IEC 62153-4-7

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INTERNATIONAL STANDARD

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colour inside

**Metallic communication cable test methods –
Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_s or coupling attenuation a_C of connectors and assemblies up to and above 3 GHz – Triaxial tube in tube method**

**Méthodes d'essai des câbles métalliques de communication –
Partie 4-7: Compatibilité électromagnétique (CEM) – Méthode d'essai pour mesurer l'impédance de transfert Z_T et l'affaiblissement d'écrantage a_s ou l'affaiblissement de couplage a_C des connecteurs et des cordons jusqu'à 3 GHz et au-dessus – Méthode triaxiale en tubes concentriques**

IEC 62153-4-7:2015-12(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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International Standard IEC 62153-4-7 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:

The document is revised and updated. The changes of the revised IEC 62153-4-3:2013, and IEC 62153-4-4:2015, are included.

Measurements can be achieved now with mismatch at the generator site, impedance matching devices are not necessary.

This bilingual version (2016-03) corresponds to the monolingual English version, published in 2015-12.

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

FDIS	Report on voting
46/572/FDIS	46/585/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.

The French version of this standard has not been voted upon.

This publication 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 communication cable test methods*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

The contents of the corrigendum of April 2016 have been included in this copy.

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

The shielded screening attenuation test set-up according to IEC 62153-4-3 and IEC 62153-4-4 have been extended to take into account the particularities of electrically short elements like connectors and cable assemblies. Due to the concentric outer tube of the triaxial set-up, measurements are independent of irregularities on the circumference and outer electromagnetic fields.

With the use of an additional resonator tube (inner tube respectively tube in tube), a system is created where the screening effectiveness of an electrically short device is measured in realistic and controlled conditions. Also a lower cut off frequency for the transition between electrically short (transfer impedance Z_T) and electrically long (screening attenuation a_S) can be achieved.

A wide dynamic and frequency range can be applied to test even super screened connectors and assemblies with normal instrumentation from low frequencies up to the limit of defined transversal waves in the outer circuit at approximately 4 GHz.

METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring of transfer impedance Z_T and screening attenuation a_s or coupling attenuation a_C of connectors and assemblies up to and above 3 GHz – Triaxial tube in tube method

1 Scope

This triaxial method is suitable to determine the surface transfer impedance and/or screening attenuation and coupling attenuation of mated screened connectors (including the connection between cable and connector) and cable assemblies. This method could also be extended to determine the transfer impedance, coupling or screening attenuation of balanced or multipin connectors and multicore cable assemblies. For the measurement of transfer impedance and screening- or coupling attenuation, only one test set-up is needed.

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

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

IEC 62153-4-4, *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*

IEC 62153-4-15, *Metallic communication cable test methods – Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with Triaxial Cell*

3 Terms and definitions

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

3.1
surface transfer impedance
Z_T
for an electrically short screen, quotient of the longitudinal voltage U_1 induced to the inner circuit by the current I_2 fed into the outer circuit or vice versa, see figure 1

Note 1 to entry: The surface transfer impedance is expressed in ohms.

Note 2 to entry: The value Z_T of an electrically short screen is expressed in ohms [Ω] or decibels in relation to 1 Ω.

Note 3 to entry: See Figure 1.

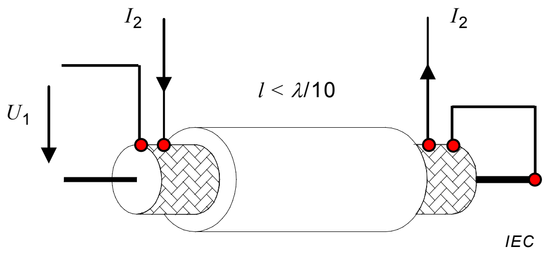

Figure 1 – Definition of Z_T

$$Z_T = \frac{U_1}{I_2} \tag{1}$$

$$Z_T \ \mathrm{dB}(\Omega) = +20 \times \log_{10}\left(\frac{|Z_T|}{1\,\Omega}\right) \tag{2}$$

3.2
effective transfer impedance
***Z*TE**
effective transfer impedance, defined as:

$$Z_{TE} = \max|Z_F \pm Z_T| \tag{3}$$

where

Z_F is the capacitive coupling impedance.

