BS IEC 62153-4-9:2018+A2:2024

BSI Standards Publication

Metallic communication cable test methods

Part 4-9: Electromagnetic compatibility (EMC) related test method for measuring coupling attenuation of screened balanced cables — Triaxial method

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National foreword

This British Standard is the UK implementation of IEC 62153-4-9:2018+A2:2024. It supersedes BS IEC 62153-4-9:2018+A1:2020, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

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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CONTENTS

FOREWORD 5
INTRODUCTION to Amendment 1 7
1 Scope 8
2 Normative references 8
3 Terms, definitions and symbols 8
4 Principle of the measuring method 10
4.1 General 10
4.2 Procedure A: measuring with standard tube (standard head) 11
4.3 Procedure B: measuring with open head 12
5 Screening parameters 13
5.1 General 13
5.2 Transfer impedance 13
5.3 Screening attenuation 13
5.4 Unbalance attenuation 14
5.5 Coupling attenuation 14
6 Measurement 15
6.1 General 15
6.2 Equipment 15
6.3 Balun requirements 15
6.4 TP-connecting unit requirements 16
6.5 Sample preparation 16
6.6 Procedure 17
6.7 Test length 17
6.8 Measurement precautions 18
7 Expression of results 18
7.1 Procedure A: measuring with a standard head 18
7.2 Procedure B: measuring with an open head 18
8 Test report 19
9 Requirements 20
10 Plots of coupling attenuation versus frequency (typical results) 20
Annex A (normative) Insertion loss of absorber with triaxial set-up 22
Annex B (informative) Physical background 24
B.1 Unbalance attenuation a_u 24
B.2 Screening attenuation a_s 25
B.3 Coupling attenuation a_c 25
Annex C (informative) Mixed mode parameters 27
C.1 Definition of mixed mode S-Parameters 27
C.2 Reference impedance of VNA 29
A1 Annex D (normative) Measuring the screening effectiveness of unscreened single or multiple balanced pairs 30
D.1 General 30
D.2 Background 30
D.3 Triaxial set-up for unscreened balanced pairs 30
D.3.1 Principle 30
D.3.2 Inner and outer system 31

AVA Documents
Document Sharing Hub
Full document details: BS IEC 62153-4-9:2018+A2:2024

D.4 Unscreened single pairs 31
D.4.1 Near-end coupling attenuation of a single unscreened balanced pair 31
D.4.2 Far end screening attenuation and coupling attenuation of single unscreened balanced pairs 32
D.5 Screening- and coupling attenuation measurement of multiple unscreened balanced pairs 32
D.6 Measurement 33
D.7 Expression of test results 33
D.8 Low frequency coupling attenuation 33
D.9 Set-up verification and measurement uncertainties 34 A1
Annex E (normative) Coupling attenuation expressed by mixed mode scattering parameter and an envelope line 36
E.1 General 36
E.2 Coupling attenuation expressed by mixed mode scattering parameter 36
E.3 Envelope line of coupling attenuation 36
Bibliography 38

