IEC 62153-4-15

Edition 2.0 2021-08
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Metallic ~~communication~~ 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



IEC 62153-4-15:2021-08 RLV(en)



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2021 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 Central Office
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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 online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. 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 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 62153-4-15

Edition 2.0 2021-08
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Metallic ~~communication~~ 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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10; 33.120.10

ISBN 978-2-8322-1011-8

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

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD....5
1 Scope....7
2 Normative references....7
3 Terms and definitions....8
4 Physical background....10
5 Principle of the test methods....10
5.1 General....10
5.2 Transfer impedance....12
5.3 Screening attenuation....13
5.4 Coupling attenuation....13
5.5 Tube-in-tube method....13
6 Test procedures....14
6.1 General....14
6.2 Triaxial cell....14
6.3 Cut-off frequencies, higher-order modes....14
6.4 Test equipment....14
6.5 Calibration procedure....16
6.6 Test leads and connecting cables to the DUT....17
7 Sample preparation....17
7.1 Coaxial connector or assembly or quasi-coaxial component....17
7.2 Balanced or multipin connectors or components....17
7.3 Cable assemblies....19
7.4 Other screened devices....19
8 Transfer impedance (short-matched)....20
8.1 General....20
8.2 Principle block diagram of transfer impedance....20
8.3 Measuring procedure....20
8.4 Evaluation of test results....21
8.5 Test report....21
9 Screening attenuation....21
9.1 General....21
9.2 Impedance matching....21
9.3 Measuring with matched conditions....22
9.3.1 Procedure....22
9.3.2 Evaluation of test results....22
9.4 Measuring with mismatch....23
9.4.1 General....23
9.4.2 Evaluaton of test results....23
9.5 Test report....24
10 Coupling attenuation....24
10.1 General....24
10.2 Procedure....24
10.2.1 Coupling attenuation with balun....24
10.2.2 Balunless coupling attenuation....25
10.3 Expression of results....25

10.4 Test report 25
~~11 Coupling transfer function ..... ~~
Annex A (informative) Principle of the triaxial test procedure 28
A.1 General 28
A.2 Transfer impedance 29
A.3 Screening attenuation 29
A.4 Coupling attenuation 30
Annex B (informative) Triaxial cell 33
~~Annex C (informative) Cut-off frequencies, higher order modes ..... ~~
~~Annex D (informative) Coupling transfer function ..... ~~
~~Annex E (informative) Attenuation versus scattering parameter S_{21} ..... ~~
Annex C (normative) Triaxial absorber cell 42
C.1 Cut-off frequencies, higher order modes 42
C.2 Absorber 43
C.3 Influence of absorber 45
Annex D (informative) Application of a moveable shorting plane 46
D.1 Coupling transfer function 46
D.2 Effect of the measurement length on the measurement cut-off frequency 47
D.3 Details of the movable shorting plane 47
D.4 Measurement results 49
Annex E (informative) Correction in the case that the receiver input impedance R is higher than the characteristic impedance of the outer circuit Z_2 52
E.1 Impedance Z_2 lower than the input impedance of the receiver 52
E.2 Correction 54
Annex F (informative) Test adapter 55
Annex G (informative) Attenuation versus scattering parameter S_{21} 56
Bibliography 58

Figure 1 – Definition of Z_T 8
Figure 2 – Principle depiction of the triaxial ~~cell~~ test setup (tube) to measure transfer impedance and screening attenuation with tube in tube in accordance with IEC 62153-4-7 11
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 12
Figure 4 – Rectangular waveguide 15
Figure 5 – Preparation of balanced or multipin connectors for transfer impedance and screening attenuation 18
Figure 6 – Preparation of balanced or multipin connectors for coupling attenuation measurement 19
Figure 7 – Test setup (principle) for transfer impedance measurement in accordance with test method B of IEC 62153-4-3 20
Figure 8 – Principle test setup for balunless coupling attenuation measurement according to IEC 62153-4-9 25
Figure A.1 – Principle test setup to measure transfer impedance and screening attenuation 28
Figure A.2 – Equivalent circuit of the principle of the test setup in Figure A.1 29
Figure A.3 – Coupling attenuation, principle of test setup with balun and standard tube 31

Figure A.4 – Coupling attenuation, principle of setup with multiport VNA and standard head 31

Figure B.1 – Principle depiction of the triaxial cell to measure transfer impedance and screening attenuation ~~at HV-assemblies~~ on a connector with tube-in-tube according to IEC 62153-4-7 33

Figure B.2 – Examples of different designs of triaxial cells 34

~~Figure C.1 – Comparison of the measurements with tube and with triaxial cell of a RG 11 cable with single braid construction, linear scale .....~~

