IEC 62153-4-15

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INTERNATIONAL STANDARD

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colour inside

**Metallic cables and other passive components test methods –
Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell**

**Méthodes d'essais des câbles métalliques et autres composants passifs –
Partie 4-15: Compatibilité électromagnétique (CEM) – Méthode d'essai pour le mesurage de l'impédance de transfert et de l'affaiblissement d'écran – ou de l'affaiblissement de couplage avec cellule triaxiale**

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Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell

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International Standard IEC 62153-4-15 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 2015. This edition constitutes a technical revision.

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

a) measurement of coupling attenuation of balanced connectors, assemblies and components with balun and balunless added;
b) application of a test adapter was added;
c) application of a moveable shorting plane;

d) application of the triaxial "absorber" cell;

e) correction of test results in the case that the receiver input impedance R is higher than the characteristic impedance of the outer circuit Z_2.

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

FDIS	Report on voting
46/814/FDIS	46/822/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all the parts in the IEC 62153-4 series, published under the general title *Metallic communication cable test methods – Electromagnetic compatibility (EMC),* 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
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METALLIC CABLES AND OTHER PASSIVE COMPONENTS TEST METHODS –

Part 4-15: Electromagnetic compatibility (EMC) – Test method for measuring transfer impedance and screening attenuation – or coupling attenuation with triaxial cell

1 Scope

This part of IEC 62153 specifies the procedures for measuring with triaxial cell the transfer impedance, screening attenuation or the coupling attenuation of connectors, cable assemblies and components, for example accessories for analogue and digital transmission systems, and equipment for communication networks and cabling.

Measurements can be achieved by applying the device under test directly to the triaxial cell or with the tube-in-tube method in accordance with IEC 62153-4-7.

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

IEC TS 62153-4-1:2014, *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 62153-4-4:2015, *Metallic communication cable test methods – Part 4-4: Electromagnetic compatibility (EMC) – Test method for measuring of the screening attenuation a_S up to and above 3 GHz, triaxial method*

IEC 62153-4-7, *Metallic communication cable test methods – Part 4-7: Electromagnetic compatibility (EMC) – Test method for measuring the transfer impedance Z_T and the screening attenuation a_s or coupling attenuation a_c of connectors and assemblies up to and above 3 GHz – Triaxial Tube in tube method*

IEC 62153-4-8, *Metallic cables and other passive components – Test methods – Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance*

IEC 62153-4-9:2018, *Metallic communication cable test methods – Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method*

IEC 62153-4-10, *Metallic communication cable test methods – Part 4-10: Electromagnetic compatibility (EMC) – Transfer impedance and screening attenuation of feed-throughs and electromagnetic gaskets – Double coaxial test method*

IEC 62153-4-16, *Metallic communication cable test methods – Part 4-16: Electromagnetic compatibility (EMC) – Extension of the frequency range to higher frequencies for transfer impedance and to lower frequencies for screening attenuation measurements using the triaxial set-up*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61196-1 and the following apply.

3.1
triaxial cell
rectangular housing in analogy to the principles of the triaxial test procedure, consisting of a non-ferromagnetic metallic material

Note 1 to entry: The triaxial test procedure is described in IEC 62153-4-3 and IEC 62153-4-4.

3.2
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 [Ω] (see Figure 1)

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

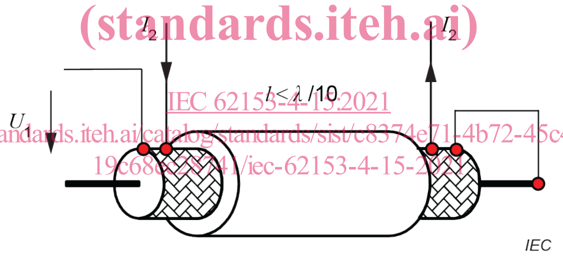

Figure 1 – Definition of Z_T

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

$$Z_T \ \text{dB}(\Omega) = 20 \cdot \lg\left(\frac{|Z_T|}{1\Omega}\right) \tag{2}$$

3.3
effective transfer impedance
Z_{TE}
impedance defined as:

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

where Z_F is the capacitive coupling impedance

3.4
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

$$a_s = 10 \cdot \lg\left(\text{Env}\left|\frac{P_1}{P_{r,max}}\right|\right) \tag{4}$$

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

$$a_s = 20 \cdot \lg \frac{150\Omega}{Z_{TE}} \tag{5}$$

where

150 Ω is the standardised impedance of the outer circuit.

3.5
coupling attenuation
a_c
for a screened balanced device, 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.

