IEC 62153-4-8

Edition 2.0 2018-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Metallic cables and other passive components – Test methods –
Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance

Câbles métalliques et autres composants passifs – Méthodes d'essai –
Partie 4-8: Compatibilité électromagnétique (CEM) – Admittance de couplage capacitif

IEC 62153-4-8:2018-06(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**METALLIC CABLES AND OTHER PASSIVE COMPONENTS –
TEST METHODS –**

**Part 4-8: Electromagnetic compatibility (EMC) –
Capacitive coupling admittance**

FOREWORD

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International Standard IEC 62153-4-8 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This edition includes the following significant technical changes with respect to the previous edition:

a) use of the triaxial set-up in a similar manner as for the measurement of the transfer impedance (see IEC 62153-4-3),

b) use of vector network analyser instead of capacitance bridge or pulse generator.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
46/684/FDIS	46/690/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62153 series, under the general title: *Metallic cables and other passive components – Test methods*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,
- replaced by a revised edition, or
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METALLIC CABLES AND OTHER PASSIVE COMPONENTS – TEST METHODS –

Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance

1 Scope

This part of IEC 62153 specifies a test method for determining the capacitive coupling admittance, the capacitive coupling impedance and the coupling capacitance by the use of a triaxial set-up in a similar manner as for the measurement of the transfer impedance (see IEC 62153-4-3). Most cables have negligible capacitive coupling; however, in the case of cables with loose single-braids, the coupling through the holes in the screen shall be determined by the measurement of the capacitive coupling admittance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62153-4-3, *Metallic communication cable test methods – Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp.

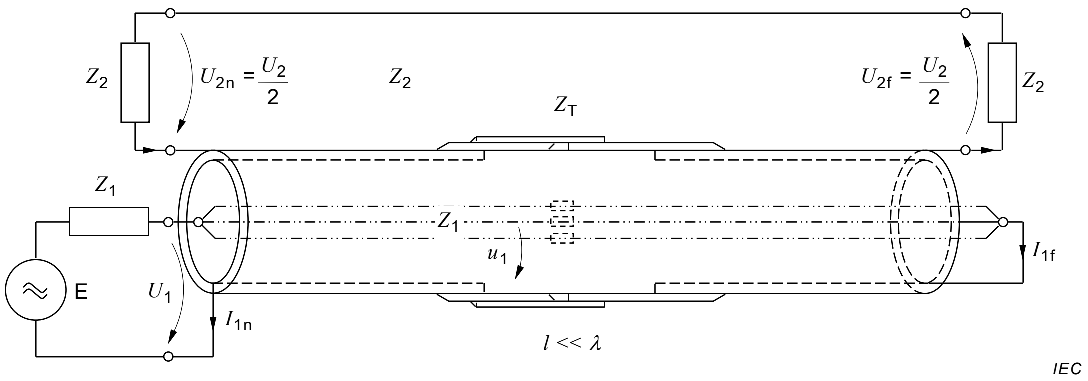
3.1
inner circuit
circuit consisting of the screens and the conductor(s) of the test specimen

Note 1 to entry: Quantities relating to the inner circuit are denoted by the subscript “1”. See Figure 1 and Figure 2.

3.2
outer circuit
circuit consisting of the screen surface and the inner surface of a surrounding test jig

Note 1 to entry: Quantities relating to the outer circuit are denoted by the subscript “2”. See Figure 1 and Figure 2.

3.3
transfer impedance
Z_T
quotient of the longitudinal voltage induced in the matched outer circuit – formed by the screen under test and the measuring jig – and the current fed into the inner circuit or vice versa (see Figure 1)



