IEC 62153-4-9

Edition 2.0 2020-07

# INTERNATIONAL STANDARD

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AMENDMENT 1

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



IEC 62153-4-9:2018-05/AMD1:2020-07(en)

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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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# FOREWORD

This amendment has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

The text of this amendment is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 46/773/FDIS | 46/776/RVD |

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

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.



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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.

*Add, after Annex C, the following new Annex D:*

# Annex D
(normative)

# Measuring the screening effectiveness of unscreened single or multiple balanced pairs

## D.1 General

IEC 62153-4-9 describes the measurement of coupling attenuation of balanced pairs with the triaxial test set-up. Due to the short circuit between the screen of the cable under test (CUT) and the triaxial tube at the near end, the method described in IEC 62153-4-9 applies only to screened balanced cables.

This annex describes the procedures for measuring coupling attenuation of unscreened single or multiple balanced pairs. Furthermore, the screening effectiveness of screened and unscreened balanced pairs at frequencies down to 9 kHz is described.

## D.2 Background

Figure D.1 shows the basic triaxial test set-up with a short circuit between the screen of the cable under test (CUT) and the tube at the near end.



Due to the energy which couples through the screen from the inner system (the CUT) into the outer system (the tube), a wave is travelling in both directions in the outer system. The short circuit at the near end causes a total reflection so that the complete energy that couples from the CUT into the outer system is travelling to the receiver and is measured as superimposed curve. The measured maximum values, respectively the envelope curve, is the screening attenuation according to IEC 62153-4-4, see also IEC TS 62153-4-1.

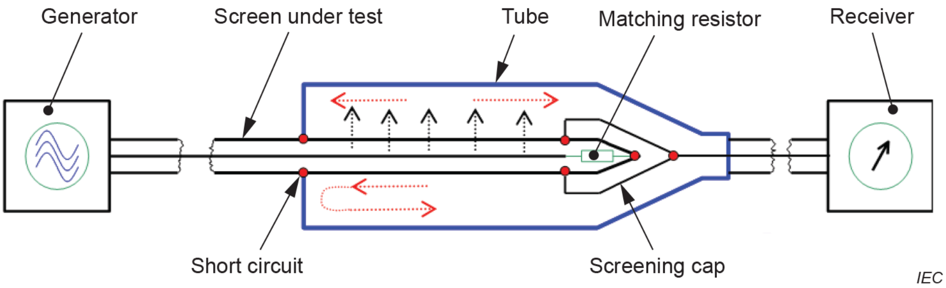


**Figure D.1 – Basic triaxial tube procedure according to IEC 62153-4-3 / IEC 62153-4-4**

The same principle applies to screened balanced cables, where also the interaction between differential mode and common mode shall be considered (see Figures 1 and 3).

## D.3 Triaxial set-up for unscreened balanced pairs

### D.3.1 Principle

Basically, it should be distinguished between single unscreened pairs and multiple unscreened pairs. In case of multiple unscreened pairs, the EMC behavior, respectively test results, depends on the treatment of the remaining pairs, e.g. grounded or not.

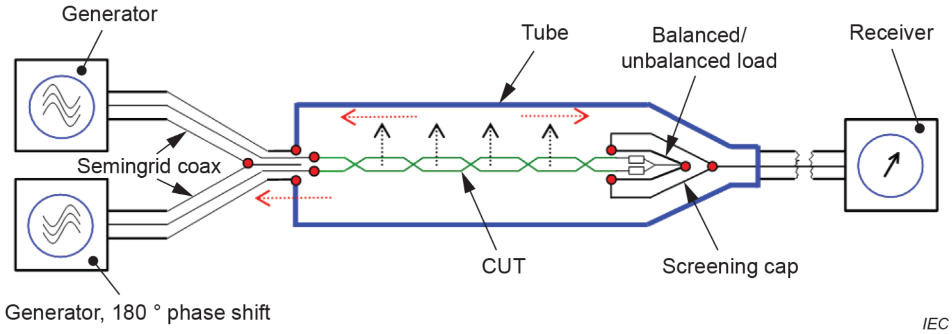


**Figure D.2 – Screening effectiveness of unscreened balanced pairs, principle set-up**

Figure D.2 shows the principle triaxial set-up for balanced unscreened single or multiple balanced pairs. The signal is fed into the tube in the differential mode via two parallel semi rigid coaxial cables of equal length with the screens connected to the tube. Due to the conversion from the differential mode into the common mode (into the tube), a wave is travelling in both directions in the test section.

