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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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METALLIC ~~COMMUNICATION~~ CABLES AND OTHER PASSIVE COMPONENTS – TEST METHODS –

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

1 Scope

This part of IEC 62153 ~~applies to metallic communications cables. It~~ specifies a test method for determining the capacitive coupling admittance ~~by the measurement of through capacitance using either a capacitance bridge or by a pulse method~~ 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 60050-726, *International Electrotechnical Vocabulary (IEV) – Part 726: Transmission lines and wave guides*~~

~~IEC 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*~~

~~IEC 62153-4-1, *Metallic communication cable test methods – Part 4-1: Electromagnetic Compatibility (EMC) – Introduction to electromagnetic (EMC) screening measurements*[1]~~

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 ~~given in IEC 60050-726, IEC 61196-1 and IEC 62153-4-1, as well as the following~~ 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.

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~~[1] To be published.~~

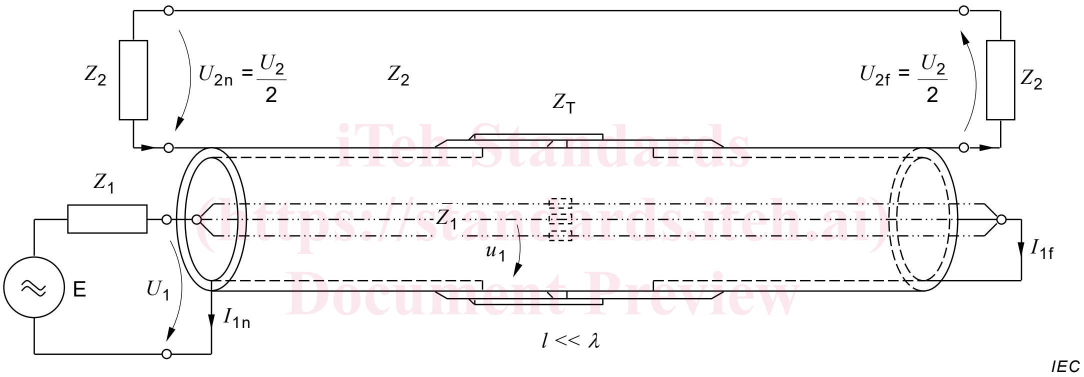
3.1
inner circuit
circuit consisting of the screens and the conductor(s) of the test specimen

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
$\boldsymbol{Z_T}$
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;

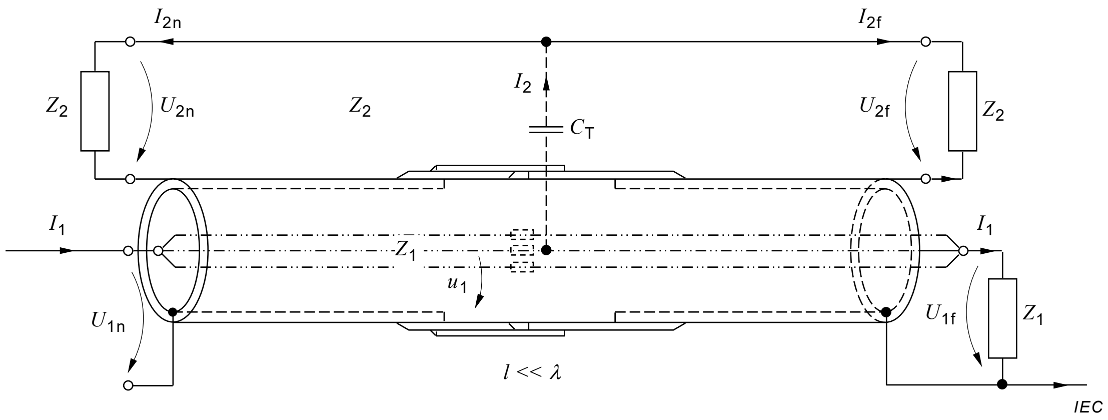
U_2 is the voltage in the inner and the outer circuits (n: near end, f: far end);

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

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

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

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

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

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

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 × 10^8m/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
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

$$Y_C = j\omega C_T \quad (4)$$

~~NOTE 1 Although most cables have negligible capacitive coupling, in the case of a loose single-braided cable, the coupling through the holes in the screen is described in terms of the through capacitance C_T or the capacitive coupling admittance Y_C.~~

~~NOTE 2 For multiconductor cables, the inner conductors are shorted together.~~

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

$$Z_{TE} = \max|Z_F \pm Z_T| \quad (5)$$

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
Z_{TE}
maximum absolute value of the sum or difference of the Z_F and Z_T at every frequency expressed in dB (Ω)

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

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
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

~~**3.2**~~
~~**capacitive or capacitance transfer impedance**~~
~~the capacitive or capacitance transfer impedance is derived as:~~

$$Z_F = j\omega C_T Z_{01} Z_{02}$$

~~where~~

~~Z_{01} is the characteristic impedance of the primary circuit (outer braid or tube and screen of the test sample);~~

~~Z_{02} is the characteristic impedance of the secondary circuit (test sample).~~

