

CLASSIFICATION OF SERVICES IN ELECTRICITY AND MAGNETISM

Version No 7.5 (dated 12 March 2009)

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 values¹: *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, multifunction 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 M Ω): *fixed resistor, resistance box*
 - 2.1.3 High values (above 1 M Ω): *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 G Ω): *ohmmeter, multimeter, multifunction transfer standard, resistance bridge*
 - 2.2.3 High values (above 1 G Ω): *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 High voltage sources: *DC kilovolt source*
- 8.1.2 High voltage meters: *DC kilovoltmeter, dedicated set-up for high voltage*
- 8.1.3 Ratios: *high voltage resistive divider, DC high voltage probe*

8.2 High voltage impedance (for low voltages see 4)

- 8.2.1 Capacitance and dissipation factor: *compressed gas capacitor, capacitor for high voltage*
- 8.2.2 Inductance and loss angle: *high voltage reactor*
- 8.2.3 Burden: real and imaginary component: *instrument transformer burden*
- 8.2.4 Resistance: *fixed high voltage resistor*

8.3 AC high voltage (for voltages ≤ 1100 V see 5.2 and 5.3) and voltage transformers

- 8.3.1 Sources: *high voltage AC source*
- 8.3.2 Meters: *AC high voltage meter, dedicated set-up for high voltage measurements (resistive and capacitive dividers)*
- 8.3.3 Peak values: *AC high voltage meter, dedicated set-up for high voltage measurements (resistive and capacitive dividers)*
- 8.3.4 Voltage transformers: ratio error and phase displacement: *voltage transformer, voltage transformer bridge*

8.4 Pulsed high voltage and current

- 8.4.1 Lightning impulse voltage parameters: *lightning impulse voltage measurement set-up, impulse calibrator, digital recorder*
- 8.4.2 Lightning impulse time parameters: *lightning impulse voltage measurement set-up, impulse calibrator, digital recorder*
- 8.4.3 Switching impulse voltage parameters: *switching impulse voltage measurement set-up, impulse calibrator, digital recorder*
- 8.4.4 Switching impulse time parameters: *switching impulse voltage measurement set-up, impulse calibrator, digital recorder*
- 8.4.5 Impulse current parameters: *dedicated measurement set-up, impulse divider*
- 8.4.6 Impulse current time parameters: *dedicated measurement set-up, impulse divider*
- 8.4.7 Impulse energy: *impulse calibrator, shunt, transducer*
- 8.4.8 Response parameters: response time, overshoot, settling time: *impulse divider, shunt, transducer*

8.5 Electric discharge

- 8.5.1 Apparent charge: *partial discharge calibrator, partial discharge measuring instrument*
- 8.5.2 Response: *electrostatic discharge target*

8.6 High AC current (for currents ≤ 100 A see 6.2 and 6.3) and current transformers

- 8.6.1 Sources: *high current AC source*
- 8.6.2 Meters: *dedicated measurement set-up, current transducer*
- 8.6.3 Current transformers: ratio error and phase displacement: *current transformer, current transformer bridge*
- 8.6.4 Pulsating current: *pulsating current measurement set-up*

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

- 8.7.1 Sources
- 8.7.2 Meters: *measurement set-up*
- 8.7.3 Ratios

BRANCH: OTHER DC AND LOW FREQUENCY MEASUREMENTS

9. Other DC and low frequency measurements

9.1 Electric charge9.1.1 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 current harmonics: *main frequency harmonics analyser, flicker meter*9.3.2 Voltage harmonic distortion: *signal generator, distortion meter, level meter*9.3.3 Non sinusoidal waveforms, harmonic measurements for current waveforms, steady state: *mains frequency harmonics analyser*9.3.4 Non sinusoidal waveforms, harmonic measurements for current waveforms, fluctuating: *mains frequency harmonics analyser*9.3.5 Flicker severity (Pst), square or sine wave modulation: *flicker meter*9.3.6 Flicker severity (Pst), complex modulation: *flicker meter***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)

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): *passive device, generator*
 - 11.3.2 Reflection coefficient (S_{ii}) in waveguide (values in linear terms: real and imaginary or magnitude): *passive device, generator*
 - 11.3.3 Transmission coefficient (S_{ij}) in coaxial line (values in linear terms: real and imaginary): *passive devices*
 - 11.3.4 Transmission coefficient (S_{ij}) in waveguide (values in linear terms: real and imaginary): *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)*
- 11.4 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*
- 11.8 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: $\tan \delta$: *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_{CI}): *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

The Classification of services Version 7.5 in Electricity and Magnetism is available under the form of an EXCEL file by clicking [here](#).