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INTERNATIONAL STANDARD

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inside

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

IEC 62153-4-3:2013(E)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method

FOREWORD

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International Standard IEC 62153-4-3 has been prepared by IEC technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

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

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

a) now three different test configurations are described;
b) formulas to calculate the maximum frequency up to which the different test configurations can be used are included (Annex E: Cut-off frequency of the triaxial set-up for the measurement of the transfer impedance);
c) the effect of ground loops is described (Annex F: impact of ground loops on low frequency measurements).

The text of this standard is based on the following documents:

FDIS	Report on voting
46/471/FDIS	46/482/RVD

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

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

A list of all parts in the IEC 62153 series, published under the general title *Metallic communication cable test methods*, can be found on the IEC website.

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.

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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 62153 consists of the following parts, under the general title *Metallic communication cable test methods:*

Part 1-1: *Metallic communication cables test methods – Part 1-1: Electrical – Measurement of the pulse/step return loss in the frequency domain using the Inverse Discrete Fourier Transformation (IDFT)*

Part 1-2: *Metallic communication cables test methods – Part 1-2: Electrical – Reflection measurement correction*[1]

Part 4-0: *Metallic communication cable test methods – Part 4-0: Electromagnetic compatibility (EMC) – Relationship between surface transfer impedance and screening attenuation, recommended limits*

Part 4-1: *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic (EMC) screening measurements*

Part 4-2: *Metallic communication cable test methods – Part 4-2: Electromagnetic compatibility (EMC) – Screening and coupling attenuation – Injection clamp method*

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

Part 4-4*:* *Metallic communication cable test methods – Part 4-4: Electromagnetic compatibility (EMC) – Shielded screening attenuation, test method for measuring of the screening attenuation as up to and above 3 GHz*

Part 4-5: *Metallic communication cables test methods – Part 4-5: Electromagnetic compatibility (EMC) – Coupling or screening attenuation – Absorbing clamp method*

Part 4-6: *Metallic communication cable test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

Part 4-7: *Metallic communication cable test methods – Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring the transfer impedance and the screening – or the coupling attenuation – Tube in tube method*

Part 4-8: *Metallic communication cable test methods – Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance*

Part 4-9: *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

Part 4-10: *Metallic communication cable test methods – Part 4-10: Electromagnetic compatibility (EMC) – Shielded screening attenuation test method for measuring the screening effectiveness of feed-throughs and electromagnetic gaskets double coaxial method*

Part 4-11: *Metallic communication cable test methods – Part 4-11: Electromagnetic compatibility (EMC) – Coupling attenuation or screening attenuation of patch cords, coaxial cable assemblies, pre-connectorized cables – Absorbing clamp method*

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[1] Under consideration.

Part 4-12:	*Metallic communication cable test methods – Part 4-12: Electromagnetic compatibility (EMC) – Coupling attenuation or screening attenuation of connecting hardware – Absorbing clamp method*
Part 4-13:	*Metallic communication cable test methods – Part 4-13: Electromagnetic compatibility (EMC) – Coupling attenuation of links and channels (laboratory conditions) – Absorbing clamp method*
Part 4-14:	*Metallic communication cable test methods – Part 4-14: Electromagnetic compatibility (EMC) – Coupling attenuation of cable assemblies (Field conditions) absorbing clamp method*

METALLIC COMMUNICATION CABLE
TEST METHODS –

Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial method

1 Scope

This part of IEC 62153 determines the screening effectiveness of a cable shield by applying a well-defined current and voltage to the screen of the cable and measuring the induced voltage in order to determine the surface transfer impedance. This test measures only the magnetic component of the transfer impedance.

NOTE The measurement of the electrostatic component (the capacitance coupling impedance) is described in IEC 62153-4-8 [1][2].

The triaxial method of measurement is in general suitable in the frequency range up to 30 MHz for a 1 m sample length and up to 100 MHz for a 0,3 m sample length, which corresponds to an electrical length less than about 1/6 of the wavelength in the sample.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/TR 62153-4-1:2010, *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic (EMC) screening measurements*

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at <http://www.electropedia.org>)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050 as well as the following apply.

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

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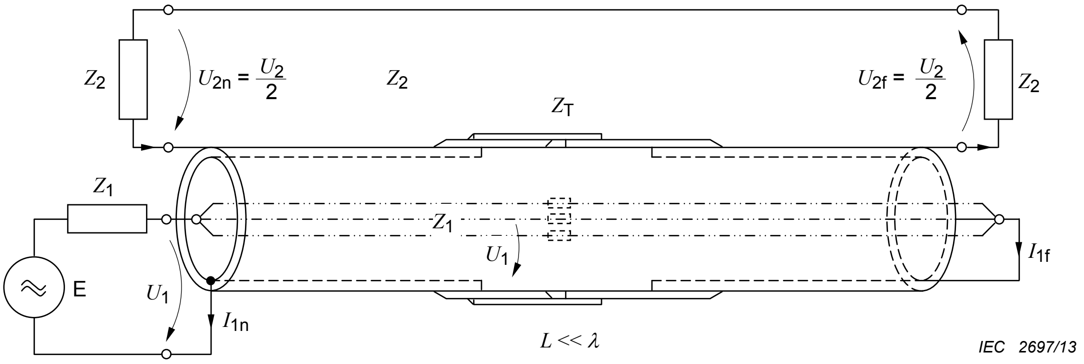
[2] Numbers in square brackets refer to the bibliography.

