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Electromagnetic characteristics of linear cable management systems (CMS)

National foreword

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Electromagnetic characteristics of linear cable management systems (CMS)

Rapport Technique - Caractéristiques électromagnétiques des systèmes linéaires de câblage

Elektromagnetische Eigenschaften von linearen Kabelführungssystemen

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Contents

European foreword

This document (CLC/TR 50659:2017) has been prepared by CLC/TC 213, “Cable management systems”.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This Technical Report provides test methods for the measurement of electromagnetic characteristics of linear Cable Management Systems (CMS).

This is a European Technical Report for cable management products used for electro-technical purposes. It relates to the Council Directives on the approximation of laws, regulations and administrative provisions of the Member States relating to Low Voltage Directive 2014/35/EU through consideration of the essential requirements of this Directive.

This European Technical Report is supported by separate standards to which references are made.

1 Scope

This Technical Report provides test methods for the measurement of the following electromagnetic characteristics of lengthwise cable management systems like conduit systems according to EN 61386 series, cable trunking systems and cable ducting systems (CTS/CDS) according to EN 50085 series and cable tray and cable ladder systems according to EN 61537:

— shielding effectiveness of magnetic field,

— transfer impedance.

This Technical Report also provides guidance on how these characteristics can be declared and may be used.

Powertrack systems covered by EN 61534 series are not covered by this edition of the Technical Report and may be considered in a new edition.

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.

EN 61000-4-5, *Electromagnetic Compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test (IEC 61000-4-5)*

EN 61000-5-7, *Electromagnetic compatibility (EMC) - Part 5-7: Installation and mitigation guidelines - Degrees of protection by enclosures against electromagnetic disturbances (EM code)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
shielding effectiveness
SE
ability of a cable management system to attenuate an electromagnetic signal as it enters or exits the CMS, quantified as the ratio of a signal received (from a transmitter) without the shield, to the signal received with the shield in place

3.2
magnetic field
constituent of an electromagnetic field which is characterized by the magnetic field strength H together with the magnetic flux density B

Note 1 to entry: In French, the term “champ magnétique” is also used for the quantity magnetic field strength.

[SOURCE: IEV 121-11-69]

3.3
signal to noise ratio
SNR
ratio in dB between the measured peak current $I_{1,\max}$ in the current loop when the current probe is connected to the current loop and the measured peak current $I_{N,\max}$ when the current probe is not connected to the current loop but in a narrow position of the current loop. Both peak currents measured at the same excitation current in the excitation winding

$$SNR\ (dB) = 20 \times \log\left(\frac{I_{1,\max}}{I_{N,\max}}\right)$$

Note 1 to entry: $I_{1,\max}$ and $I_{N,\max}$ show their maxima at different time.

3.4
electromagnetic shielding coding
coding system to indicate the degree of protection provided by a CMS against the passage of electromagnetic energy

3.5
CMS transfer impedance
Z_{CMS}
ratio of a voltage drop, between two specified points, caused by a disturbing current flowing through the cable management system and the disturbing current

This voltage drop is a combination of

- the voltage drop along this cable management system due to the current flowing through this cable management system and

- the voltage drop along a conductor contained in this cable management system due to the magnetic field arising from the current flowing through this cable management system.

3.6
virtual CMS transfer impedance
$Z_{v\ CMS}$
CMS transfer impedance defined by the ratio of the maximum asymmetrical mode voltage and the maximum disturbing current during a time domain pulse

3.7
common mode voltage (or asymmetrical voltage V_{AS})
mean of the phasor voltages appearing between each conductor and a specified reference, usually earth or frame

[SOURCE: IEV 161-04-09, modified]

3.8
shielded enclosure (or screened room)
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and the external environment

[SOURCE: IEV 161-04-37]

4 Shielding effectiveness of magnetic field

4.1 Introduction

This Technical Report defines the test method for the determination of shielding effectiveness of magnetic field (SE) for lengthwise cable management systems (CMS).

The efficiency of a shielding is quantified by its shielding effectiveness (SE). The shielding effectiveness (SE) in this Technical Report is only intended for magnetic fields.

