA to 0.32 A	$20 \cdot 10^{-6} P$	
	> 70 mW up to 1 kW	0.22 V to 1000 V > 0.32 A to 1 A	$35 \cdot 10^{-6} P$	
	> 0.22 W up to 10 kW	0.22 V to 1000 V > 1 A to 10 A	$0.2 \cdot 10^{-3} P$	
	> 2.2 W up to 1 MW	0.22 V to 1000 V > 10 A to 1000 A	$0.3 \cdot 10^{-3} P$	
Direct current power sources	1 mW up to < 200 W	1 mV to 0.2 V 1 A to 1000 A	$0.4 \cdot 10^{-3} P$	
	1 mW up to 320 W	0.2 V to 1000 V 0.1 mA to 0.32 A	$20 \cdot 10^{-6} P$	
	> 64 mW up to 1 kW	0.2 V to 1000 V > 0.32 A to 1 A	$35 \cdot 10^{-6} P$	
	> 0.2 W up to 10 kW	0.2 V to 1000 V > 1 A to 10 A	$0.2 \cdot 10^{-3} P$	
	> 2 W up to 1 MW	0.2 V to 1000 V > 10 A to 1000 A	$0.3 \cdot 10^{-3} P$	
AC voltage measuring instruments and sources	1 mV up to 2.2 mV	10 Hz to 20 Hz	$0.52 \cdot 10^{-3} U$	U = measured value
		> 20 Hz to 40 Hz	$0.52 \cdot 10^{-3} U$	
		Hz	$0.40 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.40 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.41 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.46 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.55 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.60 \cdot 10^{-3} U$	
	> 2.2 mV up to 7 mV	10 Hz to 20 Hz >	$0.22 \cdot 10^{-3} U$	
		20 Hz to 40 Hz	$0.22 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.16 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.16 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.20 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.22 \cdot 10^{-3} U$	
	> 300 kHz to 500 kHz	> 300 kHz to 500 kHz	$0.33 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.45 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical parameters

Measured quantity / Calibration object	Calibration and measurement facilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
AC voltage measuring instruments and sources	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV up to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 mV up to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV up to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 700 mV up to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	
	> 7 V up to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V up to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)					
Measured quantity / Calibration object	Measuring range / Measurement span		Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 220 V up to 1000 V		10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	U = measured value
			> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
			> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
			> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
			> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 1 kV up to 30 kV	50 Hz	$0.5 \cdot 10^{-3} U$		
	> 30 kV up to 50 kV	50 Hz	$0.6 \cdot 10^{-3} U$		
Alternating current sources and measuring instruments (ranges)	100 µA to 1 mA		10 Hz to 40 Hz	$120 \cdot 10^{-6} I$	I = measured value
	> 1 mA to 10 mA		> 40 Hz to 1 kHz;	$160 \cdot 10^{-6} I$	
			> 1 kHz to 10 kHz;	$60 \cdot 10^{-6} I$	
			> 10 mA to 1 A		
	> 1 A to 10 A		> 40 Hz to 1kHz;	$17 \cdot 10^{-6} I$	
			> 1 kHz to 10 kHz;		
	> 10 A to 20 A		10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} I$	
> 20 A to 100 A		10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} I$		
		10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$69 \cdot 10^{-6} I$ $69 \cdot 10^{-6} I$ $0.17 \cdot 10^{-3} I$		
Current clamps	1 mA up to 2.2A	40 Hz to 5 kHz	$2 \cdot 10^{-3} I$	I = measured value	
	> 2.2 A up to 20A	40 Hz to 5 kHz	$3 \cdot 10^{-3} I$		
	> 20 A up to 800 A	40 Hz up to 65 Hz	$4 \cdot 10^{-3} I$		
Current transformer	1 A to 120 A	40 Hz to 850 Hz	$0.16 \cdot 10^{-3} I$		
	1 A to 120 A	> 850 Hz to 2 kHz	$0.47 \cdot 10^{-3} I$		
	> 120 A up to 600 A	40 Hz to 400 Hz	$0.52 \cdot 10^{-3} I$		
	> 120 A up to 1000 A	40 Hz up to 65 Hz	$0.6 \cdot 10^{-3} I$		
Alternating current resistor Areas	0.1 Ω up to < 0.316 Ω		10 Hz to < 20 Hz	0.2×10^{-3}	R = measured value
			20 Hz to 500 Hz	$R 50 \cdot 10^{-6}$	
			> 500 Hz to 1 kHz	R	
	0.316 Ω up to 3.16 Ω		10 Hz to 30 Hz	$30 \cdot 10^{-6} R$	
			> 30 Hz to 55 Hz	$20 \cdot 10^{-6} R$	
			> 55 Hz to 1 kHz	$30 \cdot 10^{-6} R$	
Alternating current-		10 Hz to 30 Hz	$25 \cdot 10^{-6} R + 40 \mu\Omega$		

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
resistance	> 3.16 Ω up to 10 Ω	> 30 Hz to 55 Hz	$9 \cdot 10^{-6} R + 60 \mu\Omega$	
Areas		> 55 Hz to 1 kHz	$25 \cdot 10^{-6} R + 40 \mu\Omega$	
Charge, charge amplifier,	10 pC up to 10 ⁵ pC	50 Hz to 10 kHz	0.4%	
Charge measuring		> 10 kHz to 20kHz	0.6%	
		> 20 kHz to 50 kHz	1.0 per cent	
Phase angle	-180° to 180°	10 V to 1000 V		
between current and		0.1 A to 50 A		
voltage		45 Hz to 65 Hz	0.0051°	
Measuring instruments		> 65 Hz to 180Hz	0.0075°	
		> 180 Hz to 450 Hz	0.018°	
		> 450 Hz to 850 Hz	0.033°	
		> 850 Hz to 3 kHz	0.12°	
		> 3 kHz to 6 kHz	0.23°	
		10 V to 1000 V		
		> 50 A to 80 A		
		45 Hz to 65 Hz	0.0052°	
		> 65 Hz to 180Hz	0.0083°	
		> 180 Hz to 450 Hz	0.025°	
		> 450 Hz to 850 Hz	0.05°	
		> 850 Hz to 3 kHz	0.25°	
		10 V to 1000 V		
		> 80 A to 120 A		
		45 Hz to 65 Hz	0.0055°	
		> 65 Hz to 180Hz	0.0091°	
		> 180 Hz to 450 Hz	0.020°	
		> 450 Hz to 850 Hz	0.035°	
		> 850 Hz to 3 kHz	0.25°	
		> 3 kHz to 6 kHz	0.5°	
Phase angle between	-180° to 180°	10 V to 1,000 V		
voltages		45 Hz to 65 Hz	0.006°	
Measuring instruments		> 65 Hz to 180 Hz	0.0075°	
		> 180 Hz to 450 Hz	0.025°	
		> 450 Hz to 850 Hz	0.043°	
		> 850 Hz to 3 kHz	0.15°	
		> 3 kHz to 6 kHz	0.3°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - Electrical parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between voltages Sources	-180° to 180°	0.05 V to 10 V Measurement frequency: 40 Hz to 65 Hz 0.05 V to 0.2 V Measurement frequency: > 65 Hz to 1 kHz > 1 kHz to 2 kHz > 0.2 V to 10 V Measurement frequency: > 65 Hz to 1 kHz > 1 kHz to 2 kHz	0.015° 0.03° 0.055° 0.02° 0.035°	
Electrical power Active power in alternating current	5 mW up to 50 kW > 2.5 W up to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $\pm 0.05 \leq \cos \Phi \leq \pm 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ However, not less than 80×10^{-6} 0.14×10^{-3}	w : Uncertainty in the amplitude of the fundamental voltage component $w(I_F)$: Uncertainty in the amplitude of the current fundamental $w(\Phi_F)$: Uncertainty in the phase-shift angle
Alternating current reactive-performance	5 mvar up to 50 kvar > 2.5 var up to 120 kvar	1 V to 1,000 V 45 Hz to 65 Hz $\pm 0.05 \leq \sin \Phi \leq \pm 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ However, not less than $80 \cdot 10^{-6}$ 0.14×10^{-3}	$w(U_{rms})$: Uncertainty of the root mean square voltage $w(I_{rms})$: Uncertainty of the root mean square value of the current
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120 kVA	1 V to 1,000 V 45 Hz to 65 Hz 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ However, not less than $80 \cdot 10^{-6}$ 0.14×10^{-3}	
Tension	± 2 mV/V	Bridge span: 5 V Measurement frequency 225 Hz Measurement frequency 600 Hz	0.04 μ V/V 0.05 μ V/V 0.12 μ V/V	Calibration of 350 Ω bridge standards and the associated indicating instruments
	± 2 mV/V	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement frequency 600 Hz	0.04 μ V/V 0.04 μ V/V 0.12 μ V/V	at discrete points in 10 per cent increments
	± 5 mV/V	Bridge span: 5 V Measurement frequency 225 Hz Measurement frequency 4.8 kHz	0.06 μ V/V 0.22 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measurand / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement	Comments
Tension	$\pm 10 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz	 0.06 $\mu\text{V/V}$ 0.45 $\mu\text{V/V}$	
	$\pm 5 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	 0.06 $\mu\text{V/V}$ 0.06 $\mu\text{V/V}$ 0.22 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	 0.06 $\mu\text{V/V}$ 0.10 $\mu\text{V/V}$ 0.45 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	 0.11 $\mu\text{V/V}$	Calibration of 350 Ω bridge standards and the associated indicating instruments at discrete points in 10 per cent increments
	$\pm 20 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	 0.6 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	 3.5 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency	 4.0 $\mu\text{V/V}$	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 0.5 V	 2.0 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1 V	 1.0 $\mu\text{V/V}$ 2.0 $\mu\text{V/V}$ 2.0 $\mu\text{V/V}$ 2.0 $\mu\text{V/V}$ 2.0 $\mu\text{V/V}$ 2.0 $\mu\text{V/V}$	
Voltage ratio: DC voltage, bridge standard				

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Voltage ratio: DC voltage, bridge normal	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V	0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 5 V	0.30 μ V/V 0.25 μ V/V 0.25 μ V/V 0.25 μ V/V 0.35 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 7.5 V	0.20 μ V/V 0.20 μ V/V 0.20 μ V/V 0.20 μ V/V 0.3 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 10 V	0.10 μ V/V 0.15 μ V/V 0.15 μ V/V 0.20 μ V/V 0.3 μ V/V 1.5 μ V/V	
Voltage Ratios: DC Voltage Bridges, Measuring Instruments, Measuring Amplifiers	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 0.5 V	0.35 μ V/V 0.35 μ V/V 0.40 μ V/V 0.55 μ V/V 2.5 μ V/V	
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1 V	0.20 μ V/V 0.20 μ V/V 0.3 μ V/V 0.5 μ V/V 2.5 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Voltage relationships: DC voltage bridges, measuring instruments, measuring amplifiers	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V; 5 V; 7.5 V; 10 V	0.10 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$ 0.25 $\mu\text{V/V}$ 0.45 $\mu\text{V/V}$ 2.5 $\mu\text{V/V}$	
Frequency	10 MHz	Measurement time > 30	$1 \cdot 10^{-11} f$	f = current measured value
Frequency measurement	1 mHz to 46 GHz	Measurement time > 5	$1 \cdot 10^{-10} f$	
Frequency synthesis	1 mHz up to 50 GHz		$1 \cdot 10^{-10} f$	
Time interval	1 ns to 1000 s		$1 \cdot 10^{-10} f$ not less than 1 ns	Trigger uncertainties must be taken into account
Speed (visual)	1 min ⁻¹ to 2 · 10 ⁵ min ⁻¹	with a light-activated switch	6 · 10 ⁻⁶ not less than 0.001 min ⁻¹	
mechanical	1 min ⁻¹ to 10,000 min ⁻¹		4 · 10 ⁻⁴ not less than 0.01 min ⁻¹	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Measurement parameter / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Capacity of measuring instruments	1 nF up to 100 nF	50 Hz up to 10 kHz	$1.0 \cdot 10^{-3} C$	C: measured value using standard capacitances with 5520A / 5522A
	> 100 nF up to 1000 nF	50 Hz up to 1 kHz	$1.0 \cdot 10^{-3} C$	
		> 1 kHz up to 10 kHz	$2.5 \cdot 10^{-3} C$	
	190 pF to < 400 pF	10 Hz up to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	
	400 pF up to < 1.1 nF	10 Hz up to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF up to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF up to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF up to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to < 110 nF	10 Hz up to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF up to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF up to < 1.1 μF	10 Hz up to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF up to < 3.3 μF	10 Hz up to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF up to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF up to < 33 μF	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μF up to < 110 μF	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μF up to < 330 μF	DC up to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μF up to < 1.1 mF	DC up to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF up to < 3.3 mF	DC up to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF up to < 11 mF	DC up to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to < 33 mF	DC up to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
Alternating current amperage Current transformer	1 A to 750 A	40 Hz to 1.2 kHz	$90 \cdot 10^{-6} \cdot I$	I = measured value
	> 750 A to 2000A	40 Hz to 100 Hz	$95 \cdot 10^{-6} \cdot I$	
	1 A to 450 A	> 1.2 kHz to 2 kHz	$0.40 \cdot 10^{-3} \cdot I$	
	1 A to 100 A	> 2 kHz to 7.5 kHz	$0.41 \cdot 10^{-3} \cdot I$	
Direct current resistance Measuring instruments	330 M Ω to < 1 G Ω	$U < 1575 \text{ V}$	$4 \cdot 10^{-3} \cdot R$	
	1 G Ω to < 10 G Ω	$U < 1575 \text{ V}$	$8 \cdot 10^{-3} \cdot R$	
	10 G Ω to < 100 G Ω	with a multiplier of x	$25 \cdot 10^{-3} \cdot R$	
	0.1 T Ω to < 1 T Ω	1000 $U \leq 10 \text{ kV}$	$30 \cdot 10^{-3} \cdot R$	
AC resistance discrete values Measuring instruments	1 T Ω to 10 T Ω		$35 \cdot 10^{-3} \cdot R$	R ... measured value
	1 m Ω	50 Hz to 1 kHz	$1.0 \cdot 10^{-3} R$	
	3 m Ω			
	10 m Ω			
	30 m Ω			
	0.1 Ω	50 Hz to 1 kHz	$0.4 \cdot 10^{-3} R$	
	0.3 Ω			
	1 Ω			
	3 Ω			

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Electrical quantities

Calibration and Measurement Capabilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC resistance meters for measuring earth resistance and internal battery resistance	0.1 Ω to < 5 Ω	$I_{\max} < 700 \text{ mA}$	$2.3 \cdot 10^{-3} \cdot R + 8 \text{ m}\Omega$	R: Measured value 50 Hz to 400 Hz
	5 Ω to < 30 Ω	$I_{\max} < 250 \text{ mA}$	$1.6 \cdot 10^{-3} \cdot R + 8 \text{ m}\Omega$	
	30 Ω to < 200 Ω	$I_{\max} < 100 \text{ mA}$	$1.6 \times 10^{-3} \cdot R + 8 \text{ m}\Omega$	
	200 Ω to < 500 Ω	$I_{\max} < 45 \text{ mA}$	$1.6 \cdot 10^{-3} \cdot R$	
	0.5 k Ω to < 2 k Ω	$I_{\max} < 25 \text{ mA}$	$1.6 \cdot 10^{-3} \cdot R$	
	2 k Ω to < 5 k Ω	$I_{\max} < 10 \text{ mA}$	$1.6 \cdot 10^{-3} \cdot R$	
	5 k Ω to 10 k Ω	$I_{\max} < 5 \text{ mA}$	$1.6 \times 10^{-3} \times R$	
Earth conductor resistance testers	7 m Ω to 38 m Ω	$I_{\max} < 40 \text{ A}$	0.5 m Ω	50 Hz and 60 Hz
	19 m Ω to 75 m Ω	$I_{\max} < 40 \text{ A}$	0.6 m Ω	
	65 m Ω to 130 m Ω	$I_{\max} < 40 \text{ A}$	1.0 m Ω	
	260 m Ω to 410 m Ω	$I_{\max} < 40 \text{ A}$	1.6 m Ω	
	440 m Ω to 550 m Ω	$I_{\max} < 40 \text{ A}$	2.2 m Ω	
	0.8 Ω to 1.1 Ω	$I_{\max} < 40 \text{ A}$	4 m Ω	
	1.5 Ω to 2.0 Ω	$I_{\max} < 30 \text{ A}$	7 m Ω	
	4.2 Ω to 5.5 Ω	$I_{\max} < 21 \text{ A}$	20 m Ω	
	8 Ω to 11 Ω	$I_{\max} < 15 \text{ A}$	35 m Ω	
	15 Ω to 20 Ω	$I_{\max} < 10 \text{ A}$	35 m Ω	
	42 Ω to 55 Ω	$I_{\max} < 5 \text{ A}$	0.25 Ω	
	80 Ω to 110 Ω	$I_{\max} < 3 \text{ A}$	0.4 Ω	
	150 Ω to 200 Ω	$I_{\max} < 1.35 \text{ A}$	0.8 Ω 2	
	420 Ω to 550 Ω	$I_{\max} < 0.6 \text{ A}$	Ω 4 Ω	
	0.8 k Ω to 1.1 k Ω	$I_{\max} < 0.3 \text{ A}$	8 Ω	
	1.5 k Ω to 2.0 k Ω	$I_{\max} < 0.15 \text{ A}$		
Measuring instruments for loop resistance and internal network resistance	7 m Ω to 38 m Ω	$I_{\max} < 40 \text{ A}$	16 m Ω	R: Measured value 50 Hz to 400 Hz
	19 m Ω to 75 m Ω	$I_{\max} < 40 \text{ A}$	16 m Ω	
	65 m Ω to 130 m Ω	$I_{\max} < 40 \text{ A}$	16 m Ω	
	260 m Ω to 410 m Ω	$I_{\max} < 40 \text{ A}$	20 m Ω	
	440 m Ω to 550 m Ω	$I_{\max} < 40 \text{ A}$	22 m Ω	
	0.8 Ω to 1.1 Ω	$I_{\max} < 40 \text{ A}$	27 m Ω	
	1.5 Ω to 2.0 Ω	$I_{\max} < 30 \text{ A}$	40 m Ω	
	4.2 Ω to 5.5 Ω	$I_{\max} < 21 \text{ A}$	$15 \cdot 10^{-3} \cdot R$	
	8 Ω to 11 Ω	$I_{\max} < 15 \text{ A}$	$14 \cdot 10^{-3} \cdot R$	
	15 Ω to 20 Ω	$I_{\max} < 10 \text{ A}$	$13 \cdot 10^{-3} \cdot R$	
	42 Ω to 55 Ω	$I_{\max} < 5 \text{ A}$	$13 \cdot 10^{-3} \cdot R$	
	80 Ω to 110 Ω	$I_{\max} < 3 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	150 Ω to 200 Ω	$I_{\max} < 1.35 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	420 Ω to 550 Ω	$I_{\max} < 0.6 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	0.8 k Ω to 1.1 k Ω	$I_{\max} < 0.3 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	1.5 k Ω to 2.0 k Ω	$I_{\max} < 0.15 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
Time interval	> 10 ³ s to 10 ⁵ s		$1.5 \cdot 10^{-6} \cdot t$	t: Measured value

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - Electrical parameters

Calibration and measurement facilities (CMC)				
Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between voltage and current Sources	-180° to +180°	0.05 V to 10 V, 10 mA to 20 A, 40 Hz to 1 kHz > 1 kHz to 2 kHz	0.065° 0.1°	
		0.05 V to 10 V, > 20 A to 100 A, 40 Hz to 1 kHz > 1 kHz to 2 kHz	0.045° 0.15°	
Phase angle between currents	-180° to +180°	10 mA to 20 A, 1 A to 100 A, 40 Hz to 1 kHz > 1 kHz to 2 kHz	0.07° 0.17°	
Phase angle current transformer	-180° to +180°	10 mA to 20 A, 0.05 V to 10 V secondary voltage 1 A to 1,000 A 40 Hz to 65 Hz	0.05°	Secondary current Secondary voltage Primary current
		> 100 A to 600 A > 65 Hz to 400 Hz	0.09°	Primary current
		1 A to 100 A, > 65 Hz to 1 kHz > 1 kHz to 2 kHz	0.07° 0.17°	
Alternating current – active energy single-phase Measuring instruments	150 Ws up to 5.76 MWs	45 Hz to 65 Hz $0.25 \leq \cos \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	0.15×10	Measurement uncertainty relative to the apparent energy
Alternating current reactive power single-phase Measuring instruments	150 vars up to 5.76 Mvars	45 Hz to 65 Hz $0.25 \leq \sin \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	0.15×10	
Reactive power in alternating current		45 Hz to 65 Hz, $t = 100 \text{ s}$ 30 V to 480 V		

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - High-frequency measurement parameters
Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Oscilloscope measurement parameters	1 mV to 5 V	Square-wave voltage: 10 Hz to 10 kHz	0.35 per cent	R_i = internal resistance
Vertical deflection	1 mV to 120 V	R_i = 1 M time markers or sine wave	0.35%	
Horizontal deflection	50 ps to < 1 μ s	< 1 V	6 ps	
	1 μ s to 5 s		$1.5 \cdot 10^{-3} t$	
Rise time t_r	25 ps to 245 ps	500 mV	9 ps	t_r = the oscilloscope's intrinsic rise time
	> 245 ps up to 10 ms		$35 \cdot 10^{-3} t_r$	
	150 ps up to 10 ms	250 mV	$35 \cdot 10^{-3} t_r + 5$ ps	
	250 ps up to 10 ms	> 250 mV to 2.5 V	$35 \cdot 10^{-3} t_r + 8$ ps	
Bandwidth B	f_c 50 MHz to 26.5 GHz	0.2 V to 2 V R_i = 50 Ω	3 % f_c	f_c = -3 dB frequency point
HF attenuation	0 dB to 60 dB	300 kHz to 6 GHz	0.3 dB	50 Ω connector: N50
HF transmission phase angle ϕ	-180° to 180°	300 kHz to 6 GHz	$U_1 \cdot 180^\circ / \pi + K \cdot f$	$U_1 = \arcsin(10^{U/20} - 1)$ K: 0.1°/GHz U: Uncertainty of the Attenuation in dB
RF impedance				
Reflection coefficient	0 to 1	300 kHz to 2 GHz > 2 GHz to 6 GHz	$0.005 + 0.005 f^2$ $0.009 + 0.005 f^2$	50 Ω connector: N50
Phase angle ϕ	-180° to 180°	$0.1 < r < 1$ 300 kHz to 6 GHz	$\arcsin \frac{ r }{ r } \frac{180^\circ}{\pi}$	50 Ω connector: N50
RF power	0.1 mW to 10 mW	9 kHz to 50 MHz > 50 MHz to 5 GHz > 5 GHz to 18 GHz > 18 GHz to 26.5 GHz	$17 \cdot 10^{-3} P$ $22 \cdot 10^{-3} P$ $30 \cdot 10^{-3} P$ $40 \cdot 10^{-3} P$	50 Ω connector: N50; PC-3.5
Amplitude modulation				
Modulation depth m	0 to 1.0	$f_{MOD} < 1$ MHz	$0.025 m + 0.004$	f_{HF} = carrier frequency $f_{HF} < 4$ GHz
Frequency modulation				f_{MOD} = Modulation frequency
Frequency shift Δf	0 to 5 MHz		$0.041 \Delta f + 25$ Hz	

Appendix to Accreditation Certificate D-K-15070-01-01
Permanent Laboratory, Kirchzarten, Erich-Rieder-Straße 4 – High-frequency measurement parameters

Measured quantity / Calibration object	Calibration and measurement facilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Phase modulation Phase shift $\Delta\Phi$	0 to (4 MHz / f_{MOD}) rad		$0.041 \Delta\Phi + 0.025 \text{ rad}$	$\Delta\Phi$ = phase shift
Total Harmonic Distortion THD / Harmonic distortion factor	0 to 0.3 0 to 0.3 0 to 0.3	100 Hz to 50 kHz 100 kHz to 2 GHz 100 Hz to 50 kHz	$0.0165 THD + 0.0001$ $0.0675 THD + 0.0001$ $0.007 THD_{Audio} + 0.001$	
Flicker*) $\Delta U / U$	0.4 to 5	DIN EN 61000-4-15:2011 (115 V, 60 Hz); (230 V, 50 Hz) (115 V, 60 Hz); (230 V, 50 Hz)	$7 \cdot 10^{-3} \Delta U / U$	
Frequency	0.0083 Hz to 40 Hz		$3 \cdot 10^{-3} \Delta U / U$	
γ	10 minutes		0.5 per cent	
P_{St} (Short Term)	2 hours		1.7 per cent	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Kirchzarten, Erich-Rieder-Straße 4 - Dimensional quantities

Measured quantity / Calibration object	Calibration and measurement capabilities (CMC) Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical gauge blocks, gauge rings: Diameter *)	1 mm to 200 mm > 200 mm to 300 mm	VDI/VDE/DGQ 2618 Part 4.1:2006 Section 3.3.4 (Opt. 3)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$ $1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Gauging pins: Diameter *)	1 mm up to 200 mm	Point 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter *)	0.1 mm up to 30 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2007, point 3.2.2(Opt.1)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (single- and multi-start cylindrical External and internal threads with straight flanks and a symmetrical profile) Threaded mandrels: simple flank diameter*)	1.4 mm to 200 mm Nominal pitch: 0.3 mm up to 6 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method d is the measured value
Threaded rings: simple flank diameter*)	3 mm to 200 mm Nominal pitch: 0.5 mm up to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-ball method d is the measured Diameter
Threaded mandrels: simple flank diameter Outer diameter *)	1.4 mm up to 200 mm Nominal diameter	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Section 3.2.2 (Opt. 1) up to section 3.2.6 (Opt. 5)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Scanning methods D is the measured Diameter
Core diameter / Punch diameter *)			2 μm	
Gradient / Pitch *)			5 μm	
Thread profile angle α *)			1.5 μm	
Threaded rings: simple flank diameter Outer diameter *)	5 mm to 200 mm Nominal diameter	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Section 3.2.2 (Opt. 1) up to section 3.2.6 (Opt. 5)	$(3 + 1 / l_f)'$, but not less than 6'	Scanning methods d is the measured Diameter
Core diameter / Punch diameter *)			$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	
Gradient / Pitch *)			5 μm	
Thread profile angle α *)			2 μm	
	0.5 mm up to 8 mm		1.5 μm	
	> 27°		$(3 + 1 / l_f)'$, but not less than 6'	l_f : Flank length in mm

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - Dimensional quantities

Measured quantity / Calibration object	Calibration and measurement capabilities (CMC)			Expanded measurement uncertainty	Comments
	Measuring range / Measurement span	Test conditions / procedures			
Length of plane-parallel, spherical or cylindrical Measuring surfaces Diameter *)	0.01 mm up to 500 mm	VDI/VDE/DGQ 2618		$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	/ is the measured Length
	>500 mm up to 1000 mm	Issue 19.1:2014		$2.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	
	0.01 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)		$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm up to 2.00 mm	DIN 2275:2014		$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	/ is the measured length
Setting dimensions for micrometres *)	25 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009		$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	
Throat gauges *)	3 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and Depth measurements: Digital display *)	0 mm to 300 mm	VDI/VDE/DGQ 2618 Part 9.1:2006		$9 \mu\text{m} + 11 \cdot 10^{-6} \cdot l$	Automated measuring system
				$10 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	/ is the measured
Calipers for external, internal and depth	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006		$30 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$	/ is the measured
Depth caliper / Height gauge*)	> 500 mm up to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006 VDI/VDE/DGQ 2618 Part 9.3:2006		$50 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$	Length
Clamp-type*)micrometers *)	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001		$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Fine-adjustment measuring	0 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002			
Flush-mounted measuring screws *)	0 mm to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008			
Depth-measuring screws *)	0 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010			
Internal micrometres using a 2-point contact on the calibration object *)	13 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.7:2010		$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
	> 300 mm up to 1000 mm			$5 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Erich-Rieder-Straße 4 – Dimensional quantities

Calibration and measurement facilities (CMC)					
Measured quantity / Calibration object	Measuring range / Measurement span		Test conditions / procedures	Expanded measurement uncertainty	Comments
Internal micrometres with 3-line contact on the calibration object *)	3 mm	up to 150 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometres with a 2-line contact system	5 mm	to 100 mm	3-APD-0-0025-DE July 2023	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring instruments (Quick-access button) for external		to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring instruments (Quick-access button) for internal	2 mm	up to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Dial gauges *)	0 mm	up to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
			VDI/VDE/DGQ/DKD 2618 Part 11.4:2020	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	electronic digital dial gauges
Fine pointer *)	0 mm	up to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	0.6 μm	
Probe-type measuring instruments *)	0 mm	to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	1.0 μm	
Electrical inductive length measuring		to 100 mm	VDI/VDE/DGQ 2618 Sheet 14.1:2010	$0.6\text{ }\mu\text{m} + 1 \cdot 10^{-6} \cdot l$	
electronic incremental Length measuring devices		to 100 mm	3-APD-0-0027-DE August 2023		
Steel parallel end gauges in accordance with DIN EN ISO 3650*)	0.5 mm	up to 150 mm	VDI/VDE/DGQ 2618 Sheet 3.1:2004 Measuring the deviation the mean l_c from the nominal dimension l_n by differential measurement Measuring deviations f_0 and f_u of the centre measurement by 5-point difference measurement	For the middle ground: $0.08\text{ }\mu\text{m} + 0.7 \cdot 10^{-6} \cdot l$	l is the length of the dimension
				For f_0 and f_u : 0.07 μm	For the smallest measuring- Uncertainties are the pushability and push characteristics of both measuring surfaces of the Calibration object to check using a suitable flat glass plate
Ceramic parallel end measures in accordance with DIN EN ISO 3650 *)	0.5 mm	up to 150 mm		For the average: $0.1\text{ }\mu\text{m} + 0.8 \cdot 10^{-6} \cdot l$	
				For f_0 and f_u : 0.07 μm	
Tungsten carbide parallel end measures in accordance with DIN EN ISO 3650 *)	0.5 mm	up to 150 mm		For the average: $0.1\text{ }\mu\text{m} + 0.8 \cdot 10^{-6} \cdot l$	
				For f_0 and f_u : 0.07 μm	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - Dimensional quantities

Calibration and measurement capabilities (CMC)					
Measurand / Calibration object	Measuring range / Measuremen t span		Test conditions / procedures	Expanded measurement uncertainty	Comments
Angle, deviation from a right angle Flatness and straightness deviations*)	up to 30 µm		VDI/VDE/DGQ/DKD 2618 Part 7.1:2019 (Opt. 2)	$2.5\text{ }\mu\text{m} + 1 \cdot 10^{-6} \cdot l_z$ $4\text{ }\mu\text{m} + 5 \cdot 10^{-6} \cdot l_z$	l_z : Length of the shape and position representation up to 500 mm side length
Protractor, scale division value 1° *) Scale division 5'*)	-180° up to 180°		VDI/VDE/DGQ 2618 Part 7.2:2008	30'	
	0° to 360°			1'	
Parallelism deviation of flat rulers*) Flatness deviation *)	up to 500 mm		VDI/VDE/DGQ 2618 Part 5.1:2022	$4\text{ }\mu\text{m} + 5 \cdot 10^{-6} \cdot l$	l is the measured
				$2.2\text{ }\mu\text{m} + 3.5 \cdot 10^{-6} \cdot l$	Length
Hair rulers Straightness deviation*)	up to 500 mm		VDI/VDE/DGQ 2618 Sheet 5.2:2013	$2.2\text{ }\mu\text{m} + 3.5 \cdot 10^{-6} \cdot l$	l is the measured
Tape measures and rulers			VDI/VDE/DGQ 2618 Part 8.2:2023	$50\text{ }\mu\text{m} + 20 \cdot 10^{-6} \cdot l$	length
Tape measures	0 m up to 100 m				
Benchmarks	0 m up to 3 m				
Inclinometers	-2000 µm/m (-412")	up to 2000 µm/m (412")	3-APD-0-0244-DE 2023-01	$1.7\text{ }\mu\text{m}/\text{m}$ (0.35")	Max. side length coordinate measuring machine: 500 mm
Displacement sensors	0 mm	to 1000 mm	3-APD-0-0025-DE 2023-10	$8\text{ }\mu\text{m} + 2 \cdot 10^{-5} \cdot l$	Displacement sensors, both contact and non-contact, and those mounted on the object being measured

Appendix to Accreditation Certificate D-K-15070-01-01

Kalibrierlabor Kirchzarten site, Gewerbestraße 3, 79199 Kirchzarten

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - Dimensional quantities

Calibration and measurement capabilities (CMC)				
Measurement parameter / Calibration object	Measuring range/ Measuring range	Test conditions / Procedures	Advanced Measurement uncertainty	Comments
Coordinate measuring technology Prismatic, conical and spherical workpieces	Coordinate measuring machine with a calibrated measuring volume of: X = 3000 mm Y = 1200 mm Z = 900 mm	3-APD-0-0292-EN: January 2023 Tactile measurement in the form of single-point probing with a coordinate measuring machine and determination of standard geometries, which are defined by geometric parameters (individual points, straight lines, planes, circles, spheres, cylinders, tori), using the evaluation software of the CMM. Single-point probing is carried out with a fixed, specified measuring force or by extrapolation to a measuring force of zero. Single-point probing as 'self-centring probing' is accreditation are not used. To ensure traceability, the calibration of a comparable standard is carried out. In addition to this the following restrictions apply to be noted: Measurement points must be able to be distributed evenly across formula elements ; Coverage of at least 50 per cent of the surface area of moulded components; Analysis of formula elements	The measurement uncertainty is determined by a measurement uncertainty balance based on the VDI/VDE Guideline 2617, Part 11:2011. It is task-specific and is specified a coverage probability of 95 per cent (expansion factor k = 2). An example of measurement uncertainty for a measurement task: Parallel end gauge with two nominal dimensions, the following was used a laterally projecting probe with a length of 150 mm, determined was the expanded measurement uncertainty of the test characteristic 'distance': L = 50 mm, U = 1.8 µm L = 3000 mm, U = 26 µm	The determined measurement uncertainty may differ from the example given uncertainty given as an example for simple measurement tasks.

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Direct current	0 V 10 mV 100 mV 1 V 10 V 100 V 1000 V 1 μ V to 100 mV > 100 mV to 100 V > 100 V up to 1000 V		0.1 μ V $12 \cdot 10^{-6} U$ $1.3 \cdot 10^{-6} U$ $0.35 \cdot 10^{-6} U$ $0.25 \cdot 10^{-6} U$ $0.4 \cdot 10^{-6} U$ $0.9 \cdot 10^{-6} U$ $1.4 \cdot 10^{-6} U + 0.15 \mu$ V $0.5 \cdot 10^{-6} U$ $1.4 \cdot 10^{-6} U$	U = measured value
High voltage	> 1 kV up to 50 kV		$0.4 \cdot 10^{-3} U$	
Direct current intensity	0 A up to 10 pA > 10 pA up to 100 pA > 100 pA to 1 nA > 1 nA up to 10 nA > 10 nA up to 100 nA > 100 nA to 1 μ A > 1 μ A up to 100 mA > 100 mA up to 20 A		$1.6 \cdot 10^{-3} I + 2$ fA $0.3 \cdot 10^{-3} I$ $0.2 \cdot 10^{-3} I$ $28 \cdot 10^{-6} I$ $10 \cdot 10^{-6} I$ $1.0 \cdot 10^{-6} I$ $0.8 \cdot 10^{-6} I$ $1.5 \cdot 10^{-6} I$ $9 \cdot 10^{-6} I$	I = measured value
Direct current amperage	1 mA up to 2.2 A		$1 \cdot 10^{-3} I$	
current clamps	> 2.2 A up to 20 A		$2 \cdot 10^{-3} I$	
	> 20 A up to 1000 A		$3 \cdot 10^{-3} I$	
Direct current Current transformer	1 A to 120 A		$0.22 \cdot 10^{-3} I$	
	> 120 A to 1,000 A		$0.25 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance (discrete values)	100 μ , 1 m, 10 m, 100m 1 10 100, 1 k, 10 k 100 k 1 M 10 M 100 M 1 G 10 G 100 g		1.2 $\cdot 10^{-6} R$ 0.5 $\cdot 10^{-6} R$ 80 $\cdot 10^{-9} R$ 0.12 $\cdot 10^{-6} R$ 0.1 $\cdot 10^{-6} R$ 50 $\cdot 10^{-9} R$ 0.1 $\cdot 10^{-6} R$ 0.25 $\cdot 10^{-6} R$ 0.75 $\cdot 10^{-6} R$ 2.5 $\cdot 10^{-6} R$ 8 $\cdot 10^{-6} R$ 28 $\cdot 10^{-6} R$ 64 $\cdot 10^{-6} R$	R = measured value
Direct current resistance (discrete values)	1 T 10 T 100 tonnes		0.12 $\cdot 10^{-3} R$ 0.32 $\cdot 10^{-3} R$ 0.87 $\cdot 10^{-3} R$	R = measured value
DC resistance ranges	0 μ to < 1 m 1 m to < 10 m 10 m to < 100 m 0.1 to < 1 1 to 100 k > 100 k to 1 M > 1 M to 10 M > 10 M to 100 M > 100 to 1 G > 1 G to 10 G > 10 G up to 100 G > 100 g up to 1 T > 1 T to 10 T > 10 T to 100 T		4 $\cdot 10^{-6} R + 1$ n 3 $\cdot 10^{-6} R + 1$ n 2 $\cdot 10^{-6} R + 1$ n 0.5 $\cdot 10^{-6} R$ 0.2 $\cdot 10^{-6} R$ 0.6 $\cdot 10^{-6} R$ 1.1 $\cdot 10^{-6} R$ 2.5 $\cdot 10^{-6} R$ 8 $\cdot 10^{-6} R$ 30 $\cdot 10^{-6} R$ 82 $\cdot 10^{-6} R$ 0.14 $\cdot 10^{-3} R$ 0.35 $\cdot 10^{-3} R$ 1.2 $\cdot 10^{-3} R$	R = measured value
Direct current power	1 mW up to 2 kW > 2 kW up to 1000 kW	Product of U and I ; 1 mV $\leq U \leq 1000$ V, 100 μ A $\leq I \leq 1000$ A	8 $\cdot 10^{-6}$ 15 $\cdot 10^{-6}$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC resistance Resistors (discrete values)	0.1	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$25 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $11 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$	R = measured value
	1	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$25 \cdot 10^{-6} R$ $11 \cdot 10^{-9} R$	
	10	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$25 \cdot 10^{-6} R$ $10 \cdot 10^{-6} R$	
	100	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$12 \cdot 10^{-6} R$ $8 \cdot 10^{-6} R$ $6 \cdot 10^{-6} R$	
	1 k	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$35 \cdot 10^{-6} R$	
AC resistance Resistors (discrete values)	10 k	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz;	$85 \cdot 10^{-6} R$ $45 \cdot 10^{-6} R$ $110 \cdot 10^{-6} R$ $65 \cdot 10^{-6} R$	
AC resistance (ranges)	0.1 Ω up to 1 Ω	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 10 kHz	$35 \cdot 10^{-6} \cdot R$ $30 \cdot 10^{-6} \cdot R$ $20 \cdot 10^{-6} \cdot R$	
	1 Ω up to < 10 Ω	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 10 kHz	$35 \cdot 10^{-6} \cdot R$ $30 \cdot 10^{-6} \cdot R$ $15 \cdot 10^{-6} \cdot R$	
	10 Ω up to < 100 Ω	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 10 kHz	$35 \cdot 10^{-6} \cdot R$ $30 \cdot 10^{-6} \cdot R$ $15 \cdot 10^{-6} \cdot R$	
	100 Ω up to < 1 k Ω	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 10 kHz	$40 \cdot 10^{-6} \cdot R$ $40 \cdot 10^{-6} \cdot R$ $35 \cdot 10^{-6} \cdot R$	
	1 k Ω up to 10 k Ω	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to < 400 Hz 400 Hz to 10 kHz	$90 \cdot 10^{-6} \cdot R$ $45 \cdot 10^{-6} \cdot R$ $110 \cdot 10^{-6} \cdot R$ $65 \cdot 10^{-6} \cdot R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Charge, charge amplifiers and charge measuring instruments	1 pC to 10,000 pC	0.2 Hz to < 1 Hz 1 Hz to 10 kHz > 10 kHz to 20 kHz > 20 kHz to 50 kHz	0.5 per cent 0.4 per cent 0.6 per cent 1.0 per cent	Calibration result: Value of the transfer coefficient
AC/DC transfer – AC power sources	1 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz 1 MHz	$0.23 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.17 \cdot 10^{-3} U$ $0.25 \cdot 10^{-3} U$ $0.27 \cdot 10^{-3} U$	U = measured value
	2 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz 1 MHz	$0.13 \cdot 10^{-3} U$ $0.08 \cdot 10^{-3} U$ $0.08 \cdot 10^{-3} U$ $0.08 \cdot 10^{-3} U$ $0.08 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.18 \cdot 10^{-3} U$	
	6 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$60 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $55 \cdot 10^{-6} U$ $73 \cdot 10^{-6} U$ $0.13 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	10 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$44 \cdot 10^{-6} U$ $37 \cdot 10^{-6} U$ $37 \cdot 10^{-6} U$ $37 \cdot 10^{-6} U$ $37 \cdot 10^{-6} U$ $50 \cdot 10^{-6} U$ $60 \cdot 10^{-6} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$	U = measured value

