

TECHNICAL REPORT

**IEC
61917**

First edition
1998-06

Cables, cable assemblies and connectors – Introduction to electromagnetic (EMC) screening measurements

*Câbles, cordons et connecteurs –
Introduction aux mesures de blindage électromagnétique*



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TECHNICAL REPORT – TYPE 3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CABLES, CABLE ASSEMBLIES AND CONNECTORS –
INTRODUCTION TO ELECTROMAGNETIC (EMC)
SCREENING MEASUREMENTS**

FOREWORD

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- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 61917 which is a technical report type 3 has been prepared by subcommittee 46A: Coaxial cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, and accessories for communication and signalling.

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

Committee draft	Report on voting
46A/267/CDV	46A/284/RVC

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

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

Withdrawn

CABLES, CABLE ASSEMBLIES AND CONNECTORS – INTRODUCTION TO ELECTROMAGNETIC (EMC) SCREENING MEASUREMENTS

1 Scope and object

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 report gives a brief introduction to basic concepts and terms trying to reveal the common features of apparently different test methods. It should assist in correct interpretation of test data, and in the better understanding of screening (or shielding) and related specifications and standards.

2 Reference documents

IEC 60096-1:1986, *Radio-frequency cables – Part 1: General requirements and measuring methods*
Amendment 2 (1993)

IEC 60096-2:1961, *Radio-frequency cables – Part 2: Relevant cable specifications*
Amendment 1 (1990)

IEC 60096-4-1:1990, *Radio-frequency cables – Part 4: Specification for superscreened cables – Section 1: General requirements and test methods*

IEC 60169-1:1987, *Radio-frequency connectors – Part 1: General requirements and measuring methods*

IEC 60169-1-3:1988, *Radio frequency connectors – Part 1: General requirements and measuring methods – Section 3: Electrical tests and measuring procedures – Screening effectiveness*

IEC 61196-1:1995, *Radio-frequency cables – Part 1: Generic specification – General, definitions, requirements and test methods*

IEC 61726:1995, *Cable assemblies, cables, connectors and passive microwave components – Screening attenuation measurement by the reverberation chamber method*

3 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 (E_t , 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.

Additionally, the induced current in the screen results in *conductive* or resistive coupling.

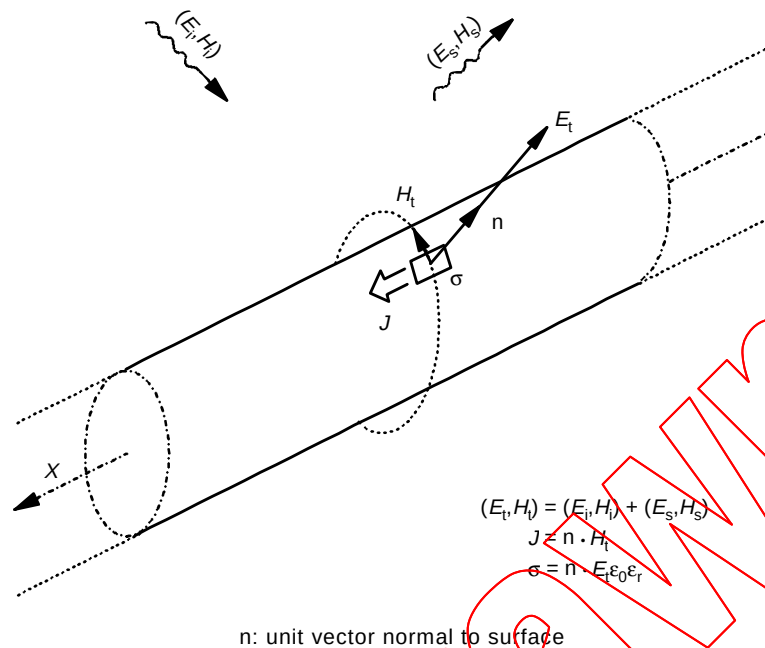
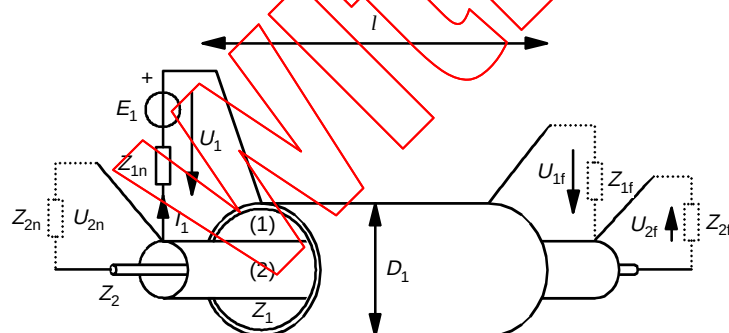


