



IEC 62153-4-9

Edition 2.1 2020-07  
CONSOLIDATED VERSION

# INTERNATIONAL STANDARD



---

**Metallic communication cable test methods –  
Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of  
screened balanced cables, triaxial method**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 33.100.10; 33.120.10

ISBN 978-2-8322-8633-3

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

## REDLINE VERSION



**Metallic communication cable test methods –  
Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of  
screened balanced cables, triaxial method**



## CONTENTS

FOREWORD .....	4
INTRODUCTION to Amendment 1 .....	6
1 Scope .....	7
2 Normative references .....	7
3 Terms, definitions and symbols .....	7
4 Principle of the measuring method .....	9
4.1 General .....	9
4.2 Procedure A: measuring with standard tube (standard head) .....	10
4.3 Procedure B: measuring with open head .....	11
5 Screening parameters .....	12
5.1 General .....	12
5.2 Transfer impedance .....	12
5.3 Screening attenuation .....	12
5.4 Unbalance attenuation .....	13
5.5 Coupling attenuation .....	13
6 Measurement .....	14
6.1 General .....	14
6.2 Equipment .....	14
6.3 Balun requirements .....	14
6.4 TP-connecting unit requirements .....	15
6.5 Sample preparation .....	15
6.6 Procedure .....	16
6.7 Test length .....	16
6.8 Measurement precautions .....	17
7 Expression of results .....	17
7.1 Procedure A: measuring with a standard head .....	17
7.2 Procedure B: measuring with an open head .....	17
8 Test report .....	18
9 Requirements .....	18
10 Plots of coupling attenuation versus frequency (typical results) .....	19
Annex A (normative) Insertion loss of absorber with triaxial set-up .....	21
Annex B (informative) Physical background .....	23
B.1 Unbalance attenuation $a_U$ .....	23
B.2 Screening attenuation $a_S$ .....	24
B.3 Coupling attenuation $a_C$ .....	24
Annex C (informative) Mixed mode parameters .....	26
C.1 Definition of mixed mode S-Parameters .....	26
C.2 Reference impedance of VNA .....	28
Annex D (normative) Measuring the screening effectiveness of unscreened single or multiple balanced pairs .....	29
D.1 General .....	29
D.2 Background .....	29
D.3 Triaxial set-up for unscreened balanced pairs .....	29
D.4 Unscreened single pairs .....	30

D.5	Screening- and coupling attenuation measurement of multiple unscreened balanced pairs .....	31
D.6	Measurement .....	32
D.7	Expression of test results .....	32
D.8	Low frequency coupling attenuation .....	32
D.9	Set-up verification and measurement uncertainties .....	33
Bibliography .....		35

Figure 1 – Coupling attenuation, principle test set-up with balun and standard tube .....	9
Figure 2 – Coupling attenuation, principle test set-up with balun and open head .....	10
Figure 3 – Coupling attenuation, principle set-up with multiport VNA and standard head .....	11
Figure 4 – Coupling attenuation, principle set-up with multiport VNA and open head .....	11
Figure 5 – Definition of transfer impedance .....	12
Figure 6 – Termination of the cable under test with balun feeding .....	16
Figure 7 – Test set-up to measure $a_{\text{tube}}$ .....	18
Figure 8 – Coupling attenuation Twinax 105, open head procedure .....	19
Figure 9 – Coupling attenuation Cat 7a, standard head procedure .....	19
Figure 10 – Coupling attenuation Cat 8.2, open head procedure .....	20
Figure A.1 – Insertion loss of absorber with triaxial set-up .....	21
Figure A.2 – Insertion loss of absorber with triaxial set-up .....	21
Figure C.1 – Common two-port network .....	26
Figure C.2 – Common four port network .....	26
Figure C.3 – Physical and logical ports of VNA .....	27
Figure C.4 – Nomenclature of mixed mode S-Parameters .....	27
Figure C.5 – Measurement configuration, single ended response .....	28
Figure C.6 – Measurement configuration, differential mode response .....	28
Figure D.1 – Basic triaxial tube procedure according to IEC 62153-4-3 / IEC 62153-4-4 .....	29
Figure D.2 – Screening effectiveness of unscreened balanced pairs, principle set-up .....	30
Figure D.3 – Configuration for near end coupling measurement of an unscreened single pair, principle set-up .....	31
Figure D.4 – Far end screening attenuation and coupling attenuation ( $S_{\text{sc}21}$ and $S_{\text{sd}21}$ ) of an unscreened balanced pair, principle set-up .....	31
Figure D.5 – Basic configuration of screening attenuation and coupling attenuation test of multiple unscreened balanced pairs .....	32
Figure D.6 – Low frequency coupling attenuation $a_{\text{C},\text{lf}}$ of a single screened and unscreened balanced pair, 3 m .....	33
Figure D.7 – Reflected mode conversion parameter $S_{\text{cd}11}$ with a TP-connecting unit having an open loop .....	34
Table 1 – Balun performance characteristics (1 MHz to 1 GHz) .....	15
Table 2 – TP-connecting unit performance characteristics (1 MHz to 2 GHz) .....	15

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### METALLIC COMMUNICATION CABLE TEST METHODS –

#### Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, 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) 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 consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.**

**IEC 62153-4-9 edition 2.1 contains the second edition (2018-05) [documents 46/681/FDIS and 46/685/RVD] and its amendment 1 (2020-07) [documents 46/773/FDIS and 46/776/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.**

IEC 62153-4-9:2018+AMD1:2020 CSV – 5 –  
© IEC 2020

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 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 multipoint respectively mixed mode VNA;
- extension of frequency range up to and above 2 GHz.