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	20 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$30 \cdot 10^{-6} U$ $26 \cdot 10^{-6} U$ $26 \cdot 10^{-6} U$ $26 \cdot 10^{-6} U$ $26 \cdot 10^{-6} U$ $38 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $98 \cdot 10^{-6} U$ $98 \cdot 10^{-6} U$	U = measured value
	40 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5kHz;10kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$24 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $31 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $90 \cdot 10^{-6} U$ $90 \cdot 10^{-6} U$	
	60 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$29 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $21 \cdot 10^{-6} U$ $20 \cdot 10^{-6} U$ $23 \cdot 10^{-6} U$ $27 \cdot 10^{-6} U$ $42 \cdot 10^{-6} U$ $86 \cdot 10^{-6} U$ $86 \cdot 10^{-6} U$	
	100 mV	10 Hz; 20Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$24 \cdot 10^{-6} U$ $18 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	200 mV	10 Hz; 20Hz;	$18 \cdot 10^{-6} U$	U = measured value
		30 Hz	$11 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$6 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$6 \cdot 10^{-6} U$	
		kHz; 2 kHz; 5 kHz; 10 kHz;	$6 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$6 \cdot 10^{-6} U$	
		70 kHz; 100 kHz;	$8 \cdot 10^{-6} U$	
		200 kHz; 300 kHz;	$8 \cdot 10^{-6} U$	
		500 kHz;	$17 \cdot 10^{-6} U$	
		700 kHz;	$22 \cdot 10^{-6} U$	
		800kHz	$27 \cdot 10^{-6} U$	
		1 MHz	$28 \cdot 10^{-6} U$	
	300 mV	10 Hz	$14 \cdot 10^{-6} U$	
		20 Hz	$11 \cdot 10^{-6} U$	
		30 Hz	$10 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$5 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$5 \cdot 10^{-6} U$	
		1 kHz; 2 kHz	$5 \cdot 10^{-6} U$	
		5 kHz; 10 kHz; 20 kHz;	$7 \cdot 10^{-6} U$	
		30 kHz; 50 kHz; 70 kHz	$7 \cdot 10^{-6} U$	
		100 kHz; 200 kHz; 300kHz;	$8 \cdot 10^{-6} U$	
		500 kHz; 700 kHz;	$18 \cdot 10^{-6} U$	
		800 kHz; 1 MHz	$18 \cdot 10^{-6} U$	
	400 mV	10 Hz; 20Hz;	$10 \cdot 10^{-6} U$	
		30 Hz	$7 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$5 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$5 \cdot 10^{-6} U$	
		kHz; 2 kHz; 5 kHz; 10 kHz;	$5 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$5 \cdot 10^{-6} U$	
		70kHz; 100 kHz;	$5 \cdot 10^{-6} U$	
		200 kHz; 300kHz;	$6 \cdot 10^{-6} U$	
		500 kHz	$15 \cdot 10^{-6} U$	
		700 kHz; 800 kHz; 1 MHz	$17 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	500 mV	10 Hz	$15 \cdot 10^{-6} U$	U = measured value
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$6 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400Hz;500Hz;	$4 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz;	$6 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30	$6 \cdot 10^{-6} U$	
		kHz, 50kHz; 70 kHz;	$6 \cdot 10^{-6} U$	
		100 kHz; 200 kHz;	$6 \cdot 10^{-6} U$	
		300kHz; 500 kHz;	$15 \cdot 10^{-6} U$	
		700 kHz;	$15 \cdot 10^{-6} U$	
	600 mV	10 Hz	$14 \cdot 10^{-6} U$	
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$7 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$4 \cdot 10^{-6} U$	
		1kHz; 2 kHz; 5 kHz	$4 \cdot 10^{-6} U$	
		10 kHz; 20 kHz;	$6 \cdot 10^{-6} U$	
		30 kHz; 50 kHz;	$4 \cdot 10^{-6} U$	
		70 kHz; 100 kHz;	$4 \cdot 10^{-6} U$	
		200 kHz; 300 kHz	$5 \cdot 10^{-6} U$	
		500 kHz; 700 kHz;	$6 \cdot 10^{-6} U$	
		800 kHz; 1 MHz	$15 \cdot 10^{-6} U$	
	700 mV	10 Hz	$15 \cdot 10^{-6} U$	
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$6 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400 Hz;	$4 \cdot 10^{-6} U$	
		500 Hz; 1kHz	$4 \cdot 10^{-6} U$	
		2 kHz; 5 kHz; 10 kHz;	$5 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$5 \cdot 10^{-6} U$	
		70 kHz; 100 kHz;	$5 \cdot 10^{-6} U$	
		200kHz; 300 kHz; 500	$6 \cdot 10^{-6} U$	
		kHz; 700 kHz;	$15 \cdot 10^{-6} U$	
		800 kHz; 1 MHz	$15 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	1 V	10 Hz	$9 \cdot 10^{-6} U$	U = measured value
		20 Hz	$8 \cdot 10^{-6} U$	
		30 Hz	$7 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz;	$4 \cdot 10^{-6} U$	
		120 Hz; 300 Hz	$4 \cdot 10^{-6} U$	
		400 Hz; 500 Hz;	$2 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz	$3 \cdot 10^{-6} U$	
		10 kHz; 20 kHz;	$4 \cdot 10^{-6} U$	
		30 kHz; 50 kHz;	$4 \cdot 10^{-6} U$	
		70 kHz; 100 kHz;	$5 \cdot 10^{-6} U$	
		200 kHz; 300kHz;	$7 \cdot 10^{-6} U$	
		500 kHz	$11 \cdot 10^{-6} U$	
		700 kHz; 800 kHz; 1 MHz	$14 \cdot 10^{-6} U$	
	2 V	10 Hz; 20 Hz; 30 Hz	$8 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$5 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$2 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$2 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz	$2 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$5 \cdot 10^{-6} U$	
		1 MHz	$6 \cdot 10^{-6} U$	
			$11 \cdot 10^{-6} U$	
			$14 \cdot 10^{-6} U$	
			$16 \cdot 10^{-6} U$	
	3 V; 4 V; 5 V; 6 V; 7 V; 8 V	10 Hz	$10 \cdot 10^{-6} U$	
		20 Hz	$8 \cdot 10^{-6} U$	
		30 Hz	$5 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$3 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$3 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$3 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$3 \cdot 10^{-6} U$	
		70kHz; 100 kHz	$4 \cdot 10^{-6} U$	
		200 kHz; 300kHz;	$5 \cdot 10^{-6} U$	
		500 kHz	$8 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$9 \cdot 10^{-6} U$	
		1 MHz	$12 \cdot 10^{-6} U$	
			$15 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement quantity / Calibration object	Measuring range / measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	10 V	10 Hz 20 Hz 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$10 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$	U = measured value
	20 V	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$8 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	
	30 V; 40 V; 50 V; 60 V; 70 V	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$	
	100 V	10 Hz 20 Hz 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$10 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC power sources	200 V	10 Hz; 20 Hz 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$10 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = measured value
	300 V; 400 V; 500 V; 600 V; 700 V; 800 V; 1000 V	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$	
AC/DC transfer – AC voltage meters	1 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz 1 MHz	$0.30 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.26 \cdot 10^{-3} U$ $0.26 \cdot 10^{-3} U$ $0.26 \cdot 10^{-3} U$ $0.32 \cdot 10^{-3} U$ $0.33 \cdot 10^{-3} U$	
	2 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$0.16 \cdot 10^{-3} U$ $0.13 \cdot 10^{-3} U$ $0.13 \cdot 10^{-3} U$ $0.13 \cdot 10^{-3} U$ $0.13 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.20 \cdot 10^{-3} U$ $0.20 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured variable / Calibration item	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	6 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$67 \cdot 10^{-6} U$ $57 \cdot 10^{-6} U$ $57 \cdot 10^{-6} U$ $57 \cdot 10^{-6} U$ $57 \cdot 10^{-6} U$ $65 \cdot 10^{-6} U$ $80 \cdot 10^{-6} U$ $0.14 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$	U = measured value
	10 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$50 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $55 \cdot 10^{-6} U$ $65 \cdot 10^{-6} U$ $0.15 \cdot 10^{-3} U$ $0.15 \cdot 10^{-3} U$	
	20 mV	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz; 1 MHz	$32 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $40 \cdot 10^{-6} U$ $50 \cdot 10^{-6} U$ $0.1 \cdot 10^{-3} U$ $0.1 \cdot 10^{-3} U$	
	40 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$30 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $43 \cdot 10^{-6} U$ $86 \cdot 10^{-6} U$ $86 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	60 mV	10 Hz; 20 Hz; 30 Hz	$30 \cdot 10^{-6} U$	U = measured value
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$25 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$25 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$25 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$25 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200 kHz;	$28 \cdot 10^{-6} U$	
		300 kHz	$43 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz;	$86 \cdot 10^{-6} U$	
		1 MHz	$86 \cdot 10^{-6} U$	
	100 mV	10 Hz; 20 Hz; 30 Hz	$24 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$18 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$8 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$8 \cdot 10^{-6} U$	
		20 kHz; 300 kHz; 50 kHz;	$8 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200 kHz;	$8 \cdot 10^{-6} U$	
		300kHz	$9 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz;	$10 \cdot 10^{-6} U$	
		1 MHz	$30 \cdot 10^{-6} U$	
	200 mV	10 Hz; 20Hz; 30 Hz	$18 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz,	$11 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$6 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$6 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz	$6 \cdot 10^{-6} U$	
		70 kHz; 100 kHz; 200 kHz;	$6 \cdot 10^{-6} U$	
		300 kHz; 500 kHz; 700kHz	$8 \cdot 10^{-6} U$	
		800 kHz; 1 MHz	$8 \cdot 10^{-6} U$	
			$17 \cdot 10^{-6} U$	
			$22 \cdot 10^{-6} U$	
			$28 \cdot 10^{-6} U$	
			$28 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	300 mV	10 Hz; 20Hz; 30 Hz 40 Hz, 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz, 2 kHz; 5 kHz; 10 kHz; 20 kHz 30 kHz; 50 kHz 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$14 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$ $18 \cdot 10^{-6} U$	U = measured value
	400 mV	10 Hz; 20 Hz; 30 Hz 40 Hz, 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz 1 kHz, 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500kHz 700 kHz; 800 kHz; 1 MHz	$10 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $17 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	500 mV	10 Hz	$15 \cdot 10^{-6} U$	U = measured value
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$6 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400 Hz	$4 \cdot 10^{-6} U$	
		500 Hz; 1 kHz; 2 kHz; 5 kHz;	$6 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$6 \cdot 10^{-6} U$	
		50 kHz; 70 kHz; 100 kHz;	$6 \cdot 10^{-6} U$	
		200 kHz; 300 kHz	$6 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz;	$15 \cdot 10^{-6} U$	
		1 MHz	$15 \cdot 10^{-6} U$	
	600 mV	10 Hz	$14 \cdot 10^{-6} U$	
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$7 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$4 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz	$4 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$6 \cdot 10^{-6} U$	
		50 kHz	$4 \cdot 10^{-6} U$	
		70 kHz; 100 kHz;	$4 \cdot 10^{-6} U$	
		200 kHz; 300 kHz	$5 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz;	$6 \cdot 10^{-6} U$	
		1 MHz	$15 \cdot 10^{-6} U$	
	700 mV	10 Hz	$15 \cdot 10^{-6} U$	
		20 Hz	$9 \cdot 10^{-6} U$	
		30 Hz	$6 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$4 \cdot 10^{-6} U$	
		1 kHz	$4 \cdot 10^{-6} U$	
		2 kHz; 5 kHz; 10 kHz; 20 kHz;	$5 \cdot 10^{-6} U$	
		30 kHz; 50 kHz; 70 kHz;	$5 \cdot 10^{-6} U$	
		100 kHz	$5 \cdot 10^{-6} U$	
		200 kHz; 300 kHz	$6 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz;	$15 \cdot 10^{-6} U$	
		1 MHz	$15 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters
Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	1 V	10 Hz	$9 \cdot 10^{-6} U$	U = measured value
		20 Hz	$8 \cdot 10^{-6} U$	
		30 Hz	$7 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$4 \cdot 10^{-6} U$	
		300 Hz	$4 \cdot 10^{-6} U$	
		400 Hz; 500 Hz; 1 kHz;	$2 \cdot 10^{-6} U$	
		2 kHz; 5 kHz	$3 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$4 \cdot 10^{-6} U$	
		50 kHz	$4 \cdot 10^{-6} U$	
		70 kHz; 100 kHz,	$5 \cdot 10^{-6} U$	
		200 kHz; 300 kHz,	$7 \cdot 10^{-6} U$	
		500 kHz	$11 \cdot 10^{-6} U$	
		700 kHz; 800 kHz; 1 MHz	$14 \cdot 10^{-6} U$	
	2 V	10 Hz; 20 Hz; 30 Hz	$8 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$5 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$2 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$2 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$2 \cdot 10^{-6} U$	
		70 kHz; 100 kHz; 200 kHz;	$2 \cdot 10^{-6} U$	
		300 kHz; 500 kHz	$5 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$6 \cdot 10^{-6} U$	
		1 MHz	$11 \cdot 10^{-6} U$	
			$14 \cdot 10^{-6} U$	
	3 V; 4 V; 5 V; 6 V; 7 V; 8 V	10 Hz	$16 \cdot 10^{-6} U$	
		20 Hz	$10 \cdot 10^{-6} U$	
		30 Hz	$8 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$5 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$3 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$3 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$3 \cdot 10^{-6} U$	
		70 kHz; 100 kHz	$3 \cdot 10^{-6} U$	
		200 kHz; 300 kHz;	$4 \cdot 10^{-6} U$	
		500 kHz	$5 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$8 \cdot 10^{-6} U$	
		1 MHz	$9 \cdot 10^{-6} U$	
			$12 \cdot 10^{-6} U$	
			$15 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC Transfer – AC voltage meters	10 V	10 Hz 20 Hz 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz, 1 MHz	$10 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $4 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$	U = measured value
	20 V	10 Hz, 20 Hz, 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$8 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $3 \cdot 10^{-6} U$ $5 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $10 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	
	30 V; 40 V; 50 V; 60 V; 70 V	10 Hz, 20 Hz, 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$	
	100 V	10 Hz 20 Hz 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$10 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $6 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC/DC transfer – AC voltage meters	200 V	10 Hz; 20 Hz 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50kHz 70 kHz; 100 kHz	$10 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = measured value
	300 V; 400 V; 500 V; 600 V; 700 V; 800 V; 1000 V	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz 30 kHz; 50 kHz 70 kHz; 100 kHz	$9 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $7 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$	
AC voltage measuring instruments and sources	1 mV	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5kHz; 10 kHz; 20 kHz; 30 kHz; 50kHz; 70 kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz 1 MHz	$0.42 \cdot 10^{-3} U$ $0.36 \cdot 10^{-3} U$ $0.36 \cdot 10^{-3} U$ $0.36 \cdot 10^{-3} U$ $0.36 \cdot 10^{-3} U$ $0.36 \cdot 10^{-3} U$ $0.43 \cdot 10^{-3} U$ $0.48 \cdot 10^{-3} U$ $0.53 \cdot 10^{-3} U$	
	2 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz 500 kHz; 700 kHz; 800 kHz 1 MHz	$0.18 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.18 \cdot 10^{-3} U$ $0.18 \cdot 10^{-3} U$ $0.21 \cdot 10^{-3} U$ $0.24 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	6 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$70 \cdot 10^{-6} U$ $60 \cdot 10^{-6} U$ $60 \cdot 10^{-6} U$ $60 \cdot 10^{-6} U$ $60 \cdot 10^{-6} U$ $70 \cdot 10^{-6} U$ $85 \cdot 10^{-6} U$ $0.17 \cdot 10^{-3} U$ $0.17 \cdot 10^{-3} U$	U = measured value
	10 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$53 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $57 \cdot 10^{-6} U$ $70 \cdot 10^{-6} U$ $0.14 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$	
	20 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$37 \cdot 10^{-6} U$ $35 \cdot 10^{-6} U$ $35 \cdot 10^{-6} U$ $35 \cdot 10^{-6} U$ $35 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $56 \cdot 10^{-6} U$ $0.11 \cdot 10^{-3} U$ $0.11 \cdot 10^{-3} U$	
	40 mV	10 Hz; 20 Hz; 30 Hz 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz; 700 kHz; 800 kHz; 1 MHz	$33 \cdot 10^{-6} U$ $31 \cdot 10^{-6} U$ $31 \cdot 10^{-6} U$ $31 \cdot 10^{-6} U$ $31 \cdot 10^{-6} U$ $40 \cdot 10^{-6} U$ $56 \cdot 10^{-6} U$ $95 \cdot 10^{-6} U$ $95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	60 mV	10 Hz; 20 Hz; 30 Hz	$31 \cdot 10^{-6} U$	U = measured value
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$25 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$25 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$25 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$25 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200 kHz;	$29 \cdot 10^{-6} U$	
		300 kHz	$43 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz	$87 \cdot 10^{-6} U$	
		1 MHz	$98 \cdot 10^{-6} U$	
	100 mV	10 Hz; 20 Hz; 30 Hz	$26 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz;	$20 \cdot 10^{-6} U$	
		120Hz; 300 Hz; 400 Hz;	$12 \cdot 10^{-6} U$	
		500 Hz;	$12 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10kHz;	$12 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$12 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200kHz;	$13 \cdot 10^{-6} U$	
		300 kHz	$14 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz	$33 \cdot 10^{-6} U$	
			$53 \cdot 10^{-6} U$	
	200 mV	10 Hz; 20Hz;	$21 \cdot 10^{-6} U$	
		30 Hz	$15 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$12 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$12 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$12 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$12 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200 kHz;	$12 \cdot 10^{-6} U$	
		300 kHz; 500 kHz; 700 kHz	$13 \cdot 10^{-6} U$	
		800 kHz; 1 MHz	$13 \cdot 10^{-6} U$	
			$25 \cdot 10^{-6} U$	
			$35 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement services (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	300 mV	10 Hz; 20 Hz; 30 Hz	$17 \cdot 10^{-6} U$	U = measured value
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$12 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$12 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz;	$12 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$12 \cdot 10^{-6} U$	
		50 kHz; 70 kHz	$12 \cdot 10^{-6} U$	
		100 kHz; 200 kHz; 300 kHz;	$13 \cdot 10^{-6} U$	
		500 kHz	$17 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$21 \cdot 10^{-6} U$	
		1 MHz	$28 \cdot 10^{-6} U$	
	500 mV; 600 mV; 700 mV	10 Hz	$18 \cdot 10^{-6} U$	
		20 Hz; 30 Hz	$13 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$10 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$10 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$10 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$10 \cdot 10^{-6} U$	
		70 kHz; 100 kHz; 200 kHz;	$11 \cdot 10^{-6} U$	
		300 kHz	$11 \cdot 10^{-6} U$	
		500 kHz; 700 kHz; 800 kHz	$21 \cdot 10^{-6} U$	
		1 MHz	U	
	1 V	10 Hz; 20 Hz; 30 Hz	$13 \cdot 10^{-6} U$	
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$11 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$10 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$10 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$10 \cdot 10^{-6} U$	
		70 kHz; 100 kHz; 200 kHz;	$10 \cdot 10^{-6} U$	
		300 kHz; 500 kHz	$11 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$15 \cdot 10^{-6} U$	
		1 MHz	$25 \cdot 10^{-6} U$	
			$60 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current Measuring instruments and Sources	2 V	10 Hz; 20 Hz; 30 Hz	$12 \cdot 10^{-6} U$	U = measured value
		40 Hz; 55 Hz; 60 Hz; 120 Hz;	$10 \cdot 10^{-6} U$	
		300 Hz; 400 Hz; 500 Hz;	$9 \cdot 10^{-6} U$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$9 \cdot 10^{-6} U$	
		20 kHz; 30 kHz; 50 kHz;	$9 \cdot 10^{-6} U$	
		70kHz; 100 kHz; 200 kHz;	$10 \cdot 10^{-6} U$	
		300 kHz; 500 kHz	$10 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$15 \cdot 10^{-6} U$	
		1 MHz	$25 \cdot 10^{-6} U$	
	3 V; 4 V; 5 V	10 Hz; 20 Hz	$15 \cdot 10^{-6} U$	
		30 Hz; 40 Hz; 55 Hz; 60 Hz;	$11 \cdot 10^{-6} U$	
		120 Hz; 300 Hz; 400 Hz;	$11 \cdot 10^{-6} U$	
		500 Hz; 1 kHz; 2 kHz; 5kHz;	$11 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$11 \cdot 10^{-6} U$	
		50kHz; 70 kHz	$11 \cdot 10^{-6} U$	
		100 kHz; 200 kHz; 300kHz;	$11 \cdot 10^{-6} U$	
		500 kHz	$15 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$25 \cdot 10^{-6} U$	
	6 V; 7 V; 8 V	10 Hz; 20 Hz	$15 \cdot 10^{-6} U$	
		30 Hz; 40 Hz; 55 Hz; 60 Hz;	$11 \cdot 10^{-6} U$	
		120 Hz; 300 Hz; 400 Hz;	$11 \cdot 10^{-6} U$	
		500Hz; 1 kHz; 2 kHz; 5 kHz;	$11 \cdot 10^{-6} U$	
		10 kHz; 20 kHz; 30 kHz;	$11 \cdot 10^{-6} U$	
		50kHz; 70 kHz	$11 \cdot 10^{-6} U$	
		100 kHz; 200 kHz; 300kHz;	$13 \cdot 10^{-6} U$	
		500 kHz	$30 \cdot 10^{-6} U$	
		700 kHz; 800 kHz	$60 \cdot 10^{-6} U$	
		1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating voltage Measuring instruments and Sources	10 V; 20 V	10 Hz; 20 Hz 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz; 100 kHz; 200 kHz; 300 kHz; 500 kHz 700 kHz; 800 kHz; 1 MHz	$13 \cdot 10^{-6} U$ $11 \cdot 10^{-6} U$ $11 \cdot 10^{-6} U$ $11 \cdot 10^{-6} U$ $11 \cdot 10^{-6} U$ $11 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $0.11 \cdot 10^{-3} U$	U = measured value
	30 V; 40 V; 50 V; 60 V; 70 V	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz 70 kHz; 100 kHz	$15 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$ $15 \cdot 10^{-6} U$ $20 \cdot 10^{-6} U$	
	100 V; 200 V	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50kHz; 70 kHz 100 kHz	$17 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $17 \cdot 10^{-6} U$ $17 \cdot 10^{-6} U$ $17 \cdot 10^{-6} U$ $32 \cdot 10^{-6} U$	
	300 V	10 Hz; 20 Hz; 30 Hz; 40Hz;55Hz;60Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz; 1 kHz 2 kHz; 5 kHz; 10 kHz; 20kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$17 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $14 \cdot 10^{-6} U$ $20 \cdot 10^{-6} U$ $32 \cdot 10^{-6} U$ $44 \cdot 10^{-6} U$ $66 \cdot 10^{-6} U$	
	500 V; 1,000 V	10 Hz; 20 Hz 30 Hz; 40 Hz; 55 Hz; 60 Hz; 120 Hz; 300 Hz; 400 Hz; 500 Hz 1 kHz; 2 kHz; 5 kHz; 10kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz 100 kHz	$24 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $25 \cdot 10^{-6} U$ $30 \cdot 10^{-6} U$ $47 \cdot 10^{-6} U$ $55 \cdot 10^{-6} U$ $66 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters
Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.52 \cdot 10^{-3} U$	U = measured value
		>20 Hz to 40 Hz	$0.52 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.40 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.40 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.41 \cdot 10^{-3} U$	
		>100 kHz to 300 kHz	$0.46 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.55 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.60 \cdot 10^{-3} U$	
	> 2.2 mV to 7 mV	10 Hz to 20 Hz	$0.22 \cdot 10^{-3} U$	
		>20 Hz to 40 Hz	$0.22 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.16 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.16 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.20 \cdot 10^{-3} U$	
		>100 kHz to 300 kHz	$0.22 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.33 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.45 \cdot 10^{-3} U$	
	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	
		>20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		>100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		>20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		>100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities
Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	
	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	U = measured value
		>20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		>100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		>20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		>100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		>20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	
	> 220 V to 1,000 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		>20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments	0.01 V up to 0.1 V	10 Hz up to 40Hz > 40 Hz to 20 kHz > 20 kHz up to 50kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz up to 1 MHz	$0.69 \cdot 10^{-3} U$ $0.53 \cdot 10^{-3} U$ $0.64 \cdot 10^{-3} U$ $1.1 \cdot 10^{-3} U$ $2.1 \cdot 10^{-3} U$ $3.6 \cdot 10^{-3} U$ $5.0 \cdot 10^{-3} U$	U = measured value
	> 0.1 V up to 0.22 V	10 Hz up to 40Hz > 40 Hz to 20 kHz > 20 kHz up to 50kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz up to 1 MHz	$0.38 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.28 \cdot 10^{-3} U$ $0.65 \cdot 10^{-3} U$ $1.1 \cdot 10^{-3} U$ $1.6 \cdot 10^{-3} U$ $3.3 \cdot 10^{-3} U$	
	> 0.22 V up to 2.2 V	10 Hz up to 40Hz > 40 Hz to 20 kHz > 20 kHz up to 50kHz > 50 kHz to 100 kHz > 100 kHz up to 300kHz > 300 kHz up to 500kHz > 500 kHz up to 1 MHz	$0.49 \cdot 10^{-3} U$ $0.09 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.29 \cdot 10^{-3} U$ $0.85 \cdot 10^{-3} U$ $2.1 \cdot 10^{-3} U$ $3.3 \cdot 10^{-3} U$	
	> 2.2 V up to 22 V	10 Hz up to 40Hz > 40 Hz to 20 kHz > 20 kHz up to 50kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz up to 1 MHz	$0.45 \cdot 10^{-3} U$ $0.07 \cdot 10^{-3} U$ $0.13 \cdot 10^{-3} U$ $0.21 \cdot 10^{-3} U$ $0.6 \cdot 10^{-3} U$ $2.0 \cdot 10^{-3} U$ $3.1 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments	> 22 V to 220 V	10 Hz to 40 Hz >40 Hz up to 20kHz > 20 kHz up to 50 kHz > 50 kHz to 100 kHz	$0.47 \cdot 10^{-3} U$ $0.09 \cdot 10^{-3} U$ $0.14 \cdot 10^{-3} U$ $0.29 \cdot 10^{-3} U$	U = Reading taken with a Fluke 5720A (ranges)
	> 220 V up to 1000 V	50 Hz up to 1 kHz	$85 \cdot 10^{-6} U$	
Alternating current with an input impedance of 50 Ω	3.2 V	10 Hz; 40 Hz; 100 Hz; 500Hz; 1 kHz; 10 kHz; 50 kHz 100 kHz; 200 kHz; 500kHz; 1 MHz; 2 MHz; 4 MHz	$0.5 \cdot 10^{-3}$	at discrete points
		5 MHz; 8 MHz	$1.1 \cdot 10^{-3}$	
		10 MHz; 15 MHz; 20 MHz	$2.0 \cdot 10^{-3}$	
		26 MHz; 30 MHz; 50 MHz	$3.2 \cdot 10^{-3}$	
	1 V; 320 mV	10 Hz; 40 Hz; 100 Hz; 500Hz; 1 kHz; 10 kHz; 50 kHz 100 kHz; 200 kHz; 500kHz; 1 MHz; 2 MHz; 4 MHz	$0.7 \cdot 10^{-3}$	
		5 MHz; 8 MHz	$1.8 \cdot 10^{-3}$	
		10 MHz; 15 MHz; 20 MHz	$3.5 \cdot 10^{-3}$	
		26 MHz; 30 MHz; 50 MHz	$5.4 \cdot 10^{-3}$	
	100 mV; 32mV; 10 mV; 3.2 mV; 1 mV	10 Hz; 40 Hz; 100 Hz; 500Hz; 1 kHz; 10 kHz; 50 kHz 100 kHz; 200 kHz; 500kHz; 1 MHz; 2 MHz; 4 MHz	$1.3 \cdot 10^{-3}$	
		5 MHz; 8 MHz	$2.7 \cdot 10^{-3}$	
		10 MHz; 15 MHz; 20 MHz	$5.2 \cdot 10^{-3}$	
		26 MHz; 30 MHz; 50 MHz	$7.9 \cdot 10^{-3}$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating Current – Direct Current – Transfer	100 μ A	10 Hz	$82 \cdot 10^{-6} /$	/ = measured value
		20 Hz	$39 \cdot 10^{-6} /$	
		30 Hz	$31 \cdot 10^{-6} /$	
		40 Hz	$34 \cdot 10^{-6} /$	
		55 Hz	$0.11 \cdot 10^{-3} /$	
		400 Hz	$63 \cdot 10^{-6} /$	
		500 Hz; 1 kHz,	$41 \cdot 10^{-6} /$	
		2 kHz	$39 \cdot 10^{-6} /$	
		5 kHz; 10 kHz	$31 \cdot 10^{-6} /$	
	300 μ A	10 Hz	$37 \cdot 10^{-6} /$	
		20 Hz	$34 \cdot 10^{-6} /$	
		30 Hz; 40 Hz;	$31 \cdot 10^{-6} /$	
		55 Hz;	$41 \cdot 10^{-6} /$	
		400 Hz	$35 \cdot 10^{-6} /$	
		500 Hz; 1 kHz	$31 \cdot 10^{-6} /$	
		2 kHz; 5 kHz; 10 kHz	$32 \cdot 10^{-6} /$	
	1 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$31 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz;	$31 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz	$31 \cdot 10^{-6} /$	
	3 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$7 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz;	$7 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz	$7 \cdot 10^{-6} /$	
		10 kHz	$8 \cdot 10^{-6} /$	
	5 mA	10 Hz; 20 Hz;	$7 \cdot 10^{-6} /$	
		30 Hz	$6 \cdot 10^{-6} /$	
		40 Hz; 55 Hz	$5 \cdot 10^{-6} /$	
		400 Hz; 500 Hz; 1 kHz; 2 kHz;	$4 \cdot 10^{-6} /$	
		5 kHz	$6 \cdot 10^{-6} /$	
		10 kHz	$8 \cdot 10^{-6} /$	
	10 mA	10 Hz	$6 \cdot 10^{-6} /$	
		20 Hz; 30 Hz	$5 \cdot 10^{-6} /$	
		40 Hz; 55 Hz; 400 Hz;	$4 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz; 5 kHz;	$4 \cdot 10^{-6} /$	
		10 kHz	$4 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Measurements

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage— Direct current intensity— Transfer	20 mA; 30 mA; 50 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz 5 kHz; 10 kHz	$8 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $4 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$	I = measured value
	100 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz 500 Hz; 1 kHz, 2 kHz 5 kHz; 10 kHz	$8 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$	
	200 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz 2 kHz; 5 kHz; 10 kHz	$7 \cdot 10^{-6} /$ $6 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$	
	300 mA; 500 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz 400 Hz; 500 Hz; 1 kHz; 2 kHz 5 kHz; 10 kHz	$6 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $4 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$	
	1 A	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$7 \cdot 10^{-6} /$ $6 \cdot 10^{-6} /$ $7 \cdot 10^{-6} /$ $5 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$	
	2 A	10 Hz 20 Hz; 30 Hz 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$7 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $7 \cdot 10^{-6} /$ $7 \cdot 10^{-6} /$ $7 \cdot 10^{-6} /$	
	3 A; 5 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$14 \cdot 10^{-6} /$ $14 \cdot 10^{-6} /$ $14 \cdot 10^{-6} /$	
	10 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$21 \cdot 10^{-6} /$ $21 \cdot 10^{-6} /$ $21 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage— Direct current intensity— Transfer	20 A	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$26 \cdot 10^{-6} /$	/ = measured value
		55 Hz; 400 Hz; 500 Hz;	$26 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz;	$26 \cdot 10^{-6} /$	
		10 kHz	$30 \cdot 10^{-6} /$	
	50 A	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$32 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz;	$32 \cdot 10^{-6} /$	
		1 kHz; 2 kHz;	$32 \cdot 10^{-6} /$	
		5 kHz; 10 kHz	$40 \cdot 10^{-6} /$	
	100 A	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$47 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz;	$47 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz;	$47 \cdot 10^{-6} /$	
		10 kHz	$92 \cdot 10^{-6} /$	
Sources of alternating current	100 μ A	10 Hz	$83 \cdot 10^{-6} /$	
		20 Hz	$40 \cdot 10^{-6} /$	
		30 Hz; 40 Hz;	$34 \cdot 10^{-6} /$	
		55 Hz;	$0.11 \cdot 10^{-3} /$	
		400 Hz	$64 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz	$42 \cdot 10^{-6} /$	
		5 kHz; 10 kHz; 20 kHz; 30 kHz;	$33 \cdot 10^{-6} /$	
		50 kHz	$47 \cdot 10^{-6} /$	
		70 kHz; 100 kHz	$77 \cdot 10^{-6} /$	
	300 μ A	10 Hz	$38 \cdot 10^{-6} /$	
		20 Hz	$34 \cdot 10^{-6} /$	
		30 Hz; 40 Hz;	$32 \cdot 10^{-6} /$	
		55 Hz;	$42 \cdot 10^{-6} /$	
		400 Hz	$36 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz;	$33 \cdot 10^{-6} /$	
		5 kHz; 10 kHz; 20 kHz;	$33 \cdot 10^{-6} /$	
		30 kHz; 50 kHz; 70 kHz	$33 \cdot 10^{-6} /$	
		100 kHz	$52 \cdot 10^{-6} /$	
			$0.11 \cdot 10^{-3} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Sources of alternating current	1 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$32 \cdot 10^{-6} /$ $32 \cdot 10^{-6} /$ $32 \cdot 10^{-6} /$ $32 \cdot 10^{-6} /$ $34 \cdot 10^{-6} /$	/ = measured value
	3 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz 20 kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$9 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$ $10 \cdot 10^{-6} /$ $12 \cdot 10^{-6} /$ $15 \cdot 10^{-6} /$	
	5 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz 20 kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$9 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $10 \cdot 10^{-6} /$ $12 \cdot 10^{-6} /$ $15 \cdot 10^{-6} /$	
	10 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$9 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $7 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $10 \cdot 10^{-6} /$ $12 \cdot 10^{-6} /$	
	20 mA; 30 mA; 50 mA; 100 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz 1 kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz 100 kHz	$10 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $10 \cdot 10^{-6} /$ $13 \cdot 10^{-6} /$	
	200 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70 kHz; 100 kHz	$9 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $10 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$ $13 \cdot 10^{-6} /$ $13 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Sources of alternating current	300 mA	10 Hz; 20 Hz	$9 \cdot 10^{-6} /$	/ = measured value
		30 Hz; 40 Hz; 55 Hz; 400 Hz;	$8 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz; 5 kHz;	$8 \cdot 10^{-6} /$	
		10 kHz; 20 kHz; 30 kHz;	$8 \cdot 10^{-6} /$	
		50kHz	$9 \cdot 10^{-6} /$	
		70 kHz; 100 kHz	$14 \cdot 10^{-6} /$	
	500 mA	10 Hz; 20 Hz; 30 Hz	$9 \cdot 10^{-6} /$	
		40 Hz; 55 Hz; 400 Hz; 500 Hz;	$8 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$8 \cdot 10^{-6} /$	
		20 kHz; 30 kHz; 50 kHz;	$8 \cdot 10^{-6} /$	
		70kHz	$9 \cdot 10^{-6} /$	
		100 kHz	$11 \cdot 10^{-6} /$	
	1 A	10 Hz; 20 Hz; 30 Hz;	$9 \cdot 10^{-6} /$	
		40 Hz; 55 Hz;	$9 \cdot 10^{-6} /$	
		400Hz; 500 Hz	$8 \cdot 10^{-6} /$	
		1kHz; 2 kHz; 5 kHz;	$11 \cdot 10^{-6} /$	
		10kHz; 20 kHz; 30kHz; 50kHz; 70kHz	$11 \cdot 10^{-6} /$	
		100 kHz	$13 \cdot 10^{-6} /$	
	2 A	10 Hz; 20 Hz; 30 Hz	$10 \cdot 10^{-6} /$	
		40 Hz; 55 Hz; 400 Hz; 500Hz;	$8 \cdot 10^{-6} /$	
		1 kHz; 2 kHz; 5 kHz; 10 kHz;	$9 \cdot 10^{-6} /$	
		20 kHz; 30 kHz; 50 kHz;	$13 \cdot 10^{-6} /$	
		70kHz	$18 \cdot 10^{-6} /$	
		100 kHz	$23 \cdot 10^{-6} /$	
	3 A	10 Hz; 20 Hz; 30 Hz;	$18 \cdot 10^{-6} /$	
		40 Hz; 55 Hz; 400 Hz;	$17 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz; 5 kHz;	$17 \cdot 10^{-6} /$	
		10 kHz; 20 kHz; 30 kHz;	$17 \cdot 10^{-6} /$	
		50kHz; 70 kHz	$18 \cdot 10^{-6} /$	
		100 kHz	$27 \cdot 10^{-6} /$	
			$29 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01
Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Sources of alternating current	5 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz 100 kHz	16 · 10 ⁻⁶ / 16 · 10 ⁻⁶ / 16 · 10 ⁻⁶ / 16 · 10 ⁻⁶ / 18 · 10 ⁻⁶ / 27 · 10 ⁻⁶ / 29 · 10 ⁻⁶ /	/ = measured value
	10 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1kHz; 2 kHz; 5 kHz; 10 kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz 100 kHz	22 · 10 ⁻⁶ / 22 · 10 ⁻⁶ / 22 · 10 ⁻⁶ / 22 · 10 ⁻⁶ / 31 · 10 ⁻⁶ / 41 · 10 ⁻⁶ / 51 · 10 ⁻⁶ / 76 · 10 ⁻⁶ /	
	20 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10kHz; 20 kHz; 30 kHz; 50 kHz; 70kHz 100 kHz	27 · 10 ⁻⁶ / 27 · 10 ⁻⁶ / 27 · 10 ⁻⁶ / 31 · 10 ⁻⁶ / 46 · 10 ⁻⁶ / 0.13 · 10 ⁻³ / 0.17 · 10 ⁻³ /	
	50 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1kHz; 2 kHz; 5 kHz; 10 kHz	33 · 10 ⁻⁶ / 33 · 10 ⁻⁶ / 33 · 10 ⁻⁶ / 40 · 10 ⁻⁶ /	
	100 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1kHz; 2 kHz; 5 kHz; 10 kHz	48 · 10 ⁻⁶ / 48 · 10 ⁻⁶ / 48 · 10 ⁻⁶ / 93 · 10 ⁻⁶ /	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical Parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current ammeters	100 μ A	10 Hz	$83 \cdot 10^{-6} /$	/ = measured value
		20 Hz	$40 \cdot 10^{-6} /$	
		30 Hz; 40Hz;	$34 \cdot 10^{-6} /$	
		55 Hz;	$0.11 \cdot 10^{-3} /$	
		400Hz	$64 \cdot 10^{-6} /$	
		500 Hz; 1 kHz; 2 kHz;	$42 \cdot 10^{-6} /$	
		5 kHz; 10 kHz	$42 \cdot 10^{-6} /$	
	300 μ A	10 Hz	$38 \cdot 10^{-6} /$	
		20 Hz	$34 \cdot 10^{-6} /$	
		30 Hz; 40Hz;	$32 \cdot 10^{-6} /$	
		55 Hz;	$42 \cdot 10^{-6} /$	
		400Hz	$36 \cdot 10^{-6} /$	
		500 Hz; 1 kHz	$32 \cdot 10^{-6} /$	
		2 kHz; 5 kHz; 10 kHz	$33 \cdot 10^{-6} /$	
	1 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$32 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz; 1 kHz;	$32 \cdot 10^{-6} /$	
		2 kHz; 5 kHz; 10 kHz	$32 \cdot 10^{-6} /$	
	3 mA; 5 mA	10 Hz; 20 Hz; 30 Hz; 40 Hz;	$10 \cdot 10^{-6} /$	
		55 Hz; 400 Hz; 500 Hz;	$10 \cdot 10^{-6} /$	
		1kHz; 2 kHz; 5 kHz	$10 \cdot 10^{-6} /$	
		10 kHz	$11 \cdot 10^{-6} /$	
	10 mA	10 Hz	$9 \cdot 10^{-6} /$	
		20 Hz; 30 Hz; 40 Hz; 55 Hz;	$8 \cdot 10^{-6} /$	
		400 Hz; 500 Hz; 1 kHz; 2 kHz;	$8 \cdot 10^{-6} /$	
		5 kHz; 10 kHz	$8 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current ammeters	20 mA; 30 mA; 50 mA; 100 mA	10 Hz 20 Hz; 30 Hz; 400 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz 5 kHz; 10 kHz	$10 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $8 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$	/ = measured value
	200 mA; 300 mA; 500 mA	10 Hz 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$10 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$ $9 \cdot 10^{-6} /$	
	1 A; 2 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$11 \cdot 10^{-6} /$ $11 \cdot 10^{-6} /$ $11 \cdot 10^{-6} /$	
	3 A; 5 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$18 \cdot 10^{-6} /$ $18 \cdot 10^{-6} /$ $18 \cdot 10^{-6} /$	
	10 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$22 \cdot 10^{-6} /$ $22 \cdot 10^{-6} /$ $22 \cdot 10^{-6} /$	
	20 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$27 \cdot 10^{-6} /$ $27 \cdot 10^{-6} /$ $27 \cdot 10^{-6} /$ $31 \cdot 10^{-6} /$	
	50 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$33 \cdot 10^{-6} /$ $33 \cdot 10^{-6} /$ $33 \cdot 10^{-6} /$ $40 \cdot 10^{-6} /$	
	100 A	10 Hz; 20 Hz; 30 Hz; 40 Hz; 55 Hz; 400 Hz; 500 Hz; 1 kHz; 2 kHz; 5 kHz; 10 kHz	$48 \cdot 10^{-6} /$ $48 \cdot 10^{-6} /$ $48 \cdot 10^{-6} /$ $93 \cdot 10^{-6} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical measurement

parameters Calibration and measurement facilities
(CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage Sources and measuring instruments (Areas)	100 μ A to 1 mA	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$120 \cdot 10^{-6} /$ $160 \cdot 10^{-6} /$ $60 \cdot 10^{-6} /$	I = measured value
	> 1 mA to 10 mA	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$46 \cdot 10^{-6} /$	
	> 10 mA to 1 A	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} /$	
	> 1 A to 10 A	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} /$	
	> 10 A to 20 A	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} /$	
	> 20 A to 100 A	10 Hz to 40 Hz >40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$69 \cdot 10^{-6} /$ $69 \cdot 10^{-6} /$ $0.17 \cdot 10^{-3} /$	
Alternating current (ranges) measuring instruments	0.1 mA up to 0.2 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz >1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.40 \cdot 10^{-3} /$ $0.21 \cdot 10^{-3} /$ $0.40 \cdot 10^{-3} /$ $1.7 \cdot 10^{-3} /$	I = Reading taken with a Fluke 5720A
	> 0.2 mA up to 2.2 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz >1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.44 \cdot 10^{-3} /$ $0.30 \cdot 10^{-3} /$ $0.72 \cdot 10^{-3} /$ $4.2 \cdot 10^{-3} /$	
	> 2.2 mA up to 22 mA	10 Hz to 40 Hz >40 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.44 \cdot 10^{-3} /$ $0.30 \cdot 10^{-3} /$ $0.46 \cdot 10^{-3} /$ $3.5 \cdot 10^{-3} /$	
	> 22 mA up to 220 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz >1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.44 \cdot 10^{-3} /$ $0.25 \cdot 10^{-3} /$ $0.37 \cdot 10^{-3} /$ $1.6 \cdot 10^{-3} /$	
	> 220 mA up to 2.2 A	20 Hz to 1 kHz >1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.43 \cdot 10^{-3} /$ $0.84 \cdot 10^{-3} /$ $7.6 \cdot 10^{-3} /$	
	> 2.2 A up to 20 A	40 Hz to 5 kHz	$0.81 \cdot 10^{-3} / + 1.2 \text{ mA}$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage	0.1 mA up to 1 A	40 Hz to 5 kHz	$2 \cdot 10^{-3} /$	I = measured value with HP3458A
AC current clamps	1 mA up to 2.2 A > 2.2 A up to 20 A > 20 A up to 800 A	40 Hz to 5 kHz 40 Hz to 5 kHz 40 Hz to 65 Hz	$2 \cdot 10^{-3} /$ $3 \cdot 10^{-3} /$ $4 \cdot 10^{-3} /$	I = measured value
Alternating current intensity Current transformer	1 A to 120 A 1 A to 120 A > 120 A up to 600 A > 120 A up to 1000 A	40 Hz to 850 Hz > 850 Hz to 2 kHz 40 Hz to 400 Hz 40 Hz to 65 Hz	$0.16 \cdot 10^{-3} /$ $0.47 \cdot 10^{-3} /$ $0.52 \cdot 10^{-3} /$ $0.6 \cdot 10^{-3} /$	
Resistance ratio AC/DC measuring bridges	0.16 to 6.3	Equal and Alternating current up to	$0.2 \cdot 10^{-6}$	Measurement uncertainty denotes the absolute value
Phase angle between voltages Measuring instruments and sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 mV / 50 mV Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz; 50 kHz	0.005° 0.008° 0.020°	U_{SIG} : Signal voltage U_{REF} : Reference voltage For discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 0.5 V / 0.5 V 1 V / 1 V 0.8 V / 1 V 1 V / 0.5 V 10 V / 10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz; 5 kHz; 10 kHz; 50 kHz 100 kHz	0.005° 0.005° 0.007° 0.008° 0.009°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 100 V / 100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz; 5 kHz; 10 kHz; 50 kHz 100 kHz	0.005° 0.005° 0.007° 0.008° 0.030°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between voltages Measuring instruments and sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 V/0.05 V 10 V/1 V V/10 V 100 V/1 V 1 V/100 V measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz 1 kHz; 5 kHz 10 kHz 50 kHz 100 kHz	0.009° 0.009° 0.020° 0.030° 0.070°	U_{SIG} : Signal voltage U_{REF} : Reference voltage For discrete measured values and frequencies
		U_{REF} / U_{SIG} 0.05 V to 0.5 V Measurement frequency: 10 Hz to 1 kHz > 1 kHz to 50 kHz	0.006° 0.010° 0.025°	U_{SIG} : Signal voltage U_{REF} : Reference voltage measurement ranges
		U_{REF} / U_{SIG} > 0.5 V to 10 V Measurement frequency: 10 Hz to 5 kHz	0.006° 0.015°	
		U_{REF} / U_{SIG} > 10 V to 100 V Measurement frequency: 10 Hz to 5 kHz >5 kHz to 50 kHz	0.006° 0.010° 0.035°	
		U_{REF} / U_{SIG} > 100 V to 630 V Measurement frequency: 10 Hz to 2.5 kHz > 2.5 kHz to 5 kHz > 5 kHz to 10 kHz 10 kHz to 20 kHz 20 kHz to 50 kHz	0.008° 0.03° 0.04° 0.05° 0.1° 0.2°	
	-180° to +180°			