Key

Z_1, Z_2	characteristic impedance of the inner and the outer circuits
U_1, U_2	voltages in the inner and the outer circuits (n: near end, f: far end)
I_1	current in the inner circuit (n: near end, f: far end)
l	length of the cable, respectively the length of the screen under test
λ	wavelength in free space

$$Z_T = \frac{U_2}{I_1} \tag{1}$$

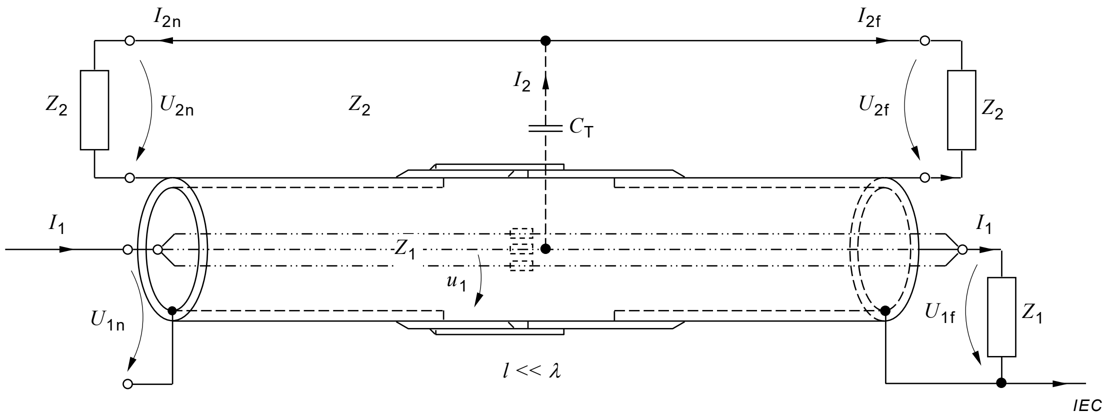
where

Z_T	is the transfer impedance;
U_2	is the voltage in the inner and the outer circuits (n: near end, f: far end);
I_1	is the current in the inner circuit (n: near end, f: far end).

Figure 1 – Definition of Z_T

Note 1 to entry: Transfer impedance is expressed in mΩ/m.

3.4
capacitive coupling impedance
Z_F
quotient of twice the voltage induced to the terminating impedance Z_2 of the matched outer circuit by a current I_1 fed (without returning over the screen) to the inner circuit and the current I_1 or vice versa (see Figure 2)



Key

Z_1, Z_2 characteristic impedance of the inner and the outer circuits

U_1, U_2 voltages in the inner and the outer circuits (n: near end, f: far end)

I_1, I_2 current in the inner and the outer circuits (n: near end, f: far end)

l length of the cable, respectively the length of the screen under test

λ wavelength in free space

$I_{2n} = I_{2f}$

$U_{1n} = U_{1f}$

$I_{2n} = I_{2f} = (1/2) \times I_2 = I_2/2$

$I_2 = I_{2n} + I_{2f}$

$$Z_F = \frac{U_{2n} + U_{2f}}{I_1} = \frac{2U_{2f}}{I_1} = Z_1 Z_2 \times j\omega C_T \quad (2)$$

where

Z_F is the capacitive coupling impedance;

Z_1, Z_2 is the characteristic impedance of the inner and the outer circuits;

U_2 is the voltage in the outer circuit (n: near end, f: far end);

I_1 is the current in the inner circuit (n: near end, f: far end);

C_T is the coupling capacitance.

Figure 2 – Definition of Z_F

Note 1 to entry: Capacitive coupling impedance is expressed in mΩ/m.

Note 2 to entry: For multiconductor cables, the inner conductors are shorted together.

Note 3 to entry: The coupling capacitance C_T is dependent on the dielectric permittivity and geometry of the outer circuit, whereas the capacitive coupling impedance is invariant with respect to the geometry of the outer circuit and nearly invariant with respect to the dielectric permittivity.

$$Z_F = Z_1 Z_2 j\omega C_T = j\omega C_T \frac{\sqrt{\varepsilon_{r1}}}{C_1 c_0} \frac{\sqrt{\varepsilon_{r2}}}{C_2 c_0} \quad (3)$$

where

Z_F is the capacitive coupling impedance;

C_T is the coupling capacitance;

ω is the circular frequency;

c_0 is the speed of light, 3×10^8 m/s;

ε_{r1} is the relative dielectric permittivity of the inner circuit (CUT);

ε_{r2} is the relative dielectric permittivity of the outer circuit (tube);

Z_1 is the impedance of the inner circuit (CUT);

Z_2 is the impedance of the outer circuit (tube);

C_1 is the capacitance of the inner circuit (CUT);

C_2 is the capacitance of the outer circuit (tube).