Figure 1 – Incident (i), scattered (s) and resulting total electromagnetic fields (E_t , H_t) with induced surface current- and surface charge-densities J (A/m) and σ (C/m²)

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 (E_t , H_t) or to the surface current- and charge- densities (J and σ). Consequently, we may simulate the coupling into the cable by reproducing through any means the surface currents and charges on the screen. Because we assume a cable of a small diameter, we may neglect higher modes and can use an additional coaxial conductor as our injection structure, as shown in figure 2.



Concept of a triaxial set-up

1) outer circuit, formed by injection cylinder and screen, characteristic impedance Z_1 ,

2) inner circuit, formed by a screen, and centre conductor, characteristic impedance Z_2 ; screening at the ends not shown.

Observe the conditions Z_{1f} , Z_{2n} , Z_{2f} and λ in figure 3a and figure 3b.

NOTE 1 – $D_1 \ll \lambda$.

NOTE 2 – Both ends of circuit (2) must be well screened.

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

4 The intrinsic screening parameters of short cables

The *intrinsic parameters* refer to an infinitesimal length of cable, like the inductance or capacitance per unit length of transmission lines. Assuming *electrically short cables*, with $l \ll \lambda$ which will always apply at low frequencies, the intrinsic screening parameters are defined and can be measured as follows:

4.1 Surface transfer impedance, Z_T

As shown in figure 2 and figure 3a (where Z_{1f} and Z_{2f} are zero):

$$Z_T = U_2 / (I_1 \cdot l) \quad (\Omega / m) \quad (4)$$

The dependence of Z_T on frequency is not simple and is often shown by plotting $\log Z_T$ against $\log$ frequency. Note that the phase of Z_T may have any value, depending on braid construction and frequency range.

NOTE – In circuit 2 of figure 3a the voltmeter and short circuit can be interchanged.

4.2 Capacitive coupling admittance, Y_C

As shown in figure 2 and figure 3b (where Z_{1f} and Z_{2f} are open circuit):

$$Y_C = j\omega C_T = I_2 / (U_1 \cdot l) \quad (\text{mho} / m) \quad (5)$$

The through capacitance (C_T) is a real capacitance and has usually a constant value up to 1 GHz and higher (with aperture $a \ll \lambda$).

While Z_T is independent of the characteristics of the coaxial circuits, C_T is dependent on those characteristics. There are two ways of overcoming this dependence:

- a) The *normalized through elastance* K_T derived from C_T is independent of the size of the outer coaxial circuit, but it depends on its permittivity:

$$K_T = C_T / (C_1 + C_2) \quad (m / F) \quad K_T \sim 1 / (\epsilon_{r1} + \epsilon_{r2}) \quad (6) \quad (7)$$

where C_1 and C_2 are the capacitance per unit length of the two coaxial circuits.

- b) The *capacitive coupling impedance* Z_F again derived from C_T is also independent of the size of the outer coaxial circuit and, for practical values of ϵ_{r1} , is only slightly dependent on its permittivity:

$$Z_F = Z_1 Z_2 Y_C = Z_1 Z_2 j\omega C_T \quad (\Omega / m) \quad Z_F \sim \sqrt{(\epsilon_{r1} \cdot \epsilon_{r2})} / (\epsilon_{r1} + \epsilon_{r2}) \quad (8) \quad (9)$$

Compared with Z_T , Z_F is usually negligible, except for open weave braids. It may, however, be significant when Z_{2n} and $Z_{2f} \gg Z_2$ (audio circuits).

