IEC 62153-4-10

Edition 2.0 2015-11

INTERNATIONAL STANDARD

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colour inside

**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**

**Méthodes d'essai des câbles métalliques de communication –
Partie 4-10: Compatibilité électromagnétique (CEM) – Impédance de transfert et affaiblissement d'écran des traversées et des joints d'étanchéité électromagnétiques – Méthode d'essai coaxiale double**

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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

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International Standard IEC 62153-4-10 has been prepared by IEC technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

This bilingual version (2020-01) corresponds to the monolingual English version, published in 2015-11.

This second edition cancels and replaces the first edition published in 2009. It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- addition of a new clause that describes a procedure for verification of the measurement set-up and further information regarding sample preparation;
- addition of a new Annex that describes how to improve measurement certainty in the very low frequency area.

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

FDIS	Report on voting
46/563/FDIS	46/580/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

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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

1 Scope

This part of IEC 62153 details a coaxial method suitable for determining the transfer impedance and/or screening attenuation of feed-throughs and electromagnetic gaskets.

The shielded screening attenuation test set-up according to IEC 62153-4-4 (triaxial method) has been modified to take into account the particularities of feed-throughs and gaskets.

A wide dynamic and frequency range can be applied to test even super screened feed-throughs and gaskets with normal instrumentation from low frequencies up to the limit of defined transversal waves in the coaxial circuits at approximately 4 GHz.

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.

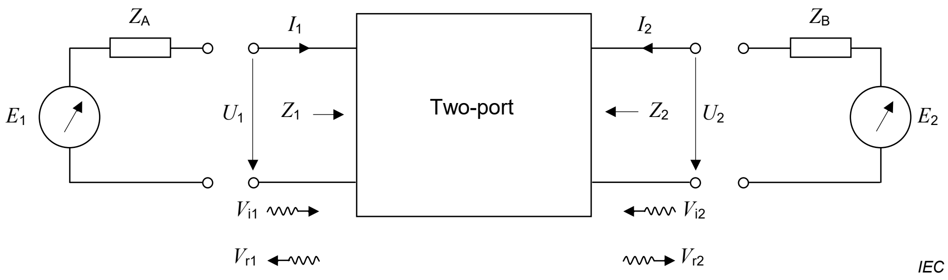
Void.

3 Terms and definitions

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

3.1
operational (Betriebs) transfer function in the forward direction H_{B21}
operational (Betriebs) scattering parameter S_{21}
quotient of the reflected square root of power wave fed into the reference impedance of the output of the two-port and the unreflected square root of the power wave consumed at the input of the two-port

EXAMPLE (see Figure 1)



Key

E_1, E_2	network analyzer at input, output respectively	V_{i1}, V_{i2}	incident square root of complex power waves (see note) at input and output, respectively
Z_A, Z_B	reference impedance at input and output respectively	V_{r1}, V_{r2}	reflected square root of complex power waves (see note) at input and output, respectively
I_1, I_2	current at input and output, respectively	Z_1, Z_2	impedance at input and output, respectively
U_1, U_2	voltage at input and output, respectively		

Figure 1 – A two-port

Note 1 to entry: Complex power is the product $U \cdot I$. Apparent power is the product $U \cdot I^*$, which is used in electrical power technique, where the angle between the voltage and current is of interest. I^* Is the complex conjugate of the current I.

S_{21} or H_{B21} is the operational (Betriebs) transfer function in the forward direction defined as follows:

$$S_{21} = \left.\frac{V_{r2}}{V_{i1}}\right|_{V_{i2}=0} = \frac{2U_2}{E_1}\sqrt{\frac{Z_A}{Z_B}} = H_{B21}$$

See Annex C of IEC TR 62152:2009.

3.2
transfer impedance
equivalent circuit of the measurement of a feed-through or gasket, shunt impedance Z_T between the primary and secondary circuit

EXAMPLE The transfer impedance of an electrically short screen is defined as the quotient of the open circuit voltage U_2 induced to the secondary circuit by the current I_1 fed into the primary circuit or vice versa. See Figure 2.

