

INTERNATIONAL STANDARD



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

Document Preview

[IEC 62153-4-3:2013](https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2024 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

International Standards
standards.iteh.ai
Document Preview

[IEC 62153-4-3:2013](https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>



IEC 62153-4-3

Edition 2.1 2024-05
CONSOLIDATED VERSION

INTERNATIONAL STANDARD



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

Document Preview

[IEC 62153-4-3:2013](https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10; 33.120.10

ISBN 978-2-8322-8895-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	9
4 Principle	12
5 Test methods.....	12
5.1 General	12
5.2 Test equipment	12
5.3 Calibration procedure	13
5.4 Sample preparation	13
5.5 Test set-up	14
5.6 Test configurations	15
5.6.1 General	15
5.6.2 Vector network analyser with S-parameter test set	15
5.6.3 (Vector) network analyser with power splitter	16
5.6.4 Separate signal generator and receiver	16
5.7 Expression of test results	17
5.7.1 Expression	17
5.7.2 Test report.....	17
6 Test method A: Matched inner circuit with damping resistor in outer circuit.....	17
6.1 General	17
6.2 Damping resistor R_2	17
6.3 Cut-off frequency.....	18
6.4 Block diagram of the set-up.....	18
6.5 Measuring procedure.....	18
6.6 Evaluation of test results	19
7 Test method B: Inner circuit with load resistor and outer circuit without damping resistor	19
7.1 General	19
7.2 Cut-off frequency.....	19
7.3 Block diagram of the set-up.....	19
7.4 Measuring procedure.....	20
7.5 Evaluation of test results	21
8 Test method C: (Mismatched)-Short-Short without damping resistor	21
8.1 General	21
8.2 Cut-off frequency.....	21
8.3 Block diagram of the set-up.....	22
8.4 Measuring procedure.....	22
8.5 Evaluation of test results	22
Annex A (normative) Determination of the impedance of the inner circuit.....	24
A.1 Impedance of inner circuit	24
Annex B (normative) Impedance matching adapter	25
B.1 Design of the impedance matching circuit.....	25
B.1.1 General	25
B.1.2 Secondary impedance Z_2 lower than primary impedance Z_1	25

B.1.3	Secondary impedance Z_2 higher than primary impedance Z_1	26
B.2	Frequency response of the impedance matching circuit.....	26
B.2.1	General	26
B.2.2	Measurement using two identical impedance matching adapters	27
B.2.3	Measurement using the open/short method	27
B.2.4	Example of a coaxial 50 Ω to 75 Ω impedance matching adapter.....	27
Annex C (normative)	Sample preparation for “milked on braid” method	29
C.1	General	29
C.2	Coaxial cables.....	30
C.3	Symmetrical and multiconductor cables	32
C.4	Verification of the sample preparation with TDR	35
Annex D (informative)	Triaxial test set-up depicted as a T-circuit	36
D.1	General	36
D.2	Scattering parameter S_{21} of the T-circuit.....	36
Annex E (informative)	Cut-off frequency of the triaxial set-up for the measurement of the transfer impedance	37
E.1	Equivalent circuit.....	37
E.2	Coupling equations.....	37
E.3	Cut-off frequency.....	38
E.4	Determination of the dielectric permittivity and impedance.....	40
Annex F (informative)	Impact of ground loops on low frequency measurements	43
F.1	General	43
F.2	Analysis of the test set-up [3]	43
Annex G (normative)	Single pair cables – Conversion of measured mixed mode scattering parameters to transfer impedance	46
G.1	General	46
G.2	Conversion formula for test method B: Inner circuit with load resistor and outer circuit without damping resistor	46
Bibliography	47
Figure 1	– Definition of Z_T	10
Figure 2	– Definition of Z_F	11
Figure 3	– Preparation of test sample for coaxial cables	14
Figure 4	– Preparation of test sample for symmetrical cables.....	14
Figure 5	– Connection to the tube	15
Figure 6	– Test set-up using a vector network analyser with the S-parameter test set.....	15
Figure 7	– 50 Ω power splitter, 2- and 3-resistor types	16
Figure 8	– Test set-up using a network analyser (NA) and a power splitter	16
Figure 9	– Test set-up using a signal generator and a receiver	16
Figure 10	– Test set-up using a signal generator and a receiver with feeding resistor	17
Figure 11	– Test set-up (principle)	18
Figure 12	– Test set-up (principle)	20
Figure 13	– Test set-up (principle)	22
Figure B.1	– Impedance matching for $Z_2 < Z_1$	25
Figure B.2	– Impedance matching for $Z_2 > Z_1$	26
Figure B.3	– Coaxial impedance matching adapters (50 Ω to 75 Ω).....	27

