CLASSIFICATION OF SERVICES IN ELECTRICITY AND MAGNETISM

Version No 9 (dated 04 June 2020)

METROLOGY AREA: ELECTRICITY AND MAGNETISM

BRANCH: DC VOLTAGE, CURRENT, AND RESISTANCE

1. DC voltage (up to 1100 V, for higher voltages see 8.1)

1.1 DC voltage sources

1.1.1 Single values[1]: *standard cell, solid state voltage standard*

1.1.2 Low value ranges (below or equal to 10 V): *DC voltage source, multifunction calibrator*

1.1.3 Intermediate values (above 10 V to 1100 V): *DC voltage source, multifunction calibrator*

1.1.4 Noise voltages (for noise currents see 3.1.5, for RF noise see 11.4): *DC voltage source, DC amplifier*

1.2 DC voltage meters

1.2.1 Very low values (below or equal to 1 mV): *nanovoltmeter, microvoltmeter*

1.2.2 Intermediate values (above 1 mV to 1100 V: *DC voltmeter, multimeter, multifuntion transfer standard*

1.3 DC voltage ratios (for input voltages up to 1100 V)

1.3.1 Up to 1100 V: *resistive divider, ratio meter*

1.3.2 Attenuation: *attenuators*

2. DC resistance

2.1 DC resistance standards and sources

2.1.1 Low values (below or equal to 1 Ω): *fixed resistor, resistance box*

2.1.2 Intermediate values (above 1 Ω to 1 MΩ): *fixed resistor, resistance box*

2.1.3 High values (above 1 MΩ): *fixed resistor, three terminal resistor, resistance box*

2.1.4 Standards for high current: *DC shunt*

2.1.5 Multiple ranges: *multifunction calibrator*

2.1.6 Temperature, power and pressure coefficients: *fixed resistor*

2.2 DC resistance meters

2.2.1 Low values (below or equal to 1 Ω): *microohmmeter, multimeter, multifunction transfer standard, resistance bridge*

2.2.2 Intermediate values (above 1 Ω to 1 GΩ): *ohmmeter, multimeter, multifunction transfer standard, resistance bridge*

2.2.3 High values (above 1 GΩ): *multimeter, multifunction transfer standard, teraohmmeter, resistance bridge*

2.3 DC resistance ratios

2.3.1 DC resistance ratios: *resistance ratio devices*

3. DC current (up to 100 A, for higher currents see 8.7)

3.1 DC current sources

3.1.1 Low values (below or equal to 0.1 mA): *current generator, multifunction calibrator*

3.1.2 Intermediate values (above 0.1 mA to 20 A): *current generator, multifunction calibrator*

3.1.3 High values (above 20 A to 100 A): *current generator*

3.1.4 Transconductance ratio

3.1.5 Noise currents (for noise voltages see 1.1.4, for RF noise see 11.4): *DC current source, DC amplifier*

3.2 DC current meters

3.2.1 Low values (below or equal to 0.1 mA): *picoammeter, nanoammeter, multimeter, multifunction transfer standard*

3.2.2 Intermediate values (above 0.1 mA to 20 A): *current comparator*

3.2.3 High values (above 20 A to 100 A): *current transducer, dedicated equipment for heavy current*

3.3 DC current ratios

[1] For each service, the instruments or artefacts are indicated in italic characters.

3.3.1 Ratios up to 100 A: *resistive dividers, DC current comparators, current transducers*

BRANCH: IMPEDANCE UP TO THE MEGAHERTZ RANGE

4. Impedance (up to the MHz range)

4.1 AC resistance

4.1.1 Real component (or modulus) and imaginary component (or argument or time constant): *fixed resistor*
4.1.2 AC/DC difference: *fixed resistor*
4.1.3 Resistors for high current: *AC current shunt*
4.1.4 Meters: *LCR meter (LCR: Inductance, Capacitance, Resistance)*
4.1.5 AC resistance ratios: *resistance ratio devices*

4.2 Capacitance

4.2.1 Capacitance and dissipation factor for low loss capacitors: *standard capacitor (sealed, dry-nitrogen or fused silica dielectric)*
4.2.2 Capacitance and dissipation factor for dielectric capacitors: *fixed capacitor, switched capacitor, capacitance box*
4.2.3 Capacitance and dissipation factor for transformed capacitors: *fixed capacitor, switched capacitor*
4.2.4 Meters: *capacitance bridge, LCR meter (LCR: Inductance, Capacitance, Resistance)*