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 the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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.**

## INTRODUCTION to Amendment 1

The goal of this amendment is to extend 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.

## 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*



## FINAL VERSION



---

**Metallic communication cable test methods –  
Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of  
screened balanced cables, triaxial method**



## CONTENTS

FOREWORD .....	4
INTRODUCTION to Amendment 1 .....	6
1 Scope .....	7
2 Normative references .....	7
3 Terms, definitions and symbols .....	7
4 Principle of the measuring method .....	9
4.1 General .....	9
4.2 Procedure A: measuring with standard tube (standard head) .....	10
4.3 Procedure B: measuring with open head .....	11
5 Screening parameters .....	12
5.1 General .....	12
5.2 Transfer impedance .....	12
5.3 Screening attenuation .....	12
5.4 Unbalance attenuation .....	13
5.5 Coupling attenuation .....	13
6 Measurement .....	14
6.1 General .....	14
6.2 Equipment .....	14
6.3 Balun requirements .....	14
6.4 TP-connecting unit requirements .....	15
6.5 Sample preparation .....	15
6.6 Procedure .....	16
6.7 Test length .....	16
6.8 Measurement precautions .....	17
7 Expression of results .....	17
7.1 Procedure A: measuring with a standard head .....	17
7.2 Procedure B: measuring with an open head .....	17
8 Test report .....	18
9 Requirements .....	18
10 Plots of coupling attenuation versus frequency (typical results) .....	19
Annex A (normative) Insertion loss of absorber with triaxial set-up .....	21
Annex B (informative) Physical background .....	23
B.1 Unbalance attenuation $a_U$ .....	23
B.2 Screening attenuation $a_S$ .....	24
B.3 Coupling attenuation $a_C$ .....	24
Annex C (informative) Mixed mode parameters .....	26
C.1 Definition of mixed mode S-Parameters .....	26
C.2 Reference impedance of VNA .....	28
Annex D (normative) Measuring the screening effectiveness of unscreened single or multiple balanced pairs .....	29
D.1 General .....	29
D.2 Background .....	29
D.3 Triaxial set-up for unscreened balanced pairs .....	29
D.4 Unscreened single pairs .....	30

D.5	Screening- and coupling attenuation measurement of multiple unscreened balanced pairs .....	31
D.6	Measurement .....	32
D.7	Expression of test results .....	32
D.8	Low frequency coupling attenuation .....	32
D.9	Set-up verification and measurement uncertainties .....	33
	Bibliography .....	35
	Figure 1 – Coupling attenuation, principle test set-up with balun and standard tube .....	9
	Figure 2 – Coupling attenuation, principle test set-up with balun and open head .....	10
	Figure 3 – Coupling attenuation, principle set-up with multiport VNA and standard head .....	11
	Figure 4 – Coupling attenuation, principle set-up with multiport VNA and open head .....	11
	Figure 5 – Definition of transfer impedance .....	12
	Figure 6 – Termination of the cable under test with balun feeding .....	16
	Figure 7 – Test set-up to measure $a_{\text{tube}}$ .....	18
	Figure 8 – Coupling attenuation Twinax 105, open head procedure .....	19
	Figure 9 – Coupling attenuation Cat 7a, standard head procedure .....	19
	Figure 10 – Coupling attenuation Cat 8.2, open head procedure .....	20
	Figure A.1 – Insertion loss of absorber with triaxial set-up .....	21
	Figure A.2 – Insertion loss of absorber with triaxial set-up .....	21
	Figure C.1 – Common two-port network .....	26
	Figure C.2 – Common four port network .....	26
	Figure C.3 – Physical and logical ports of VNA .....	27
	Figure C.4 – Nomenclature of mixed mode S-Parameters .....	27
	Figure C.5 – Measurement configuration, single ended response .....	28
	Figure C.6 – Measurement configuration, differential mode response .....	28
	Figure D.1 – Basic triaxial tube procedure according to IEC 62153-4-3 / IEC 62153-4-4 .....	29
	Figure D.2 – Screening effectiveness of unscreened balanced pairs, principle set-up .....	30
	Figure D.3 – Configuration for near end coupling measurement of an unscreened single pair, principle set-up .....	31
	Figure D.4 – Far end screening attenuation and coupling attenuation ( $S_{\text{sc}21}$ and $S_{\text{sd}21}$ ) of an unscreened balanced pair, principle set-up .....	31
	Figure D.5 – Basic configuration of screening attenuation and coupling attenuation test of multiple unscreened balanced pairs .....	32
	Figure D.6 – Low frequency coupling attenuation $a_{\text{C},\text{lf}}$ of a single screened and unscreened balanced pair, 3 m .....	33
	Figure D.7 – Reflected mode conversion parameter $S_{\text{cd}11}$ with a TP-connecting unit having an open loop .....	34
	Table 1 – Balun performance characteristics (1 MHz to 1 GHz) .....	15
	Table 2 – TP-connecting unit performance characteristics (1 MHz to 2 GHz) .....	15

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### METALLIC COMMUNICATION CABLE TEST METHODS –

#### Part 4-9: Electromagnetic compatibility (EMC) – Coupling attenuation of screened balanced cables, 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) 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 consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.**

**IEC 62153-4-9 edition 2.1 contains the second edition (2018-05) [documents 46/681/FDIS and 46/685/RVD] and its amendment 1 (2020-07) [documents 46/773/FDIS and 46/776/RVD].**

**This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.**

IEC 62153-4-9:2018+AMD1:2020 CSV – 5 –  
© IEC 2020

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 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 multipoint respectively mixed mode VNA;
- extension of frequency range up to and above 2 GHz.

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 the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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.**

## 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.

## 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*