IEC TS 62153-4-1

Edition 1.0 2014-01

TECHNICAL SPECIFICATION

colour inside

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

IEC TS 62153-4-1:2014-01(EN)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE XD

ICS 33.100

ISBN 978-2-8322-1311-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic screening measurements

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 62153-4-1, which is a technical specification, has been prepared by IEC technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

This first edition of technical specification IEC/TS 62153-4-1 cancels and replaces the second edition of the technical report IEC/TR 62153-4-1 published in 2010. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to IEC/TR 62153-4-1:

a) comparison of the frequency response of different triaxial test set-ups to measure the transfer impedance of cable screens;
b) background of the shielded screening attenuation test method (IEC 62153-4-4);
c) background of the shielded screening attenuation test method for measuring the screening effectiveness of feed-throughs and electromagnetic gaskets (IEC 62153-4-10);
d) background of the shielded screening attenuation test method for measuring the screening effectiveness of RF connectors and assemblies (IEC 62153-4-7).

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
46/465/DTS	46/492/RVC

Full information on the voting for the approval of this technical specification 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 of the IEC 62153 series, 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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- 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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METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic (EMC) screening measurements

1 Scope

This part of IEC 62153 deals with screening measurements. Screening (or shielding) is one basic way of achieving electromagnetic compatibility (EMC). However, a confusingly large number of methods and concepts is available to test for the screening quality of cables and related components, and for defining their quality. This technical specification gives a brief introduction to basic concepts and terms trying to reveal the common features of apparently different test methods. It is intended to assist in correct interpretation of test data, and in the better understanding of screening (or shielding) and related specifications and standards.

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 60096-1:1986, *Radio-frequency cables – Part 1: General requirements and measuring methods*[1]

IEC 60096-4-1, *Radio-frequency cables – Part 4: Specification for superscreened cables – Section 1: General requirements and test methods*[1]

IEC 60169-1-3, *Radio-frequency connectors - Part 1: General requirements and measuring methods - Section Three: Electrical tests and measuring procedures: Screening effectiveness*

IEC 61196-1:2005, *Coaxial communication cables - Part 1: Generic specification - General, definitions and requirements*

IEC 61726, *Cable assemblies, cables, connectors and passive microwave components - Screening attenuation measurement by the reverberation chamber method*

IEC 62153-4-2, *Metallic communication cable test methods - Part 4-2: Electromagnetic compatibility (EMC) - Screening and coupling attenuation - Injection clamp method*

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) - Shielded screening attenuation, test method for measuring of the screening attenuation as up to and above 3 GHz*

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

[1] This publication has been withdrawn.

IEC 62153-4-6, *Metallic communication cable test methods - Part 4-6: Electromagnetic compatibility (EMC) - Surface transfer impedance - Line injection method*

IEC 62153-4-7, *Metallic communication cable test methods - Part 4-7: Electromagnetic compatibility (EMC) - Test method for measuring the transfer impedance and the screening - or the coupling attenuation - Tube in tube method*

IEC 62153-4-10, *Metallic communication cable test methods - Part 4-10: Electromagnetic compatibility (EMC) - Shielded screening attenuation test method for measuring the screening effectiveness of feed-throughs and electromagnetic gaskets double coaxial method*

IEC/TR 62152:2009, *Transmission properties of cascaded two-ports or quadripols – Background of terms and definitions*

EN 50289-1-6: 2002, *Communication cables – Specifications for test methods Part 1-6: Electrical test methods – Electromagnetic performance*

CISPR 25, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*

3 Symbols interpretation

This clause gives the interpretation of the symbols used throughout this specification.

α_1, α_2 attenuation constants of primary and secondary circuit

a_s screening attenuation

a_{sn} normalized screening attenuation with phase velocity difference not greater than 10 % and 150 Ω characteristic impedance of the injection line

(Z_s=150 Ω and $|\Delta v/v_1|$=10 % or $\varepsilon_{r1}/\varepsilon_{r2n}$=1,21)

c_o velocity of light in free space

$c_o = 3 \times 10^8$ m/s

C_T through capacitance of the braided cable

CUT cable or component under test

E e.m.f.

f frequency

f far end

f_c cut-off frequency

f_{cf} far end cut-off frequency

f_{cn} near end cut-off frequency

Φ_1 the total flux of the magnetic field induced by the disturbing current I_1

Φ'_{12} the direct leaking magnetic flux

Φ''_{12} complete magnetic flux in the braid

I_1, U_1 current and voltage in the primary circuit (feeding system)

I_F current coupled by the feed through capacitance to the secondary system (measuring system)

ε_{r1} relative permittivity of the injection line (feeding system)