Figure 1 – Coupling attenuation, principle test set-up with balun and standard tube 10
Figure 2 – Coupling attenuation, principle test set-up with balun and open head 11
Figure 3 – Coupling attenuation, principle set-up with multiport VNA and standard head 12
Figure 4 – Coupling attenuation, principle set-up with multiport VNA and open head 12
Figure 5 – Definition of transfer impedance 13
Figure 6 – Termination of the cable under test with balun feeding 17
Figure 7 – Test set-up to measure a_{tube} 19
Figure 8 – Coupling attenuation Twinax 105, open head procedure 20
Figure 9 – Coupling attenuation Cat 7a, standard head procedure 21
Figure 10 – Coupling attenuation Cat 8.2, open head procedure 21
Figure A.1 – Insertion loss of absorber with triaxial set-up 22
Figure A.2 – Insertion loss of absorber with triaxial set-up 22
Figure C.1 – Common two-port network 27
Figure C.2 – Common four port network 27
Figure C.3 – Physical and logical ports of VNA 28
Figure C.4 – Nomenclature of mixed mode S-Parameters 28
Figure C.5 – Measurement configuration, single ended response 29
Figure C.6 – Measurement configuration, differential mode response 29
Figure D.1 – Basic triaxial tube procedure according to IEC 62153-4-3 / IEC 62153-4-4 30
Figure D.2 – Screening effectiveness of unscreened balanced pairs, principle set-up 31
Figure D.3 – Configuration for near end coupling measurement of an unscreened single pair, principle set-up 32
Figure D.4 – Far end screening attenuation and coupling attenuation (S_{sc21} and S_{sd21}) of an unscreened balanced pair, principle set-up 32
Figure D.5 – Basic configuration of screening attenuation and coupling attenuation test of multiple unscreened balanced pairs 33
Figure D.6 – Low frequency coupling attenuation $a_{C,lf}$ of a single screened and unscreened balanced pair, 3 m 34
Figure D.7 – Reflected mode conversion parameter S_{cd11} with a TP-connecting unit having an open loop 34

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Full document details: BS IEC 62153-4-9:2018+A2:2024

Figure E.1 – Example of coupling attenuation with envelope line 37

Table 1 – Balun performance characteristics (1 MHz to 1 GHz)..... 16
Table 2 – TP-connecting unit performance characteristics (1 MHz to 2 GHz) 16

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METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method

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International Standard IEC 62153-4-9 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

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

– two test procedures, open head and standard head procedure;
– measuring with balun or with multiport respectively mixed mode VNA;
– extension of frequency range up to and above 2 GHz.

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

FDIS	Report on voting
46/681/FDIS	46/685/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62153 series can be found, under the general title *Metallic communication cable test methods*, 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 "http://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
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INTRODUCTION to Amendment 1

The goal of this amendment is to extent IEC 62153-4-9 such that also the coupling attenuation of unscreened single or multiple balanced pairs or unscreened quads can be measured with the triaxial test procedure.

Further complement is the extension of the usable frequency range down to frequencies below 9 kHz to measure the low frequency coupling attenuation of screened and unscreened balanced pairs or quads.

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METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, triaxial method

1 Scope

This part of IEC 62153 applies to metallic communication cables. It specifies a test method for determining the coupling attenuation a_C of screened balanced cables. Due to the concentric outer tube, measurements are independent of irregularities on the circumference and external electromagnetic fields.

A wide dynamic and frequency range can be applied to test even super screened cables with normal instrumentation from low frequencies up to the limit of defined transversal waves in the outer circuit at approximately 4 GHz. However, when using a balun, the upper frequency is limited by the properties of the balun.

Measurements can be performed with standard tube procedure (respectively with standard test head) according to IEC 62153-4-4 or with open tube (open test head) procedure.

The procedure described herein to measure the coupling attenuation a_C is based on the procedure to measure the screening attenuation a_S according to IEC 62153-4-4.

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 60050-726, *International Electrotechnical Vocabulary – Chapter 726: Transmission lines and waveguides*

IEC TS 62153-4-1, *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 62153-4-5, *Metallic communication cables test methods – Part 4-5: Electromagnetic compatibility (EMC) – Coupling or screening attenuation – Absorbing clamp method*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in IEC 60050-726, IEC TS 62153-4-1 and IEC 62153-4-4, as well as the following symbols apply.

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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

a_s is the screening attenuation which is comparable to the results of the absorbing clamp method in dB;

a_c is the coupling attenuation related to the radiating impedance of 150 Ω in dB;

a_u is the unbalanced attenuation;

$a_{m,min}$ is the attenuation recorded as minimum envelope curve of the measured values in dB;

a_z is the additional attenuation of a possible inserted adapter, if not otherwise eliminated e.g. by the calibration, in dB;

C_T is the through capacitance of the outer conductor in F/m;

c_0 is the vacuum velocity in m/s;

dx is the differential length operator of integration;

λ_0 is the vacuum wavelength in m;

