

Akkreditierung



Die Deutsche Akkreditierungsstelle bestätigt mit dieser **Akkreditierungsurkunde**, dass das Kalibrierlaboratorium

Rohde & Schwarz Meßgerätebau GmbH
Mühldorfstraße 15, 81671 München

die Anforderungen gemäß DIN EN ISO/IEC 17025:2018 für die in der Anlage zu dieser Urkunde aufgeführten Konformitätsbewertungstätigkeiten erfüllt. Dies schließt zusätzliche bestehende gesetzliche und normative Anforderungen an das Kalibrierlaboratorium ein, einschließlich solcher in relevanten sektoralen Programmen, sofern diese in der Anlage zu dieser Urkunde ausdrücklich bestätigt werden.

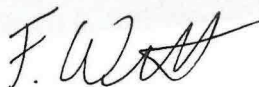
Die Anforderungen an das Managementsystem in der DIN EN ISO/IEC 17025 sind in einer für Kalibrierlaboratorien relevanten Sprache verfasst und stehen insgesamt in Übereinstimmung mit den Prinzipien der DIN EN ISO 9001.

Diese Akkreditierung wurde gemäß Art. 5 Abs. 1 Satz 2 VO (EG) 765/2008, nach Durchführung eines Akkreditierungsverfahrens unter Beachtung der Mindestanforderungen der DIN EN ISO/IEC 17011 und auf Grundlage einer Bewertung und Entscheidung durch den eingesetzten Akkreditierungsausschuss ausgestellt.

Diese Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 23.07.2024 mit der Akkreditierungsnummer D-K-15195-01.

Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 49 Seiten.

Registrierungsnummer der Akkreditierungsurkunde: **D-K-15195-01-00**



Berlin, 23.07.2024

Im Auftrag Dr. Florian Witt
Fachbereichsleitung

Diese Urkunde gibt den Stand zum Zeitpunkt des Ausstellungsdatums wieder. Der jeweils aktuelle Stand der gültigen und überwachten Akkreditierung ist der Datenbank akkreditierter Stellen der Deutschen Akkreditierungsstelle zu entnehmen (www.dakks.de).

Deutsche Akkreditierungsstelle

Standort Berlin
Spittelmarkt 10
10117 Berlin

Standort Frankfurt am Main
Europa-Allee 52
60327 Frankfurt am Main

Standort Braunschweig
Bundesallee 100
38116 Braunschweig

Die Deutsche Akkreditierungsstelle GmbH (DAkkS) ist die beliehene nationale Akkreditierungsstelle der Bundesrepublik Deutschland gemäß § 8 Absatz 1 AkkStelleG i. V. m. § 1 Absatz 1 AkkStelleGBV. Die DAkkS ist als nationale Akkreditierungsbehörde gemäß Art. 4 Abs. 4 VO (EG) 765/2008 und Tz. 4.7 DIN EN ISO/IEC 17000 durch Deutschland benannt.

Die Akkreditierungsurkunde ist gemäß Art. 11 Abs. 2 VO (EG) 765/2008 im Geltungsbereich dieser Verordnung von den nationalen Behörden als gleichwertig anzuerkennen sowie von den WTO-Mitgliedsstaaten, die sich in bilateralen- oder multilateralen Gegenseitigkeitsabkommen verpflichtet haben, die Urkunden von Akkreditierungsstellen, die Mitglied bei ILAC oder IAF sind, als gleichwertig anzuerkennen.

Die DAkkS ist Unterzeichnerin der Multilateralen Abkommen zur gegenseitigen Anerkennung der European co-operation for Accreditation (EA), des International Accreditation Forum (IAF) und der International Laboratory Accreditation Cooperation (ILAC).

Der aktuelle Stand der Mitgliedschaft kann folgenden Webseiten entnommen werden:

EA: www.european-accreditation.org

ILAC: www.ilac.org

IAF: www.iaf.nu

Deutsche Akkreditierungsstelle

Annex to the Accreditation Certificate D-K-15195-01-00 according to DIN EN ISO/IEC 17025:2018

Valid from: 23.07.2024

Date of issue: 23.07.2024

Holder of accreditation certificate:

Rohde & Schwarz Meßgerätebau GmbH
Mühldorfstraße 15, 81671 München

with the locations

Rohde & Schwarz Meßgerätebau GmbH
Rohde-und-Schwarz-Straße 1, 87700 Memmingen

Rohde & Schwarz Meßgerätebau GmbH
Graf Zeppelin-Straße 18, 51147 Köln

Rohde & Schwarz Meßgerätebau GmbH
Spidrova 49, 38501 Vimperk, Tschechien

Rohde & Schwarz Meßgerätebau GmbH
Avenida de Manoteras 64, 28050 Madrid, Spanien

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

The management system requirements of DIN EN ISO/IEC 17025 are written in the language relevant to the operations of calibration laboratories and they conform to the general to the principles of DIN EN ISO 9001.

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

Abbreviations used: see last page

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This document is a translation. The definitive version is the original German annex to the accreditation certificate.

Annex to the Accreditation Certificate D-K-15195-01-00

Calibration in the fields:

Electrical quantities

DC and low frequency quantities

- DC voltage^{a)}
- AC voltage^{a)}
- DC current^{a)}
- AC current^{a)}
- DC resistance^{a)}
- AC/DC Transfer
- Capacitance^{a)}

Time and frequency

- Time interval^{a)}
- Frequency^{a)}

High frequency quantities

- HF voltage^{a)}
- HF power^{a)}
- HF attenuation^{a)}
- HF impedance^{a)}
- Scattering quantities^{a)}
- HF noise
- Waveform quantities^{a)}
- Modulation quantities^{a)}
- Antenna quantities^{a)}
- Rise Time^{a)}

^{a)} also on-site calibration and mobile laboratory

Annex to the Accreditation Certificate D-K-15195-01-00

Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
DC voltage Sources, Measuring instruments	1.018 V		$2 \cdot 10^{-6} \cdot U$	U: Measured value
	10 V		$1 \cdot 10^{-6} \cdot U$	
DC current Measuring instruments	0 V to 500 V		$10 \cdot 10^{-6} \cdot U + 1 \mu V$	I: Measured value
	> 500 V to 1 kV		$10 \cdot 10^{-6} \cdot U$	
Sources	0 μA to 10 μA		1 nA	I: Measured value
	> 10 μA to 220 mA		$0.1 \cdot 10^{-3} \cdot I$	
Sources	> 220 mA to 2.2 A		$0.14 \cdot 10^{-3} \cdot I$	I: Measured value
	0 μA to 10 μA		1 nA	
Sources	> 10 μA to 100 mA		$0.1 \cdot 10^{-3} \cdot I$	I: Measured value
	> 100 mA to 60 A		$0.2 \cdot 10^{-3} \cdot I$	
DC resistance Resistance, measuring instruments	0 Ω to 100 k Ω		$15 \cdot 10^{-6} \cdot R + 60 \mu \Omega$	R: Measured value
	> 100 k Ω to 1 M Ω		$20 \cdot 10^{-6} \cdot R + 2 \Omega$	
	> 1 M Ω to 10 M Ω		$60 \cdot 10^{-6} \cdot R + 0.1 k\Omega$	
	> 10 M Ω to 100 M Ω		$0.6 \cdot 10^{-3} \cdot R$	
	> 100 M Ω to 1 G Ω		$5.1 \cdot 10^{-3} \cdot R$	
AC voltage Measuring instruments	1 mV to 220 V	10 Hz to < 20 Hz	$0.40 \cdot 10^{-3} \cdot U + 8 \mu V$	U: Measured value
		20 Hz to 20 kHz	$0.21 \cdot 10^{-3} \cdot U + 2 \mu V$	
		> 20 kHz to 50 kHz	$0.20 \cdot 10^{-3} \cdot U + 2 \mu V$	
		> 50 kHz to 100 kHz	$0.50 \cdot 10^{-3} \cdot U + 2 \mu V$	
	1 mV to 22 V	> 100 kHz to 300 kHz	$1.0 \cdot 10^{-3} \cdot U + 18 \mu V$	Umax = $22 \cdot 10^6 \cdot V$ Hz/ f[Hz]
		> 300 kHz to 500 kHz	$1.8 \cdot 10^{-3} \cdot U + 20 \mu V$	
		> 500 kHz to 1 MHz	$4.0 \cdot 10^{-3} \cdot U + 20 \mu V$	
	> 22 V to Umax	> 100 kHz to 300 kHz	$1.0 \cdot 10^{-3} \cdot U + 16 mV$	Umax = $22 \cdot 10^6 \cdot V$ Hz/ f[Hz]
		> 300 kHz to 500 kHz	$5.0 \cdot 10^{-3} \cdot U + 30 mV$	
	> 500 kHz to 1 MHz	> 300 kHz to 500 kHz	$5.0 \cdot 10^{-3} \cdot U + 30 mV$	Umax = $22 \cdot 10^6 \cdot V$ Hz/ f[Hz]
> 500 kHz to 1 MHz		$8.0 \cdot 10^{-3} \cdot U + 80 mV$		
> 220 V to 1 kV	15 Hz to 50 Hz	$0.40 \cdot 10^{-3} \cdot U + 2.5 mV$	Umax = $22 \cdot 10^6 \cdot V$ Hz/ f[Hz]	
	> 50 Hz to 1 kHz	$0.11 \cdot 10^{-3} \cdot U + 2.5 mV$		
Sources	1 mV to 3.5 V	10 Hz to 30 Hz	$3.3 \cdot 10^{-3} \cdot U + 3 \mu V$	Voltage at 50 Ω
		> 30 Hz to 120 Hz	$1.6 \cdot 10^{-3} \cdot U + 3 \mu V$	
		> 120 Hz to 120 kHz	$1.3 \cdot 10^{-3} \cdot U + 3 \mu V$	
		> 120 kHz to 2 MHz	$1.5 \cdot 10^{-3} \cdot U + 3 \mu V$	
		> 2 MHz to 10 MHz	$3.5 \cdot 10^{-3} \cdot U + 3 \mu V$	
		> 10 MHz to 20 MHz	$11.0 \cdot 10^{-3} \cdot U + 3 \mu V$	
		> 20 MHz to 30 MHz	$25.0 \cdot 10^{-3} \cdot U + 15 \mu V$	
		> 30 MHz to 50 MHz	$40.0 \cdot 10^{-3} \cdot U + 15 \mu V$	
Sources	1 mV to 10 mV	10 Hz to 20 kHz	$0.5 \cdot 10^{-3} \cdot U + 4 \mu V$	Voltage at 50 Ω
		> 20 kHz to 50 kHz	$0.8 \cdot 10^{-3} \cdot U + 4 \mu V$	
		> 50 kHz to 100 kHz	$5.0 \cdot 10^{-3} \cdot U + 4 \mu V$	
		> 100 kHz to 1 MHz	$12.0 \cdot 10^{-3} \cdot U + 10 \mu V$	

Valid from: 23.07.2024

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Annex to the Accreditation Certificate D-K-15195-01-00

Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
AC voltage Sources	> 10 mV to 100 V	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 1 MHz	$0.5 \cdot 10^{-3} \cdot U + 2 \mu V$ $0.5 \cdot 10^{-3} \cdot U + 2 \mu V$ $1.4 \cdot 10^{-3} \cdot U + 2 \mu V$ $4.0 \cdot 10^{-3} \cdot U + 2 \mu V$ $11.0 \cdot 10^{-3} \cdot U + 10 \mu V$	U: Measured value
	> 100 V to 700 V	10 Hz to 20 Hz > 20 Hz to 50 kHz > 50 kHz to 100 kHz	$0.8 \cdot 10^{-3} \cdot U + 2 mV$ $1.4 \cdot 10^{-3} \cdot U + 2 mV$ $3.2 \cdot 10^{-3} \cdot U + 2 mV$	
AC current Measuring instruments	100 μA to 220 μA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 16 nA$ $0.2 \cdot 10^{-3} \cdot I + 10 nA$ $0.3 \cdot 10^{-3} \cdot I + 12 nA$ $1.1 \cdot 10^{-3} \cdot I + 0.1 \mu A$	I: Measured value
	> 220 μA to 2.2 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 40 nA$ $0.2 \cdot 10^{-3} \cdot I + 35 nA$ $0.22 \cdot 10^{-3} \cdot I + 110 nA$ $1.2 \cdot 10^{-3} \cdot I + 1 \mu A$	
	> 2.2 mA to 22 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 400 nA$ $0.2 \cdot 10^{-3} \cdot I + 350 nA$ $0.22 \cdot 10^{-3} \cdot I + 550 nA$ $1.2 \cdot 10^{-3} \cdot I + 5 \mu A$	
	> 22 mA to 220 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 4 \mu A$ $0.2 \cdot 10^{-3} \cdot I + 3.5 \mu A$ $0.22 \cdot 10^{-3} \cdot I + 3.5 \mu A$ $1.2 \cdot 10^{-3} \cdot I + 10 \mu A$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.2 \cdot 10^{-3} \cdot I + 35 \mu A$ $0.47 \cdot 10^{-3} \cdot I + 80 \mu A$ $7.1 \cdot 10^{-3} \cdot I + 160 \mu A$	
	> 2.2 A to < 3 A	10 Hz to 45 Hz > 45 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$2 \cdot 10^{-3} \cdot I + 100 \mu A$ $0.7 \cdot 10^{-3} \cdot I + 100 \mu A$ $6.6 \cdot 10^{-3} \cdot I + 1 mA$ $28 \cdot 10^{-3} \cdot I + 5 mA$	
	3 A to < 11 A	45 Hz to 100 Hz > 100 Hz to 1 kHz > 1 kHz to 5 kHz	$0.7 \cdot 10^{-3} \cdot I + 2 mA$ $1.1 \cdot 10^{-3} \cdot I + 2 mA$ $0.3 \cdot 10^{-3} \cdot I + 16 nA$	
	Sources	100 μA to 1.2 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 10 kHz	

Annex to the Accreditation Certificate D-K-15195-01-00

Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
AC current Sources	> 1.2 mA to 120 mA	> 10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 10 kHz	$6.0 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $3.2 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $2.3 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	f: Measured value
	> 120 mA to 1 A	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$6.0 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $3.3 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $2.7 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $4.7 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	
Frequency Oscillators Measuring instruments	0.1 MHz		$5 \cdot 10^{-12} \cdot f$	f: Measured value U_{TRIG} : Trigger-uncertainty
	1 MHz			
	5 MHz			
	10 MHz			
	0.1 MHz to 110 GHz		$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{\text{TRIG}}^2}$	
Time interval	1 ns to 100 s		$\sqrt{(1 \text{ ns})^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{\text{TRIG}}^2}$	t: Measured value
HF-Power Sources with mismatch correction	100 μW to 10 mW	> DC to 1 MHz	$1.8 \cdot 10^{-3} \cdot P$	P: Measured value PC Type-N ²⁾ to 18 GHz WG R220 ²⁾ WG R320 ²⁾ WG R400 ²⁾ WG R620 ²⁾ WG R620 ²⁾ WG: R900 ²⁾ WG: R900 ²⁾
		> 1 MHz to 50 MHz	$2.3 \cdot 10^{-3} \cdot P$	
		> 50 MHz to 100 MHz	$2.5 \cdot 10^{-3} \cdot P$	
		> 100 MHz to 2.5 GHz	$4.0 \cdot 10^{-3} \cdot P$	
		2.5 GHz to 8 GHz	$6.0 \cdot 10^{-3} \cdot P$	
		> 8 GHz to 12.4 GHz	$7.7 \cdot 10^{-3} \cdot P$	
		> 12.4 GHz to 18 GHz	$10 \cdot 10^{-3} \cdot P$	
		18 GHz to 26.5 GHz	$5.3 \cdot 10^{-3} \cdot P$	
		26.5 GHz to 40 GHz	$5.6 \cdot 10^{-3} \cdot P$	
		40 GHz to 50 GHz	$15 \cdot 10^{-3} \cdot P$	
		50 GHz to 67 GHz	$29 \cdot 10^{-3} \cdot P$	
		> 67 GHz to 75 GHz	$32 \cdot 10^{-3} \cdot P$	
		75 GHz to 95 GHz	$32 \cdot 10^{-3} \cdot P$	
> 95 GHz to 110 GHz	$33 \cdot 10^{-3} \cdot P$			
HF-Power Sensors with mismatch correction	100 nW to 10 μW	> DC to 100 MHz	$5.8 \cdot 10^{-3} \cdot P$	P: Measured value PC Type-N ²⁾ to 18 GHz PC-3.5 ²⁾ to 33 GHz PC-2.92 ²⁾ to 40 GHz PC-2.4 ²⁾ to 50 GHz PC-1.85 ²⁾ to 67 GHz PC-1.00 ²⁾ to 110 GHz
		> 100 MHz to 2.5 GHz	$7.0 \cdot 10^{-3} \cdot P$	
		> 2.5 GHz to 4 GHz	$8.0 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 8 GHz	$10 \cdot 10^{-3} \cdot P$	
		> 8 GHz to 12.4 GHz	$13 \cdot 10^{-3} \cdot P$	
		> 12.4 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 18 GHz to 26.5 GHz	$15 \cdot 10^{-3} \cdot P$	
		> 26.5 GHz to 40 GHz	$19 \cdot 10^{-3} \cdot P$	

Valid from: 23.07.2024

Date of issue: 23.07.2024

Annex to the Accreditation Certificate D-K-15195-01-00

Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power Sensors with mismatch correction	10 μ W to 200 mW	> DC to 1 MHz > 1 MHz to 100 MHz > 100 MHz to 2.5 GHz 2.5 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$3.0 \cdot 10^{-3} \cdot P$ $3.4 \cdot 10^{-3} \cdot P$ $5.1 \cdot 10^{-3} \cdot P$ $6.8 \cdot 10^{-3} \cdot P$ $8.4 \cdot 10^{-3} \cdot P$ $11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	P: Measured value
	10 μ W to 125 mW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$37 \cdot 10^{-3} \cdot P$ $41 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
HF-Power Sources. Measuring instruments with mismatch correction	0.2 fW to < 10 pW	> DC to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
	100 pW to < 100 uW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$45 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	100 nW to 200 mW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$ $35 \cdot 10^{-3} \cdot P$	
	100 μ W to 125 mW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$40 \cdot 10^{-3} \cdot P$ $42 \cdot 10^{-3} \cdot P$ $44 \cdot 10^{-3} \cdot P$	
without mismatch correction	> 200 mW to 20 W	> DC to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	
	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	

