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Edition 2.0 2015-04

INTERNATIONAL STANDARD

colour inside

Metallic communication cable test methods – Part 4-4: Electromagnetic compatibility (EMC) – Test method for measuring of the screening attenuation a_s up to and above 3 GHz, triaxial method

IEC 62153-4-4:2015-04(en)

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International Standard IEC 62153-4-4 has been prepared by 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 2006 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition. Impedance matching adapters are no longer required when measuring devices have a characteristic impedance different from the characteristic impedance of the test equipment. The reflection loss due to a mismatch is taken into account by a (calculated) correction factor.

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

FDIS	Report on voting
46/545/FDIS	46/554/RVD

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

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.

The committee has decided that the contents of this 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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 CABLE TEST METHODS –

Part 4-4: Electromagnetic compatibility (EMC) – Test method for measuring of the screening attenuation a_s up to and above 3 GHz, triaxial method

1 Scope

This part of IEC 62153 describes a test method to determine the screening attenuation a_s of metallic communication cable screens. Due to the concentric outer tube, measurements are independent of irregularities on the circumference and outer electromagnetic field.

A wide dynamic 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.

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 62153-4-1, *Metallic communication cable test methods – Part 4-1: Electromagnetic Compatibility (EMC) – Introduction to electromagnetic screening measurements*

3 Symbols and theoretical background

3.1 Electrical symbols

Z_1	characteristic impedance of the primary circuit (cable under test)
Z_2	characteristic impedance of the secondary circuit
Z_S	normalized value of the characteristic impedance of the environment of a typical cable installation (150 Ω). It is in no relation to the impedance of the outer circuit of the test set-up Z_2 Z_S is always 150 Ω (arbitrary determined) whereas Z_2 is varying with the dimensions of the CUT and inner diameter of the tube
R	input impedance of the receiver
Z_T	transfer impedance of the cable under test in Ω/m
$Z_F = Z_1 \times Z_2 \times j\omega \times C_T$	capacitive coupling impedance of the cable under test in Ω/m
f	frequency in Hz
C_T	through capacitance of the outer conductor per unit length in F/m
ε_{r1}	relative dielectric permittivity of the cable under test
ε_{r2}	relative dielectric permittivity of the secondary circuit
$\varepsilon_{r2,n}$	normalized value of the relative dielectric permittivity of the environment of the cable
l	effective coupling length
λ_0	vacuum wavelength

c_0	vacuum velocity
a_s	screening attenuation which is comparable to the results of the absorbing clamp method
P_1	feeding power of the primary circuit
P_2	measured power received on the input impedance R of the receiver in the secondary circuit
P_r	radiated power in the environment of the cable, which is comparable to $P_{2,n} + P_{2,f}$ of the absorbing clamp method
S_{11}	scattering parameter S_{11} (complex quantity) of the set-up where the primary side of the two port is the DUT and the secondary side is the tube
S_{21}	scattering parameter S_{21} (complex quantity) of the set-up where the primary side of the two port is the DUT and the secondary side is the tube

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

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

$$\varphi_3 = \varphi_2 - \varphi_1 = 4\pi\sqrt{\varepsilon_{r2}}\, l / \lambda_0$$

3.2 Theoretical background

There will be a variation of the voltage U_2 on the far end, caused by the electromagnetic coupling through the screen and superimposition of the partial waves caused by the surface transfer impedance Z_T, the capacitive coupling impedance Z_F (travelling to the far and near end) and the totally reflected waves from the near end.

For exact calculation, if feedback from the secondary to the primary circuit is negligible, the ratio of the far-end voltages U_1 and U_2 are given by

$$\left|\frac{U_2}{U_1}\right| \approx \left| \underbrace{\frac{Z_T - Z_F}{\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}} \times \left[1 - e^{-j\varphi_1}\right]}_{A} + \underbrace{\frac{Z_T + Z_F}{\sqrt{\varepsilon_{r1}} + \sqrt{\varepsilon_{r2}}} \times \left[1 - e^{-j\varphi_2}\right]}_{B} \right| \times \underbrace{\left|\frac{1}{\omega \cdot Z_1}\right|}_{C} \times \underbrace{\left|\frac{c_0}{2 + (Z_2 / R - 1) \times \left(1 - e^{-j\varphi_3}\right)}\right|}_{D} \quad (1)$$

i.e. formally | $A + B$ | $\times C \times D$, where $A \times C$ is the far-end crosstalk, $B \times C$ is the reflected near-end crosstalk and D is the mismatch factor.