Z_T of an electrically short screen is expressed in Ω or decibels in relation to 1 Ω.

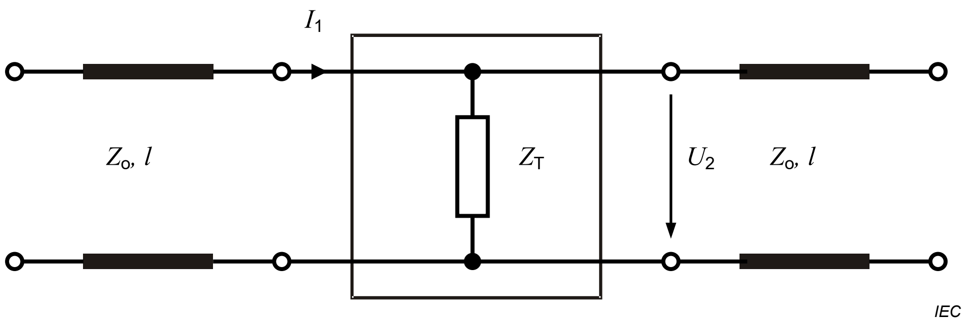


Figure 2 – Equivalent circuit of the test set-up and definition of Z_T

$$Z_T = \frac{U_2}{I_1} \qquad (1)$$

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

3.3
operational (Betriebs) attenuation
the quotient of the unreflected square root of power wave fed into the reference impedance of the input of the two-port and the square root of the power wave consumed by the load of the two-port expressed in dB and radians

Note 1 to entry: See IEC TR 62152.

3.4
screening attenuation
a_s
logarithmic ratio of the incident (unreflected) square root of power wave fed into the nominal impedance of the primary circuit of the test set-up and the periodic maximum values of the square root of power wave $V_{r2,\,max}$ coupled into the secondary circuit of the test set-up when its characteristic impedance Z_o is normalized to 150 Ω

EXAMPLE

$$\begin{aligned} a_s &= -20 \times \log_{10}\left(\mathrm{Env}\left|\frac{V_{r2,max}}{V_{i1}}\right|\right) + 20 \times \log_{10}\left|\frac{\sqrt{150\ \Omega}}{\sqrt{Z_o}}\right| = \\ &= 20 \times \log_{10}\left|\frac{1}{\mathrm{Env}(S_{21,max})}\right| + 20 \times \log_{10}\left|\frac{\sqrt{150\ \Omega}}{\sqrt{Z_o}}\right| = \\ &= \mathrm{Min.\ Env}\ (A_{B21}) + 20 \times \log_{10}\left|\frac{\sqrt{150\ \Omega}}{\sqrt{Z_o}}\right| \end{aligned} \tag{3}$$

where

a_s	is the screening attenuation expressed in dB;
Env (A_{B21})	is the operational attenuation recorded as the envelope curve of the measured values in dB (See 7.1);
Min.Env (A_{B21})	is the operational attenuation recorded as the minimum envelope curve of the measured values in dB (See 7.1);
150 Ω	is the standardized impedance of the secondary (“outer” or disturbed) circuit.

The screening attenuation, expressed in dB of an electrically short device is:

$$a_s \approx 20 \times \log_{10}\left|\frac{50\,\Omega}{Z_T}\right| \tag{4}$$

where

a_s	is the screening attenuation expressed in Ω;
Z_T	is the transfer impedance of the device under test.

Note 1 to entry: Formula (4) may be deduced from Formulas (3) and (5) as follows, assuming an electrically short device:

$a_s = 20 \times \log_{10}\left|\frac{\sqrt{Z_o \times 150\,\Omega}}{2 \times Z_T}\right|$. If we assume that $150\ \Omega \approx 3 \times Z_o$, then

$a_s = 20 \times \log_{10}\left|\frac{150\,\Omega}{2\sqrt{3} \times Z_T}\right|$ and approximate $2\sqrt{3} \approx 3$ then $a_s \approx 20 \times \log_{10}\left|\frac{50\,\Omega}{Z_T}\right|$ and Formula (4) is valid.