Valid from: 23.07.2024

Date of issue: 23.07.2024

Annex to the Accreditation Certificate D-K-15195-01-00

Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power Sources, Measuring instruments	> 200 mW to 2 W	> 18 GHz to 26.5 GHz	$25 \cdot 10^{-3} \cdot P$	
	> 200 mW to 1 W	> 26.5 GHz to 40 GHz	$31 \cdot 10^{-3} \cdot P$	
	> 20 W to 2 kW	> DC to 1 GHz	$24 \cdot 10^{-3} \cdot P$	
Display Linearity, Tuned HF Power, Attenuation	0 dB to 21 dB	> DC to 40 GHz	0.003 dB	A: Measured value
	> 21 dB to 111 dB	> DC to 40 GHz	$0.003 \text{ dB} + 0.0002 \cdot A$	
	> 111 dB to 121 dB	> DC to 40 GHz	0.03 dB	
	0 dB to 11 dB	> 40 GHz to 67 GHz	0.005 dB	
	> 11 dB to 111 dB	> 40 GHz to 67 GHz	$0.005 \text{ dB} + 0.0004 \cdot A$	
	0 dB to 21 dB	75 GHz	0.005 dB	
	0 dB to 60 dB	> 67 GHz to 110 GHz	$0.03 \text{ dB} + 0.001 \cdot A$	
	> 60 dB to 80 dB	> 67 GHz to 110 GHz	0.6 dB	
	> 80 dB to 90 dB	> 67 GHz to 110 GHz	1.8 dB	
		0 dB to 10 dB	65 GHz to < 70 GHz	0.11 dB
	0 dB to 10 dB	70 GHz to 85 GHz	0.10 dB	
HF-Transmission Phase angle φ	- 180 ° to 180 °	> DC to 100 MHz	0.5 °	Depending on attenuation value
		> 100 MHz to 10 GHz	0.7 °	
		> 10 GHz to 20 GHz	1.0 °	
		> 20 GHz to 40 GHz	1.8 °	
		> 40 GHz to 67 GHz	2.0 °	
		> 67 GHz to 110 GHz	3.0 °	
HF-Impedance Reflection factor	0.0 to 0.4	> DC to 10 GHz	0.0034	PC Type-N ²⁾
	> 0.4 to 1.0	> DC to 10 GHz	$0.0015 + 0.005 \cdot \Gamma $	
	0.0 to 0.4	> 10 GHz to 18 GHz	0.0034	Γ : Magnitude of complex reflection Factor
	> 0.4 to 1.0	> 10 GHz to 18 GHz	$0.01 \cdot \Gamma $	
	0.0 to 0.4	> 18 GHz to 33 GHz	0.0065	PC-3.5 ²⁾
	> 0.4 to 1.0	> 18 GHz to 33 GHz	$0.001 + 0.013 \cdot \Gamma $	
	0.0 to 0.4	> 33 GHz to 40 GHz	0.011	PC-2.92 ²⁾
	> 0.4 to 1.0	> 33 GHz to 40 GHz	$0.005 + 0.016 \cdot \Gamma $	
	0.0 to 1.0	> DC to 2 GHz	$0.0035 + 0.0042 \cdot \Gamma ^2$	PC-2.4 ²⁾ . PC-1.85 ²⁾
		> 2 GHz to 10 GHz	$0.0037 + 0.0050 \cdot \Gamma ^2$	
		> 10 GHz to 20 GHz	$0.0042 + 0.0069 \cdot \Gamma ^2$	
		> 20 GHz to 30 GHz	$0.0055 + 0.0101 \cdot \Gamma ^2$	
		> 30 GHz to 40 GHz	$0.0067 + 0.0120 \cdot \Gamma ^2$	
		> 40 GHz to 50 GHz	$0.0085 + 0.0151 \cdot \Gamma ^2$	
	> 50 GHz to 67 GHz	$0.0113 + 0.0183 \cdot \Gamma ^2$		
0.0 to 1.0	> DC to 2 GHz	$0.0036 + 0.0049 \cdot \Gamma ^2$	PC-1.00 ²⁾	
	> 2 GHz to 10 GHz	$0.0036 + 0.0052 \cdot \Gamma ^2$		
	> 10 GHz to 20 GHz	$0.0041 + 0.0068 \cdot \Gamma ^2$		
	> 20 GHz to 30 GHz	$0.0049 + 0.0095 \cdot \Gamma ^2$		
	> 30 GHz to 40 GHz	$0.0056 + 0.0117 \cdot \Gamma ^2$		
	> 40 GHz to 50 GHz	$0.0063 + 0.0131 \cdot \Gamma ^2$		
	> 50 GHz to 67 GHz	$0.0074 + 0.0173 \cdot \Gamma ^2$		
	> 67 GHz to 90 GHz	$0.0093 + 0.0213 \cdot \Gamma ^2$		
	> 90 GHz to 110 GHz	$0.0122 + 0.0280 \cdot \Gamma ^2$		
	> 110 GHz bis 114 GHz	$0.0142 + 0.0331 \cdot \Gamma ^2$		

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Permanent Laboratory, Location Memmingen

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Impedance Reflection factor	0.0 to 1.0	50 GHz to 75 GHz 60 GHz to 90 GHz 75 GHz to 110 GHz	$0.01 + 0.008 \cdot \Gamma $ $0.01 + 0.008 \cdot \Gamma $ $0.01 + 0.008 \cdot \Gamma $	Connector: R620 Connector: R740 Connector: R900
	0.0 to 0.6	65 GHz to < 70 GHz	0.027	Free space impedance
	> 0.6 to 1.0	65 GHz to < 70 GHz	0.032	
	0.0 to 0.6	70 GHz to 85 GHz	0.026	
	> 0.6 to 1.0	70 GHz to 85 GHz	0.029	
HF-Impedance Phase angle	- 180 ° to 180 °	> DC to 110 GHz	$U_s \cdot 180^\circ / \pi$	$U_s = \arcsin(U/ \Gamma)$ U: Uncertainty of reflection factor
Modulation quantities	0.0 to 1.0	> DC $f_m \leq 100$ kHz	$0.001 \cdot m + K$	m: Measurement value f_{HF} = Carrier frequency f_m = modulation freq. $f_{HF} > 5 \cdot f_m^{(3)}$
Amplitude modulation		100 kHz < $f_m \leq 1$ MHz	$0.002 \cdot m + K$	
Modulation degree m		1 MHz < $f_m \leq 10$ MHz	$0.007 \cdot m + K$	
Frequency modulation	10 Hz to 16 MHz	10 Hz < $f_m \leq 100$ kHz	$1 \cdot 10^{-3} \cdot \Delta f + K$	Δf : Measurement value $f_{HF} > 5 \cdot (f_m + \Delta f)^{(3)}$
Frequency deviation Δf		100 kHz < $f_m \leq 200$ kHz	$2 \cdot 10^{-3} \cdot \Delta f + K$	
		200 kHz < $f_m \leq 10$ MHz	$5 \cdot 10^{-3} \cdot \Delta f + K$	
Phase modulation	(10 Hz/ f_m) to (16 MHz/ f_m) rad	10 Hz < $f_m \leq 100$ kHz	$1 \cdot 10^{-3} \cdot \Delta \phi + K$	$\Delta \phi$: Measurement value $f_{HF} > 5 \cdot f_m^{(3)}$
Phase deviation $\Delta \phi$		100 kHz < $f_m \leq 200$ kHz	$2 \cdot 10^{-3} \cdot \Delta \phi + K$	
		200 kHz < $f_m \leq 10$ MHz	$5 \cdot 10^{-3} \cdot \Delta \phi + K$	
Waveform quantities	7 ps to 15 ps	Voltage range dependent on rise-time	4 ps	t: Measurement value
Rise time	> 15 ps to 25 ps		3 ps	
Pulse spectrum	> 25 ps to 100 ns 0.1 μ Vs to 50 μ Vs		9 kHz to 150 kHz	$40 \cdot 10^{-3} \cdot t + 2$ ps $25 \cdot 10^{-3} \cdot IS$
Cispr 16-1-1:2019	3 nVs to 1 μ Vs	150 kHz to 30 MHz	$25 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$27 \cdot 10^{-3} \cdot IS$	
Antenna factor	Depending on antenna	20 MHz to 1 GHz	0.45 dB	with ground reflection
3-Antenna method Free-field		20 MHz to < 10 GHz	0.35 dB	without ground reflection
		10 GHz to 18 GHz	0.40 dB	
		20 MHz to < 2 GHz	0.40 dB	SAE ARP958:1999
Full absorber facility			2 GHz to 18 GHz	0.55 dB
		20 MHz to 18 GHz	0.60 dB	
Antenna factor (ECSM)	Depending on antenna	9 kHz to 30 MHz	1.2 dB	monopole antennas ECSM procedure
Antenna factor		CISPR 16-1-6:2022		loop antennas standard field procedure

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Phase noise	> -77 dBc/Hz ^{a)}	1 Hz ^{b)}	1.5 dB	Carrier frequency:
Oscillators	-85 Bc/Hz to -77dBc/Hz	1 Hz	2.5 dB	100 MHz to 500 MHz
Measuring instruments	> -92 dBc/Hz	3 Hz to 10 Hz	1.5 dB	a) Phase noise to
	-100 dBc/Hz to -92 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -106 dBc/Hz	10 Hz to 100 Hz	1.5 dB	Carrier level in dBc/Hz
	-114 dBc/Hz to -106 dBc/Hz	10 Hz to 100 Hz	2.5 dB	b) Offset frequency to carrier frequency
	> -136 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-146 dBc/Hz to -136 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -160 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-168 dBc/Hz to -160 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -167 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-175 dBc/Hz to -167 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -174 dBc/Hz	100 kHz to 1 MHz	1.5 dB	
	-182 dBc/Hz to -174 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -186 dBc/Hz	1 MHz to 10 MHz	1.5 dB	Carrier frequency 500 MHz to 1 GHz
	-192 dBc/Hz to -186 dBc/Hz	1 MHz to 10 MHz	2.5 dB	
	> -64 dBc/Hz	1 Hz	1.5 dB	
	-73 dBc/Hz to -64 dBc/Hz	1 Hz	2.5 dB	
	> -82 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-90 dBc/Hz to -82 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -95 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-103 dBc/Hz to -95 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
> -123 dBc/Hz	100 Hz to 1 kHz	1.5 dB		
-131 dBc/Hz to -123 dBc/Hz	100 Hz to 1 kHz	2.5 dB		
> -153 dBc/Hz	1 kHz to 10 kHz	1.5 dB		
-161 dBc/Hz to -153 dBc/Hz	1 kHz to 10 kHz	2.5 dB		
> -170 dBc/Hz	10 kHz to 100 kHz	1.5 dB		
-178 dBc/Hz to -170 dBc/Hz	10 kHz to 100 kHz	2.5 dB		
> -172 dBc/Hz	100 kHz to 1 MHz	1.5 dB		
-180 dBc/Hz to -172 dBc/Hz	100 kHz to 1 MHz	2.5 dB		
> -172 dBc/Hz	1 MHz to 10 MHz	1.5 dB		
-180 dBc/Hz to -172 dBc/Hz	1 MHz to 10 MHz	2.5 dB		

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Phase noise Oscillators Measuring instruments	> -55 dBc/Hz	1 Hz	1.5 dB	Carrier frequency: 1 GHz to 3 GHz
	-67 dBc/Hz to -55 dBc/Hz	1 Hz	2.5 dB	
	> -67 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-93 dBc/Hz to -85 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -114 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-122 dBc/Hz to -114 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -146 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-155 dBc/Hz to -146 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -166 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-174 dBc/Hz to -166 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -168 dBc/Hz	100 kHz to 1 MHz	1.5 dB	
	-176 dBc/Hz to -168 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -168 dBc/Hz	1 MHz to 10MHz	1.5 dB	
	-76 dBc/Hz to -168 dBc/Hz	1 MHz to 10 MHz	2.5 dB	

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Phase noise Oscillators Measuring instruments	> -49 dBc/Hz	1 Hz	1.5 dB	Carrier frequency: 3 GHz to 6 GHz
	-57 dBc/Hz to -49 dBc/Hz	1 Hz	2.5 dB	
	> -62 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-70 dBc/Hz to -62 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -76 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-84 dBc/Hz to -76 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -105 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-113 dBc/Hz to -105 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -138 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-146 dBc/Hz to -138 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -156 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-164 dBc/Hz to -156 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -158 dBc/Hz	100 kHz to 1 MHz	1.5 dB	
	-166 dBc/Hz to -158 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -158 dBc/Hz	1 MHz to 10 MHz	1.5 dB	
	-166 dBc/Hz to -158 dBc/Hz	1 MHz to 10 MHz	2.5 dB	
	> -54 dBc/Hz	1 Hz	1.5 dB	Carrier frequency: 6 GHz to 8 GHz
	-62 dBc/Hz to -54 dBc/Hz	1 Hz	2.5 dB	
	> -68 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-76 dBc/Hz to -68 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -95 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-103 dBc/Hz to -95 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -122 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-130 dBc/Hz to -122 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -138 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-146 dBc/Hz to -138 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
> -142 dBc/Hz	10 kHz to 100 kHz	1.5 dB		
-146 dBc/Hz to -142 dBc/Hz	10 kHz to 100 kHz	2.5 dB		
> -142 dBc/Hz	100 kHz to 1 MHz	1.5 dB		
-150 dBc/Hz to -142 dBc/Hz	100 kHz to 1 MHz	2.5 dB		
> -142 dBc/Hz	1 MHz to 10 MHz	1.5 dB		
-150 dBc/Hz to -142 dBc/Hz	1 MHz to 10 MHz	2.5 dB		
Transfer function Amount	20 MHz to 50 GHz	Fourier transform of the impulse response	$2 \cdot 10^{-4} \cdot f / \text{GHz} + 0.02$	f: frequency in GHz
Phase			$3.5 \cdot 10^{-2} \cdot f / \text{GHz} + 0.75^\circ$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
DC voltage Sources. Measuring instruments	0 V to 500 V > 500 V to 1 kV		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$ $16 \cdot 10^{-6} \cdot U$	U: Measured value
DC current Measuring instruments	0 μA to 10 μA > 10 μA to 220 mA > 220 mA to 2.2 A 2.2 A to 3 A > 3 A to 11 A		1 nA $0.1 \cdot 10^{-3} \cdot I$ $0.14 \cdot 10^{-3} \cdot I$ $0.41 \cdot 10^{-3} \cdot I$ $0.55 \cdot 10^{-3} \cdot I + 500 \mu\text{A}$	I: Measured value
Sources	0 μA to 10 μA > 10 μA to 100 mA > 100 mA to 60 A		1 nA $0.1 \cdot 10^{-3} \cdot I$ $0.2 \cdot 10^{-3} \cdot I$	
DC resistance Resistance, measuring instruments	0 Ω to 100 k Ω > 100 k Ω to 1 M Ω > 1 M Ω to 10 M Ω > 10 M Ω to 100 M Ω > 100 M Ω to 1 G Ω		$15 \cdot 10^{-6} \cdot R + 60 \mu\Omega$ $15 \cdot 10^{-6} \cdot R + 2 \Omega$ $50 \cdot 10^{-6} \cdot R + 100 \text{ k}\Omega$ $0.6 \cdot 10^{-3} \cdot R$ $5.1 \cdot 10^{-3} \cdot R$	R: Measured value
AC voltage Measuring instruments	1 mV to 220 V	10 Hz to < 20 Hz 20 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.40 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.21 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $0.20 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	U: Measured value
	1 mV to 22 V	> 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$1.0 \cdot 10^{-3} \cdot U + 18 \mu\text{V}$ $1.8 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$ $4.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
	> 22 V to U_{max}	> 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$1.0 \cdot 10^{-3} \cdot U + 16 \text{ mV}$ $5.0 \cdot 10^{-3} \cdot U + 30 \text{ mV}$ $8.0 \cdot 10^{-3} \cdot U + 80 \text{ mV}$	$U_{\text{max}} = 22 \cdot 10^6 \text{ V Hz} / f[\text{Hz}]$
	> 220 V to 1 kV	15 Hz to 50 Hz > 50 Hz to 1 kHz	$0.40 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$ $0.11 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$	
	1 mV to 3.5 V	10 Hz to 30 Hz > 30 Hz to 120 Hz > 120 Hz to 120 kHz > 120 kHz to 2 MHz > 2 MHz to 10 MHz > 10 MHz to 20 MHz > 20 MHz to 30 MHz > 30 MHz to 50 MHz	$3.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $1.6 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $1.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $1.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $3.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $11.0 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$ $25.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$ $40.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$	Voltage at 50 Ω
Sources	1 mV to 10 mV	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 1 MHz	$0.5 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $0.8 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $5.0 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $12.0 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 10 mV to 100 V	10 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz 100 kHz to 300 kHz > 300 kHz to 1 MHz	$0.5 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $0.5 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $1.4 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $0.4 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$ $11 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	U: Measured value Voltage at 50 Ω