ε_{r1} is the relative dielectric permittivity of the cable under test;

ε_{r2} is the relative dielectric permittivity of the secondary circuit;

$\varepsilon_{r2,n}$ is a normalised value of the relative dielectric permittivity of the environment of the cable;

f is the frequency in Hz;

j is the imaginary operator (square root of minus one);

L is the transmission line parameter-inductance;

l is the effective coupling length in m;

φ is a phase factor in the ratio of the secondary to primary circuit end voltages (U_1/U_2);

P_1 is the feeding power of the primary circuit in W;

P_2 is the measured power received on the input impedance;

R of the receiver in the secondary circuit in W;

P_r is the radiated power in the environment of the cable, which is comparable to P_{2n} + P_{2f} of the absorbing clamp method in W;

$P_{r,max}$ is the periodic maximum value of the common mode radiated power in W;

P_s is the radiated power in the normalised environment of the cable under test,

(Z_s = 150 Ω and $|\Delta v / v_1|$ = 10 %) in W,

$$\varphi_1 = 2\pi \times \left(\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}\right) \times l / \lambda_0 \quad (1)$$

$$\varphi_2 = 2\pi \times \left(\sqrt{\varepsilon_{r1}} + \sqrt{\varepsilon_{r2}}\right) \times l / \lambda_0 \quad (2)$$

$$\varphi_3 = \varphi_2 - \varphi_1 = 4\pi \times \sqrt{\varepsilon_{r2}} \times l / \lambda_0 \quad (3)$$

R is the input impedance of the receiver in Ω;

R_{DM} is the differential mode termination, Ω;

S is the summing function;

T is the coupling transfer function;

U_1 is the input voltage of the primary circuit formed by the cable in V;

U_2 is the output voltage of the secondary circuit in V;

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Ω is the radian frequency ω;

Z_1 is the (differential mode) characteristic impedance of the cable under test (primary circuit) in Ω;

Z_2 is the characteristic impedance of the secondary circuit in Ω;

Z_{com} is the common mode (unbalanced);

Z_{diff} is the nominal characteristic impedance of the differential mode (balanced);

Z_F is the capacitive coupling impedance of the cable under test in Ω/m,

$$Z_F = Z_1 \cdot Z_2 \cdot j \cdot 2 \cdot \pi \cdot f \cdot C_T \quad (4)$$

Z_S is the normalised value of the characteristic impedance of the environment of the cable;

Z_T is the transfer impedance of the cable under test in Ω/m;

4 Principle of the measuring method

4.1 General

Coupling attenuation of screened balanced cables describes the overall effect against electromagnetic interference (EMI) taking into account both the unbalance attenuation of the pair and the screening attenuation of the screen.

The disturbing circuit (the inner or primary circuit) consists of the test cable which is fed by a generator and is impedance-matched at the near and far ends. The disturbed circuit (the outer or secondary circuit) is formed by the solid metallic tube and the short section of the cable under test covered by the tube. The disturbed circuit (the outer or secondary circuit) is terminated at the near end in a short circuit and is terminated at the far end with a calibrated receiver or network analyser.

The voltage peaks at the far end of the secondary circuit are measured with a calibrated receiver or network analyser. For this measurement a matched receiver is not necessary. These voltage peaks are not dependant on the input impedance of the receiver, provided that the input impedance of the receiver is lower than the characteristic impedance of the secondary circuit. However, it is advantageous to have a low mismatch, for example by selecting a range of tube diameters for several cable sizes.

To measure the coupling attenuation as well as to measure the unbalance attenuation a differential signal is required. This can, for example, be generated using a balun which converts the unbalanced signal of a 50 Ω network analyser into a balanced signal.