### D.3.2 Inner and outer system

In the basic triaxial system according to Figure D.1, the inner system is formed by the cable under test (CUT) and the outer system is formed by the tube and the outer conductor of the CUT (the inner conductor of the outer system is the outer conductor of the inner system). At the near end, the screen is connected to the tube by a short circuit. This principle is valid for both coaxial and screened balanced cables.



In case of unscreened balanced cables, the inner system is the CUT (the differential mode) and the outer system is formed by the tube and the common mode of the CUT.



Since there is no screen on the unscreened pair, there is no short circuit at the near end as in the basic triaxial set-up according to Figure D.1; hence coupling measurements can be performed on both ends.

## D.4 Unscreened single pairs

### D.4.1 Near-end coupling attenuation of a single unscreened balanced pair

The back-travelling energy at the near end in Figure D.2 is considered as the near end coupling. It can be measured as $S_{cd11}$, where $S_{cd11}$ is also the unbalance attenuation (TCL) of the unscreened cable under test (CUT) at the near end.

Figure D.3 shows the configuration for near-end coupling measurement of unscreened single pairs.

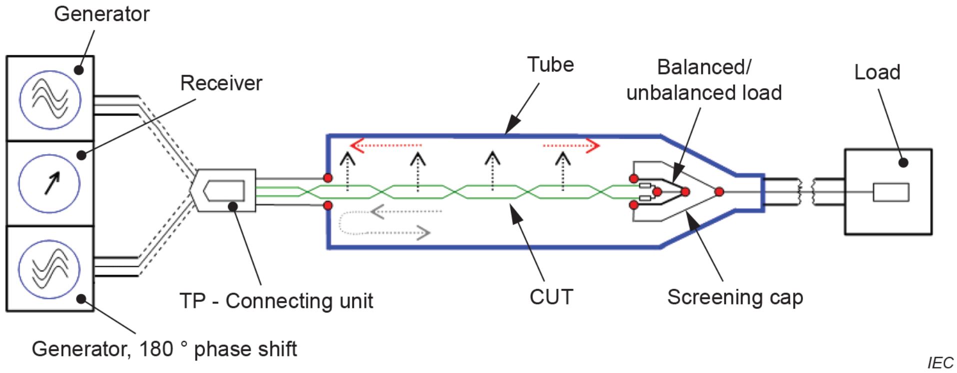


**Figure D.3 – Configuration for near end coupling measurement of an unscreened single pair, principle set-up**

A differential and common mode termination is required for each pair at the far end of the cable. For cables with 100 Ω characteristic impedance, two 50 Ω resistors are used.

### D.4.2 Far end screening attenuation and coupling attenuation of single unscreened balanced pairs

Figure D.4 shows the set-up for the far end screening attenuation ($S_{sc21}$) and the far end coupling attenuation ($S_{sd21}$) measurement of an unscreened pair.



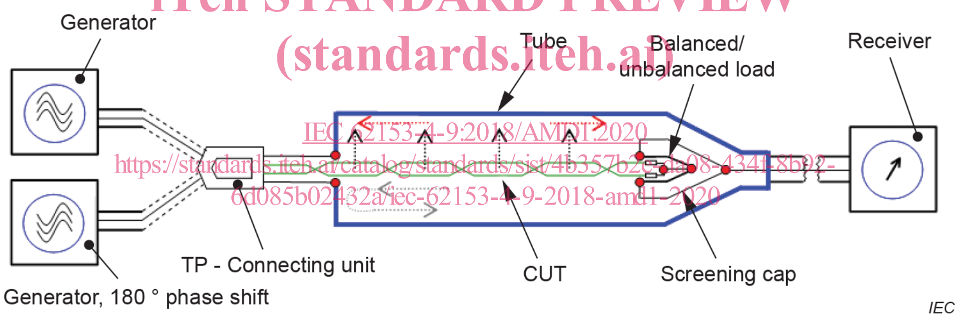


**Figure D.4 – Far end screening attenuation and coupling attenuation ($S_{sc21}$ and $S_{sd21}$) of an unscreened balanced pair, principle set-up**