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
AC voltage Sources	> 100 V to 700 V	10 Hz to 20 Hz > 20 Hz to 50 kHz > 50 kHz to 100 kHz	$0.8 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $1.4 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $3.2 \cdot 10^{-3} \cdot U + 2 \text{ mV}$	U: Measured value
AC current Measuring instruments	100 μ A to 220 μ A	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 16 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 10 \text{ nA}$ $0.3 \cdot 10^{-3} \cdot I + 12 \text{ nA}$ $1.1 \cdot 10^{-3} \cdot I + 0.1 \mu\text{A}$	I: Measured value
	> 220 μ A to 2.2 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 40 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 35 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 110 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	
	> 2.2 mA to 22 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 400 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 350 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 550 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 5 \mu\text{A}$	
	> 22 mA to 220 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 4 \mu\text{A}$ $0.2 \cdot 10^{-3} \cdot I + 3.5 \mu\text{A}$ $0.22 \cdot 10^{-3} \cdot I + 3.5 \mu\text{A}$ $0.47 \cdot 10^{-3} \cdot I + 10 \mu\text{A}$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.2 \cdot 10^{-3} \cdot I + 35 \mu\text{A}$ $0.47 \cdot 10^{-3} \cdot I + 80 \mu\text{A}$ $7.1 \cdot 10^{-3} \cdot I + 160 \mu\text{A}$	
	> 2.2 A to < 3 A	10 Hz to 45 Hz > 45 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$2 \cdot 10^{-3} \cdot I + 100 \mu\text{A}$ $0.7 \cdot 10^{-3} \cdot I + 100 \mu\text{A}$ $6.6 \cdot 10^{-3} \cdot I + 1 \text{ mA}$ $28 \cdot 10^{-3} \cdot I + 5 \text{ mA}$	
	3 A to < 11 A	45 Hz to 100 Hz > 100 Hz to 1 kHz > 1 kHz to 5 kHz	$0.7 \cdot 10^{-3} \cdot I + 2 \text{ mA}$ $1.1 \cdot 10^{-3} \cdot I + 2 \text{ mA}$ $33 \cdot 10^{-3} \cdot I + 2 \text{ mA}$	
Sources	100 μ A to 1.2 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 10 kHz	$6.0 \cdot 10^{-3} \cdot I + 0.1 \mu\text{A}$ $3.5 \cdot 10^{-3} \cdot I + 0.1 \mu\text{A}$ $2.6 \cdot 10^{-3} \cdot I + 0.1 \mu\text{A}$	
	> 1.2 mA to 120 mA	> 10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 10 kHz	$6.0 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $3.2 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $2.3 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	
	> 120 mA to 1 A	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$6.0 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $3.3 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $2.7 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$ $4.7 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	

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Capacitance	1.1 nF to < 3.3 nF	10 Hz to 3 kHz	$6 \cdot 10^{-3} \cdot C + 0.01 \text{ nF}$	C: Measured value
	3.3 nF to < 11 nF	10 Hz to 1 kHz	$2.8 \cdot 10^{-3} \cdot C + 0.01 \text{ nF}$	
	11 nF to < 33 nF	10 Hz to 1 kHz	$2.8 \cdot 10^{-3} \cdot C + 0.1 \text{ nF}$	
	33 nF to < 110 nF	10 Hz to 1 kHz	$2.8 \cdot 10^{-3} \cdot C + 0.1 \text{ nF}$	
	110 nF to < 330 nF	10 Hz to 1 kHz	$2.8 \cdot 10^{-3} \cdot C + 0.3 \text{ nF}$	
	0.33 μF to < 1.10 μF	10 Hz to 600 Hz	$2.8 \cdot 10^{-3} \cdot C + 1 \text{ nF}$	
	1.1 μF to < 11 μF	10 Hz to 300 Hz	$2.8 \cdot 10^{-3} \cdot C + 3 \text{ nF}$	
	11 μF to < 33 μF	10 Hz to 120 Hz	$4.5 \cdot 10^{-3} \cdot C + 30 \text{ nF}$	
	33 μF to < 110 μF	DC to 80 Hz	$5 \cdot 10^{-3} \cdot C + 100 \text{ nF}$	
	110 μF to < 330 μF	DC to 80 Hz	$5 \cdot 10^{-3} \cdot C + 300 \text{ nF}$	
0.33 mF to < 1.1 mF	DC to 50 Hz	$5 \cdot 10^{-3} \cdot C + 1 \text{ μF}$		
Frequency Oscillators Measuring instruments	0.1 MHz		$5 \cdot 10^{-12} \cdot f$	f: Measured value U_{TRIG} : Trigger-uncertainty
	1 MHz			
	5 MHz			
	10 MHz			
	0.1 mHz to 110 GHz		$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{\text{TRIG}}^2}$	
Time period	1 ns to 100 s		$\sqrt{(1 \text{ ns})^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{\text{TRIG}}^2}$	t: Measured value
HF-Power HF-Power Sensors with mismatch correction	100 nW to 10 μW	> DC to 100 MHz	$5.8 \cdot 10^{-3} \cdot P$	P: Measured value PC Type-N ²⁾ to 18 GHz PC-3.5 ²⁾ to 33 GHz PC-2.92 ²⁾ to 40 GHz PC-2.4 ²⁾ to 50 GHz PC-1.85 ²⁾ to 67 GHz PC-1.00 ²⁾ to 110 GHz
		> 100 MHz to 2.4 GHz	$7.0 \cdot 10^{-3} \cdot P$	
		> 2.4 GHz to 4 GHz	$8.0 \cdot 10^{-3} \cdot P$	
		> 4 GHz to 8 GHz	$10 \cdot 10^{-3} \cdot P$	
		> 8 GHz to 12.4 GHz	$13 \cdot 10^{-3} \cdot P$	
	> 12.4 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$		
	> 18 GHz to 26.5 GHz	$15 \cdot 10^{-3} \cdot P$		
	> 26.5 GHz to 40 GHz	$19 \cdot 10^{-3} \cdot P$		
	10 μW to 200 mW	> DC to 1 MHz	$3.0 \cdot 10^{-3} \cdot P$	
		> 1 MHz to 100 MHz	$3.4 \cdot 10^{-3} \cdot P$	
> 100 MHz to 2.4 GHz		$5.1 \cdot 10^{-3} \cdot P$		
2.4 GHz to 8 GHz		$6.8 \cdot 10^{-3} \cdot P$		
> 8 GHz to 12.4 GHz		$8.4 \cdot 10^{-3} \cdot P$		
> 12.4 GHz to 18 GHz	$11 \cdot 10^{-3} \cdot P$			
> 18 GHz to 26.5 GHz	$14 \cdot 10^{-3} \cdot P$			
> 26.5 GHz to 40 GHz	$17 \cdot 10^{-3} \cdot P$			
> 40 GHz to 50 GHz	$21 \cdot 10^{-3} \cdot P$			
> 50 GHz to 67 GHz	$33 \cdot 10^{-3} \cdot P$			
HF-Power Sources	1 mW	50 MHz	$4.0 \cdot 10^{-3} \cdot P$	
	10 μW to 200 mW	> DC to 100 MHz > 100 MHz to 1 GHz	$5.0 \cdot 10^{-3} \cdot P$ $6.0 \cdot 10^{-3} \cdot P$	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power Sources. Measuring instruments with mismatch correction	0.2 fW to < 10 pW	> DC to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	P: Measured value
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
	100 pW to < 100 uW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$45 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	100 nW to 200 mW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$ $35 \cdot 10^{-3} \cdot P$	
	10 µW to 125 mW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$40 \cdot 10^{-3} \cdot P$ $42 \cdot 10^{-3} \cdot P$ $44 \cdot 10^{-3} \cdot P$	
without mismatch correction	> 200 mW to 20 W	> DC to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	
	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	
	> 200 mW to 2 W	> 18 GHz to 26.5 GHz	$25 \cdot 10^{-3} \cdot P$	
	> 200 mW to 1 W	> 26.5 GHz to 40 GHz	$31 \cdot 10^{-3} \cdot P$	
Display Linearity. Level distance, Attenuation	0 dB to 21 dB	> DC to 40 GHz	0.003 dB	A: Measured value
	> 21 dB to 111 dB	> DC to 40 GHz	$0.003 \text{ dB} + 0.0002 \cdot A$	
	> 111 dB to 121 dB	> DC to 40 GHz	0.03 dB	
	0 dB to 11 dB	> 40 GHz to 67 GHz	0.005 dB	
	> 11 dB to 111 dB	> 40 GHz to 67 GHz	$0.005 \text{ dB} + 0.0004 \cdot A$	
	0 dB to 60 dB	> 67 GHz to 110 GHz	$0.03 \text{ dB} + 0.001 \cdot A$	
	> 60 dB to 80 dB > 80 dB to 90 dB	> 67 GHz to 110 GHz > 67 GHz to 110 GHz	0.6 dB 1.8 dB	

Valid from: 23.07.2024

Date of issue: 23.07.2024

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Permanent Laboratory, Location Vimperk

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Transmission Phase angle φ	-180° to 180°	> DC to 100 MHz > 100 MHz to 10 GHz > 10 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 67 GHz > 67 GHz to 110 GHz	0.5° 0.7° 1.0° 1.8° 2.0° 3.0°	Dependent on Attenuation value
HF-Impedance Reflection factor	0.0 to 0.4	> DC to 10 GHz	0.0034	PC Type-N ²⁾ Γ : Magnitude of complex reflection factor PC-3.5 ²⁾
	> 0.4 to 1.0	> DC to 10 GHz	0.0015 + 0.005 · Γ	
	0.0 to 0.4	> 10 GHz to 18 GHz	0.0034	PC-2.92 ²⁾
	> 0.4 to 1.0	> 10 GHz to 18 GHz	0.01 · Γ	
	0.0 to 0.4	> 18 GHz to 33 GHz	0.0065	PC-2.4 ²⁾ . PC-1.85 ²⁾
	> 0.4 to 1.0	> 18 GHz to 33 GHz	0.001 + 0.013 · Γ	
	0.0 to 0.4	> 33 GHz to 40 GHz	0.011	
	> 0.4 to 1.0	> 33 GHz to 40 GHz	0.005 + 0.016 · Γ	
	0.0 to 1.0	> DC to 2 GHz > 2 GHz to 10 GHz > 10 GHz to 20 GHz > 20 GHz to 30 GHz > 30 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	0.0035 + 0.0042 · Γ ² 0.0037 + 0.0050 · Γ ² 0.0042 + 0.0069 · Γ ² 0.0055 + 0.0101 · Γ ² 0.0067 + 0.0120 · Γ ² 0.0085 + 0.0151 · Γ ² 0.0113 + 0.0183 · Γ ²	
	0.0 to 1.0	> DC to 2 GHz > 2 GHz to 10 GHz > 10 GHz to 20 GHz > 20 GHz to 30 GHz > 30 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz > 67 GHz to 90 GHz > 90 GHz to 110 GHz > 110 GHz to 114 GHz	0.0036 + 0.0049 · Γ ² 0.0036 + 0.0052 · Γ ² 0.0041 + 0.0068 · Γ ² 0.0049 + 0.0095 · Γ ² 0.0056 + 0.0117 · Γ ² 0.0063 + 0.0131 · Γ ² 0.0074 + 0.0173 · Γ ² 0.0093 + 0.0213 · Γ ² 0.0122 + 0.0280 · Γ ² 0.0142 + 0.0331 · Γ ²	PC-1.00 ²⁾
	0.0 to 1.0	50 GHz to 75 GHz 60 GHz to 90 GHz 90 GHz to 110 GHz	0.01 + 0.008 · Γ 0.01 + 0.008 · Γ 0.01 + 0.008 · Γ	Connector: R620 Connector: R740 Connector: R900
HF-Impedance Phase angle	-180° to 180°	> DC to 110 GHz	$U_s \cdot 180^\circ / \pi$	$U_s = \arcsin(U/ \Gamma)$ U : Uncertainty of reflection factor
Modulation quantities Amplitude modulation Modulation degree m	0.0 to 1.0	> DC $f_m \leq 100$ kHz 100 kHz < $f_m \leq 1$ MHz 1 MHz < $f_m \leq 10$ MHz	0.001 · $m + K$ 0.002 · $m + K$ 0.007 · $m + K$	m : measured value f_{HF} = Carrier frequency f_m = Modulation freq. $f_{HF} > 5 \cdot f_m^{3)}$
Frequency modulation Frequency deviation Δf	10 Hz to 16 MHz	10 Hz < $f_m \leq 100$ kHz 100 kHz < $f_m \leq 200$ kHz 200 kHz < $f_m \leq 10$ MHz	$1 \cdot 10^{-3} \cdot \Delta f$ $2 \cdot 10^{-3} \cdot \Delta f$ $5 \cdot 10^{-3} \cdot \Delta f$	Δf : measured value $f_{HF} > 5 \cdot f_m^{3)}$

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Phase modulation	(10 Hz/ to (16 MHz/	10 Hz < f_m ≤ 100 kHz	$1 \cdot 10^{-3} \cdot \Delta\phi$	$\Delta\phi$: measured value $f_{HF} > 5 \cdot f_m^{(3)}$
Phase deviation $\Delta\phi$	f_m) rad f_m) rad	100 kHz < f_m ≤ 200 kHz 200 kHz < f_m ≤ 10 MHz	$2 \cdot 10^{-3} \cdot \Delta\phi$ $5 \cdot 10^{-3} \cdot \Delta\phi$	
Waveform quantities	7 ps to 15 ps	Voltage range dependent on rise-time	4 ps	t: measured value
Rise time	> 15 ps to 25 ps		3 ps	
	> 25 ps to 100 ns		$40 \cdot 10^{-3} \cdot t + 2$ ps	
Pulse spectrum	0.1 μ Vs to 50 μ Vs	9 kHz to 150 kHz	$25 \cdot 10^{-3} \cdot IS$	IS: measured value
Cispr 16-1-1:2019	3 nVs to 1 μ Vs	150 kHz to 30 MHz	$25 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$27 \cdot 10^{-3} \cdot IS$	
Phase noise	> -77 dBc/Hz ^{a)}	1 Hz ^{b)}	1.5 dB	Carrier frequency: 100 MHz to 500 MHz
Oscillators,	-85 dBc/Hz to -77 dBc/Hz	1 Hz	2.5 dB	
Measuring instruments	> -92 dBc/Hz	3 Hz to 10 Hz	1.5 dB	a) Phase noise with regard to Carrier level in dBc/Hz
	-100 dBc/Hz to -92 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -106 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-114 dBc/Hz to -106 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -136 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-146 dBc/Hz to -136 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -160 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-168 dBc/Hz to -160 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -167 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-175 dBc/Hz to -167 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -174 dBc/Hz	100 kHz to 1 MHz	1.5 dB	b) Offset frequency to carrier frequency
	-182 dBc/Hz to -174 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -186 dBc/Hz	1 MHz to 10 MHz	1.5 dB	
	-192 dBc/Hz to -186 dBc/Hz	1 MHz to 10 MHz	2.5 dB	
	-64 dBc/Hz	1 Hz ^{b)}	1.5 dB	
	-73 dBc/Hz to -64 dBc/Hz	1 Hz	2.5 dB	
	> -82 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-90 dBc/Hz to -82 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -95 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-103 dBc/Hz to -95 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -123 dBc/Hz	100 Hz to 1 kHz	1.5 dB	Carrier frequency: 500 MHz to 1 GHz
	-131 dBc/Hz to -123 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -153 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-161 dBc/Hz to -153 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -170 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-178 dBc/Hz to -170 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -172 dBc/Hz	100 kHz to 1 MHz	1.5 dB	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Phase noise Oscillators, Measuring instruments	-180 dBc/Hz to -172 dBc/Hz	100 kHz to 1 MHz	2.5 dB	Carrier frequency: 500 MHz to 1 GHz
	> -172 dBc/Hz	1 MHz to 10 MHz	1.5 dB	
	-180 dBc/Hz to -172 dBc/Hz	1 MHz to 10 MHz	2.5 dB	Carrier frequency: 1 GHz to 3 GHz
	-55 dBc/Hz	1 Hz	1.5 dB	
	-67 dBc/Hz to -55 dBc/Hz	1 Hz	2.5 dB	
	> -67 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-79 dBc/Hz to -67 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -85 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-93 dBc/Hz to -85 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -114 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-122 dBc/Hz to -114 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -146 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-155 dBc/Hz to -146 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -166 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-174 dBc/Hz to -166 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -168 dBc/Hz	100 kHz to 1 MHz	1.5 dB	
	-176 dBc/Hz to -168 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -168 dBc/Hz	1 MHz to 10 MHz	1.5 dB	
	-76 dBc/Hz to -168 dBc/Hz	1 MHz to 10 MHz	2.5 dB	Carrier frequency: 3 GHz to 6 GHz
	> -49 dBc/Hz	1 Hz	1.5 dB	
-57 dBc/Hz to -49 dBc/Hz	1 Hz	2.5 dB		
> -62 dBc/Hz	3 Hz to 10 Hz	1.5 dB		
-70 dBc/Hz to -62 dBc/Hz	3 Hz to 10 Hz	2.5 dB		
> -76 dBc/Hz	10 Hz to 100 Hz	1.5 dB		
-84 dBc/Hz to -76 dBc/Hz	10 Hz to 100 Hz	2.5 dB		
> -105 dBc/Hz	100 Hz to 1 kHz	1.5 dB		
-113 dBc/Hz to -105 dBc/Hz	100 Hz to 1 kHz	2.5 dB		
> -138 dBc/Hz	1 kHz to 10 kHz	1.5 dB		
-146 dBc/Hz to -138 dBc/Hz	1 kHz to 10 kHz	2.5 dB		
> -156 dBc/Hz	10 kHz to 100 kHz	1.5 dB		
-164 dBc/Hz to -156 dBc/Hz	10 kHz to 100 kHz	2.5 dB		
> -158 dBc/Hz	100 kHz to 1 MHz	1.5 dB		
-166 dBc/Hz to -158 dBc/Hz	100 kHz to 1 MHz	2.5 dB		
> -158 dBc/Hz	1 MHz to 10 MHz	1.5 dB		
-166 dBc/Hz to -158 dBc/Hz	1 MHz to 10 MHz	2.5 dB		

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
	> -54 dBc/Hz	1 Hz	1.5 dB	Carrier frequency: 6 GHz to 8 GHz
	-62 dBc/Hz to -54 dBc/Hz	1 Hz	2.5 dB	
	> -68 dBc/Hz	3 Hz to 10 Hz	1.5 dB	
	-76 dBc/Hz to -68 dBc/Hz	3 Hz to 10 Hz	2.5 dB	
	> -95 dBc/Hz	10 Hz to 100 Hz	1.5 dB	
	-103 dBc/Hz to -95 dBc/Hz	10 Hz to 100 Hz	2.5 dB	
	> -122 dBc/Hz	100 Hz to 1 kHz	1.5 dB	
	-130 dBc/Hz to -122 dBc/Hz	100 Hz to 1 kHz	2.5 dB	
	> -138 dBc/Hz	1 kHz to 10 kHz	1.5 dB	
	-146 dBc/Hz to -138 dBc/Hz	1 kHz to 10 kHz	2.5 dB	
	> -142 dBc/Hz	10 kHz to 100 kHz	1.5 dB	
	-146 dBc/Hz to -142 dBc/Hz	10 kHz to 100 kHz	2.5 dB	
	> -142 dBc/Hz	100 kHz to 1 MHz	1.5 dB	
	-150 dBc/Hz to -142 dBc/Hz	100 kHz to 1 MHz	2.5 dB	
	> -142 dBc/Hz	1 MHz to 10 MHz	1.5 dB	
	-150 dBc/Hz to -142 dBc/Hz	1 MHz to 10 MHz	2.5 dB	

²⁾ By the use of different connection systems the measurement uncertainty increases.