3.3
screening attenuation
***a*s**
for electrically long devices, i.e. above the cut-off frequency, logarithmic ratio of the feeding power P_1 and the periodic maximum values of the coupled power $P_{r,max}$ in the outer circuit

$$a_s = -10\log_{10}\left(\mathrm{Env}\left|\frac{P_{r,max}}{P_1}\right|\right) \tag{4}$$

where

Env is the minimum envelope curve of the measured values in dB

Note 1 to entry: The screening attenuation of an electrically short device is defined as:

$$a_s = -20\log_{10}\frac{150\,\Omega}{Z_{TE}} \tag{5}$$

where

150 Ω is the standardized impedance of the outer circuit.

3.4
coupling attenuation
***a*C**
for a screened balanced device, the sum of the unbalance attenuation a_U of the symmetric pair and the screening attenuation a_S of the screen of the device under test

Note 1 to entry: For electrically long devices, i.e. above the cut-off frequency, the coupling attenuation a_C is defined as the logarithmic ratio of the feeding power P_1 and the periodic maximum values of the coupled power $P_{r,max}$ in the outer circuit.

3.5
coupling length
length of cable inside the test jig between the end of the extension tube and the screening cap (see Figure 2)

Note 1 to entry: the coupling length is electrically short, if

$$\lambda_o / l > 10 \cdot \sqrt{\varepsilon_{r1}} \text{ or } f < \frac{c_o}{10 \cdot l \cdot \sqrt{\varepsilon_{r1}}} \quad (6)$$

or electrically long, if

$$\lambda_o / l \leq 2 \cdot \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right| \text{ or } f > \frac{C_o}{2 \cdot l \cdot \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right|} \quad (7)$$

where

l is the effective coupling length in m;

λ_o is the free space wave length in m;

ε_{r1} is the resulting relative permittivity of the dielectric of the cable;

ε_{r2} is the resulting relative permittivity of the dielectric of the secondary circuit;

f is the frequency in Hz;

c_o is the velocity of light in free space.

3.6
device under test
device consisting of the mated connectors with their attached cables

4 Physical background

See respective clauses of IEC TS 62153-4-1, IEC 62153-4-3, IEC 62153-4-4 and Annexes C and D.

5 Principle of the test methods

5.1 General

The IEC 62153-4-x series describes different test procedures to measure screening effectiveness on communication cables, connectors and components with triaxial test set-up.

Table 1 gives an overview about IEC 62153-4-x test procedures with triaxial test set-up.

Table 1 – IEC 62153, Metallic communication cable test methods – Test procedures with triaxial test set-up

	Metallic Communication Cable test methods – Electromagnetic compatibility (EMC)
IEC TR 62153-4-1 Ed.3	Introduction to electromagnetic (EMC) screening measurements
IEC 62153-4-3 Ed.2	Surface transfer impedance – Triaxial method
IEC 62153-4-4Ed.2	Shielded screening attenuation, test method for measuring of the screening attenuation a_S up to and above 3 GHz
IEC 62153-4-7	Shielded screening attenuation test method for measuring the transfer impedance Z_T and the screening attenuation a_S or the coupling attenuation a_C of RF-connectors and assemblies up to and above 3 GHz, tube in tube method
IEC 62153-4-9	Coupling attenuation of screened balanced cables, triaxial method
IEC 62153-4-10	Shielded screening attenuation test method for measuring the screening effectiveness of feedtroughs and electromagnetic gaskets double coaxial method
IEC 62153-4-15	Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell (under consideration)
IEC 62153-4-16	Technical report on the relationship between transfer impedance and screening attenuation (under consideration)

Usually RF connectors have mechanical dimensions in the longitudinal axis in the range of 20 mm to maximum 50 mm. With the definition of electrical short elements we get cut off or corner frequencies for the transition between electrically short and long elements of about 1 GHz or higher for usual RF-connectors.