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Sources	-180° to +180°	U_{REF} / U_{SIG} 1 mA to 2 A / 0.05 V to 100 V Measurement frequency: 10 Hz to 1 kHz >1 kHz to 10 kHz	0.009° 0.045° 0.50°	U_{SIG} : Signal voltage U_{REF} : Reference voltage measurement ranges
		U_{REF} / U_{SIG} > 2 A to 20 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz >1 kHz to 10 kHz	0.02° 0.1° 1.0°	
		U_{REF} / U_{SIG} > 20 A to 100 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz >1 kHz to 10 kHz	0.025° 0.20° 2.0°	
		U_{REF} / U_{SIG} 1 mA to 2 A / 0.05 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.009° 0.045°	
		U_{REF} / U_{SIG} > 2 A to 20 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.02° 0.1°	
		U_{REF} / U_{SIG} > 20 A to 100 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.025° 0.20°	
Phase angle between current and voltage Measuring instruments	-180° to +180°	U_{REF} / U_{SIG} 1 mA to 2 A / 0.05 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.009° 0.045°	
		U_{REF} / U_{SIG} > 2 A to 20 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.02° 0.1°	
		U_{REF} / U_{SIG} > 20 A to 100 A / 1 V to 100 V Measurement frequency: 10 Hz to 1 kHz	0.025° 0.20°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/0.05 V 1 mA/0.5 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.007° 0.02° 0.08°	U_{SIG} : Signal voltage U_{REF} : Reference voltage for discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/1 V 10 mA/1 V 20 mA/1 V 50 mA/1 V 100 mA/1 V 200 mA/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.005° 0.010° 0.070°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/1 V, 1 A/1 V, 2 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.006° 0.040° 0.40°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/1 V 10 A/1 V 20 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.010° 0.090° 0.90°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/1 V 100 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.020° 0.15° 1.5°	U_{SIG} : Signal voltage U_{REF} : Reference voltage For discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/10 V 10 mA/10 V 20 mA/10 V 50 mA/10 V 100 mA/10 V 200 mA/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.006° 0.020° 0.080°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/10 V 1 A/10 V 2 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.007° 0.040° 0.40°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/10 V 10 A/10 V 20 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.015° 0.09° 0.90°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/10 V 100 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.020° 0.15° 1.5°	U_{SIG} : Signal voltage U_{REF} : Reference voltage for discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/100 V 10 mA/100 V 20 mA/100 V 50 mA/100 V 100 mA/100 V 200 mA/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.008° 0.025° 0.09°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/100 V 1 A/100 V 2 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.007° 0.04° 0.40°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/100 V 10 A/100 V 20 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.015° 0.09° 0.90°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Sources	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/100 V 100 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.020° 0.15° 1.5°	U_{SIG} : Signal voltage U_{REF} : Reference voltage For discrete measured values and frequencies
Phase angle between current and voltage Measuring instruments	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/0.05 V 1 mA/0.5 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.007° 0.02°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/1 V 10 mA/1 V 20 mA/1 V 50 mA/1 V 100 mA/1 V 200 mA/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.005° 0.010°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/1 V, 1 A/1 V, 2 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.006° 0.040°	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Measuring instruments	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/1 V 10 A/1 V 20 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.010° 0.090°	U_{SIG} : Signal voltage U_{REF} : Reference voltage for discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/1 V 100 A/1 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.020° 0.15°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/10 V 10 mA/10 V 20 mA/10 V 50 mA/10 V 100 mA/10 V 200 mA/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.006° 0.020°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/10 V 1 A/10 V 2 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.007° 0.040°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and Suspense Measuring instruments	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/10 V 10 A/10 V 20 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.015° 0.09°	U_{SIG} : Signal voltage U_{REF} : Reference voltage for discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/10 V 100 A/10 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.020° 0.15°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 1 mA/100 V 10 mA/100 V 20 mA/100 V 50 mA/100 V 100 mA/100 V 200 mA/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz 5 kHz; 10 kHz	 0.008° 0.025°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase angle between current and voltage Measuring instruments	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 500 mA/100 V, 1 A/100 V, 2 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.007° 0.04°	U_{SIG} : Signal voltage U_{REF} : Reference voltage For discrete measured values and frequencies
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 5 A/100 V 10 A/100 V 20 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.015° 0.09°	
	0°; 30°; 60°; 75°; 90°; 150°; 180°; 270°; 300°	U_{REF} / U_{SIG} 50 A/100 V 100 A/100 V Measurement frequency: 10 Hz; 40 Hz; 55 Hz; 400 Hz; 1 kHz	 0.020° 0.15°	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Inductance Measuring instruments, Sources, Decadic normals	100 μ H	1 kHz; 10 kHz	$0.3 \cdot 10^{-3}$	
	1 mH	1 kHz 10 kHz	$65 \cdot 10^{-6}$ $0.15 \cdot 10^{-3}$	
	10 mH	1 kHz 10 kHz	$55 \cdot 10^{-6}$ $0.16 \cdot 10^{-3}$	
	100 mH	1 kHz 10 kHz	$65 \cdot 10^{-6}$ $0.21 \cdot 10^{-3}$	
	1 H	100 Hz 1 kHz	$0.1 \cdot 10^{-3}$ $70 \cdot 10^{-6}$	
	10 hours	100 Hz 1 kHz	$0.2 \cdot 10^{-3}$ $0.2 \cdot 10^{-3}$	
Inductance Measuring instruments, Sources	0.1 mH to 1 mH	1 kHz to 10 kHz	$5.5 \cdot 10^{-3}$	
	> 1 mH to 10 mH	1 kHz to 10 kHz	$1.5 \cdot 10^{-3}$	
	> 10 mH to 100 mH	1 kHz to 10 kHz	$2.0 \cdot 10^{-3}$	
	> 0.1 hours to 1 hour	1 kHz	$0.4 \cdot 10^{-3}$	
	> 1 H to 10 H	100 Hz to 1 kHz	$1.5 \cdot 10^{-3}$	
Capacity of measuring instruments, Decadic normals	1 pF	50 Hz 100 Hz 1 kHz 10 kHz 400 kHz 100 kHz; 1 MHz	$6 \cdot 10^{-3}$ $2.5 \cdot 10^{-3}$ $0.3 \cdot 10^{-3}$ $0.2 \cdot 10^{-3}$ $6.1 \cdot 10^{-3}$ $3.5 \cdot 10^{-3}$	
	10 pF	50 Hz 100 Hz 1 kHz 10 kHz 100 kHz; 400kHz; 1 MHz	$0.6 \cdot 10^{-3}$ $0.4 \cdot 10^{-3}$ $35 \cdot 10^{-6}$ $40 \cdot 10^{-6}$ $75 \cdot 10^{-6}$ $110 \cdot 10^{-6}$	
	100 pF	50 Hz 100 Hz 1 kHz; 10kHz; 100 kHz; 400kHz; 1 MHz	$80 \cdot 10^{-6}$ $40 \cdot 10^{-6}$ $25 \cdot 10^{-6}$ $35 \cdot 10^{-6}$ $65 \cdot 10^{-6}$ $0.35 \cdot 10^{-3}$	
	1 nF	50 Hz 100 Hz 1 kHz 10 kHz 100 kHz 400 kHz 1 MHz	$35 \cdot 10^{-6}$ $25 \cdot 10^{-6}$ $15 \cdot 10^{-6}$ $22 \cdot 10^{-6}$ $75 \cdot 10^{-6}$ $0.45 \cdot 10^{-3}$ $3 \cdot 10^{-3}$	
	10 nF	50 Hz; 100 Hz; 1 kHz 10 kHz	$35 \cdot 10^{-6}$ $55 \cdot 10^{-6}$	
	100 nF	50 Hz; 100 Hz; 1 kHz; 10 kHz	$55 \cdot 10^{-6}$ $75 \cdot 10^{-6}$	
	1 μ F	50 Hz 100 Hz 1 kHz 10 kHz	$55 \cdot 10^{-6}$ $70 \cdot 10^{-6}$ $55 \cdot 10^{-6}$ $110 \cdot 10^{-6}$	
	10 μ F	50 Hz; 100 Hz; 1 kHz 10 kHz	0.2×10^{-3} 0.4×10^{-3}	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Capacity Sources, measuring instruments, standards	10 pF up to 100 pF	50 Hz up to 1kHz > 1 kHz up to 10kHz > 10 kHz up to 100kHz > 100 kHz to 400 kHz > 400 kHz to 1 MHz	$4.9 \cdot 10^{-3} C$ $0.4 \cdot 10^{-3} C$ $3.0 \cdot 10^{-3} C$ $1.6 \cdot 10^{-3} C$ $2.2 \cdot 10^{-3} C$	C = measured value
	> 100 pF up to 1 nF	50 Hz up to 1kHz > 1 kHz up to 10kHz > 10 kHz up to 100kHz > 100 kHz to 400 kHz > 400 kHz up to 1 MHz	$0.2 \cdot 10^{-3} C$ $2.3 \cdot 10^{-3} C$ $3.5 \cdot 10^{-3} C$ $1.5 \cdot 10^{-3} C$ $3.6 \cdot 10^{-3} C$	
	> 1 nF up to 10 nF	50 Hz up to 1 kHz > 1 kHz up to 10 kHz	$2.8 \cdot 10^{-3} C$ $2.4 \cdot 10^{-3} C$	
	> 10 nF up to 100 nF	50 Hz up to 1 kHz > 1 kHz up to 10 kHz	$4.3 \cdot 10^{-3} C$ $2.0 \cdot 10^{-3} C$	
	> 100 nF up to 1 μ F	50 Hz up to 100Hz > 100 Hz up to 1kHz > 1 kHz to 10 kHz	$0.11 \cdot 10^{-3} C$ $1.0 \cdot 10^{-3} C$ $0.5 \cdot 10^{-3} C$	
	> 1 μ F up to 10 μ F	50 Hz up to 100Hz > 100 Hz up to 1kHz > 1 kHz up to 10 kHz	$0.58 \cdot 10^{-3} C$ $0.38 \cdot 10^{-3} C$ $0.43 \cdot 10^{-3} C$	
	190 pF up to <400pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to 110nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
Capacity of measuring instruments	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	With 5520A / 5522A
	330 nF to < 1.1 μ F	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μ F up to <3.3 μ F	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μ F to <11 μ F	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μ F up to < 33 μ F	10 Hz up to 120 Hz	$6.0 \cdot 10^{-3} C$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Capacity of measuring instruments	33 μ F up to <110 μ F 110 μ F to < 330 μ F 330 μ F to < 1.1 mF 1.1 mF to < 3.3 mF 3.3 mF to <11mF 11 mF up to < 33 mF 33 mF up to 110 mF	10 Hz to 80 Hz DC to 50 Hz DC up to 20Hz DC to 6 Hz DC to 2 Hz DC to 0.6 Hz DC up to 0.2 Hz	6.5 · 10 ⁻³ C 6.0 · 10 ⁻³ C 6.0 · 10 ⁻³ C 6.0 · 10 ⁻³ C 6.0 · 10 ⁻³ C 8.0 · 10 ⁻³ C 11 · 10 ⁻³ C	C = measured value
DC capacity Sources, measuring instruments	1 μ F up to 70 μ F > 70 μ F up to 200 μ F > 200 μ F up to 110 mF	DC method	2.6 · 10 ⁻³ 0.55 · 10 ⁻³ 0.30 · 10 ⁻³	
Tension	± 2 mV/V	Bridge span: 5 V Measurement frequency 225 Hz Measurement	0.04 μ V/V 0.05 μ V/V 1.0 μ V/V	Calibration of 350 Ω bridge standards and the associated indicating instruments
	± 2 mV/V	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	0.05 μ V/V 0.05 μ V/V 1.0 μ V/V	at discrete points in 10 per cent increments
	± 5 mV/V	Bridge span: 5 V Measurement frequency 225 Hz	0.15 μ V/V 1.0 μ V/V	
	± 10 mV/V	Bridge span: 5 V Measurement frequency 225 Hz	0.10 μ V/V 0.30 μ V/V	
	± 5 mV/V	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	0.1 μ V/V 0.1 μ V/V 1.0 μ V/V	
	± 10 mV/V	Bridge voltage: 2.5 V Measurement frequency 225 Hz Measurement	0.4 μ V/V 0.4 μ V/V 0.4 μ V/V	
	± 10 mV/V	Bridge span: 1 V Measurement frequency	0.40 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tension	$\pm 20 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	0.60 $\mu\text{V/V}$	Calibration of 350 Ω bridge standards and the associated indicating instruments at discrete points in 10 per cent increments
	$\pm 100 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	5.0 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency:	5.0 $\mu\text{V/V}$	
Direct current Bridge standards	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 0.5 V	0.4 $\mu\text{V/V}$ 0.35 $\mu\text{V/V}$ 0.35 $\mu\text{V/V}$ 0.35 $\mu\text{V/V}$ 0.35 $\mu\text{V/V}$ 0.35 $\mu\text{V/V}$	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 1.0 V	0.2 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$ 0.25 $\mu\text{V/V}$	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 2.5 V	0.1 $\mu\text{V/V}$ 0.07 $\mu\text{V/V}$ 0.07 $\mu\text{V/V}$ 0.07 $\mu\text{V/V}$ 0.07 $\mu\text{V/V}$ 0.20 $\mu\text{V/V}$	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 5.0 V	0.04 $\mu\text{V/V}$ 0.035 $\mu\text{V/V}$ 0.035 $\mu\text{V/V}$ 0.035 $\mu\text{V/V}$ 0.045 $\mu\text{V/V}$ 0.15 $\mu\text{V/V}$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tension Direct current Bridge standards	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 7.5 V	0.025 μ V/V 0.025 μ V/V 0.025 μ V/V 0.025 μ V/V 0.04 μ V/V 0.15 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 10.0 V	0.02 μ V/V 0.015 μ V/V 0.020 μ V/V 0.025 μ V/V 0.035 μ V/V 0.075 μ V/V	
Direct current Bridges, measuring instruments, Measurement amplifier	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 0.5 V	0.35 μ V/V 0.35 μ V/V 0.40 μ V/V 0.55 μ V/V 2.5 μ V/V	With K148
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 1 V	0.20 μ V/V 0.20 μ V/V 0.30 μ V/V 0.50 μ V/V 2.5 μ V/V	
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	DC voltage, bridge voltage: 2.5 V; 5 V; 7.5 V; 10 V	0.10 μ V/V 0.15 μ V/V 0.25 μ V/V 0.45 μ V/V 2.5 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measurand / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	50.0 μ W	1 mA / 0.05 V // 10 Hz to 10 kHz Phase angle: 0°	$0.2 \times 10^{-3} P$	P = AC active power Discrete points for current, voltage and phase angle
	43.3 μ W	phase angle: $\pm 30^\circ$	$0.3 \times 10^{-3} P$	
	25.0 μ W	phase angle: $\pm 60^\circ$	$0.8 \cdot 10^{-3} P$	
	12.9 μ W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	500 μ W	1 mA / 0.5 V / 10 Hz to 10 kHz Phase angle: 0°	$0.2 \times 10^{-3} P$	
	433 μ W	Phase angle: $\pm 30^\circ$	$0.2 \times 10^{-3} P$	
	250 μ W	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	129 μ W	Phase angle: $\pm 75^\circ$	$0.7 \cdot 10^{-3} P$	
	1.0 mW	1 mA / 1 V / 10 Hz to 10 kHz phase angle: 0°	$0.1 \times 10^{-3} P$	
	0.9 mW	Phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	0.5 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	0.3 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	
	10.0 mW	10 mA / 1 V / 10 Hz to 10 kHz phase angle: 0°	$0.1 \times 10^{-3} P$	
	8.7 mW	Phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	5.0 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	2.6 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	
	20.0 mW	20 mA / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	17.3 mW	phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	10.0 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	5.2 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	
	50.0 mW	50 mA / 1 V / 10 Hz to 10 kHz phase angle: 0°	$50 \cdot 10^{-6} P$	
	47.3 mW	Phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	25.0 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	12.9 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	
	100.0 mW	100 mA / 1 V / 10 Hz to 10 kHz phase angle: 0°	$50 \cdot 10^{-6} P$	
	86.6 mW	Phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	50.0 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	25.9 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	200.0 mW	200 mA / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	P = AC active power Discrete points for current, voltage and phase angle
	173.2 mW	phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	100.0 mW	phase angle: $\pm 60^\circ$	$0.4 \cdot 10^{-3} P$	
	51.8 mW	Phase angle: $\pm 75^\circ$	$0.8 \cdot 10^{-3} P$	
	500.0 mW	500 mA / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	433.0 mW	phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	250.0 mW	phase angle: $\pm 60^\circ$	$2.0 \cdot 10^{-3} P$	
	129.4 mW	Phase angle: $\pm 75^\circ$	$3.0 \cdot 10^{-3} P$	
	1.0 W	1 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	0.9 W	phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	0.5 W	phase angle: $\pm 60^\circ$	$2.0 \cdot 10^{-3} P$	
	0.3 W	Phase angle: $\pm 75^\circ$	$3.0 \cdot 10^{-3} P$	
	2.0 W	2 A / 1 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: $\pm 30^\circ$ phase angle: $\pm 60^\circ$	$50 \cdot 10^{-6} P$	
	1.7 W		$0.5 \cdot 10^{-3} P$	
	1.0 W		$2.0 \cdot 10^{-3} P$	
	0.5 W	Phase angle: $\pm 75^\circ$	$3.0 \cdot 10^{-3} P$	
	5.0 W	5 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	4.3 W	phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-3} P$	
	2.5 W	phase angle: $\pm 60^\circ$	$4.0 \cdot 10^{-3} P$	
	1.3 W	Phase angle: $\pm 75^\circ$	$8.0 \cdot 10^{-3} P$	
	10.0 W	10 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	8.7 W	phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-3} P$	
	5.0 W	phase angle: $\pm 60^\circ$	$4.0 \cdot 10^{-3} P$	
	2.6 W	Phase angle: $\pm 75^\circ$	$8.0 \cdot 10^{-3} P$	
	20.0 W	20 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	17.3 W	phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-3} P$	
	10.0 W	phase angle: $\pm 60^\circ$	$4.0 \cdot 10^{-3} P$	
	5.2 W	Phase angle: $\pm 75^\circ$	$8.0 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	50.0 W	50 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$0.3 \times 10^{-3} P$	P = AC active power Discrete points for current, voltage and phase angle
	43.3 W	phase angle: $\pm 30^\circ$	$3.0 \times 10^{-3} P$	
	25.0 W	phase angle: $\pm 60^\circ$	$6.0 \times 10^{-3} P$	
	12.9 W	Phase angle: $\pm 75^\circ$	$10 \times 10^{-3} P$	
	100.0 W	100 A / 1 V / 10 Hz to 10 kHz Phase angle: 0°	$0.3 \times 10^{-3} P$	
	86.6 W	phase angle: $\pm 30^\circ$	$3.0 \times 10^{-3} P$	
	50.0 W	phase angle: $\pm 60^\circ$	$6.0 \times 10^{-3} P$	
	25.9 W	Phase angle: $\pm 75^\circ$	$10 \times 10^{-3} P$	
	10.0 mW	1 mA / 10 V / 10 Hz to 10 kHz Phase angle: 0°	$0.1 \times 10^{-3} P$	
	8.7 mW	phase angle: $\pm 30^\circ$	$0.3 \times 10^{-3} P$	
	5.0 mW	phase angle: $\pm 60^\circ$	$0.7 \times 10^{-3} P$	
	2.6 mW	Phase angle: $\pm 75^\circ$	$2.0 \times 10^{-3} P$	
	100.0 mW	10 mA / 10 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \times 10^{-6} P$	
	86.6 mW	phase angle: $\pm 30^\circ$	$0.3 \times 10^{-3} P$	
	50.0 mW	phase angle: $\pm 60^\circ$	$0.7 \times 10^{-3} P$	
	25.9 mW	Phase angle: $\pm 75^\circ$	$2.0 \times 10^{-3} P$	
	200.0 mW	20 mA / 10 V / 10 Hz to 10 kHz phase angle: 0°	$50 \times 10^{-6} P$	
	173.2 mW	Phase angle: $\pm 30^\circ$	$0.3 \times 10^{-3} P$	
	100.0 mW	phase angle: $\pm 60^\circ$	$0.7 \times 10^{-3} P$	
	51.8 mW	Phase angle: $\pm 75^\circ$	$2.0 \times 10^{-3} P$	
	500.0 mW	50 mA / 10 V / 10 Hz to 10 kHz Phase angle: 0°	$50 \times 10^{-6} P$	
	433.0 mW	phase angle: $\pm 30^\circ$	$0.5 \times 10^{-3} P$	
	250.0 mW	phase angle: $\pm 60^\circ$	$1.0 \times 10^{-3} P$	
	129.4 mW	Phase angle: $\pm 75^\circ$	$2.0 \times 10^{-3} P$	
	1.0 W	100 mA / 10 V / 10 Hz to 10 kHz phase angle: 0°	$50 \times 10^{-6} P$	
	0.9 W	Phase angle: $\pm 30^\circ$	$0.5 \times 10^{-3} P$	
	0.5 W	phase angle: $\pm 60^\circ$	$1.0 \times 10^{-3} P$	
	0.3 W	Phase angle: $\pm 75^\circ$	$2.0 \times 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	2.0 W 1.7 W 1.0 W 0.5 W	200 mA / 10 V / 10 Hz to 10 kHz phase angle: 0° Phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $0.5 \cdot 10^{-3} P$ $1.0 \cdot 10^{-3} P$ $2.0 \cdot 10^{-3} P$	P = AC active power Discrete points for current, voltage and phase angle
	10.0 W 8.7 W 5.0 W 2.6 W	1 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $0.5 \cdot 10^{-3} P$ $2.0 \cdot 10^{-3} P$ $3.0 \cdot 10^{-3} P$	
	20.0 W 17.3 W 10.0 W 5.2 W	2 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $0.5 \cdot 10^{-3} P$ $2.0 \cdot 10^{-3} P$ $3.0 \cdot 10^{-3} P$	
	50.0 W 43.3 W 25.0 W 12.9 W	5 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $1.0 \cdot 10^{-3} P$ $3.0 \cdot 10^{-3} P$ $7.0 \cdot 10^{-3} P$	
	100.0 W 86.6 W 50.0 W 25.9 W	10 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $1.0 \cdot 10^{-3} P$ $3.0 \cdot 10^{-3} P$ $7.0 \cdot 10^{-3} P$	
	200.0 W 173.2 W 100.0 W 51.8 W	20 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$50 \cdot 10^{-6} P$ $1.0 \cdot 10^{-3} P$ $3.0 \cdot 10^{-3} P$ $7.0 \cdot 10^{-3} P$	
	500.0 W 433.0 W 250.0 W 129.4 W	50 A / 10 V / 10 Hz to 10 kHz Phase angle: 0° phase angle: ±30° phase angle: ±60° Phase angle: ±75°	$0.2 \cdot 10^{-3} P$ $2.0 \cdot 10^{-3} P$ $5.0 \cdot 10^{-3} P$ $1.0 \cdot 10^{-2} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	1000.0 W	100 A / 10 V / 10 Hz to 10 kHz phase angle: 0 °	$0.2 \times 10^{-3} P$	P = AC active power Discrete points for current, voltage and phase angle
	866.0 W	Phase angle: $\pm 30^\circ$	$2.0 \cdot 10^{-3} P$	
	500.0 W	phase angle: $\pm 60^\circ$	$5.0 \cdot 10^{-3} P$	
	258.8 W	Phase angle: $\pm 75^\circ$	$1.0 \cdot 10^{-2} P$	
	100.0 mW	1 mA / 100 V / 10 Hz to 10 kHz Phase angle: 0 °	$50 \cdot 10^{-6} P$	
	86.6 mW	Phase angle: $\pm 30^\circ$	$0.3 \cdot 10^{-3} P$	
	50.0 mW	phase angle: $\pm 60^\circ$	$0.8 \cdot 10^{-3} P$	
	25.9 mW	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	1.0 W	10 mA / 100 V / 10 Hz to 10 kHz Phase angle: 0 °	$50 \cdot 10^{-6} P$	
	0.9 W	phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	0.5 W	phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	0.3 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	2.0 W	20 mA / 100 V / 10 Hz to 10 kHz Phase angle: 0 °	$50 \cdot 10^{-6} P$	
	1.7 W	phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	1.0 W	phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	0.5 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	5.0 W	50 mA / 100 V / 10 Hz to 10 kHz Phase angle: 0 °	$50 \cdot 10^{-6} P$	
	4.3 W	Phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	2.5 W	phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	1.3 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	10.0 W	100 mA / 100 V / 10 Hz to 10 kHz phase angle: 0 °	$50 \cdot 10^{-6} P$	
	8.7 W	Phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	5.0 W	phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	2.6 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	20.0 W	200 mA / 100 V / 10 Hz to 10 kHz phase angle: 0 °	$50 \cdot 10^{-6} P$	
	17.3 W	Phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	10.0 W	phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	5.2 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01
Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	100.0 W	1 A / 100 V // 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	P = AC active power Discrete points for current, voltage and phase angle
	86.6 W	phase angle: $\pm 30^\circ$	$0.5 \cdot 10^{-3} P$	
	50.0 W	phase angle: $\pm 60^\circ$	$2.0 \cdot 10^{-3} P$	
	25.9 W	Phase angle: $\pm 75^\circ$	$3.0 \cdot 10^{-3} P$	
	200.0 W	2 A / 100 V // 10 Hz to 10 kHz Phase angle: 0° phase angle:	$50 \cdot 10^{-6} P$	
	173.2 W	$\pm 30^\circ$ phase angle: $\pm 60^\circ$	$0.5 \cdot 10^{-3} P$	
	100.0 W	Phase angle: $\pm 75^\circ$	$2.0 \cdot 10^{-3} P$	
	51.8 W		$3.0 \cdot 10^{-3} P$	
	500.0 W	5 A / 100 V // 10 Hz to 10 kHz Phase angle: 0° phase angle:	$50 \cdot 10^{-6} P$	
	433.0 W	$\pm 30^\circ$ phase angle: $\pm 60^\circ$	$1.0 \cdot 10^{-3} P$	
	250.0 W	Phase angle: $\pm 75^\circ$	$3.0 \cdot 10^{-3} P$	
	129.4 W		$7.0 \cdot 10^{-3} P$	
	1,000 W	10 A / 100 V // 10 Hz to 10 kHz Phase angle: 0°	$50 \times 10^{-6} P$	
	866 W	phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-3} P$	
	500 W	phase angle: $\pm 60^\circ$	$3.0 \cdot 10^{-3} P$	
	258.8 W	Phase angle: $\pm 75^\circ$	$7.0 \cdot 10^{-3} P$	
	2000 W	20 A / 100 V // 10 Hz to 10 kHz Phase angle: 0°	$50 \cdot 10^{-6} P$	
	1732 W	phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-3} P$	
	1000 W	phase angle: $\pm 60^\circ$	$3.0 \cdot 10^{-3} P$	
	517.6 W	Phase angle: $\pm 75^\circ$	$7.0 \cdot 10^{-3} P$	
	5,000 W	50 A / 100 V // 10 Hz to 10 kHz Phase angle: 0°	$0.2 \times 10^{-3} P$	
	4330 W	phase angle: $\pm 30^\circ$	$2.0 \cdot 10^{-3} P$	
	2500 W	phase angle: $\pm 60^\circ$	$5.0 \cdot 10^{-3} P$	
	1294 W	Phase angle: $\pm 75^\circ$	$1.0 \cdot 10^{-2} P$	
	10,000 W	100 A / 100 V // 10 Hz to 10 kHz Phase angle: 0°	$0.2 \times 10^{-3} P$	
	8660 W	phase angle: $\pm 30^\circ$	$2.0 \times 10^{-3} P$	
	5000 W	phase angle: $\pm 60^\circ$	$5.0 \cdot 10^{-3} P$	
	2588 W	Phase angle: $\pm 75^\circ$	$10 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (discrete points)	25 kW	50 A / 500 V / 40 Hz to 850 Hz Phase angle: 0°	$85 \times 10^{-6} P$	P = AC active power Discrete points for current, voltage and phase angle
	21.7 kW	phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	12.5 kW	phase angle: $\pm 60^\circ$	$0.5 \cdot 10^{-3} P$	
	6.5 kW	Phase angle: $\pm 75^\circ$	$1.0 \cdot 10^{-3} P$	
	40 kW	80 A / 500 V / 40 Hz to 850 Hz Phase angle: 0°	$85 \cdot 10^{-6} P$	
	34.6 kW	phase angle: $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	20 kW	phase angle: $\pm 60^\circ$	$0.5 \cdot 10^{-3} P$	
	10.4 kW	Phase angle: $\pm 75^\circ$	$1.0 \cdot 10^{-3} P$	
AC active power sources and measuring instruments (ranges)	50 μ W to 500 mW	50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz phase angle: 0°	$0.17 \cdot 10^{-3} P$	
		50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz Phase angle: 0° to $\pm 30^\circ$	$0.2 \cdot 10^{-3} P$	
	50 μ W to 500 mW	50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz Phase angle: 30° to 60° and -30° to -60°	$0.3 \cdot 10^{-3} P$	
		50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz Phase angle: 60° to 75° and -60° to -75°	$0.6 \cdot 10^{-3} P$	
	> 500 mW to 500 W	5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 0°	$0.1 \cdot 10^{-3} P$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 0° to $\pm 30^\circ$	$0.1 \cdot 10^{-3} P$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: $\pm 30^\circ$ to $\pm 60^\circ$	$0.3 \cdot 10^{-3} P$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: $\pm 60^\circ$ to $\pm 75^\circ$	$0.6 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (ranges)	> 500 W to 10 kW	25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 0 °	0.1 · 10 ⁻³ P	P = AC active power
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 0° to ±30°	0.15 · 10 ⁻³ P	
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: ±30° to ±60°	0.35 · 10 ⁻³ P	
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: ±60° to ±75°	0.75 · 10 ⁻³ P	
	50 μW to 500 μW	0.05 V to 0.5 V 1 mA >1 kHz to 10 kHz Phase angle: 0° to ±30° Phase angle: >±30° to ±60° Phase angle: >±60° to ±75°	0.3 × 10 ⁻³ P 0.8 · 10 ⁻³ P 7.0 · 10 ⁻³	
	> 0.5 mW to 200 mW	0.5 V to 1 V 1 mA to 200 mA > 1 kHz to 10 kHz Phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±75°	0.2 × 10 ⁻³ P 0.4 · 10 ⁻³ P 0.8 · 10 ⁻³ P	
	> 200 mW to 20 W	0.1 V to 1 V > 200 mA to 20 A > 1 kHz to 10 kHz Phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±75°	1.0 × 10 ⁻³ P 4.0 · 10 ⁻³ P 8.0 · 10 ⁻³ P	
	> 20 W to 100 W	0.1 V to 1 V > 20 A to 100 A >1 kHz to 10 kHz phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±60° phase	3.0 × 10 ⁻³ P 6.0 · 10 ⁻³ P 10 · 10 ⁻³ P	
	10 mW to 200 mW	> 1 V to 10 V 1 mA to < 200 mA > 1 kHz to 10 kHz Phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±75°	0.3 × 10 ⁻³ P 0.7 × 10 ⁻³ P 2.0 · 10 ⁻³ P	
	> 200 mW to 20 W	> 1 V to 10 V > 200 mA to 20 A > 1 kHz to 10 kHz Phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±75°	0.5 × 10 ⁻³ P 2.0 · 10 ⁻³ P 3.0 · 10 ⁻³ P	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active power in alternating current Sources and measuring instruments (ranges)	> 20 W to 1,000 W	> 1 V to 10 V > 20 A to 100 A > 1 kHz to 10 kHz phase angle: 0° to ±30° Phase angle: >±30° to ±60° Phase angle: >±60° to ±75°	$2.0 \times 10^{-3} P$ $5.0 \cdot 10^{-3} P$ $10 \cdot 10^{-3} P$	P = AC active power
	100 mW to 20 W	> 10 V to 100 V 1 mA to 200 mA > 1 kHz to 10 kHz Phase angle: 0° to ±30° phase angle: >±30° to ±60° phase angle: >±60° to ±75°	$0.5 \times 10^{-3} P$ $1.0 \cdot 10^{-3} P$ $2.0 \cdot 10^{-3} P$	
	> 20 W to 1,000 W	> 10 V to 100 V > 200 mA to 10 A > 1 kHz to 10 kHz Phase angle: 0° to ±30° Phase angle: >±30° to ±60° Phase angle: >±60° to ±75°	$1.5 \times 10^{-3} P$ $3.0 \cdot 10^{-3} P$ $7.0 \cdot 10^{-3} P$	
	> 1 kW to 10 kW	> 10 V to 100 V > 10 A to 100 A > 1 kHz to 10 kHz phase angle: 0° to ±30° Phase angle: >±30° to ±60° Phase angle: >±60° to ±75°	$2.0 \times 10^{-3} P$ $5.0 \cdot 10^{-3} P$ $10 \cdot 10^{-3} P$	
	> 10 kW to 80 kW	500 V ≤ U ≤ 1000 V 20 A ≤ I ≤ 80 A 40 Hz to 850 Hz Phase angle: 0°	$85 \cdot 10^{-6} P$	
		500 V ≤ U ≤ 1000 V 20 A ≤ I ≤ 80 A 40 Hz to 850 Hz Phase angle: 0° to ±30°	$0.25 \cdot 10^{-3} P$	
		500 V ≤ U ≤ 1000 V 20 A ≤ I ≤ 80 A 40 Hz to 850 Hz Phase angle: Phase angle from 30° to 60°: -30° to -	$0.65 \cdot 10^{-3} P$	
		500 V ≤ U ≤ 1000 V 20 A ≤ I ≤ 80 A 40 Hz to 850 Hz Phase angle: Phase angle from 60° to 75°: -60° to -	$1.5 \cdot 10^{-3} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	50.0 μVAr 43.3 μVAr 25.0 μVAr 12.9 μVAr	1 mA / 0.05 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.2 \times 10^{-3} Q$ $0.3 \times 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	Q= AC reactive power Discrete points for current, voltage and phase angle
	500 μVAr 433 μVAr 250 μVAr 129 μVAr	1 mA / 0.5 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.2 \times 10^{-3} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.7 \cdot 10^{-3} Q$	
	1.0 mVAr 0.9 mVAr 0.5 mVAr 0.3 mVAr	1 mA / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$: Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.1 \times 10^{-3} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	
	10.0 mVAr 8.7 mVAr 5.0 mVAr 2.6 mVAr	10 mA / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.1 \times 10^{-3} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	
	20.0 mVAr 17.3 mVAr 10.0 mVAr 5.2 mVAr	20 mA / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	
	50.0 mVAr 47.3 mVAr 25.0 mVAr 12.9 mVAr	50 mA / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	
	100.0 mVAr 86.6 mVAr 50.0 mVAr 25.9 mVAr	100 mA / 1 V 10 Hz to 10 kHz Phase angle: 90° Phase angle: Phase angle $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.2 \times 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	200.0 mVAr 173.2 mVAr 100.0 mVAr 51.8 mVAr	200 mA / 1 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.2 \cdot 10^{-3} Q$ $0.4 \cdot 10^{-3} Q$ $0.8 \cdot 10^{-3} Q$	Q= AC reactive power Discrete points for current, voltage and phase angle
	500.0 mVAr 433.0 mVAr 250.0 mVAr 129.4 mVAr	500 mA / 1 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$	
	1.0 VAr 0.9 VAr 0.5 VAr 0.3 VAr	1 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \times 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$	
	2.0 VAr 1.7 VAr 1.0 VAr 0.5 VAr	2 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$	
	5.0 VAr 4.3 VAr 2.5 VAr 1.3 VAr	5 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$: Phase angle of $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $4.0 \cdot 10^{-3} Q$ $8.0 \cdot 10^{-3} Q$	
	10.0 VAr 8.7 VAr 5.0 VAr 2.6 VAr	10 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $4.0 \cdot 10^{-3} Q$ $8.0 \cdot 10^{-3} Q$	
	20.0 VAr 17.3 VAr 10.0 VAr 5.2 VAr	20 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \times 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $4.0 \cdot 10^{-3} Q$ $8.0 \cdot 10^{-3} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	50.0 VAr 43.3 VAr 25.0 VAr 12.9 VAr	50 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.3 \times 10^{-3} Q$ $3.0 \times 10^{-3} Q$ $6.0 \cdot 10^{-3} Q$ $10 \cdot 10^{-3} Q$	Q= AC reactive power Discrete points for current, voltage and phase angle
	100.0 VAr 86.6 VAr 50.0 VAr 25.9 VAr	100 A / 1 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.3 \times 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$ $6.0 \cdot 10^{-3} Q$ $10 \cdot 10^{-3} Q$	
	10.0 mVAr 8.7 mVAr 5.0 mVAr 2.6 mVAr	1 mA / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.1 \times 10^{-3} Q$ $0.3 \cdot 10^{-3} Q$ $0.7 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	
	100.0 mVAr 86.6 mVAr 50.0 mVAr 25.9 mVAr	10 mA / 10 V / 10 Hz to 10 kHz Phase angle: 90° Phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.3 \cdot 10^{-3} Q$ $0.7 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	
	200.0 mVAr 173.2 mVAr 100.0 mVAr 51.8 mVAr	20 mA / 10 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.3 \cdot 10^{-3} Q$ $0.7 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	
	500.0 mVAr 433.0 mVAr 250.0 mVAr 129.4 mVAr	50 mA / 10 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $1.0 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	
	1.0 VAr 0.9 VAr 0.5 VAr 0.3 VAr	100 mA / 10 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $1.0 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	2.0 VAr 1.7 VAr 1.0 VAr 0.5 VAr	200 mA / 10 V / 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle $\pm 60^\circ$: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \times 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $1.0 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	Q= AC reactive power Discrete points for current, voltage and phase angle
	10.0 VAr 8.7 VAr 5.0 VAr 2.6 VAr	1 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \times 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$	
	20.0 VAr 17.3 VAr 10.0 VAr 5.2 VAr	2 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $0.5 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$	
	50.0 VAr 43.3 VAr 25.0 VAr 12.9 VAr	5 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$ $7.0 \cdot 10^{-3} Q$	
	100.0 VAr 86.6 VAr 50.0 VAr 25.9 VAr	10 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \times 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$ $7.0 \cdot 10^{-3} Q$	
	200.0 VAr 173.2 VAr 100.0 VAr 51.8 VAr	20 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$50 \cdot 10^{-6} Q$ $1.0 \cdot 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$ $7.0 \cdot 10^{-3} Q$	
	500.0 VAr 433.0 VAr 250.0 VAr 129.4 VAr	50 A / 10 V // 10 Hz to 10 kHz Phase angle: 90° Phase angle: $\pm 60^\circ$ Phase angle of: $\pm 30^\circ$ Phase angle: $\pm 15^\circ$	$0.2 \cdot 10^{-3} Q$ $2.0 \times 10^{-2} Q$ $2.0 \cdot 10^{-2} Q$ $1.0 \cdot 10^{-2} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01
Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical parameters