³⁾ K: Uncertainty includes typical disturbances on carrier frequencies up to 3GHz. On carrier frequencies above 3GHz, disturbances, e.g. spurious deviation, has to be determined and considered in dependence of the measurement object.

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Permanent Laboratory, Location Köln

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
DC voltage Sources, Measuring instruments	1 V; 1.018 V 10 V		$2 \cdot 10^{-6} \cdot U$ $1 \cdot 10^{-6} \cdot U$	U: Measured value
	0 V to 1 kV > 1 kV to 10 kV > 10 kV to 20 kV > 20 kV to 30 kV		$3 \cdot 10^{-6} \cdot U + 0.2 \mu V$ $0.1 \cdot 10^{-3} \cdot U$ $6 \cdot 10^{-3} \cdot U$ $22 \cdot 10^{-3} \cdot U$	
DC current Measuring instruments	1 μA to 10 A > 10 A to 200 A		$10 \cdot 10^{-6} \cdot I$ $0.2 \cdot 10^{-3} \cdot I$	I: Measured value
Direct resistance Resistance, measuring instruments	1 Ω 10 k Ω 0.1 m Ω to < 1 m Ω 1 m Ω to < 1 Ω 1 Ω to 100 k Ω > 100 k Ω to 1 M Ω > 1 M Ω to 10 M Ω > 10 M Ω to 100 M Ω > 100 M Ω to 1 G Ω > 1 G Ω to 10 G Ω		$2 \cdot 10^{-6} \cdot R$ $2 \cdot 10^{-6} \cdot R$ $50 \cdot 10^{-6} \cdot R$ $10 \cdot 10^{-6} \cdot R$ $3 \cdot 10^{-6} \cdot R$ $5 \cdot 10^{-6} \cdot R$ $30 \cdot 10^{-6} \cdot R$ $0.1 \cdot 10^{-3} \cdot R$ $0.2 \cdot 10^{-3} \cdot R$ $2 \cdot 10^{-3} \cdot R$	R: Measured value
Measuring instruments	0 Ω to 20 Ω > 20 Ω to 100 k Ω > 100 k Ω to 1 M Ω > 1 M Ω to 10 M Ω > 10 M Ω to 100 M Ω > 100 M Ω to 1 G Ω > 1 G Ω to 10 G Ω		$3 \cdot 10^{-6} \cdot R + 20 \mu \Omega$ $3 \cdot 10^{-6} \cdot R$ $5 \cdot 10^{-6} \cdot R$ $30 \cdot 10^{-6} \cdot R$ $0.1 \cdot 10^{-3} \cdot R$ $0.5 \cdot 10^{-3} \cdot R$ $5 \cdot 10^{-3} \cdot R$	
AC voltage and AC/DC Transfer Sources, Measuring instruments	1 mV to < 220 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	$0.2 \cdot 10^{-6} \cdot U + 0.5 \mu V$ $75 \cdot 10^{-6} \cdot U + 0.5 \mu V$ $35 \cdot 10^{-6} \cdot U + 0.5 \mu V$ $70 \cdot 10^{-6} \cdot U + 0.5 \mu V$ $0.1 \cdot 10^{-3} \cdot U + 1 \mu V$	U: Measured value
	1 mV to 70 V 1 mV to 22 V	> 100 kHz to 300 kHz > 300 kHz to 1 MHz	$0.2 \cdot 10^{-3} \cdot U + 1.5 \mu V$ $1.1 \cdot 10^{-3} \cdot U + 4 \mu V$	
	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	$0.2 \cdot 10^{-3} \cdot U$ $0.1 \cdot 10^{-3} \cdot U$ $41 \cdot 10^{-6} \cdot U$ $0.14 \cdot 10^{-3} \cdot U$ $0.5 \cdot 10^{-3} \cdot U$	
	> 1 kV to 7 kV	45 Hz to 60 Hz	$2 \cdot 10^{-3} \cdot U$	
	1 mV to 7 V	1 MHz to 2 MHz > 2 MHz to 10 MHz > 10 MHz to 20 MHz > 20 MHz to 30 MHz	$0.6 \cdot 10^{-3} \cdot U + 2 \mu V$ $1.0 \cdot 10^{-3} \cdot U + 2.5 \mu V$ $1.5 \cdot 10^{-3} \cdot U + 4 \mu V$ $3.5 \cdot 10^{-3} \cdot U + 8 \mu V$	Voltage at 50 Ω
	0.1 V to 2 V	> 50 MHz to 100 MHz > 100 MHz to 200 MHz > 200 MHz to 300 MHz > 300 MHz to 500 MHz > 500 MHz to 1 GHz	$4 \cdot 10^{-3} \cdot U$ $5 \cdot 10^{-3} \cdot U$ $7 \cdot 10^{-3} \cdot U$ $10 \cdot 10^{-3} \cdot U$ $15 \cdot 10^{-3} \cdot U$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
AC current and AC/DC-Transfer	1 mA to 10 A	10 Hz to < 10 kHz	$0.1 \cdot 10^{-3} \cdot I$	<i>I</i> : Measured value
AC current Sources Measuring instruments	> 10 A to 200 A	20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 20 kHz	$3 \cdot 10^{-3} \cdot I$ $2 \cdot 10^{-3} \cdot I$ $5 \cdot 10^{-3} \cdot I$	
Capacitance	1 nF	1 kHz	$30 \cdot 10^{-6} \cdot C$	C: Measured value substitution method direct measurement with brige
	0.1 pF to < 1 pF	50 Hz to < 100 Hz 100 Hz to < 200 Hz 200 Hz to < 1 kHz 1 kHz to 10 kHz	$0.1 \cdot C$ $10 \cdot 10^{-3} \cdot C$ $1 \cdot 10^{-3} \cdot C$ $0.4 \cdot 10^{-3} \cdot C$	
	1 pF to < 10 pF	50 Hz to < 100 Hz 100 Hz to < 1 kHz 1 kHz to 10 kHz	$10 \cdot 10^{-3} \cdot C$ $1 \cdot 10^{-3} \cdot C$ $0.15 \cdot 10^{-3} \cdot C$	
	10 pF to 100 pF	50 Hz to < 1 kHz 1 kHz to 10 kHz	$0.5 \cdot 10^{-3} \cdot C$ $0.1 \cdot 10^{-3} \cdot C$	
	100 pF to < 50 nF	50 Hz to 10 kHz	$0.1 \cdot 10^{-3} \cdot C$	
	50 nF to 200 nF	50 Hz to < 1 kHz 1 kHz to 10 kHz	$0.1 \cdot 10^{-3} \cdot C$ $0.4 \cdot 10^{-3} \cdot C$	
	200 nF to < 1 μF	50 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.1 \cdot 10^{-3} \cdot C$ $0.5 \cdot 10^{-3} \cdot C$ $2 \cdot 10^{-3} \cdot C$	
	1 μF to 5 μF	50 Hz to 1 kHz > 1 kHz to 2 kHz > 2 kHz to 5 kHz > 5 kHz to 10 kHz	$0.1 \cdot 10^{-3} \cdot C$ $0.4 \cdot 10^{-3} \cdot C$ $3 \cdot 10^{-3} \cdot C$ $10 \cdot 10^{-3} \cdot C$	
	5 μF to 10 μF	50 Hz to 1 kHz > 1 kHz to 2 kHz > 2 kHz to 5 kHz > 5 kHz to 10 kHz	$0.2 \cdot 10^{-3} \cdot C$ $0.8 \cdot 10^{-3} \cdot C$ $5 \cdot 10^{-3} \cdot C$ $20 \cdot 10^{-3} \cdot C$	
	10 μF to 100 μF	50 Hz to 1 kHz	$3 \cdot 10^{-3} \cdot C$	
Frequency Oscillators Measuring instruments	0.1 MHz 1 MHz 5 MHz 10 MHz		$5 \cdot 10^{-12} \cdot f$	<i>f</i> : Measured value U_{TRIG} : Trigger- uncertainty
	0.1 mHz to 110 GHz		$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{TRIG}^2}$	
Time interval	1 ns to 10 000 s		$\sqrt{(1 \text{ ns})^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{TRIG}^2}$	<i>t</i> : Measured value

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power HF-Power Sensors with mismatch correction	100 nW to 10 µW	> DC to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 4 GHz > 4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	$5.8 \cdot 10^{-3} \cdot P$ $7.0 \cdot 10^{-3} \cdot P$ $8.0 \cdot 10^{-3} \cdot P$ $10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$	P: Measured value PC Type-N ²⁾ to 18 GHz PC-3.5 ²⁾ to 33 GHz PC-2.92 ²⁾ to 40 GHz PC-2.4 ²⁾ to 50 GHz PC-1.85 ²⁾ to 67 GHz PC-1.00 ²⁾ to 110 GHz
	10 µW to 200 mW	> DC to 1 MHz > 1 MHz to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$3.0 \cdot 10^{-3} \cdot P$ $3.4 \cdot 10^{-3} \cdot P$ $5.1 \cdot 10^{-3} \cdot P$ $6.8 \cdot 10^{-3} \cdot P$ $8.4 \cdot 10^{-3} \cdot P$ $11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	
Sources	1 mW	50 MHz	$4.0 \cdot 10^{-3} \cdot P$	
	10 µW to 200 mW	> DC to 100 MHz > 100 MHz to 1 GHz	$5.0 \cdot 10^{-3} \cdot P$ $6.0 \cdot 10^{-3} \cdot P$	
Sources. Measuring instruments with mismatch correction	0.2 fW to < 10 pW	> DC to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
	100 pW to < 100 uW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$45 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	

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Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power Sources. Measuring instruments with mismatch correction	100 nW to 200 mW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$ $35 \cdot 10^{-3} \cdot P$	P: Measured value
	10 µW to 125 mW	> 67 GHz to 75 GHz > 75 GHz to 95 GHz > 95 GHz to 110 GHz	$40 \cdot 10^{-3} \cdot P$ $42 \cdot 10^{-3} \cdot P$ $44 \cdot 10^{-3} \cdot P$	
	> 200 mW to 20 W	> DC to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	
	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	
	> 200 mW to 2 W	> 20 GHz to 26.5 GHz	$25 \cdot 10^{-3} \cdot P$	
	> 200 mW to 1 W	> 26.5 GHz to 40 GHz	$31 \cdot 10^{-3} \cdot P$	
	without mismatch correction	> 20 W to 2 kW	> DC to 1 GHz	
> 20 W to 500 W		> 1 GHz to 4 GHz	$30 \cdot 10^{-3} \cdot P$	
> 4 W to 500 W		> 4 GHz to 10 GHz	$30 \cdot 10^{-3} \cdot P$	
> 4 W to 100 W		> 10 GHz to 18 GHz	$40 \cdot 10^{-3} \cdot P$	
> 2 kW to 10 kW		> DC to 1 GHz	$41 \cdot 10^{-3} \cdot P$	
Display Linearity Level distance, Attenuation	0 dB to 21 dB	> DC to 40 GHz	0.003 dB	A: Measured value
	> 21 dB to 111 dB	> DC to 40 GHz	$0.003 \text{ dB} + 0.0002 \cdot A$	
	> 111 dB to 121 dB	> DC to 40 GHz	0.03 dB	
	0 dB to 11 dB	> 40 GHz to 67 GHz	0.005 dB	
	> 11 dB to 111 dB	> 40 GHz to 67 GHz	$0.005 \text{ dB} + 0.0004 \cdot A$	
	0 dB to 60 dB	> 67 GHz to 110 GHz	$0.03 \text{ dB} + 0.001 \cdot A$	
	> 60 dB to 80 dB	> 67 GHz to 110 GHz	0.6 dB	
HF-Transmission Phase angle φ	- 180 ° to 180 °	> DC to 100 MHz > 100 MHz to 10 GHz > 10 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 67 GHz > 67 GHz to 110 GHz	0.5 ° 0.7 ° 1.0 ° 1.8 ° 2.0 ° 3.0 °	Dependent on Attenuation value

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HF-Impedance Reflection factor	0.0 to 0.4	> DC to 10 GHz	0.0034	PC Type-N ²⁾ Γ : Magnitude of complex reflection factor
	> 0.4 to 1.0	> DC to 10 GHz	$0.0015 + 0.005 \cdot \Gamma $	
	0.0 to 0.4	> 10 GHz to 18 GHz	0.0034	PC-3.5 ²⁾
	> 0.4 to 1.0	> 10 GHz to 18 GHz	$0.01 \cdot \Gamma $	
	0.0 to 0.4	> 18 GHz to 33 GHz	0.0065	PC-2.92 ³⁾
	> 0.4 to 1.0	> 18 GHz to 33 GHz	$0.001 + 0.013 \cdot \Gamma $	
	0.0 to 0.4	> 33 GHz to 40 GHz	0.011	PC-2.4 ²⁾ , PC-1.85 ²⁾
> 0.4 to 1.0	> 33 GHz to 40 GHz	$0.005 + 0.016 \cdot \Gamma ^2$		
0.0 to 1.0	> DC to 2 GHz	$0.0035 + 0.0042 \cdot \Gamma ^2$		
	> 2 GHz to 10 GHz	$0.0037 + 0.0050 \cdot \Gamma ^2$		
	> 10 GHz to 20 GHz	$0.0042 + 0.0069 \cdot \Gamma ^2$		
	> 20 GHz to 30 GHz	$0.0055 + 0.0101 \cdot \Gamma ^2$		
	> 30 GHz to 40 GHz	$0.0067 + 0.0120 \cdot \Gamma ^2$		
	> 40 GHz to 50 GHz	$0.0085 + 0.0151 \cdot \Gamma ^2$		
> 50 GHz to 67 GHz	$0.0113 + 0.0183 \cdot \Gamma ^2$			
0.0 to 1.0	> DC to 2 GHz	$0.0036 + 0.0049 \cdot \Gamma ^2$	PC-1.00 ²⁾	
	> 2 GHz to 10 GHz	$0.0036 + 0.0052 \cdot \Gamma ^2$		
	> 10 GHz to 20 GHz	$0.0041 + 0.0068 \cdot \Gamma ^2$		
	> 20 GHz to 30 GHz	$0.0049 + 0.0095 \cdot \Gamma ^2$		
	> 30 GHz to 40 GHz	$0.0056 + 0.0117 \cdot \Gamma ^2$		
	> 40 GHz to 50 GHz	$0.0063 + 0.0131 \cdot \Gamma ^2$		
	> 50 GHz to 67 GHz	$0.0074 + 0.0173 \cdot \Gamma ^2$		
	> 67 GHz to 90 GHz	$0.0093 + 0.0213 \cdot \Gamma ^2$		
> 90 GHz to 110 GHz	$0.0122 + 0.0280 \cdot \Gamma ^2$			
> 110 GHz to 114 GHz	$0.0142 + 0.0331 \cdot \Gamma ^2$			
0.0 to 1.0	50 GHz to 75 GHz	$0.01 + 0.008 \cdot \Gamma $	Connector: R620 Connector: R740 Connector: R900	
	60 GHz to 90 GHz	$0.01 + 0.008 \cdot \Gamma $		
	75 GHz to 110 GHz	$0.01 + 0.008 \cdot \Gamma $		
HF-Impedance Phase angle φ	- 180 ° to 180 °	> DC to 110 GHz	$U_s \cdot 180^\circ / \pi$	$U_s = \arcsin(U/ \Gamma)$ U : Uncertainty of reflection factor
Modulation quantities Amplitude modulation Modulation degree m	0.01 to 1.0	> DC $f_m \leq 100$ kHz 100 kHz < $f_m \leq 1$ MHz 1 MHz < $f_m \leq 10$ MHz	$0.001 \cdot m + K$ $0.002 \cdot m + K$ $0.007 \cdot m + K$	m : Measured value f_{HF} = Carrier frequency f_m = Modulation freq. $f_{HF} > 5 \cdot f_m^{3)}$
Frequency modulation Frequency deviation Δf	10 Hz to 16 MHz	10 Hz < $f_m \leq 100$ kHz 100 kHz < $f_m \leq 200$ kHz 200 kHz < $f_m \leq 10$ MHz	$1 \cdot 10^{-3} \cdot \Delta f + K$ $2 \cdot 10^{-3} \cdot \Delta f + K$ $5 \cdot 10^{-3} \cdot \Delta f + K$	Δf : Measured value $f_{HF} > 5 \cdot (f_m + \Delta f)^{3)}$
Phase modulation Phase deviation $\Delta\phi$	(10 Hz/ f_m) rad to (16 MHz/ f_m) rad	10 Hz < $f_m \leq 100$ kHz 100 kHz < $f_m \leq 200$ kHz 200 kHz < $f_m \leq 10$ MHz	$1 \cdot 10^{-3} \cdot \Delta\phi + K$ $2 \cdot 10^{-3} \cdot \Delta\phi + K$ $5 \cdot 10^{-3} \cdot \Delta\phi + K$	$\Delta\phi$: Measured value $f_{HF} > 5 \cdot (f_m + \Delta\phi)^{3)}$

