INTERNATIONAL STANDARD

IEC 62153-4-4

First edition
2006-05

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

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International Standard IEC 62153-4-4 has been prepared by subcommittee 46A: Coaxial cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

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

FDIS	Report on voting
46A/799/FDIS	46A/816/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.

IEC 62153 consists of the following parts under the general title *Metallic communication cable test methods:*

Part 1-1:	Electrical – Measurement of the pulse/step return loss in the frequency domain using the Inverse Discrete Fourier Transformation (IDFT)
Part 1-2:	Reflection measurement correction[1]
Part 4-0:	Electromagnetic Compatibility (EMC) – Relationship between Surface transfer impedance and Screening attenuation, recommended limits[1]
Part 4-1:	Electromagnetic Compatibility (EMC) – Introduction to electromagnetic (EMC) screening measurements[1]
Part 4-2:	Electromagnetic compatibility (EMC) – Screening and coupling attenuation – Injection clamp method
Part 4-3:	Electromagnetic Compatibility (EMC) – Surface transfer impedance – Triaxial method
Part 4-4:	Electromagnetic Compatibility (EMC) – Shielded screening attenuation, test method for measuring of the screening attenuation "as " up to and above 3 GHz
Part 4-5:	Electromagnetic Compatibility (EMC) – Coupling or screening attenuation – absorbing clamp method
Part 4-6:	Electromagnetic Compatibility (EMC) – Surface transfer impedance – line injection method
Part 4-7:	Electromagnetic Compatibility (EMC) – Shielded screening attenuation, test method for measuring the Transfer impedance ZT, the screening attenuation as and the coupling attenuation ac of RF-Connectors up to and above 3 GHz; Tube in Tube method
Part 4-8:	Electromagnetic Compatibility (EMC) – Capacitive Coupling Admittance [1]

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

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

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[1] Under consideration.

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

1 Scope

This part of IEC 62153 determines 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 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.

2 Normative references

The following referenced documents are indispensable for the application 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 61917:1998, *Cables, cable assemblies and connectors – Introduction to electromagnetic (EMC) screening measurements* [2]

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 the cable under test (150 Ω outer circuit impedance Z_2)
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

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[2] This is under revision and will be replaced by IEC 62153-4-1.

λ_o	vacuum wavelength
c_o	vacuum velocity
a_s	screening attenuation which is comparable to the results of the absorbing clamp method
a_{sn}	normalized screening attenuation (Z_S = 150 Ω and $\lvert\Delta v/v_1\rvert$ = 10 %)
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
P_S	radiated power in the normalized environment of the cable under test (Z_S = 150 Ω and $\lvert\Delta v/v_1\rvert$ = 10 %)

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

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

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

3.2 Theoretical background

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

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

i.e. formally **|** $A + B$ **|** × C × D, where AC is the far-end crosstalk, BC 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 AC and BC are given, if	$\varphi_{1,2} = (2N + 1) \times \pi$ and N is an integer.

A more detailed description of the subject will be given in future IEC 62153-4-1 (which is intended to be a revision of IEC 61917).

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.

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

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

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

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.

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 Relationship between length 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 increasing transfer impedance. Therefore, the screening attenuation is defined only at high frequencies.

The coupling length is electrically short, if

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

or electrically long, if

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

where

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

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

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

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

therefore

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

A more detailed description of the subject will be given in future IEC 62153-4-0 (which is intended to be a revision of IEC 61196-1:1995, Amendment 1:1999, Clause 14).

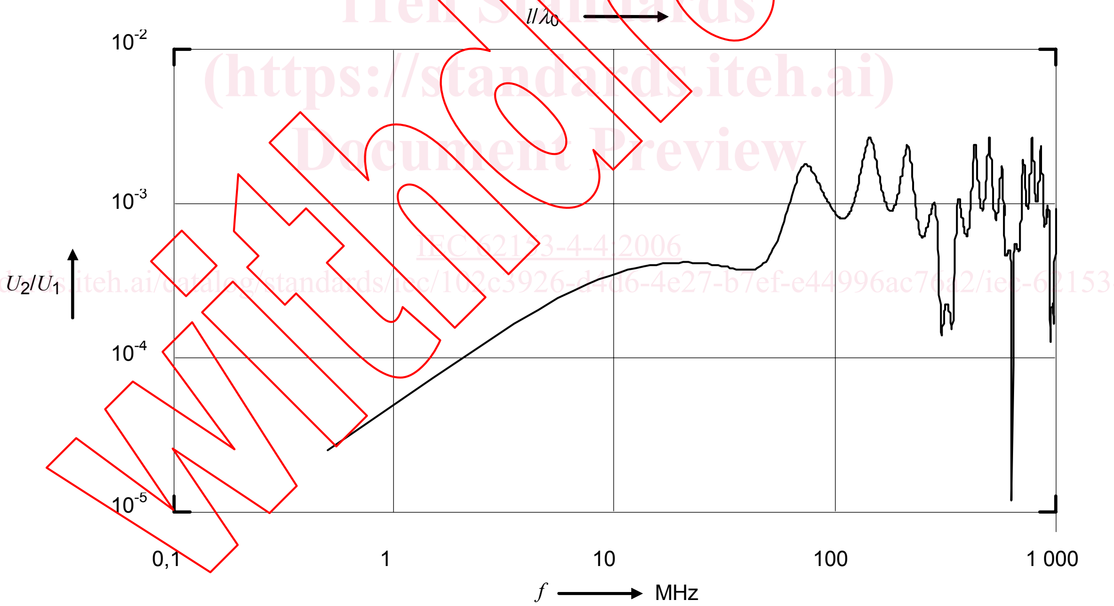

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Figure 1 – Relationship of U_2/U_1 on a log (f) scale for a single braided cable