To measure the screening attenuation instead of transfer impedance also in the lower frequency range, the tube in tube procedure was designed. The electrically length of the RF-connector is extended by a RF-tightly closed metallic extension tube (tube in tube). See Figure 2.

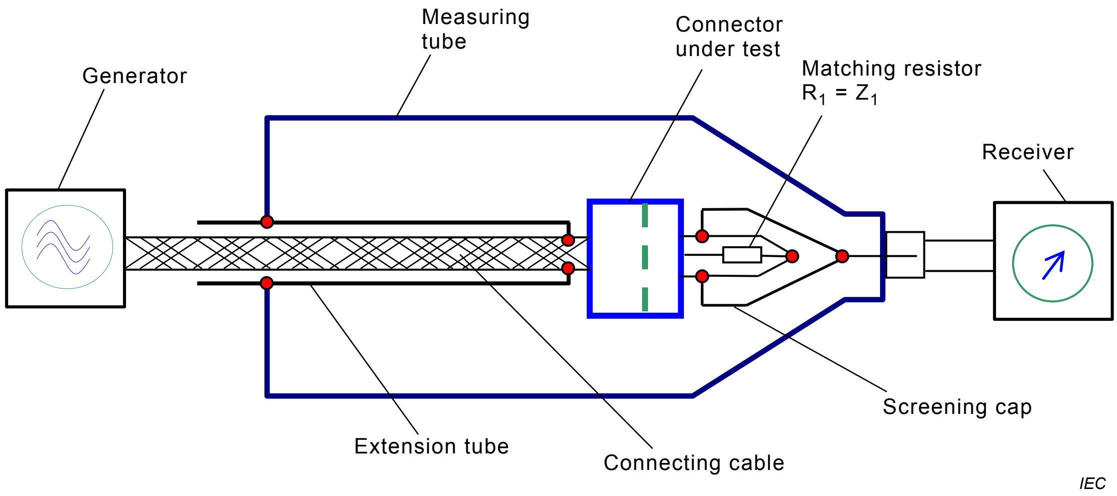

Figure 2 – Principle of the test set-up to measure transfer impedance and screening or coupling attenuation of connectors with tube in tube

The tube in tube test set up is based on the triaxial system according to IEC 62153-4-3 and IEC 62153-4-4 consisting of the DUT, a solid metallic tube and (optional) a RF-tight extension tube. The matched device under test, DUT, which is fed by a generator, forms the disturbing circuit which may also be designated as the inner or the primary circuit. The connecting cables to the DUT are additionally screened by the tube in tube.

The disturbed circuit, which may also be designated as the outer or the second circuit, is formed by the outer conductor of the device under test (and the extension tube), connected to the connecting cable and a solid metallic tube, having the DUT under test in its axis.

5.2 Transfer impedance

The test determines the screening effectiveness of a shielded cable by applying a well-defined current and voltage to the screen of the cable, the assembly or the device under test and measuring the induced voltage in secondary circuit in order to determine the surface transfer impedance. This test measures only the magnetic component of the transfer impedance. To measure the electrostatic component (the capacitance coupling impedance), the method described in IEC 62153-4-8 should be used.

The triaxial method of the measurement is in general suitable in the frequency range up to 30 MHz for a 1 m sample length and 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 is found in Clause 9 of IEC TS 62153-4-1:2014 as well as in IEC 62153-4-3.

5.3 Screening attenuation

The disturbing or primary circuit is the matched cable, assembly or device under test. The disturbed or secondary circuit consists of the outer conductor (or the outermost layer in the case of multiscreen cables or devices) of the cable or the assembly or the device under test and a solid metallic housing, having the device under test in its axis (see Figure 3).