As an activating source a 8/20 µs impulses current shall be used.

The electrical field shielding effectiveness (SE) of metallic cable management systems is not covered by this Technical Report.

While a screen is a technical provision, the shielding effectiveness shows the performance of this screen with regard to Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI).

4.2 Declaration

4.2.1 General

The shielding effectiveness of magnetic field shall be declared using the electromagnetic shielding coding described in 4.2.2 and the additional rules described in 4.2.3.

4.2.2 Electromagnetic shielding coding

The electromagnetic shielding coding consists of “EM” followed by five positions according to Table 1.

Table 1 — Electromagnetic shielding coding

CMS Type	EM	First position	Second position	Third position	Fourth position	Fifth position
Cable tray and cable ladder systems	EM	A letter representing the frequency band as shown in Table 2	A number being the test result for CMS with cover running in a plane parallel to the plane of the excitation winding (Figure 2a)	A number being the test result for CMS without cover running in a plane parallel to the plane of the excitation winding (Figure 2b)	A number being the test result for CMS with cover running in a plane perpendicular to the plane of the excitation winding (Figure 2c)	A number being the test result for CMS without cover running in a plane perpendicular to the plane of the excitation winding (Figure 2d)
Cable trunking systems	EM	A letter representing the frequency band as shown in Table 2	A number being the test result for CMS with cover running in a plane parallel to the plane of the excitation winding (Figure 2a)	NA	A number being the test result for CMS with cover running in a plane perpendicular to the plane of the excitation winding (Figure 2c)	NA
Cable ducting systems	EM	A letter representing the frequency band as shown in Table 2	A number being the test result for CMS with the larger dimension running in a plane parallel to the plane of the excitation winding (Figure 2a)	NA	A number being the test result for CMS with the larger dimension running in a plane perpendicular to the plane of the excitation winding (Figure 2c)	NA
Conduit systems	EM	A letter representing the frequency band as shown in Table 2	A number being the test result for CMS running in the plane of the excitation winding (Figure 2a)	NA	A number being the test result for CMS running in the plane of the excitation winding (Figure 2c)	NA
NOTE “NA” means “not applicable”.						

Table 2 — Frequency band code

Frequency band	Frequency band code
10 kHz - 100 kHz	A
100 kHz - 1 MHz	B

The test method currently using 8/20 µs impulses current included in this Technical Report only allows declaration for frequency band 10 kHz – 100 kHz (Frequency band code A).

4.2.3 Additional rules

The declared shielding effectiveness shall be the measured shielding effectiveness in dB rounded to the closest integer, always using two digits.

Examples: 17,49 dB will be 17 and 17,5 dB will be 18. 9,2 dB will be 09.

When shielding effectiveness can be declared, “XX” means not declared.

4.2.4 Example of declaration

Declaring for a cable tray system “EM A-37-20-09-XX” for shielding effectiveness of magnetic field means, for a frequency band of 10 kHz - 100 kHz,

— a shielding effectiveness of 37 dB for CMS with cover running in a plane parallel to the plane of the excitation winding

— a shielding effectiveness of 20 dB for CMS without cover running in a plane parallel to the plane of the excitation winding

— a shielding effectiveness of 9 dB for CMS with cover running in a plane perpendicular to the plane of the excitation winding

— a shielding effectiveness not declared for CMS without cover running in a plane perpendicular to the plane of the excitation winding

Declaring for a cable trunking system “EM A-37-NA-09-NA” for shielding effectiveness of magnetic field means, for a frequency band of 10 kHz - 100 kHz,

— a shielding effectiveness of 37 dB for CMS with cover running in a plane parallel to the plane of the excitation winding

— a shielding effectiveness of 9 dB for CMS with cover running in a plane perpendicular to the plane of the excitation winding

Declaring for a conduit system “EM A-70-NA-70-NA” for shielding effectiveness of magnetic field means, for a frequency band of 10 kHz - 100 kHz,

— a shielding effectiveness of 70 dB for CMS running in the plane of the excitation winding.

4.3 Test arrangement

4.3.1 General

The test arrangement is shown in Figures 1a to 1c.