In the measurement, both primary and secondary circuits are low impedance. This leads to a 6 dB lower A_{B21} than in e.g. the tube measurement of connectors; see IEC 62153-4-7.

3.5
device under test
DUT
connector's body or screen, intended to be mounted to a shielding or screening wall (or box), or an electromagnetic gasket

3.6
triaxial test method
method for measuring the transfer impedance and screening attenuation of passive transmission components like cables and connectors in an triaxial arrangement

Note 1 to entry: Primarily used for components with elongated dimensions and therefore distributed coupling over the transfer impedance along the components.

See also IEC TS 62153-4-1.

3.7
double coaxial test method
method for measuring the transfer impedance and screening attenuation of passive transmission components like connector feed-throughs and electro magnetical gaskets in an cascaded arrangement

Note 1 to entry: Primarily used for short components with concentrated transfer impedance.

See also IEC TS 62153-4-1.

4 Principle of the test method

Figure 3 shows a typical feed-through construction where a coaxial connection is brought into a screened housing to a printed circuit board. Important are the coaxial connector body's and electromagnetic gasket's reliable connection to the screening or shielding box.

The electromagnetic tightness of a connector body's mounting or a gasket is measured as transfer impedance and/or screening attenuation.

The test set-up consists of two RF-tight coaxial systems separated by a metallic wall to which the DUT is mounted. The feed-through test set-up is shown in Figure 4. The gasket test set-up is shown in Figure 5. Here the gasket is pressed between two metallic plates.

The nominal impedances of both sides of the coaxial fixture should be the same as that of the test equipment. The generator side is called the primary circuit or inner circuit and the receiver side is called the secondary circuit or outer circuit.

The set-up is the same for measuring the transfer impedance and the screening attenuation.

Annex A gives a theoretical model of the test set-up. Useful information concerning the triaxial measurement technique is given in [3][1].