3.6
coupling length
length of cable that is inside the test jig, i.e. the length of the screen under test

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

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

or electrically long, if

$$\lambda_o / L \leq 2 \cdot \left|\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}\right| \quad \text{or} \quad f > \frac{c_o}{2 \cdot L \cdot \left|\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}\right|} \tag{7}$$

where

L is the effective coupling length, in m;

λ_0 is the free space wavelength, 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_0 is the velocity of light in free space, in m/s.

3.7
device under test
DUT
connector with mating connector and attached connecting cables or cable assembly consisting of the assembly with their attached mated connectors and with connecting cables

4 Physical background

See IEC TS 62153-4-1, IEC 62153-4-3, IEC 62153-4-4, and Annex A to Annex F.

5 Principle of the test methods

5.1 General

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

Table 1 gives an overview of the test procedures of the IEC 62153-4 series carried out with the triaxial test setup.

Table 1 – IEC 62153-4 series, Metallic communication cable test methods – Test procedures with triaxial test setup

IEC 62153-4 series	Metallic communication cable test methods – Electromagnetic compatibility (EMC)
IEC TS 62153-4-1	Introduction to electromagnetic screening measurements
IEC 62153-4-3	Surface transfer impedance – Triaxial method
IEC 62153-4-4	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
IEC 62153-4-16	Extension of the frequency range to higher frequencies for transfer impedance and to lower frequencies for screening attenuation measurements using the triaxial setup

Larger connectors, cable assemblies, and components do not fit into the commercially available test rigs (tubes) of the triaxial test procedures of IEC 62153-4-3, IEC 62153-4-4, and IEC 62153-4-7, respectively, which were designed originally to measure transfer impedance and screening attenuation on communication cables, connectors, and assemblies.

Since rectangular housings with RF-tight caps are easier to manufacture than tubes, the "triaxial cell" was designed to test larger devices, such as connectors, assemblies and components. The principles of the triaxial test procedures in accordance with IEC 62153-4-3, IEC 62153-4-4 and IEC 62153-4-7 can be transferred to rectangular housings. Tubes and rectangular housings may be operated in combination in one test setup (see Figure 2 and Figure 3).

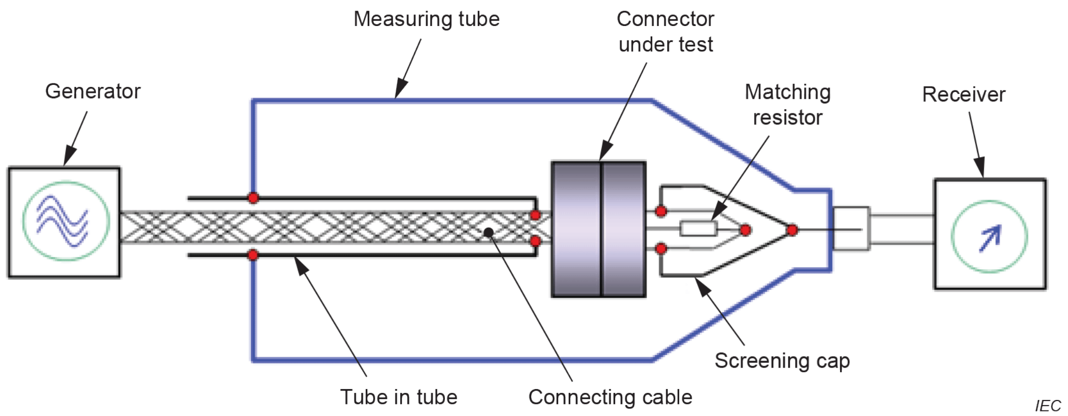

Figure 2 – Principle depiction of the triaxial test setup (tube) to measure transfer impedance and screening attenuation with tube in tube in accordance with IEC 62153-4-7

In principle, the triaxial cell can be used in accordance with all triaxial procedures of Table 1, where originally a cylindrical tube is used. The screening effectiveness of connectors, assemblies or other components can be measured, in principle, in the tube as well as in the triaxial cell. Test results of measurements with tubes and with triaxial cells correspond well.