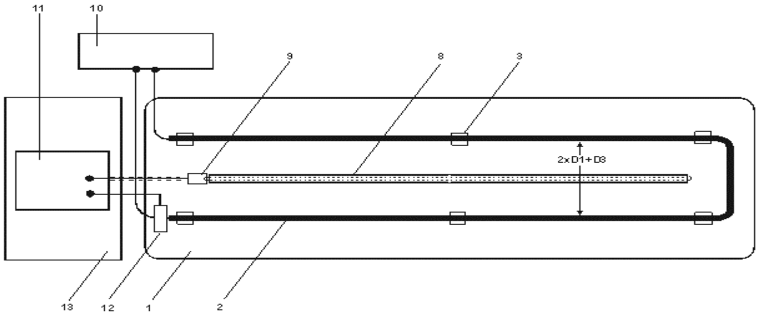


Figure 1a — Test arrangement without CMS

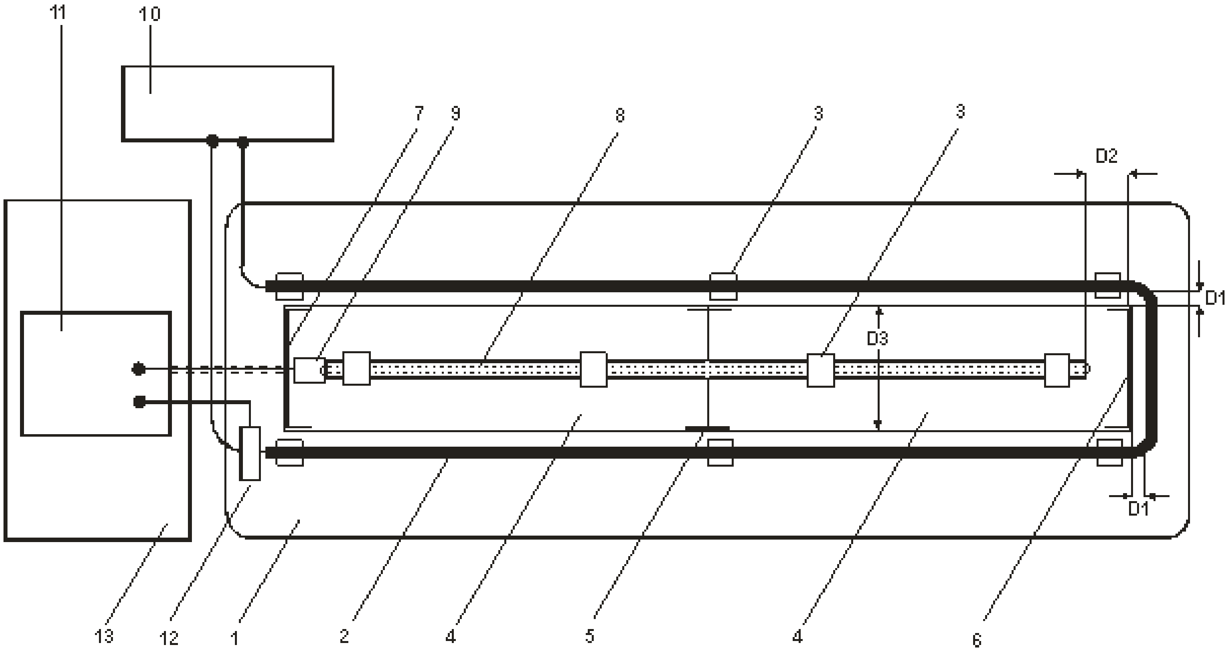


Figure 1b — Test arrangement for CMS without cover

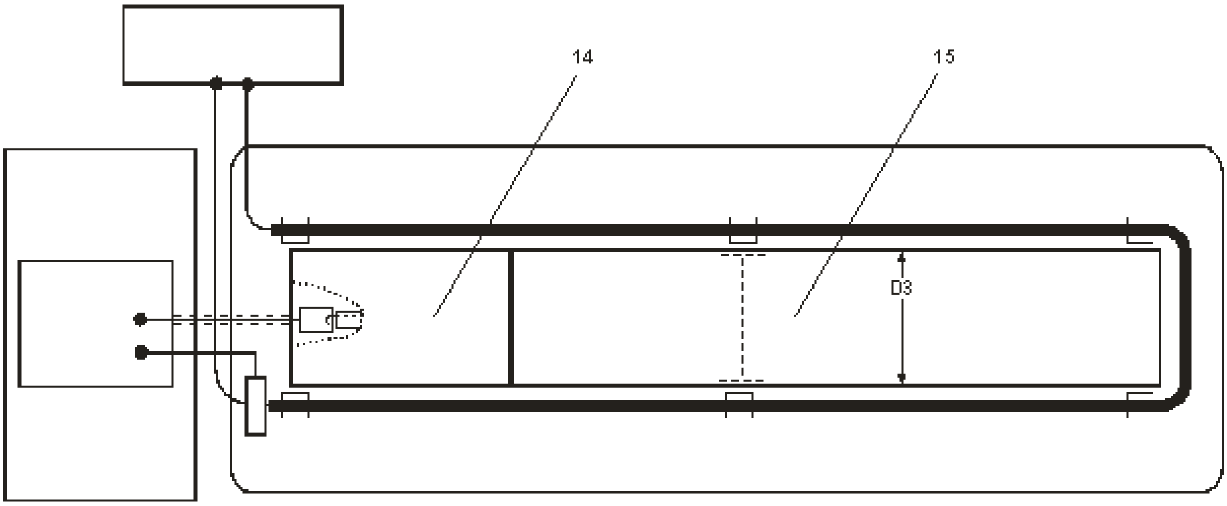


Figure 1c — Test arrangement for CMS with cover

Key

1	table without any conductive part
2	excitation winding
3	plastic fixings
4	samples each (1000 ± 3) mm
5	junction
6	terminating fitting
7	terminating fitting with central opening of up to approximately 50 mm x 50 mm
8	current loop
9	current probe
10	surge current generator
11	oscilloscope
12	current probe excitation winding
13	shielding cabinet
14	cover (500 ± 3) mm
15	cover (1500 ± 3) mm
D1	gap between excitation winding and sample (30 ± 3) mm
D2	gap between current loop and terminating fitting if any or extremity of the sample (150 ± 5) mm on both sides
D3	width of the sample measured in the plane of the excitation winding

Figure 1 — Test arrangement for the measurement of shielding effectiveness of magnetic field

The excitation winding shall be spaced at least 800 mm from any conductive part in any direction except on the feeding side.

4.3.2 Table

The test arrangement shall be placed on a table made of non conductive material (example: wood). The table shall be sufficiently stable to carry safely all the components before and while testing. To avoid measurement errors, the table shall not have any conductive part and its height shall be at least 800 mm.

4.3.3 Sample