Calibration and measurement capabilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	1,000.0VAr 866.0 VAr 500.0 VAr 258.8 VAr	100 A / 10 V 10 Hz to 10 kHz Phase angle: 90° phase angle: ±60° Phase angle of ±30 ° Phase angle: ±15 °	0.2 · 10 ⁻³ Q 2.0 × 10 ⁻² Q 2.0 · 10 ⁻² Q 1.0 · 10 ⁻² Q	Q= AC reactive power Discrete points for current, voltage and phase angle
	100.0 m VAr 86.6 m VAr 50.0 m VAr 25.9 m VAr	1 mA / 100 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: ±60° Phase angle: ±30 ° Phase angle: ±15 °	50 · 10 ⁻⁶ Q 0.3 · 10 ⁻³ Q 0.8 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	
	1.0 VAr 0.9 VAr 0.5 VAr 0.3 VAr	10 mA / 100 V // 10 Hz to 10 kHz Phase angle: 90° Phase angle: ±60° Phase angle of :±30° Phase angle: ±15 °	50 × 10 ⁻⁶ Q 0.5 · 10 ⁻³ Q 1.0 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	
	2.0 VAr 1.7 VAr 1.0 VAr 0.5 VAr	20 mA / 100 V // 1.0 Hz to 10 kHz Phase angle: 90° phase angle: ±60° Phase angle: ±30 ° Phase angle: ±15 °	50 · 10 ⁻⁶ Q 0.5 · 10 ⁻³ Q 1.0 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	
	5.0 VAr 4.3 VAr 2.5 VAr 1.3 VAr	50 mA / 100 V// 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of ±60°: ±30 ° Phase angle: ±15°	50 · 10 ⁻⁶ Q 0.5 · 10 ⁻³ Q 1.0 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	
	10.0 VAr 8.7 VAr 5.0 VAr 2.6 VAr	100 mA / 100 V // 10 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of ±60°: ±30 ° Phase angle: ±15 °	50 · 10 ⁻⁶ Q 0.5 · 10 ⁻³ Q 1.0 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	
	20.0 VAr 17.3 VAr 10.0 VAr 5.2 VAr	200 mA/100 V// 0 Hz to 10 kHz Phase angle: 90° phase angle: Phase angle of ±60°: ±30 ° Phase angle: ±15 °	50 · 10 ⁻⁶ Q 0.5 · 10 ⁻³ Q 1.0 · 10 ⁻³ Q 2.0 · 10 ⁻³ Q	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)		1 A / 100 V // 10 Hz to 10 kHz		Q= AC reactive power
	100.0 VAr	Phase angle: 90°	$50 \cdot 10^{-6} Q$	Discrete points for current, voltage and phase angle
	86.6 VAr	phase angle: $\pm 60^\circ$	$0.5 \cdot 10^{-3} Q$	
	50.0 VAr	Phase angle: $\pm 30^\circ$	$2.0 \cdot 10^{-3} Q$	
	25.9 VAr	Phase angle: $\pm 15^\circ$	$3.0 \cdot 10^{-3} Q$	
	200.0 VAr	2 A / 100 V // 10 Hz to 10 kHz	$50 \cdot 10^{-6} Q$	
	173.2 VAr	Phase angle: 90°	$0.5 \cdot 10^{-3} Q$	
	100.0 VAr	phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$	$2.0 \cdot 10^{-3} Q$	
	51.8 VAr	Phase angle: $\pm 15^\circ$	$3.0 \cdot 10^{-3} Q$	
	500.0 VAr	5 A / 100 V // 10 Hz to 10 kHz	$50 \cdot 10^{-6} Q$	
	433.0 VAr	Phase angle: 90°	$1.0 \cdot 10^{-3} Q$	
	250.0 VAr	Phase angle: Phase angle of $\pm 60^\circ$: $\pm 30^\circ$	$3.0 \cdot 10^{-3} Q$	
	129.4 VAr	Phase angle: $\pm 15^\circ$	$7.0 \cdot 10^{-3} Q$	
	1000 VAr	10 A / 100 V // 10 Hz to 10 kHz	$50 \cdot 10^{-6} Q$	
	866 VAr	Phase angle: 90°	$1.0 \cdot 10^{-3} Q$	
	500 VAr	Phase angle: $\pm 60^\circ$	$3.0 \cdot 10^{-3} Q$	
	258.8 VAr	Phase angle of: $\pm 30^\circ$	$7.0 \cdot 10^{-3} Q$	
		Phase angle: $\pm 15^\circ$		
	2000 VAr	20 A / 100 V // 10 Hz to 10 kHz	$50 \cdot 10^{-6} Q$	
	1732 VAr	Phase angle: 90°	$1.0 \cdot 10^{-3} Q$	
	1000 VAr	phase angle: $\pm 60^\circ$	$3.0 \cdot 10^{-3} Q$	
	517.6 VAr	Phase angle of: $\pm 30^\circ$	$7.0 \cdot 10^{-3} Q$	
		Phase angle: $\pm 15^\circ$		
	5,000 VAr	50 A / 100 V // 10 Hz to 10 kHz	$0.2 \times 10^{-3} Q$	
	4,330 VAr	Phase angle: 90°	$2.0 \cdot 10^{-3} Q$	
	2,500 VAr	phase angle: $\pm 60^\circ$	$5.0 \cdot 10^{-3} Q$	
	1294 VAr	Phase angle: $\pm 30^\circ$	$1.0 \cdot 10^{-2} Q$	
		Phase angle: $\pm 15^\circ$		
	10,000 VAr	100 A / 100 V // 10 Hz to 10 kHz	$0.2 \times 10^{-3} Q$	
	8,660 VAr	Phase angle: 90°	$2.0 \cdot 10^{-3} Q$	
	5,000 VAr	phase angle: $\pm 60^\circ$	$5.0 \cdot 10^{-3} Q$	
	2588 VAr	Phase angle of: $\pm 30^\circ$	$1.0 \cdot 10^{-3} Q$	
		Phase angle: $\pm 15^\circ$		

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (discrete points)	25 kVAr	50 A / 500 V // 40 Hz to 850 Hz Phase angle: 90°	$85 \cdot 10^{-6} Q$	Q = AC reactive power Discrete points for current, voltage and phase angle
	21.7 kVAr	phase angle: $\pm 60^\circ$	$0.2 \cdot 10^{-3} Q$	
	12.5 kVAr	Phase angle of: $\pm 30^\circ$	$0.5 \cdot 10^{-3} Q$	
	6.5 kVAr	Phase angle: $\pm 15^\circ$	$1.0 \cdot 10^{-3} Q$	
	40 kVAr	80 A / 500 V // 40 Hz to 850 Hz Phase angle: 90°	$85 \cdot 10^{-6} Q$	
	34.6 kVAr	Phase angle: $\pm 60^\circ$	$0.2 \cdot 10^{-3} Q$	
	20 kVAr	Phase angle of: $\pm 30^\circ$	$0.5 \cdot 10^{-3} Q$	
	10.4 kVAr	Phase angle: $\pm 15^\circ$	$1.0 \cdot 10^{-3} Q$	
Alternating current reactive power Sources and measuring instruments (ranges)	50 μ VAr to 500 mVAr	50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz phase angle: $\pm 90^\circ$	$0.17 \cdot 10^{-3} Q$	Q = AC reactive power
		50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz phase angle: 90° to 60° Phase angle from: -90° to -60°	$0.2 \cdot 10^{-3} Q$	
		50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz Phase angle: 60° to 30°: Phase angle from: -60° to -30°	$0.3 \cdot 10^{-3} Q$	
		50 mV $\leq U \leq 5$ V 1 mA $\leq I \leq 100$ mA 10 Hz to 1 kHz phase angle: 30° to 15°: Phase angle from: -30° to -15°	$0.6 \cdot 10^{-3} Q$	
	> 500 mVAr to 500 VAr	5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 90°	$0.1 \cdot 10^{-3} Q$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 90° to 60° Phase angle from: -90° to -60°	$0.1 \cdot 10^{-3} Q$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 60° to 30° Phase angle from: -60° to -30°	$0.3 \cdot 10^{-3} Q$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 30° to 15°: Phase angle from: -30° to -15°	$0.6 \cdot 10^{-3} Q$	
		5 V $\leq U \leq 500$ V 100 mA $\leq I \leq 1$ A 16 Hz to 1 kHz Phase angle: 30° to 15°: Phase angle from: -30° to -15°	$0.6 \cdot 10^{-3} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (ranges)	> 500 VAR to 10 kVAR	25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 90°	0.1 × 10 ⁻³ Q	Q = AC reactive power
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 90° to 60° Phase angle: -90° to -60°	0.15 × 10 ⁻³ Q	
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 60° to 30°: Phase angle from: -60° to -30°	0.35 × 10 ⁻³ Q	
		25 V ≤ U ≤ 500 V 1 A ≤ I ≤ 20 A 16 Hz to 1 kHz Phase angle: 30° to 15°: Phase angle from: -30° to -15°	0.75 × 10 ⁻³ Q	
	50 μVAR to 500 μVAR	0.05 V to 0.5 V 1 mA > Phase angle from 1 kHz to 10 kHz: ±90° to ±60° Phase angle: <±60° to ±30° Phase angle: <±30° to ±15°	0.3 × 10 ⁻³ Q 0.8 × 10 ⁻³ Q 7.0 × 10 ⁻³ Q	
	> 0.5 mVAR to 200 mVAR	0.5 V to 1 V 1 mA to 1 kHz to 10 kHz Phase angle: ±90° to ±60° Phase angle: <±60° to ±30° Phase angle: <±30° to ±15°	0.2 × 10 ⁻³ Q 0.4 · 10 ⁻³ Q 0.8 · 10 ⁻³ Q	
	> 200 mVAR to 20 VAR	> 0.1 V to 1 V > 200 mA to 20 A > 1 kHz to 10 kHz Phase angle: ±90° to ±60° Phase angle: <±60° to ±30° Phase angle: <±30° to ±15°	1.0 × 10 ⁻³ Q 4.0 · 10 ⁻³ Q 8.0 · 10 ⁻³ Q	
	> 20 VAR to 100 VAR	> 0.1 V to 1 V > 20 A to 100 A > Phase angle from 1 kHz to 10 kHz: ±90° to ±60° Phase angle: <±60° to ±30° Phase angle: <±30° to ±15°	3.0 × 10 ⁻³ Q 6.0 · 10 ⁻³ Q 10.0 · 10 ⁻³ Q	
	10 mVAR to 200 mVAR	> 1 V to 10 V 1 mA to 1 kHz to 10 kHz Phase angle: ±90° to ±60°	0.3 · 10 ⁻³ Q	
		Phase angle: < ±60° to ±30° Phase angle: < ±30° to ±15°	0.7 · 10 ⁻³ Q 2.0 × 10 ⁻³ Q	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Alternating current reactive power Sources and measuring instruments (ranges)	> 200 mVAr to 20 VAr	> 1 V to 10 V > 200 mA to 20 A > 1 kHz to 10 kHz Phase angle: $\pm 90^\circ$ to $\pm 60^\circ$ phase angle: $< \pm 60^\circ$ to $\pm 30^\circ$ phase angle: $< \pm 30^\circ$ to $\pm 15^\circ$	$0.3 \times 10^{-3} Q$ $0.7 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	Q= AC reactive power
	> 20 VAr to 1,000 VAr	> 1 V to 10 V > 20 A to 100 A > 1 kHz to 10 kHz phase angle: $\pm 90^\circ$ to $\pm 60^\circ$ phase angle: $< \pm 60^\circ$ to $\pm 30^\circ$ phase angle: $< \pm 30^\circ$ to $\pm 15^\circ$	$2.0 \times 10^{-3} Q$ $5.0 \cdot 10^{-3} Q$ $10 \cdot 10^{-3} Q$	
	100 mVAr to 20 VAr	> 10 V to 100 V 1 mA to 200 mA > 1 kHz to 10 kHz Phase angle: $\pm 90^\circ$ to $\pm 60^\circ$ phase angle: $< \pm 60^\circ$ to $\pm 30^\circ$ phase angle: $< \pm 30^\circ$ to $\pm 15^\circ$	$0.5 \times 10^{-3} Q$ $1.0 \cdot 10^{-3} Q$ $2.0 \cdot 10^{-3} Q$	
	> 20 VAr to 1000 VAr	> 10 V to 100 V > 200 mA to 10 A > 1 kHz to 10 kHz Phase angle: $\pm 90^\circ$ to $\pm 60^\circ$ phase angle: $< \pm 60^\circ$ to $\pm 30^\circ$ phase angle: $< \pm 30^\circ$ to $\pm 15^\circ$	$1.5 \times 10^{-3} Q$ $3.0 \cdot 10^{-3} Q$ $7.0 \cdot 10^{-3} Q$	
	> 1 kVAr to 10 kVAr	> 10 V to 100 V > 10 A to 100 A > 1 kHz to 10 kHz phase angle: Phase angle from $\pm 90^\circ$ to $\pm 60^\circ$: $< \pm 60^\circ$ to $\pm 30^\circ$: $< \pm 30^\circ$ to $\pm 15^\circ$	$2.0 \times 10^{-3} Q$ $5.0 \cdot 10^{-3} Q$ $10.0 \cdot 10^{-3} Q$	
	> 10 kVAr to 80 kVAr	500 V $\leq U \leq 1000$ V 20 A $\leq I \leq 80$ A 40Hz to 850 Hz Phase angle: $\pm 90^\circ$	$85 \cdot 10^{-6} Q$	
		500 V $\leq U \leq 1000$ V 20 A $\leq I \leq 80$ A 40Hz to 850 Hz Phase angle: 90° to 60° Phase angles from: -90° to -60°	$0.25 \times 10^{-3} Q$	
		500 V $\leq U \leq 1000$ V 20 A $\leq I \leq 80$ A 40Hz to 850 Hz Phase angle: 60° to 30° : Phase angle from: -60° to -30°	$0.65 \times 10^{-3} Q$	
		500 V $\leq U \leq 1000$ V 20 A $\leq I \leq 80$ A 40Hz to 850 Hz Phase angle: 30° to 15° Phase angle from: -30° to -15°	$1.5 \times 10^{-3} Q$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current – apparent power Sources and measuring instruments (ranges)	50 μ VA to 500 μ VA	50 mV $\leq U \leq$ 500 mV I = 1 mA 10 Hz to 10 kHz	$0.17 \times 10^{-3} S$	S = AC reactive power
	500 μ VA to 5 mVA	U = 500 mV 10 mA $\leq I \leq$ 100 mA 10 Hz to 10 kHz	$0.16 \times 10^{-3} S$	
	5 mVA to 50 mVA	U = 500 mV 10 mA $\leq I \leq$ 100 mA 10 Hz to 10 kHz	$55 \cdot 10^{-6} S$	
	50 mVA to 500 mVA	500 mV $\leq U \leq$ 5 V I = 100 mA 10 Hz to 10 kHz	$30 \cdot 10^{-6} S$	
	500 mVA to 5 VA	5 V $\leq U \leq$ 50 V I = 100 mA 16 Hz to 10 kHz	$25 \cdot 10^{-6} S$	
	5 VA to 500 VA	50 V $\leq U \leq$ 500 V 100 mA $\leq I \leq$ 1 A 16 Hz to 10 kHz	$50 \cdot 10^{-6} S$	
	500 VA to 5 kVA	U = 500 V 1 A $\leq I \leq$ 10 A 16 Hz to 5 kHz	$60 \times 10^{-6} S$	
	5 kVA to 10 kVA	U = 500 V; 1 A $\leq I \leq$ 20 A 16 Hz to 5 kHz	$60 \cdot 10^{-6} S$	
	10 kVA to 80 kVA	500 V $\leq U \leq$ 1000 V 20 A $\leq I \leq$ 80 A 40 Hz to 850 Hz	$85 \cdot 10^{-6} S$	

Appendix to Accreditation Certificate D-K-15070-01-01

Kirchzarten Permanent Laboratory, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Harmonic overtones				Up to the 100th harmonic at most
Suspense				
Measuring instruments	1 V to 1000 V 1 V to 180 V	40 Hz to 850 Hz > 850 Hz to 5	$0.5 \cdot 10^{-3}$ $0.8 \cdot 10^{-3}$	
Sources	1 V to 1,000 V 1 V to 180 V	40 Hz to 850 Hz > 850 Hz to 5	$0.4 \cdot 10^{-3}$ $0.4 \cdot 10^{-3}$	
Electricity				
Measuring instruments	0.01 A to 80 A 0.01 A to 20 A	40 Hz to 850 Hz > 850 Hz to 5	$4.0 \cdot 10^{-3}$ 3.0 %	At low frequencies are possible trigger uncertainties U_{Tr} or U_{Tr} must be taken into account.
Sources	0.01 A to 80 A 0.01 A to 20 A	40 Hz to 850 Hz > 850 Hz to 5 kHz	$4.0 \cdot 10^{-3}$ 3.0 %	
Frequency	10 MHz	Measurement time > 30	$1 \cdot 10^{-11} f$	
Frequency measurement	1 mHz up to 46 GHz	Measurement time > 5 mins	$\sqrt{(1 \cdot 10^{-10} f)^2 + U_{Tr}^2}$	
Frequency synthesis	1 mHz up to 50 GHz		$1 \cdot 10^{-10} f$	
Time interval	1 ns up to 1000 s		$\sqrt{(1 \cdot 10^{-10} t)^2 + U_{Tr}^2 + 1 ns^2}$	
Speed				
(visual)	1 min ⁻¹ to $2 \cdot 10^5$ min ⁻¹	with a light-activated switch	$6 \cdot 10^{-6}$ but not less than 0.001 min ⁻¹	
mechanical	1 min ⁻¹ to 10,000 min ⁻¹		$4 \cdot 10^{-4}$ but not less than 0.01 min ⁻¹	
Oscilloscope calibrators				
Vertical deflection	1 mV to 5 V 1 mV to 200 V	Square-wave voltage: 10 Hz to 10 kHz $R_i = 1 \text{ M}$	$20 \cdot 10^{-6} + 1 \text{ } \mu\text{V}$	
Horizontal deflection	1 ns to 1 s > 1 s to 5 s	Timestamps Measurement time > 5 min $R_i =$	$(1 \cdot 10^{-10} t)^2 + U_{Tr}^2$ $\sqrt{(5 \cdot 10^{-10} t)^2 + U_{Tr}^2}$	$t =$ current reading Trigger uncertainty U_{Tr} to be taken into
Rise time t_r	18 ps to 100 ps > 100 ps to 10 ms	20 mV to 1 V	$\sqrt{8 \text{ ps}^2 + 4.5 \cdot 10^{-2} \cdot t_r + 3 \text{ ps}^2}$	External trigger signal required

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Oscilloscope measurement parameters	1 mV up to 5 V 1 mV to 120 V	Sine wave frequency 10 Hz to 10 kHz $R_i = 50$	0.35 per cent 0.35%	R_i Internal resistance
Horizontal deflection	50 ps to < 1 μ s 1 μ s to 5 s	Time markers or sine waves < 1 V	6 ps $1.5 \cdot 10^{-3} \cdot t$	t = current reading
Rise time t_r	180 ps to 450 ps > 450 ps to 10 ms	250 mV 250 mV to 1 V	40 ps $4.5 \cdot 10^{-2} \cdot t_r$	t_r = current ascent time
Bandwidth B	f_c 50 MHz to 26.5 GHz	0.2 V to 2 V $R_i = 50$ $ \Gamma_{oszi} \leq 0.05$ $ \Gamma_{oszi} \leq 0.1$ $ \Gamma_{oszi} \leq 0.15$ $ \Gamma_{oszi} \leq 0.2$	12 MHz 13 MHz 14 MHz 15 MHz	f_c = Frequency at the -3dB point $f_{Ref} = 5\% f_c$ $ \Gamma_{oszi} $: Oszi's reflection factor
Total Harmonic Distortion	0 to 0.3	100 Hz up to 50 kHz	$0.0001 + 0.0165 \cdot THD$	
THD / Total Harmonic Distortion	0 to 0.3 0 to 0.3	100 kHz to 2 GHz 100 Hz up to 50 kHz	$0.0001 + 0.0675 \cdot THD$ $0.001 + 0.007 \cdot THD_{Audio}$	
Flicker*) $\Delta U / U$ Frequency γ	0.4 to 5 0.0083 Hz to 40 Hz 10 minutes 2 hours	DIN EN 61000-4-15:2011 (115 V, 60 Hz); (230 V, 50 Hz) (115 V, 60 Hz); (230 V, 50 Hz)	$7 \cdot 10^{-3} \cdot \Delta U / U$ $3 \cdot 10^{-3} \cdot \Delta U / U$ 0.5% 1.7%	
P_{st} (Short Term) P_{lt} (Long Term)				
Transformation ratio of current transformers	40 A to 400 A (primary) 10 mA to 5 A (secondary) > 400 A to 4,000 A (primary) 100 mA to 5 A (secondary)	DC	$20 \cdot 10^{-6}$ $24 \cdot 10^{-6}$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - High-frequency
measurement parameters Calibration and measurement
capabilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
RF power	> 1 pW to 0.1 mW	2.5 MHz to 2 GHz	$(0.025 + 0.14 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5 ; 50 Ω; $ \Gamma $ KG ≤ 0.2
Power meters		> 2 GHz to 18 GHz > 18 GHz to 26.5 GHz	$(0.049 + 0.21 \cdot \Gamma) \cdot P$ $(0.071 + 0.32 \cdot \Gamma) \cdot P$	Connector system: PC-3.5; 50 Ω; $ \Gamma $ KG ≤ 0.2
RF power	> 1 pW to 0.1 mW	2.5 MHz to 2 GHz	$(0.035 + 0.13 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5 ; 50 Ω; $ \Gamma $ KG ≤ 0.2
Signal generators		> 2 GHz to 18 GHz 18 GHz to 26.5 GHz	$(0.053 + 0.2 \cdot \Gamma) \cdot P$ $(0.074 + 0.31 \cdot \Gamma) \cdot P$	Connector: PC-3.5; 50 Ω, $ \Gamma $ KG ≤ 0.2
	0.1 mW to 10 mW	9 kHz to <0.1 MHz	$17 \cdot 10^{-3} \cdot P$	N-connector; 50 Ω
		0.1 MHz to 50 MHz	$10 \cdot 10^{-3} \cdot P$	$ \Gamma \leq 0.3$
		>50 MHz to 6 GHz	$15 \cdot 10^{-3} \cdot P$	
		>6 GHz to 18 GHz	$20 \cdot 10^{-3} \cdot P$	
	10 mW to 50 W	0.1 MHz to 2 GHz	$20 \cdot 10^{-3} \cdot P$	$ \Gamma \leq 0.5$
		0.1 MHz to 2 GHz	$30 \cdot 10^{-3} \cdot P$	
		0.1 MHz to 2 GHz	$40 \cdot 10^{-3} \cdot P$	
		0.1 MHz to 2 GHz	$123 \cdot 10^{-3} \cdot P$	$ \Gamma $ of the KG ≤ 0.1 $ \Gamma $ of the KG ≤ 0.3 $ \Gamma $ for the KG ≤ 0.5
	0.1 mW to 10 mW	10 MHz to 1 GHz	$20 \cdot 10^{-3} \cdot P$	3.5 mm PC connector; 50 Ω; $ \Gamma \leq 0.3$
		> 1 GHz to 10 GHz	$30 \cdot 10^{-3} \cdot P$	
		> 10 GHz to 18 GHz	$40 \cdot 10^{-3} \cdot P$	
		> 18 GHz to 26.5 GHz	$45 \cdot 10^{-3} \cdot P$	
		10 MHz to 1 GHz	$40 \cdot 10^{-3} \cdot P$	$ \Gamma \leq 0.5$
		> 1 GHz to 10 GHz	$80 \cdot 10^{-3} \cdot P$	
		>10GHz to 18 GHz	$100 \cdot 10^{-3} \cdot P$	
		> 18 GHz to 26.5 GHz	$110 \cdot 10^{-3} \cdot P$	

3) When other connector systems are used, the measurement uncertainty increases.

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - High-frequency measurement parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments	
RF power Power meters	0.1 mW up to 10 mW	9 kHz to < 0.1 MHz	$17 \cdot 10^{-3} \cdot P$	N connector; 50 Ω ₃) Γ ≤ 0.3	
		0.1 MHz to 50 MHz	$6.0 \cdot 10^{-3} \cdot P$		
		> 50 MHz to 6 GHz	$12 \cdot 10^{-3} \cdot P$		
		> 6 GHz to 18 GHz	$20 \cdot 10^{-3} \cdot P$		
	> 10 mW to 50 W	32 MHz to 1 GHz	$20 \cdot 10^{-3} \cdot P$		
	0.1 mW up to 10 mW	10 MHz to 1 GHz	$10 \cdot 10^{-3} \cdot P$	PC-3.5 connector; 50 Ω ₃) Γ ≤ 0.3	
> 1 GHz to 10 GHz		$15 \cdot 10^{-3} \cdot P$			
> 10 GHz to 18 GHz		$20 \cdot 10^{-3} \cdot P$			
> 18 GHz to 26.5 GHz		$25 \cdot 10^{-3} \cdot P$			
Phase noise Signal generators	Phase noise relative to carrier amplitude in dBc/Hz > -87 dBc/Hz > -99 dBc/Hz > -104 dBc/Hz > -111 dBc/Hz > -131 dBc/Hz > -137 dBc/Hz	Offset frequency relative to the carrier frequency 100 Hz 1 kHz 10 kHz 100 kHz 1 MHz		Carrier frequency: 100 MHz – 1 GHz	
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
	> -80 dBc/Hz > -96 dBc/Hz > -101 dBc/Hz > -109 dBc/Hz > -126 dBc/Hz > -136 dBc/Hz	100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz	2.5 dB	> 1 MHz – 3 GHz	
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
	> -72 dBc/Hz > -93 dBc/Hz > -98 dBc/Hz > -106 dBc/Hz > -120 dBc/Hz > -135 dBc/Hz	100 Hz 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz	2.5 dB	> 3 GHz – 6 GHz	
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
			2.5 dB		
	HF noise indicator Receivers / Measuring	10 Hz up to 50 GHz	dbm/Hz to 0 dBm/Hz -165	1 dB	
	Signal level difference Measuring instruments / Sources	0 dBc up to 90 dBc	9 kHz to 7 GHz	1.5 dB	SNR > 20 dB
> 7 GHz to 13.6 GHz			2.3 dB		
>13.6 GHz to 26.5 GHz			3 dB		
> 90 dBc up to 100 dBc		9 kHz to 7 GHz	4.5 dB	SNR > 20 dB	
		> 7 GHz to 13.6 GHz > 13.6 GHz to 26.5 GHz	4.8 dB 5.3 dB		

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - High-frequency

measurement parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement	Test conditions / procedures	Expanded measurement uncertainty	Comments
Filter bandwidth Measuring instruments	1 Hz to 40 MHz		1 %	SNR > 70 dB
Form factor Measuring instruments	1:1 to 4:1 > 4:1 to 10:1 > 10:1 to 18:1		5.5% 7% 8.5 per cent	SNR > 20 dB
Amplitude modulation: Degree of modulation m	0.0 to ≤ 1.0	$f_{MOD} < 1 \text{ MHz}$	$0.004 + 0.025 \cdot m$	f_{HF} = carrier frequency $f_{HF} < 4 \text{ GHz}$ f_{MOD} = Modulation frequency Absolute
Frequency modulation Frequency shift Δf	0 Hz to 5 MHz	$f_{MOD} < 1 \text{ MHz}$	$0.041 \cdot \Delta f + 25 \text{ Hz}$	f_{HF} = Carrier frequency $f_{RF} < 4 \text{ GHz}$ f_{MOD} = modulation frequency Δf = frequency deviation Absolute measurement
Phase modulation Phase shift $\Delta\Phi$	0 to $(4 \text{ MHz} / f_{MOD}) \text{ rad}$	$f_{MOD} < 1 \text{ MHz}$	$0.025 \text{ rad} + 0.041 \cdot \Delta\Phi$	f_{HF} = Carrier frequency $f_{HF} < 4 \text{ GHz}$ f_{MOD} = Modulation frequency $\Delta\Phi$ = phase shift Absolute measurement
Distortion factor k	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	AM demodulation method f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{HF} = 0 \text{ dBm}$	0.030 0.029 0.025	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency P_{HF} = Carrier level
	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	FM and PM demodulation methods f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{HF} = 0 \text{ dBm}$ $\Delta f \leq 50 \text{ kHz}$	0.09	Absolute measurement uncertainty

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - High-frequency
measurement parameters Calibration and measurement
capabilities (CMC)

Measured variable / Calibration item	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Pulse-shaped measured variables *) Spectral stress- Amplitude density (Measuring/Displaying)	$S_0 = 13.5 \mu\text{Vs}$	DIN EN 55016-1-1:2020 CISPR 16-1-1:2019 CISPR Volume A 9 kHz to 0.15 MHz	0.30 dB	Pulse frequency 1 Hz to 100 Hz $f_G, f_L \leq 0.05$ (Plot)
	$S_0 = 0.316 \mu\text{Vs}$	CISPR Part B > 0.15 MHz to 30 MHz	0.30 dB	Heart rate 1 Hz to 1,000 Hz $f_G, f_L \leq 0.07$ (Display)
	$S_0 = 0.0044 \mu\text{Vs}$	CISPR Part C > 30 MHz to 300 MHz	0.36 dB	Heart rate 1 Hz to 1,000 Hz $f_G, f_L \leq 0.12$ (Display)
	$S_0 = 0.0044 \mu\text{Vs}$	CISPR Part D > 300 MHz to 1 GHz	0.40 dB	
HF current clamp *) Transfer certificate— Resistance dB(Ω)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 55016-1-2:2019 4.4 mA	0.3 dB 0.5 dB 0.8 dB	
HF Bulk Current Injection Clamp Meter*) Insertion loss (dB)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 61000-4-6:2014 4.4 mA	0.3 dB 0.5 dB 1.5 dB	
Burst generators *) Voltage pulse	100 V to 4,400 V	DIN EN 61000-4-4:2013 under load (R_L) at $R_L = 50 \Omega$ to $R_L = 1 \text{ k}\Omega$	2.2 %	$R_L = \text{load resistor}$
Ascent time and Pulse width	3 ns to 1 μs		2.5 %	
Burst duration and Burst period	100 ns to 1 s		0.25 %	
Surge generators *) Measuring and Plotting Voltage Amplitude	250 V to 7,000 V	DIN EN 61000-4-5:2019 with or without Coupling and Decoupling network	3.5 %	
Current amplitude	5 A to 5 kA		3.5 %	
Ascent time and Pulse width	400 ns to 1 ms		3.5 %	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanentes Laboratorium Kirchzarten, Gewerbestraße 3 - High-frequency measurement

parameters Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
HF attenuation	0 dB to 60 dB	9 kHz to 26.5 GHz > 26.5 GHz to 40GHz > 40 GHz to 50 GHz	0.06 dB 0.09 dB 0.11 dB	50 Ω connector: N50; PC-3.5; PC-2.4 ₃)
	> 60 dB up to 90 dB	9 kHz to 26.5 GHz	0.12 dB	
HF reflection coefficient	0 to 1	9 kHz to 10 GHz > 10 GHz to 18GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 50 GHz	0.003 + 0.0035 Γ 0.004 + 0.0040 Γ 0.004 + 0.0045 Γ 0.007 + 0.0060 Γ	50 Ω connector: N50; PC-3.5; PC-2.4 ₃) Γ : Amount of the complex Reflectance factor
HF attenuation Phase angle φ	-180° to 180°	9 kHz to 50 GHz	$U_S \cdot 180^\circ / \pi + K \cdot f$	$U_S = \arcsin(U(\Gamma)/ \Gamma)$ $K = 0.025^\circ/\text{GHz}$ 50 Ω connector: N50; PC-3.5; PC-2.4 ₃)
HF transmission phase, phase angle φ	-180° to 180°	9 kHz to 50 GHz	$U_T \cdot 180^\circ / \pi + K \cdot f + 0.3^\circ$	$U_T = \arcsin(10^{U/20} - 1)$ $K: 0.05^\circ/\text{GHz}$ U : Uncertainty regarding the
Electrostatic discharge (ESD)				I_p = first discharge current peak
Current pulse I_p	1 A to 120 A	DIN EN 61000-4-2	3.0%	I_{30} = current at 30 ns
Reference values	1 A to 120 A		3.5%	I_{60} = current at 60 ns
Current pulse	0.6 ns up to 1 μs		3.5%	
I_{30} Current	1 kV up to 30 kV		5.0%	
			0.5 %	

3) When other connector systems are used, the measurement uncertainty increases.

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Dimensional parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical calibration standards, gauge rings: Diameter *)	1 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), section 3.3.5 (Opt.1)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Gauging pins: Diameter *)	1 mm to 200 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter*)	0.1 mm to 30 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start cylindrical external and internal threads with straight edges, symmetrical profile)				
Threaded mandrels: simpler	1.4 mm to 200 mm nominal pitch: 0.3 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method d is the measured value
Threaded rings: simpler	Nominal pitch from 3 mm to 200 mm: 0.5 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-ball method d is the measured Diameter
Length *) of plane-parallel, spherical or cylindrical measuring surfaces*)	0.01 mm to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, Section 3.3.4(Opt.3), Point 3.3.5 (Opt. 4)	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges*)	0.03 mm to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Fitting dimensions for Clamp-on micrometres *)	25 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Dimensional measurements

Calibration and Measurement Capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Throat gauges *)	3 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)	$0.8\text{ }\mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and	0 mm to 500 mm > 500 mm up to 1000 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured Length
Depth caliper /		VDI/VDE/DGQ 2618 Part 9.2:2006	$50\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	
Height gauge *)		VDI/VDE/DGQ 2618 Part 9.3:2006		
Clamp-type micrometres *)	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Precision dial gauges*)	0 mm to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002		
Flush-mounted measuring	0 mm to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008		
Depth micrometers *)	0 mm to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010		
Internal micrometres with two-point contact on the calibration object *)	13 mm to 300 mm	VDI/VDE/DGQ 2618 Part 10.7:2010		
	> 300 mm to 500 mm		$5\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with a 2-line contact system	5 mm to 100 mm	3-APD-0-0025-EN 2023:07	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometers with a 3-line contact system	3 mm to 150 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring devices (quick-	up to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring devices (quick-	2 mm to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Dial gauges *)	0 mm to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Part 11.4:2020	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	electronic digital dial gauges
Fine pointer *)	0 mm to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	$0.6\text{ }\mu\text{m}$	
Sensor-arm gauges *)	0 mm to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	$1.0\text{ }\mu\text{m}$	
electrical inductive Length measuring devices *)	up to 100 mm	VDI/VDE/DGQ 2618 Sheet 14.1:2010	$0.6\text{ }\mu\text{m} + 1 \cdot 10^{-6} \cdot l$	
electronic incremental Length measuring devices	up to 100 mm	3-APD-0-0027-DE August 2023	$0.6\text{ }\mu\text{m} + 1 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Dimensional measurements

Calibration and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measuremen t span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Coordinate measurement technology Coordinate measuring machines with optical probing Measuring projectors, measuring microscopes *)	Devices with a single measuring plane with a diagonal measurement of $\leq$ 450 mm	Calibration of metrological characteristics in accordance with DKD-R 4-3 Sheet 18.1:2018, as well as the standards and guidelines listed below: DIN EN ISO		Measuring systems with visual probing or electronic edge detection
		Determination of the touch-off deviation P_{SX} , P_{SY} and P_{SZD} using a circular standard according to VDI/VDE 2617 Sheet 6.1:2021	0.5 μm	
		Determination of the scanning error of the image processing system P_{SVX} , P_{SVY} and P_{SVZD} using a circular normal in accordance with VDI/VDE 2617 Sheet 6.1:2021	0.5 μm	
		Determination of the length measurement deviation E_{UXY} , E_{UX} and E_{UY} using a ruler or circle template in accordance with DIN EN ISO 10360-7:2011	$0.5 \mu\text{m} + 0.7 \cdot 10^{-6} \cdot l$	/ is the measured length

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Dimensional measurements

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Coordinate measuring technology Coordinate measuring machines with optical probing		Determination of the length measurement error of the image processing system E_{UV} using a line scale or a circular matrix in accordance with DIN EN ISO 10360-7:2011	0.5 μm	
Measuring projectors, measuring microscopes *)	up to 100 mm	Determination of the length measurement deviation E_{UZ} using a parallel end gauge or a depth-setting standard in accordance with DIN EN ISO 10360-7:2011	$0.5 \mu\text{m} + 0.7 \cdot 10^{-6} \cdot l$	/ is the measured length
	up to 100 μm		0.25 μm	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV up to 2.2V > 2.2 V to 11 V > 11 V to 22 V > 22 V up to 220V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = set value
Direct current Sources	0 V 1 mV to 100 mV > 100 V up to 1 V > 1 V to 10 V > 10 V to 100V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	U = measured value
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5$ V	U = measured value
Direct current Measuring instruments and sources	0 A 0.1 μ A up to < 1 μ A 1 μ A to < 10 μ A 10 μ A up to < 100 μ A 100 μ A up to 320mA > 320 mA up to 1A > 1 A up to 10A > 10 A to > 150 A 150 A up to 2000 A	Precision Open Standard resistor and voltmeter	0.2 nA $35 \cdot 10^{-6} I + 21$ pA $50 \cdot 10^{-6} I + 6$ pA $15 \cdot 10^{-6} I + 0.4$ nA $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$ $0.3 \times 10^{-3} I$	I = set value
Direct current Current clamps	1 mA up to 2.2A > 2.2 A up to 20A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and Measurement Capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance	0 Ω		50 $\mu\Omega$	R = set value on the Fluke 5700A
	1 Ω ; 1.9 Ω		$95 \cdot 10^{-6} R$	
	10 Ω		$28 \cdot 10^{-6} R$	
	19 Ω		$27 \cdot 10^{-6} R$	
	100 Ω ; 190 Ω ;		$17 \cdot 10^{-6} R$	
	1 k Ω		$13 \cdot 10^{-6} R$	
	1.9 k Ω		$13 \cdot 10^{-6} R$	
	10 k Ω		$12 \cdot 10^{-6} R$	
	19 k Ω		$12 \cdot 10^{-6} R$	
	100 k Ω		$14 \cdot 10^{-6} R$	
	190 k Ω		$14 \cdot 10^{-6} R$	
	1 M Ω		$20 \cdot 10^{-6} R$	
	1.9 M Ω		$21 \cdot 10^{-6} R$	
	10 M Ω		$40 \cdot 10^{-6} R$	
	19 M Ω		$48 \cdot 10^{-6} R$	
	100 M Ω		$110 \cdot 10^{-6} R$	
	0 Ω		100 $\mu\Omega$	R = value measured by the HP 3458A
	1 Ω to 10 Ω		$16 \cdot 10^{-6} R + 50 \mu\Omega$	
	> 10 Ω to 100 Ω		$12 \cdot 10^{-6} R + 500 \mu\Omega$	
	> 100 Ω up to 1 k Ω		$15 \cdot 10^{-6} R$	
	> 1 k Ω to 10 k Ω		$15 \cdot 10^{-6} R$	
	> 10 k Ω to 100 k Ω		$15 \cdot 10^{-6} R$	
	> 100 k Ω to 1 M Ω		$35 \cdot 10^{-6} R$	
	> 1 M Ω to 10 M Ω		$150 \cdot 10^{-6} R$	
	> 10 M Ω to 100 M Ω		$600 \cdot 10^{-6} R$	
	> 100 M Ω up to 1 G Ω		$5 \cdot 10^{-3} R$	
	0.001 Ω to 0.1 Ω	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$	
	> 0.1 Ω to 1 M Ω		$20 \cdot 10^{-6} R$	
	> 1 M Ω up to 100 M Ω		$30 \cdot 10^{-6} R$	

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
DC resistance (ranges) Measuring instruments	1 Ω to < 11 Ω 11 Ω to < 33 Ω 33 Ω to < 110 Ω 110 Ω to < 330 Ω 330 Ω to < 1.1 kΩ 1.1 kΩ to < 3.3 kΩ 3.3 kΩ to < 11 kΩ 11 kΩ to < 33 kΩ 33 kΩ to < 110 kΩ 110 kΩ up to < 330 kΩ 330 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to < 33 MΩ 33 MΩ to < 110 MΩ 110 MΩ to < 330 MΩ 330 MΩ up to < 1.1 GΩ		$0.12 \cdot 10^{-3} R$ $33 \cdot 10^{-6} R$ $29 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $32 \cdot 10^{-6} R$ $33 \cdot 10^{-6} R$ $62 \cdot 10^{-6} R$ $0.13 \cdot 10^{-3} R$ $0.25 \cdot 10^{-3} R$ $0.5 \cdot 10^{-3} R$ $3 \cdot 10^{-3} R$ $15 \cdot 10^{-3} R$	R = set value for Fluke 5520A / 5522A
AC voltage measuring instruments and sources	1 mV to 2.2 mV > 2.2 mV to 7 mV	10 Hz to 20 Hz > 20 Hz to 40Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz 10 Hz to 20 Hz > 20 Hz to 40Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$0.52 \cdot 10^{-3} U$ $0.52 \cdot 10^{-3} U$ $0.40 \cdot 10^{-3} U$ $0.40 \cdot 10^{-3} U$ $0.41 \cdot 10^{-3} U$ $0.46 \cdot 10^{-3} U$ $0.55 \cdot 10^{-3} U$ $0.60 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.20 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.33 \cdot 10^{-3} U$ $0.45 \cdot 10^{-3} U$	U = measured value

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	
	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement capabilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	
	> 220 V to 1000 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 0.7 kV to 1 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$	
	> 1 kV to 7 kV		$3.5 \cdot 10^{-3} U + 2.0 V$	
Alternating current amperage Sources and measuring instruments	100 μ A to 1 mA	10 Hz to 40 Hz	$120 \cdot 10^{-6} I$	I = measured value
		> 40 Hz to 1 kHz;	$160 \cdot 10^{-6} I$	
		> 1 kHz to 10 kHz;	$60 \cdot 10^{-6} I$	
	> 1 mA to 10 mA	10 Hz to 40 Hz	$46 \cdot 10^{-6} I$	
		> 40 Hz to 1 kHz;		
		> 1 kHz to 10 kHz;		

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage Sources and measuring instruments	> 10 mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} /$	/ = measured value
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} /$	
	> 10 A to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} /$	
	> 20 A up to 100 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$69 \cdot 10^{-6} /$ $69 \cdot 10^{-6} /$ $0.17 \cdot 10^{-3} /$	
Sources	100 A up to 2000 A	50 Hz	$3.0 \cdot 10^{-3} \cdot /$	Current transformer
Current clamps	1 mA up to 2.2 A	40 Hz to 5 kHz	$2 \cdot 10^{-3} /$	/ = measured value
	> 2.2 A up to 20 A	40 Hz to 5 kHz	$3 \cdot 10^{-3} /$	
	> 20 A up to 800 A	40 Hz to 65 Hz	$4 \cdot 10^{-3} /$	
Capacity of measuring instruments	190 pF up to <400pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to <110nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μF	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF up to <3.3μF	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF to < 33μF	10 Hz up to 120Hz	$6.0 \cdot 10^{-3} C$	
	33 μF up to <110μF	10 Hz to 80Hz	$6.5 \cdot 10^{-3} C$	
	110 μF to < 330 μF	DC up to 50Hz	$6.0 \cdot 10^{-3} C$	
	330 μF up to <1.1 mF	DC up to 20Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to <3.3mF	DC to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF up to <11mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 100nF	50 Hz to 10 kHz	$1.0 \times 10^{-3} C$	
	> 100 nF up to 1000 nF	50Hz to 1 kHz > 1 kHz to 10 kHz	$1.0 \cdot 10^{-3} C$ $2.5 \cdot 10^{-3} C$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measuremen t span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Frequency	1 mHz to 46 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tf}$	f = current reading U_{Tf} = Trigger uncertainty
Time interval	1 μ s to 1000 s min ⁻¹		$2 \cdot 10^{-9} \cdot t + 2$ ns	t = current reading
Rotational speed visually	1 min ⁻¹ up to 100,000	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV up to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μ W to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300	Product of U and I:	$30 \cdot 10^{-6} P$	P calculated power
	W > 300 W up to 1 kW	1 mV $\leq U \leq$ 1000 V	$200 \cdot 10^{-6} P$	
	> 1 kW up to 1 MW	100 μ A $\leq I \leq$ 2000 A	$300 \cdot 10^{-6} P$	
Active AC power		1 V to 1000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$	Uncertainty in the amplitude of the fundamental voltage Uncertainty of the amplitude of the current fundamental Φ Uncertainty in the phase shift angle Uncertainty of the root mean square voltage Uncertainty of the root mean square value of the current
	5 mW up to 50 kW > 2.5 W up to 120 kW	0.1 A to 50 A > 50 A to 120 A	not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	
		1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$	
Reactive power		0.1 A to 50 A > 50 A to 120 A	not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	
	5 mvar up to 50 kvar > 2.5 var up to 120			
	0.1 VA up to 50 kVA > 50 VA up to 120	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical quantities

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tension	$\pm 2 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz Measurement	0.04 $\mu\text{V/V}$ 0.05 $\mu\text{V/V}$ 1.0 $\mu\text{V/V}$	Calibration of 350 Ω bridge standards and the associated indicating instruments
	$\pm 2 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	0.05 $\mu\text{V/V}$ 0.05 $\mu\text{V/V}$ 1.0 $\mu\text{V/V}$	at discrete points in 10 per cent increments
	$\pm 5 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz	0.15 $\mu\text{V/V}$ 1.0 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz	0.10 $\mu\text{V/V}$ 0.30 $\mu\text{V/V}$	
	$\pm 5 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	0.1 $\mu\text{V/V}$ 0.1 $\mu\text{V/V}$ 1.0 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement	0.4 $\mu\text{V/V}$ 0.4 $\mu\text{V/V}$ 0.4 $\mu\text{V/V}$	Calibration of 350 Ω bridge standards and the associated indicating instruments
	$\pm 10 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	0.40 $\mu\text{V/V}$	at discrete points in 10 per cent increments
	$\pm 20 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	0.60 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 1 V Measurement frequency	5.0 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency	5.0 $\mu\text{V/V}$	

