

### 3.1 Calibration and Measurement Capabilities

The Calibration and Measurement Capabilities (CMCs) of the division 2 are based on the Appendix C of the BIPM database. They are being reviewed in a two-step process whereas in the first step a 100 percent review by the members of EURAMET takes place followed by a statistical check by Regional Metrology Organizations (RMOs) under the supervision of the *Joint Committees of the BIPM and the Regions (JCRB)* of the CIPM. The CMC entries can be viewed in the following list. Each entry is directly linked to the corresponding entry of the BIPM database.

Calibration services outside of the CIPM MRA (without CMC entries in the BIPM database) are only offered as [additional services](#) to a certain extent by the division 2. Furthermore, internal calibration services in the field of Electricity, Temperature and Humidity are provided for all divisions of the PTB.

The CMC entries listed in Appendix C of the BIPM database are divided into the following chapters:

Chapter	Title	Remarks
1 DC voltage	<a href="#">1.1 DC voltage sources</a>	-
	<a href="#">1.2 DC voltage meters</a>	-
	<a href="#">1.3 DC voltage ratios</a>	-
2 DC resistance	<a href="#">2.1 DC resistance standards and sources</a>	-
	<a href="#">2.2 DC resistance meters</a>	-
	2.3 DC resistance ratios	no records
3 DC current	<a href="#">3.1 DC current sources</a>	-
	<a href="#">3.2 DC current meters</a>	-
	<a href="#">3.3 DC current ratios</a>	-
4 Impedance (up to the MHz range)	<a href="#">4.1 AC resistance</a>	-
	<a href="#">4.2 Capacitance</a>	-
	<a href="#">4.3 Inductance</a>	-
5 AC voltage (up to the MHz range)	<a href="#">5.1 AC/DC voltage transfer</a>	-
	<a href="#">5.2 AC voltage up to 1100 V</a>	-
	<a href="#">5.3 AC voltage ratio up to 1100 V, attenuation and gain</a>	-
6 AC current	<a href="#">6.1 AC/DC current transfer</a>	-
	<a href="#">6.2 AC current up to 100 A</a>	-
	<a href="#">6.3 AC current ratio up to 100 A</a>	-

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<b>7</b> AC power	<a href="#">7.1 AC power and energy</a>	-
<b>8</b> High voltage and current	<a href="#">8.1 High DC voltage</a>	-
	<a href="#">8.2 High voltage impedance</a>	-
	<a href="#">8.3 AC high voltage and voltage transformers</a>	-
	<a href="#">8.4 Pulsed high voltage and current</a>	-
	<a href="#">8.5 Electric discharge</a>	-
	<a href="#">8.6 High AC current and current transformers</a>	-
	8.7 High DC current	no records
<b>9</b> Other DC and low frequency measurements	9.1 Electric charge	no records
	<a href="#">9.2 Phase angle</a>	-
	9.3 Current and voltage waveform	no records
<b>10</b> Electric and magnetic fields	<a href="#">10.1 Electric fields below 50 kHz</a>	-
	<a href="#">10.2 Magnetic fields below 50 kHz</a>	-
	<a href="#">10.3 Electromagnetic fields above 50 kHz</a>	-
	10.4 EMC, Immunity	only PTB in-house
	10.5 EMC, Emission	only PTB in-house
	10.6 EMC, Test Procedures	only PTB in-house
<b>11</b> Radio frequency measurements	<a href="#">11.1 Radio frequency power</a>	-
	<a href="#">11.2 Scalar RF reflection coefficient and attenuation</a>	-
	<a href="#">11.3 Scattering parameters</a>	-
	11.4 Noise	no records
	11.5 Antenna properties	no records
	<a href="#">11.6 Signal and pulse characteristics</a>	-
	<a href="#">11.7 Radio frequency voltage and current</a>	-
	11.8 Lumped impedance/admittance (using RF techniques)	no records
	<a href="#">11.9 Characteristic impedance</a>	-

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<b>12 Measurements on materials</b>	<a href="#">12.1 Electrical conductivity</a>	-
	12.2 Dielectric properties	no records
	<a href="#">12.3 Soft magnetic sheet and powder materials</a>	-
	<a href="#">12.4 Soft magnetic bulk material</a>	-
	<a href="#">12.5 Feebly magnetic, paramagnetic and diamagnetic material</a>	-
	<a href="#">12.6 Hard magnetic material</a>	-
	12.7 Magnetic data storage media	no records