The sample shall consist of two lengths of the cable management system of (1000 ± 3) mm length and a system component for their junction, if any (coupler). Both ends of the sample shall be closed by a terminating fitting if it exists in the Cable Management System. In such a terminating fitting, an opening of up to approximately 50mm x 50mm (diameter 50mm) can be made to insert a current probe and connect the current probe to the current loop.

The sample shall be installed according to the manufacturer's instructions, e.g. with the recommended torques.

4.3.4 Excitation winding

The excitation winding shall consist of a copper tube having a diameter of at least 28 mm and a wall thickness of at least 1,5 mm together with the relevant fittings or means providing appropriate junction and connection. All parts of the excitation winding shall be connected in a way providing high conductivity with means, such as, soldering, screwing, etc. allowing an effective contact on the whole circumference of the tube. High conductivity shall be checked by measuring the contact resistance, with a current of at least 10 A, which shall not be higher than 10 mΩ.

NOTE The 1,5 mm minimum thickness of the wall of the copper tube is intended to provide adequate resistance to bending of the tube during the test.

The excitation winding shall be fixed with non conductive elements to avoid movement during testing.

The width of the excitation winding shall be such that the distance to the CMS is 30 mm ± 3 mm.

4.3.5 Surge current generator

The test shall be carried out with a hybrid surge current generator of 8/20 μs impulses according to EN 61000-4-5 with 2 Ω output impedance and capable of generating a wave shape with a peak current above 200 A.