1 Figures in square brackets refer to the Bibliography.

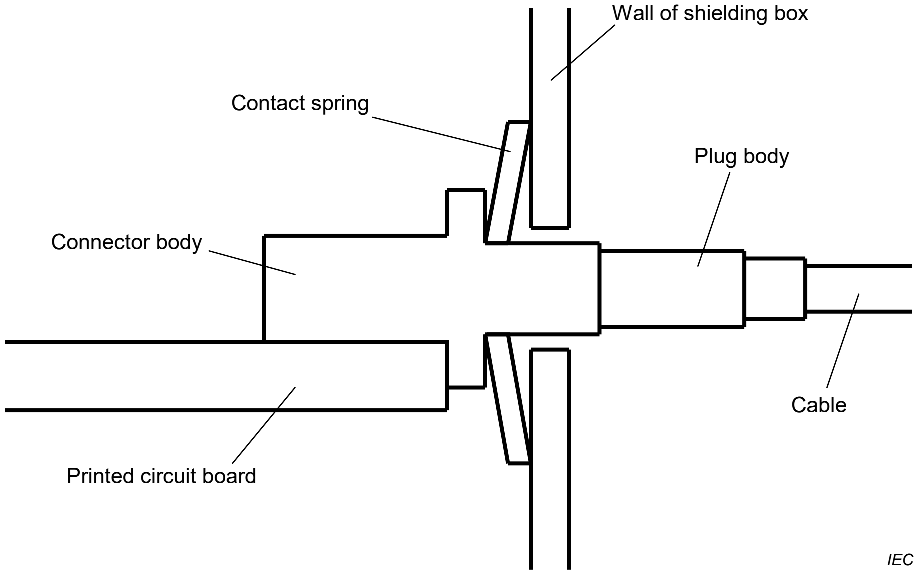
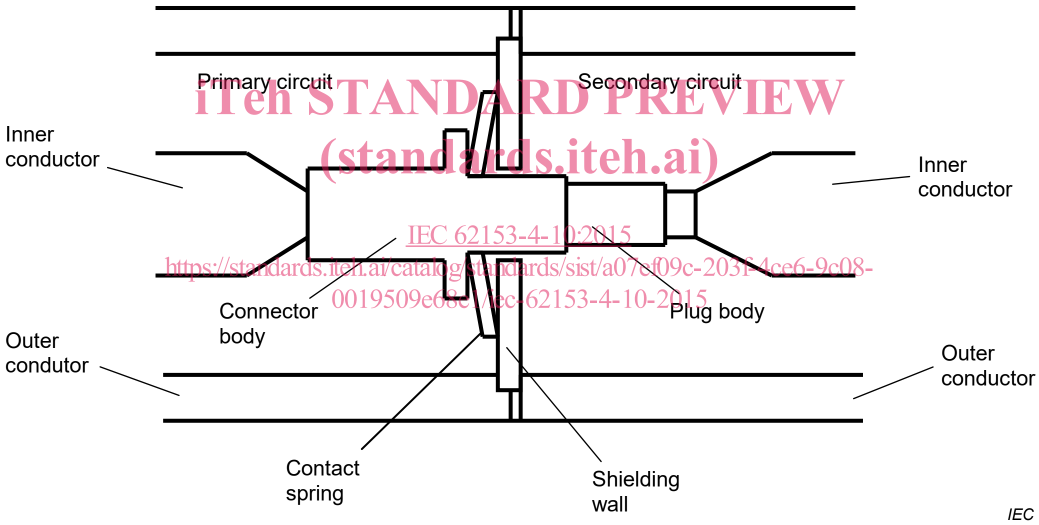
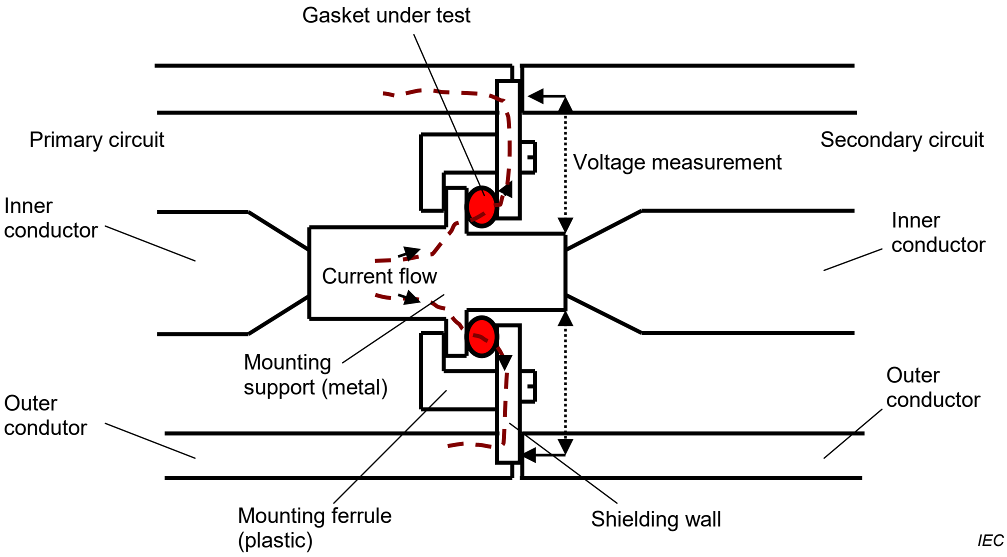


Figure 3 – Cross-section of a typical feed-through configuration



NOTE It is important that the coupled voltage is measured without any disturbing extra coupling voltage not coming from the feed-through under test (compare with Figure 5).

Figure 4 – Cross-section of the test fixture with a connector



In test rig design, care shall be taken that the disturbing current in the primary circuit cannot cause unwanted transition voltages in the measuring secondary circuit. Separate voltage and current "contacts" are a must.

One should not end in a situation where transition or contact resistances of the test rig influence the test results. Special care shall be taken to design the mounting of the test plate between the primary and secondary circuits or systems. Figure 5 shows how to avoid bringing the transition resistance between the mounting plate and primary circuit into the disturbing voltage measurement circuit formed by the secondary circuit of the test system.