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Rise time	200 ps to 1 s	1 mV to 100 V in 50 Ω	$20 \cdot 10^{-3} \cdot t + (50 \text{ ps})^2/t$	t: Measured value
	2 ns to 1 s	100 V to 5 kV in 50 Ω	$20 \cdot 10^{-3} \cdot t + (0.3 \text{ ns})^2/t$	e.g. Burst according to EN 61000-4-4 :2013
	3 ns to 1 s	100 V to 8 kV in 1 kΩ	$20 \cdot 10^{-3} \cdot t + (0.5 \text{ ns})^2/t$	e.g. Surge according to EN 61000-4-5:2019
	10 ns to 1 s	100 V to 15 kV with HV-Probe	$20 \cdot 10^{-3} \cdot t + (2.2 \text{ ns})^2/t$	
	20 ns to 10 μs	1 mA to 5 kA with current transformer	$20 \cdot 10^{-3} \cdot t + (5 \text{ ns})^2/t$	
	0.7 ns to 500 ns	1 A to 150 A with ESD-Target	$30 \cdot 10^{-3} \cdot t$	ESD according to EN 61000-4-2:2009
Pulse duration	0.5 ns to 10 s		$2 \cdot 10^{-3} \cdot t + 10 \text{ ps} + \delta t_{\text{TRIG}}$	δt_{TRIG} : Triggeruncertainty
Repetition time	1 ns to 10 s			
Burst duration	5 ns to 10 s			
Burst period	5 ns to 10 s			
Pulse voltage	10 mV to 500 V	200 ps ≤ Δt ≤ 1 s at 50 Ω	$20 \cdot 10^{-3} \cdot U, \Delta t \geq 20 \text{ ns}$	U: Measured value Δt: Pulse duration
	10 V to 5 kV 10 V to 8 kV	2,5 ns ≤ Δt ≤ 1 s at 50 Ω 2,5 ns ≤ Δt ≤ 1 s at 1 kΩ	$30 \cdot 10^{-3} \cdot U, \Delta t < 20 \text{ ns}$	e.g. Burst according to EN 61000-4-4:2013
	10 V to 15 kV	10 ns ≤ Δt ≤ 1 s, high resistance		e.g. Surge according to EN 61000-4-5:2019
Pulse current	1 A to 5 kA	20 ns ≤ Δt ≤ 10 ms	$20 \cdot 10^{-3} \cdot I$	I: Measured value
ESD-current pulse	1 A to 150 A	Current peak	$40 \cdot 10^{-3} \cdot I$	I: Measured value
	0.2 A to 150 A	Current grid values after 30 ns and 60 ns	$25 \cdot 10^{-3} \cdot I$	Calibration with Target according to EN 61000-4-2:2009
Pulse spectrum	0.1 μVs to 50 μVs	9 kHz to 150 kHz	$25 \cdot 10^{-3} \cdot I_S$	I _S : Measured value CISPR 16-1-1:2019
	3 nVs to 1 μVs	150 kHz to 30 MHz	$25 \cdot 10^{-3} \cdot I_S$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$27 \cdot 10^{-3} \cdot I_S$	
Antenna factor (ECSM)	Depending on antenna	9 kHz to 30 MHz CISPR 16-1-6:2022	1.2 dB	monopole antennas ECSM procedure
Antenna factor				loop antennas standard field procedure

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DC voltage meters	0 V to 2.2 V		$5 \cdot 10^{-6} \cdot U + 1.5 \mu\text{V}$	U: Measured value
	> 2.2 V to 22 V		$5 \cdot 10^{-6} \cdot U$	
	> 22 V to 1100 V		$10 \cdot 10^{-6} \cdot U$	
sources	0 mV to 100 mV		$5 \cdot 10^{-6} \cdot U + 1.5 \mu\text{V}$	
	> 0.1 V to 1 V		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	
	> 1 V to 10 V		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	
	> 10 V to 100 V		$10 \cdot 10^{-6} \cdot U + 30 \mu\text{V}$	
	> 100 V to 1000 V		$12 \cdot 10^{-6} \cdot U + 100 \mu\text{V}$	
DC current meters and sources	0.1 μA to 1.0 μA		$21 \cdot 10^{-6} \cdot I + 40 \text{ pA}$	I: Measured value
	> 1.0 μA to 10 μA		$21 \cdot 10^{-6} \cdot I + 120 \text{ pA}$	
	> 10 μA to 100 μA		$21 \cdot 10^{-6} \cdot I + 1 \text{ nA}$	
	> 100 μA to 1.0 mA		$21 \cdot 10^{-6} \cdot I + 6 \text{ nA}$	
	> 1.0 mA to 10 mA		$21 \cdot 10^{-6} \cdot I + 60 \text{ nA}$	
	> 10 mA to 100 mA		$36 \cdot 10^{-6} \cdot I + 0.6 \mu\text{A}$	
	> 100 mA to 1.0 A		$110 \cdot 10^{-6} \cdot I + 10 \mu\text{A}$	
	> 100 mA to 1.0 A		$5 \cdot 10^{-5} \cdot I$	
Only sources	> 1 A to 20 A		$7 \cdot 10^{-5} \cdot I$	
DC resistance meters	1 Ω		$0.11 \cdot 10^{-3} \cdot R$	R: Measured value
	1.9 Ω		$0.11 \cdot 10^{-3} \cdot R$	
	10 Ω		$27 \cdot 10^{-6} \cdot R$	
	19 Ω		$27 \cdot 10^{-6} \cdot R$	
	100 Ω		$12 \cdot 10^{-6} \cdot R$	
	190 Ω		$12 \cdot 10^{-6} \cdot R$	
	1 k Ω		$9.9 \cdot 10^{-6} \cdot R$	
	1.9 k Ω		$10 \cdot 10^{-6} \cdot R$	
	10 k Ω		$9.9 \cdot 10^{-6} \cdot R$	
	19 k Ω		$10 \cdot 10^{-6} \cdot R$	
	100 k Ω		$13 \cdot 10^{-6} \cdot R$	
	190 k Ω		$13 \cdot 10^{-6} \cdot R$	
	1 M Ω		$23 \cdot 10^{-6} \cdot R$	
	1.9 M Ω		$25 \cdot 10^{-6} \cdot R$	
	10 M Ω		$47 \cdot 10^{-6} \cdot R$	
19 M Ω		$57 \cdot 10^{-6} \cdot R$		
100 M Ω		$0.14 \cdot 10^{-3} \cdot R$		

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DC Resistance sources and meters	0 Ω to 100 kΩ > 100 kΩ to 1 MΩ > 1 MΩ to 10 MΩ > 10 MΩ to 100 MΩ > 100 MΩ to 1 GΩ		$15 \cdot 10^{-6} \cdot R + 60 \mu\Omega$ $20 \cdot 10^{-6} \cdot R + 2 \Omega$ $60 \cdot 10^{-6} \cdot R + 0.1 \text{ k}\Omega$ $0.6 \cdot 10^{-3} \cdot R$ $5.1 \cdot 10^{-3} \cdot R$	R: Measured value
AC voltage meters	2 mV to 220 V 2 mV to 22 mV	10 Hz to < 20 Hz 20 Hz to < 40 Hz 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$0.40 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $0.21 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$ $1.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$ $1.8 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$ $4.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	U: Measured value
	22 mV to 220 mV	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	$0.15 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$ $0.20 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$ $0.21 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 18 \mu\text{V}$ $1.0 \cdot 10^{-3} \cdot U + 18 \mu\text{V}$ $1.8 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$ $4.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
	220 mV to 2.2 V	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	$0.1 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$ $0.1 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.1 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 30 \mu\text{V}$ $0.5 \cdot 10^{-3} \cdot U + 80 \mu\text{V}$ $1.3 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$ $2.0 \cdot 10^{-3} \cdot U + 300 \mu\text{V}$	
	2.2 V to 22 V	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	$0.10 \cdot 10^{-3} \cdot U + 150 \mu\text{V}$ $0.10 \cdot 10^{-3} \cdot U + 50 \mu\text{V}$ $0.10 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 600 \mu\text{V}$ $1.3 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $2.7 \cdot 10^{-3} \cdot U + 3.5 \text{ mV}$	
	22 V to 220 V	20 Hz to < 40 Hz 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.15 \cdot 10^{-3} \cdot U + 1.5 \text{ mV}$ $0.10 \cdot 10^{-3} \cdot U + 0.6 \text{ mV}$ $0.10 \cdot 10^{-3} \cdot U + 1 \text{ mV}$ $0.50 \cdot 10^{-3} \cdot U + 3 \text{ mV}$	
	> 22 V to U_{MAX}	> 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$1.8 \cdot 10^{-3} \cdot U + 16 \text{ mV}$ $5.0 \cdot 10^{-3} \cdot U + 40 \text{ mV}$ $8.0 \cdot 10^{-3} \cdot U + 80 \text{ mV}$	U_{MAX} : $22 \cdot 10^6 \cdot \text{V Hz} / f [\text{Hz}]$
	> 220 V to 1 kV	15 Hz to 50 Hz > 50 Hz to 1 kHz	$0.40 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$ $0.11 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$	

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AC voltage meters	2 mV to 3.5 V	10 Hz to 30 Hz	$3.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	U: Measured value
		> 30 Hz to 120 Hz	$1.6 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 120 Hz to 120 kHz	$1.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 120 kHz to 2 MHz	$1.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 2 MHz to 10 MHz	$3.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 10 MHz to 20 MHz	$11.0 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 20 MHz to 30 MHz	$25.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$	
	2 mV to 10 mV	1 Hz to < 40 Hz	$0.35 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		40 Hz to 1 kHz	$0.21 \cdot 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.35 \cdot 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.0 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$	
		> 100 kHz to 300 kHz	$12.0 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 10 mV to 100 mV	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 100 mV to 1 V	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 40 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$	
	> 1 V to 10 V	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 400 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 1 \text{ mV}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 1 \text{ mV}$	

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AC voltage sources	> 10 V to 100 V	1 Hz to < 40 Hz 40 Hz to 1 kHz > 1 kHz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 1 MHz	$0.21 \cdot 10^{-3} \cdot U + 30 \text{ mV}$ $0.21 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $0.21 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $0.35 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $1.3 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $4.0 \cdot 10^{-3} \cdot U + 10 \text{ mV}$ $15 \cdot 10^{-3} \cdot U + 10 \text{ mV}$	U: Measured value
	> 100 V to 700 V	1 Hz to < 40 Hz 40 Hz to 1 kHz > 1 kHz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.45 \cdot 10^{-3} \cdot U + 40 \text{ mV}$ $0.45 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $0.65 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $1.3 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $3.1 \cdot 10^{-3} \cdot U + 20 \text{ mV}$	
AC current meters	100 μ A to 220 μ A	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 16 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 10 \text{ nA}$ $0.3 \cdot 10^{-3} \cdot I + 12 \text{ nA}$ $1.1 \cdot 10^{-3} \cdot I + 0.1 \mu\text{A}$	I: Measured value
	> 220 μ A to 2.2 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 50 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 35 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 110 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 1 \mu\text{A}$	
	> 2.2 mA to 22 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 400 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 350 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 550 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 5 \mu\text{A}$	
	> 22 mA to 220 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 4 \mu\text{A}$ $0.2 \cdot 10^{-3} \cdot I + 3.5 \mu\text{A}$ $0.22 \cdot 10^{-3} \cdot I + 4.5 \mu\text{A}$ $1.2 \cdot 10^{-3} \cdot I + 10 \mu\text{A}$	
	> 220 mA to 2.2 A	20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$0.26 \cdot 10^{-3} \cdot I + 40 \mu\text{A}$ $0.47 \cdot 10^{-3} \cdot I + 160 \mu\text{A}$ $7.1 \cdot 10^{-3} \cdot I + 160 \mu\text{A}$	
	2.2 A to 11 A	45 Hz to 5 kHz > 5 kHz to 10 kHz	$0.92 \cdot 10^{-3} \cdot I + 2 \text{ mA}$ $3.6 \cdot 10^{-3} \cdot I + 2 \text{ mA}$	
	sources	100 μ A to 1 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 45 Hz to 10 kHz	
sources	> 1 mA to 10 mA	> 10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 2.2 \mu\text{A}$ $1.5 \cdot 10^{-3} \cdot I + 2.2 \mu\text{A}$ $0.35 \cdot 10^{-3} \cdot I + 2 \mu\text{A}$ $0.7 \cdot 10^{-3} \cdot I + 2 \mu\text{A}$	
	> 10 mA to 100 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 22 \mu\text{A}$ $1.5 \cdot 10^{-3} \cdot I + 22 \mu\text{A}$ $0.35 \cdot 10^{-3} \cdot I + 20 \mu\text{A}$ $0.7 \cdot 10^{-3} \cdot I + 20 \mu\text{A}$	
	> 100 mA to 1 A	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 220 \mu\text{A}$ $1.6 \cdot 10^{-3} \cdot I + 220 \mu\text{A}$ $1 \cdot 10^{-3} \cdot I + 220 \mu\text{A}$ $3 \cdot 10^{-3} \cdot I + 220 \mu\text{A}$	
	> 1 A to 11 A	50 Hz to 120 Hz	$2.3 \cdot 10^{-3} \cdot I + 450 \mu\text{A}$	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
RF-Power Sensors with mismatch correction	100 nW to 10 µW	8 kHz to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 4 GHz > 4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	$5.8 \cdot 10^{-3} \cdot P$ $7.0 \cdot 10^{-3} \cdot P$ $8.0 \cdot 10^{-3} \cdot P$ $10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$	P: Measured value
	10 µW to 200 mW	8 kHz to 1 MHz > 1 MHz to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$3.0 \cdot 10^{-3} \cdot P$ $3.4 \cdot 10^{-3} \cdot P$ $5.1 \cdot 10^{-3} \cdot P$ $6.8 \cdot 10^{-3} \cdot P$ $8.4 \cdot 10^{-3} \cdot P$ $11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	
RF-Power Sources and meters with mismatch correction	0.2 fW to < 10 pW	8 kHz to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	8 kHz to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
RF-Power Sources and meters with mismatch correction	100 nW to 200 mW	8 kHz to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$ $35 \cdot 10^{-3} \cdot P$	
Sources and meters without mismatch correction	> 200 mW to 20 W	8 kHz to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	
	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	
	> 200 mW to 2 W > 200 mW to 1 W > 20 W to 2 kW	> 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 8 kHz to 1 GHz	$25 \cdot 10^{-3} \cdot P$ $31 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
RF-Power ratio Sources and meters	> 0 dB to 0.1 dB > 0 dB to 70 dB > 70 dB to 120 dB	8 kHz to 67 GHz	0.005 dB 0.05 dB 0.09 dB	
Only Meters	> 0 dB to 21 dB > 21 dB to 30 dB > 30 dB to 40 dB > 40 dB to 50 dB > 50 dB to 60 dB > 60 dB to 70 dB > 70 dB to 80 dB > 80 dB to 90 dB > 90 dB to 100 dB > 100 dB to 110 dB > 110 dB to 120 dB	50 MHz to 1 GHz	0.005 dB 0.010 dB 0.012 dB 0.013 dB 0.014 dB 0.015 dB 0.016 dB 0.017 dB 0.018 dB 0.019 dB 0.020 dB	
RF-Attenuation Step attenuator	> 0 dB to 0.1 dB > 0.1 dB to 20 dB > 20 dB to 40 dB > 40 dB to 60 dB > 60 dB to 80 dB > 80 dB to 90 dB	10 MHz to 200 MHz	0.007 dB 0.010 dB 0.014 dB 0.016 dB 0.019 dB 0.023 dB	
Meters	> 0 dB to 0.1 dB > 0.1 dB to 20 dB > 20 dB to 40 dB > 40 dB to 60 dB > 60 dB to 80 dB > 80 dB to 90 dB	10 MHz to 200 MHz	0.010 dB 0.020 dB 0.023 dB 0.024 dB 0.027 dB 0.030 dB	
Scattering quantities Reflection coefficient (S_{11}) Magnitude	0.0 to 0.2 > 0.2 to 1.0	> 9 kHz to 10 GHz	0.0035 $0.0035 + 0.0039 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 10 GHz to 18 GHz	0.0041 $0.0041 + 0.0040 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 18 GHz to 30 GHz	0.0059 $0.0059 + 0.0055 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 30 GHz to 40 GHz	0.0070 $0.0070 + 0.0050 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 40 GHz to 50 GHz	0.0092 $0.0092 + 0.0088 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 50 GHz to 60 GHz	0.012 $0.012 + 0.011 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 60 GHz to 67 GHz	0.012 $0.012 + 0.014 \cdot S_{11} ^2$	

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This document is a translation. The definitive version is the original German annex to the accreditation certificate.