When connected to the excitation winding, the tolerance of the shape of the current shall be:

- peak current I_{max}: ± 10 %
- wave front duration T_1: ± 30 %
- time to half value T_2: ± 20 %
- minimum peak current 200 A

NOTE The inductance of a 60 cm wide CMS and a 2 m long excitation winding can reach a value of around 8 μH.

4.3.6 Current loop

The current loop shall consist of a flexible copper conductor with a cross section of 2,5mm^2, fixed by a non-metallic support preferably made of plastic or wood (see Figure 3 for an example). The centre distance d (see Figure 3) of the copper conductors shall be 30 mm ± 1mm or 10 mm ± 1mm for smaller CMS.

Compliance with this distance can be checked by measuring the spacing between the grooves accommodating the copper conductor in the insulated holder.

NOTE For cable management systems that cannot be opened (e.g. CDS and conduits) having an internal diameter less than 30 mm the distance d of the copper conductors may be reduced to 10 mm.

The current loop shall be fixed in the plane of the excitation winding, in the centre of the excitation winding (±1 mm) (see Figure 2). The distance between the current loop and the terminating fitting, if any, or extremity of the sample shall be (150 ± 5) mm (See D2 in Figure 1).

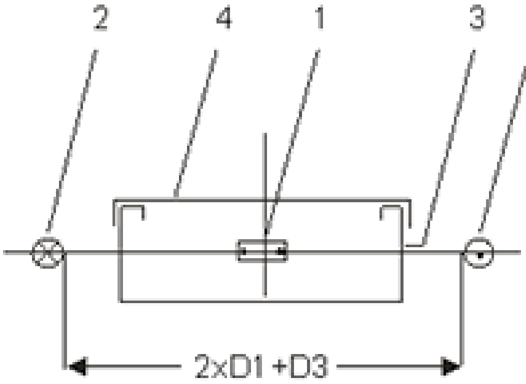


Figure 2a — For CMS with cover running in a plane parallel to the plane of the excitation winding

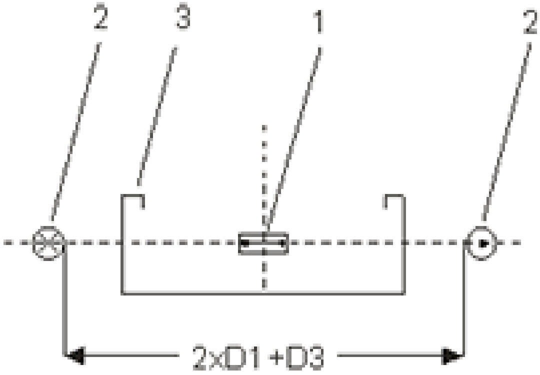


Figure 2b — For CMS without cover running in a plane parallel to the plane of the excitation winding

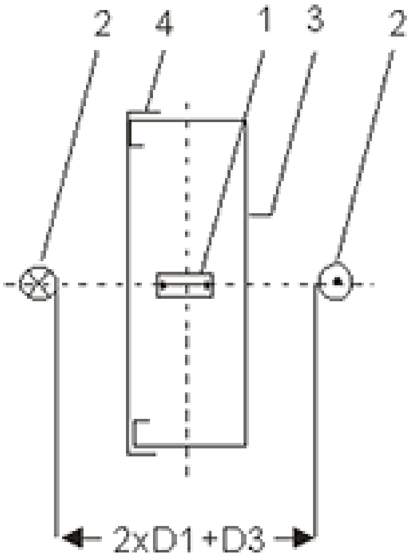


Figure 2c — For CMS with cover running in a plane perpendicular to the plane of the excitation winding