4.3 Inductance

4.3.1 Self inductance and equivalent series resistance, low values (lower than 1 mH): *fixed inductor, variable inductor, inductance box*
4.3.2 Self inductance and equivalent series resistance, intermediate values (above or equal to 1 mH to 1 H): *fixed inductor, variable inductor, inductance box*
4.3.3 Self inductance and equivalent series resistance, high values (higher than 1 H): *fixed inductor, variable inductor, inductance box*
4.3.4 Mutual inductance: *fixed mutual inductor*
4.3.5 Meters: *LCR meter (LCR: Inductance, Capacitance, Resistance)*
4.3.6 Quality factor: *Q-standards*

BRANCH: AC VOLTAGE, CURRENT, AND POWER

5. AC voltage (up to the MHz range)

5.1 AC/DC voltage transfer (for frequencies higher than 1 MHz see 11.7.1)

5.1.1 AC/DC transfer difference at low voltages (typically below or equal to 0.5 V): *thermal converter with amplifier, micropotentiometer, AC/DC transfer standard*
5.1.2 AC/DC transfer difference at medium voltages (typically above 0.5 V to 5 V): *thermal converter (directly connected), AC/DC transfer standard*
5.1.3 AC/DC transfer difference at higher voltages (typically above 5 V): *thermal converter with range extender, AC/DC transfer standard*

5.2 AC voltage up to 1100 V (for high voltage see 8.3)

5.2.1 Sources: *multifunction calibrator*
5.2.2 Meters: *AC voltmeter, multimeter, multifunction transfer standard*

5.3 AC voltage ratio up to 1100 V (voltage transformers excluded)**, attenuation and gain** (for high voltage and voltage transformers, see 8.3)

5.3.1 Real component (or modulus) and imaginary component (or argument): *inductive voltage divider, AC bridge standard, attenuator box, syncro-resolver*
5.3.2 Attenuation and gain: *passive device, attenuator box, inductive voltage divider*

6. AC current

6.1 AC/DC current transfer

6.1.1 AC/DC transfer difference: *thermal converter plus shunt, AC/DC transfer standard plus shunt*

6.2 AC current up to 100 A (for high current see 8.6)

6.2.1 Sources: *multifunction calibrator, transconductance amplifier*
6.2.2 Meters: *AC ammeter, multimeter, multifunction transfer standard*

6.3 AC current ratio up to 100 A (current transformers excluded, for high current and current transformers, see 8.6)

6.3.1 Real component (or modulus) and imaginary component (or argument)

7. AC power

7.1 AC power and energy

7.1.1 Single phase (frequencies below or equal to 400 Hz): *power meter, energy meter, power converter, wattmeter*

7.1.2 Single phase (frequencies above 400 Hz): *power meter, energy meter, power converter, wattmeter*

7.1.3 Three phase: *power meter, energy meter*

BRANCH: HIGH VOLTAGE AND CURRENT

8. High voltage and current

8.1 High DC voltage (for voltages lower than 1100 V see 1)

8.1.1

8.1.2

8.1.3 High DC voltage ratio: *DC high voltage divider, DC high voltage probe*

8.1.4 Average value of DC voltage: *DC voltage measuring system, DC voltage source, DC voltmeter*

8.1.5 RMS value of DC voltage ripple: *DC voltage measuring system, DC voltage source, DC voltmeter*

8.2 High voltage impedance (for low voltages see 4)

8.2.1 Capacitance and dissipation factor: *compressed gas capacitor, capacitor for high voltage, capacitance bridge, dissipation factor standard*

8.2.2 Inductance and loss angle: *high voltage reactor, inductance bridge*

8.2.3 Burden: real and imaginary component (real component/imaginary component/modulus/argument[1]): *instrument transformer burden*

8.2.4 Resistance: *high voltage resistor*

8.3 High AC voltage (for voltages <= 1100 V see 5.2 and 5.3) **and voltage transformers**

8.3.1

8.3.2

8.3.3 Peak value of high AC voltage: *AC peak voltage responding measuring system, AC peak voltmeter*

8.3.4 Voltage transformers: ratio error and phase displacement: *voltage transformer, voltage transformer bridge, voltage divider, voltage probe*

8.3.5 RMS value for high AC voltage: *RMS responding measuring system, AC voltmeter, AC voltage source*

8.3.6 Rectified average value of high AC voltage: *AC rectified average voltage responding measuring system, AC rectified average voltmeter*