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)



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

where

Z_1, Z_2	is the characteristic impedance of the inner and the outer circuits;
U_1, U_2	are the voltages 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);
L	is the length of the cable, respectively the length of the screen under test;
λ	is the wavelength in free space.

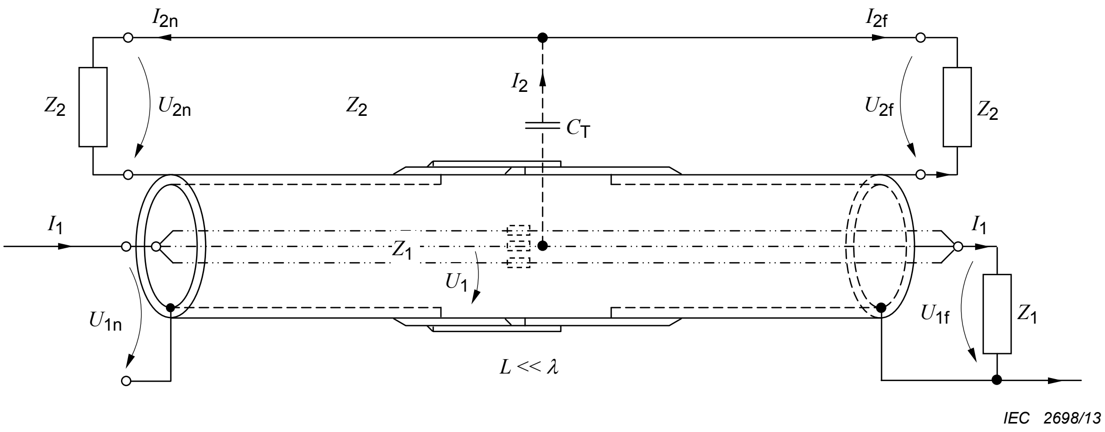
Figure 1 – Definition of Z_T

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)



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

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

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

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

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

where

Z_1, Z_2	is the characteristic impedance of the inner and the outer circuits;
U_1, U_2	are the voltages 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);
I_2	is the current in the outer circuit (n: near end, f: far end);
C_T	is the coupling capacitance;
L	is the length of the cable, respectively the length of the screen under test;
λ	is the wavelength in free space.

Figure 2 – Definition of Z_F

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

3.5
effective transfer impedance
Z_{TE}

3.5.1
effective transfer impedance
Z_{TE}
maximum absolute value of the sum or difference of the Z_F and Z_T at every frequency

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

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

3.5.2
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)

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

where

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

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

3.6
coupling length

L_c

length of cable which is inside the test jig, i.e. the length of the screen under test

Note 1 to entry: The coupling length together with the test method has an impact on the maximum frequency up to which the transfer impedance could be measured. A detailed description can be found in Clause 8 of IEC/TR 62153-4-1:2010.

3.7
cut-off frequency

maximum frequency up to which the transfer impedance can be measured

Note 1 to entry: The cut-off frequency varies with the coupling length and the used test method. A detailed description can be found in Clause 8 of IEC/TR 62153-4-1:2010. The calculation of the cut-off frequency is described in Annex E.

4 Principle

The test determines the screening effectiveness of a shielded cable by applying a well-defined current and voltage to the screen of the cable and measuring the induced voltage in a secondary circuit in order to determine the surface transfer impedance. This test measures only the magnetic component of the transfer impedance. The measurement of the electrostatic component (the capacitance coupling impedance) is described in IEC 62153-4-8.

The triaxial method of measurement is in general suitable in the frequency range up to 30 MHz for a 1 m sample length and up to 100 MHz for a 0,3 m sample length, which corresponds to an electrical length less than 1/6 of the wavelength in the sample. A detailed description can be found in Clause 8 of IEC/TR 62153-4-1:2010.

5 Test methods

5.1 General

The measurements shall be carried out at the temperature of (23 ± 3) °C.

The test method determines the transfer impedance of a cable by measuring the cable in a triaxial test set-up. The triaxial set-up can be realised by a rigid tube or by using a milked on braid. Different methods using different load conditions are possible and are described below. All the different methods give the same results up to their corresponding cut-off frequency.

5.2 Test equipment

The measurements can be performed using a vector network analyser (VNA) or alternatively a separate signal generator and a selective measuring receiver.