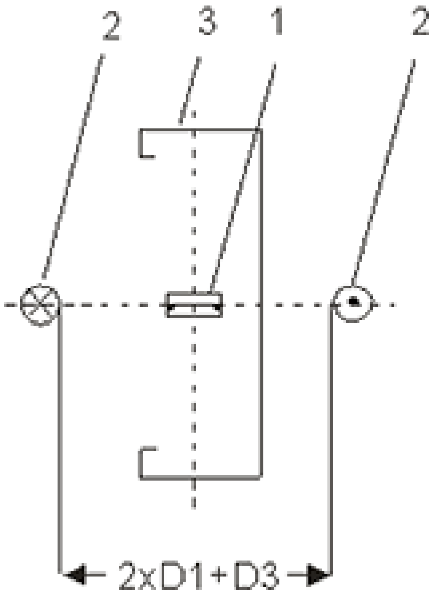
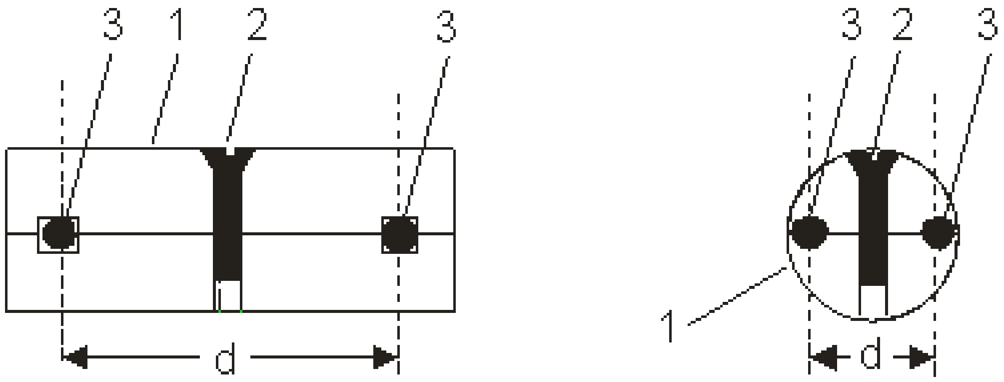


Figure 2d — For CMS without cover running in a plane perpendicular to the plane of the excitation winding

Key

1	current loop
2	excitation winding
3	cable tray/ladder or base of trunking
4	cover
D1	gap between excitation winding and sample (30 ± 3) mm
D3	width of the sample measured in the plane of the excitation winding

Figure 2 — Position of the current loop within the sample



Key

1	insulated holder
2	plastic screw
3	flexible copper conductor 2,5 mm^2
d	distance 30 mm ± 1 mm or for small CMS 10 mm ± 1 mm

Figure 3 — Examples for arrangements of the current loop

4.3.7 Current probe

The current in the current loop shall be measured with a probe.

The bandwidth of the probe shall be at least 50 MHz. The uncertainty in measurement of the scaling factor shall be less than 3 %.

When using Hall effect probe, it is necessary to degauss the current probe at each measurement to avoid any unwanted offset.

The lower cut off frequency shall be lower than 1 kHz and the upper cut off frequency shall be greater than 50 MHz in order to measure the current correctly and within 3 % accuracy. This requirement originates from the spectra of an 8/20 µs impulses current as shown in Figure 4.