The total oscillations of D are

<2 dB, if	$1 < Z_2/R < 1{,}25$
3 dB, if	$Z_2/R = 1{,}4$
but	10 dB and more, if $Z_2/R > 3$.
Maximum values of $A \times C$ and $B \times C$ are given, if	$\varphi_{1,2} = (2N + 1) \times \pi$ and N is an integer.

The voltage ratio measured is not dependent on the diameter of the outer tube of the triaxial test set-up or on the characteristic impedance Z_2 of the outer system, provided that Z_2 is larger than the input impedance of the receiver.

A more detailed description of the subject is given in IEC 62153-4-1.

3.3 Screening attenuation

The logarithmic ratio of the feeding power P_1 and the periodic maximum values of the power $P_{r,max}$ which may be radiated due to the peaks of voltage U_2 in the outer circuit is termed screening attenuation a_s.

$$a_s = -10 \times \log_{10}\left(Env\left| \frac{P_{r,max}}{P_1} \right| \right) \tag{2}$$

The relationship of the radiated power P_r to the measured power P_2 received on the input impedance R is

$$\frac{P_r}{P_2} = \frac{P_{r,max}}{P_{2,max}} = \frac{R}{2 \times Z_S} \tag{3}$$

At high frequencies and when the cable under test is electrically long:

$$\sqrt{\left| \frac{P_{2,max}}{P_1} \right|} \approx \frac{c_o}{\omega\sqrt{Z_1 \times R}} \times \left| \frac{Z_T - Z_F}{\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}} + \frac{Z_T + Z_F}{\sqrt{\varepsilon_{r1}} + \sqrt{\varepsilon_{r2}}} \right| \tag{4}$$

3.4 Impact of coupling length and relationship between the screening attenuation and the surface transfer impedance Z_T

The relationship between the effective coupling length of the cable under test and the electrical wave length is important for the characteristic curve of the screening attenuation (see Figures 1 and 2). In the frequency range of electrically short coupling lengths, the measured attenuation decreases with increasing length. Therefore, it is necessary to define the related length.

With electrically long lengths, the screening attenuation formed by the maximum envelope curve to the coupling voltage ratio is constant for a 6 dB/octave (20 dB/decade) increasing transfer impedance. Therefore, the screening attenuation is defined only at high frequencies.

The coupling length is electrically short, if

$$\lambda_0 / l > 10 \times \sqrt{\varepsilon_{r1}} \quad \text{or} \quad f < \frac{c_0}{10 \times l \times \sqrt{\varepsilon_{r1}}} \tag{5}$$

or electrically long, if

$$\lambda_0 / l \leq 2 \times \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right| \quad \text{or} \quad f > \frac{c_0}{2 \times l \times \left| \sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}} \right|} \tag{6}$$

where

l is the effective coupling length in metres (approximately 2 m in Figure 3);

λ_0 is the free space wavelength in metres;

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.

The measured voltage ratio is related to the transfer impedance Z_T for electrically short coupling length by

$$Z_T \times l \approx Z_1 \times \left| \frac{U_2}{U_1} \right| \quad (7)$$

Also, at high frequencies, Z_T can be calculated if Z_F is negligible:

$$Z_T \approx \left| \frac{\omega \times \sqrt{Z_1 \times R} \times \left| \varepsilon_{r1} - \varepsilon_{r2} \right|}{2 \times c_o \times \sqrt{\varepsilon_{r1}}} \times \sqrt{\left| \frac{P_{2max}}{P_1} \right|} \right| \quad (8)$$

therefore

$$\sqrt{\left| \frac{P_{2max}}{P_1} \right|} \approx \left| \frac{Z_T \times 2 \times c_o \times \sqrt{\varepsilon_{r1}}}{\omega \times \sqrt{Z_1 \times R} \times \left| \varepsilon_{r1} - \varepsilon_{r2} \right|} \right| \quad (9)$$

A more detailed description of the subject is given in IEC 62153-4-1.