Figure B.4 – Attenuation of 50 Ω to 75 Ω impedance matching adapter.....	28
Figure C.1 – Coaxial cables: preparation of cable end “A” (1 of 2)	30
Figure C.2 – Coaxial cables: preparation of cable end “B”	32
Figure C.3 – Symmetrical cables: preparation of cable end “A” (1 of 2)	33
Figure C.4 – Symmetrical cables: preparation of cable end “B”	34
Figure C.5 – Typical resonance of end “A”	35
Figure C.6 – Typical resonance of end “B”	35
Figure D.1 – Triaxial set-up depicted as a T-circuit	36
Figure E.1 – Equivalent circuit of the triaxial set-up	37
Figure E.2 – Frequency response of the triaxial set-up for different load conditions	39
Figure E.3 – Measurement of S_{11} of the outer circuit (tube) having a length of 50 cm	41
Figure F.1 – Triaxial test set-up	43
Figure F.2 – Equivalent circuits of the triaxial set-up	44
Figure F.3 – Example showing the impact of the measurement error.....	45

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC 62153-4-3:2013](#)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-3: Electromagnetic compatibility (EMC) – Surface transfer impedance – Triaxial 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62153-4-3 edition 2.1 contains the second edition (2013-10) [documents 46/471/FDIS and 46/482/RVD] and its amendment 1 (2024-05) [documents 46/991/FDIS and 46/1003/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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 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).

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 document and its amendment 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, or
- revised.

[IEC 62153-4-3:2013](https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>

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 correction¹*
- 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*

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*

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[IEC 62153-4-3:2013](https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013)

<https://standards.iteh.ai/catalog/standards/iec/cd6fa6df-0a03-4721-a371-ac9f09fbc1b7/iec-62153-4-3-2013>

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-2013 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

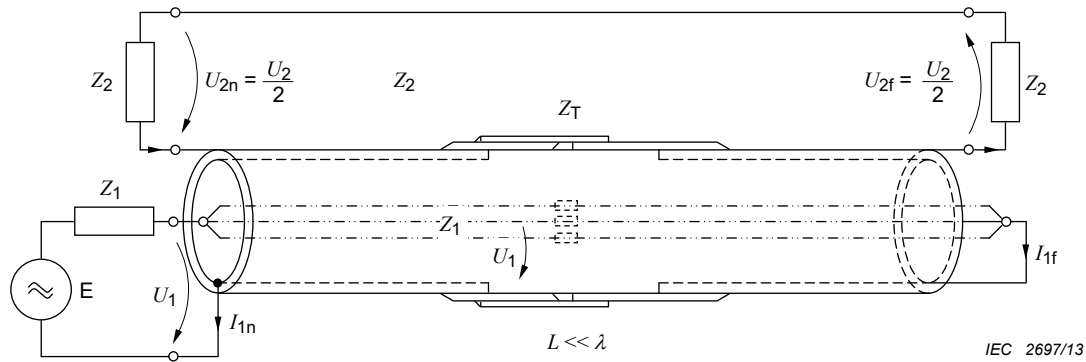
² Numbers in square brackets refer to the bibliography.

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.

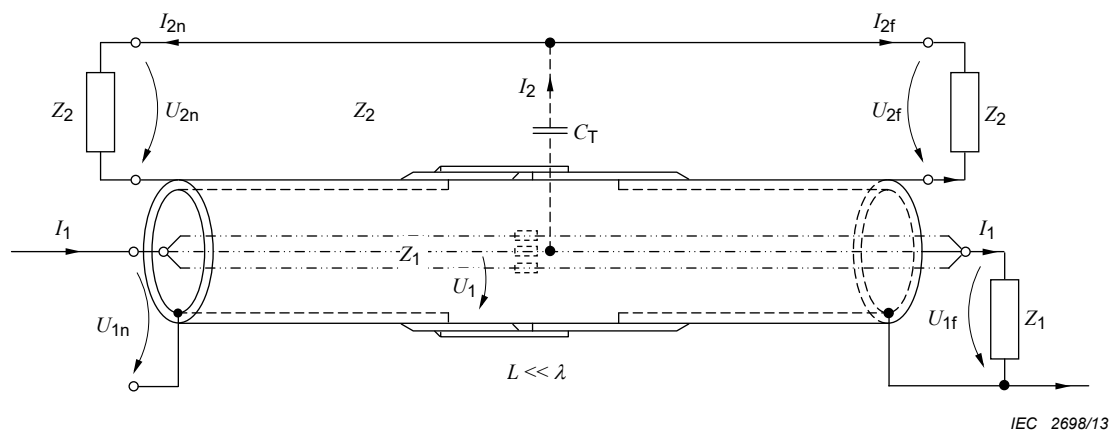
Figure 1 – Definition of Z_T

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 $m\Omega/m$

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

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

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)

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

where

$Z_{T,ref}$ 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