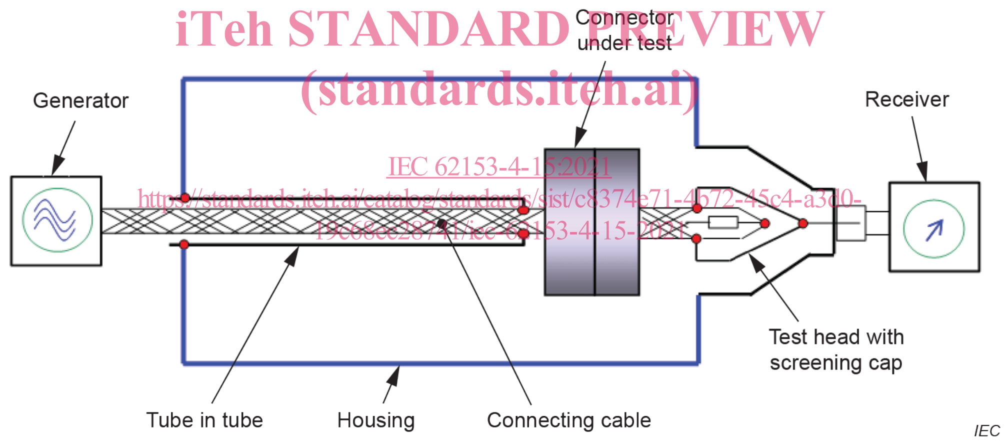

Figure 3 – Principle depiction of the triaxial cell to measure transfer impedance and screening attenuation of connectors or assemblies with tube in tube in accordance with IEC 62153-4-7

The triaxial cell test setup is based on the triaxial system in accordance with IEC 62153-4-3 and IEC 62153-4-4, consisting of the DUT, a solid metallic housing and an RF-tight extension tube (optional). The matched device under test (DUT), which is fed by a generator via a connecting cable, 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 connecting cable (or the tube in tube, if applicable) and a solid metallic housing or cell having the DUT in its axis.

5.2 Transfer impedance

The test determines the screening effectiveness of a shielded device 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 the secondary circuit in order to determine the surface transfer impedance. This test measures only the galvanic and magnetic components of the transfer impedance. To measure the electrostatic component (the capacitance coupling impedance), the method described in IEC 62153-4-8 shall be used.

The triaxial method for the measurement of the transfer impedance 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 can be 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 component 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 housings of an appropriate size. A detailed description can be found in Clause 10 of IEC TS 62153-4-1:2014, as well as in IEC 62153-4-4.

5.4 Coupling attenuation

The coupling attenuation of screened balanced pairs describes the global effect against electromagnetic interference (EMI) and takes into account the screening attenuation of the screen and the unbalance attenuation of the pair. A detailed description of coupling attenuation can be found in IEC 62153-4-9.

5.5 Tube-in-tube method

If required, measurements in accordance with IEC 62153-4-7 can also be achieved in the triaxial cell, using the triaxial cell instead of the tube fixture (see Figure 2 and Figure 3).

6 Test procedures

6.1 General

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

6.2 Triaxial cell

The triaxial cell consists of a rectangular housing in analogy to the principles of the triaxial test procedures in accordance with IEC 62153-4-3 and IEC 62153-4-4. The material of the housing shall be of non-ferromagnetic metallic material. The length of the housing should be preferably 1 m.

Reflections of the transmitted signal can occur (in the outer circuit) owing to the deviation of the characteristic impedances. The plane of the short circuit at the near end (generator side) should be therefore preferably directly on the wall of the housing.

At the receiver side, the transition of the housing to the coaxial system impedance (50 Ω-system) should be also directly on the wall of the housing.

6.3 Cut-off frequencies, higher-order modes

The triaxial test procedure uses the principle of transverse electromagnetic wave propagation (TEM – waves). At higher frequencies, the triaxial cell becomes in principle a cavity resonator, or a rectangular waveguide, which exhibits resonances depending on its dimensions; see Figure 4.

Above these resonance frequencies, propagation of TEM waves is disturbed and measurements of screening attenuation with triaxial test method are limited.

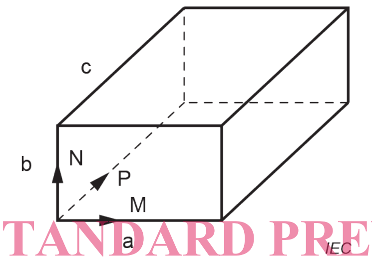

Figure 4 – Rectangular waveguide

The cut-off frequency f_c of a rectangular cavity resonator is given by:

$$f_c = \frac{c_0}{2a} \tag{8}$$

For a rectangular cavity resonator, the resonance frequencies can be calculated using Equation (9). For this calculation, one of the parameters M, N, P can be set to zero.

$$f_{MNP} = \frac{c_0}{2}\sqrt{\left(\frac{M}{a}\right)^2 + \left(\frac{N}{b}\right)^2 + \left(\frac{P}{c}\right)^2} \tag{9}$$

where

M, N are the number of modes (even, 2 of 3 > 0);

a,b,c are the dimensions of the cavity;

c_0 is the velocity of light in free space.

NOTE Conductive parts inside the cavity resonator or a poor centring of the DUT in the triaxial cell can lead to deviating resonance frequencies or to muting them.

Measurements of screening attenuation can be achieved up to the first cut-off frequency (M, N = 1).

The frequency range of the triaxial cell can be extended up to and above 3 GHz by using absorber material placed on the bottom of the cell, see Annex C.