As $C_T \propto \frac{C_1 C_2}{\varepsilon_{r1}+\varepsilon_{r2}}$ one gets $Z_F \propto \frac{\sqrt{\varepsilon_{r1}\varepsilon_{r2}}}{\varepsilon_{r1}+\varepsilon_{r2}}$; and $\frac{\sqrt{\varepsilon_{r1}\varepsilon_{r2}}}{\varepsilon_{r1}+\varepsilon_{r2}} \approx 0{,}5$ for relative dielectric permittivity in the inner and outer circuit in the range from 1 to 3.

3.5
capacitive coupling admittance
$\boldsymbol{Y_C}$
quotient of the current induced in the secondary (inner) circuit to the voltage development in the primary (outer) circuit. For electrically short uniform cables

$$Y_C = j\omega C_T \tag{4}$$

3.6
effective transfer impedance
$\boldsymbol{Z_{TE}}$
maximum absolute value of the sum or difference of the Z_F and Z_T at every frequency

$$Z_{TE} = \max\left|Z_F \pm Z_T\right| \tag{5}$$

Note 1 to entry: The effective transfer impedance is expressed in Ω.

3.7
effective transfer impedance related to a reference impedance of 1 Ω
$\boldsymbol{Z_{TE}}$
maximum absolute value of the sum or difference of the Z_F and Z_T at every frequency expressed in dB (Ω)

$$Z_{TE} = +20 \times \log_{10}\left(\frac{|Z_{TE}|}{Z_{T,ref}}\right) \tag{6}$$

where

$Z_{T,ref}$ is the reference transfer impedance with a value of 1 Ω

Note 1 to entry: The effective transfer impedance is expressed in dB (Ω).

3.8
coupling length
$\boldsymbol{L_c}$
length of cable which is inside the test jig, i.e. the length of the screen under test

3.9
cut-off frequency
maximum frequency up to which the capacitive coupling admittance can be measured

4 Principle

The test determines the screening effectiveness of a shielded cable by applying a well-defined voltage to the screen of the cable and measuring the induced voltage in a secondary circuit in order to determine the capacitive coupling admittance. This test measures only the electrostatic component of the effective transfer impedance Z_{TE}. To measure the magnetic component (the surface transfer impedance), the method described in IEC 62153-4-3 shall be used.

5 Test method

5.1 General

If not otherwise specified, the measurements shall be carried out at the temperature of (23 ± 3) °C.

The test method determines the capacitive coupling admittance of a cable screen by measuring the cable in a triaxial test set-up. A test configuration with an open circuit in the inner and outer circuit shall be used. This emphasizes the capacitive coupling compared to the magnetic coupling and results in a 6 dB higher signal compared to a configuration where the inner circuit is matched.

The test results are valid in a frequency range up to about 25 MHz, see 5.2. The coupling capacitance C_T is independent on the frequency. Therefore for frequencies above the cut-off frequency, the test results of the capacitive coupling admittance can be extrapolated with 20 dB/decade, see 3.5.

5.2 Cut-off frequency

The cut-off frequency length product is roughly:

$$f_{cut} \times l \approx \frac{1}{\sqrt{\varepsilon_{r1} + \varepsilon_{r2}}} \frac{c_0}{2\pi} \tag{7}$$

where

l is the coupling length of the cable under test;

c_0 is the speed of light, 3×10^8 m/s;

ε_{r1} is the relative dielectric permittivity of the inner circuit (CUT);

ε_{r2} is the relative dielectric permittivity of the outer circuit (tube).

I.e. for a coupling length of 1 m and dielectric permittivities of 2,3 and 1,1 in the inner respectively outer circuit, the maximum frequency for the measurement of the capacitive coupling admittance is 25 MHz.