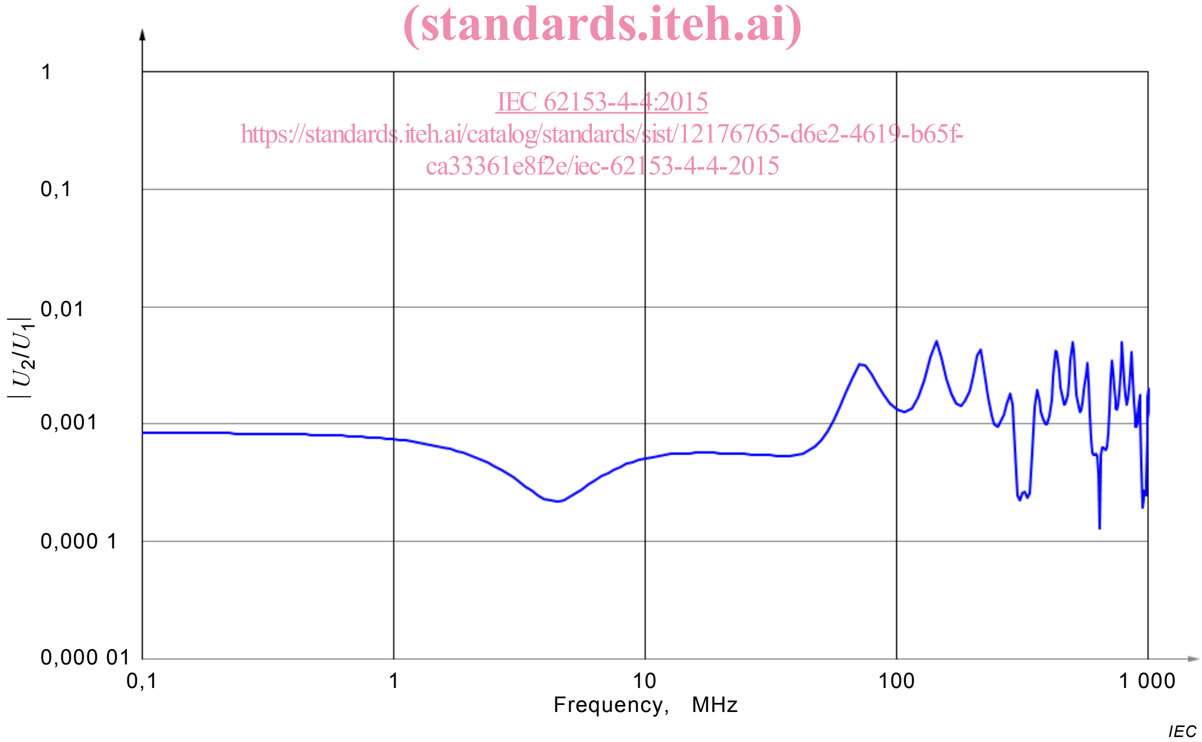

Figure 1 – Relationship of U_2/U_1 on a log (f) scale for a single braided cable

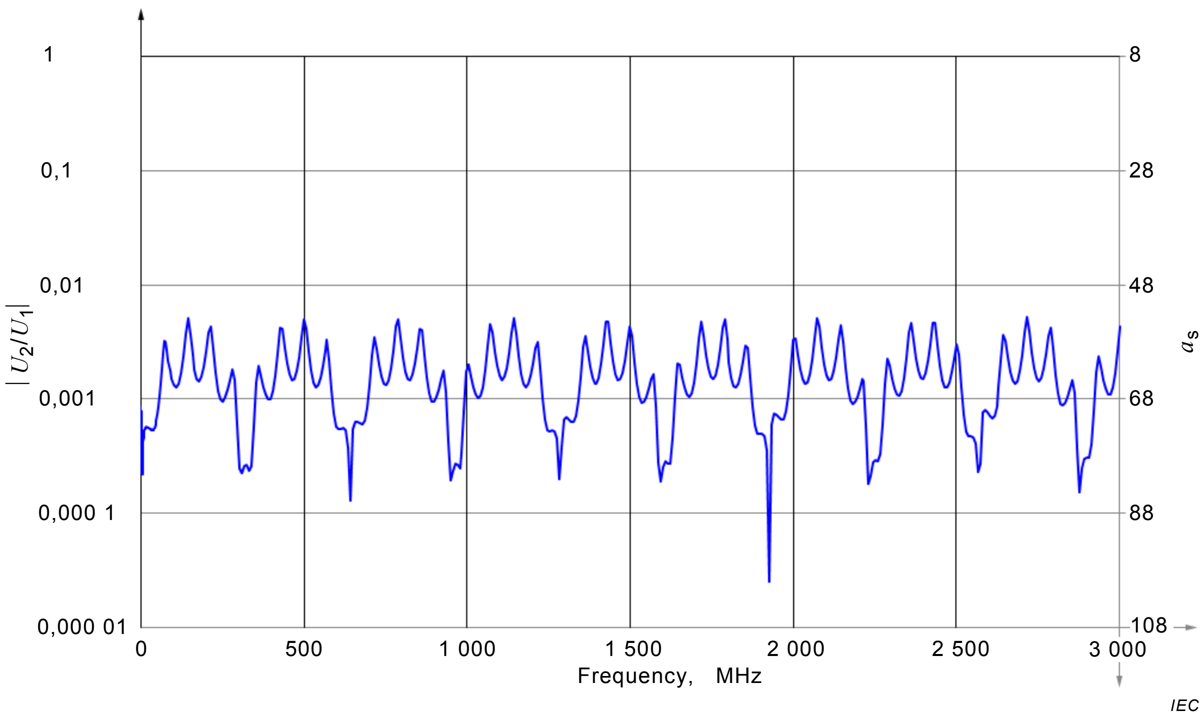

Figure 2 – Relationship of U_2/U_1 on a linear (f) scale and screening attenuation