The voltage peaks at the far end of the secondary circuit have to be measured. The near end of the secondary circuit is short-circuited. For this measurement, a matched receiver is not necessary. The expected voltage peaks at the far end are not dependent on the input impedance of the receiver, provided that it is lower than the characteristic impedance of the secondary circuit. However, it is an advantage to have a low mismatch, for example, by selecting of housings of sufficient size. A detailed description could be found in Clause 10 of IEC TS 62153-4-1:2014 as well as in IEC 62153-4-4.

5.4 Coupling attenuation

Balanced cables, connectors, assemblies or devices which are driven in the differential mode may radiate a small part of the input power, due to irregularities in the symmetry. For unscreened balanced cables, connectors, assemblies or devices, this radiation is related to the unbalance attenuation a_u. For screened balanced cables, connectors or assemblies, the unbalance causes a current in the screen which is then coupled by the transfer impedance and capacitive coupling impedance into the outer circuit. The radiation is attenuated by the screen of the component and is related to the screening attenuation a_s.

Consequently the effectiveness against electromagnetic disturbances of shielded balanced cables, connectors or assemblies is the sum of the unbalance attenuation a_u of the pair and the screening attenuation a_s of the screen. Since both quantities usually are given in a logarithmic ratio, they may simply be added to form the coupling attenuation a_c:

$$a_c = a_u + a_s \tag{8}$$

Coupling attenuation a_c is determined from the logarithmic ratio of the feeding power P_1 and the periodic maximum values of the power $P_{r,max}$ (which may be radiated due to the peaks of voltage U_2 in the outer circuit):

$$a_c = -10 \log_{10}\left(\text{Env}\left|\frac{P_{r,max}}{P_1}\right|\right) \tag{9}$$

where

Env is the minimum envelope curve of the measured values in dB.

The relationship of the radiated power P_r to the measured power P_2 received on the input impedance R is:

$$\frac{P_s}{P_2} = \frac{P_{S\,max}}{P_{2\,max}} = \frac{R}{2 \cdot Z_s} \tag{10}$$

There will be a variation of the voltage U_2 on the far end, caused by the electromagnetic coupling through the screen and superposition of the partial waves caused by the surface transfer impedance Z_T ,the capacitive coupling impedance Z_F (travelling to the far and near end) and the totally reflected waves from the near end.

To feed the balanced device under test, a differential mode signal is necessary. This can be achieved with a two-port network analyser (generator and receiver) and a balun or a multiport network analyser. The procedure to measure coupling attenuation with a multiport network analyser is under consideration.

6 Test procedure

6.1 General

The measurements shall be carried out at the temperature of (23 ± 3) °C. The test method determines the transfer impedance or the screening attenuation or the coupling attenuation of a DUT by measuring in a triaxial test set-up according to IEC 62153-4-3 and IEC 62153-4-4.

6.2 Tube in tube procedure

Usually RF connectors have mechanical dimensions in the longitudinal axis in the range of 20 mm to maximum 50 mm. With the definition of electrically short elements, we get cut off or corner frequencies or corner for the transition between electrically short and long elements of about 1 GHz or higher for usual RF-connectors.

In the frequency range up to the cut off frequency, where the device under test (DUT) is electrically short, the transfer impedance of the DUT can be measured. For frequencies above the cut-off frequency, where the DUT is electrically long, the screening attenuation can be measured.

By extending the electrically length of the RF-connector by a RF-tightly closed metallic extension tube (tube in tube), the tested combination becomes electrically long and the cut-off frequency is moved towards the lower frequency range. In this way, also in the lower frequency range, the screening attenuation may be measured and the effective transfer impedance of electrical short devices calculated.

The test set up is a triaxial system consisting of the DUT, a solid metallic tube and a RF-tight extension tube. The matched device under test, DUT, which is fed by a generator forms the disturbing circuit which may also be designated as the inner or the primary circuit.

The disturbed circuit, which may also be designated as the outer or the second circuit, is formed by the outer conductor of the device under test, connected to the extension tube and a solid metallic tube having the DUT under test in its axis.

The principle of the test set-up is shown in Figure 2 and Figure 3. The set-up is the same for measuring the transfer impedance and the screening- or the coupling attenuation, whereas the length of the inner and the outer tube may vary.