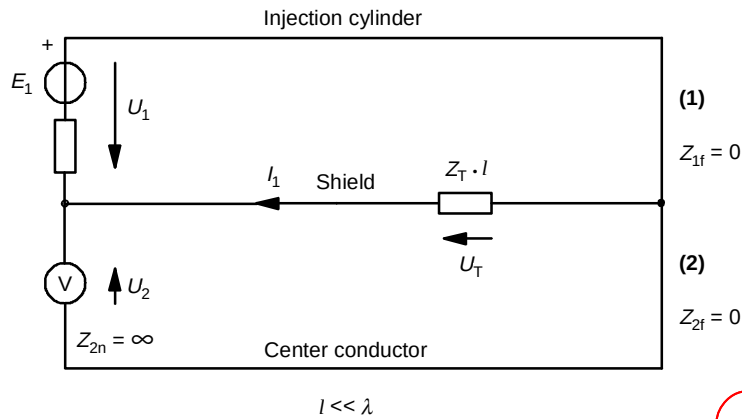


Figure 3a – Equivalent circuit for the definition and possible testing of Z

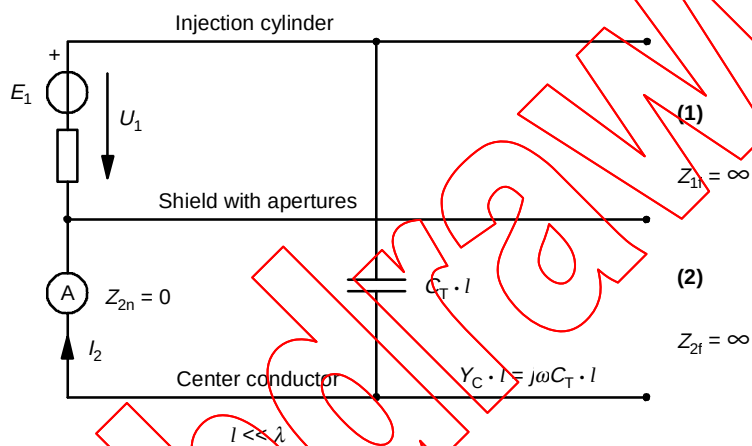
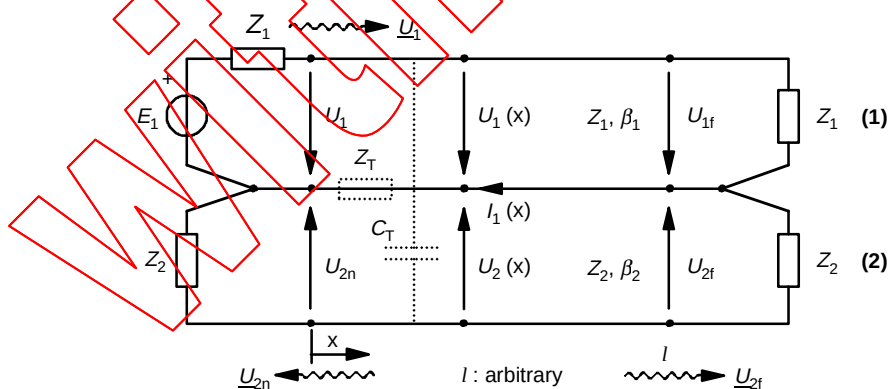


Figure 3b – Equivalent circuit for the definition and possible testing of $Y_c = j \omega C_T$



NOTE – Z_T and C_T are distributed (not correctly shown here). The loads Z_2 at the ends may represent matched receivers.

Figure 3c – Definition of electrical quantities in a set-up that is matched at all ends

Figure 3 – Defining and measuring screen parameters – Equivalent circuits