8.4 Pulsed high voltage and current

8.4.1 Parameters for lightning impulse voltage (lightning impulse voltage peak value/test voltage value/extreme value/front time/time to half value/time to chopping/scale factor/... [add parameters as appropriate][1]): *lightning impulse voltage measuring system, impulse calibrator, digital recorder*

8.4.2

8.4.3 Parameters for switching impulse voltage (switching impulse voltage test voltage value/scale factor/time to peak/time to half value/time to zero/time above 90%/setting time of step response/partial response time of step response/... [add parameters as appropriate][1]): *switching impulse voltage measuring system, impulse divider, impulse calibrator, digital recorder*

8.4.4

8.4.5 Parameters for impulse current (impulse current peak value/scale factor/front time/time to half value/duration/total duration/charge/impulse energy/setting time of step response/partial response time of step response... [add parameters as appropriate][1]): *impulse current measuring system, impulse shunt/divider, digital recorder*

8.4.6

8.4.7

8.4.8

8.4.9 Parameters for other impulse voltage types (peak value/front time/time to half value/duration/total duration/charge/impulse energy/settling time of step response/partial response time of step response/... [add parameters as appropriate][1]): *other impulse measuring systems*

8.5 Electric discharge

8.5.1 Apparent charge: *partial discharge calibrator, partial discharge measuring instrument*

8.5.2 Response: *electrostatic discharge target*

[1] Select one quantity

8.5.3 Rise time of partial discharge pulse: *partial discharge calibrator*

8.6 High AC current (for currents <= 100 A see 6.2 and 6.3) **and current transformers**

8.6.1

8.6.2

8.6.3 Current transformers: ratio error and phase displacement: *current transformer, current transformer bridge*

8.6.4

8.6.5 High AC current RMS value: *AC current measuring system, AC current meter, AC current source*

8.6.6 Other AC current parameter (average value/energy/... [add parameters as appropriate][2]): *AC current measuring system*

8.7 High DC current (for currents below or equal to 100 A see 3, for shunts see 2.1.4)

8.7.1

8.7.2

8.7.3 High DC current ratio: *DC current transformer*

8.7.4 High DC current average value: *DC current measuring system, DC current probe, DC source*

BRANCH: OTHER DC AND LOW FREQUENCY MEASUREMENTS

9. Other DC and low frequency measurements

9.1 Electric charge

9.1.1 Sources: *q-source*

9.1.2 Meters: *q-meter*

9.2 Phase angle

9.2.1 Sources: *phase source*

9.2.2 Meters: *phase meter*

9.2.3 Phase shift: *phase shifters, phase shift measuring devices*

9.3 Current and voltage waveform

9.3.1 Main frequency harmonics: *mains frequency harmonics analyzer*

9.3.2 Mains frequency harmonic distortion: *mains frequency harmonic analyzer, signal generator, distortion meter, level meter*

9.3.3

9.3.4 Mains frequency fluctuating harmonics (non sinusoidal waveforms/harmonic measurements for voltage/current waveforms/fluctuating harmonics[2]): *mains frequency harmonics analyzer*

9.3.5 Mains frequency voltage fluctuations, square / sine wave / other modulation (flicker severity (Pst), square/sine wave/Modulation [add modulation type as appropriate][2]): *flicker meter*

9.3.6

9.3.7 Mains frequency interharmonic: mains frequency analyzer

BRANCH: ELECTRIC AND MAGNETIC FIELDS

10. Electric and magnetic fields

10.1 Electric fields below 50 kHz

10.1.1 Electrostatic field strength: *electrostatic field meter, electrostatic generator*

10.1.2 Electric field strength: *field strength probe, electric field meter*

10.2 Magnetic fields below 50 kHz

10.2.1 Magnetic flux: *flux meter, flux etalon*

10.2.2 DC magnetic flux density and applied magnetic field strength: *magnetic flux density meter, magnetic field strength meter*

10.2.3 AC magnetic flux density and applied magnetic field strength: *magnetic flux density meter, magnetic field strength meter*