Updated: 2019-10-24 by Dr. K. Baaske

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### Additional Services

Quantity	Instrument or Artifact	Method of Measurement	Minimum value	Maximum value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Is the expanded uncertainty a relative one?
Phase angle	Power meter	Sampling System	$-\pi$	$+\pi$	rad	Voltage, current, frequency	30V to 240V 0,005A to 100A 16,7Hz to 1000Hz	20 - 400	$\mu$ rad	2	95%	Yes
Signal and pulse characteristics: step response	Electrical pulse-generator or optical photodiode	70 GHz sampling oscilloscope, femtosecond laser (only for photodiode)	-0.1 (multivariate quantity)	1.5 (multivariate quantity)	Voltage versus time	Bandwidth	1 GHz to 5 GHz	0.005 to 0.1 (multivariate quantity)	Voltage versus time	2	95 %	No
DC-Power	Power meter		1,5	1,2E6	Watt	Voltage, current,	10 V to 1000 V 0,002 A to 1200 A	50 - 210	$\mu$ W/W	2	95%	No
Signal and pulse characteristics: step response	Ultrafast photodiode	Optoelectronic time-domain measurements based on femtosecond lasers	-0.1 (multivariate quantity)	1.5 (multivariate quantity)		Nominal bandwidth, type of coaxial connector, excitation wavelength	70 GHz or 100 GHz, 1.85 mm or 1.0 mm, 1550 nm	Typically between 0.005 - 0.3 (multivariate quantity, depends on MC simulations)		2	95%	No

Antenna gain	Antenna	Vector Network Analyzer	10	316		Connector: PC 2.4 (50 Ohm) Waveguide Waveguide	1 to 50 GHz 50 to 75 GHz 75 to 110 GHz	0,035 0,072 1,12		2	95%	No
Power density	Security scanner	Spectrum analyzer	1E-8	10	mW/cm <sup>2</sup>	Frequency	3 GHz to 11 GHz 50 GHz to 110 GHz	0,32		2	95%	Yes
AC-Power	Power Analyzer	Direct Comparison	3	3360	VA	Voltage, Current, Frequency,  cos(phi)	30 V to 240 V, 0,1 A to 14 A, 15 Hz to 20 kHz, 0 to 1	6,5E-5 6,5E-5 to 1,4E-3 6,5E-5 to 1,4E-3	VA/VA, W/VA, var/VA	2	95%	No
DC-Current	Current Sensors, Calibrators	Direct Comparison	0,5	1200	A			100 to 200	µA / A	2	95%	No

Relative permittivity	Split-cylinder resonator	Transmission measurement of TE <sub>0np</sub> resonances	1	100	-	temperature, Humidity, resonant frequencies (depending on dielectric properties and sample thickness)	23 ± 0,5°C, 50 ± 10%, 2 - 30 GHz	3%		2	95%	Yes
Loss tangent	Split-cylinder resonator	Transmission measurement of TE <sub>0np</sub> resonances	0.00005	0.01	-	Temperature, Humidity, resonant frequencies (depending on dielectric properties and sample thickness)	23 ± 0,5°C, 50 ± 10%, 2 - 30 GHz	0.0001		2	95%	No
DC current: Current ratio	Ultrastable Low-noise Current Amplifier Type N688S ("noise-optimized")	Calibration with cryogenic current comparator (14-bit)	1000:1	1000:1		Temperature	19 °C to 27 °C	7.5E-8		2	95%	Yes

DC resistance: Transresistance	Ultrastable Low-noise Current Amplifier Type N688S ("noise- optimized")	Calibration with cryogenic current comparator (14- bit) and standard resistor	1E6	1E6	$\Omega$	Tempera- -ture	19 °C to 27 °C	30	nOhm/ Ohm	2	95%	Yes
DC current: Current ratio	Ultrastable Low-noise Current Amplifier Type C259E ("low- current")	Calibration with cryogenic current comparator (14- bit)	1000:1	1000:1		Tempera- -ture	19 °C to 27 °C	2.1E-6		2	95%	Yes
DC resistance: Transresistance	Ultrastable Low-noise Current Amplifier Type C259E ("low- current")	Calibration with cryogenic current comparator (14- bit) and standard resistor	5E6	5E6	$\Omega$	Tempera- -ture	19 °C to 27 °C	75	nOhm/ Ohm	2	95%	Yes

Updated 2021-12-06 by Dr. K. Baaske

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