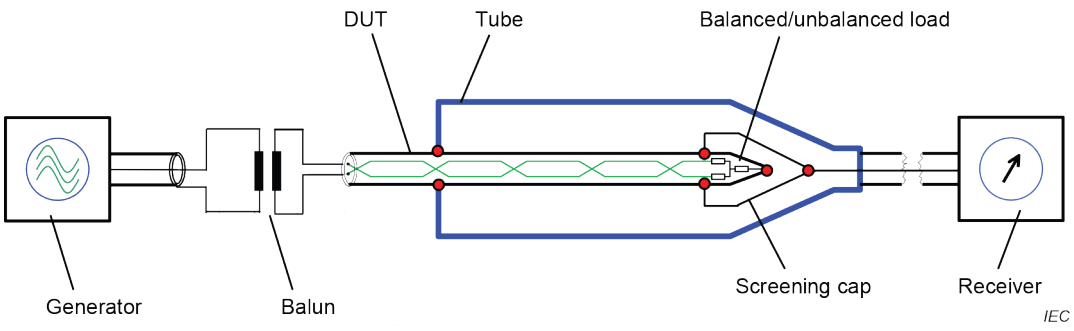

Figure 1 – Coupling attenuation, principle test set-up with balun and standard tube

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Alternatively, a balanced signal may be obtained by using a vector network analyser (VNA) having two generators with a phase shift of 180°. Another alternative is to measure with a multi-port VNA (virtual balun). The properties of balanced pairs are determined mathematically from the measured values of each single conductor of the pair against reference ground. The coverable frequency range for the determination of the reflection and transmissions characteristics of symmetrical pairs is no longer limited by the balun but by the VNA and the connection technique.

A detailed definition of mixed mode S-parameters for measurements with virtual balun is given in Annex B.

The test set-up (see Figures 1, 2, 3 and 4) is a triaxial system consisting of an outer solid metallic tube in which the cable under test (CUT) is concentrically positioned.

At the near end, the screen of the screened cable under test is short circuited with the solid metallic tube.

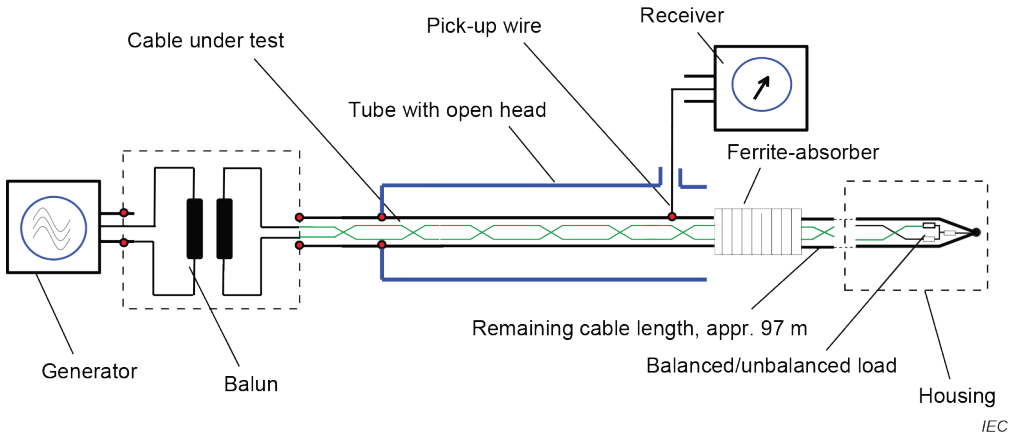

Figure 2 – Coupling attenuation, principle test set-up with balun and open head

At the far end, the tube can be equipped with a “test head” which can be removed from the tube for easier connecting of the CUT. The set-up according to IEC 62153-4-4 is designated as the standard procedure, respectively the procedure with standard head. The advantage is an overall closed and shielded set-up.

Alternatively, the tube can be equipped with an open head at the far end (see Figures 2 and 4).

4.2 Procedure A: measuring with standard tube (standard head)

The set-up detailed in Procedure A uses the standard test-head and is in principle the same as described in IEC 62153-4-4. The screened balanced DUT can be fed either in common mode or in differential mode. In this way, both, screening attenuation of the screen or coupling attenuation of the screened pair can be measured. In principle, with the same set-up, also the transfer impedance of the screen can be measured (taking into account the length of the DUT).

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