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Phase	- 180 ° to 180 °	> 8 kHz to 67 GHz	$180^\circ/\pi \cdot U_s$	$U_s = \arcsin(U(S_{ii}^2)/ S_{ii} ^2)$
Transmission (S_{ij}) Magnitude and phase	0 to 30 dB	> 9 kHz to 100 kHz	0.05 dB, 0.4°	Measurement uncertainty (in dB) and as phase displacement (in °)
	> 30 dB to 40 dB		0.07 dB, 0.5°	
	> 40 dB to 50 dB		0.12 dB, 0.8°	
	> 50 dB to 60 dB		0.32 dB, 2.1°	
	> 60 dB to 80 dB	0.32 dB + $0.13 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		
	0 to 30 dB	> 100 kHz to 50 MHz	0.05 dB, 0.4°	
	> 30 dB to 40 dB		0.06 dB, 0.4°	
	> 40 dB to 50 dB		0.09 dB, 0.6°	
	> 50 dB to 60 dB		0.19 dB, 1.3°	
	> 60 dB to 80 dB	0.19 dB + $0.076 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		
0 to 30 dB	> 50 MHz to 200 MHz	0.05 dB, 0.4°		
> 30 dB to 40 dB		0.06 dB, 0.4°		
> 40 dB to 60 dB		0.08 dB, 0.6°		
> 60 dB to 80 dB		0.32 dB, 2.1°		
> 80 dB to 90 dB		1.0 dB		
0 to 30 dB	> 200 MHz to 20 GHz	0.04 dB, 0.9°		
> 30 dB to 40 dB		0.06 dB, 0.9°		
> 40 dB to 60 dB		0.07 dB, 0.9°		
> 60 dB to 80 dB		0.15 dB, 1.3°		
> 80 dB to 90 dB		0.32 dB		
0 to 30 dB	> 20 GHz to 40 GHz	0.06 dB, 1.3°		
> 30 dB to 40 dB		0.08 dB, 1.3°		
> 40 dB to 60 dB		0.09 dB, 1.3°		
> 60 dB to 80 dB		0.33 dB, 2.5°		
> 80 dB to 90 dB		0.96 dB		
0 to 30 dB	> 40 GHz to 50 GHz	0.11 dB, 1.7°		
> 30 dB to 40 dB		0.12 dB, 1.7°		
> 40 dB to 60 dB		0.13 dB, 1.7°		
> 60 dB to 80 dB		0.34 dB, 2.7°		
> 80 dB to 90 dB		0.96 dB		
0 to 30 dB	> 50 GHz to 67 GHz	0.15 dB, 2.2°		
> 30 dB to 40 dB		0.16 dB, 2.3°		
> 40 dB to 60 dB		0.20 dB, 2.4°		
> 60 dB to 90 dB		0.20 dB + $0.09 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Modulation quantities Sources and meters Amplitude modulation Modulation degree m	0 to 1.0	$f_m \leq 100 \text{ kHz}$	$0.001 \cdot m + 2.5 \cdot 10^{-5}$	m : Measured value
		$100 \text{ kHz} < f_m \leq 1 \text{ MHz}$	$0.002 \cdot m + 5 \cdot 10^{-5}$	
		$1 \text{ MHz} < f_m \leq 10 \text{ MHz}$	$0.007 \cdot m + 3 \cdot 10^{-4}$	
Frequency modulation Frequency deviation Δf	10 Hz to 16 MHz	$10 \text{ Hz} < f_m \leq 100 \text{ kHz}$	$1 \cdot 10^{-3} \cdot \Delta f + K$	Δf : Measured value K : Contribution of noise
		$100 \text{ kHz} < f_m \leq 200 \text{ kHz}$	$2 \cdot 10^{-3} \cdot \Delta f + K$	
		$200 \text{ kHz} < f_m \leq 10 \text{ MHz}$	$5 \cdot 10^{-3} \cdot \Delta f + K$	
Phase modulation Phase deviation $\Delta \phi$	10 Hz / f_m to 16 MHz / f_m	$10 \text{ Hz} < f_m \leq 100 \text{ kHz}$	$1 \cdot 10^{-3} \cdot \Delta \phi + K$	$\Delta \phi$: Measured value
		$100 \text{ kHz} < f_m \leq 200 \text{ kHz}$	$2 \cdot 10^{-3} \cdot \Delta \phi + K$	
		$200 \text{ kHz} < f_m \leq 10 \text{ MHz}$	$5 \cdot 10^{-3} \cdot \Delta \phi + K$	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Waveform quantities				
CISPR Pulse		CISPR 16-1-1:2019		
Impulse area (<i>I_S</i>)	0.1 μVs to 50 μVs	9 kHz to 150 kHz	$35 \cdot 10^{-3} \cdot I_S$	<i>I_S</i> : Measured value
Meters	3 nVs to 1 μVs	150 kHz to 30 MHz	$35 \cdot 10^{-3} \cdot I_S$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$36 \cdot 10^{-3} \cdot I_S$	
	0.4 nVs to 200 nVs	1 GHz to < 8 GHz	$13 \cdot 10^{-3} \cdot I_S$	
	0.4 nVs to 200 nVs	8 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot I_S$	
Relative Response Ratio	0.1 μVs to 200 nVs	9 kHz to 18 GHz	0.55 %	
Rise time		EN 61000-4-4:2013		
DC pulse generator	200 ps to 1 s	1 mV to 100 V in 50 Ω	$20 \cdot 10^{-3} \cdot t + (50 \text{ ps})^2/t$	<i>t</i> : Measured value
	2 ns to 1 s	100 V to 5 kV in 50 Ω	$20 \cdot 10^{-3} \cdot t + (0.3 \text{ ns})^2/t$	
	3 ns to 1 s	100 V to 8 kV in 1 kΩ	$20 \cdot 10^{-3} \cdot t + (0.5 \text{ ns})^2/t$	
	10 ns to 1 s	EN 61000-4-5:2019	$20 \cdot 10^{-3} \cdot t + (2.2 \text{ ns})^2/t$	
	20 ns to 10 μs	100 V to 15 kV	$20 \cdot 10^{-3} \cdot t + (5 \text{ ns})^2/t$	
		1 mA to 5 kA		
	0.7 ns to 500 ns	EN 61000-4-2:2009	$30 \cdot 10^{-3} \cdot t$	
RF pulse generator	0.5 ns to 20 ns	1 A to 150 A		
Pulse duration	0.5 ns to 10 s	100 MHz to 67 GHz		$2 \cdot 10^{-3} \cdot t + 10 \text{ ps} + \delta t_{\text{TRIG}}$ <i>δt_{TRIG}</i> : Trigger uncertainty
Repetition time	1 ns to 10 s			
Burst duration	5 ns to 10 s			
Burst period	5 ns to 10 s			

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Pulse voltage	10 mV to 500 V 10 V to 8 kV	EN 61000-4-4:2013 $200 \text{ ps} \leq \Delta t \leq 1 \text{ s}$ $2.5 \text{ ns} \leq \Delta t \leq 1 \text{ s}$	$20 \cdot 10^{-3} \cdot U$ $30 \cdot 10^{-3} \cdot U$	U : Measured value Δt : Pulse duration
	10 V to 15 kV	EN 61000-4-5:2019 $10 \text{ ns} \leq \Delta t \leq 1 \text{ s}$	$30 \cdot 10^{-3} \cdot U$	
Pulse current	0.2 A to 150 A 1 A to 150 A 1 A to 5 kA	EN 61000-4-2:2009 $10 \text{ ns} \leq \Delta t \leq 10 \text{ ms}$ $0.5 \text{ ns} \leq \Delta t \leq 10 \text{ ns}$ $20 \text{ ns} \leq \Delta t \leq 10 \text{ ms}$	$25 \cdot 10^{-3} \cdot I$ $40 \cdot 10^{-3} \cdot I$ $20 \cdot 10^{-3} \cdot I$	I : Measured value
Voltage division factor	0 dB to 30 dB	EN 55016-1-2:201	0.10 dB	
		9 kHz to 250 MHz		
Complex impedance Z Magnitude	0.2 Ω to 70 Ω	EN 55016-1-2:2019 9 kHz to 10 MHz	$0.17 \Omega +$ $0.08 \cdot 10^{-3} \cdot Z ^2 / \Omega$	Z : Measured value
	35 Ω to 70 Ω	> 10 MHz to 30 MHz	$0.22 \Omega +$ $0.12 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	30 Ω to 80 Ω	> 30 MHz to 230 MHz	$0.7 \Omega +$ $0.18 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 120 Ω to 180 Ω	150 kHz to 24 MHz	$0.5 \Omega + 0.05 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 100 Ω to 220 Ω	> 24 MHz to 80 MHz	$0.7 \Omega + 0.07 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 30 Ω to 220 Ω	> 80 MHz to 300 MHz	$1.8 \Omega + 0.1 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
Phase	-180° to 180°		$180^\circ / \pi \cdot U_s$	$U_s =$ $\arcsin(U(Z)/ Z)$
Frequency oscillators, measuring instruments	0.1 MHz, 1 MHz, 2MHz, 2.5 MHz, 5 MHz, 10 MHz		$5 \cdot 10^{-12} \cdot f$	f : Measured value U_{REP} : Repeatability- uncertainty t : Measured value
Time interval	1 Hz to 67 GHz		$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{\text{REP}}^2}$	
	$1 \cdot 10^{-9} \text{ s}$ to $1.8 \cdot 10^{-5} \text{ s}$		$\sqrt{1 \text{ ns}^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{\text{REP}}^2}$	

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On-site calibration and mobile laboratory, Location Köln

Calibration and Measurement Capabilities (CMC)

Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Direct voltage Sources, Measuring instruments	0 V to 500 V		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	U: Measured value
	500 V to 1000 V		$16 \cdot 10^{-6} \cdot U$	
	> 1 kV to 10 kV		$2 \cdot 10^{-3} \cdot U$	
	> 10 kV to 20 kV		$6 \cdot 10^{-3} \cdot U$	
	> 20 kV to 30 kV		$22 \cdot 10^{-3} \cdot U$	
Direct current, sources Measuring instruments	1 μA to 1 A		$0.1 \cdot 10^{-3} \cdot I + 1 \text{nA}$	I: Measured value
	> 1 A to 200 A		$0.2 \cdot 10^{-3} \cdot I$	
Direct resistance Resistance, measuring instruments	0 Ω to 100 k Ω		$15 \cdot 10^{-6} \cdot R + 60 \mu\Omega$	R: Measured value
	> 100 k Ω to 1 M Ω		$20 \cdot 10^{-6} \cdot R + 2 \Omega$	
	> 1 M Ω to 10 M Ω		$60 \cdot 10^{-6} \cdot R + 0.1 \text{k}\Omega$	
	> 10 M Ω to 100 M Ω		$0.6 \cdot 10^{-3} \cdot R$	
	> 100 M Ω to 1 G Ω		$5.1 \cdot 10^{-3} \cdot R$	
AC voltage Measuring instruments	1 mV to 220 V	10 Hz to < 20 Hz	$0.4 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$	U: Measured value
		20 Hz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$	
		> 20 kHz to 100 kHz	$0.5 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 200 to 1000 V	50 Hz to 1 kHz	$0.2 \cdot 10^{-3} \cdot U$	Voltage at 50 Ω
	1 mV to 10 V	100 kHz to 1 MHz	$2 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$	
1 mV to 3.5 V	> 1 MHz to 10 MHz	$2.5 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$		
	> 10 MHz to 20 MHz	$4 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$		
	> 20 MHz to 50 MHz	$10 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$		
Voltage sources	1 mV to 100 V	10 Hz to 20 kHz	$0.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	U: Measured value
		> 20 kHz to 50 kHz	$0.7 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.5 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$	
	1 mV to 10 V	100 kHz to 1 MHz	$11 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 100 V to 1000 V	10 Hz to 20 kHz	$0.8 \cdot 10^{-3} \cdot U$	
> 1 kV to 7 kV	> 20 kHz to 50 kHz	$1.5 \cdot 10^{-3} \cdot U$		
	> 50 kHz to 100 kHz	$3.2 \cdot 10^{-3} \cdot U$		
	45 Hz to 60 Hz	$2 \cdot 10^{-3} \cdot U$		
HF-Voltage	0.5 V to 3 V	100 kHz to 30 MHz	$10 \cdot 10^{-3} \cdot U$	U: Measured value
		30 MHz to 100 MHz	$10 \cdot 10^{-3} \cdot U$	
	0.5 V to 2 V	> 100 MHz to 500 MHz	$20 \cdot 10^{-3} \cdot U$	
		> 500 MHz to 1 GHz	$30 \cdot 10^{-3} \cdot U$	
AC current Measuring instruments	1 mA to 220 mA	20 Hz to 1 kHz	$0.4 \cdot 10^{-3} \cdot I$	I: Measured value
		> 1 kHz to 5 kHz	$0.5 \cdot 10^{-3} \cdot I$	
		> 5 kHz to 10 kHz	$3.0 \cdot 10^{-3} \cdot I$	
	> 220 mA to 2.2 A	20 Hz to 1 kHz	$0.4 \cdot 10^{-3} \cdot I$	
		> 1 kHz to 5 kHz	$0.8 \cdot 10^{-3} \cdot I$	
> 5 kHz to 10 kHz	$7.7 \cdot 10^{-3} \cdot I$			

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
AC current Current sources	1 mA to 120 mA	20 Hz to 45 Hz 45 Hz to 20 kHz	$3.0 \cdot 10^{-3} \cdot I$ $2.0 \cdot 10^{-3} \cdot I$	
	> 120 mA to 1A	20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 20 kHz	$3.0 \cdot 10^{-3} \cdot I$ $2.5 \cdot 10^{-3} \cdot I$ $4.5 \cdot 10^{-3} \cdot I$	
	> 1 A bis 200 A	10 Hz to 20 Hz > 20 Hz to 5 kHz > 5 kHz to 20 kHz	$3.0 \cdot 10^{-3} \cdot I$ $2.0 \cdot 10^{-3} \cdot I$ $5.0 \cdot 10^{-3} \cdot I$	
Capacitance	100 pF to <1 nF	1 kHz to 10 kHz	$1.5 \cdot 10^{-3} \cdot C$	C: Measured value
	1 nF to 1 μF	50 Hz to 10 kHz	$1.0 \cdot 10^{-3} \cdot C$	
	> 1 μF to 10 μF	50 Hz to 1 kHz	$1.0 \cdot 10^{-3} \cdot C$	
	> 1 μF to 10 μF	> 1 kHz to 10 kHz	$3 \cdot 10^{-3} \cdot C$	
HF-Power	100 nW to 10 μW	> DC to 100 MHz	$5.8 \cdot 10^{-3} \cdot P$	P: Measured value

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Power Sensors with mismatch correction		> 100 MHz to 2.4 GHz > 2.4 GHz to 4 GHz > 4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	$7.0 \cdot 10^{-3} \cdot P$ $8.0 \cdot 10^{-3} \cdot P$ $10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$	PC Type-N ²⁾ to 18 GHz PC-3.5 ²⁾ to 33 GHz PC-2.92 ²⁾ to 40 GHz PC-2.4 ²⁾ to 50 GHz PC-1.85 ²⁾ to 67 GHz PC-1.00 ²⁾ to 110 GHz
	10 µW to 200 mW	> DC to 1 MHz > 1 MHz to 100 MHz > 100 MHz to 2.4 GHz 2.4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$3.0 \cdot 10^{-3} \cdot P$ $3.4 \cdot 10^{-3} \cdot P$ $5.1 \cdot 10^{-3} \cdot P$ $6.8 \cdot 10^{-3} \cdot P$ $8.4 \cdot 10^{-3} \cdot P$ $11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	
HF-Power Sources. Measuring instruments with mismatch correction	10 µW to 200 mW	> DC to 100 MHz > 100 MHz to 1 GHz	$5.0 \cdot 10^{-3} \cdot P$ $6.0 \cdot 10^{-3} \cdot P$	
	0.2 fW to < 10 pW	> DC to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
	100 pW to < 100 µW	> 67 GHz to 75 GHz > 75 GHz to 90 GHz > 90 GHz to 110 GHz	$45 \cdot 10^{-3} \cdot P$ $47 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	100 pW to 200 mW	> DC to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	
	100 µW to 125 mW	> 67 GHz to 75 GHz > 75 GHz to 90 GHz > 90 GHz to 110 GHz	$40 \cdot 10^{-3} \cdot P$ $42 \cdot 10^{-3} \cdot P$ $44 \cdot 10^{-3} \cdot P$	
	> 200 mW to 20 W	> DC to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	

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HF-Power Sources. Measuring instruments with mismatch correction	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	P: Measured value
	> 200 mW to 2 W	> 18 GHz to 26.5 GHz	$25 \cdot 10^{-3} \cdot P$	
	> 200 mW to 1 W	> 26.5 GHz to 40 GHz	$31 \cdot 10^{-3} \cdot P$	
without mismatch correction	> 20 W to 2 kW	> DC to 1 GHz	$24 \cdot 10^{-3} \cdot P$	
	> 20 W to 500 W	> 1 GHz to 4 GHz	$30 \cdot 10^{-3} \cdot P$	
	> 4 W to 500 W	> 4 GHz to 10 GHz	$30 \cdot 10^{-3} \cdot P$	
	> 4 W to 100 W	> 10 GHz to 18 GHz	$40 \cdot 10^{-3} \cdot P$	
	> 2 kW to 10 kW	> DC to 250 MHz	$41 \cdot 10^{-3} \cdot P$	
Display Linearity Level distance, Attenuation	0 dB to 21 dB	> DC to 40 GHz	0.003 dB	A: Measured value
	> 21 dB to 111 dB	> DC to 40 GHz	$0.003 \text{ dB} + 0.0002 \cdot A$	
	> 111 dB to 121 dB	> DC to 40 GHz	0.03 dB	
	0 dB to 11 dB	> 40 GHz to 67 GHz	0.005 dB	
	> 11 dB to 111 dB	> 40 GHz to 67 GHz	$0.005 \text{ dB} + 0.0004 \cdot A$	
	0 dB to 60 dB	> 67 GHz to 110 GHz	$0.03 \text{ dB} + 0.001 \cdot A$	
	> 60 dB to 80 dB	> 67 GHz to 110 GHz	0.6 dB	
	> 80 dB to 90 dB	> 67 GHz to 110 GHz	1.8 dB	
HF-Transmission Phase angle φ	-180° to 180°	> DC to 100 MHz	0.5°	Dependent on Attenuation value
		> 100 MHz to 10 GHz	0.7°	
		> 10 GHz to 20 GHz	1.0°	
		> 20 GHz to 40 GHz	1.8°	
		> 40 GHz to 67 GHz	2.0°	
		> 67 GHz to 110 GHz	3.0°	
HF-Impedance Reflection factor	0.0 to 0.4	> DC to 10 GHz	0.0034	PC Type-N ²⁾ Γ : Magnitude of complex reflection factor
	> 0.4 to 1.0	> DC to 10 GHz	$0.0015 + 0.005 \cdot \Gamma $	
	0.0 to 0.4	> 10 GHz to 18 GHz	0.0034	PC-3.5 ²⁾
	> 0.4 to 1.0	> 10 GHz to 18 GHz	$0.01 \cdot \Gamma $	
	0.0 to 0.4	> 18 GHz to 26.5 GHz	0.0065	PC-2.92 ²⁾
	> 0.4 to 1.0	> 18 GHz to 26.5 GHz	$0.001 + 0.013 \cdot \Gamma $	
	0.0 to 0.4	> 26.5 GHz to 40 GHz	0.011	PC-2.4 ²⁾ , PC-1.85 ²⁾
	> 0.4 to 1.0	> 26.5 GHz to 40 GHz	$0.005 + 0.016 \cdot \Gamma $	
	0.0 to 1.0	> DC to 2 GHz	$0.0035 + 0.0042 \cdot \Gamma ^2$	
		> 2 GHz to 10 GHz	$0.0037 + 0.0050 \cdot \Gamma ^2$	
> 10 GHz to 20 GHz		$0.0042 + 0.0069 \cdot \Gamma ^2$		
> 20 GHz to 30 GHz		$0.0055 + 0.0101 \cdot \Gamma ^2$		
> 30 GHz to 40 GHz		$0.0067 + 0.0120 \cdot \Gamma ^2$		
> 40 GHz to 50 GHz		$0.0085 + 0.0151 \cdot \Gamma ^2$		
> 50 GHz to 67 GHz	$0.0113 + 0.0183 \cdot \Gamma ^2$			