The CUT shall be matched with 50/50/0 Ω; that means 100 Ω for the differential mode and 25 Ω for the common mode. The 25 Ω common mode load is in series to the receiver of the network analyser.

## D.5 Screening- and coupling attenuation measurement of multiple unscreened balanced pairs

Figure D.5 shows the configuration for measuring the coupling attenuation of multiple unscreened pairs.

All pairs of the CUT shall be matched at the far end with a PCB 50/50/0 Ω and connected at the near end with an appropriate TP-connecting unit according to Table 2. The TP-connecting unit shall be connected to ground potential.

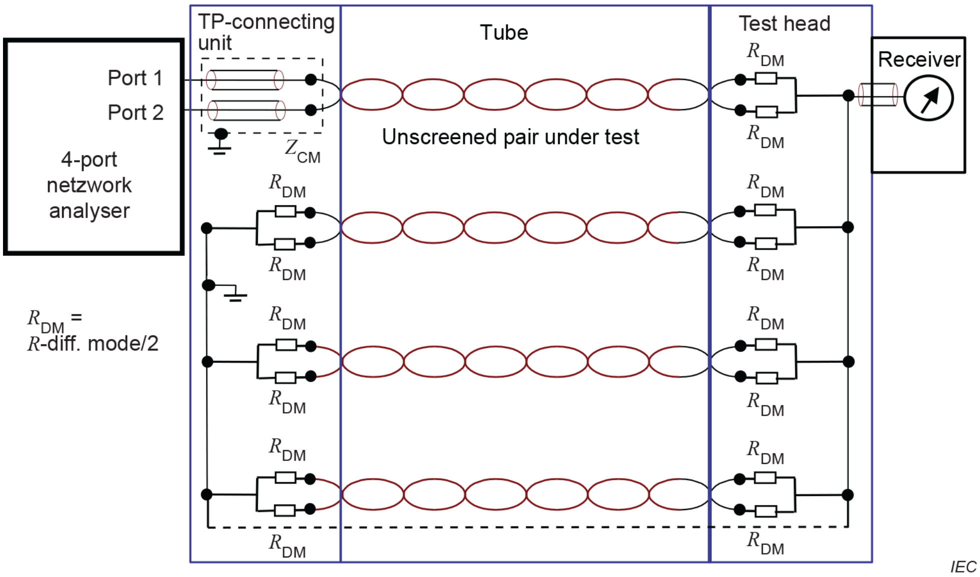


**Figure D.5 – Basic configuration of screening attenuation and coupling attenuation test of multiple unscreened balanced pairs**

## D.6 Measurement



Balunless procedures of Clause 6 in accordance with Figures D.3 and D.4 apply for the measurement.

## D.7 Expression of test results



Subclause 7.1 applies for the expression of test results.

## D.8 Low frequency coupling attenuation

The lower cut off frequency to measure the coupling attenuation is given by equation (13), see Subclause 6.7. That means, coupling attenuation of screened and unscreened balanced pairs with manageable length can be measured only from about 30 MHz upwards. A test procedure for the EMC behaviour of screened balanced cables at lower frequencies is needed for applications like 10 Mbit/s (IEEE 802.3cg) and 100 Mbit/s (IEEE 802.3bw).

Since unscreened pairs have no screen, measuring of transfer impedance as specified for coaxial and for screened balanced cables is not possible.

Alternatively, the "low frequency coupling attenuation" $a_{C,lf}$ is introduced. The test set-up is the same as the set-up for coupling attenuation according to Figure 8, but starting in principle from DC. Low frequency coupling attenuation $a_{C,lf}$ can be measured on both screened and unscreened balanced pairs.