~~NOTE For multiconductor cables, the inner conductors are shorted together.~~

~~4 Test equipment~~

~~4.1 General~~

~~The apparatus is of the "triple coaxial" form. The inner conductor(s) of the test sample is shielded at one end by means of a metal disc connected to the screen or by means of a screened termination without its resistor. The test sample is coaxially mounted inside a test jig. The outer conductor of the test jig is either a metal tube or is formed by applying a braid over the sheath of the test sample (or over a further insulating tube if the test sample has no sheath). The tube of braid is open-ended at the side opposite the metal disc.~~

~~4.2 Capacitance bridge method~~

~~The screen of the test sample is connected to the middle of a capacitance bridge, see Figure 1.~~

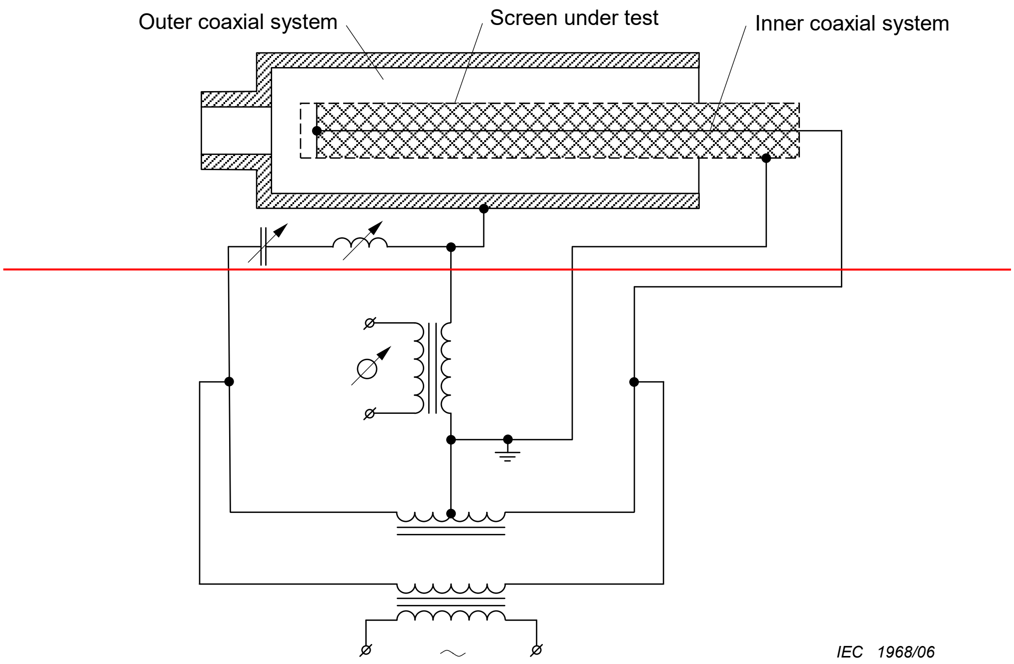


Figure 1 – Layout of the test circuit for the measurement of through capacitance by capacitance bridge method

4.3 Pulse method

The equipment combinations given in Table 1 are suggested to achieve a sensitivity of about 1 division on an oscilloscope screen for a value of C_T equal to 10^{-15} F/m, which is typically equivalent to a resolution of 1 mΩ/m in the derived value of Z_F.

Table 1 – Equipment combinations

Pulse generator		Oscilloscope	
Output pulse	Rise-time	Sensitivity	Bandwidth
10 V	100 ns	100 µV/div	1 MHz
100 V	100 ns	1 µV/div	1 MHz

5 Procedure

5.1 Capacitance bridge method

At a frequency of approximately 1 kHz, the capacitance is measured between the inner conductor(s) of the test sample and the metal tube or outer braid.

5.2 Pulse method

The signal from a pulse generator is fed to the outer coaxial system (exciting circuit) and to one channel of the oscilloscope (V_1) (see Figure 2). The inner conductor(s) of the test sample is connected to the other channel of the oscilloscope (V_2). In order to avoid reflections from connector mismatch, V_2 is recorded as mean pulse height displayed 1 µs to 2 µs after the initiation of the pulse.