It is important that the coupled voltage is measured without any disturbing extra coupling voltage not coming from the gasket under test (compare with Figure 4).

Figure 5 – Cross-section of the test fixture with an electromagnetic gasket

5 Procedure

5.1 Equipment

The test fixture set-up is shown in Figures 3, 4 and 5 and consists of the following:

– a double coaxial test fixture where the sides are separated by metallic wall/walls for mounting of the DUT (Figure 4) (feed-through) or the gasket pressed between two plates, the first one belonging to the centre conductor and primary circuit and the second one to the outer conductor and secondary circuit, Figure 5;

– the RF-tight double coaxial, test fixture which should have preferably a diameter such that the characteristic impedance to the outer tube is 50 Ω respectively the nominal impedance of the network analyzer or generator and receiver;

– a signal generator with the same characteristic impedance as the test fixture with the mounted DUT or an impedance matching adapter, completed with a power amplifier if necessary for very high screening attenuation;

– a receiver with a calibrated step attenuator or a network analyzer (NWA).

NOTE The generator and the receiver may be included in a network analyzer.

5.2 Dynamic range

The dynamic range (noise floor) of the test setup shall be tested by replacing the DUT by a solid metallic plate.

5.3 Verification of the test set-up

In order to verify the proper function of the applied instrumentation and the calculation of the transfer impedance according to 7.1, it is recommended to do a verification measurement by use of a reference device with known characteristics. An example design of such a device is given in Annex B.

5.4 Sample preparation

The feed-through connector or gasket shall be mounted into the fixture according to the manufacturer’s instructions. The specification of the applied contact zones is of particular interest since this defines the contact resistance as an integral part of the transfer impedance of the DUT. Deviating test fixture contact characteristics will result in variations of the measured transfer impedance and screening attenuation, respectively.

6 Measurement

6.1 General

The operational attenuation $A_{B21}(Z_T = \infty)$ of the test fixture with an open circuited DUT ($Z_T = \infty$) shall be measured and recorded vs. frequency.

The operational attenuation A'_{B21} with the feed-through connector mounted to the plate or the gasket inserted is measured and recorded vs. frequency.

The operational attenuation of the feed-through or gasket is then:

$$A_{B21} = A'_{B21} - A_{B21}(Z_T = \infty)$$

6.2 Screening attenuation

See 3.4.

6.3 Transfer impedance

See 3.2.

7 Expression of results

7.1 Transfer impedance

$$Z_T = \frac{S_{21} Z_o}{2} = \frac{H_{B21} Z_o}{2}$$

$$\left|Z_T\right| = \frac{\left|Z_o\right|}{2} \times 10^{-\frac{A_{B21}}{20}} \tag{5}$$

where

Z_o is the nominal characteristic impedance of the primary and secondary circuits, equal to the impedance of the generator and receiver.

NOTE Contrary to the measurement of the transfer impedance of cable screens, the transfer impedance of the connector is not related to length.

7.2 Screening attenuation

The screening attenuation a_s has to be normalized to the agreed standard conditions where the impedance of the "outer world" or secondary circuit is Z_S = 150 Ω:

$$a_s = \text{Min.Env}\left(A_{B21}\right) + 10 \times \log_{10}\left|\frac{Z_S = 150\,\Omega}{Z_o}\right| \tag{6}$$

where

a_s is the screening attenuation related to a secondary or outer circuit ("radiating") impedance of 150 Ω in dB;

Min.Env (A_{B21}) is the operational attenuation recorded as the minimum envelope curve of the measured values in dB (see 7.1);

Z_o is the characteristic impedance of the fixture in Ω.

NOTE At frequencies higher than the limit of the electrically short feed-through the measurement, results will be similar to screening attenuation measurement of a long transmission line.

7.3 Requirements

The results of the transfer impedance and/or the screening attenuation shall comply with the value indicated in a relevant specification.