Appendix to Accreditation Certificate D-K-15070-01-01
On-site calibration – Electrical parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tension Direct current Bridge standards	0 mV/V -2 mV/V to +2 mV/V 5mV/V to +5 mV/V -10mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 0.5 V	2.0 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1.0 V	1.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V	0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 5.0 V	0.3 μ V/V 0.25 μ V/V 0.25 μ V/V 0.25 μ V/V 0.35 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 7.5 V	0.2 μ V/V 0.2 μ V/V 0.2 μ V/V 0.2 μ V/V 0.3 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 10.0 V	0.1 μ V/V 0.15 μ V/V 0.15 μ V/V 0.2 μ V/V 0.3 μ V/V 1.5 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – Electrical parameters

Calibration and measurement services (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tension Direct current Bridges, measuring instruments, Measurement amplifier	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 0.5 V	0.35 μ V/V 0.35 μ V/V 0.40 μ V/V 0.55 μ V/V 2.5 μ V/V	With K148
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1 V	0.20 μ V/V 0.20 μ V/V 0.30 μ V/V 0.50 μ V/V 2.5 μ V/V	
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V; 5 V; 7.5 V; 10 V	0.10 μ V/V 0.15 μ V/V 0.25 μ V/V 0.45 μ V/V 2.5 μ V/V	
Alternating current – active energy single-phase Measuring instruments	150 Ws up to 5.76 MWs	45 Hz to 65 Hz $0.25 \leq \cos \varphi_f \leq 1$ $t = 100$ s 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10^{-3}$	Measurement uncertainty relative to the apparent energy
Alternating current reactive power single-phase Measuring instruments	150 vars up to 5.76 Mvars	45 Hz to 65 Hz $0.25 \leq \sin \varphi_f \leq 1$ $t = 100$ s 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10^{-3}$	
Reactive power in alternating current single-phase Measuring instruments	600 VAs up to 5.76 MVAs	45 Hz to 65 Hz, $t = 100$ s 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10^{-3}$	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – high-frequency and radiation parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Oscilloscope measurement parameters: vertical deflection	5 mV to 5 V	$R_i = 50 \Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$	Rectangular stress 10 Hz to 10 kHz
	5 mV up to 120 V	$R_i = 1 M\Omega$	$2.4 \cdot 10^{-3} U + 40 \mu V$	
	5 ns to 520 ms		$3 \cdot 10^{-6} t + 1 \text{ ns}$	t : current time t_r = intrinsic rise time of the oscilloscope
	> 20 ms up to 5 s		$30 \cdot 10^{-6} t + 1.2 \cdot 10^{-3} t^2$	
Horizontal deflection	150 ps up to 10 ms	250 mV	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$	t_r = intrinsic rise time of the oscilloscope
Ascent time	250 ps up to 10 ms	> 250 mV to 2.5 V $R_i = 50 \Omega$	$35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	
HF impedance (reflection coefficient) Single-gate measurement $ S_{11} $ Amount $ \Gamma $	0.0 to 1.0	45 MHz up to 5 GHz	$0.01 + 0.01 \Gamma $	Connector; PC-7; 50 Ω
		> 5 GHz up to 18 GHz	$0.015 + 0.01 \Gamma $	
		9 kHz to 5 GHz	$0.01 + 0.01 \Gamma $	N-connector; 50 Ω
		> 5 GHz up to 18 GHz	$0.015 + 0.01 \Gamma $	
Phase ϕ	-180° to 180°	45 MHz to 5 GHz	$0.01 + 0.005 \Gamma $	Connector; PC 3.5; 50 Ω
		> 5 GHz up to 18 GHz	$0.015 + 0.01 \Gamma $	
		> 18 GHz up to 26.5 GHz	$0.02 + 0.02 \Gamma $	
Phase ϕ	-180° to 180°	9 kHz up to 18 GHz	$\arcsin \frac{U(\Gamma)}{ \Gamma } \cdot \frac{180^\circ}{\pi}$	N-connector; 50 Ω .
		$0.1 \leq \Gamma \leq 1$		
		45 MHz up to 18 GHz		PC-7; 50 Ω
		45 MHz up to 26.5 GHz		PC-3.5
Phase ϕ	-180° to 180°	$0.1 \leq \Gamma \leq 1$		
		up to 1 GHz		

Appendix to Accreditation Certificate D-K-15070-01-01
On-site calibration – high-frequency and radiation parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
HF impedance (Reflectance) Second-order measurement $ S_{11} $ & $ S_{22} $ Amount $ \Gamma $	0.0 to 1.0	45 MHz to 5 GHz > 5 GHz up to 18 GHz	$0.015 + 0.01 \Gamma $ $0.02 + 0.01 \Gamma $	PC-7; 50 Ω ₃)
		9 kHz to 5 GHz > 5 GHz up to 18 GHz	$0.015 + 0.01 \Gamma $ $0.02 + 0.01 \Gamma $	N-connector; 50 Ω . 3)
		45 MHz to 5 GHz > 5 GHz up to 18 GHz > 18 GHz up to 26.5 GHz	$0.01 + 0.005 \Gamma $ $0.015 + 0.01 \Gamma $ $0.02 + 0.02 \Gamma $	PC-3.5 ₃)
	-180° to 180°	9 kHz to 18 GHz $0.1 \leq \Gamma \leq 1$	$\arcsin \frac{U(\Gamma)}{ \Gamma } \cdot \frac{180^\circ}{\pi}$	N-connector; 50 Ω .
		45 MHz up to 18 GHz $0.1 \leq \Gamma \leq 1$		PC-7; 50 Ω
		45 MHz up to 26.5 GHz $0.1 \leq \Gamma \leq 1$ GHz		PC-3.5
HF - Attenuation Switchable attenuators, Fixed attenuators Absolute Damping values	0 dB to 60 dB	9 kHz to 18 GHz	0.3 dB	Connector system: N; 50 Ω $I/\Gamma \leq 0.1$
	> 60 dB to 90 dB		0.3 dB	
	0 dB to 60 dB	45 MHz to 20 GHz > 20 GHz to 26.5 GHz	0.3 dB 0.5 dB	Connector system PC-3.5; 50 Ω 45 MHz to 20 GHz $I/\Gamma \leq 0.1$ < 20 GHz to 26.5 GHz $I/\Gamma \leq 0.15$
	> 60 dB to 90 dB	45 MHz to 20 GHz > 20 GHz to 26.5 GHz	0.3 dB 0.5 dB	
RF power Power meters	> 1 pW to 0.1 mW	2.5 MHz to 2 GHz > 2 GHz to 18 GHz > 18 GHz to 26.5 GHz	$(0.025 + 0.14 \cdot \Gamma) \cdot P$ $(0.049 + 0.21 \cdot \Gamma) \cdot P$ $(0.071 + 0.32 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5; 50 Ω ; $ \Gamma $ KG ≤ 0.2
RF power Signal generators	> 1 pW up to 0.1 mW	2.5 MHz to 2 GHz > 2 GHz to 18 GHz > 18 GHz to 26.5 GHz	$(0.035 + 0.13 \cdot \Gamma) \cdot P$ $(0.053 + 0.2 \cdot \Gamma) \cdot P$ $(0.074 + 0.31 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5; 50 Ω ; $ \Gamma $ KG ≤ 0.2
		9 kHz to 50 MHz > 50 to 5 GHz > 5 GHz up to 18 GHz	$17 \cdot 10^{-3} \cdot P$ $22 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$	
	0.1 mW up to 10 mW	50 MHz to 5 GHz > 5 GHz up to 18 GHz > 18 GHz to 26.5 GHz	$22 \cdot 10^{-3} \cdot P$ $32 \cdot 10^{-3} \cdot P$ $40 \cdot 10^{-3} \cdot P$	PC 3.5 connector; 50 Ω ₃) $ \Gamma \leq 0.3$

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – high-frequency and radiation parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
RF power Power meters	0.1 mW up to 10 mW	9 kHz to 50 MHz > 50 MHz to 5 GHz > 5 GHz to 18 GHz	$17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $28 \cdot 10^{-3} \cdot P$	N-type connector; 50 Ω ₃ $ \Gamma \leq 0.3$
	0.1 mW up to 10 mW	50 MHz to 5 GHz > 5 GHz to 18 GHz > 18 GHz to 26.5 GHz	$22 \cdot 10^{-3} \cdot P$ $32 \cdot 10^{-3} \cdot P$ $40 \cdot 10^{-3} \cdot P$	3.5 mm PC connector; 50 Ω ₃ $ \Gamma \leq 0.3$
Signal level difference Measuring instruments / Sources	0 dBc up to 90 dBc	9 kHz to 7 GHz > 7 GHz to 13.6 GHz > 13.6 GHz to 26.5 GHz	1.5 dB 2.3 dB 3 dB	SNR > 20 dB
	> 90 dBc up to 100 dBc	9 kHz to 7 GHz > 7 GHz to 13.6 GHz > 13.6 GHz to 26.5 GHz	4.5 dB 4.8 dB 5.3 dB	SNR > 20 dB
Filter bandwidth Measuring instruments	1 Hz to 40 MHz		1 per cent	SNR > 70 dB
HF noise indicator Receivers / Measuring	10 Hz up to 50 GHz	-165 dBm/Hz to 0 dBm/Hz	1 dB	
Form factor Measuring instruments	1:1 to 4:1		5.5 %	SNR > 20 dB
	> 4:1 to 10:1		7 %	
	> 10:1 to 18:1		8.5 %	

3) When other connector systems are used, the measurement uncertainty increases.

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – high-frequency and radiation parameters

Calibration and measurement capabilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Amplitude modulation: Degree of modulation m	0.0 to ≤ 1.0	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.004 + 0.025 \cdot m$	f_{HF} = carrier frequency f_{MOD} = Modulation frequency
Frequency modulation Frequency shift Δf	0 Hz to 5 MHz	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.041 \cdot \Delta f + 25 \text{ Hz}$	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency
Phase modulation Phase shift $\Delta\Phi$	0 to $(4 \text{ MHz} / f_{MOD}) \text{ rad}$	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.025 \text{ rad} + 0.041 \cdot \Delta\Phi$	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency
Distortion factor k	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	AM demodulation method f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{HF} = 0 \text{ dBm}$	0.030 0.029 0.025	f_{HF} = carrier frequency f_{MOD} = Modulation frequency P_{HF} = Carrier level
	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	FM & PM demodulation methods f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{HF} = 0 \text{ dBm}$ $\Delta f \leq 50 \text{ kHz}$	0.09	Absolute measurement uncertainty
Pulse-shaped measured quantities*) Spectral stress- Amplitude density (Measuring/Displaying)	$S_0 = 13.5 \text{ } \mu\text{Vs}$	DIN EN 55016-1-1:2020 CISPR 16-1-1:2019 CISPR Part A 9 kHz to 0.15 MHz	0.50 dB	Pulse frequency 1 Hz to 100 Hz $\Gamma_G, \Gamma_L \leq 0.05$ (Plot)
	$S_0 = 0.316 \text{ } \mu\text{Vs}$	CISPR Part B > 0.15 MHz to 30 MHz	0.50 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.07$ (Plot)
	$S_0 = 0.0044 \text{ } \mu\text{Vs}$	CISPR Part C > 30 MHz to 300 MHz	0.6 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.12$ (Plot)
	$S_0 = 0.0044 \text{ } \mu\text{Vs}$	CISPR Part D > 300 MHz to 1 GHz	0.6 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.12$ (Plot)
HF current clamp*) Transfer certificate— Resistance dB(Ω)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 55016-1-2:2019 4.4 mA	0.3 dB 0.5 dB 0.8 dB	
HF Bulk Current Injection Clamp Meter Insertion loss (dB)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 61000-4-6:2014 4.4 mA	0.3 dB 0.5 dB 1.5 dB	

Appendix to Accreditation Certificate D-K-15070-01-01

On-site calibration – high-frequency and radiation parameters

Calibration and measurement services (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Phase noise Signal generators	Phase noise relative to carrier amplitude in dBc/Hz	Offset frequency relative to the carrier frequency		Carrier frequency:
	> -87 dBc/Hz	100 Hz	2.5 dB	100 MHz – 1 GHz
	> -99 dBc/Hz	1 kHz	2.5 dB	
	> -104 dBc/Hz	10 kHz	2.5 dB	
	> -111 dBc/Hz	100 kHz	2.5 dB	
	> -131 dBc/Hz	1 MHz	2.5 dB	
	> -137 dBc/Hz		2.5 dB	
	> -80 dBc/Hz	100 Hz,	2.5 dB	> 1 MHz – 3 GHz
	> -96 dBc/Hz	1 kHz,	2.5 dB	
	> -101 dBc/Hz	10 kHz,	2.5 dB	
	> -109 dBc/Hz	100kHz,	2.5 dB	
	> -126 dBc/Hz	1 MHz	2.5 dB	
	> -136 dBc/Hz	10 MHz	2.5 dB	
	> -72 dBc/Hz	100 Hz	2.5 dB	> 3 GHz – 6 GHz
	> -93 dBc/Hz	1 kHz	2.5 dB	
	> -98 dBc/Hz	10 kHz	2.5 dB	
	> -106 dBc/Hz	100 kHz	2.5 dB	
	> -120 dBc/Hz	1 MHz	2.5 dB	
	> -135 dBc/Hz	10 MHz	2.5 dB	
Voltage pulse burst generators	100 V up to 4400 V	DIN EN 61000-4-4:2013 under load(R_L) across $R_L = 50\Omega$ across $R_L = 1k\Omega$	2.2 %	R_L = Load resistance
	3 ns up to 1 μ s		2.5 %	
	100 ns up to 1 s		0.25 %	
	250 V up to 7000 V	DIN EN 61000-4-5:2019 with or without a coupling and decoupling network	3.5 %	
	5 A up to 5 kA		3.5 %	
	400 ns to 1 ms		3.5 %	
Rise time and pulse width				
Burst duration and burst period				
Surge generators				
Voltage amplitude				
Current amplitude				
Rise time and				

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V to 220 V > 220 V to 1,000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = set value
Direct current Sources	0 V 1 mV to 100 mV > 100 V to 1 V > 1 V to 10 V > 10 V to 100 V > 100 V to 1,000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	U = measured value
High voltage	> 1 kV to 10 kV		$2.5 \cdot 10^{-3} U + 2.5$ V	U = measured value
Direct current Measuring instruments and sources	0 A 0,1 μ A to < 1 μ A 1 μ A to < 10 μ A 10 μ A to < 100 μ A 100 μ A to 320 mA > 320 mA to 1 A > 1 A to 10 A > 10 A to > 150 A 150 A to 2000 A	Precision Open Standard resistor and voltmeter Current transformer	0.2 nA $35 \cdot 10^{-6} I + 21$ pA $50 \cdot 10^{-6} I + 6$ pA $15 \cdot 10^{-6} I + 0.4$ nA $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$ $0.3 \times 10^{-3} I$	I = set value
Direct current Current clamps	1 mA to 2.2 A > 2.2 A to 20 A > 20 A to 1,000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC resistance	0 Ω		50 $\mu\Omega$	R = set value on the Fluke 5700A
	1 Ω ; 1.9 Ω		$95 \cdot 10^{-6} R$	
	10 Ω		$28 \cdot 10^{-6} R$	
	19 Ω		$27 \cdot 10^{-6} R$	
	100 Ω ; 190 Ω ;		$17 \cdot 10^{-6} R$	
	1 k Ω		$13 \cdot 10^{-6} R$	
	1.9 k Ω		$13 \cdot 10^{-6} R$	
	10 k Ω		$12 \cdot 10^{-6} R$	
	19 k Ω		$12 \cdot 10^{-6} R$	
	100 k Ω		$14 \cdot 10^{-6} R$	
	190 k Ω		$14 \cdot 10^{-6} R$	
	1 M Ω		$20 \cdot 10^{-6} R$	
	1.9 M Ω		$21 \cdot 10^{-6} R$	
	10 M Ω		$40 \cdot 10^{-6} R$	
	19 M Ω		$48 \cdot 10^{-6} R$	
	100 M Ω		$110 \cdot 10^{-6} R$	
	0 Ω		100 $\mu\Omega$	R = value measured by HP 3458A
	1 Ω to 10 Ω		$16 \cdot 10^{-6} R + 50 \mu\Omega$	
	> 10 Ω to 100 Ω		$12 \cdot 10^{-6} R + 500 \mu\Omega$	
	> 100 Ω to 1 k Ω		$15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$	
	> 1 k Ω to 10 k Ω		$15 \cdot 10^{-6} R$ $35 \cdot 10^{-6} R$	
	> 10 k Ω to 100 k Ω		$150 \cdot 10^{-6} R$ $600 \cdot 10^{-6} R$	
	> 100 k Ω to 1 M Ω		$5 \cdot 10^{-3} R$	
	> 1 M Ω to 10 M Ω			
	> 10 M Ω to 100 M Ω			
	> 100 M Ω to 1 G Ω			
	0.001 Ω to 0.1 Ω	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$	
	> 0.1 Ω to 1 M Ω		$20 \cdot 10^{-6} R$	
	> 1 M Ω to 100 M Ω		$30 \cdot 10^{-6} R$	

Mobile Laboratory – Electrical Parameters

Calibration and measurement capabilities (CMC)

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Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and Measurement Capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	
	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 220 V to 10 00 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 0.7 kV to 1 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$	
	> 1 kV to 7 kV		$3.5 \cdot 10^{-3} U + 2.0 V$	
Alternating current amperage Sources and measuring instruments	100 μ A to 1 nA	10 Hz to 40 Hz	$120 \cdot 10^{-6} I$	I = measured value
		> 40 Hz to 1 kHz;	$160 \cdot 10^{-6} I$	
		> 1 kHz to 10 kHz;	$60 \cdot 10^{-6} I$	
	> 1 mA to 10 mA	10 Hz to 40 Hz	$46 \cdot 10^{-6} I$	
	> 10 mA to 1 A	10 Hz to 40 Hz	$17 \cdot 10^{-6} I$	I = measured value
		> 40 Hz to 1 kHz;		
		> 1 kHz to 10 kHz;		
	> 1 A to 10 A	10 Hz to 40 Hz	$32 \cdot 10^{-6} I$	
		> 40 Hz to 1 kHz;		
		> 1 kHz to 10 kHz;		
	> 10 A to 20 A	10 Hz to 40 Hz	$39 \cdot 10^{-6} I$	
		> 40 Hz to 1 kHz;		
	> 20 A up to 100 A	10 Hz to 40 Hz	$69 \cdot 10^{-6} I$	
		> 40 Hz to 1 kHz;	$69 \cdot 10^{-6} I$	
		> 1 kHz to 10 kHz;	$0.17 \cdot 10^{-3} I$	
Current clamps	1 mA up to 2.2 A	40 Hz to 5 kHz	$2 \cdot 10^{-3} I$	I = measured value
	> 2.2 A to 20 A	40 Hz to 5 kHz	$3 \cdot 10^{-3} I$	
	> 20 A up to 800 A	40 Hz up to 65 Hz	$4 \cdot 10^{-3} I$	
Capacity of measuring instruments	190 pF up to <400 pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 pF$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 pF$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 pF$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 pF$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 pF$	
	33 nF up to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 pF$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF up to < 1.1 μ F	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μ F up to < 3.3 μ F	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μ F up to < 11 μ F	10 Hz up to 150 Hz	$4.5 \cdot 10^{-3} C$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement capabilities (CMC)				
Measurement parameter / Calibration item	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Capacity of measuring instruments	11 μ F up to < 33 μ F	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	With 5520A / 5522A
	33 μ F up to < 110 μ F	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μ F up to < 330 μ F	DC up to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μ F to < 1.1 mF	DC up to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC up to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 100 nF	50 Hz to 10 kHz	$1.0 \cdot 10^{-3} C$	C: value measured using standard capacitances
	> 100 nF to 1000 nF	Hz to 1 kHz	$1.0 \cdot 10^{-3} C$	
		> 1 kHz up to 10 kHz	$2.5 \cdot 10^{-3} C$	
Frequency	1 mHz to 46 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tr}$	f = current measured value U_{Tr} = Trigger uncertainty
Time interval	1 μ s to 1000 s		$2 \cdot 10^{-9} \cdot t + 2$ ns	t = current reading
Rotational speed visually	1 min ⁻¹ to 100,000 min ⁻¹	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV up to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μ W to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300 W	Product of U and I 1	$30 \cdot 10^{-6} P$	P : calculated power
	> 300 W to 1 kW	mV $\leq U \leq 1000$ V	$200 \cdot 10^{-6} P$	
	> 1 kW to 1 MW	100 μ A $\leq I \leq 2000$ A	$300 \cdot 10^{-6} P$	
Active AC power	5 mW up to 50 kW > 2.5 W up to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$w(U_F)$... Uncertainty in the amplitude of the fundamental voltage $w(I_F)$... Uncertainty in the amplitude of the current fundamental $W(\Phi_F)$... Uncertainty in the phase-shift angle $W(U_{rms})$... Uncertainty of the root-mean-square voltage value $W(I_{rms})$... Uncertainty of the root mean square value of the current
AC reactive power	5 mvar up to 50 kvar > 2.5 var to 120 kvar	1 V to 1,000 V, 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120 kVA	1 V to 1000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than 80×10^{-6} not less than 0.14×10^{-3}	
Alternating current Total Harmonic Distortion (THD)	0 to 0.3	0.1 kHz to 50 kHz	$0.0002 + 0.0165 \times \text{THD}$	
Direct current strength Current transformer	1 A to 120 A > 120 A to 1000 A > 1,000 A to 2,000 A		$0.15 \times 10^{-3} \times I$ $0.20 \cdot 10^{-3} \cdot I$ $0.30 \cdot 10^{-3} \cdot I$	I = measured value
Alternating current Current transformer	1 A to 20 A > 20 A to 1000 A	50 Hz 50 Hz	$0.7 \times 10^{-3} \times I + 0.01 \text{ A}$ $5.2 \times 10^{-3} \cdot I + 0.05 \text{ A}$	I = measured value
Alternating current amperage	1 A to 750 A	40 Hz to 1.2 kHz	$90 \cdot 10^{-6} \cdot I$	I = measured value
	> 750 A to 2000 A	40 Hz to 100 Hz	$95 \cdot 10^{-6} \cdot I$	
	1 A to 450 A	> 1.2 kHz to 2 kHz	$0.40 \times 10^{-3} \times I$	
	1 A to 100 A	> 2 kHz to 7.5 kHz	$0.41 \times 10^{-3} \times I$	
Direct current resistance Measuring instruments	330 MΩ to < 1 GΩ 1 GΩ to < 10 GΩ 10 GΩ to < 100 GΩ 0.1 TΩ to < 1 TΩ 1 TΩ to 10 TΩ	U < 1575 V with a x1000 multiplier, U ≤ 10 kV	$4 \cdot 10^{-3} \cdot R$ $8 \cdot 10^{-3} \cdot R$ $25 \cdot 10^{-3} \cdot R$ $30 \cdot 10^{-3} \cdot R$ $35 \cdot 10^{-3} \cdot R$	
AC resistance discrete values Measuring instruments	1 mΩ 3 mΩ 10 mΩ 30 mΩ 0.1 Ω 0.3 Ω 1 Ω 3 Ω	50 Hz to 1 kHz 50 Hz to 1 kHz	$1.0 \times 10^{-3} \times R$ $0.4 \times 10^{-3} \times R$	R: Measured value
AC resistance meters for earth resistance and internal battery resistance	0.1 Ω to < 5 Ω 5 Ω to < 30 Ω 30 Ω to < 200 Ω 200 Ω to < 500 Ω 0.5 kΩ to < 2 kΩ 2 kΩ to < 5 kΩ 5 kΩ to 10 kΩ	I _{max} < 700 mA I _{max} < 250 mA I _{max} < 100 mA I _{max} < 45 mA I _{max} < 25 mA I _{max} < 10 mA I _{max} < 5 mA	$2.3 \times 10^{-3} \times R + 8 \text{ mΩ}$ $1.6 \times 10^{-3} \times R + 8 \text{ mΩ}$ $1.6 \times 10^{-3} \times R + 8 \text{ mΩ}$ $1.6 \times 10^{-3} \times R$ $1.6 \times 10^{-3} \times R$ $1.6 \times 10^{-3} \times R$ $1.6 \times 10^{-3} \times R$	A: Measured value 50 Hz to 400 Hz
Earth conductor resistance testers	7 mΩ to 38 mΩ 19 mΩ to 75 mΩ 65 mΩ to 130 mΩ 260 mΩ to 410 mΩ	I _{max} < 40 A I _{max} < 40 A I _{max} < 40 A I _{max} < 40 A	0.5 mΩ 0.6 mΩ 1.0 mΩ 1.6 mΩ	50 Hz and 60 Hz

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Earth conductor resistance testers	440 mΩ to 550 mΩ	$I_{max} < 40 \text{ A}$	2.2 mΩ	
	0.8 Ω to 1.1 Ω	$I_{max} < 40 \text{ A}$	4 mΩ	
	1.5 Ω to 2.0 Ω	$I_{max} < 30 \text{ A}$	7 mΩ	
	4.2 Ω to 5.5 Ω	$I_{max} < 21 \text{ A}$	20 mΩ	
	8 Ω to 11 Ω	$I_{max} < 15 \text{ A}$	35 mΩ	
	15 Ω to 20 Ω	$I_{max} < 10 \text{ A}$	35 mΩ	
	42 Ω to 55 Ω	$I_{max} < 5 \text{ A}$	0.25 Ω	
	80 Ω to 110 Ω	$I_{max} < 3 \text{ A}$	0.4 Ω	
	150 Ω to 200 Ω	$I_{max} < 1.35 \text{ A}$	0.8 Ω	
	420 Ω to 550 Ω	$I_{max} < 0.6 \text{ A}$	2 Ω	
	0.8 kΩ to 1.1 kΩ	$I_{max} < 0.3 \text{ A}$	4 Ω	
	1.5 kΩ to 2.0 kΩ	$I_{max} < 0.15 \text{ A}$	8 Ω	
Measuring instruments for loop resistance and internal network resistance	7 mΩ to 38 mΩ	$I_{max} < 40 \text{ A}$	16 mΩ	A: Measured value 50 Hz to 400 Hz
	19 mΩ to 75 mΩ	$I_{max} < 40 \text{ A}$	16 mΩ	
	65 mΩ to 130 mΩ	$I_{max} < 40 \text{ A}$	16 mΩ	
	260 mΩ to 410 mΩ	$I_{max} < 40 \text{ A}$	20 mΩ	
	440 mΩ to 550 mΩ	$I_{max} < 40 \text{ A}$	22 mΩ	
	0.8 Ω to 1.1 Ω	$I_{max} < 40 \text{ A}$	27 mΩ	
	1.5 Ω to 2.0 Ω	$I_{max} < 30 \text{ A}$	40 mΩ	
	4.2 Ω to 5.5 Ω	$I_{max} < 21 \text{ A}$	$15 \cdot 10^{-3} \cdot R$	
	8 Ω to 11 Ω	$I_{max} < 15 \text{ A}$	$14 \cdot 10^{-3} \cdot R$	
	15 Ω to 20 Ω	$I_{max} < 10 \text{ A}$	$13 \cdot 10^{-3} \cdot R$	
	42 Ω to 55 Ω	$I_{max} < 5 \text{ A}$	$13 \cdot 10^{-3} \cdot R$	
	80 Ω to 110 Ω	$I_{max} < 3 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	150 Ω to 200 Ω	$I_{max} < 1.35 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	420 Ω to 550 Ω	$I_{max} < 0.6 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	0.8 kΩ to 1.1 kΩ	$I_{max} < 0.3 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
	1.5 kΩ to 2.0 kΩ	$I_{max} < 0.15 \text{ A}$	$12 \cdot 10^{-3} \cdot R$	
Time interval	> 10s up to 10s		$1.5 \times 10^{-6} \times t$	t: Measured value
Alternating current – active energy single-phase Measuring instruments	150 Ws up to 5.76 MWs	45 Hz to 65 Hz $0.25 \leq \cos \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	0.15×10	Measurement uncertainty relative to the apparent energy
Alternating current reactive power single-phase Measuring instruments	150 vars up to 5.76 Mvars	45 Hz to 65 Hz $0.25 \leq \sin \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	0.15×10	
Reactive power in alternating current single-phase	600 VA up to 5.76 MVA	45 Hz to 65 Hz, $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	0.15×10	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – High-frequency and radiation parameters

Calibration and measurement services (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Oscilloscope measurement parameters: vertical	5 mV up to 5 V 5 mV to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$ $2.4 \cdot 10^{-3} U + 40 \mu V$	Rectangular voltage 10 Hz to 10 kHz
Horizontal deflection	5 ns up to 520 ms > 20 ms up to 5 s		$3 \cdot 10^{-6} t + 1 \text{ ns}$ $30 \cdot 10^{-6} t + 1.2 \cdot 10^{-3} t^2$	t: current time
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V $R_i = 50 \Omega$	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$ $35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	t_r = intrinsic rise time of the oscilloscope
HF impedance (reflection coefficient) Single-gate measurement $ S_{11} $ Amount $ \Gamma $	0.0 to 1.0	45 MHz up to 5 GHz > 5 GHz up to 18 GHz	$0.01 + 0.01 \Gamma $ $0.015 + 0.01 \Gamma $	Connector; PC-7; 50 Ω
		9 kHz to 5 GHz > 5 GHz up to 18 GHz	$0.01 + 0.01 \Gamma $ $0.015 + 0.01 \Gamma $	N connector; 50 Ω
		45 MHz to 5 GHz > 5 GHz to 18 GHz	$0.01 + 0.005 \Gamma $ $0.015 + 0.01 \Gamma $	Connector; PC 3.5; 50 Ω
		> 18 GHz to 26.5 GHz $0.1 \leq \Gamma \leq 1$	$0.02 + 0.02 \Gamma $	
Phase ϕ	-180° to 180°	9 kHz to 18 GHz $0.1 \leq \Gamma \leq 1$	$\arcsin \frac{U(\Gamma)}{ \Gamma } \cdot \frac{180^\circ}{\pi}$	N-connector; 50 Ω .
		45 MHz to 18 GHz $0.1 \leq \Gamma \leq 1$		PC-7; 50 Ω
		45 MHz up to 26.5 GHz $0.1 \leq \Gamma \leq 1$		PC-3.5

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – High-frequency and radiation parameters

Calibration and measurement services (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
HF impedance (Reflectance) Second-gate measurement $ S_{11} $ & $ S_{22} $ Amount $ \Gamma $	0.0 to 1.0	45 MHz to 5 GHz	$0.015 + 0.01 \Gamma $	PC-7; 50 Ω)
		> 5 GHz to 18 GHz	$0.02 + 0.01 \Gamma $	
		9 kHz to 5 GHz	$0.015 + 0.01 \Gamma $	N-connector; 50 Ω . 3)
		> 5 GHz to 18 GHz	$0.02 + 0.01 \Gamma $	
Phase ϕ	-180° to 180°	45 MHz to 5 GHz	$0.01 + 0.005 \Gamma $	PC-3.53)
		> 5 GHz to 18 GHz	$0.015 + 0.01 \Gamma $	
		> 18 GHz to 26.5 GHz	$0.02 + 0.02 \Gamma $	
		9 kHz to 18 GHz $0.1 \leq \Gamma \leq 1$		N-connector; 50 Ω .
HF – Attenuation Switchable attenuators, Fixed attenuation elements Absolute Damping values	0 dB to 60 dB	9 kHz to 18 GHz	0.3 dB	Connector system: N; 50 Ω
				$I/\Gamma \leq 0.1$
	> 60 dB to 90 dB	45 MHz to 20 GHz	0.3 dB	Connector system PC-3.5; 50 Ω
				45 MHz to 20 GHz $I/\Gamma \leq 0.1$
RF power Power meters	> 1 pW to 0.1 mW	2.5 MHz to 2 GHz	$(0.025 + 0.14 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5 ;
		> 2 GHz to 18 GHz	$(0.049 + 0.21 \cdot \Gamma) \cdot P$	50 Ω ; $ \Gamma _{KG} \leq 0.2$
		> 18 GHz to 26.5 GHz	$(0.071 + 0.32 \cdot \Gamma) \cdot P$	
RF power Signal generators	> 1 pW up to 0.1 mW	2.5 MHz to 2 GHz	$(0.035 + 0.13 \cdot \Gamma) \cdot P$	Connector system: N, PC-3.5 ;
		> 2 GHz to 18 GHz	$(0.053 + 0.2 \cdot \Gamma) \cdot P$	50 Ω ; $ \Gamma _{KG} \leq 0.2$
		> 18 GHz to 26.5 GHz	$(0.074 + 0.31 \cdot \Gamma) \cdot P$	
	0.1 mW up to 10 mW	9 kHz to 50 MHz	$17 \cdot 10^{-3} \cdot P$	N-connector; 50 Ω 3)
		> 50 MHz to 5 GHz	$22 \cdot 10^{-3} \cdot P$	$ \Gamma \leq 0.3$
		> 5 GHz to 18 GHz	$30 \cdot 10^{-3} \cdot P$	
	0.1 mW up to 10 mW	50 MHz to 5 GHz	$22 \cdot 10^{-3} \cdot P$	PC 3.5 connector; 50 Ω 3)
		> 5 GHz to 18 GHz	$32 \cdot 10^{-3} \cdot P$	$ \Gamma \leq 0.3$
		> 18 GHz to 26.5 GHz	$40 \cdot 10^{-3} \cdot P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – High-frequency and radiation parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
RF power Power meters	0.1 mW up to 10 mW	9 kHz to 50 MHz > 50 MHz to 5 GHz > 5 GHz to 18 GHz	$17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $28 \cdot 10^{-3} \cdot P$	N-connector; 50 Ω ₃ $ \Gamma \leq 0.3$
	0.1 mW up to 10 mW	50 MHz to 5 GHz > 5 GHz to 18 GHz > 18 GHz to 26.5 GHz	$22 \cdot 10^{-3} \cdot P$ $32 \cdot 10^{-3} \cdot P$ $40 \cdot 10^{-3} \cdot P$	PC 3.5 connector; 50 Ω $ \Gamma \leq 0.3$
Signal level difference Measuring instruments / Sources	0 dBc up to 30 dBc	9 kHz to 7 GHz > 7 GHz to 13.6 GHz > 13.6 GHz to 26.5 GHz	1.5 dB 2.3 dB 3 dB	SNR > 20 dB
	> 90 dBc to 100 dBc	9 kHz to 7 GHz > 7 GHz to 13.6 GHz > 13.6 GHz up to 26.5 GHz	4.5 dB 4.8 dB 5.3 dB	SNR > 20 dB
Filter bandwidth Measuring instruments	1 Hz to 40 MHz		1 per cent	SNR > 70 dB
HF noise indicator Receivers / Measuring instruments	10 Hz to 50 GHz	-165 dbm/Hz to 0 dBm/Hz	1 dB	
Form factor Measuring instruments	1:1 to 4:1		5.5 per cent	SNR > 20 dB
	> 4:1 to 10:1		7 per cent	
	> 10:1 to 18:1		8.5 per cent	

3) When other connector systems are used, the measurement uncertainty increases.

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – High-frequency and radiation parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Amplitude modulation: Degree of modulation m	0.0 to ≤ 1.0	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.004 + 0.025 \cdot m$	f_{HF} = carrier frequency f_{MOD} = Modulation frequency
Frequency modulation Frequency shift Δf	0 Hz to 5 MHz	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.041 \cdot \Delta f + 25 \text{ Hz}$	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency
Phase modulation Phase shift $\Delta\Phi$	0 to $(4 \text{ MHz} / f_{MOD}) \text{ rad}$	$f_{HF} < 4 \text{ GHz}$ $f_{MOD} < 1 \text{ MHz}$	$0.025 \text{ rad} + 0.041 \cdot \Delta\Phi$	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency
Distortion factor k	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	AM demodulation method f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{HF} = 0 \text{ dBm}$	0.030 0.029 0.025	f_{HF} = Carrier frequency f_{MOD} = Modulation frequency P_{HF} = Carrier level
	> 0.0001 to 0.01 > 0.01 to 0.1 > 0.1 to 0.2	FM & PM demodulation methods f_{HF} : 150 kHz to 2 GHz $f_{MOD} = 1 \text{ kHz}$ $P_{RF} = 0 \text{ dBm}$ $\Delta f \leq 50 \text{ kHz}$	0.09	Absolute measurement uncertainty
Pulse-shaped measured variables*) Spectral stress- Amplitude density (Measuring/Displaying)	$S_0 = 13.5 \text{ } \mu\text{Vs}$	<i>DIN EN 55016-1-1:2020</i> CISPR 16-1-1:2019 CISPR Part A 9 kHz to 0.15 MHz	0.50 dB	Pulse frequency 1 Hz to 100 Hz $\Gamma_G, \Gamma_L \leq 0.05$ (Plot)
	$S_0 = 0.316 \text{ } \mu\text{Vs}$	CISPR Part B > 0.15 MHz to 30 MHz	0.50 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.07$ (Plot)
	$S_0 = 0.0044 \text{ } \mu\text{Vs}$	CISPR Part C > 30 MHz to 300 MHz	0.6 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.12$ (Plot)
	$S_0 = 0.0044 \text{ } \mu\text{Vs}$	CISPR Part D > 300 MHz to 1 GHz	0.6 dB	Heart rate 1 Hz to 1,000 Hz $\Gamma_G, \Gamma_L \leq 0.12$ (Display)
HF current clamp*) Transfer certificate— Resistance dB(Ω)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 55016-1-2:2019 4.4 mA	0.3 dB 0.5 dB 0.8 dB	
HF Bulk Current Injection*) Current clamp Insertion loss (dB)	9 kHz to 100 MHz > 100 MHz to 400 MHz > 400 MHz to 1 GHz	DIN EN 61000-4-6:2014 4.4 mA	0.3 dB 0.5 dB 1.5 dB	

Appendix to Accreditation Certificate D-K-15070-01-01
Mobile Laboratory – High-frequency and radiation parameters

Calibration and measurement facilities (CMC)

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Phase noise Signal generators	Phase noise relative to carrier amplitude in dBc/Hz > -87 dBc/Hz > -99 dBc/Hz > -104 dBc/Hz > -111 dBc/Hz > -131 dBc/Hz > -137 dBc/Hz	Offset frequency relative to the carrier frequency 100 Hz	2.5 dB	Carrier frequency: 100 MHz – 1 GHz
		1 kHz	2.5 dB	
		10 kHz	2.5 dB	
		100 kHz	2.5 dB	
		1 MHz	2.5 dB	
		10 MHz	2.5 dB	
	> -80 dBc/Hz > -96 dBc/Hz > -101 dBc/Hz > -109 dBc/Hz > -126 dBc/Hz > -136 dBc/Hz	100 Hz	2.5 dB	> 1 MHz – 3 GHz
		1 kHz	2.5 dB	
		10 kHz	2.5 dB	
		100 kHz	2.5 dB	
		1 MHz	2.5 dB	
		10 MHz	2.5 dB	
	> -72 dBc/Hz > -93 dBc/Hz > -98 dBc/Hz > -106 dBc/Hz > -120 dBc/Hz > -135 dBc/Hz	100 Hz	2.5 dB	> 3 GHz – 6 GHz
		1 kHz	2.5 dB	
		10 kHz	2.5 dB	
		100 kHz	2.5 dB	
		1 MHz	2.5 dB	
		10 MHz	2.5 dB	
Voltage pulse burst generators	100 V up to 4400 V	DIN EN 61000-4-4 under load (R _L) at R _L = 50 Ω across R _L = 1 kΩ	2.2 per cent	R _L = load resistance
	3 ns up to 1 μs		2.5 per cent	
	100 ns up to 1 s		0.25 per cent	
Surge generators	250 V up to 7000 V	DIN EN 61000-4-5 with or without a coupling and decoupling network	3.5 per cent	
Voltage amplitude	5 A up to 5 kA		3.5 per cent	
Current amplitude	400 ns up to 1 ms		3.5 per cent	
Rise time and pulse width				

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Dimensional Parameters

Measured quantity / Calibration object	Calibration and measurement facilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Length Cylindrical calibration standards, gauge rings: Diameter *)	1 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Gauging pins: Diameter *)	1 mm to 200 mm	Section 3.3.4 (Opt. 3), Section 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter*)	0.1 mm to 30 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2007, point 3.2.2 (Opt. 1)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start cylindrical external and internal threads with straight edges, symmetrical profile) Threaded mandrels: simple flank diameter *)	1.4 mm to 200 mm nominal pitch: 0.3 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method d is the measured Diameter
Threaded rings: simple flank diameter *)	Nominal pitch from 3 mm to 200 mm: 0.5 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-sphere method d is the measured Diameter
Length *) of plane-parallel, spherical or cylindrical measuring surfaces *)	0.01 mm to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt. 3),	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Setting dimensions for micrometres *)	25 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Dimensional Parameters

Measured quantity / Calibration object	Calibration and measurement facilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Throat gauges *)	3 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)	$0.8\text{ }\mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and Depth measurements *)	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured Length
Depth gauge / Height gauge *)	> 500 mm to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006	$50\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	
		VDI/VDE/DGQ 2618 Part 9.3:2006		
Clamp micrometers *)	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Fine-adjustment measuring *)	0 mm to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002		
Sunk-head measuring screws *)	0 mm to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008		
Depth micrometers *)	0 mm to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010		
Internal micrometers with 2-point contact on the calibration object *)	13 mm to 300 mm	VDI/VDE/DGQ 2618 Sheet 10.7:2010	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
	> 300 mm to 500 mm		$5\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with a 2-line contact system	5 mm to 100 mm	3-APD-0-0025-DE 2023:07	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometers with 3-line contact on the calibration object *)	3 mm to 150 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring instruments (Quick-access button) for external	up to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring instruments (Quick-access button) for internal	2 mm to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mobile Laboratory – Dimensional Parameters

Measured quantity / Calibration object	Calibration and measurement services (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Dial gauges *)	0 mm to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Part 11.4:2020		electronic digital dial gauges
Fine pointer *)	0 mm to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	$0.6 \mu\text{m}$	
Sensor-arm gauges *)	0 mm to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	$1.0 \mu\text{m}$	
Electronic inductive length measuring	up to 100 mm	VDI/VDE/DGQ 2618 Sheet 14.1:2010	$0.6 \mu\text{m} + 1 \cdot 10^{-6} \cdot l$	
electronic incremental Length measuring devices	up to 100 mm	3-APD-0-0027-DE 2023-08	$0.6 \mu\text{m} + 1 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Munich Calibration Laboratory, Nikolaus-Otto-Straße 2, 85221 Dachau

