



BSI Standards Publication

Metallic cables and other passive components 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 — Triaxial tube in tube method

National foreword

This British Standard is the UK implementation of EN IEC 62153-4-7:2021. It is identical to IEC 62153-4-7:2021. It supersedes BS EN 62153-4-7:2016+A1:2018, which will be withdrawn on 14 March 2022.

The UK participation in its preparation was entrusted to Technical Committee EPL/46, Cables, wires and waveguides, radio frequency connectors and accessories for communication and signalling.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Date	Text affected
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English Version

**Metallic cables and other passive components 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 -
Triaxial tube in tube method
(IEC 62153-4-7:2021)**

Méthodes d'essai des câbles métalliques et autres
composants passifs - 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 - Méthode triaxiale en tubes concentriques
(IEC 62153-4-7:2021)

Prüfverfahren für metallische Kommunikationskabel - Teil 4-
7: Elektromagnetische Verträglichkeit (EMV) - Prüfverfahren
zur Messung von Kopplungswiderstand Z_T und von Schirm
 a_S - oder Kopplungsdämpfung a_C von HF-Steckverbindern
und konfektionierten Kabeln bis zu und über 3 GHz - Rohr-
im-Rohr-Verfahren
(IEC 62153-4-7:2021)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 46/812/FDIS, future edition 3 of IEC 62153-4-7, prepared by IEC/TC 46 “Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62153-4-7:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-05-27
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-08-27

This document supersedes EN 62153-4-7:2016 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

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Endorsement notice

The text of the International Standard IEC 62153-4-7:2021 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 62153-4-16 NOTE Harmonized as EN IEC 62153-4-16¹

¹ To be published. Stage at time of publication: FprEN IEC 62153-4-16:2021.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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	-	Metallic communication cable test methods- - Part 4-4: Electromagnetic compatibility (EMC) - Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial 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 62153-4-15	2015	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		-

EN IEC 62153-4-7:2021 (E)

IEC 62153-4-16	-	Metallic cables and other passive-components 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	-
-	-	Coaxial cables - Part 9-2: Sectional specification for coaxial cables for analogue and digital transmission - Indoor droop cables for systems operating at 5 MHz – 3 000 MHz	EN 50117-9-2 2019

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**METALLIC CABLES AND OTHER PASSIVE
COMPONENTS 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 –
Triaxial tube in tube method**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 62153-4-7 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This third edition cancels and replaces the second edition published in 2015 and its Amendment 1:2018. 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. It now includes IEC 62153-4-7:2015/COR1:2016 and IEC 62153-4-7:2015/AMD1:2018. Furthermore, the changes of the revised IEC 62153-4-9:2018 are included.

Measurements of the coupling attenuation can be achieved now by using a mixed mode network analyser (virtual balun). The following new annexes have been added:

- Annex E contains informative information about the direct measurement of screening effectiveness of connectors;
- Annex F gives normative information about mixed mode parameters;
- Annex G contains normative information about accessories for measuring coupling attenuation;
- Annex H discusses the low frequency screening attenuation.

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

FDIS	Report on voting
46/812/FDIS	46/820/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 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 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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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 CABLES AND OTHER PASSIVE COMPONENTS 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 – Triaxial tube in tube method

1 Scope

This part of IEC 62153 deals with the triaxial tube in tube method. 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 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 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, *Metallic communication cable test methods – Part 4-4: Electromagnetic compatibility (EMC) – Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial 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 62153-4-15:2015, *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*

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*

EN 50117-9-2:2019, *Coaxial cables – Part 9-2: Sectional specification for coaxial cables for analogue and digital transmission – Indoor droop cables for systems operating at 5 MHz – 3 000 MHz*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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>

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

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.

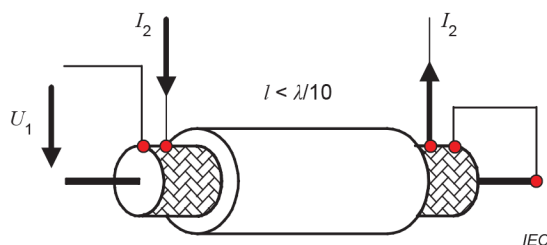


Figure 1 – Definition of Z_T

$$Z_T = \frac{U_1}{I_2} \quad (1)$$

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

3.2

effective transfer impedance

Z_{TE}

maximum absolute value of the sum or difference of the capacitive coupling impedance Z_F and the transfer impedance Z_T at every frequency:

$$Z_{TE} = \max |Z_F \pm Z_T| \quad (3)$$

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

$$a_S = -10 \times \log_{10} \left(\text{Env} \left| \frac{P_{r,max}}{P_1} \right| \right) \quad (4)$$

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

$$a_S = 20 \times \log_{10} \frac{150 \Omega}{Z_{TE}} \quad (5)$$

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 device under test

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

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

or electrically long, if

$$\frac{\lambda_o}{l} \leq \pi \times \left| \sqrt{\epsilon_{r1}} \pm \sqrt{\epsilon_{r2}} \right| \quad \text{or} \quad f \geq \frac{c_o}{\pi \times l \times \left| \sqrt{\epsilon_{r1}} \pm \sqrt{\epsilon_{r2}} \right|} \quad (7)$$

where

l is the effective coupling length, in m;

λ_o 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_o is the velocity of light in free space.

3.6

device under test

DUT

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, IEC 62153-4-9 and Annex C and Annex D.