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
HF-Impedance Reflection factor	0.0 to 1.0	> DC to 2 GHz > 2 GHz to 10 GHz > 10 GHz to 20 GHz > 20 GHz to 30 GHz > 30 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz > 67 GHz to 90 GHz > 90 GHz to 110 GHz > 110 GHz to 114 GHz	0.0036 + 0.0049 · Γ ² 0.0036 + 0.0052 · Γ ² 0.0041 + 0.0068 · Γ ² 0.0049 + 0.0095 · Γ ² 0.0056 + 0.0117 · Γ ² 0.0063 + 0.0131 · Γ ² 0.0074 + 0.0173 · Γ ² 0.0093 + 0.0213 · Γ ² 0.0122 + 0.0280 · Γ ² 0.0142 + 0.0331 · Γ ²	Connector ²⁾ : PC-1.00
	0.0 to 1.0	50 GHz to 75 GHz 60 GHz to 90 GHz 90 GHz to 110 GHz	0.01 + 0.008 · Γ 0.01 + 0.008 · Γ 0.01 + 0.008 · Γ	Connector: R620 Connector: R740 Connector: R900
HF-Impedance Phase angle φ	-180° to 180°	> DC to 110 GHz	$U_s \cdot 180^\circ / \pi$	$U_s = \arcsin(U/ \Gamma)$ U: Uncertainty of reflection factor
Frequency	0.1 MHz 1 MHz 5 MHz 10 MHz	Messzeit > 120 min	$1 \cdot 10^{-11} \cdot f$	f: Measured value U _{TRIG} : Trigger-uncertainty
	0.1 mHz to 110 GHz	Messzeit > 5 min	$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{TRIG}^2}$	
Time interval	1 ns to 10 000 s		$\sqrt{(1 \text{ ns})^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{TRIG}^2}$	
Modulation quantities Amplitude modulation Modulation degree m	0.01 to 1.0	> DC $f_m \leq 100 \text{ kHz}$ 100 kHz < $f_m \leq 1 \text{ MHz}$ 1 MHz < $f_m \leq 10 \text{ MHz}$	0.002 · m + K 0.005 · m + K 0.02 · m + K	m: Measured value f_{HF} = Carrier frequency f_m = Modulation freq. $f_{HF} > 5 \cdot f_m^{(3)}$
Frequency modulation Frequency deviation Δf	10 Hz to 16 MHz	10 Hz < $f_m \leq 100 \text{ kHz}$ 100 kHz < $f_m \leq 200 \text{ kHz}$ 200 kHz < $f_m \leq 10 \text{ MHz}$	$1 \cdot 10^{-3} \cdot \Delta f + K$ $2 \cdot 10^{-3} \cdot \Delta f + K$ $5 \cdot 10^{-3} \cdot \Delta f + K$	Δf: Measured value $f_{HF} > 5 \cdot (f_m + \Delta f)^{(3)}$
Phase modulation Phase deviation Δφ	(10 Hz/ f_m) rad to (16 MHz/ f_m) rad	10 Hz < $f_m \leq 100 \text{ kHz}$ 100 kHz < $f_m \leq 200 \text{ kHz}$ 200 kHz < $f_m \leq 10 \text{ MHz}$	$1 \cdot 10^{-3} \cdot \Delta \phi + K$ $2 \cdot 10^{-3} \cdot \Delta \phi + K$ $5 \cdot 10^{-3} \cdot \Delta \phi + K$	Δφ: Measured value $f_{HF} > 5 \cdot (f_m + \Delta \phi)^{(3)}$

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Waveform quantities	200 ps to 1 s	1 mV to 100 V in 50 Ω	$20 \cdot 10^{-3} \cdot t + (50 \text{ ps})^2/t$	t: Measured value
Rise time	2 ns to 1 s	100 V to 5 kV in 50 Ω	$20 \cdot 10^{-3} \cdot t + (0.3 \text{ ns})^2/t$	e.g. Burst according to EN 61000-4-4:2013
	3 ns to 1 s	100 V to 8 kV in 1 kΩ	$20 \cdot 10^{-3} \cdot t + (0.5 \text{ ns})^2/t$	e.g. Surge according to EN 61000-4-5:2019
	10 ns to 1 s	100 V to 15 kV. with HV-Probe	$20 \cdot 10^{-3} \cdot t + (2.2 \text{ ns})^2/t$	
	20 ns to 10 μs	1 mA to 5 kA with current transformer	$20 \cdot 10^{-3} \cdot t + (5 \text{ ns})^2/t$	
	0.7 ns to 500 ns	1 A to 150 A with ESD-Target	$30 \cdot 10^{-3} \cdot t$	ESD according to EN 61000-4-2:2009
Pulse duration	0.5 ns to 10 s		$2 \cdot 10^{-3} \cdot t + 10 \text{ ps} + \delta t_{\text{TRIG}}$	δt_{TRIG} : Trigger uncertainty
Repetition time	1 ns to 10 s			
Burst duration	5 ns to 10 s			
Burst period	5 ns to 10 s			
Pulse voltage	10 mV to 500 V	200 ps ≤ Δt ≤ 1 s at 50 Ω	$20 \cdot 10^{-3} \cdot U \cdot \Delta t \geq 20 \text{ ns}$	U: Measured value Δt: Pulse duration
	10 V to 5 kV	2.5 ns ≤ Δt ≤ 1 s at 50 Ω	$30 \cdot 10^{-3} \cdot U \cdot \Delta t < 20 \text{ ns}$	e.g. Burst according to EN 61000-4-4:2013
	10 V to 8 kV	2.5 ns ≤ Δt ≤ 1 s at 1 kΩ		e.g. Surge according to EN 61000-4-5:2019
	10 V to 15 kV	10 ns ≤ Δt ≤ 1 s, high resistance		
Pulse current	1 A to 5 kA	20 ns ≤ Δt ≤ 10 ms	$20 \cdot 10^{-3} \cdot I$	I: Measured value
ESD-current pulse	1 A to 150 A	Current peak	$40 \cdot 10^{-3} \cdot I$	I: Measured value
	1 A to 150 A	Current grid values after 30 ns und 60 ns	$25 \cdot 10^{-3} \cdot I$	Calibration with Target according to EN 61000-4-2:2009
Pulse spectrum	0.1 μVs to 50 μVs	9 kHz to 150 kHz	$25 \cdot 10^{-3} \cdot IS$	IS: Measured value CISPR 16-1-1:2019
	3 nVs to 1 μVs	150 kHz to 30 MHz	$25 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$27 \cdot 10^{-3} \cdot IS$	
Antenna factor (ECSM)	Depending on antenna	9 kHz to 30 MHz CISPR 16-1-6:2022	1.2 dB	monopole antennas ECSM procedure
Antenna factor				loop antennas standard field procedure

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DC voltage meters	0 V to 2.2 V		$5 \cdot 10^{-6} \cdot U + 1.5 \mu\text{V}$	U: Measured value
	> 2.2 V to 22 V		$5 \cdot 10^{-6} \cdot U$	
	> 22 V to 1100 V		$10 \cdot 10^{-6} \cdot U$	
sources	0 mV to 100 mV		$5 \cdot 10^{-6} \cdot U + 1.5 \mu\text{V}$	
	> 0.1 V to 1 V		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	
	> 1 V to 10 V		$10 \cdot 10^{-6} \cdot U + 1 \mu\text{V}$	
	> 10 V to 100 V		$10 \cdot 10^{-6} \cdot U + 30 \mu\text{V}$	
	> 100 V to 1000 V		$12 \cdot 10^{-6} \cdot U + 100 \mu\text{V}$	
DC current meters and sources	0.1 μA to 1.0 μA		$21 \cdot 10^{-6} \cdot I + 40 \text{ pA}$	I: Measured value
	> 1.0 μA to 10 μA		$21 \cdot 10^{-6} \cdot I + 120 \text{ pA}$	
	> 10 μA to 100 μA		$21 \cdot 10^{-6} \cdot I + 1 \text{ nA}$	
	> 100 μA to 1.0 mA		$21 \cdot 10^{-6} \cdot I + 6 \text{ nA}$	
	> 1.0 mA to 10 mA		$21 \cdot 10^{-6} \cdot I + 60 \text{ nA}$	
	> 10 mA to 100 mA		$36 \cdot 10^{-6} \cdot I + 0.6 \mu\text{A}$	
	> 100 mA to 1.0 A		$110 \cdot 10^{-6} \cdot I + 10 \mu\text{A}$	
	> 100 mA to 1.0 A		$5 \cdot 10^{-5} \cdot I$	
	> 1 A to 20 A		$7 \cdot 10^{-5} \cdot I$	
	Only sources	> 20 A to 100 A		
DC resistance meters	1 Ω		$0.11 \cdot 10^{-3} \cdot R$	R: Measured value
	1.9 Ω		$0.11 \cdot 10^{-3} \cdot R$	
	10 Ω		$27 \cdot 10^{-6} \cdot R$	
	19 Ω		$27 \cdot 10^{-6} \cdot R$	
	100 Ω		$12 \cdot 10^{-6} \cdot R$	
	190 Ω		$12 \cdot 10^{-6} \cdot R$	
	1 k Ω		$9.9 \cdot 10^{-6} \cdot R$	
	1.9 k Ω		$10 \cdot 10^{-6} \cdot R$	
	10 k Ω		$9.9 \cdot 10^{-6} \cdot R$	
	19 k Ω		$10 \cdot 10^{-6} \cdot R$	
	100 k Ω		$13 \cdot 10^{-6} \cdot R$	
	190 k Ω		$13 \cdot 10^{-6} \cdot R$	
	1 M Ω		$23 \cdot 10^{-6} \cdot R$	
	1.9 M Ω		$25 \cdot 10^{-6} \cdot R$	
	10 M Ω		$47 \cdot 10^{-6} \cdot R$	
19 M Ω		$57 \cdot 10^{-6} \cdot R$		
100 M Ω		$0.14 \cdot 10^{-3} \cdot R$		

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DC Resistance sources and meters	0 Ω to 100 kΩ > 100 kΩ to 1 MΩ > 1 MΩ to 10 MΩ > 10 MΩ to 100 MΩ > 100 MΩ to 1 GΩ		$15 \cdot 10^{-6} \cdot R + 60 \mu\Omega$ $20 \cdot 10^{-6} \cdot R + 2 \Omega$ $60 \cdot 10^{-6} \cdot R + 0.1 \text{ k}\Omega$ $0.6 \cdot 10^{-3} \cdot R$ $5.1 \cdot 10^{-3} \cdot R$	R: Measured value
AC voltage meters	2 mV to 220 V 2 mV to 22 mV	10 Hz to < 20 Hz 20 Hz to < 40 Hz 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$0.40 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $0.21 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$ $1.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$ $1.8 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$ $4.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	U: Measured value
	22 mV to 220 mV	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	$0.15 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$ $0.20 \cdot 10^{-3} \cdot U + 5 \mu\text{V}$ $0.21 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 18 \mu\text{V}$ $1.0 \cdot 10^{-3} \cdot U + 18 \mu\text{V}$ $1.8 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$ $4.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
	220 mV to 2.2 V	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	$0.1 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$ $0.1 \cdot 10^{-3} \cdot U + 8 \mu\text{V}$ $0.1 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 30 \mu\text{V}$ $0.5 \cdot 10^{-3} \cdot U + 80 \mu\text{V}$ $1.3 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$ $2.0 \cdot 10^{-3} \cdot U + 300 \mu\text{V}$	
	2.2 V to 22 V	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	$0.10 \cdot 10^{-3} \cdot U + 150 \mu\text{V}$ $0.10 \cdot 10^{-3} \cdot U + 50 \mu\text{V}$ $0.10 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$ $0.15 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$ $0.50 \cdot 10^{-3} \cdot U + 600 \mu\text{V}$ $1.3 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $2.7 \cdot 10^{-3} \cdot U + 3.5 \text{ mV}$	
	22 V to 220 V	20 Hz to < 40 Hz 40 Hz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.15 \cdot 10^{-3} \cdot U + 1.5 \text{ mV}$ $0.10 \cdot 10^{-3} \cdot U + 0.6 \text{ mV}$ $0.10 \cdot 10^{-3} \cdot U + 1 \text{ mV}$ $0.50 \cdot 10^{-3} \cdot U + 3 \text{ mV}$	
	> 22 V to U_{MAX}	> 100 kHz to 300 kHz > 300 kHz to 500 kHz > 500 kHz to 1 MHz	$1.8 \cdot 10^{-3} \cdot U + 16 \text{ mV}$ $5.0 \cdot 10^{-3} \cdot U + 40 \text{ mV}$ $8.0 \cdot 10^{-3} \cdot U + 80 \text{ mV}$	$U_{\text{MAX}} \cdot 22 \cdot 10^6 \cdot \text{V Hz} / f [\text{Hz}]$
	> 220 V to 1 kV	15 Hz to 50 Hz > 50 Hz to 1 kHz	$0.40 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$ $0.11 \cdot 10^{-3} \cdot U + 2.5 \text{ mV}$	

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AC voltage meters	2 mV to 3.5 V	10 Hz to 30 Hz	$3.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	U: Measured value
		> 30 Hz to 120 Hz	$1.6 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 120 Hz to 120 kHz	$1.3 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 120 kHz to 2 MHz	$1.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 2 MHz to 10 MHz	$3.5 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 10 MHz to 20 MHz	$11.0 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		> 20 MHz to 30 MHz	$25.0 \cdot 10^{-3} \cdot U + 15 \mu\text{V}$	
	2 mV to 10 mV	1 Hz to < 40 Hz	$0.35 \cdot 10^{-3} \cdot U + 3 \mu\text{V}$	
		40 Hz to 1 kHz	$0.21 \cdot 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.35 \cdot 10^{-3} \cdot U + 1.3 \mu\text{V}$	
		> 20 kHz to 50 kHz	$1.0 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 6 \mu\text{V}$	
		> 100 kHz to 300 kHz	$12.0 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 10 mV to 100 mV	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 4 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 2 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 10 \mu\text{V}$	
	> 100 mV to 1 V	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 40 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 20 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 100 \mu\text{V}$	
	> 1 V to 10 V	1 Hz to < 40 Hz	$0.10 \cdot 10^{-3} \cdot U + 400 \mu\text{V}$	
		40 Hz to 1 kHz	$0.10 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 1 kHz to 20 kHz	$0.2 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 20 kHz to 50 kHz	$0.35 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 50 kHz to 100 kHz	$1.0 \cdot 10^{-3} \cdot U + 200 \mu\text{V}$	
		> 100 kHz to 300 kHz	$3.5 \cdot 10^{-3} \cdot U + 1 \text{ mV}$	
		> 300 kHz to 1 MHz	$10 \cdot 10^{-3} \cdot U + 1 \text{ mV}$	