Another way to obtain the cut-off frequency is to observe the phase of the capacitive coupling admittance respectively measured forward transmission scattering parameter S_{21}, see 5.8. The cut-off frequency is reached when the phase starts to deviate from 90 degrees.

5.3 Test equipment

The measurement shall be performed using a vector network analyser.

5.4 Coupling length

The coupling length shall be not shorter than 0,5 m and not longer than 1,0 m.

5.5 Sample preparation

The test sample shall have a length not more than 50 % longer than the coupling length.

Coaxial cables are prepared as shown in Figure 3.

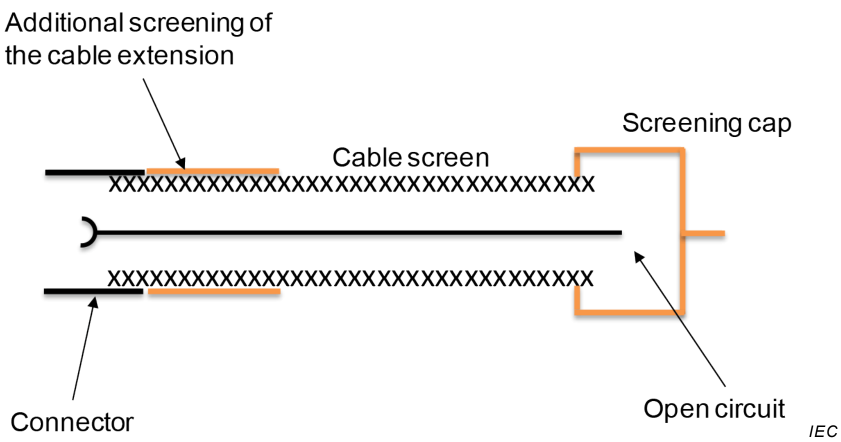


Figure 3 – Preparation of test sample for coaxial cables

One end of the coaxial cable is prepared with a connector to make a connection to the receiver. The other end of the coaxial cable is prepared with a well screened open circuit. The open circuit shall be made in a way resulting in a small stray capacitance. To minimize unwanted coupling into the tube, the exceeding length outside the tube shall be screened with an additional tight screen, which shall be in contact with the cable screen (e.g. by wrapping a metal foil with minimum 20 % overlap around the cable screen).

All connections shall be made RF tight and with low RF-contact resistance so that the impact of the sample preparation is negligible compared to the test results.

Screened symmetrical cables are treated as a quasi coaxial system, see Figure 4. Therefore the conductors of all pairs/quads shall be connected together at both ends. All screens, including those of individually screened pairs/quads, shall be connected together at both ends. The screens shall be connected over the whole circumference.

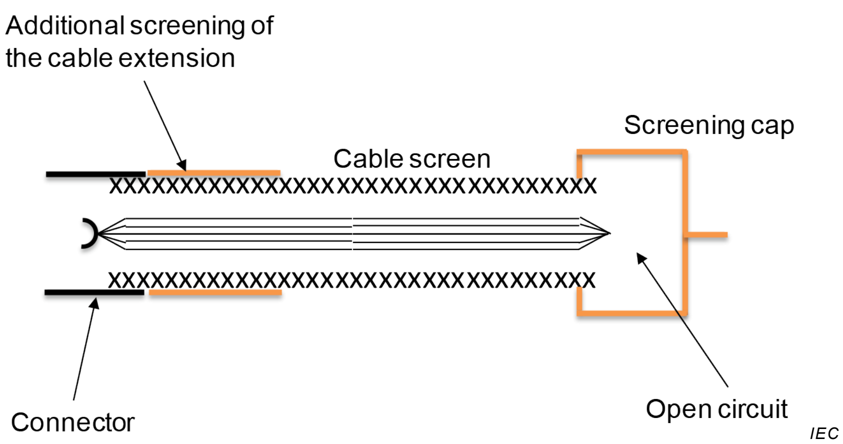


Figure 4 – Preparation of test sample for symmetrical cables