~~Figure C.2 – Comparison of the measurements with tube and with triaxial cell of a cable RG 11 with single braid construction, log scale .....~~

~~Figure D.1 – Measured coupling transfer function of a braided screen vs. frequency with the triaxial cell .....~~

~~Figure E.1 – Measurement with HP8753D of S_{21} of a 3dB attenuator .....~~

~~Figure E.2 – Measurement with ZVRE of S_{21} of a 3dB attenuator .....~~

Figure C.1 – Cavity or rectangular waveguide 42

Figure C.2 – Comparison of the measurements of a RG 214 cable with 40 mm tube and triaxial cells 43

Figure C.3 – Principle of the triaxial cell with tube in tube and ferrite tiles as absorber 43

Figure C.4 – Comparison of the measurements of an RG 214 with 40 mm tube and triaxial cells with magnetic absorber 44

Figure C.5 – Examples of magnetic flat absorber 44

Figure C.6 – Setup for correction measurement 45

Figure C.7 – Correction measurement 45

Figure D.1 – Measured coupling transfer function of a braided screen versus frequency with the triaxial cell 46

Figure D.2 – Cross-section of triaxial cell with movable shorting plane 48

Figure D.3 – Crosscut of plane shortening housing and tube-in-tube 48

Figure D.4 – Detail H of Figure D.3: contact between plane and housing 49

Figure D.5 – Detail G of Figure D.3: contact between plane and tube-in-tube 49

Figure D.6 – Compilation of transfer impedance test results with different shorting plane distances 50

Figure E.1 – Example of forward transfer scattering parameter S_{21} for different impedances in the outer circuit where the receiver input impedance is 50 Ω 53

Figure E.2 – DUT with uniform cylindrical shape in the centre of the cell 54

Figure F.1 – Principle of the test setup to measure transfer impedance and screening or coupling attenuation of connectors 55

Figure F.2 – Principle of the test setup to measure transfer impedance and screening attenuation on a cable assembly 55

Figure G.1 – Measurement with HP8753D of S_{21} of a 3 dB attenuator 56

Figure G.2 – Measurement with ZVRE of S_{21} of a 3 dB attenuator 57

Table 1 – IEC 62153-4 series, Metallic communication cable test methods – Test procedures with triaxial test setup 10

~~Table C.1 – Resonance frequencies of different triaxial cells .....~~

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

METALLIC ~~COMMUNICATION~~ 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

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

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 62153-4-15:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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,
- replaced by a revised edition, or
- amended.

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.

METALLIC ~~COMMUNICATION~~ 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 ~~(in accordance with the scope of IEC technical committee 46)~~.

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:~~2013~~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) – ~~Shielded screening attenuation,~~ 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 ~~communication~~ cables and other passive components – Test methods – Part 4-8: Electromagnetic compatibility (EMC) – Capacitive coupling admittance*

IEC 62153-4-9:~~2009~~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) – ~~Shielded screening attenuation test method for measuring the screening effectiveness~~ Transfer impedance and screening attenuation of feed-throughs and electromagnetic gaskets – Double coaxial test method*

IEC ~~TS~~ 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.

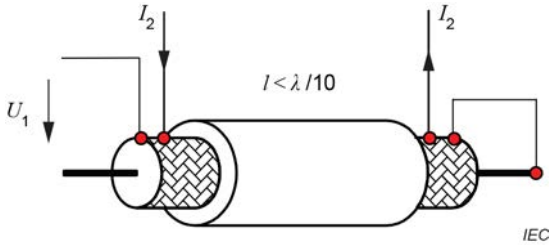


Figure 1 – Definition of Z_T

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

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

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

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

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

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

~~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:

$$a_s = 20 \cdot \lg \frac{150\Omega}{Z_{TE}} \quad (5)$$

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

$$\lambda_0 / L > 10 \cdot \sqrt{\varepsilon_{r1}} \quad \text{or} \quad f < \frac{c_0}{10 \cdot L \cdot \sqrt{\varepsilon_{r1}}} \quad (6)$$

or electrically long, if ~~<~~

$$\lambda_0 / L \leq 2 \cdot \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right| \quad \text{or} \quad f > \frac{c_0}{2 \cdot L \cdot \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right|} \quad (7)$$

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 ~~TS~~ 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-x series according to Table 1~~ 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 ~~components~~ devices, such as connectors, assemblies and components. The principles of the triaxial test procedures in accordance with ~~IEC 62153-4-x series~~ IEC 62153-4-3, IEC 62153-4-4 and IEC 62153-4-7 can be transferred to rectangular housings. Tubes and rectangular housings ~~can~~ may be operated in combination in one test setup (see Figure 2 and Figure 3).