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AC voltage sources	> 10 V to 100 V	1 Hz to < 40 Hz 40 Hz to 1 kHz > 1 kHz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz > 100 kHz to 300 kHz > 300 kHz to 1 MHz	$0.21 \cdot 10^{-3} \cdot U + 30 \text{ mV}$ $0.21 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $0.21 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $0.35 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $1.3 \cdot 10^{-3} \cdot U + 2 \text{ mV}$ $4.0 \cdot 10^{-3} \cdot U + 10 \text{ mV}$ $15 \cdot 10^{-3} \cdot U + 10 \text{ mV}$	U: Measured value
	> 100 V to 700 V	1 Hz to < 40 Hz 40 Hz to 1 kHz > 1 kHz to 20 kHz > 20 kHz to 50 kHz > 50 kHz to 100 kHz	$0.45 \cdot 10^{-3} \cdot U + 40 \text{ mV}$ $0.45 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $0.65 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $1.3 \cdot 10^{-3} \cdot U + 20 \text{ mV}$ $3.1 \cdot 10^{-3} \cdot U + 20 \text{ mV}$	
AC current meters	100 µA to 220 µA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 16 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 10 \text{ nA}$ $0.3 \cdot 10^{-3} \cdot I + 12 \text{ nA}$ $1.1 \cdot 10^{-3} \cdot I + 0.1 \text{ µA}$	I: Measured value
	> 220 µA to 2.2 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 50 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 35 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 110 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 1 \text{ µA}$	
	> 2.2 mA to 22 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 400 \text{ nA}$ $0.2 \cdot 10^{-3} \cdot I + 350 \text{ nA}$ $0.22 \cdot 10^{-3} \cdot I + 550 \text{ nA}$ $1.2 \cdot 10^{-3} \cdot I + 5 \text{ µA}$	
	> 22 mA to 220 mA	10 Hz to 20 Hz > 20 Hz to 1 kHz > 1 kHz to 5 kHz > 5 kHz to 10 kHz	$0.3 \cdot 10^{-3} \cdot I + 4 \text{ µA}$ $0.2 \cdot 10^{-3} \cdot I + 3.5 \text{ µA}$ $0.22 \cdot 10^{-3} \cdot I + 4.5 \text{ µA}$ $1.2 \cdot 10^{-3} \cdot I + 10 \text{ µA}$	
	> 220 mA to 2.2 A	20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$0.26 \cdot 10^{-3} \cdot I + 40 \text{ µA}$ $0.47 \cdot 10^{-3} \cdot I + 160 \text{ µA}$ $7.1 \cdot 10^{-3} \cdot I + 160 \text{ µA}$	
	2.2 A to 11 A	45 Hz to 5 kHz > 5 kHz to 10 kHz	$0.92 \cdot 10^{-3} \cdot I + 2 \text{ mA}$ $3.6 \cdot 10^{-3} \cdot I + 2 \text{ mA}$	
	sources	100 µA to 1 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 45 Hz to 10 kHz	
sources	> 1 mA to 10 mA	> 10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 2.2 \text{ µA}$ $1.5 \cdot 10^{-3} \cdot I + 2.2 \text{ µA}$ $0.35 \cdot 10^{-3} \cdot I + 2 \text{ µA}$ $0.7 \cdot 10^{-3} \cdot I + 2 \text{ µA}$	
	> 10 mA to 100 mA	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 22 \text{ µA}$ $1.5 \cdot 10^{-3} \cdot I + 22 \text{ µA}$ $0.35 \cdot 10^{-3} \cdot I + 20 \text{ µA}$ $0.7 \cdot 10^{-3} \cdot I + 20 \text{ µA}$	
	> 100 mA to 1 A	10 Hz to 20 Hz > 20 Hz to 45 Hz > 45 Hz to 5 kHz > 5 kHz to 10 kHz	$4.0 \cdot 10^{-3} \cdot I + 220 \text{ µA}$ $1.6 \cdot 10^{-3} \cdot I + 220 \text{ µA}$ $1 \cdot 10^{-3} \cdot I + 220 \text{ µA}$ $3 \cdot 10^{-3} \cdot I + 220 \text{ µA}$	
	> 1 A to 11 A	50 Hz to 120 Hz	$2.3 \cdot 10^{-3} \cdot I + 450 \text{ µA}$	

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RF-Power Sensors with mismatch correction	100 nW to 10 µW	8 kHz to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 4 GHz > 4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz	$5.8 \cdot 10^{-3} \cdot P$ $7.0 \cdot 10^{-3} \cdot P$ $8.0 \cdot 10^{-3} \cdot P$ $10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$	P: Measured value
	10 µW to 200 mW	8 kHz to 1 MHz > 1 MHz to 100 MHz > 100 MHz to 2.4 GHz > 2.4 GHz to 8 GHz > 8 GHz to 12.4 GHz > 12.4 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$3.0 \cdot 10^{-3} \cdot P$ $3.4 \cdot 10^{-3} \cdot P$ $5.1 \cdot 10^{-3} \cdot P$ $6.8 \cdot 10^{-3} \cdot P$ $8.4 \cdot 10^{-3} \cdot P$ $11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $21 \cdot 10^{-3} \cdot P$ $33 \cdot 10^{-3} \cdot P$	
RF-Power Sources and meters with mismatch correction	0.2 fW to < 10 pW	8 kHz to 8 GHz > 8 GHz to 20 GHz	$21 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	
	1 fW to < 10 pW	> 20 GHz to 40 GHz	$29 \cdot 10^{-3} \cdot P$	
	10 fW to < 10 pW	> 40 GHz to 50 GHz > 50 GHz to 67 GHz	$43 \cdot 10^{-3} \cdot P$ $49 \cdot 10^{-3} \cdot P$	
	10 pW to < 100 nW	8 kHz to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 20 GHz > 20 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$15 \cdot 10^{-3} \cdot P$ $17 \cdot 10^{-3} \cdot P$ $20 \cdot 10^{-3} \cdot P$ $26 \cdot 10^{-3} \cdot P$ $34 \cdot 10^{-3} \cdot P$ $43 \cdot 10^{-3} \cdot P$	
RF-Power Sources and meters with mismatch correction	100 nW to 200 mW	8 kHz to 100 MHz > 100 MHz to 8 GHz > 8 GHz to 18 GHz > 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 40 GHz to 50 GHz > 50 GHz to 67 GHz	$10 \cdot 10^{-3} \cdot P$ $13 \cdot 10^{-3} \cdot P$ $16 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$ $30 \cdot 10^{-3} \cdot P$ $35 \cdot 10^{-3} \cdot P$	
Sources and meters without mismatch correction	> 200 mW to 20 W	8 kHz to 100 MHz > 100 MHz to 4 GHz	$11 \cdot 10^{-3} \cdot P$ $14 \cdot 10^{-3} \cdot P$	
	> 200 mW to 4 W	> 4 GHz to 8 GHz > 8 GHz to 12.5 GHz > 12.5 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot P$ $19 \cdot 10^{-3} \cdot P$ $23 \cdot 10^{-3} \cdot P$	
	> 200 mW to 2 W > 200 mW to 1 W > 20 W to 2 kW	> 18 GHz to 26.5 GHz > 26.5 GHz to 40 GHz > 8 kHz to 1 GHz	$25 \cdot 10^{-3} \cdot P$ $31 \cdot 10^{-3} \cdot P$ $24 \cdot 10^{-3} \cdot P$	

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RF-Power ratio Sources and meters	> 0 dB to 0.1 dB > 0 dB to 70 dB > 70 dB to 120 dB	8 kHz to 67 GHz	0.005 dB 0.05 dB 0.09 dB	
Only Meters	> 0 dB to 21 dB > 21 dB to 30 dB > 30 dB to 40 dB > 40 dB to 50 dB > 50 dB to 60 dB > 60 dB to 70 dB > 70 dB to 80 dB > 80 dB to 90 dB > 90 dB to 100 dB > 100 dB to 110 dB > 110 dB to 120 dB	50 MHz to 1 GHz	0.005 dB 0.010 dB 0.012 dB 0.013 dB 0.014 dB 0.015 dB 0.016 dB 0.017 dB 0.018 dB 0.019 dB 0.020 dB	
RF-Attenuation Step attenuator	> 0 dB to 0.1 dB > 0.1 dB to 20 dB > 20 dB to 40 dB > 40 dB to 60 dB > 60 dB to 80 dB > 80 dB to 90 dB	10 MHz to 200 MHz	0.007 dB 0.010 dB 0.014 dB 0.016 dB 0.019 dB 0.023 dB	
Meters	> 0 dB to 0.1 dB > 0.1 dB to 20 dB > 20 dB to 40 dB > 40 dB to 60 dB > 60 dB to 80 dB > 80 dB to 90 dB	10 MHz to 200 MHz	0.010 dB 0.020 dB 0.023 dB 0.024 dB 0.027 dB 0.030 dB	

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This document is a translation. The definitive version is the original German annex to the accreditation certificate.

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Scattering quantities				
Reflection coefficient (S_{11}) Magnitude	0.0 to 0.2 > 0.2 to 1.0	> 9 kHz to 10 GHz	0.0035 $0.0035 + 0.0039 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 10 GHz to 18 GHz	0.0041 $0.0041 + 0.0040 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 18 GHz to 30 GHz	0.0059 $0.0059 + 0.0055 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 30 GHz to 40 GHz	0.0070 $0.0070 + 0.0050 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 40 GHz to 50 GHz	0.0092 $0.0092 + 0.0088 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 50 GHz to 60 GHz	0.012 $0.012 + 0.011 \cdot S_{11} ^2$	
	0.0 to 0.2 > 0.2 to 1.0	> 60 GHz to 67 GHz	0.012 $0.012 + 0.014 \cdot S_{11} ^2$	

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Phase	- 180 ° to 180 °	> 8 kHz to 67 GHz	$180^\circ/\pi \cdot U_s$	$U_s = \arcsin(U(S_{ii}^2)/ S_{ii} ^2)$
Transmission (S_{ij}) Magnitude and phase	0 to 30 dB	> 9 kHz to 100 kHz	0.05 dB, 0.4°	Measurement uncertainty in dB and as phase displacement in °
	> 30 dB to 40 dB		0.07 dB, 0.5°	
	> 40 dB to 50 dB		0.12 dB, 0.8°	
	> 50 dB to 60 dB		0.32 dB, 2.1°	
	> 60 dB to 80 dB	0.32 dB + $0.13 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		
	0 to 30 dB	> 100 kHz to 50 MHz	0.05 dB, 0.4°	
	> 30 dB to 40 dB		0.06 dB, 0.4°	
	> 40 dB to 50 dB		0.09 dB, 0.6°	
	> 50 dB to 60 dB		0.19 dB, 1.3°	
	> 60 dB to 80 dB	0.19 dB + $0.076 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		
0 to 30 dB	> 50 MHz to 200 MHz	0.05 dB, 0.4°		
> 30 dB to 40 dB		0.06 dB, 0.4°		
> 40 dB to 60 dB		0.08 dB, 0.6°		
> 60 dB to 80 dB		0.32 dB, 2.1°		
> 80 dB to 90 dB		1.0 dB		
0 to 30 dB	> 200 MHz to 20 GHz	0.04 dB, 0.9°		
> 30 dB to 40 dB		0.06 dB, 0.9°		
> 40 dB to 60 dB		0.07 dB, 0.9°		
> 60 dB to 80 dB		0.15 dB, 1.3°		
> 80 dB to 90 dB		0.32 dB		
0 to 30 dB	> 20 GHz to 40 GHz	0.06 dB, 1.3°		
> 30 dB to 40 dB		0.08 dB, 1.3°		
> 40 dB to 60 dB		0.09 dB, 1.3°		
> 60 dB to 80 dB		0.33 dB, 2.5°		
> 80 dB to 90 dB		0.96 dB		
0 to 30 dB	> 40 GHz to 50 GHz	0.11 dB, 1.7°		
> 30 dB to 40 dB		0.12 dB, 1.7°		
> 40 dB to 60 dB		0.13 dB, 1.7°		
> 60 dB to 80 dB		0.34 dB, 2.7°		
> 80 dB to 90 dB	0.96 dB			
0 to 30 dB	> 50 GHz to 67 GHz	0.15 dB, 2.2°		
> 30 dB to 40 dB		0.16 dB, 2.3°		
> 40 dB to 60 dB		0.20 dB, 2.4°		
> 60 dB to 90 dB		0.20 dB + $0.09 \cdot (S_{ij} [\text{dB}] - 60 \text{ dB})$		

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Modulation quantities				
Sources and meters				
Amplitude modulation				
Modulation degree m	0 to 1.0	$f_m \leq 100 \text{ kHz}$	$0.001 \cdot m + 2.5 \cdot 10^{-5}$	m : Measured value
		$100 \text{ kHz} < f_m \leq 1 \text{ MHz}$	$0.002 \cdot m + 5 \cdot 10^{-5}$	
		$1 \text{ MHz} < f_m \leq 10 \text{ MHz}$	$0.007 \cdot m + 3 \cdot 10^{-4}$	
Frequency modulation	10 Hz to 16 MHz	$10 \text{ Hz} < f_m \leq 100 \text{ kHz}$	$1 \cdot 10^{-3} \cdot \Delta f + K$	Δf : Measured value
Frequency deviation Δf		$100 \text{ kHz} < f_m \leq 200 \text{ kHz}$	$2 \cdot 10^{-3} \cdot \Delta f + K$	
		$200 \text{ kHz} < f_m \leq 10 \text{ MHz}$	$5 \cdot 10^{-3} \cdot \Delta f + K$	
Phase modulation	10 Hz / f_m to 16 MHz / f_m	$10 \text{ Hz} < f_m \leq 100 \text{ kHz}$	$1 \cdot 10^{-3} \cdot \Delta \phi + K$	$\Delta \phi$: Measured value
Phase deviation $\Delta \phi$		$100 \text{ kHz} < f_m \leq 200 \text{ kHz}$	$2 \cdot 10^{-3} \cdot \Delta \phi + K$	
		$200 \text{ kHz} < f_m \leq 10 \text{ MHz}$	$5 \cdot 10^{-3} \cdot \Delta \phi + K$	
Waveform quantities				
CISPR Pulse		CISPR 16-1-1:2019		
Impulse area (IS)	0.1 μVs to 50 μVs	9 kHz to 150 kHz	$35 \cdot 10^{-3} \cdot IS$	IS : Measured value
Meters	3 nVs to 1 μVs	150 kHz to 30 MHz	$35 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	30 MHz to 1 GHz	$36 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	1 GHz to < 8 GHz	$13 \cdot 10^{-3} \cdot IS$	
	0.4 nVs to 200 nVs	8 GHz to 18 GHz	$15 \cdot 10^{-3} \cdot IS$	
Relative Response Ratio	0.1 Hz to 1 MHz	9 kHz to 18 GHz	0.55 %	
Rise time		EN 61000-4-4:2013		
DC pulse generator	200 ps to 1 s	1 mV to 100 V in 50 Ω	$20 \cdot 10^{-3} \cdot t + (50 \text{ ps})^2/t$	t : Measured value
	2 ns to 1 s	100 V to 5 kV in 50 Ω	$20 \cdot 10^{-3} \cdot t + (0.3 \text{ ns})^2/t$	
	3 ns to 1 s	100 V to 8 kV in 1 k Ω	$20 \cdot 10^{-3} \cdot t + (0.5 \text{ ns})^2/t$	
	10 ns to 1 s	EN 61000-4-5:2019	$20 \cdot 10^{-3} \cdot t + (2.2 \text{ ns})^2/t$	
	20 ns to 10 μs	100 V to 15 kV	$20 \cdot 10^{-3} \cdot t + (5 \text{ ns})^2/t$	
		1 mA to 5 kA		
	0.7 ns to 500 ns	EN 61000-4-2:2009	$30 \cdot 10^{-3} \cdot t$	
RF pulse generator	0.5 ns to 20 ns	1 A to 150 A		
Pulse duration	0.5 ns to 10 s	100 MHz to 67 GHz	1 ns	
Repetition time	1 ns to 10 s		$2 \cdot 10^{-3} \cdot t + 10 \text{ ps} + \delta t_{\text{TRIG}}$	δt_{TRIG} : Trigger uncertainty
Burst duration	5 ns to 10 s			
Burst period	5 ns to 10 s			

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Measurement quantity / Calibration item	Range	Measurement conditions / procedure	Expanded uncertainty of measurement	Remarks
Pulse voltage	10 mV to 500 V 10 V to 8 kV	EN 61000-4-4:2013 $200 \text{ ps} \leq \Delta t \leq 1 \text{ s}$ $2.5 \text{ ns} \leq \Delta t \leq 1 \text{ s}$	$20 \cdot 10^{-3} \cdot U$ $30 \cdot 10^{-3} \cdot U$	U : Measured value Δt : Pulse duration
	10 V to 15 kV	EN 61000-4-5:2019 $10 \text{ ns} \leq \Delta t \leq 1 \text{ s}$	$30 \cdot 10^{-3} \cdot U$	
Pulse current	0.2 A to 150 A	EN 61000-4-2:2009 $10 \text{ ns} \leq \Delta t \leq 10 \text{ ms}$	$25 \cdot 10^{-3} \cdot I$	I : Measured value
	1 A to 150 A	$0.5 \text{ ns} \leq \Delta t \leq 10 \text{ ns}$	$40 \cdot 10^{-3} \cdot I$	
	1 A to 5 kA	$20 \text{ ns} \leq \Delta t \leq 10 \text{ ms}$	$20 \cdot 10^{-3} \cdot I$	
Voltage division factor	0 dB to 30 dB	EN 55016-1-2:2019 9 kHz to 250 MHz	0.10 dB	
Complex impedance Z Magnitude	0.2 Ω to 70 Ω	EN 55016-1-2:2019 9 kHz to 10 MHz	$0.17 \Omega + 0.08 \cdot 10^{-3} \cdot Z ^2 / \Omega$	Z : Measured value
	35 Ω to 70 Ω	> 10 MHz to 30 MHz	$0.22 \Omega + 0.12 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	30 Ω to 80 Ω	> 30 MHz to 230 MHz	$0.7 \Omega + 0.18 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 120 Ω to 180 Ω	150 kHz to 24 MHz	$0.5 \Omega + 0.05 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 100 Ω to 220 Ω	> 24 MHz to 80 MHz	$0.7 \Omega + 0.07 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
	> 30 Ω to 220 Ω	> 80 MHz to 300 MHz	$1.8 \Omega + 0.1 \cdot 10^{-3} \cdot Z ^2 / \Omega$	
Phase	-180° to 180°		$180^\circ / \pi \cdot U_s$	$U_s = \arcsin(U(Z)/ Z)$
Frequency oscillators, measuring instruments	0.1 MHz, 1 MHz, 2MHz, 2.5 MHz, 5 MHz, 10 MHz		$5 \cdot 10^{-11} \cdot f$	f : Measured value
Time interval	1 Hz to 67 GHz		$\sqrt{(1 \cdot 10^{-10} \cdot f)^2 + U_{\text{REP}}^2}$	U_{REP} : Repeatability-uncertainty t : Measured value
	$1 \cdot 10^{-9} \text{ s}$ to $1.8 \cdot 10^{-5} \text{ s}$		$\sqrt{1 \text{ ns}^2 + (1 \cdot 10^{-10} \cdot t)^2 + U_{\text{REP}}^2}$	

Abbreviations used:

CISPR	Comité international spécial des perturbations radioélectriques
CMC	Calibration and measurement capabilities
DIN	German institute for standardization