Munich Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V up to 220V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = set value
Direct current Sources	0 V 1 mV to 100 mV > 100 V to 1 V > 1 V to 10 V > 10 V to 100 V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	U = measured value
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5$ V	U = measured value
Direct current Measuring instruments and sources	0 A 0.1 μ A up to < 1 μ A 1 μ A to < 10 μ A 10 μ A up to < 100 μ A 100 μ A to 320 mA > 320 mA up to 1 A > 1 A up to 10 A > 10 A to > 150 A 150 A up to 2000 A	Precision Open Standard resistor and voltmeter Current transformer	0.2 nA $35 \cdot 10^{-6} I + 21$ pA $50 \cdot 10^{-6} I + 6$ pA $15 \cdot 10^{-6} I + 0.4$ nA $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$ $0.3 \times 10^{-3} I$	I = set value
Direct current Current clamps	1 mA up to 2.2 A > 2.2 A to 20 A > 20 A to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance	$0\ \Omega$ $1\ \Omega; 1.9\ \Omega$ $10\ \Omega$ $19\ \Omega$ $100\ \Omega; 190\ \Omega;$ $1\ \text{k}\Omega$ $1.9\ \text{k}\Omega$ $10\ \text{k}\Omega$ $19\ \text{k}\Omega$ $100\ \text{k}\Omega$ $190\ \text{k}\Omega$ $1\ \text{M}\Omega$ $1.9\ \text{M}\Omega$ $10\ \text{M}\Omega$ $19\ \text{M}\Omega$ $100\ \text{M}\Omega$		$50\ \mu\Omega$ $95 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $27 \cdot 10^{-6} R$ $17 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $21 \cdot 10^{-6} R$ $40 \cdot 10^{-6} R$ $48 \cdot 10^{-6} R$ $110 \cdot 10^{-6} R$	R = set value on the Fluke 5700A
	$0\ \Omega$ $1\ \Omega\ \text{to}\ 10\ \Omega$ $> 10\ \Omega\ \text{to}\ 100\ \Omega$ $> 100\ \Omega\ \text{to}\ 1\ \text{k}\Omega$ $> 1\ \text{k}\Omega\ \text{to}\ 10\ \text{k}\Omega$ $> 10\ \text{k}\Omega\ \text{to}\ 100\ \text{k}\Omega$ $> 100\ \text{k}\Omega\ \text{to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{up to}\ 10\ \text{M}\Omega$ $> 10\ \text{M}\Omega\ \text{up to}\ 100\ \text{M}\Omega$ $> 100\ \text{M}\Omega\ \text{up to}\ 1\ \text{G}\Omega$		$100\ \mu\Omega$ $16 \cdot 10^{-6} R + 50\ \mu\Omega$ $12 \cdot 10^{-6} R + 500\ \mu\Omega$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $35 \cdot 10^{-6} R$ $150 \cdot 10^{-6} R$ $600 \cdot 10^{-6} R$ $5 \cdot 10^{-3} R$	R = value measured by HP 3458A
	$0.001\ \Omega\ \text{to}\ 0.1\ \Omega$ $> 0.1\ \Omega\ \text{to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{up to}\ 100\ \text{M}\Omega$	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $30 \cdot 10^{-6} R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC resistance (ranges) Measuring instruments	$1\ \Omega$ to $< 11\ \Omega$ $11\ \Omega$ to $< 33\ \Omega$ $33\ \Omega$ to $< 110\ \Omega$ $110\ \Omega$ to $< 330\ \Omega$ $330\ \Omega$ up to $< 1.1\text{k}\Omega$ $1.1\text{k}\Omega$ to $< 3.3\text{k}\Omega$ $3.3\text{k}\Omega$ to $< 11\text{k}\Omega$ $11\text{k}\Omega$ to $< 33\text{k}\Omega$ $33\text{k}\Omega$ to $< 110\text{k}\Omega$ $110\text{k}\Omega$ up to $< 330\text{k}\Omega$ $330\text{k}\Omega$ to $< 1.1\text{M}\Omega$ $1.1\text{M}\Omega$ to $< 3.3\text{M}\Omega$ $3.3\text{M}\Omega$ to $< 11\text{M}\Omega$ $11\text{M}\Omega$ to $< 33\text{M}\Omega$ $33\text{M}\Omega$ to $< 110\text{M}\Omega$ $110\text{M}\Omega$ up to $< 330\text{M}\Omega$ $330\text{M}\Omega$ up to $< 1.1\text{G}\Omega$		$0.12 \cdot 10^{-3} R$ $33 \cdot 10^{-6} R$ $29 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $32 \cdot 10^{-6} R$ $33 \cdot 10^{-6} R$ $62 \cdot 10^{-6} R$ $0.13 \cdot 10^{-3} R$ $0.25 \cdot 10^{-3} R$ $0.5 \cdot 10^{-3} R$ $3 \cdot 10^{-3} R$ $15 \cdot 10^{-3} R$	R = set value for Fluke 5520A / 5522A
AC resistance	$0.1\ \Omega$ up to $2\ \Omega$	50 Hz to 400 Hz	$10 \cdot 10^{-3} \cdot R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and Measurement Capabilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.52 \cdot 10^{-3} U$	U = measured value
		> 20 Hz to 40 Hz	$0.52 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.40 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.40 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.41 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.46 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.55 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.60 \cdot 10^{-3} U$	
	> 2.2 mV to 7 mV	10 Hz to 20 Hz	$0.22 \cdot 10^{-3} U$	
		> 20 Hz to 40 Hz	$0.22 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.16 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.16 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.20 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.22 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.33 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.45 \cdot 10^{-3} U$	
	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement capabilities (CMC)

Measured quantity /	Measuring range /	Test conditions / Procedures	Expanded measurement	Comments
AC voltage measuring instruments and sources	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	
	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	
	> 220 V to 1,000 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 0.7 kV to 1 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$	
	> 1 kV to 7 kV		$3.5 \cdot 10^{-3} U + 2.0 V$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage Sources and measuring instruments	100 μ A to 1 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$120 \cdot 10^{-6} /$ $160 \cdot 10^{-6} /$ $60 \cdot 10^{-6} /$	/ = measured value
	> 1 mA to 10 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$46 \cdot 10^{-6} /$	
	> 10 mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} /$	
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} /$	
	> 10 A to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} /$	
	1 mA up to 2.2 A	40 Hz to 5 kHz	$2 \cdot 10^{-3} /$	
Current clamps	> 2.2 A to 20 A	40 Hz to 5 kHz	$3 \cdot 10^{-3} /$	
	> 20 A up to 800 A	40 Hz to 65 Hz	$4 \cdot 10^{-3} /$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Capacity Measuring instruments	190 pF to < 400 pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$ 4.5	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$\cdot 10^{-3} C + 8 \text{ pF}$ 4.0	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$\cdot 10^{-3} C + 8 \text{ pF}$ 2.5	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$\cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μF	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF up to < 3.3 μF	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF to < 33 μF	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μF to < 110 μF	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μF to < 330 μF	DC up to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μF up to < 1.1 mF	DC up to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC up to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 100 nF	50 Hz to 10 kHz	$1.0 \times 10^{-3} C$	C: measured value using standard capacitances
	> 100 nF up to 1000 nF	50 Hz to 1 kHz	$1.0 \cdot 10^{-3} C$	
		> 1 kHz up to 10 kHz	$2.5 \times 10^{-3} C$	
Frequency	1 mHz to 1 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tf}$	f = current reading U_{Tf} = Trigger uncertainty
Time interval	1 μs to 1000 s		$2 \cdot 10^{-9} \cdot t + 2 \text{ ns}$	t = current reading
Rotational speed visually	1 min ⁻¹ to 100,000 min ⁻¹	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV up to 1000 V at 45 Hz up to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μW to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300 W	Product of U and I: 1 mV $\leq U \leq 1000 \text{ V}$	$30 \cdot 10^{-6} P$	P calculated power
	> 300 W up to 1 kW	100 $\mu\text{A} \leq I \leq 2000 \text{ A}$	$200 \cdot 10^{-6} P$	
	> 1 kW up to 1 MW		$300 \cdot 10^{-6} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Active AC power	5 mW up to 50 kW > 2.5 W up to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	... Uncertainty in the amplitude of the fundamental voltage ... Uncertainty in the amplitude of the fundamental current Φ ... Uncertainty of the phase-shift angle ... Uncertainty of the root-mean-square voltage
AC reactive power	5 mvar up to 50 kvar > 2.5 var up to 120	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	... Uncertainty of the root mean square value of the current
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120 kVA	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical quantities

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Tension	$\pm 2 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz Measurement frequency 600 Hz Measurement frequency 4.8 kHz	0.04 $\mu\text{V/V}$ 0.05 $\mu\text{V/V}$ 0.12 $\mu\text{V/V}$	Calibration of 350 Ω bridge standards and the associated display units
	$\pm 2 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement frequency 600 Hz Measurement frequency 4.8 kHz	0.04 $\mu\text{V/V}$ 0.04 $\mu\text{V/V}$ 0.12 $\mu\text{V/V}$	at discrete points in 10 per cent increments
	$\pm 5 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz Measurement frequency 4.8 kHz	0.06 $\mu\text{V/V}$ 0.22 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 5 V Measurement frequency 225 Hz Measurement frequency 4.8 kHz	0.06 $\mu\text{V/V}$ 0.45 $\mu\text{V/V}$	
	$\pm 5 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement frequency 600 Hz Measurement frequency: 4.8 kHz	0.06 $\mu\text{V/V}$ 0.06 $\mu\text{V/V}$ 0.22 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 225 Hz Measurement frequency 600 Hz Measurement frequency 4.8 kHz	0.06 $\mu\text{V/V}$ 0.10 $\mu\text{V/V}$ 0.45 $\mu\text{V/V}$	
	$\pm 10 \text{ mV/V}$	Bridge span: 1 V Measurement frequency 600 Hz	0.11 $\mu\text{V/V}$	
	$\pm 20 \text{ mV/V}$	Bridge span: 1 V Measurement frequency 4.8 kHz	0.6 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 1 V Measurement frequency: 4.8 kHz	3.5 $\mu\text{V/V}$	
	$\pm 100 \text{ mV/V}$	Bridge span: 2.5 V Measurement frequency 4.8 kHz	4.0 $\mu\text{V/V}$	
Tension		Bridge span:		

Appendix to Accreditation Certificate D-K-15070-01-01
Permanent Laboratory, Munich – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC voltage bridge standards	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	0.5 V	2.0 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V 2.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1 V	1.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V 2.0 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V	0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 0.5 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 5 V	0.30 μ V/V 0.25 μ V/V 0.25 μ V/V 0.25 μ V/V 0.35 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 7.5 V	0.20 μ V/V 0.20 μ V/V 0.20 μ V/V 0.20 μ V/V 0.3 μ V/V 1.5 μ V/V	
	0 mV/V -2 mV/V to +2 mV/V -5 mV/V to +5 mV/V	Bridge span: 10 V	0.10 μ V/V 0.15 μ V/V 0.15 μ V/V	
Tension	-10 mV/V to +10 mV/V		0.20 μ V/V	
Direct current	-20 mV/V to +20 mV/V		0.3 μ V/V	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Electrical Quantities

Calibration and measurement services (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Bridge standards	-100 mV/V to +100 mV/V		1.5 μ V/V	
Voltage Ratios: DC Voltage Bridges, Measuring Instruments, Measurement Amplifiers	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 0.5 V	0.35 μ V/V 0.35 μ V/V 0.40 μ V/V 0.55 μ V/V 2.5 μ V/V	
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 1 V	0.20 μ V/V 0.20 μ V/V 0.3 μ V/V 0.5 μ V/V 2.5 μ V/V	
	-2 mV/V to +2 mV/V -5 mV/V to +5 mV/V -10 mV/V to +10 mV/V -20 mV/V to +20 mV/V -100 mV/V to +100 mV/V	Bridge span: 2.5 V; 5 V; 7.5 V; 10 V	0.10 μ V/V 0.15 μ V/V 0.25 μ V/V 0.45 μ V/V 2.5 μ V/V	
Cargo Charge amplifier, Charge measuring instruments	1 pC up to 10 ⁴ pC	0.2 Hz to < 1 Hz 1 Hz to 10 kHz > 10 kHz to 20 kHz > 20 kHz to 50 kHz	0.5 % 0.4 % 0.6 % 1.0 %	
Oscilloscope measurement parameters: vertical	5 mV up to 5 V 5 mV up to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu$ V $2.4 \cdot 10^{-3} U + 40 \mu$ V	U - Measured value: square-wave voltage
Horizontal deflection	5 ns to 520 ms > 20 ms to 5 s		$3 \cdot 10^{-6} T + 1$ ns $30 \cdot 10^{-6} T + 1.2 \cdot 10^{-4} T^2$	
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V	$35 \cdot 10^{-3} \cdot t_r + 5$ ps $35 \cdot 10^{-3} \cdot t_r + 8$ ps	t_r = intrinsic rise time of the oscilloscope

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Dimensional Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical calibration standards, gauge rings: Diameter *)	1 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), section 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Gauge pins: Diameter *)	1 mm up to 200 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter *)	0.1 mm up to 30 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start cylindrical external and internal threads with straight edges, symmetrical profile)				
Threaded mandrels: simpler	1.4 mm up to 200 mm Nominal pitch: 0.3 mm up to 6 mm	VDI/VDE/DGQ 2618 Part 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method D is the measured value
Threaded rings: simpler	3 mm to 200 mm Nominal pitch: 0.5 mm up to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-sphere method d is the measured Diameter
Length of plane-parallel, spherical or cylindrical Measuring surfaces *)	0.01 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm up to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Fitting dimensions for Clamp-type micrometres *)	25 mm up to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Dimensional Quantities

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration item	Measuring range / Measuremen t span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Throat gauges *)	3 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)	$0.8\text{ }\mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and	0 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured Length
Depth caliper / Height gauge *)	> 500 mm up to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006	$50\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	
		VDI/VDE/DGQ 2618 Part 9.3:2006		
Clamp micrometers *)	0 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Fine-adjustment measuring screws	0 mm to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002		
Flush-mounted measuring screws	0 mm up to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008		
Depth-measuring screws *)	0 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010		
Internal micrometres with two-point contact on the calibration object *)	13 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.7:2010	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
	> 300 mm to 500 mm		$5\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with a 2-line contact system	5 mm up to 100 mm	3-APD-0-0025-DE 2023:07	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometers with 3-point contact on the calibration object *)	3 mm up to 100 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring devices (quick-	to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring devices (quick-	2 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Permanent Laboratory, Munich – Dimensional Quantities

Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Dial gauges *)	0 mm to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	3 μm + 10 · 10 ⁻⁶ · l	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Part 11.4:2020		electronic digital dial gauges
Fine pointer *)	0 mm up to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	0.6 μm	
Sensor-arm measuring instruments *)	0 mm to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	1.0 μm	
Angle of rotation	0° to 360°	VDI/VDE/DKD 2648 – Part 1:2024	0.02°	
Direct-read rotary encoders		VDI/VDE/DKD 2648 Part 2:2024	0.80°	
Indirect rotary encoders *)		Rotational speed < 0.5 rpm		
	Rotational speed > 0.5 rpm	0.25°		

Appendix to Accreditation Certificate D-K-15070-01-01
Essen Calibration Laboratory, Hermann-Drescher-Weg 4 a-d, 45329 Essen
Essen Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V up to 220V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	U = set value
Direct current Sources	0 V 1 mV up to 100mV > 100 V to 1 V > 1 V to 10 V > 10 V to 100V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	U = measured value
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5$ V	U = measured value
Direct current Measuring instruments and sources	0 A 0.1 μ A up to <1 μ A 1 μ A to <10 μ A 10 μ A up to <100 μ A 100 μ A to 320 mA > 320 mA up to 1A > 1 A up to 10A > 10 A to > 150 A 150 A up to 2000 A	Precision Open Standard resistor and voltmeter	0.2 nA $35 \cdot 10^{-6} I + 21$ pA $50 \cdot 10^{-6} I + 6$ pA $15 \cdot 10^{-6} I + 0.4$ nA $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$ $0.3 \cdot 10^{-3} I$	I = set value
Direct current Current clamps	1 mA up to 2.2A > 2.2 A up to 20A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Direct current resistance	$0\ \Omega$ $1\ \Omega; 1.9\ \Omega$ $10\ \Omega$ $19\ \Omega$ $100\ \Omega; 190\ \Omega;$ $1\ \text{k}\Omega$ $1.9\ \text{k}\Omega$ $10\ \text{k}\Omega$ $19\ \text{k}\Omega$ $100\ \text{k}\Omega$ $190\ \text{k}\Omega$ $1\ \text{M}\Omega$ $1.9\ \text{M}\Omega$ $10\ \text{M}\Omega$ $19\ \text{M}\Omega$ $100\ \text{M}\Omega$		$50\ \mu\Omega$ $95 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $27 \cdot 10^{-6} R$ $17 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $21 \cdot 10^{-6} R$ $40 \cdot 10^{-6} R$ $48 \cdot 10^{-6} R$ $110 \cdot 10^{-6} R$	R = set value on the Fluke 5700A
	$0\ \Omega$ $1\ \Omega\ \text{to}\ 10\ \Omega$ $> 10\ \Omega\ \text{to}\ 100\ \Omega$ $> 100\ \Omega\ \text{to}\ 1\ \text{k}\Omega$ $> 1\ \text{k}\Omega\ \text{to}\ 10\ \text{k}\Omega$ $> 10\ \text{k}\Omega\ \text{to}\ 100\ \text{k}\Omega$ $> 100\ \text{k}\Omega\ \text{to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{to}\ 10\ \text{M}\Omega$ $> 10\ \text{M}\Omega\ \text{up to}\ 100\ \text{M}\Omega$ $> 100\ \text{M}\Omega\ \text{up to}\ 1\ \text{G}\Omega$		$100\ \mu\Omega$ $16 \cdot 10^{-6} R + 50\ \mu\Omega$ $12 \cdot 10^{-6} R + 500\ \mu\Omega$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $35 \cdot 10^{-6} R$ $150 \cdot 10^{-6} R$ $600 \cdot 10^{-6} R$ $5 \cdot 10^{-3} R$	R = value measured by HP 3458A
	$0.001\ \Omega\ \text{up to}\ 0.1\ \Omega$ $> 0.1\ \Omega\ \text{up to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{up to}\ 100\ \text{M}\Omega$	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $30 \cdot 10^{-6} R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC resistance (ranges) Measuring instruments	$1\ \Omega$ to $< 11\ \Omega$ $11\ \Omega$ to $< 33\ \Omega$ $33\ \Omega$ to $< 110\ \Omega$ $110\ \Omega$ to $< 330\ \Omega$ $330\ \Omega$ to $< 1.1\ \text{k}\Omega$ $1.1\ \text{k}\Omega$ to $< 3.3\ \text{k}\Omega$ $3.3\ \text{k}\Omega$ to $< 11\ \text{k}\Omega$ $11\ \text{k}\Omega$ up to $< 33\ \text{k}\Omega$ $33\ \text{k}\Omega$ to $< 110\ \text{k}\Omega$ $110\ \text{k}\Omega$ to $< 330\ \text{k}\Omega$ $330\ \text{k}\Omega$ to $< 1.1\ \text{M}\Omega$ $1.1\ \text{M}\Omega$ to $< 3.3\ \text{M}\Omega$ $3.3\ \text{M}\Omega$ to $< 11\ \text{M}\Omega$ $11\ \text{M}\Omega$ to $< 33\ \text{M}\Omega$ $33\ \text{M}\Omega$ to $< 110\ \text{M}\Omega$ $110\ \text{M}\Omega$ up to $< 330\ \text{M}\Omega$ $330\ \text{M}\Omega$ up to $< 1.1\ \text{G}\Omega$		$0.12 \cdot 10^{-3} R$ $33 \cdot 10^{-6} R$ $29 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $32 \cdot 10^{-6} R$ $33 \cdot 10^{-6} R$ $62 \cdot 10^{-6} R$ $0.13 \cdot 10^{-3} R$ $0.25 \cdot 10^{-3} R$ $0.5 \cdot 10^{-3} R$ $3 \cdot 10^{-3} R$ $15 \cdot 10^{-3} R$	R = set value for Fluke 5520A / 5522A
AC resistance	$0.1\ \Omega$ up to $2\ \Omega$	50 Hz to 400 Hz	$10 \cdot 10^{-3} \cdot R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Quantities

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.52 \cdot 10^{-3} U$	U = measured value
		> 20 Hz to 40 Hz	$0.52 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.40 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.40 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.41 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.46 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.55 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.60 \cdot 10^{-3} U$	
	> 2.2 mV to 7 mV	10 Hz to 20 Hz	$0.22 \cdot 10^{-3} U$	
		> 20 Hz to 40 Hz	$0.22 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.16 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.16 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.20 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.22 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.33 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.45 \cdot 10^{-3} U$	
	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	
	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	
	> 220 V to 1,000 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 0.7 kV to 1 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$	
	> 1 kV to 7 kV		$3.5 \cdot 10^{-3} U + 2.0 V$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Alternating current amperage Sources and measuring instruments	100 μ A to 1 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$120 \cdot 10^{-6} /$ $160 \cdot 10^{-6} /$ $60 \cdot 10^{-6} /$	/ = measured value
	> 1 mA to 10 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$46 \cdot 10^{-6} /$	
Current clamps	> 10 mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} /$	/ = measured value
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} /$	
	> 10 A to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} /$	
	1 mA up to 2.2 A	40 Hz up to 5 kHz	$2 \cdot 10^{-3} /$	
	> 2.2 A up to 20 A	40 Hz to 5 kHz	$3 \cdot 10^{-3} /$	
	> 20 A to 800 A	40 Hz up to 65 Hz	$4 \cdot 10^{-3} /$	
Capacity of measuring instruments	190 pF up to <400 pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μ F	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μ F up to < 3.3 μ F	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Capacity of measuring instruments	3.3 μ F to < 11 μ F	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	With 5520A / 5522A
	11 μ F to < 33 μ F	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μ F to < 110 μ F	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μ F up to <330 μ F	DC to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μ F up to <1.1 mF	DC to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to <33 mF	DC up to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 100 nF	50 Hz to 10 kHz	$1.0 \times 10^{-3} C$	
	> 100 nF up to 1000 nF	50 Hz up to 1 kHz	$1.0 \times 10^{-3} C$	C: measured value using standard capacitances
		> 1 kHz up to 10 kHz	$2.5 \times 10^{-3} C$	
Frequency	1 mHz to 1 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tr}$	f = current measured value U_{Tr} = trigger uncertainty
Time interval	1 μ s to 1000 min ⁻¹		$2 \cdot 10^{-9} \cdot t + 2$ ns	t = current reading
Rotational speed visually	1 min ⁻¹ up to 100,000	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV up to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μ W to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	P calculated power
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300 W	Product of U and I: 1 mV $\leq$ U $\leq$ 1000 V	$30 \cdot 10^{-6} P$	
	>300 W to 1 kW	100 μ A $\leq$ I $\leq$ 2000 A	$200 \cdot 10^{-6} P$	
	>1 kW up to 1 MW		$300 \times 10^{-6} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active AC power	5 mW up to 50 kW > 2.5 W to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$w(U_F)$... Uncertainty in the amplitude of the fundamental voltage $W(I_F)$... Uncertainty in the amplitude of the fundamental current $W(\Phi_F)$... Uncertainty of the phase shift angle
AC reactive power	5 mvar up to 50 kvar > 2.5 var up to 120 kvar	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$W(U_{rms})$... Uncertainty in the root mean square value of the voltage $W(I_{rms})$... Uncertainty of the root mean square value of the current
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120 kVA	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	
Oscilloscopes:				U - Measured value: square-wave voltage
Vertical deflection	5 mV to 5 V 5 mV up to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$ $2.4 \cdot 10^{-3} U + 40 \mu V$	
Horizontal deflection	5 ns to 520 ms > 20 ms up to 5 s		$3 \cdot 10^{-6} T + 1 \text{ ns}$ $30 \cdot 10^{-6} T + 1.2 \cdot 10^{-4} T^2$	
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$ $35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	t_r = intrinsic rise time of the oscilloscope

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Dimensional Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical gauge blocks, gauge rings: Diameter *)	1 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), section 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Gauging pins: Diameter *)	1 mm up to 200 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter *)	0.1 mm up to 30 mm	VDI/VDE/DGQ 2618 Sheet 4.2:2007, point 3.2.2 (Opt.1)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start external and internal cylindrical threads with straight edges, symmetrical profile)				
Threaded mandrels: simpler	1.4 mm to 200 mm Nominal pitch: 0.3 mm up to 6 mm	VDI/VDE/DGQ 2618 Part 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method d is the measured value
Threaded rings: simpler	3 mm to 200 mm Nominal pitch: 0.5 mm up to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-sphere method d is the measured Diameter
Threaded mandrels: simple flank diameter *)	1.4 mm up to 200 mm Nominal diameter	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Section 3.2.2 (Opt. 1) up to Point 3.2.6 (Opt. 5)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Scanning methods d is the measured
Outer diameter *)			2 μm	Diameter
Core diameter / Hole diameter *)			5 μm	
Slope / Pitch			1.5 μm	
Thread profile angle α			$(3 + 1 / l_F)'$, but not less than 6'	l_F : Flank length in mm
Threaded rings: simple flank diameter *)	5 mm up to 200 mm Nominal diameter	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Section 3.2.2 (Opt. 1) up to Point 3.2.6 (Opt. 5)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Scanning methods d is the measured
Outer diameter			5 μm	Diameter
Core diameter / Drill hole diameter c			2 μm	
Slope / Scale			1.5 μm	
Thread profile angle α *)	> 27°		$(3 + 1 / l_F)'$, but not less than 6'	l_F : Flank length in mm

Appendix to Accreditation Certificate D-K-15070-01-01

Essen Permanent Laboratory – Dimensional Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length of plane-parallel, spherical or cylindrical measuring surfaces*)	0.01 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, Section 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm up to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Fitting dimensions for Adjustable micrometers *)	25 mm up to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	
Throat gauges *)	3 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Section 3.3.2 (Opt. 2)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and	0 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured
Depth caliper / Height gauge *)	> 500 mm up to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006 VDI/VDE/DGQ 2618 Part 9.3:2006	$50 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$	Length
Clamp micrometres *)	0 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Fine-adjustment screws *)	0 mm to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002		
Flush-mounted measuring	0 mm up to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008		
Depth-measuring screws *)	0 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with two-point contact on the calibration object *)	13 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.7:2010	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
	> 300 mm up to 500 mm		$5 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with a 2-line contact system	5 mm up to 100 mm	3-APD-0-0025-EN 2023:07	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometers with 3-point contact on the calibration object *)	3 mm to 100 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter

Appendix to Accreditation Certificate D-K-15070-01-01
Essen Permanent Laboratory – Dimensional Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Lever-type measuring devices (quick-	to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured Length
Lever-type measuring instruments	2 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured Length
Dial gauges *)	0 mm up to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Part 11.4:2020	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	electronic digital dial gauges
Fine pointer *)	0 mm up to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	$0.6 \mu\text{m}$	
Probe-type measuring instruments *)	0 mm up to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	$1.0 \mu\text{m}$	
electrical inductive Length measuring devices	to 100 mm	VDI/VDE/DGQ 2618 Sheet 14.1:2010	$0.6 \mu\text{m} + 1 \cdot 10^{-6} \cdot l$	
electronic incremental Length measuring devices	to 100 mm	3-APD-0-0027-DE August 2023	$0.6 \mu\text{m} + 1 \cdot 10^{-6} \cdot l$	
Angle of perpendicularity Deviation *)	to 30 μm	VDI/VDE/DGQ/DKD 2618 Sheet 7.1:2019, point 3.2.2.2(Opt.2)	$2.5 \mu\text{m} + 1 \cdot 10^{-6} \cdot l_z$	l_z : Length of the shape and position representation up to 500 mm side length
Flatness and Deviation from			$4 \mu\text{m} + 5 \cdot 10^{-6} \cdot l_z$	
protractor				
Scale division value 1° *)	-180° up to 180°	VDI/VDE/DGQ 2618	30'	
Scale division value 5'*)	0° to 360°	Sheet 7.2:2008	1'	
Parallelism deviation in flat rulers *)	up to 500 mm	VDI/VDE/DGQ 2618 Sheet 5.1:2022	$4 \mu\text{m} + 5 \cdot 10^{-6} \cdot l$	l is the measured Length
Flatness deviation *)			$2.2 \mu\text{m} + 3.5 \cdot 10^{-6} \cdot l$	
Hair rulers		VDI/VDE/DGQ 2618		l is the measured Length
Deviation from	up to 500 mm	Sheet 5.2:2013	$2.2 \mu\text{m} + 3.5 \cdot 10^{-6} \cdot l$	Length
Inclinometers *)	-2000 $\mu\text{m}/\text{m}$ up to 2000 $\mu\text{m}/\text{m}$ (-412") (412")	APD-0-0244-DE 2023-01	$1.7 \mu\text{m}/\text{m}$ (0.35")	Maximum side length of the KG: 500 mm
Tape measures and rulers				
Tape measures	0 m up to 100 m	VDI/VDE/DGQ 2618 Part 8.2:2023	$50 \mu\text{m} + 20 \cdot 10^{-6} \cdot l$	l is the measured length
Benchmarks	0 m up to 3 m			

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Calibration Laboratory, Meiendorfer Straße 205, 22145 Hamburg

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and Measurement Capabilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V to 220 V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	$U = \text{set value}$
Direct current Sources	0 V 1 mV to 100 mV > 100 V to 1 V > 1 V up to 10V > 10 V to 100 V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	$U = \text{measured value}$
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5 \text{ V}$	$U = \text{measured value}$
Direct current Measuring instruments and sources	0 A	Precision Open	0.2 nA	$I = \text{set value}$
	0.1 μ A up to < 1 μ A 1 μ A to < 10 μ A 10 μ A up to < 100 μ A 100 μ A to 320 mA > 320 mA up to 1 A > 1 A up to 10 A > 10 A to > 150 A	Standard resistor and voltmeter	$35 \cdot 10^{-6} I + 21 \text{ pA}$ $50 \cdot 10^{-6} I + 6 \text{ pA}$ $15 \cdot 10^{-6} I + 0.4 \text{ nA}$ $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$	
	150 A up to 2000 A	Current transformer	$0.3 \times 10^{-3} I$	
Direct current intensity Current clamps	1 mA up to 2.2 A > 2.2 A up to 20 A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance	0 Ω		50 $\mu\Omega$	R = set value for Fluke 5700A
	1 Ω ; 1.9 Ω		$95 \cdot 10^{-6} R$	
	10 Ω		$28 \cdot 10^{-6} R$	
	19 Ω		$27 \cdot 10^{-6} R$	
	100 Ω ; 190 Ω ;		$17 \cdot 10^{-6} R$	
	1 k Ω		$13 \cdot 10^{-6} R$	
	1.9 k Ω		$13 \cdot 10^{-6} R$	
	10 k Ω		$12 \cdot 10^{-6} R$	
	19 k Ω		$12 \cdot 10^{-6} R$	
	100 k Ω		$14 \cdot 10^{-6} R$	
	190 k Ω		$14 \cdot 10^{-6} R$	
	1 M Ω		$20 \cdot 10^{-6} R$	
	1.9 M Ω		$21 \cdot 10^{-6} R$	
	10 M Ω		$40 \cdot 10^{-6} R$	
	19 M Ω		$48 \cdot 10^{-6} R$	
	100 M Ω		$110 \cdot 10^{-6} R$	
	0 Ω		100 $\mu\Omega$	R = value measured by HP 3458A
	1 Ω to 10 Ω		$16 \cdot 10^{-6} R + 50 \mu\Omega$	
	> 10 Ω to 100 Ω		$12 \cdot 10^{-6} R + 500 \mu\Omega$	
	> 100 Ω to 1 k Ω		$15 \cdot 10^{-6} R$	
	> 1 k Ω to 10 k Ω		$15 \cdot 10^{-6} R$	
	> 10 k Ω to 100 k Ω		$15 \cdot 10^{-6} R$	
	> 100 k Ω to 1 M Ω		$35 \cdot 10^{-6} R$	
	> 1 M Ω to 10 M Ω		$150 \cdot 10^{-6} R$	
	> 10 M Ω to 100 M Ω		$600 \cdot 10^{-6} R$	
	> 100 M Ω up to 1 G Ω		$5 \cdot 10^{-3} R$	
	0.001 Ω to 0.1 Ω	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$	
	> 0.1 Ω to 1 M Ω		$20 \cdot 10^{-6} R$	
	> 1 M Ω up to 100 M Ω		$30 \cdot 10^{-6} R$	
	1 m Ω	Substitution method	$0.1 \cdot 10^{-3} \cdot R$	
	10 m Ω		$30 \cdot 10^{-6} \cdot R$	
Direct current resistance	100 m Ω		$30 \cdot 10^{-6} \cdot R$	
	1 Ω		$30 \cdot 10^{-6} \cdot R$	
	1 m Ω to 10 m Ω	Substitution method	$0.1 \cdot 10^{-3} \cdot R$	
	> 10 m Ω up to 1 Ω	Substitution method	$30 \cdot 10^{-6} \cdot R$	
	0.1 Ω up to 2 Ω	Direct procedure	$50 \cdot 10^{-6} \cdot R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
DC resistance (ranges) Measuring instruments	$1\ \Omega$ to $< 11\ \Omega$ $11\ \Omega$ to $< 33\ \Omega$ $33\ \Omega$ up to $< 110\ \Omega$ $110\ \Omega$ to $< 330\ \Omega$ $330\ \Omega$ to $< 1.1\ \text{k}\Omega$ $1.1\ \text{k}\Omega$ to $< 3.3\ \text{k}\Omega$ $3.3\ \text{k}\Omega$ to $< 11\ \text{k}\Omega$ $11\ \text{k}\Omega$ to $< 33\ \text{k}\Omega$ $33\ \text{k}\Omega$ to $< 110\ \text{k}\Omega$ $110\ \text{k}\Omega$ to $< 330\ \text{k}\Omega$ $330\ \text{k}\Omega$ to $< 1.1\ \text{M}\Omega$ $1.1\ \text{M}\Omega$ to $< 3.3\ \text{M}\Omega$ $3.3\ \text{M}\Omega$ to $< 11\ \text{M}\Omega$ $11\ \text{M}\Omega$ to $< 33\ \text{M}\Omega$ $33\ \text{M}\Omega$ to $< 110\ \text{M}\Omega$ $110\ \text{M}\Omega$ up to $< 330\ \text{M}\Omega$ $330\ \text{M}\Omega$ up to $< 1.1\ \text{G}\Omega$		$0.12 \cdot 10^{-3} R$ $33 \cdot 10^{-6} R$ $29 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $32 \cdot 10^{-6} R$ $33 \cdot 10^{-6} R$ $62 \cdot 10^{-6} R$ $0.13 \cdot 10^{-3} R$ $0.25 \cdot 10^{-3} R$ $0.5 \cdot 10^{-3} R$ $3 \cdot 10^{-3} R$ $15 \cdot 10^{-3} R$	R = set value for Fluke 5520A / 5522A
AC resistance	$0.1\ \Omega$ up to $2\ \Omega$ $> 2\ \Omega$ up to $5\ \Omega$ $> 5\ \Omega$ up to $20\ \Omega$ $> 20\ \Omega$ up to $200\ \Omega$	50 Hz to 400 Hz 50 Hz 50 Hz 50 Hz	$10 \cdot 10^{-3} \cdot R$ $9 \cdot 10^{-3} \cdot R$ $5 \cdot 10^{-3} \cdot R$ $5 \cdot 10^{-3} \cdot R$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	1 mV to 2.2 mV	10 Hz to 20 Hz	$0.52 \cdot 10^{-3} U$	U = measured value
		> 20 Hz to 40 Hz	$0.52 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.40 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.40 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.41 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.46 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.55 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.60 \cdot 10^{-3} U$	
	> 2.2 mV to 7 mV	10 Hz to 20 Hz	$0.22 \cdot 10^{-3} U$	
		> 20 Hz to 40 Hz	$0.22 \cdot 10^{-3} U$	
		> 40 Hz to 20 kHz	$0.16 \cdot 10^{-3} U$	
		> 20 kHz to 50 kHz	$0.16 \cdot 10^{-3} U$	
		> 50 kHz to 100 kHz	$0.20 \cdot 10^{-3} U$	
		> 100 kHz to 300 kHz	$0.22 \cdot 10^{-3} U$	
		> 300 kHz to 500 kHz	$0.33 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.45 \cdot 10^{-3} U$	
	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	
	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01
Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	
	> 220 V to 1000 V	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$27 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$45 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$45 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$65 \cdot 10^{-6} U$	
High voltage	> 0.7 kV to 1 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$	
	> 1 kV to 7 kV		$3.5 \cdot 10^{-3} U + 2.0 V$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement capabilities (CMC)

Measurement parameter / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Alternating current amperage Sources and measuring instruments	100 μ A to 1 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	120 $\cdot 10^{-6}$ / 160 $\cdot 10^{-6}$ / 60 $\cdot 10^{-6}$ /	I = measured value
	> 1 mA to 10 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	46 $\cdot 10^{-6}$ /	
Current clamps	> 10 mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	17 $\cdot 10^{-6}$ /	I = measured value
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	32 $\cdot 10^{-6}$ /	
	> 10 A to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	39 $\cdot 10^{-6}$ /	
	1 mA up to 2.2A	40 Hz to 5 kHz	2 $\cdot 10^{-3}$ /	
	> 2.2 A up to 20A	40 Hz to 5 kHz	3 $\cdot 10^{-3}$ /	
	> 20 A up to 800 A	40 Hz up to 65 Hz	4 $\cdot 10^{-3}$ /	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Capacity of measuring instruments	190 pF to < 400 pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz up to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μF	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF to < 3.3 μF	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF to < 33 μF	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μF up to < 110 μF	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μF to < 330 μF	DC up to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μF to < 1.1 mF	DC up to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF up to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 10 nF	50 Hz to 10 kHz 50 Hz to 1 kHz	$1.0 \cdot 10^{-3}$	C: measured value using standard capacitances
	> 100 nF to 1000 nF	> 1 kHz up to 10 kHz	$C \cdot 1.0 \cdot 10^{-3}$	
			$2.5 \cdot 10^{-3} C$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and Measurement Capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measuring span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Frequency	1 mHz to 1 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tr}$	f = current reading U_{Tr} = Trigger uncertainty
Time interval	1 μ s to 1000 s		$2 \cdot 10^{-9} \cdot t + 2$ ns	t = current reading
Rotational speed visually	1 min ⁻¹ to 100,000 min ⁻¹	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μ W to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300W	Product of U and I:	$30 \cdot 10^{-6} P$	P calculated power
	> 300 W to 1 kW	$1 \text{ mV} \leq U \leq 1000 \text{ V}$	$200 \cdot 10^{-6} P$	
	>1 kW up to 1 MW	$100 \mu\text{A} \leq I \leq 2000 \text{ A}$	$300 \cdot 10^{-6} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Hamburg Permanent Laboratory – Electrical Quantities

Calibration and measurement services (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active AC power	5 mW up to 50 kW > 2.5 W up to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	$w(U_F)$... Uncertainty in the amplitude of the fundamental voltage $w(I_F)$... Uncertainty in the amplitude of the fundamental current $w(\Phi_F)$... Uncertainty of the phase-shift angle $w(U_{rms})$... Uncertainty of the root mean square voltage $w(I_{rms})$... Uncertainty of the root mean square value of the current
AC reactive power	5 mvar up to 50kvar > 2.5 var up to 120	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0,1 A bis 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than 0.14×10^{-3}	
Oscilloscopes:				
Vertical deflection	5 mV to 5 V 5 mV up to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$ $2.4 \cdot 10^{-3} U + 40 \mu V$	U - Measured value: square-wave voltage
Horizontal deflection	5 ns to 520 ms > 20 ms up to 5 s		$3 \cdot 10^{-6} T + 1 \text{ ns}$ $30 \cdot 10^{-6} T + 1.2 \cdot 10^{-4} T^2$	
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$ $35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	t_r = intrinsic rise time of the oscilloscope

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Calibration Laboratory, Kurhessenstraße 11, 64546 Mörfelden-Walldorf

**Mörfelden-Walldorf Permanent Laboratory – Electrical quantities Calibration
and measurement facilities (CMC)**

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V to 220 V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	$U = \text{set value}$
Direct current Sources	0 V 1 mV to 100 mV > 100 V up to 1 V > 1 V to 10 V > 10 V to 100V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	$U = \text{measured value}$
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5 \text{ V}$	$U = \text{measured value}$
Direct current Measuring instruments and sources	0 A 0.1 μ A up to < 1 μ A 1 μ A to < 10 μ A 10 μ A up to < 100 μ A 100 μ A up to 320 mA > 320 mA up to 1 A > 1 A to 10 A > 10 A to > 150 A 150 A to 2000 A	Precision Open Standard resistor and voltmeter Current transformer	0.2 nA $35 \cdot 10^{-6} I + 21 \text{ pA}$ $50 \cdot 10^{-6} I + 6 \text{ pA}$ $15 \cdot 10^{-6} I + 0.4 \text{ nA}$ $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$ $0.3 \times 10^{-3} I$	$I = \text{set value}$
Direct current Current clamps	1 mA to 2.2 A > 2.2 A up to 20 A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical quantities Calibration
and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measuremen t span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
DC resistance Measuring instruments	0 Ω 1 Ω ; 1.9 Ω 10 Ω 19 Ω 100 Ω ; 190 Ω ; 1 k Ω 1.9 k Ω 10 k Ω 19 k Ω 100 k Ω 190 k Ω 1 M Ω 1.9 M Ω 10 M Ω 19 M Ω 100 M Ω		50 $\mu\Omega$ $95 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $27 \cdot 10^{-6} R$ $17 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $21 \cdot 10^{-6} R$ $40 \cdot 10^{-6} R$ $48 \cdot 10^{-6} R$ $110 \cdot 10^{-6} R$	R = set value for the Fluke 5700A
Sources	0 Ω 1 Ω to 10 Ω > 10 Ω to 100 Ω > 100 Ω to 1 k Ω > 1 k Ω to 10 k Ω > 10 k Ω up to 100k Ω > 100 k Ω to 1 M Ω > 1 M Ω to 10 M Ω > 10 M Ω to 100M Ω > 100 M Ω up to 1 G Ω 0.001 Ω to 0.1 Ω > 0.1 Ω up to 1M Ω > 1 M Ω up to 100 M Ω		100 $\mu\Omega$ $16 \cdot 10^{-6} R + 50 \mu\Omega$ $12 \cdot 10^{-6} R + 500 \mu\Omega$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ $35 \cdot 10^{-6} R$ $150 \cdot 10^{-6} R$ $600 \cdot 10^{-6} R$ $5 \cdot 10^{-3} R$ $50 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $30 \cdot 10^{-6} R$	R = value measured by HP 3458A
		Substitution method using a standard resistor		

Mörfelden-Walldorf Permanent Laboratory – Electrical quantities Calibration
and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance measuring instruments	1 Ω to < 11 Ω 11 Ω to < 33 Ω 33 Ω up to <110Ω 110 Ω to < 330 Ω 330 Ω to < 1.1 kΩ 1.1 kΩ to < 3.3 kΩ 3.3 kΩ to < 11 kΩ 11 kΩ to < 33 kΩ 33 kΩ to < 110 kΩ 110 kΩ to < 330 kΩ 330 kΩ to < 1.1 MΩ 1.1 MΩ to < 3.3 MΩ 3.3 MΩ up to < 1MΩ 11 MΩ to < 33 MΩ 33MΩ up to <110MΩ 110 MΩ up to < 330 MΩ 330 MΩ up to < 1.1 GΩ		$0.12 \cdot 10^{-3} R$ $33 \cdot 10^{-6} R$ $29 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $32 \cdot 10^{-6} R$ $33 \cdot 10^{-6} R$ $62 \cdot 10^{-6} R$ $0.13 \cdot 10^{-3} R$ $0.25 \cdot 10^{-3} R$ $0.5 \cdot 10^{-3} R$ $3 \cdot 10^{-3} R$ $15 \cdot 10^{-3} R$	R = set value for Fluke 5520A / 5522A
AC resistance	0.1 Ω up to 2 Ω	50 Hz to 400 Hz	$10 \cdot 10^{-3} \cdot R$	
AC voltage measuring instruments and sources	1 mV to 2.2 mV > 2.2 mV to 7 mV	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz 10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$0.52 \cdot 10^{-3} U$ $0.52 \cdot 10^{-3} U$ $0.40 \cdot 10^{-3} U$ $0.40 \cdot 10^{-3} U$ $0.41 \cdot 10^{-3} U$ $0.46 \cdot 10^{-3} U$ $0.55 \cdot 10^{-3} U$ $0.60 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.16 \cdot 10^{-3} U$ $0.20 \cdot 10^{-3} U$ $0.22 \cdot 10^{-3} U$ $0.33 \cdot 10^{-3} U$ $0.45 \cdot 10^{-3} U$	U = measured value