a_s on a linear (f) scale for a single braided cable

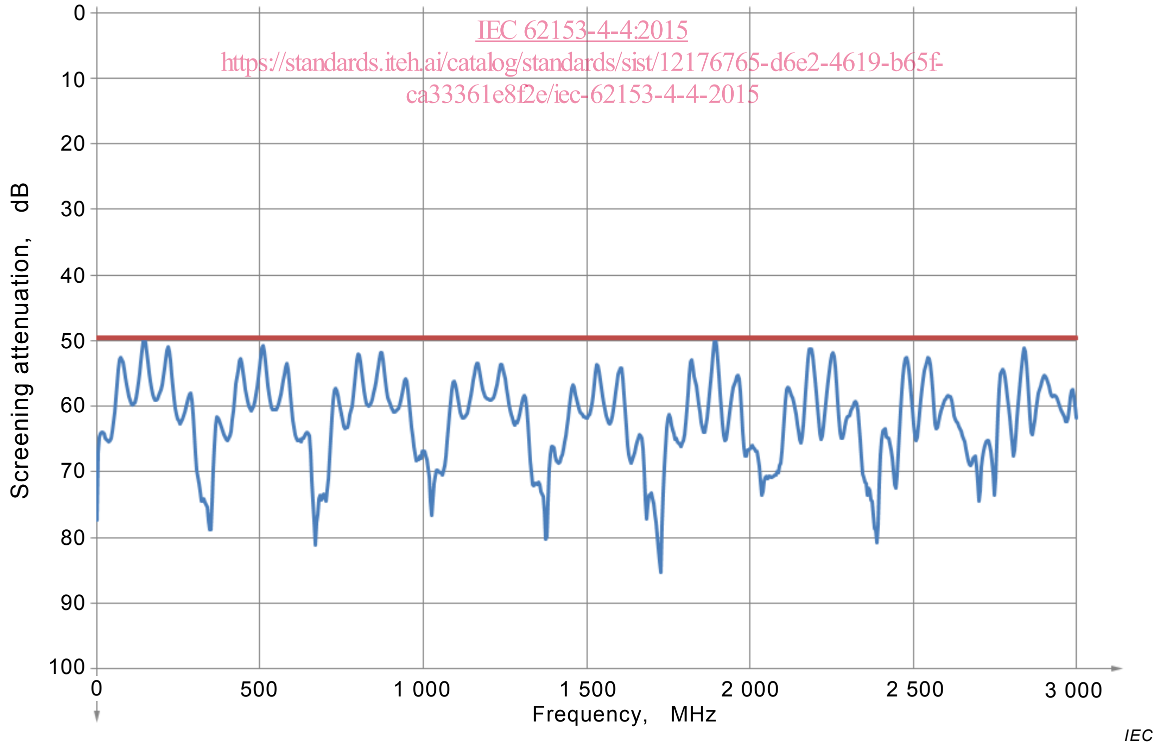

Figure 3 – Measured screening attenuation a_s formed by the maximum envelope curve to the measured coupling voltage ratio U_2/U_1 of a single braided cable