10.2.4 DC shielding factor (ratio of DC magnetic flux density)

10.2.5 AC shielding factor (ratio of AC magnetic flux density)

10.2.6 Turn area (ratio of magnetic flux and magnetic flux density): *pick up coil*

10.2.7 Magnetic flux density or magnetic field strength per unit current: *field coils*

10.2.8 Magnetic field gradient: *gradiometers*

10.3 Electromagnetic fields above 50 kHz

10.3.1 Electric field strength: *field probe*

10.3.2 Magnetic field strength: *field probe*

10.3.3 Power flux density: *field probe*

10.3.4 Magnetic flux density

10.3.5 Magnetic field strength per unit current

10.3.6 Turn area (ratio of magnetic flux and magnetic flux density)

[2] Select one quantity

BRANCH: RADIO FREQUENCY MEASUREMENTS

11. Radio frequency measurements

11.1 Radio frequency power

11.1.1 Absolute power in coaxial line: *power meter, power source*
11.1.2 Absolute power in waveguide: *power meter, power source*
11.1.3 Calibration factor and effective efficiency in coaxial line: *thermistor, barretter and power sensor*
11.1.4 Calibration factor and effective efficiency in waveguide: *thermistor, barretter and power sensor*
11.1.5 Non-CW power (absolute or relative): *peak power sensor, sensors with time resolution*
11.1.6 Power measurements in balanced lines: *power meter (e.g. in 150 ohm)*

11.2 **Scalar RF reflection coefficient and attenuation** (not using a VNA or similar device) (magnitude)

11.2.1 Reflection coefficient in coaxial line (values in linear terms): *passive device*
11.2.2 Reflection coefficient in waveguide (values in linear terms): *passive device*
11.2.3 Attenuation in coaxial line (values in dB): *passive device*
11.2.4 Attenuation in waveguide (values in dB): *passive device*
11.2.5 Directivity, effective source match: *multiports, splitter*
11.2.6 Reflection and attenuation measurements in balanced lines

11.3 Scattering parameters (vectors)

11.3.1 Reflection coefficient (S_{ii}) in coaxial line (values in linear terms: real and imaginary or magnitude and phase): *passive device, generator*
11.3.2 Reflection coefficient (S_{ii}) in waveguide (values in linear terms: real and imaginary or magnitude and phase): *passive device, generator*
11.3.3 Transmission coefficient (S_{ij}) in coaxial line (values in linear or logarithmic terms: real and imaginary or magnitude and phase): *passive devices*
11.3.4 Transmission coefficient (S_{ij}) in waveguide (values in linear or logarithmic terms: real and imaginary or magnitude and phase): *passive devices*
11.3.5 Directivity, effective source match: *multiports, splitter*
11.3.6 Reflection coefficient (S_{ii}) for common mode systems: *common mode absorbing devices (CMAD), coupling-decoupling network (CDN)*
11.3.7 Transmission coefficient (S_{ij}) for common mode systems: *common mode absorbing devices (CMAD)*
11.3.8 Reflection coefficient (Sii) in planar line systems (values in linear terms: real and imaginary or magnitude and phase): *passive device, generator*
11.3.9 Transmission coefficient (Sij) in planar line systems (values in linear or logarithmic terms: real and imaginary or magnitude and phase): *passive devices*

11.4 Noise (for LF noise voltages and currents see 1.1.4 and 3.1.5)

11.4.1 Noise temperature or excess noise ratio in coaxial line: *noise source*
11.4.2 Noise temperature or excess noise ratio in waveguide: *noise source*
11.4.3 Amplifier noise parameters: *two-port amplifier, mixers*
11.4.4 Phase noise: *oscillator, two-port device*
11.4.5 Radio brightness temperature, spectral radiance in free space: *wide aperture noise radiometer*

11.5 Antenna properties

11.5.1 Antenna factor: *antenna dipole, loop antenna, log antenna*
11.5.2 Antenna gain: *antenna dipole, horn antenna, log periodic*
11.5.3 Other properties (pattern, beam width, …): *antenna dipole, horn antenna, log periodic*

11.6 Signal and pulse characteristics (phase noise see 11.4.4)

11.6.1 Pulse amplitude: *oscilloscope, pulse and function generator*
11.6.2 Pulse time parameters: *oscilloscope, pulse and function generator*
11.6.3 Modulation, AM and FM: *signal generator, spectrum analyser, modulation meter, jitter meter*
11.6.4 Distortion and harmonic content: *signal generator, spectrum analyser, distortion meter*