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical Quantities Calibration
and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical Quantities Calibration
and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	
	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	U	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical quantities Calibration
and measurement facilities (CMC)

Measurement parameter / Calibration object	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 220 V to 1000 V	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$ $27 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6}$ U $U = \text{measured value}$
High voltage	> 0.7 kV up to 1 kV > 1 kV up to 7 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 \text{ V}$ $3.5 \cdot 10^{-3} U + 2.0 \text{ V}$
Alternating current amperage Sources and measuring instruments	100µAup to 1 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$120 \cdot 10^{-6} I$ $160 \cdot 10^{-6} I$ $60 \cdot 10^{-6} I$ $I = \text{measured value}$
	> 1 mA to 10 mA	10 Hz to 40 Hz > 40 Hz to 1kHz; > 1 kHz to 10 kHz;	$46 \cdot 10^{-6} I$
	> 10mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} I$
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} I$
	> 10Aup to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} I$
Current clamps	1 mA to 2.2 A > 2.2 A to 20 A > 20 A to 800 A	40 Hz to 5 kHz 40 Hz to 5 kHz 40 Hz to 65 Hz	$2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$ $4 \cdot 10^{-3} I$ $I = \text{measured value}$

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical quantities Calibration
and measurement facilities (CMC)

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Capacity of measuring instruments	190 pF to < 400 pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μF	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF up to < 3.3 μF	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF to < 33 μF	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μF to < 110 μF	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μF to < 330 μF	DC up to 50 Hz	$6.0 \cdot 10^{-3} C$	
	330 μF to < 1.1 mF	DC up to 20 Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC up to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF up to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF up to 10 nF	50 Hz to 10 kHz	$1.0 \times 10^{-3} C$	C: measured value using standard capacitances
	> 100 nF up to 1000 nF	Hz to 1 kHz	$1.0 \cdot 10^{-3} C$	
		> 1 kHz up to 10 kHz	$2.5 \times 10^{-3} C$	
Frequency	1 mHz to 1 GHz		$2 \cdot 10^{-9} \cdot f + U_{\text{tr}}$	f = current measured value U_{tr} = trigger uncertainty
Time interval	1 μs to 1000 s		$2 \cdot 10^{-9} \cdot t + 2 \text{ ns}$	t = current reading
Rotational speed visually	1 min^{-1} to 100,000 min^{-1}	with a light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min^{-1}	
Active AC power Measuring instruments		33 mV up to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF: Power factor
	109 μW to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW up to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300 W	Product of U and I: 1 mV $\leq U \leq 1000 \text{ V}$	$30 \cdot 10^{-6} P$	P calculated power
	> 300 W to 1 kW	100 $\mu\text{A} \leq I \leq 2000 \text{ A}$	$200 \cdot 10^{-6} P$	
	> 1 kW up to 1 MW		$300 \cdot 10^{-6} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Mörfelden-Walldorf Permanent Laboratory – Electrical Quantities Calibration

and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Active AC power	5 mW up to 50 kW > 2.5 W up to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$w(U_F)$... Uncertainty in the amplitude of the fundamental voltage $w(I_F)$... Uncertainty in the amplitude of the fundamental current $w(\Phi_F)$... Uncertainty of the phase shift angle $w(U_{rms})$... Uncertainty of the root-mean-square voltage $w(I_{rms})$... Uncertainty of the root mean square value of the current
AC reactive power	5 mvar to 50 kvar > 2.5 var to 120 kvar	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120	1 V to 1000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	
Oscilloscopes – Vertical deflection	5 mV to 5 V 5 mV to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$ $2.4 \cdot 10^{-3} U + 40 \mu V$	U – Measured value: square-wave voltage
Horizontal deflection	5 ns to 520 ms > 20 ms to 5 s		$3 \cdot 10^{-6} T + 1 \text{ ns}$ $30 \cdot 10^{-6} T + 1.2 \cdot 10^{-4} T^2$	
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$ $35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	t_r = intrinsic rise time of the oscilloscope

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Calibration Laboratory, Tönnhäuser Weg 100–106, 21423 Winsen (Luhe)

Winsen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)				
Measurement parameter / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current Measuring instruments	0 V 1 mV to 2.2 V > 2.2 V to 11 V > 11 V to 22 V > 22 V to 220 V > 220 V up to 1000 V		0.1 μ V $7 \cdot 10^{-6} U + 1 \mu$ V $9 \cdot 10^{-6} U$ $8 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$ $12 \cdot 10^{-6} U$	$U = \text{set value}$
Direct current Sources	0 V 1 mV to 100 mV > 100 V to 1 V > 1 V up to 10V > 10 V to 100 V > 100 V up to 1000 V		0.1 μ V $8 \cdot 10^{-6} U + 1 \mu$ V $11 \cdot 10^{-6} U$ $9 \cdot 10^{-6} U$ $13 \cdot 10^{-6} U$ $16 \cdot 10^{-6} U$	$U = \text{measured value}$
High voltage	> 1 kV up to 10 kV		$2.5 \cdot 10^{-3} U + 2.5 \text{ V}$	$U = \text{measured value}$
Direct current Measuring instruments and sources	0 A	Precision Open	0.2 nA	$I = \text{set value}$
	0.1 μ A up to < 1 μ A 1 μ A to < 10 μ A 10 μ A up to < 100 μ A 100 μ A up to 320 mA > 320 mA up to 1 A A > 1 A to 10 A > 10 A to > 150 A	Standard resistor and voltmeter	$35 \cdot 10^{-6} I + 21 \text{ pA}$ $50 \cdot 10^{-6} I + 6 \text{ pA}$ $15 \cdot 10^{-6} I + 0.4 \text{ nA}$ $18 \cdot 10^{-6} I$ $15 \cdot 10^{-6} I + 6 \mu$ A $0.2 \cdot 10^{-3} I$ $0.3 \times 10^{-3} I$	
	150 A up to 2000 A	Current transformer	$0.3 \times 10^{-3} I$	
Direct current Current clamps	1 mA up to 2.2 A > 2.2 A up to 20 A > 20 A up to 1000 A		$1 \cdot 10^{-3} I$ $2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance Measuring instruments	$0\ \Omega$ $1\ \Omega; 1.9\ \Omega$ $10\ \Omega$ $19\ \Omega$ $100\ \Omega; 190\ \Omega;$ $1\ \text{k}\Omega$ $1.9\ \text{k}\Omega$ $10\ \text{k}\Omega$ $19\ \text{k}\Omega$ $100\ \text{k}\Omega$ $190\ \text{k}\Omega$ $1\ \text{M}\Omega$ $1.9\ \text{M}\Omega$ $10\ \text{M}\Omega$ $19\ \text{M}\Omega$ $100\ \text{M}\Omega$		$50\ \mu\Omega$ $95 \cdot 10^{-6} R$ $28 \cdot 10^{-6} R$ $27 \cdot 10^{-6} R$ $17 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $13 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $12 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $14 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $21 \cdot 10^{-6} R$ $40 \cdot 10^{-6} R$ $48 \cdot 10^{-6} R$ $110 \cdot 10^{-6} R$	R = set value on the Fluke 5700A
Sources	$0\ \Omega$ $1\ \Omega\ \text{to}\ 10\ \Omega$ $> 10\ \Omega\ \text{upto} 100\ \Omega$ $> 100\ \Omega\ \text{to}\ 1\ \text{k}\Omega$ $> 1\ \text{k}\Omega\ \text{to}\ 10\ \text{k}\Omega$ $> 10\ \text{k}\Omega\ \text{to}\ 100\ \text{k}\Omega$ $> 100\ \text{k}\Omega\ \text{to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{to}\ 10\ \text{M}\Omega$ $> 10\ \text{M}\Omega\ \text{up to} 100\ \text{M}\Omega$ $> 100\ \text{M}\Omega\ \text{up to}\ 1\ \text{G}\Omega$		$100\ \mu\Omega$ $16 \cdot 10^{-6} R + 50\ \mu\Omega$ $12 \cdot 10^{-6} R + 500\ \mu\Omega$ $15 \cdot 10^{-6} R$ $15 \cdot 10^{-6} R$ R $15 \cdot 10^{-6} R$ $35 \cdot 10^{-6} R$ $150 \cdot 10^{-6} R$ $600 \cdot 10^{-6} R$ $5 \cdot 10^{-3} R$	R = value measured by HP 3458A
	$0.001\ \Omega\ \text{up to}\ 0.1\ \Omega$ $> 0.1\ \Omega\ \text{up to}\ 1\ \text{M}\Omega$ $> 1\ \text{M}\Omega\ \text{up to}\ 100\ \text{M}\Omega$	Substitution method using a standard resistor	$50 \cdot 10^{-6} R$ $20 \cdot 10^{-6} R$ $30 \cdot 10^{-6} R$	

Winsen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Direct current resistance Measuring instruments	1 Ω to < 11 Ω 11 Ω to < 33 Ω 33 Ω to < 110 Ω 110 Ω to < 330 Ω 330 Ω to < 1.1 kΩ 1.1 kΩ to < 3.3 kΩ 3.3 kΩ to < 11 kΩ 11 kΩ up to < 33kΩ 33 kΩ to < 110 kΩ 110 kΩ to < 330 kΩ 330 kΩ to < 1.1 MΩ 1.1 MΩ up to <3.3MΩ 3.3 MΩ to < 11 MΩ 11 MΩ to <33MΩ 33MΩ up to <110MΩ 110 MΩ up to < 330 MΩ 330 MΩ up to < 1.1 GΩ		0.12 · 10 ⁻³ <i>R</i> 33 · 10 ⁻⁶ <i>R</i> 29 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 28 · 10 ⁻⁶ <i>R</i> 32 · 10 ⁻⁶ <i>R</i> 33 · 10 ⁻⁶ <i>R</i> 62 · 10 ⁻⁶ <i>R</i> 0.13 · 10 ⁻³ <i>R</i> 0.25 · 10 ⁻³ <i>R</i> 0.5 · 10 ⁻³ <i>R</i> 3 · 10 ⁻³ <i>R</i> 15 · 10 ⁻³ <i>R</i>	<i>R</i> = set value for Fluke 5520A / 5522A
AC resistance	0.1 Ω up to 2 Ω	50 Hz to 400 Hz	10 · 10 ⁻³ · <i>R</i>	
AC voltage measuring instruments and sources	1 mV to 2.2 mV	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	0.52 · 10 ⁻³ <i>U</i> 0.52 · 10 ⁻³ <i>U</i> 0.40 · 10 ⁻³ <i>U</i> 0.40 · 10 ⁻³ <i>U</i> 0.41 · 10 ⁻³ <i>U</i> 0.46 · 10 ⁻³ <i>U</i> 0.55 · 10 ⁻³ <i>U</i> 0.60 · 10 ⁻³ <i>U</i>	<i>U</i> = measured value
	> 2.2 mV to 7 mV	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	0.22 · 10 ⁻³ <i>U</i> 0.22 · 10 ⁻³ <i>U</i> 0.16 · 10 ⁻³ <i>U</i> 0.16 · 10 ⁻³ <i>U</i> 0.20 · 10 ⁻³ <i>U</i> 0.22 · 10 ⁻³ <i>U</i> 0.33 · 10 ⁻³ <i>U</i> 0.45 · 10 ⁻³ <i>U</i>	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 7 mV to 22 mV	10 Hz to 20 Hz	$80 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$80 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$65 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$75 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$75 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$95 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.19 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.21 \cdot 10^{-3} U$	
	> 22 mV to 70 mV	10 Hz to 20 Hz	$70 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$58 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$35 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$35 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$45 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$55 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$0.11 \cdot 10^{-3} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 mV to 220 mV	10 Hz to 20 Hz	$39 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$35 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$25 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$25 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$28 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$42 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$85 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.1 \cdot 10^{-3} U$	
	> 220 mV to 700 mV	10 Hz to 20 Hz	$25 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$22 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$12 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$12 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$14 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$27 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$40 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Parameters

Calibration and Measurement Capabilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 700 mV to 2.2 V	10 Hz to 20 Hz	$20 \cdot 10^{-6} U$	U = measured value
		> 20 Hz to 40 Hz	$14 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$10 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$10 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$11 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$22 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$68 \cdot 10^{-6} U$	
	> 2.2 V to 7 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$12 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$13 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$13 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$95 \cdot 10^{-6} U$	
	> 7 V to 22 V	10 Hz to 20 Hz	$17 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$11 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$11 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$11 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$30 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.11 \cdot 10^{-3} U$	
	> 22 V to 70 V	10 Hz to 20 Hz	$18 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$16 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$15 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$15 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$	
		> 100 kHz to 300 kHz	$25 \cdot 10^{-6} U$	
		> 300 kHz to 500 kHz	$40 \cdot 10^{-6} U$	
		> 500 kHz to 1 MHz	$0.13 \cdot 10^{-3} U$	
	> 70 V to 220 V	10 Hz to 20 Hz	$19 \cdot 10^{-6} U$	
		> 20 Hz to 40 Hz	$18 \cdot 10^{-6} U$	
		> 40 Hz to 20 kHz	$17 \cdot 10^{-6} U$	
		> 20 kHz to 50 kHz	$17 \cdot 10^{-6} U$	
		> 50 kHz to 100 kHz	$32 \cdot 10^{-6} U$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
AC voltage measuring instruments and sources	> 220 V to 10 000 V	10 Hz to 20 Hz > 20 Hz to 40 Hz > 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$25 \cdot 10^{-6} U$ $27 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $45 \cdot 10^{-6} U$ $65 \cdot 10^{-6} U$	U = measured value
High voltage	> 0.7 kV to 1 kV > 1 kV to 7 kV	50 Hz	$2.5 \cdot 10^{-3} U + 0.25 V$ $3.5 \cdot 10^{-3} U + 2.0 V$	
Alternating current amperage Sources and measuring instruments	100 μ A to 1 μ A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$120 \cdot 10^{-6} I$ $160 \cdot 10^{-6} I$ $60 \cdot 10^{-6} I$	I = measured value
	> 1 mA to 10 mA	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$46 \cdot 10^{-6} I$	
	> 10 mA to 1 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$17 \cdot 10^{-6} I$	
	> 1 A to 10 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$32 \cdot 10^{-6} I$	
	> 10 A to 20 A	10 Hz to 40 Hz > 40 Hz to 1 kHz; > 1 kHz to 10 kHz;	$39 \cdot 10^{-6} I$	
Current clamps	1 mA up to 2.2 A > 2.2 A to 20 A > 20 A up to 800 A	40 Hz to 5 kHz 40 Hz to 5 kHz 40 Hz up to 65 Hz	$2 \cdot 10^{-3} I$ $3 \cdot 10^{-3} I$ $4 \cdot 10^{-3} I$	I = measured value

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Quantities

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Capacity of measuring instruments	190 pF up to <400pF	10 Hz to 10 kHz	$4 \cdot 10^{-3} C + 8 \text{ pF}$	With 5520A / 5522A
	400 pF to < 1.1 nF	10 Hz to 10 kHz	$4.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$4.0 \cdot 10^{-3} C + 8 \text{ pF}$	
	3.3 nF to <11nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 8 \text{ pF}$	
	11nF to < 33 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	33 nF up to < 110 nF	10 Hz to 1 kHz	$2.5 \cdot 10^{-3} C + 80 \text{ pF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$4.5 \cdot 10^{-3} C$	
	330 nF to < 1.1 μF	10 Hz to 600 Hz	$4.5 \cdot 10^{-3} C$	
	1.1 μF up to <3.3 μF	10 Hz to 300 Hz	$4.5 \cdot 10^{-3} C$	
	3.3 μF to < 11 μF	10 Hz to 150 Hz	$4.5 \cdot 10^{-3} C$	
	11 μF to < 33 μF	10 Hz to 120 Hz	$6.0 \cdot 10^{-3} C$	
	33 μF to < 110 μF	10 Hz to 80 Hz	$6.5 \cdot 10^{-3} C$	
	110 μF to < 330 μF	DC up to 50Hz	$6.0 \cdot 10^{-3} C$	
	330 μF to < 1.1 mF	DC up to 20Hz	$6.0 \cdot 10^{-3} C$	
	1.1 mF to < 3.3 mF	DC up to 6 Hz	$6.0 \cdot 10^{-3} C$	
	3.3 mF to < 11 mF	DC to 2 Hz	$6.0 \cdot 10^{-3} C$	
	11 mF to < 33 mF	DC to 0.6 Hz	$8.0 \cdot 10^{-3} C$	
	33 mF up to 110 mF	DC up to 0.2 Hz	$11 \cdot 10^{-3} C$	
	1 nF to 100 nF	50 Hz to 10 kHz	$1.0 \times 10^{-3} C$	C: value measured using standard capacitances
	> 100 nF to 1000 nF	50 Hz to 1 kHz	$1.0 \cdot 10^{-3} C$	
		> 1 kHz to 10 kHz	$2.5 \times 10^{-3} C$	
Frequency	1 mHz to 1 GHz		$2 \cdot 10^{-9} \cdot f + U_{Tr}$	f = current reading U_{Tr} = Trigger uncertainty
Time interval	1 μs to 1000 s		$2 \cdot 10^{-9} \cdot t + 2 \text{ ns}$	t = current measured value
Rotational speed visually	1 min ⁻¹ to 100,000 min ⁻¹	with light-activated switch	$8 \cdot 10^{-6}$ but not less than 0.006 min ⁻¹	
Active AC power Measuring instruments		33 mV up to 1000 V 45 Hz to 65 kHz $PF = 1$		P = value set using the Fluke 5520A/5522A PF : Power factor
	109 μW to < 11 kW	33 mA up to < 11 A	$1.4 \cdot 10^{-3} P$	
	363 mW to 20 kW	11 A to 20 A	$2.0 \cdot 10^{-3} P$	
Direct current power Measuring instruments	1 mW to 300 W		$0.5 \cdot 10^{-3} P$	
	> 300 W up to 20 kW		$1.0 \cdot 10^{-3} P$	
Sources	1 mW up to 300 W	Product of U and I 1 mV $\leq U \leq 1000$ V	$30 \cdot 10^{-6} P$	P : calculated power
	> 300 W to 1 kW	100 $\mu\text{A} \leq I \leq 2000$ A	$200 \cdot 10^{-6} P$	
	> 1 kW up to 1 MW		$300 \cdot 10^{-6} P$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Electrical Parameters

Calibration and measurement services (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Active AC power	5 mW up to 50 kW > 2.5 W to 120 kW	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$w(U_F)$... Uncertainty in the amplitude of the fundamental voltage $w(I_F)$... Uncertainty in the amplitude of the fundamental current $w(\Phi_F)$... Uncertainty of the phase shift angle
AC reactive power	5 mvar up to 50 kvar > 2.5 var up to 120 kvar	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	$w(U_{rms})$... Uncertainty in the root mean square value of the voltage $w(I_{rms})$... Uncertainty of the root mean square value of the current
Reactive power	0.1 VA up to 50 kVA > 50 VA up to 120 kVA	1 V to 1,000 V 45 Hz to 65 Hz $0.05 \leq \cos \varphi \leq 1$ 0.1 A to 50 A > 50 A to 120 A	$2\sqrt{w(U_F)^2 + w(I_F)^2 + w(\Phi_F)^2}$ not less than $80 \cdot 10^{-6}$ not less than $0.14 \cdot 10^{-3}$	
Oscilloscopes:				U : Measured value: square-wave voltage
Vertical deflection	5 mV to 5 V 5 mV to 120 V	$R_i = 50 \Omega$ $R_i = 1 M\Omega$	$3.5 \cdot 10^{-3} U + 35 \mu V$ $2.4 \cdot 10^{-3} U + 40 \mu V$	
Horizontal deflection	5 ns to 520 ms > 20 ms to 5 s		$3 \cdot 10^{-6} T + 1 \text{ ns}$ $30 \cdot 10^{-6} T + 1.2 \cdot 10^{-4} T^2$	
Ascent time	150 ps up to 10 ms 250 ps up to 10 ms	250 mV > 250 mV to 2.5 V	$35 \cdot 10^{-3} \cdot t_r + 5 \text{ ps}$ $35 \cdot 10^{-3} \cdot t_r + 8 \text{ ps}$	t_r : Self-rising time of the oscilloscope
Alternating current – active energy single-phase Measuring instruments	150 Ws up to 5.76 MWs	45 Hz to 65 Hz $0.25 \leq \cos \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10$	Measurement uncertainty relating to apparent energy
Alternating current reactive power single-phase Measuring instruments	150 vars up to 5.76 Mvars	45 Hz to 65 Hz $0.25 \leq \sin \varphi_F \leq 1$ $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10$	
Reactive power in alternating current single-phase	600 VAs up to 5.76 MVAs	45 Hz to 65 Hz, $t = 100 \text{ s}$ 30 V to 480 V 0.2 A to 120 A	$0.15 \cdot 10$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Dimensional Parameters

Calibration and measurement capabilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical gauge blocks, gauge rings: Diameter *)	1 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), point 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Gauging pins: Diameter *)	1 mm to 200 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter *)	0.1 mm to 30 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start cylindrical external and internal threads with straight edges, symmetrical profile)				
Threaded mandrels: simpler	1.4 mm to 200 mm nominal pitch: 0.3 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.8:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Three-wire method d is the measured Diameter
Threaded rings: simpler	Nominal pitch from 3 mm to 200 mm: 0.5 mm to 6 mm	VDI/VDE/DGQ 2618 Part 4.9:2006 Section 3.2.2 (Opt. 1)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	Two-sphere method d is the measured Diameter
Length of plane-parallel, spherical or cylindrical Measurement surfaces *)	0.01 mm to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Fitting dimensions for Clamp micrometers *)	25 mm to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Dimensional Quantities

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Throat gauges *)	3 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)	$0.8\text{ }\mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and Depth measurements	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured Length
Depth caliper / Height gauge *)	> 500 mm up to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006	$50\text{ }\mu\text{m} + 30 \cdot 10^{-6} \cdot l$	
		VDI/VDE/DGQ 2618 Part 9.3:2006		
Clamp-on micrometers *)	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Fine-adjustment screws *)	0 mm to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002		
Flush-mounted measuring screws *)	0 mm to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008		
Depth micrometres *)	0 mm to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010		
Internal micrometres with two- point contact on the calibration object *)	13 mm to 300 mm	VDI/VDE/DGQ 2618	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
	> 300 mm up to 500 mm	Part 10.7:2010	$5\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometers with a 2- line contact system on the calibration object	5 mm to 100 mm	3-APD-0-0025-EN 2023:07	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometres with 3-line contact on the calibration object *)	3 mm to 100 mm	VDI/VDE/DGQ 2618 Part 10.8:2002	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring devices (quick-action probes) for External dimensions *)	up to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring devices (quickactiongauges) for Internal measurements*)	2 mm to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Dial gauges *)	0 mm to 100 mm	VDI/VDE/DGQ/DKD 2618 Sheet 11.1:2021	$3\text{ }\mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Issue 11.4:2020		electronic digital dial gauges
Fine pointer *)	0 mm to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	0.6 μm	
Sensor-lever measuring instruments *)	0 mm to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	1.0 μm	

Appendix to Accreditation Certificate D-K-15070-01-01

Winsen Permanent Laboratory – Dimensional Quantities

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Tape measures and rulers		VDI/VDE/DGQ 2618 Part 8.2:2023	$50 \mu\text{m} + 20 \cdot 10^{-6} \cdot l$	/ is the measured Length
Tape measures	0 m to 100 m			
Standards	0 m to 3 m			

Appendix to Accreditation Certificate D-K-15070-01-01

Heidenheim Permanent Laboratory – Dimensional quantities Calibration and

measurement capabilities (CMC)				
Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Length Cylindrical calibration standards, gauge rings: Diameter *)	1 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d = is the measured diameter
Gauging pins: Diameter *)	1 mm to 200 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Test probes: Diameter *)	0.1 mm up to 30 mm		$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	
Thread gauges (one and multi-start cylindrical external and internal threads with straight edges, symmetrical profile)	Nominal diameter 1.4 mm up to 200 mm	VDI/VDE/DGQ 2618 Sheet 4.8:2006 Section 3.2.2 (Opt.1) to Point 3.2.6 (Opt. 5)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d = is the measured Diameter
Threaded mandrels: simple flank diameter			$2 \mu\text{m}$	
Outer diameter *)			$5 \mu\text{m}$	
Core diameter or Puncture diameter *)			$1.5 \mu\text{m}$	
Slope or pitch *)			$(3 + 1 / l_F)'$, but not less than $6'$	
Thread profile angle α *)	$> 27^\circ$			l_F = Flank length in mm
Threaded rings: simple flank diameter *)	Nominal diameter: 5 mm to 200 mm	VDI/VDE/DGQ 2618 Sheet 4.9:2006 Section 3.2.2 (Opt. 1) up to Point 3.2.6 (Opt. 5)	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d = is the measured Diameter
Outer diameter *)			$5 \mu\text{m}$	
Core diameter or Hole diameter *)			$2 \mu\text{m}$	
Gradient or pitch *)			$1.5 \mu\text{m}$	
Thread profile angle α *)	$> 27^\circ$		$(3 + 1 / l_F)'$, but not less than $6'$	l_F = Flank length in mm

Appendix to Accreditation Certificate D-K-15070-01-01

Heidenheim Permanent Laboratory – Dimensional quantities Calibration and

Measured quantity / Calibration object	measurement capabilities (CMC)		Expanded measurement uncertainty	Comments
	Measuring range / Measurement span	Measurement conditions / procedures		
Length				
of plane-parallel, spherical or cylindrical measuring surfaces *)	0.01 mm to 500 mm	VDI/VDE/DGQ 2618 Part 19.1:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Diameter *)	0.01 mm to 200 mm	VDI/VDE/DGQ 2618 Part 4.1:2006, clause 3.3.4 (Opt.3), Point 3.3.5 (Opt. 4)	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured diameter
Feeler gauges *)	0.03 mm to 2.00 mm	DIN 2275:2014	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	l is the measured length
Fitting dimensions for Screw gauges *)	25 mm up to 500 mm	VDI/VDE/DGQ 2618 Sheet 4.4:2009	$1.5 \mu\text{m} + 2 \cdot 10^{-6} \cdot l$	
Throat gauges *)	3 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 4.7:2005 Point 3.3.2 (Opt. 2)	$0.8 \mu\text{m} + 2 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Calipers for external, internal and	0 mm to 500 mm	VDI/VDE/DGQ 2618 Part 9.1:2006	$30 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$ $50 \mu\text{m} + 30 \cdot 10^{-6} \cdot l$	l is the measured Length
Depth caliper *)	> 500 mm to 1000 mm	VDI/VDE/DGQ 2618 Part 9.2:2006		
Height gauge *)		VDI/VDE/DGQ 2618 Part 9.3:2006		

Appendix to Accreditation Certificate D-K-15070-01-01
Heidenheim Permanent Laboratory – Dimensional Parameters Calibration

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Clamp-on micrometers *)	0 mm up to 500 mm	VDI/VDE/DGQ 2618 Part 10.1:2001	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Precision dial adjustment	0 mm up to 200 mm	VDI/VDE/DGQ 2618 Part 10.3:2002	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Flush-mounted measuring screws *)	0 mm to 50 mm	VDI/VDE/DGQ 2618 Part 10.4:2008	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Depth micrometers *)	0 mm up to 300 mm	VDI/VDE/DGQ 2618 Part 10.5:2010	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Internal micrometres with a 2-line contact on the calibration object	5 mm up to 100 mm	3-APD-0-0025-EN 2023:07	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Internal micrometers with 3-point contact on the calibration object *)	3 mm up to 150 mm	VDI/VDE/DGQ/DKD 2618 Part 10.8:2024	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot d$	d is the measured Diameter
Lever-type measuring devices(quickactin gauges) for External dimensions *)	up to 200 mm	VDI/VDE/DGQ 2618 Part 12.1:2005	$7 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	l is the measured length
Lever-type measuring instruments	2 mm to 200 mm	VDI/VDE/DGQ 2618 Part 13.1:2005	$7 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	
Dial gauges *)	0 mm to 100 mm	VDI/VDE/DGQ/DKD 2618 Part 11.1:2021	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	mechanical dial gauges
		VDI/VDE/DGQ/DKD 2618 Part 11.4:2020	$3 \mu\text{m} + 10 \cdot 10^{-6} \cdot l$	electronic digital dial gauges
Fine pointer *)	0 mm up to 3 mm	VDI/VDE/DGQ 2618 Part 11.2:2002	0.6 μm	
Probe-type measuring instruments *)	0 mm up to 1.6 mm	VDI/VDE/DGQ 2618 Part 11.3:2002	1.0 μm	

Appendix to Accreditation Certificate D-K-15070-01-01

Heidenheim Permanent Laboratory - Dimensional quantities Calibration and

Measured quantity / Calibration object	measurement capabilities (CMC)		Expanded measurement uncertainty	Comments
	Measuring range / Measurement span	Test conditions / procedures		
Coordinate measuring technology Prismatic, conical and spherical workpieces	Coordinate measuring machine with a calibrated measuring volume of: X = 700 mm Y = 1400 mm Z = 500 mm	3-APD-0-0292-DE: July 2024 Tactile measurement in the form of single-point probing using a coordinate measuring machine and the determination of standard geometries defined by geometric parameters (individual points, straight lines, planes, circles, spheres, cylinders, tori), using the CMM's analysis software. Single-point probing is carried out using a fixed, pre-set measuring force or by extrapolating to a measuring force of zero. Single-point probing as 'self-centring probing' is not used within the scope of accreditation. To ensure traceability, a comparable standard is calibrated. In addition, the following restrictions must be observed: It must be possible to distribute measurement points evenly across formula elements; Coverage of at least 50 per cent of the surface area of moulded components; Analysis of medium-sized structural elements	The measurement uncertainty is determined by means of a measurement uncertainty analysis based on the VDI/VDE 2617 Part 11:2011 guideline. It is task-specific and is used for a A coverage probability of 95 per cent is stated (expansion factor $k = 2$). An example of measurement uncertainty for a measurement task: Parallel measurement with two nominal dimensions; a laterally projecting probe with a length of 150 mm was used; the expanded measurement uncertainty of the test characteristic 'distance' was determined: L = 50 mm, U = 2.3 μm L = 1400 mm, U = 13.7 μm	The measured uncertainty may differ significantly from the uncertainty given as an example for simple measurement tasks.

Appendix to Accreditation Certificate D-K-15070-01-01

Abbreviations used:

CMC	Calibration and measurement capabilities (Kalibrier- und Messmöglichkeiten)
DIN	German Institute for Standardisation (DIN)
DKD-R	Guideline of the German Calibration Service (DKD), published by the Physikalisch-Technische Bundesanstalt
DGQ	German Society for Quality (DGQ)
VDE	Association for Electrical, Electronic and Information Technologies
VDI	(VDE). Association of German Engineers (VDI).
VDI/VDE/DGQ 2618	VDI series of guidelines on the control of test equipment
APD	Calibration procedure developed in-house by the laboratory

German Accreditation Body

Appendix to the partial accreditation certificate D-K-15070-01-02 in accordance with DIN EN ISO/IEC 17025:2018

Valid from: 5 March 2026

Date of issue: 5 March 2026

This appendix forms part of the accreditation certificate D-K-15070-01-00.

Holder of the partial accreditation certificate:

**Testo Industrial Services GmbH
Gewerbestraße 3, 79199 Kirchzarten**

with the locations

**Testo Industrial Services GmbH
Calibration Laboratory, Kirchzarten,
Gewerbestraße 3, 79199 Kirchzarten**

**Testo Industrial Services
GmbH, Kirchzarten Calibration
Laboratory
Erich-Rieder Straße 4, 79199 Kirchzarten**

**Testo Industrial Services GmbH
Calibration Laboratory, Munich
Nikolaus-Otto-Straße 2, 85221 Dachau**

**Testo Industrial Services GmbH
Calibration Laboratory, Essen
Hermann-Drescher-Weg 4 a–d, 45329 Essen**

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

Appendix to Partial Accreditation Certificate D-K-15070-01-02

**Testo Industrial Services GmbH
Calibration Laboratory,
Hamburg
Meiendorfer Straße 205, 22145 Hamburg**

**Testo Industrial Services GmbH
Calibration Laboratory,
Mörfelden-Walldorf
Kurfürstenstraße 11, 64546 Mörfelden-Walldorf**

**Testo Industrial Services GmbH
Calibration Laboratory, Winsen
Tönnhäuser Weg 100–106, 21423 Winsen (Luhe)**

The calibration laboratory meets the requirements of DIN EN ISO/IEC 17025:2018 for carrying out the conformity assessment activities listed in this Annex. The calibration laboratory complies with any additional statutory and regulatory requirements, including those set out in relevant sectoral programmes, provided that these are expressly confirmed below.

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

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Calibration in the following areas:

Thermodynamic parameters

Temperature measurement parameters

- Resistance thermometers ^{a)}
- Thermocouples, thermocouples ^{a)}
- Radiation thermometer
- Temperature fixed-point cells
- Temperature block calibrators ^{a)}
- Temperature display devices and simulators ^{a), b)}
- Climate chambers (temperature) ^{c)}
- Temperature transmitter, data logger ^{a)}

Moisture parameters

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

Chemical and medical parameters; Chemical analyses and reference materials

- Measuring instruments for electrolytic conductivity - pH value
- Gas mixtures

Mechanical parameters

- Strength
- Scales ^{c)}
- Pressure ^{a)}
- Torque ^{a)}

Acceleration

Flow measurement parameters

- Flow velocity of gases
- Volume of flowing gases
- Mass of flowing gases
- Volume of flowing liquids
- Mass of flowing liquids

Acoustic parameters

- ^{a)} including on-site calibration
- ^{b)} including mobile laboratory
- ^{c)} on-site calibration only

Within the measurement quantities/calibration objects marked with *) , the calibration laboratory is permitted to apply the standards/calibration guidelines listed here, in different editions, without the need for prior notification to or approval from DAkkS. The calibration laboratory maintains an up-to-date list of all standards and calibration guidelines within its flexible scope of accreditation.

Calibration and measurement capabilities

Calibration laboratory location: Gewerbestraße 3, 79199 Kirchzarten.....	5
Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Mechanical Measurements	5
Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 – Acoustics	7
Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Thermodynamic quantities.....	9
Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Flow measurement parameters	14
Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 - Chemical and medical parameters	14
On-site calibration	15
On-site calibration – thermodynamic parameters	15
On-site calibration – Mechanical parameters	19
On-site calibration – flow measurement parameters	20
Mobile laboratory	21
Mobile Laboratory – Thermodynamic Parameters	21
Mobile Laboratory – Mechanical Parameters	23
Kalibrierlabor Kirchzarten site, Erich-Rieder Straße 4, 79199 Kirchzarten.....	24
Kirchzarten Permanent Laboratory, Erich-Rieder Straße 4 – Thermodynamic parameters	24
Permanentes Laboratorium Kirchzarten, Erich-Rieder Straße 4 - Mechanical parameters	25
Calibration Laboratory Munich, Nikolaus-Otto-Straße 2, 85221 Dachau	26
Permanent Laboratory, Munich – Mechanical Quantities	26
Permanent Laboratory, Munich – Flow-related parameters	27
Permanent Laboratory, Munich – Thermodynamic Parameters	29
Essen Calibration Laboratory, Hermann-Drescher-Weg 4a-d, 45329 Essen	31
Essen Permanent Laboratory – Thermodynamic Parameters	31
Calibration Laboratory Hamburg, Meiendorfer Straße 205, 22145 Hamburg	32
Permanent Laboratory, Hamburg – Thermodynamic Parameters	32
Mörfelden-Walldorf Calibration Laboratory, Kurhessenstraße 11, 64546 Mörfelden-Walldorf	34
Mörfelden-Walldorf Permanent Laboratory – Thermodynamic Parameters	34
Winsen Calibration Laboratory, Tönnhäuser Weg 100–106, 21423 Winsen (Luhe)	37
Winsen Permanent Laboratory – Thermodynamic Parameters.....	37
Winsen Permanent Laboratory – Mechanical Parameters.....	38
Abbreviations used	39

Calibration Laboratory, Gewerbestraße 3, 79199 Kirchzarten

Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Mechanical quantities

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Acceleration Vibration transducer, vibration measuring device	0.1 m/s ² to 20 m/s ²	Sinusoidal Excitation DKD-R 3-1		Complex transfer coefficient (magnitude / phase).
		0.2 Hz to < 0.4 Hz	2.5 % / 1.6°	Transducer mass up to 0.9 kg, displacement amplitude up to 100 mm
		0.4 Hz to < 1 Hz	1.5 % / 1.6°	
		1 Hz to < 16 Hz	0.8 % / 0.8°	
		16 Hz	0.55 % / 0.6°	
		> 16 Hz to 63 Hz	0.8 % / 0.8°	
		> 63 Hz to 160 Hz	1.0 % / 1.1°	
	1 m/s ² to 200 m/s ²	Sinusoidal Excitation DKD-R 3-1		Complex transfer coefficient (magnitude / phase).
		5 Hz to < 10 Hz	1.5 % / 1.5°	Transducer mass up to 0.2 kg, displacement amplitude up to 8 mm
		10 Hz to < 20 Hz	0.8 % / 0.8°	
		20 Hz to 1 kHz	0.6 % / 0.6°	
		> 1 kHz to 5 kHz	0.8 % / 0.8°	
		> 5 kHz to 10 kHz	2.0 % / 1.5°	
		> 10 kHz to 15 kHz	2.5 per cent / 2.5	
	1 m/s ² to 500 m/s ²	Sinusoidal Excitation DKD-R 3-1		Complex transfer coefficient (magnitude / phase).
		3 Hz to < 5 Hz	1.6 % / 1.1°	Transducer mass up to 0.5 kg, displacement amplitude up to 10 mm
		5 Hz to < 20 Hz	1.1 % / 1.1°	
		20 Hz to < 80 Hz	0.8 % / 0.8°	
		80 Hz	0.55 % / 0.6°	
		> 80 Hz to 1 kHz	0.8 % / 0.8°	
		> 1 kHz to 5 kHz	1.3 % / 1.1°	
Vibration calibrator	0.1 m/s ² to 100 m/s ²	Sinusoidal excitation		
		10 Hz to < 20 Hz	0.8 %	
		20 Hz to 1 kHz	0.6 %	
		> 1 kHz to 5 kHz	0.8 %	
		> 5 kHz to 10 kHz	2.0 %	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Mechanical

quantities Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Pressure *) Negative and positive overpressure p_e	-1 bar to -0.03 bar	DKD-R 6-1: 2014	$10 \mu\text{bar} + 5 \cdot 10^{-5} \cdot p_e$	p_e = Measured value for pressure medium: Gas
	> -0.03 bar to < -1 mbar		$50 \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	-1 mbar to < 0 mbar		4 μbar	
	0 bar		0.6 μbar	
	> 0 mbar to < 0.2 mbar		4 μbar	
	0.2 mbar to 3.6 mbar		0.7 μbar	
	> 3.6 mbar to 0.2 bar		$2 \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	> 0.2 bar to 2 bar		$30 \mu\text{bar} + 2.5 \cdot 10^{-5} \cdot p_e$	
	> 2 bar to 20 bar		$0.05 \text{ mbar} + 2.5 \cdot 10^{-5} \cdot p_e$	
	> 20 bar to 100 bar		$0.5 \text{ mbar} + 2.5 \cdot 10^{-5} \cdot p_e$	
	> 100 bar to 400 bar		$6 \text{ mbar} + 3.5 \cdot 10^{-5} \cdot p_e$	
	0 bar		$7 \cdot 10^{-5} \cdot p_e$ at least 7.5 mbar	Print medium: Oil
	2 bar to 1200 bar			
Absolute pressure p_{abs}	0.01 bar to 2 bar	DKD-R 6-1: 2014 $p_{\text{abs}} = p_e + p_{\text{amb}}$	$15 \mu\text{bar} + 2.5 \cdot 10^{-5} \cdot p_{\text{abs}}$	p_{abs} = measured value for gas pressure medium The measurement uncertainty associated with the residual gas
	> 2 bar to 20 bar		$170 \mu\text{bar} + 2.5 \cdot 10^{-5} \cdot p_{\text{abs}}$	
	> 20 bar to 101 bar		$0.6 \text{ mbar} + 2.5 \cdot 10^{-5} \cdot p_{\text{abs}}$	
	> 101 bar to 401 bar		$7 \text{ mbar} + 3.5 \cdot 10^{-5} \cdot p_{\text{abs}}$	p_{abs} = Measured value of the pressure medium: Oil The measurement uncertainty of the
	1 bar 3 bar to 1201 bar		$7 \cdot 10^{-5} \cdot p_{\text{abs}}$ at least 7.5 mbar	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

**Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 –
Acoustics Calibration and measurement capabilities
(CMC)**

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Acoustics *)				
Measuring microphone /	Transmission ratio: -60 dB to +20 dB (relative to 1 V/Pa)	DIN EN 61094-8:2013		
Sound pressure level (free field)	125 Hz to < 250 Hz	Substitution procedure in a low-reflection chamber using a ½-inch standard at	0.35 dB	
Free-field no-load or free-field operating transmission ratio	250 Hz to 8 kHz	Sound pressure level: 74 dB to 94 dB	0.30 dB	
	> 8 kHz to 10 kHz		0.40 dB	
	> 10 kHz to 20 kHz		0.45 dB	
Measuring microphone /	Transmission ratio: -60 dB to +20 dB (relative to 1 V/Pa)	DIN EN IEC 60942:2018		
Sound pressure level (pressure)	250 Hz / 124 dB	Calibration using a reference standard	0.15 dB	
Pressure-idle or pressure-operating transmission measurement	1000 Hz / 94 dB	Pistonfon	0.15 dB	
	1000 Hz / 114 dB	Calibrator	0.15 dB	
	Transmission coefficient: -60 dB to +20 dB (relative to 1 V/Pa)	DIN EN 61094-5:2016		1/2-inch microphones only
	31.5 Hz to 5 kHz	Calibration using a reference standard	0.20 dB	
	> 5 kHz to 10 kHz	Comparative measurement using an electroacoustic coupler (SQ-4.2) at	0.25 dB	
	> 10 kHz to 16 kHz		0.50 dB	
Sound level meter /	Display deviation in the frequency range:	DIN EN 61672-3:2017		
Sound pressure level display (free field)	125 Hz to < 250 Hz	Substitution procedure in a low-reflection chamber using a ½-inch standard at	0.50 dB	
	250 Hz to 8 kHz	Sound pressure level: 74 dB to 94 dB	0.40 dB	
	> 8 kHz to 10 kHz		0.50 dB	
	> 10 kHz to 20 kHz		0.60 dB	
Sound level meter /	Measurement deviation at the reference point:	DIN EN 61672-3:2017		
Sound pressure level display (pressure)	250 Hz / 124 dB	Calibration using a reference standard	0.15 dB	
	1 kHz / 94 dB	Pistonfon	0.15 dB	
	1 kHz / 114 dB	Calibrator	0.15 dB	
		Calibrator		