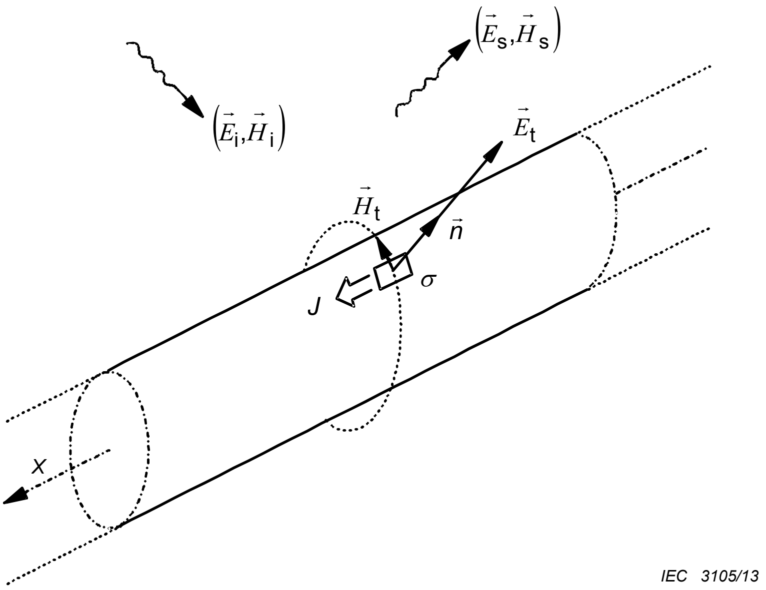
ε_{r2} relative permittivity of the cable (measuring system)

L	cable length, coupling length
L_1	(external) inductance of the outer circuit
L_2	(external) inductance of the inner circuit
M'_{12}	mutual inductance related to direct leakage of the magnetic flux Φ'_{12}
M''_{12}	mutual inductance related to the magnetic flux Φ''_{12} (or ½ Φ''_{12}) in the braid
	$M'_{12} = \frac{\Phi'_{12}}{j\omega I_1}$ and $M''_{12} = \frac{1}{2} \cdot \frac{\Phi''_{12}}{j\omega I_1}$
M_T	effective mutual inductance per unit length for braided screens
	$M_T = M'_{12} - M''_{12}$
	where M'_{12} relates to the direct leakage of the magnetic flux and M''_{12} relates to the magnetic flux in the braid [24]
n	near end
P_1	sending power
P_{2f}	far end measured power
P_{2n}	near end measured power
P_r	radiated power in the environment of the cable, which is comparable to $P_{2n}+P_{2f}$ of the absorbing clamp method of 12.4 of IEC 61196-1:1995
P_s	radiated power in the normalised environment of the cable under test
	(Z_s=150 Ω and $\lvert\Delta v/v_1\rvert$=10 % or $\varepsilon_{r1}/\varepsilon_{r2n}$=1,21)
R	load resistance of secondary circuit (input resistance of receiver)
R_T	screen resistance per unit length
T	coupling transfer function
T_f	far end transfer function
T_n	near end transfer function
U'_2	the disturbing voltage induced by Φ'_{12}
U''_{rh}	the disturbing voltage induced by ½ Φ''_{12} of the right hand lay contribution
U''_{lh}	the disturbing voltage induced by ½ Φ''_{12} of the left hand lay contribution
U''_2	is equal to U''_{rh} and U''_{lh} (= the disturbing voltage induced by ½ Φ''_{12})
v	phase velocity
v_1	phase velocity of the "primary" system (feeding system)
v_2	phase velocity of the "secondary" system (measuring system)
v_{r1}	relative phase velocity of the "primary" system (feeding system)
v_{r2}	relative phase velocity of the "secondary" system (measuring system)
Z_1	characteristic impedance of the "primary" system (feeding system or line (1))
Z_2	characteristic impedance of the cable under test (CUT) (measuring system or line (2))
Z_{1f}	terminating impedance of the line (1) in the far end
Z_{2n}	terminating impedance of the line (2) in the near end
Z_{2f}	terminating impedance of the line (2) in the far end (in a matched set-up
	$Z_{1f} = Z_1$ and $Z_{2n} = Z_{2f} = Z_2$)
	$Z_{12} = \sqrt{Z_1 Z_2}$

Z_a	surface impedance of the braided cable
Z_F	capacitive coupling impedance per unit length
Z_f	capacitive coupling impedance
Z_T	surface transfer impedance per unit length
Z_{Th}	transfer impedance of a tubular homogeneous screen per unit length
Z_t	surface transfer impedance
Z_{TEn}	effective transfer impedance (= $\mid Z_F + Z_T \mid$) per unit length in the near end
Z_{TEf}	effective transfer impedance (= $\mid Z_F - Z_T \mid$) per unit length in the far end
$Z_{TEn,f}$	effective transfer impedance (= $\mid Z_F \pm Z_T \mid$) per unit length in the near end or in the far end
Z_{TE}	effective transfer impedance (= max $\mid Z_{TEn}, Z_{TEf} \mid$) per unit length
Z_{te}	effective transfer impedance (= max $\mid Z_f \pm Z_t \mid$)
Z_{ten}	normalized effective transfer impedance of a cable
	(Z_1 = 150 Ω and $\mid v_1 - v_2 \mid / v_2 \leq$ 10 % velocity difference in relation to velocity of CUT