5 Principle of the test methods

5.1 General

IEC 62153-4 (all parts) 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 (all parts) 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 TS 62153-4-1	Introduction to electromagnetic (EMC) screening measurements
IEC 62153-4-3	Surface transfer impedance – Triaxial method
IEC 62153-4-4	Test method for measuring of the screening attenuation as up to and above 3 GHz, triaxial method
IEC 62153-4-7	Test method for measuring the transfer impedance Z_T and the screening attenuation a_s or coupling attenuation a_C of RF-connectors and assemblies up to and above 3 GHz – Triaxial tube in tube method
IEC 62153-4-9	Coupling attenuation of screened balanced cables, triaxial method
IEC 62153-4-10	Transfer impedance and screening attenuation of feed-throughs and electromagnetic gaskets – Double coaxial test 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 set-up

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 electrical length of the RF-connector is extended by a RF-tightly closed metallic extension tube (tube in tube). See Figure 2.

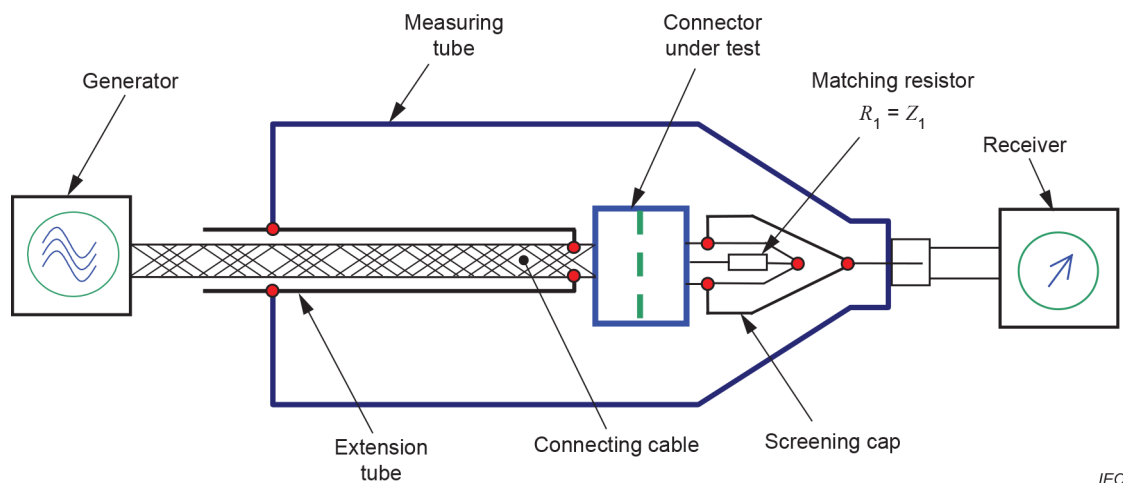


Figure 2 – Principle of the test set-up to measure transfer impedance and screening or coupling attenuation of connectors with tube in tube

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 shall 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 can be found in Clause 10 of IEC TS 62153-4-1:2014 as well as in IEC 62153-4-4. Additional Information on the interpretation of screening attenuation test results at frequencies below the cut-off frequency can be found in Annex H.

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 :

$$a_C = a_U + a_S \quad (8)$$

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):

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

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

$$\frac{P_R}{P_2} = \frac{P_{Rmax}}{P_{2max}} = \frac{R}{2 \times Z_S} \quad (10)$$

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 procedures to measure coupling attenuation are described in Clause 10. Annex G gives normative information on accessories for coupling attenuation measurements.

6 Test procedure

6.1 General

The measurements shall be carried out at the temperature of $(23 \pm 3) ^\circ\text{C}$. 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, IEC 62153-4-4 and IEC 62153-4-9.

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.

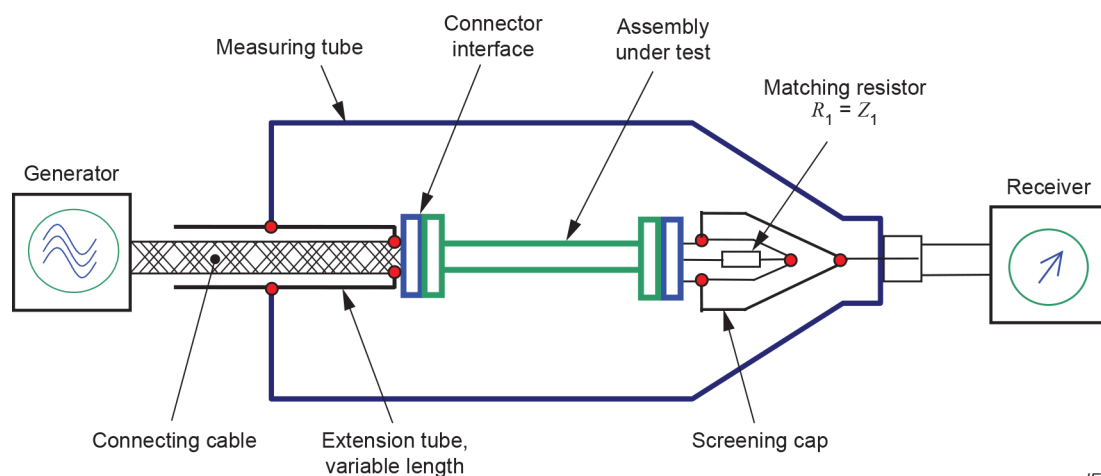
In the frequency range up to the cut off frequency, where the device under test (DUT) is electrically short, the transfer impedance of the DUT can be measured. For frequencies above the cut-off frequency, where the DUT is electrically long, the screening attenuation can be measured.

By extending the electrical 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.



IEC

Figure 3 – Principle of the test set-up to measure transfer impedance and screening attenuation of a cable assembly