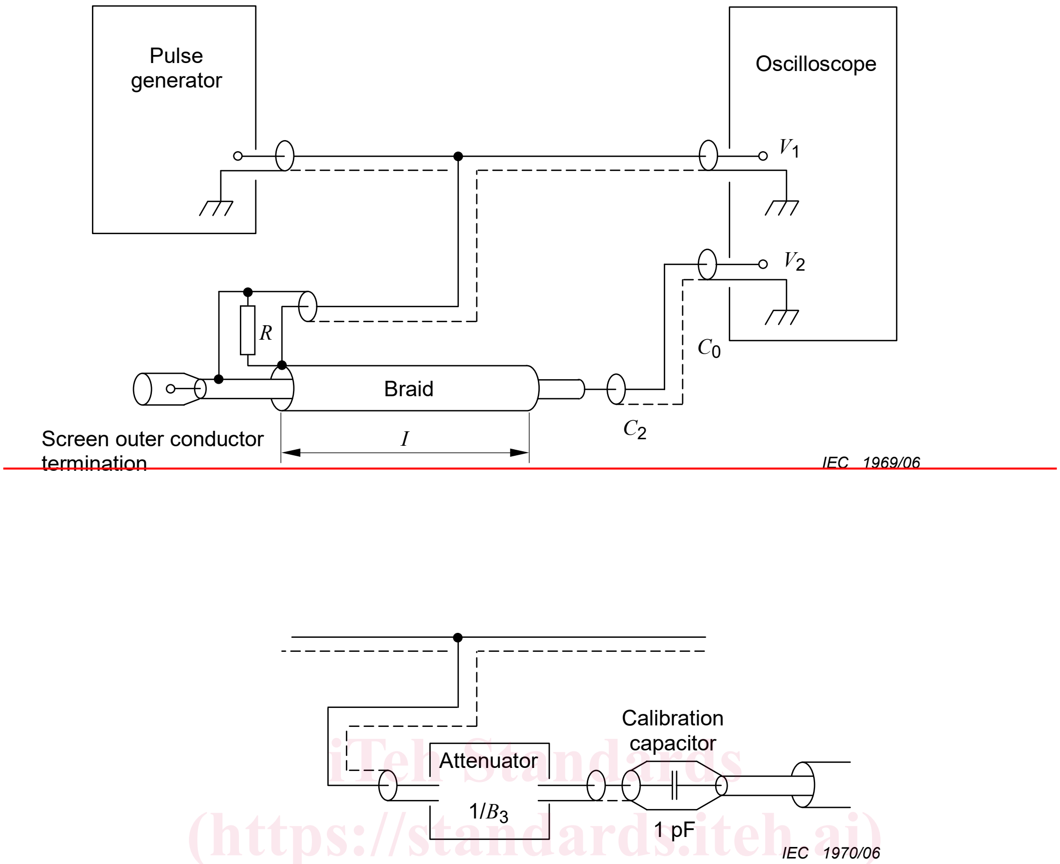


Figure 2 – Layout of test circuit for the measurement of through capacitance by pulse method

6 Measurement precautions

6.1 Capacitance bridge method

The screen under test shall have a length of between 0,5 m and 5 m to ensure that corrections for the connecting cable capacitance and measuring instrument capacitance do not unduly degrade the system accuracy.

6.2 Pulse method

The measuring circuit is not terminated in its characteristic impedance at either end so the overall length should be kept short to allow resonances to die away before the measurement is taken. The cable end is screened to avoid crosstalk from the pulse generator output. The exciting circuit is terminated to limit any resonances to the measuring circuit. The terminating resistance is placed at the drive end to avoid possible error from the surface transfer impedance contributions should any significant current flow in the screen under test.

To determine the sensitivity and calibrate the test equipment, an attenuator and a small calibration capacitor are used. To avoid introducing additional error, calibration can be effected at any level by substituting the calibration capacitor in place of the screened open circuit termination and connecting the pulse generator to it via the attenuator. In this way, the total measuring circuit capacitance is unchanged and the calibration level is C_3/B_3, the attenuator again being $1/B_3$.

If the pulse is correctly terminated before calibration there will be no change in the value of V_1, otherwise there will be a small change in V_1 as shown on the oscilloscope trace when the attenuator is substituted in place of the load resistor R_1.

Crosstalk sensitivity, which may limit the minimum detectable signal, is established by disconnecting at point P_3 and observing the V_2 oscilloscope trace with other settings normal. Care should be taken to screen the open end of the measuring cable, to maintain screen continuity by touching the connector bodies together and to set the pulse generator and the oscilloscope gain for the maximum desired sensitivity.

7 Expression of results

If the bridge method is used, the value of C_T in pF/m is the bridge reading divided by the length of the test sample.

If the pulse method is used the value of the through capacitance C_T is determined from:

$$C_T = (C_2 + C_0 / l) V_2 / V_1$$

where

C_2 is the capacitance of the inner dielectric of the test sample in pF/m;

l is the length of the test sample under the injection braid in m;

C_0 is the stray capacitance in pF/m;

V_1 is the reference pulse voltage;

V_2 is the coupled pulse voltage.

The stray capacitance consists of coupling capacitance, the oscilloscope input capacitance and the additional capacitance of the test sample outside the test length.

The capacitive coupling admittance Y_C in S/m is derived from:

$$Y_C = 2\pi f C_T / l$$

where

C_T is the through capacitance in pF/m;

l is the length of the test sample in m;

f is the frequency in Hz.

8 Determination of the capacitive or capacitance transfer impedance Z_F

The capacitive or capacitance transfer impedance can be readily derived from a measurement of the through capacitance of a braid if the characteristic impedance of the inner and outer coaxial lines are known. Both Z_{01} and Z_{02} can be obtained using the equipment assembled (see Figure 3) as a time domain reflectometer (TDR) so long as the pulse generator rise-time and the oscilloscope response are sufficiently fast.

NOTE For a 1 m test sample, the signal delay (go and return) is about 10 ns. A pulse generator with a rise-time of 4 ns and an oscilloscope with a bandwidth of 100 MHz gives a net rise-time of 5,5 ns which is sensibly shorter than the pulse length from the cable.