4 Electromagnetic phenomena

It is assumed that if an electromagnetic field is incident on a screened cable, there is only weak coupling between the external field and that inside, and that the cable diameter is very small compared with both the cable length and the wavelength of the incident field. The superposition of the external incident field and the field scattered by the cable yields the total electromagnetic field $(\vec{E}_t, \vec{H}_t)$ in Figure 1. The total field at the screen's surface may be considered as the source of the coupling; electric field penetrates through apertures by electric or capacitive coupling; also magnetic fields penetrate through apertures by inductive or magnetic coupling. In addition, the induced current in the screen results in conductive or resistive coupling.



Key

$(\vec{E}_i, \vec{H}_i)$	incident electromagnetic field
$(\vec{E}_s, \vec{H}_s)$	scattered electromagnetic field
$(\vec{E}_t, \vec{H}_t)$	total electromagnetic field
x	positive axial cable direction
σ	induced surface charge density- (C/m^2)
$\vec{n}$	unit vector normal to the surface
ε_o, ε_r	permittivity, free space and relative

Figure 1 – Total electromagnetic field $(\vec{E}_t, \vec{H}_t)$

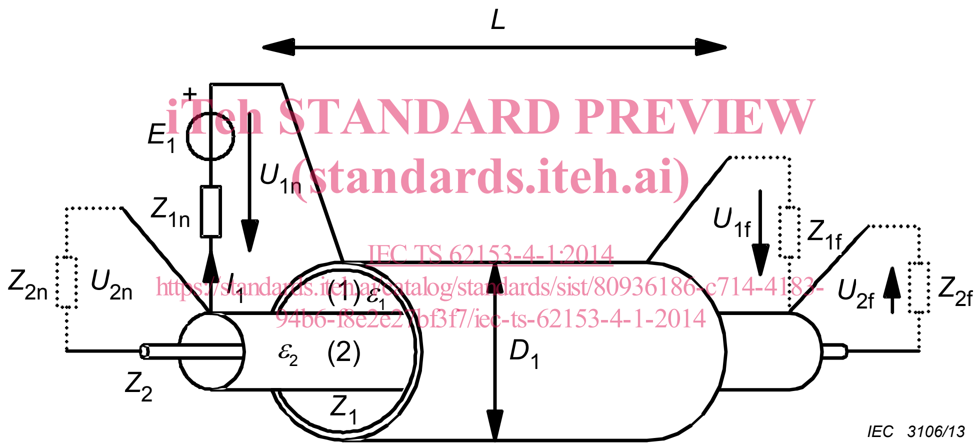
$$\left(\vec{E}_t, \vec{H}_t\right) = \left(\vec{E}_i, \vec{H}_i\right) + \left(\vec{E}_s, \vec{H}_s\right) \quad (1)$$

$$J = \vec{n} \cdot \vec{H}_t \quad (2)$$

$$\sigma = \vec{n} \cdot \vec{E}_t \varepsilon_o \varepsilon_r \quad (3)$$

where the symbols are described in the key of Figure 1.

As the field at the surface of the screen is directly related to density of surface current and surface charge, the coupling may be assigned either to the total field $\left(\vec{E}_t, \vec{H}_t\right)$ or to the surface current- and charge- densities (J and σ). Consequently, the coupling into the cable may be simulated by reproducing, through any suitable means, the surface currents and charges on the screen. Because the cable diameter is assumed to be small, the higher modes may be neglected and it is possible to use an additional coaxial conductor as the injection structure, as shown in Figure 2.



Key (for Figures 2,3,4,5)

(1), (2)	outer circuit (1), tube, respectively inner circuit (2), cable
$Z_{1,2}$	characteristic impedance of the outer circuit (1), tube, respectively inner circuit (2), cable
$\varepsilon_{1,2}$	dielectric permittivity of the outer circuit (1), tube, respectively inner circuit (2), cable
$\beta_{1,2}$	phase constant of the outer circuit (1), tube, respectively inner circuit (2), cable
$\lambda_{1,2}$	wave length of the outer circuit (1), tube, respectively inner circuit (2), cable
L	coupling length
D_1	diameter of injection cylinder-tube
V	voltmeter
A	ammeter
Z_{1n}, Z_{1f}	load resistance at the near end, respectively far end of the outer circuit (1), tube
Z_{2n}, Z_{2f}	load resistance at the near end, respectively far end of the inner circuit (2), cable
E_1	EMF of the generator
I_1, I_2	current in the outer circuit (1), tube, respectively inner circuit (2), cable
U_{1n}, U_{1f}	voltage at the near end, respectively far end of the outer circuit (1), tube
U_{2n}, U_{2f}	voltage at the near end, respectively far end of the inner circuit (2), cable

Figure 2 – Defining and measuring screening parameters – A triaxial set-up