The measuring equipment consists of the following:

a) a vector network analyser (with an S-parameter test set); or alternatively

- a signal generator with the same characteristic impedance as the coaxial system of the cable under test or with an impedance adapter and complemented with a power amplifier if necessary for very high screening attenuation;
- a receiver with optional low noise amplifier for very high screening attenuation;
- the generator and receiver shall have the same system impedance:

  $Z_G = Z_R = Z_0$

b) impedance matching circuit if necessary

- primary side: nominal impedance of generator;
- secondary side: nominal impedance of the inner circuit;
- return loss: >10 dB.

Optional equipments are:

1) time domain reflectometer (TDR) with a rise time of less than 200 ps or a network analyser with maximum frequency up to 5 GHz and time domain capability;
2) plotter.

5.3 Calibration procedure

The calibration shall be established at the same frequency points at which the measurement of the transfer impedance is done, i.e. in a logarithmic frequency sweep over the whole frequency range, which is specified for the transfer impedance.

When using a vector network analyser with an S-parameter test set, a full two-port calibration shall be established including the connecting cables used to connect the test set-up to the test equipment. The reference planes for the calibration are the connector interface of the connecting cables.

When using a (vector) network analyser without an S-parameter test set, i.e. by using a power splitter, a THRU calibration shall be established including the connecting cables used to connect the test set-up to the test equipment.

When using a separate signal generator and receiver, the composite loss of the connecting cables shall be measured and the calibration data shall be saved, so that the results may be corrected.

$$a_{\mathrm{cal}} = 10\log_{10}\left(\frac{P_1}{P_2}\right) = -20\log_{10}\left(S_{21}\right) \qquad (1)$$

where

P_1 is the power fed during the calibration procedure;

P_2 is the power at the receiver during the calibration procedure.

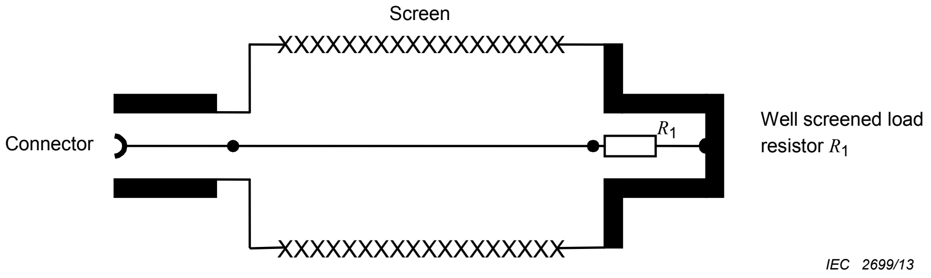
If amplifiers are used, their gain shall be measured over the above-mentioned frequency range and the data shall be saved.

If an impedance matching adapter is used, the attenuation shall be measured over the above-mentioned frequency range and the data shall be saved (see Annex B).

5.4 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.



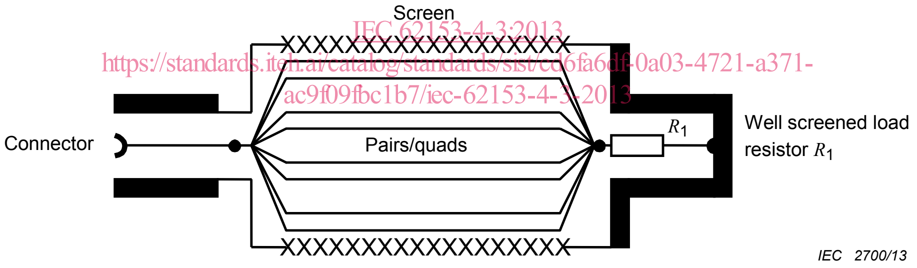
IEC 2699/13

Figure 3 – Preparation of test sample for coaxial cables

One end of the coaxial cable is loaded with a well-screened resistor, R_1. The value of R_1 depends on the test method used (as detailed below), i.e. either a short circuit or equal to the characteristic impedance of the inner circuit, Z_1, or equal to the generator impedance. R_1 is chosen as a standard value resistor, whose resistance is close (within 10 %) to Z_1.

The other end is prepared with a connector to make a connection to the generator or the impedance matching adapter (depending on the used method). All connections shall be made so that the R.F.-contact resistance can be neglected with respect to the results.

Screened symmetrical cables are treated as a quasi-coaxial system. Therefore, the conductors of all pairs/quads shall be connected together at both ends (other configurations of connection are under study). All screens, including those of individually screened pairs/quads, shall be connected over the whole circumference. See also Figure 4.



IEC 2700/13

Figure 4 – Preparation of test sample for symmetrical cables

5.5 Test set-up

The test sample shall be fitted to the test set-up. The test set-up is an apparatus of a triple coaxial form. The cable screen forms both the outer conductor of the inner circuit and the inner conductor of the outer circuit.

In the rigid set-up, the outer conductor of the outer circuit is a well-conductive tube of non-ferromagnetic metal (for example brass, copper or aluminium) with a short circuit to the screen on the fed side of the cable (see Figure 5).

In the flexible set-up, the outer conductor of the outer circuit is a tinned copper braid having a coverage >70 % and braid angle <30° which is pulled over the entire length of the cable under test (see Annex C).