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

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

12 Measurements on materials	12.1 Electrical conductivity	-
	12.2 Dielectric properties	no records
	12.3 Soft magnetic sheet and powder materials	-
	12.4 Soft magnetic bulk material	-
	12.5 Feebly magnetic, paramagnetic and diamagnetic material	-
	12.6 Hard magnetic material	-
	12.7 Magnetic data storage media	no records

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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 Confi-dence	Is the expanded uncertainty a relative one?
DC current: Current ratio	Ultrastable Low-noise Current Amplifier	Calibration with cryogenic current comparator (14-bit)	1000:1	1000:1		Tempe-rature	19 °C to 27 °C	2E-8		2	95%	Yes
DC resistance: Transresistance	Ultrastable Low-noise Current Amplifier	Calibration with cryogenic current comparator (14-bit) and standard resistor	1E6	1E6	Ω	Tempe-rature	19 °C to 27 °C	20	nOhm/ Ohm	2	95%	Yes
Phase angle	Power meter	Sampling System	-π	+π	rad	Voltage, current, frequen-cy	30V – 240V 0.005A – 100A 16.7Hz – 1000Hz	20 - 400	µrad	2	95%	Yes
DC-Power	Power meter		1.5	1.2E6	Watt	Voltage, current,	10 V – 1000 V 0.002 A – 1200 A	50 - 210	µW/W	2	95%	No

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**	**Band-width**	**1 GHz – 5 GHz**	**0.005 – 0.1 (multiva-riate quantity)**	**Voltage ver-sus time**	**2**	**95 %**	**No**
Signal and pulse characteristics: step response	**50 GHz, 70 GHz, and 100 GHz sampling oscilloscopes**	**Optoelectronic time-domain measurements based on femtosecond lasers**	**-0.1 (multivariate quantity)**	**1.5 (multivariate quantity)**	**Voltage versus time**	**Type of coaxial connector**	**1.85 mm or 1.0 mm**	**Typically between 0.005 - 0.3 (multivariate quantity, depends on MC simulations)**	**Voltage versus time**	**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 band-width, type of coaxial connec-tor, excita-tion wave-length**	**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**
Hard magnetic material: Remanent magnetic flux density Br, remanent magnetic polarisation J_r	**Permanent magnetic material cylinder**	**Electromagnet, coil system, Fluxmeter**	**0.1**	**2**	**T**			**0.001 – 0.02**		**2**	**95%**	**Yes**

Hard magnetic material: Coercivity H_{cB}	**Permanent magnetic material cylinder**	**Electromagnet, coil system, Fluxmeter**	**1**	**1000**	**kA/m**			**0.003 – 0.01**		**2**	**95%**	**Yes**
Hard magnetic material: Coercivity H_{cJ}	**Permanent magnetic material cylinder**	**Electromagnet, coil system, Fluxmeter**	**1**	**2300**	**kA/m**			**0.003 – 0.01**		**2**	**95%**	**Yes**
Hard magnetic material: Maximum Energy product (B·H)max	**Permanent magnetic material cylinder**	**Electromagnet, coil system, Fluxmeter**	**5**	**500**	**kJ/m³**			**0.005 – 0.02**		**2**	**95%**	**Yes**
Antenna gain	**Antenna**	**Vector Network Analyzer**	**10**	**316**		**Connec-tor: N (50 Ohm) PC 2.4 (50 Ohm) Wave-guide Wave-guide**	**1 – 18 GHz 1 – 50 GHz 50 – 75 GHz 75 – 110 GHz**	**0.035 0.035 0.072 1.12**		**2**	**95%**	**No**
Power density	**Security scanner**	**Spectrum analyzator**	**1E-8**	**10**	**mW/ cm²**	**Frequen-cy**	**3 GHz – 11 GHz 50 GHz – 110 GHz**	**0.32**		**2**	**95%**	**Yes**

AC-Power	**Power Analyzer**	**Direct Comparison**	**3**	**3360**	**VA**	**Voltage, Current, Frequen-cy, |cos(phi)|**	**30 V – 240 V, 0.1 A – 14 A, 15 Hz – 20 kHz, 0 – 1**	**6.5E-5 6.5E-5 – 1.4E-3 6.5E-5 – 1.4E-3**	**VA/VA, W/VA, var/VA**	**2**	**95%**	**No**
DC-Current	**Current Sensors, Calibrators**	**Direct Comparison**	**0.5**	**1200**	**A**			**100 – 200**	**µA / A**	**2**	**95%**	**No**
Relative permittivity	**Split-cylinder resonator**	**Transmission measurement of TE0np resonances**	**1**	**100**	**-**	**temperature, Humi-dity, 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 TE0np resonances**	**0.00005**	**0.01**	**-**	**temperature, Humi-dity, resonant frequencies (depending on dielectric properties and sample thickness)**	**23 ±0,5°C, 50±10%, 2 - 30 GHz**	**0.0001**		**2**	**95%**	**No**

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