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 -

Acoustics Calibration and measurement facilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Sound level calibrator Sound pressure level (pressure)	Sound pressure level: 74 dB to 130 dB (referenced to 20 µPa) 250 Hz / 124 dB 1000 Hz / 94 dB 1000 Hz / 114 dB	DIN EN IEC 60942:2018 Substitution method using traceable calibrators	0.15 dB	
Frequency	250 Hz / 1000 Hz		0.1 Hz	

Appendix to Partial Accreditation Certificate D-K-15070-01-02
Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Thermodynamic
Parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature Fixed-point cells	-189.3442 °C	G-ITS-90, Part 2.3:2021 Argon triple point	4.0 mK	Comparison with a reference fixed-point cell using standard resistance thermometers
	-38.8344 °C	G-ITS-90, Part 2.4:2021 Mercury triple point	1.0 mK	
	0.01 °C	G-ITS-90, Part 2.2:2018 Triple point of water	0.5 mK	
	29.7646 °C	G-ITS-90, Part 2.4:2021 Melting point of	0.8 mK	
	156.5985 °C	G-ITS-90, Part 2.4:2021 Indium freezing point	2.5 mK	
	231.928 °C	G-ITS-90, Part 2.4:2021 Zinner freezing point	1.5 mK	
	419.527 °C	G-ITS-90, Part 2.4:2021 Zinker solidification	2.0 mK	
	660.323 °C	G-ITS-90, Part 2.4:2021 Aluminium solidification point	7.0 mK	
Standard platinum resistance thermometers (SPRTs), direct-reading thermometers and temperature transmitters with resistance sensors (SPRTs)	-196 °C to -189.3442 °C	EURAMET Technical Guide No. 1:2017	8.0 mK	Extrapolation
	-189.3442 °C	G-ITS-90, Part 2.3:2021 Argon triple point	4.0 mK	Calibration at temperature reference points
	-38.8344 °C	G-ITS-90, Part 2.4:2021 Mercury triple point	1.5 mK	
	0.01 °C	G-ITS-90, Part 2.2:2018 Triple point of water	0.5 mK	
	29.7646 °C	G-ITS-90, Part 2.4:2021 Melting point of	1.0 mK	
	156.5985 °C	G-ITS-90, Part 2.4:2021 Indium freezing point	2.5 mK	
	231.928 °C	G-ITS-90, Part 2.4:2021 Zinner freezing point	2.5 mK	
	419.527 °C	G-ITS-90, Part 2.4:2021 Zinker solidification	2.5 mK	
	660.323 °C	G-ITS-90, Part 2.4:2021 Aluminium solidification point	7.0 mK	
	-189.3442 °C to 0.01 °C	G-ITS-90, Part 5:2021 Key points: Ar, Ed.,	6.0 mK	Calibration at temperature reference points with characteristic curve determination in accordance with ITS-90
	-38.8344 °C to 29.7646 °C	G-ITS-90, Part 5:2021 Key points: Hg, TPW,	2.0 mK	
	0 °C to 156.5985 °C	G-ITS-90, Part 5:2021 Key points: TPW, In	3.5 mK	
	0 °C to 231.928 °C	G-ITS-90, Part 5:2021 Key points: TPW, In,	3.5 mK	
	0 °C to 419.527 °C	G-ITS-90, Part 5:2021 Key points: TPW, Sn,	4.0 mK	
	0 °C to 660.323 °C	G-ITS-90, Part 5:2021 Fixed points: TPW, Sn,	8.0 mK	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory, Calibration Laboratory, Gewerbestraße 3 – Thermodynamic quantities

Calibration and measurement capabilities (CMC)

Measured variable / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Resistance thermometers, resistance thermometers with display *)	–196 °C	DKD-R 5-1:2018 in liquid nitrogen	15 mK	Comparison with a reference thermometer
	0.00 °C	DKD-R 5-1:2018 Ice Point	5.0 mK	
	–120 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	10 mK	
	> 200 °C to 300 °C		15 mK	
	> 300 °C to 420 °C		20 mK	
	> 420 °C to 500 °C		50 mK	
	> 500 °C to 660 °C	DKD-R 5-1:2018 in a tunnel	0.20 K	
Resistance thermometer with transmitter	–40 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	15 mK	Comparison with a reference thermometer
	> 200 °C to 500 °C		25 mK	
Resistance thermometers, resistance thermometers with display, resistance thermometers with transmitter *)	–40 °C to –30 °C	DKD-R 5-1:2023 in the climate chamber	0.30 K	Comparison with a reference thermometer
	> –30 °C to 150 °C		0.15 K	
	> 150 °C to 180 °C		0.90 K	
Precious metal thermocouples *)	0.01 °C	DKD-R 5-3:2018 Triple point of	0.4 K	Calibration at temperature fixed points of the ITS 90
	231.928 °C	DKD-R 5-3:2018 Zinner freezing point	0.4 K	
	419.527 °C	DKD-R 5-3:2018 Zinker freezing point	0.4 K	
	660.323 °C	DKD-R 5-3:2018 Aluminium freezing point	0.4 K	
	961.78 °C	DKD-R 5-3:2018 Silver freezing point	0.5 K	
	0 °C to 1000 °C	DKD-R 5-3:2018 in conjunction with DKD-R 5-6:2018 at temperature fixed points	0.6 K	Calibration at fixed temperature points with determination of characteristic curves The measurement uncertainty applies to the calibration curve
Precious-metal thermocouples, precious-metal thermocouples with display *)	–40 °C to 500 °C	DKD-R 5-3:2018 in a liquid bath	0.5 K	Comparison with a reference thermometer
	> 500 °C to 1000 °C	DKD-R 5-3:2018 in a tunnel	0.8 K	
	> 1,000 °C to 1,200 °C	DKD-R 5-3:2018 in a spherical	1.6 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Thermodynamic quantities Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Measurement conditions / procedures	Expanded measurement uncertainty	Comments
Base metal thermocouples, base metal thermocouples with display *)	–196 °C	DKD-R 5-3:2018 in liquid nitrogen	0.5 K	Comparison with a reference thermometer
	–90 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.2 K	
	200 °C to 400 °C		0.4 K	
	> 400 °C to 500 °C		0.5 K	
	> 500 °C to 1000 °C	DKD-R 5-3:2018 in a tunnel kiln,	1.0 K	
	> 1,000 °C to 1,200 °C		1.6 K	
Thermocouples with transmitters *)	–80 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.5 K	Comparison with a reference thermometer
	> 200 °C to 500 °C		1.0 K	
	> 500 °C to 1000 °C	DKD-R 5-3:2018 in a tunnel	2.0 K	
Liquid-in-glass thermometer *)	–80 °C to < 0 °C	PTB Test Regulations, Volume 1	20 mK	Comparison with a reference thermometer
	0 °C to 200 °C		10 mK	
Calibration baths	–80 °C to < 200 °C	3-APD-0-0155-EN: January 2023	10 mK	Comparison with a reference thermometer
	200 °C to 300 °C		15 mK	
Temperature block calibrators *)	–90 °C to 125 °C	DKD-R 5-4:2018	0.04 K	Comparison with a reference thermometer
	> 125 °C to 150 °C		0.05 K	
	> 150 °C to 300 °C		0.25 K	
	> 300 °C to 650 °C		0.50 K	
	> 650 °C to 1200 °C		2.5 K	
Contact-type surface thermometers	50 °C to 100 °C	3-APD-0-0016-DE: January 2023	0.8 K	t = measured value in °C
	> 100 °C to 500 °C		$0.008 \text{ K} \cdot t / ^\circ\text{C}$	
Radiation thermometer	–18 °C to 60 °C	3-APD-0-0018-DE: January 2023	0.6 K	Calibration using a liquid-cooled cavity radiator
	> 60 °C to 100 °C		0.9 K	
	> 100 °C to 350 °C	Spectral range: 8 µm to 14 µm	1.2 K	
Temperature simulators for resistance thermometers *)	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory – Calibration Laboratory, Gewerbestraße 3 – Thermodynamic quantities Calibration and measurement capabilities (CMC)

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation: Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without a reference- Position compensation: Type	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 - Thermodynamic parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / Procedures	Expanded measurement uncertainty	Comments
Freezing point and dew point temperatures Dew point gauges, transmitters and hygrometers	-32 °C to < -25 °C	3APD00036DE: January 2023 1-Temperature, 2-Pressure Humidity	90 mK	Primary generator
	-25 °C to < 0 °C	3-APD-0-0035-DE: January 2023 1-temperature, 1- or 2-pressure humidity	35 mK	
	0 °C to < 70 °C		30 mK	
	70 °C to < 90 °C		40 mK	
	90 °C to 95 °C		45 mK	
	-25 °C to 95 °C	3-APD-0-0037-DE: January 2023 in the climate	130 m K	Comparison with a dew point hygrometer
Relative humidity Dew point mirror	2% to 98%	3-APD-0-0035-EN: January 2023 1-temperature, 1- or 2-pressure humidity generator with temperature chamber 3 °C to 98 °C;	0.1% + 0.003 · rH	rH = measured value Measurement uncertainty expressed as the absolute value of the relative humidity
Electric psychrometes	2% to 98%		0.3% + 0.007 · rH	
Hygrometer, data logger, transmitter *)	2 % to 98 %	DKD-R 5-8:2019 1-temperature, 1- or 2-pressure humidity generator with temperature chamber 3 °C to 98 °C;	0.2% + 0.003 · rH	rH = measured value Measurement uncertainty expressed as the absolute value of the relative humidity
	5 % to 30 %	DKD-R 5-8:2019 in the climate chamber Temperature range: -18 °C to < 0 °C	2.0 %	rH = measured value References: Dew point gauges and resistance thermometers
	> 30 per cent to 60 per cent		3.9 %	
	> 60 per cent to 95 per cent		6.2 %	
	5% to 95%	DKD-R 5-8:2019 in the climate chamber Temperature range: 0 °C to < 25 °C	0.3% + 0.007 · rH	Measurement uncertainty expressed as the absolute value of the relative humidity
		DKD-R 5-8:2019 in the climate chamber Temperature range:	0.2% + 0.005 · rH	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 - Flow-related measurement parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Gas flow Flow velocity of gases	0.1 m/s to 68 m/s	Measurement using a low-turbulence free jet	0.5 per cent; but not less than 0.01m/s	
Volume flow rate dV/dt of flowing gases	15 m³/h to 2,000 m³/h	3-APD-0-0055-DE: January 2023	1.5 per cent; but not less than 0.3m³/h	
Mass flow dm/dt of flowing gases	15 kg/h to 2000 kg/h	Air at ambient conditions	1.5 per cent; but not less than 0.3m³/h	

Permanentes Laboratorium Calibration Laboratory, Gewerbestraße 3 - Chemical and medical parameters Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Electrolytic conductivity Conductivity meters and facilities	1.3 µS/cm to < 5	3-APD-0-0265-EN: January 2023	1.5 per cent	discrete values
	5 µS/cm to < 100 µS/cm		0.7 per cent	
	100 µS/cm to < 706 µS/cm		0.5 per cent	
	706 µS/cm to 100 mS/cm		0.3 per cent	
pH value pH metres and equipment	pH 1.68 to pH 10	3-APD-0-0266-EN: January 2023	0.03 pH	
Exhaust gas / flue gas analysers Oxygen (O) gas concentration ₂	0.0% vol 1.4% vol	3-APD-0-0169-DE: January 2023	0.02% vol 0.035% vol 0.060% vol 0.12% vol	ppm vol = $10^{-6} \cdot m_3/m_3$ % vol = $10^{-2} \cdot m_3/m_3$
Carbon monoxide, CO	80 ppm vol 100 ppm vol 300 ppm vol 400 ppm vol 700 ppm vol		3 ppm vol 3 ppm vol 7.5 ppm vol 10 ppm vol 17.5 ppm vol 125 ppm vol	
Carbon dioxide CO ₂	0.0% vol 0.1% vol 0.5% vol 17% vol 38.5%		0.03% vol 0.03% vol 0.03% vol 0.41% vol 0.9% vol	
Nitric oxide NO	150 ppm		3.8 ppm vol 7.5 ppm vol	
Nitrogen dioxide NO ₂	100 ppm		3.0 ppm by	
Sulphur dioxide SO ₂	100 ppm		3.0 ppm by	
Methane CH ₄	5,000 ppm		120 ppm by	

Valid from: 5 March 2026

Date of issue: 5 March 2026

On-site calibration

On-site calibration – thermodynamic parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature Resistance thermometer, resistance thermometer with display *)	0.00 °C	DKD-R 5-1:2018 Ice point	10 mK	Comparison with a reference thermometer
	–80 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	10 mK	
	> 200 °C to 300 °C	DKD-R 5-1:2018 in the block	0.5 K	
	> 300 °C to 660 °C	DKD-R 5-1:2018 in the	3.0 K	
Resistance thermometer with transmitter *)	–80 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	25 mK	Comparison with a reference thermometer
	> 200 °C to 300 °C		0.5 K	
	> 300 °C to 500 °C	DKD-R 5-1:2018 in the block	3.0 K	
Resistance thermometers with display, resistance thermometers with transmitter *)	–40 °C to < 0 °C	DKD-R 5-1:2018 in a climate chamber	0.30 K	Comparison with a reference thermometer
	0 °C to 50 °C		0.15 K	
	> 50 °C to 80 °C		0.25 K	
	> 80 °C to 120 °C		0.40 K	
	> 120 °C to 180 °C		0.90 K	
Base-metal thermocouples, base-metal thermocouples with display *)	–80 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.2 K	Comparison with a reference thermometer
	> 200 °C to 300 °C	DKD-R 5-3:2018 in the block	0.5 K	
	> 300 °C to 1000 °C	DKD-R 5-3:2018 in the	3.0 K	
Thermocouples with transmitters *)	–80 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.3 K	Comparison with a reference thermometer
	> 200 °C to 1000 °C	DKD-R 5-3:2018 in the	3.5 K	
Calibration baths	–80 °C to < 200 °C	3-APD-0-0155-EN: January 2023	10 mK	Comparison with a reference
	200 °C to 300 °C		15 mK	
Block calibrators *)	–90 °C to 125 °C	DKD-R 5-4:2018	0.04 K	Comparison with a reference thermometer
	> 125 °C to 150 °C		0.05 K	
	> 150 °C to 300 °C		0.25 K	
	> 300 °C to 650 °C		0.5	
	> 650 °C to 800 °C		2.5 K	
	> 800 °C to 1000 °C		4 K	
Temperature simulators for resistance thermometers *)	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

On-site calibration – thermodynamic parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation: Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1,750 °C 250 °C to 1,750 °C	DKD-R 5-5:2018 without a reference-Position compensation: Type	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

On-site calibration – thermodynamic parameters

Calibration and measurement capabilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Measurement points in climate chambers *)	–90 °C to 0 °C	DKD-R 5-7:2025 Method C	0.3 K	Measuring medium: Air Comparison with resistance thermometers
	> 0 °C to 100 °C		0.2 K	
	> 100 °C to 200 °C		0.3 K	
	> 200 °C to 350 °C		0.5 K	
Climate cabinets with recirculating air *)	–90 °C to 0 °C	DKD-R 5-7:2025 Methods A and B	0.5 K	Measuring medium: Air Comparison with resistance thermometers
	> 0 °C to 100 °C		0.3 K	
	> 100 °C to 200 °C		0.5 K	
	> 200 °C to 350 °C		0.8 K	
Dew point temperature Dew point measuring instruments, hygrometers	–25 °C to 70 °C	3-APD-0-0164-EN: January 2023 1-Temperature, 2-Pressure and Humidity Generator	0.09 K	Comparison with the dew point mirror
Relative humidity Measurement points in climate chambers *)	5 % to 30 %	DKD-R 5-7:2025 Method C Temperature range: –10 °C to 95 °C Freezing point $\geq -25^{\circ}\text{C}$	0.3 %	Measuring medium: air The humidity reference is calculated from the dew point and air temperature Measurement uncertainty expressed as the absolute value of the relative humidity
	> 30 % to 60 %		0.4 %	
	> 60 % to 98 %		0.6 %	
Climate-controlled cabinets *)	5 % to 30 %	DKD-R 5-7:2025 Methods A and B Temperature range: –10 °C to 95 °C Freezing point $\geq -25^{\circ}\text{C}$	0.4 %	
	> 30 % to 60 %		0.6 %	
	> 60 % to 98 %		0.8 %	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

On-site calibration – Thermodynamic parameters

Calibration and measurement facilities (CMC)				
Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Relative humidity Hygrometer, data logger, transducers *)	10 % to 95 %	DKD-R 5-8:2019 1-Temperature, 2-Pressure Humidity Generator Chamber temperature: 0 °C to 70 °C	0.6 %	References: Dew point gauges and resistance thermometers Measurement uncertainty expressed as the absolute value of the relative
	5 % to 95 %	DKD-R 5-8:2019 in the mixed-gas generator Chamber temperature: 10 °C to < 20 °C	$0.3\% + 0.015 \cdot rH$	rH = measured value References: Dew-point mirror hygrometer Measurement uncertainty expressed as the absolute value of the relative humidity
	5% to 95%	DKD-R 5-8:2019 1-Temperature, 2-Pressure Humidity Generator Chamber temperature: 20 °C to 30 °C	$0.3\% + 0.007 \cdot rH$	
	5 % to 95 %	DKD-R 5-8:2019 1-Temperature, 2-Pressure and Humidity Generator Chamber temperature: > 30	$0.3\% + 0.015 \cdot rH$	
Hygrometers, data loggers, transducers *)	10 % to 95 %	DKD-R 5-8:2019 Humidifier with a limited usable volume Chamber temperature: 0 °C to 40 °C	0.9%	References: Dew-point gauges and resistance thermometers Measurement uncertainty expressed as the absolute value of the relative humidity
	10 % to 95 %	DKD-R 5-8:2019 Humidifier with a limited usable volume Chamber temperature: > 40 °C to 70 °C	2.0 %	

Appendix to partial accreditation certificate D-K-15070-01-02

On-site calibration – Mechanical parameters

Calibration and measurement facilities (CMC)

Measured variable /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Scales *) non-automatic electronic scales	0 kg to 10 kg	EURAMET cg-18 Version 4.0	$1 \cdot 10^{-6}$	with Class E weights ²
	> 10 kg to 80 kg	On-site calibration	$5 \cdot 10^{-6}$	
Torque *) Calibration equipment	0.2 N·m to 1000 N·m	DKD-R 10-8:2020	$2 \cdot 10^{-3}$	
Torque transducers, - sensors, - measuring chains	0.4 N·m to < 10 N·m	DIN 51309:2022	$2 \cdot 10^{-3}$	
	10 N·m to 5,000 N·m		$0.5 \cdot 10^{-3}$	
Hand-operated torque screwdrivers	1 N·m to 1000 N·m	DIN EN ISO 6789-2:2017	1 %	
Pressure *) Negative and positive overpressure p_e	-1 bar to -0.03 bar	DKD-R 6-1: 2014	$12 \mu\text{bar} + 5.2 \times 10^{-5} \cdot p_e$	p_e = Pressure medium reading: Gas
	> -0.03 bar to < -1 mbar		$50 \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	-1 mbar to < 0 mbar		4 μbar	
	0 bar		2 μbar	
	> 0 mbar to < 0.2 mbar		4 μbar	
	0.2 mbar to 3.6 mbar		0.7 μbar	
	> 3.6 mbar to 0.2 bar		$2 \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	> 0.2 bar to 2 bar		$30 \mu\text{bar} + 2.7 \times 10^{-5} \cdot p_e$	
	> 2 bar to 20 bar		$75 \mu\text{bar} + 2.7 \times 10^{-5} \cdot p_e$	
	> 20 bar to 100 bar		$0.5 \text{ mbar} + 3.0 \cdot 10^{-5} \cdot p_e$	
	> 100 bar up to 400 bar		$7 \text{ mbar} + 3.5 \times 10^{-5} \cdot p_e$	
	0 bar		$7.2 \cdot 10^{-5} \cdot p_e$ at least 7.5 mbar	Print medium: Oil
	2 bar to 1200 bar			
Absolute pressure p_{abs}	0.01 bar to 2 bar	DKD-R 6-1: 2014 $p_{\text{abs}} = p_e + p_{\text{amb}}$	$17 \mu\text{bar} + 2.7 \times 10^{-5} \cdot p_{\text{abs}}$	p_{abs} = Measured value: gas pressure The measurement uncertainty associated with the residual gas measurement must be taken into account.
	> 2 bar to 20 bar		$180 \mu\text{bar} + 2.7 \times 10^{-5} \cdot p_{\text{abs}}$	
	> 20 bar to 101 bar		$0.5 \text{ mbar} + 3.0 \cdot 10^{-5} \cdot p_{\text{abs}}$	
	> 101 bar to 401 bar		$7 \text{ mbar} + 3.5 \times 10^{-5} \cdot p_{\text{abs}}$	
	1 bar		$7 \cdot 10^{-5} \cdot p_{\text{abs}}$ at least 7.5 mbar	p_{abs} = Pressure medium reading: Oil The measurement uncertainty of the
	3 bar to 1201 bar			

Appendix to Partial Accreditation Certificate D-K-15070-01-02

On-site calibration – flow measurement parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measurement range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Flow of liquids Volumetric flow rate dV/dt from flowing liquids	0.01 L/min up to 250 L/min	3-APD-0-0251-DE: January 2023 Volumetric comparison measurement (References: Turbines, gear meters, Coriolis meters; MID, etc.)	0.15 %	Measuring instruments with analogue output, frequency output and visual display
Mass flow dm/dt from flowing liquids	0.01 kg/min up to 250 kg/min	Density ranging from 700kg/m ³ to 1100/m ³ Viscosity from 0.8 mm ² /s to 1600 mm ² /s	0.20%	
Gas flow Volume flow dV/dt from flowing gases	0.001 L/min up to 250 L/min	3-APD-0-0251-EN: January 2023 Volumetric comparison measurement (References: Coriolis, piston calibrator, ...)	0.50 %	under standard conditions $p_N=1013.25\text{mbar}$ $T_N=0^\circ\text{C}$
Mass flow dm/dt from flowing gases	1.3 mg/min up to 312 g/min	Calibration medium: Compressed air (with air quality in accordance with DIN ISO 8573-1; clean, oil-free air with a maximum relative humidity of 55 per cent) at room temperature up to a maximum gauge pressure of 10 bar	0.50%	
Volume flow dV/dt from flowing gases	5 mL/min to 250 L/min	3-APD-0-0251-DE: January 2023 Volumetric comparative measurement (References: Coriolis, piston calibrator, ...) Calibration medium: N ₂ , CO ₂ , Ar, CH ₄ , He (Purity > 99.99% by volume); Room temperature up to a maximum of 10 bar gauge pressure	0.50 %	Measuring instruments with analogue output, frequency output and visual display In the standard state: $p_N = 1013.25\text{ mbar}$ $T_N = 0^\circ\text{C}$ and $\rho_{N\text{N}_2} = 1.250\text{ kg/m}^3$ $\rho_{N\text{CO}_2} = 1.976\text{ kg/m}^3$ $\rho_{N\text{Ar}} = 1.783\text{ kg/m}^3$ $\rho_{N\text{CH}_4} = 0.717\text{ kg/m}^3$ $\rho_{N\text{He}} = 0.1785\text{ kg/m}^3$

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Mobile laboratory

Mobile Laboratory – Thermodynamic Parameters

Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	Performance curve according to DIN EN IEC 60751:2023
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without compensation for reference points Type R,	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— Type J compensation Type T Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without compensation for reference points Type, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Mobile Laboratory – Thermodynamic Parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1,750 °C 250 °C to 1,750 °C	DKD-R 5-5:2018 without a reference-position compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation Typ J, Typ T, Typ K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1,000 °C –200 °C to 1,300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without compensation for reference points Type J, Type T, Type E, Type K, Type N, Type C,	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Mobile Laboratory – Mechanical Parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Pressure *) Negative and positive overpressure p_e	-1 bar to -0.03 bar	DKD-R 6-1: 2014	$12\text{ }\mu\text{bar} + 5.2 \times 10^{-5} \cdot p_e$	p_e = Pressure medium reading: Gas
	> -0.03 bar to < -1 mbar		$50\text{ }\mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	-1 mbar to < 0 mbar		4 μbar	
	0 bar		2 μbar	
	> 0 mbar to < 0.2 mbar		4 μbar	
	0.2 mbar to 3.6 mbar		1 μbar	
	> 3.6 mbar to 0.2 bar		$2\text{ }\mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	> 0.2 bar to 2 bar		$30\text{ }\mu\text{bar} + 2.7 \times 10^{-5} \cdot p_e$	
	> 2 bar to 20 bar		$75\text{ }\mu\text{bar} + 2.7 \times 10^{-5} \cdot p_e$	
	> 20 bar to 100 bar		$0.5\text{ mbar} + 3.0 \cdot 10^{-5} \cdot p_e$	
	> 100 bar to 400 bar		$7\text{ mbar} + 3.5 \times 10^{-5} \cdot p_e$	
	0 bar		$7.2 \cdot 10^{-5} \cdot p_e$ at least 7.5 mbar	Print medium: Oil
	2 bar to 1200 bar			
Absolute pressure p_{abs}	0.01 bar to 2 bar	DKD-R 6-1: 2014 $p_{\text{abs}} = p_e + p_{\text{amb}}$	$17\text{ }\mu\text{bar} + 2.7 \times 10^{-5} \cdot p_{\text{abs}}$	p_{abs} = Measured value for gas as the pressure medium The measurement uncertainty associated with the residual gas
	> 2 bar to 20 bar		$180\text{ }\mu\text{bar} + 2.7 \times 10^{-5} \cdot p_{\text{abs}}$	
	> 20 bar to 101 bar		$0.5\text{ mbar} + 3.0 \cdot 10^{-5} \cdot p_{\text{abs}}$	
	> 101 bar to 401 bar		$7\text{ mbar} + 3.5 \times 10^{-5} \times p_{\text{abs}}$	p_{abs} = Pressure medium reading: Oil The measurement uncertainty of the
	1 bar		$7 \cdot 10^{-5} \cdot p_{\text{abs}}$ at least 7.5 mbar	
	3 bar to 1201 bar			

Kalibrierlabor Kirchzarten site, Erich-Rieder Straße 4, 79199 Kirchzarten

Kirchzarten Permanent Laboratory, Erich-Rieder Straße 4 – Thermodynamic parameters

Measured variable / Calibration object	Calibration and measurement capabilities (CMC)			Comments
	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S,	0.10 K 0.10 K	
Temperature simulators for base-metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	
Temperature display devices for precious metal thermocouples *)	–50 °C to 1750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S,	0.10 K 0.10 K	
		DKD-R 5-5:2018		

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanentes Laboratorium Kirchzarten, Erich-Rieder Straße 4 - Thermodynamic parameters

Calibration and measurement facilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature display devices for base metal thermocouples *)	-200 °C to 1200 °C -200 °C to 400 °C -200 °C to 1300 °C	with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	-200 °C to 1200 °C -200 °C to 400 °C -200 °C to 1000 °C -200 °C to 1300 °C -200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Permanentes Laboratorium Kirchzarten, Erich-Rieder-Straße 4 - Mechanical parameters

Calibration and measurement capabilities (CMC)				
Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Torque *) Hand-operated torque screwdrivers	0.01 N·m to 0.2 N·m	DIN EN ISO 6789-2:2017 DIN EN ISO 6789-2:2017	$1 \cdot 10^{-2}$	
torque wrenches with a display Calibration equipment for torque tools	> 0.2 N·m to 1 kN·m	DKD-R 3-7:2018 DKD-R 10-8:2020	$2 \cdot 10^{-3}$	
Torque - transducers, - sensors, - measuring chains	10 N·m to 5 kN·m	DIN 51309:2022	0.5×10^{-3}	
Force *) Force measuring instruments,	10 N to 250 kN	DKD-R 3-3:2018 DIN EN ISO 376:2011	$5 \cdot 10^{-4}$	

Calibration Laboratory Munich, Nikolaus-Otto-Straße 2, 85221 Dachau

Permanent Laboratory, Munich – Mechanical Parameters

Calibration and measurement capabilities (CMC)

Measurand / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Acceleration *) Vibration transducer, vibration measuring instrument	0.1 m/s ² to 20 m/s ²	Sinusoidal Excitation DKD-R 3-1		Complex transmission coefficient (Amount / Phase). Transducer mass up to 0.9 kg, displacement amplitude up to 100 mm
		0.2 Hz to < 0.4 Hz	2.5 per cent / 1.6	
		0.4 Hz to < 1 Hz	1.5 per cent / 1.6	
		1 Hz to < 16 Hz	0.8% / 0.8°	
		16 Hz	0.55 per cent / 0.6°	
		> 16 Hz to 63 Hz	0.8% / 0.8°	
		> 63 Hz to 160 Hz	1.0% / 1.1°	
	1 m/s ² to 200 m/s ²	Sinusoidal Excitation DKD-R 3-1		Complex transfer coefficient (magnitude / phase). Transducer mass up to 0.2 kg, displacement amplitude up to 8 mm
		5 Hz to < 10 Hz	1.5 per cent / 1.5	
		10 Hz to < 20 Hz	0.8% / 0.8°	
		20 Hz to 1 kHz	0.6% / 0.6°	
		> 1 kHz to 5 kHz	0.8% / 0.8°	
		> 5 kHz to 10 kHz	2.0% / 1.5°	
		> 10 kHz to 15 kHz	2.5 per cent / 2.5	
		> 15 kHz to 20 kHz	3.0% / 3.0°	
Vibration calibrator	1 m/s ² to 100 m/s ²	Sinusoidal excitation DIN ISO 16063-		
		10 Hz to < 20 Hz	0.8%	
		20 Hz to 1 kHz	0.6 per cent	
		> 1 kHz to 5 kHz	0.8 per cent	
		> 5 kHz to 10 kHz	2.0 per cent	
Torque *) hand- operated torque screwdrivers	0.2 N·m to 1000 N·m	DIN EN ISO 6789- 2:2017	2 · 10 ⁻³	
torque wrenches with a display		DKD-R 3-7:2018		
Calibration equipment for torque tools		DKD-R 10-8:2020		
Torque transducers, torque measuring		DIN 51309:2022		
Strength *) Tensile force, compressive force, force measuring	10 N to 100 kN	DKD-R 3-3:2018	1 · 10 ⁻³	

Appendix to Partial Accreditation Certificate D-K-15070-01-02
Permanent Laboratory, Munich – Mechanical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Pressure *) Positive and negative overpressure p_e	-1 bar to < -0.1 bar	DKD-R 6-1:2014	$0.2 \text{ mbar} + 1 \times 10^{-4} \times p_e$	p_e = measured value for gas as the pressure medium
	-0.1 bar to < 0 bar		$50 \text{ } \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	0 bar		10 μbar	
	> 0 bar to 0.1 bar		$50 \text{ } \mu\text{bar} + 1 \cdot 10^{-4} \cdot p_e$	
	> 0.1 bar to 10 bar		$0.2 \text{ mbar} + 1 \cdot 10^{-4} \cdot p_e$	
	> 10 bar to 250 bar		$2 \cdot 10^{-4} \cdot p_e$	
Absolute pressure p_{abs}	0.03 bar to 10 bar	DKD-R 6-1:2014 $p_{\text{abs}} = p_e + p_{\text{amb}}$	$0.2 \text{ mbar} + 1 \times 10^{-4} \times p_{\text{abs}}$	p_{abs} = Measured value of the pressure medium: Gas The measurement uncertainty of the
	> 10 bar to 251 bar		$2 \cdot 10^{-4} \cdot p_{\text{abs}}$	

Permanent Laboratory, Munich – Flow Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measuring span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Flow of liquids Volume flow rate dV/dt of flowing liquids Mass flow rate dm/dt of flowing liquids	1.2 m ³ /h up to 340 m ³ /h	Comparison measurements with reference flowmeters	0.1 %	
	1,200 kg/h up to 3.4×10^5 kg/h	Calibration medium: Water 3-APD-0-0171-DE: June 2023		
Volumetric flow rate dV/dt of flowing liquids	0.1 mL/min up to 15 mL/min 0.8 mL/min to 40 L/min 10 mL/min to 300 L/min	Volumetric measurement: piston calibrator	0.08%	Measuring instruments with analogue output, frequency output and visual display
	1 L/min to 1,200 L/min	Liquids with a density of 700 kg/m ³ to 1,100 kg/m ³	0.05%	
Mass flow dm/dt of flowing liquids	0.1 g/min to 15 kg/min 0.6 g/min to 32 kg/min 8 g/min to 240 kg/min 0.8 kg/min to 1,000 kg/min	Viscosity of 0.3 mm ² /s to 1,600 mm ² /s 3-APD-0-0090-DE: May 2023	0.12%	
			0.09%	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory, Munich – Flow-related parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measuring	Test conditions / procedures	Expanded measurement uncertainty	Comments
Volume V of flowing liquids	25 mL to 2.5 L	3-APD-0-0090-DE: 2023-05 Flow rates not less than 0.5 mL/min	0.08%	Measuring instruments with analogue output, frequency output and visual display
	190 mL to 19 L	3-APD-0-0090-DE: 2023-05 Flow rates not less than 1 mL/min		
	410 mL to 41 L	3-APD-0-0090-DE: 2023-05 Flow rates not less than 10 mL/min		
Gas flow Volume flow rate dV/dt of flowing gases	1 mL/min to < 3 mL/min	3-APD-0-0088-DE: 2023-01 Laminar flow elements for dry air (dew point < -15°C)	0.40%	Measuring instruments with analogue output, frequency output and visual display Under normal conditions $p_N = 1013.25$ mbar $T_N = 0$ °C
	3 mL/min to 1000 L/min		0.33%	
	8 L/min to 15,000 L/min	3-APD-0-0088-DE: January 2023: Critical nozzles – dry air (dew point < -15°C)	0.24%	
Volumetric flow rate dV/dt of flowing gases	5 mL/min to 250 L/min	3-APD-0-0251-DE: January 2023 Volumetric comparison measurement (References: Coriolis, piston calibrator, ...) Calibration medium: N ₂ , CO ₂ , Ar, CH ₄ , He (Purity > 99.99 vol. %); Room temperature up to a maximum of 10 bar gauge pressure	0.50 %	Measuring instruments with analogue output, frequency output and visual display Under standard conditions: $p_N = 1013.25$ mbar $T_N = 0$ °C and $\rho_{N_2} = 1.250$ kg/m ³ $\rho_{N_2CO_2} = 1.976$ kg/m ³ $\rho_{N_2Ar} = 1.783$ kg/m ³ $\rho_{N_2CH_4} = 0.717$ kg/m ³ $\rho_{N_2He} = 0.1785$ kg/m ³
Mass flow dm/dt of flowing gases	1.3 g/min to < 3.9 g/min	3-APD-0-0088-DE: January 2023: Laminar flow elements dry air (dew point < -15°C)	0.42%	
	3.9 g/min to < 1300 g/min		0.36%	
	10 g/min to 15,000 g/min	3-APD-0-0088-DE: January 2023: Critical Nozzles dry air (dew point < -15°C)	0.24%	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory, Munich – Thermodynamic Parameters Calibration
and measurement facilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation TypeR, TypS, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C – 200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation TypeJ, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C – 200 °C to 400 °C – 200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory, Munich – Thermodynamic Parameters Calibration
and measurement facilities (CMC)

Measured variable / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature display devices for precious metal thermocouples *)	–50 °C to 1750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J Type T Type E Type K Type N Type C Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Essen Calibration Laboratory, Hermann-Drescher-Weg 4a-d, 45329 Essen

Permanent Laboratory Essen – Thermodynamic Parameters Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1,750 °C 250 °C to 1,750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory Essen – Thermodynamic Quantities Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Calibration Laboratory Hamburg, Meiendorfer Straße 205, 22145 Hamburg

Hamburg Permanent Laboratory – Thermodynamic Parameters Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance thermometers *)	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Permanent Laboratory Hamburg - Thermodynamic parameters Calibration and measurement facilities (CMC)

Measured quantity /	Measuring range /	Test conditions / procedures	Expanded measurement	Comments
Temperature simulators for precious metal thermocouples *)	–50 °C to 1750 °C	DKD-R 5-5:2018 with reference points— compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation: Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensatio: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without a reference- Position compensation: Type	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— Compensatio: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Mörfelden-Walldorf Calibration Laboratory, Kurhessenstraße 11, 64546 Mörfelden-Walldorf

Mörfelden-Walldorf Permanent Laboratory – Thermodynamic Parameters

Calibration and measurement facilities (CMC)

Measurement parameter / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Resistance thermometers,	–40 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	10 mK	Comparison with a reference thermometer
Resistance thermometer with transmitter	–40 °C to 200 °C	DKD-R 5-1:2018 in a liquid bath	15 mK	Comparison with a reference thermometer
Resistance thermometers with display, resistance thermometers with transmitter *)	–40 °C to < 0 °C	DKD-R 5-1:2018 in the climate chamber	0.30 K	Comparison with a reference thermometer
	0 °C to 50 °C		0.15 K	
	> 50 °C to 80 °C		0.25 K	
	> 80 °C to 120 °C		0.40 K	
	> 120 °C to 180 °C		0.90 K	
Precious-metal thermocouples, precious-metal thermocouples with display	–40 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.5 K	Comparison with a reference thermometer
Base-metal thermocouples, base-metal thermocouples with display *)	–40 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.2 K	Comparison with a reference thermometer
Thermocouples with transmitters *)	–40 °C to 200 °C	DKD-R 5-3:2018 in a liquid bath	0.3 K	Comparison with a reference thermometer
Calibration baths	–40 °C to 200 °C	3-APD-0-0155-EN: January 2023	10 mK	Comparison with a reference thermometer
Temperature block calibrators *)	–40 °C to 150 °C	DKD-R 5-4:2018	0.05 K	Comparison with a reference thermometer
Radiation thermometer	–18 °C to 60 °C	3-APD-0-0018-DE: January 2023 Spectral range: 8 µm to 14 µm	0.6 K	Calibration using a liquid-cooled cavity radiator
	> 60 °C to 100 °C		0.9 K	
	> 100 °C to 350 °C		1.2 K	
Temperature simulators for resistance thermometers *)	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature display devices for resistance	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Mörfelden-Walldorf Permanent Laboratory – Thermodynamic Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature simulators for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation: Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation: Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference points— compensation: Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without a comparative— Position compensation: Type R, Type S, Type B	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference points— compensation: Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation: Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Mörfelden-Walldorf Permanent Laboratory - Thermodynamic parameters

Calibration and measurement facilities (CMC)

Measurement parameter /	Measuring range /	Measurement conditions /	Expanded measurement	Comments
Freezing point / dew point temperature Dew point gauges, transmitters, hygrometers	-32 °C to -25 °C	3-APD-0-0036-DE: January 2023 1-Temperature-2-Pressure Humidity Generator	90 mK	
	> -25 °C to -10 °C		60 mK	
	> -10 °C to 40 °C		90 mK	
	> 40 °C to 70 °C		0.12 K	
Relative humidity Hygrometer, transducer	10 % to 20 %	DKD-R 5-8:2019 1-temperature, 2-pressure humidity generator	0.7 %	Measurement uncertainty as the absolute value of the relative humidity
	> 20 % to 40 %		1.3 %	
	> 40 % to 85 %		2.1 %	
	10 % to 40 %	DKD-R 5-8:2019 1-temperature, 2-pressure humidity generator	0.3 %	
	> 40 % to 80 %		0.6 %	
	> 80 % to 95 %		0.7 %	
	10% to 40%	DKD-R 5-8:2019 1-temperature, 2-pressure humidity generator > 20 °C to 70 °C	0.3 %	
	> 40 % to 80 %		0.5 %	
	> 80 % to 95 %		0.6 %	

Winsen Calibration Laboratory, Tönnhäuser Weg 100–106, 21423 Winsen (Luhe)

Winsen Permanent Laboratory – Thermodynamic Parameters Calibration and measurement capabilities (CMC)

Measured variable / Calibration object	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature measurement parameters Temperature simulators	–200 °C to 850 °C	DKD-R 5-5:2018	0.016 K	Performance curve according to DIN EN IEC 60751:2023
Temperature displays for resistance thermometers *)	–200 °C to 850 °C	DKD-R 5-5:2018	0.030 K	
Temperature simulators for precious metal thermocouples *)	–50 °C to 1750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature simulators for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Appendix to Partial Accreditation Certificate D-K-15070-01-02

Winsen Permanent Laboratory – Thermodynamic Parameters Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Temperature display devices for precious metal thermocouples *)	–50 °C to 1,750 °C	DKD-R 5-5:2018 with reference point compensation Type R, Type S	0.10 K	Performance curve according to DIN EN 60584-1:2014
	–50 °C to 1750 °C 250 °C to 1750 °C	DKD-R 5-5:2018 without reference point compensation Type R, Type S, Type B	0.10 K 0.10 K	
Temperature display devices for base metal thermocouples *)	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1300 °C	DKD-R 5-5:2018 with reference point compensation Type J, Type T, Type K	0.08 K 0.08 K 0.09 K	Performance curve according to DIN EN 60584-1:2014
	–200 °C to 1200 °C –200 °C to 400 °C –200 °C to 1000 °C –200 °C to 1300 °C –200 °C to 1300 °C 0 °C to 1300 °C 100 °C to 1300 °C	DKD-R 5-5:2018 without reference point compensation Type J, Type T, Type E, Type K, Type N, Type C, Type A	0.05 K 0.05 K 0.05 K 0.07 K 0.05 K 0.6 K 0.4 K	

Winsen Permanent Laboratory – Mechanical Parameters

Calibration and measurement facilities (CMC)

Measured quantity / Calibration item	Measuring range / Measurement span	Test conditions / procedures	Expanded measurement uncertainty	Comments
Pressure *) Positive and negative overpressure	–1 bar to 10 bar	DKD-R 6-1:2014	$0.2 \text{ mbar} + 1 \times 10^{-4} \times p_e$	p_e = Measured value for gas as the pressure medium
	> 10 bar to 250 bar		$2 \cdot 10^{-4} \cdot p_e$	
Absolute pressure p_{abs}	0.03 bar to 11 bar	DKD-R 6-1:2014 $p_{abs} = p_e + p_{amb}$	$0.2 \text{ mbar} + 1 \times 10^{-4} \times$	p_{abs} = Measured value of the pressure medium: Gas The measurement uncertainty of the barometer must be taken into account
	> 11 bar to 251 bar		$2 \cdot 10^{-4} \cdot p_{abs}$	

Abbreviations used

APD	Calibration method developed in-house by Testo Industrial Services GmbH
CMC	Calibration and measurement capabilities German Institute for Standardisation
DIN	(DIN)
DKD-R	Guideline of the German Calibration Service (DKD), published by the Physikalisch-Technische Bundesanstalt
EURAMET	European Association of National Metrology Institutes
G-ITS-90, Part 2.2	BIPM Guide to the Realisation of the ITS-90, Triple Point of Water;
G-ITS-90, Part 2.3	BIPM Guide to the Realisation of the ITS-90, Cryogenic Fixed Points
G-ITS-90, Part 2.4	BIPM Guide to the Realisation of ITS-90: Metal Fixed Points for Contact Thermometry
G-ITS-90, Part 5	BIPM Guide to the Realisation of ITS-90, Platinum Resistance Thermometry