Low frequency coupling attenuation $a_{C,lf}$ includes the unbalance attenuation of the pair over the whole frequency range, the transfer impedance of the screen (if any) at lower frequencies and the screening attenuation at higher frequencies.

Since the results of the low frequency coupling attenuation are depending on the length of the CUT and cannot (readily) be extrapolated to other lengths, a test length of 3 m is specified to get comparable test results. Results of a suitable test length of 3 m are shown in Figure D.6.

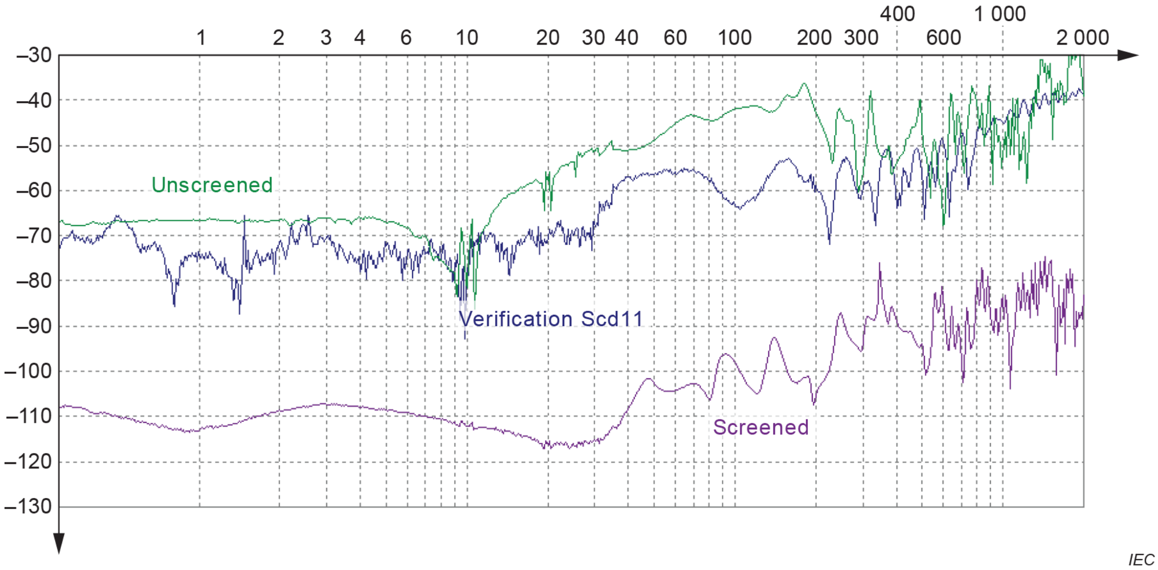


**Figure D.6 – Low frequency coupling attenuation $a_{C,lf}$ of a single screened and unscreened balanced pair, 3 m**

Test set-up verification shall be performed according to Clause D.9.



## D.9 Set-up verification and measurement uncertainties

Optimally calibrated and phase-stabilized measuring devices (VNA, test leads and connecting units) show a specific frequency-dependent course of a system-mode conversion.



This is at low frequencies between –80 dB and –70 dB and increases with increasing frequencies at about –60 dB to –40 dB. Depending on the phase position, this system-mode conversion superimposes the mode conversion of the test object constructively or destructively. The result of the measurement is thereby falsified and, in particular, very strong if the amount of the mode conversion of the test object approaches or even undershoots the amount of the system mode conversion.

All low frequency coupling attenuation ($a_{C,lf}$) measurements and measurements of high coupling attenuation values may be victims of such overlays. The system values shall therefore be recorded and included in the measurement uncertainty analysis.

An estimation of the system mode conversion can be done by e.g. recording the reflected mode conversion parameter $S_{cd11}$ with a TP-connecting unit having an open loop.

Figure D.7 shows an example of the reflected mode conversion parameter $S_{cd11}$ with a TP-connecting unit having an open loop.