11.7 Radio frequency voltage and current (for frequencies lower than 1 MHz see 5 and 6)

11.7.1 RF/DC difference: *thermal voltage converter, AC/DC current standard*
11.7.2 RF voltage sources: *RF generator*
11.7.3 RF voltage meters: *RF voltmeter*
11.7.4 RF current: *RF current generator*
11.7.5 RF transfer impedance: *RF current clamp, ESD target*
11.7.6 RF voltage division factor: *burst adaptor, oscilloscope probes*
11.7.7 RF coupling factor: *coupling-decoupling network (CDN), EM current clamp, absorbing clamp*

- 11.7.8 Flatness of RF voltage sources: *RF voltage sources*
- 11.7.9 Flatness of RF voltage meters: *RF voltage meters*

11.8 Lumped impedance/admittance (using RF techniques)

- 11.8.1 Resistance or conductance (*R, G*)
- 11.8.2 Inductance (*L*)
- 11.8.3 Capacitance (*C*)
- 11.8.4 Quality factor (*Q*): *Q-standard, Q-meter*

11.9 Characteristic impedance

- 11.9.1 Mechanical dimensions: *coaxial airline, waveguide*
- 11.9.2 Electrical parameters: *coaxial airline*

BRANCH: MATERIALS

12. Measurements on materials

12.1 Electrical conductivity

- 12.1.1 Metallic materials: *metallic bar, sheet, reference material*
- 12.1.2 Liquids (see also subject field "Amount of Substance"): *liquid, reference material, electrolytic cell*
- 12.1.3 Semiconducting and similar materials: *reference wafers*

12.2 Dielectric properties

- 12.2.1 Relative permittivity: real and/or imaginary part: *solid materials, liquid materials*
- 12.2.2 Dielectric loss tangent: tan δ: *solid materials, liquid materials*

12.3 Soft magnetic sheet and powder materials

- 12.3.1 Specific total power loss: *Epstein, ring and single sheet sample*
- 12.3.2 Peak value of DC magnetic polarisation: *Epstein, ring and single sheet sample*
- 12.3.3 Peak value of AC magnetic polarisation: *Epstein, ring and single sheet sample*
- 12.3.4 Peak value of magnetic field strength: *Epstein, ring and single sheet sample*
- 12.3.5 RMS value of magnetic field strength: *Epstein, ring and single sheet sample*
- 12.3.6 Specific apparent power: *Epstein, ring and single sheet sample*
- 12.3.7 Relative peak permeability: *Epstein, ring and single sheet sample*
- 12.3.8 Complex relative permeability
- 12.3.9 Density: *Epstein, ring and single sheet sample*
- 12.3.10 Resistivity: *Epstein, ring and single sheet sample*

12.4 Soft magnetic bulk material

- 12.4.1 Magnetic polarisation: *rod, cylinder*
- 12.4.2 Magnetic field strength: *rod, cylinder*
- 12.4.3 Remanent magnetic flux density: *rod, cylinder*
- 12.4.4 Coercive magnetic field strength: *rod, cylinder*
- 12.4.5 Magnetic saturation polarisation: *rod, cylinder*
- 12.4.6 Relative permeability: *rod, cylinder*

12.5 Feebly magnetic, paramagnetic and diamagnetic material

- 12.5.1 DC magnetic susceptibility or relative magnetic permeability: *rod, cylinder*

12.6 Hard magnetic material

- 12.6.1 Remanent magnetic flux density: *cylinder, rectangular parallelepiped*
- 12.6.2 Coercive field strength (H_{CB}, H_{CJ}): *cylinder, rectangular parallelepiped*
- 12.6.3 Maximum energy product $(B.H)_{max}$: *cylinder, rectangular parallelepiped*
- 12.6.4 Magnetic moment: *cylinder, rectangular parallelepiped*
- 12.6.5 Magnetic flux density: *cylinder, rectangular parallelepiped*
- 12.6.6 Magnetic polarisation: *cylinder, rectangular parallelepiped*
- 12.6.7 Relative recoil permeability

12.7 Magnetic data storage media

- 12.7.1 Signal amplitude of magnetic stripes: *magnetic stripes*
- 12.7.2 Surface profile of magnetic stripes: *magnetic stripes*
- 12.7.3 Reference field of diskettes: *diskettes*
- 12.7.4 Signal amplitude of diskettes: *diskettes*
- 12.7.5 Resolution of diskettes: *diskettes*
- 12.7.6 Peak shift of diskettes: *diskettes*
- 12.7.7 Overwrite of diskettes: *diskettes*
- 12.7.8 Video and audio tapes

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