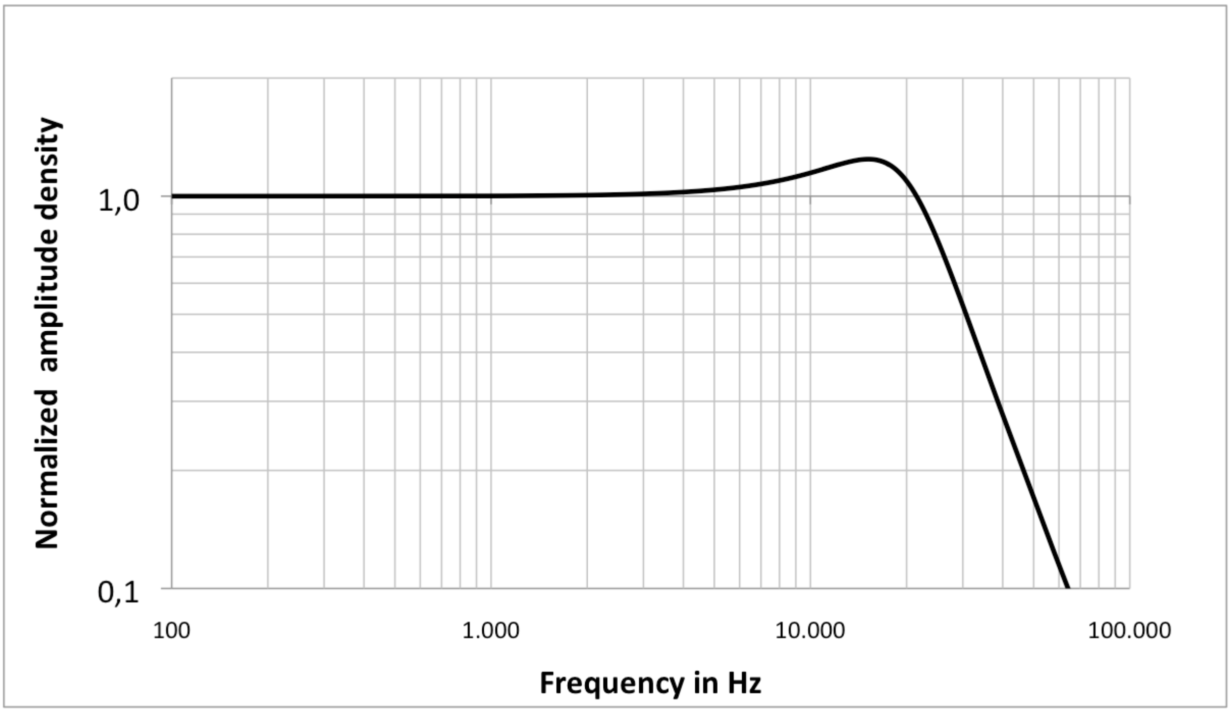


Figure 4 — Spectra of a 8/20 µs impulses current

The current probe for the measurement of the loop current shall be capable of measuring small currents of some 10 mA in the environment of the magnetic field of the excitation winding which is feed by some 100 A. Therefore, a good shielding of the current probe is recommended.

4.3.8 Shielding cabinet for the measuring equipment

It is recommended to use a steel cabinet with connected mains filter to achieve the required signal to noise ratio SNR of at least 26 dB. It is recommended to arrange the oscilloscope and, if applicable, the receiver of the current probe inside the shielding cabinet.

4.3.9 Oscilloscope

The bandwidth of the oscilloscope shall be at least 50 MHz. The uncertainty in measurement shall be less than 3 %.

4.4 Test method

4.4.1 Climatic conditions

The climatic conditions in the laboratory shall be within any limits specified for the operation of the test equipment by their respective manufacturers.

4.4.2 Conditioning/Ageing

The sample shall be aged as follows:

The necessity to carry out conditioning or ageing before the shielding effectiveness test is under consideration.

4.4.3 Principle

Relative measurements are used for the determination of the shielding effectiveness (SE) of cable management systems (CMS) so that the absolute values are irrelevant.

4.4.4 Measurement of the signal to noise ratio (SNR)

Before each comparative measurement the SNR shall be determined according to the following procedure:

1) Connect the current probe to the current loop and inject 3 times a surge current of 8/20 µs impulses of e.g. 200 A into the excitation winding. Measure the peak current $I_{1,\max}$ in the current loop.

   The average of the 3 measurements is calculated.

2) Disconnect the current probe but leave it in a narrow position of the current loop. Inject the same current 3 times into the excitation winding, e.g. 200 A. Measure the peak noise current $I_{\mathrm{N,max}}$ in the current loop.

   The average of the 3 measurements is calculated.

3) Determine the SNR as follows:

$$SNR\ (dB) = 20 \times \log\left(\frac{I_{1,\max}}{I_{N,\max}}\right)$$

The SNR shall be at least 26 dB.

4.4.5 Measurement of the shielding effectiveness (SE)

4.4.5.1 General

The arrangement of the excitation winding, the current loop, the current probe and the line to the oscilloscope shall be the same for the measurement without CMS and the measurement with the tested CMS (see Figure 1).

Measurements shall be carried out in different positions in accordance with the manufacturer’s declaration according to 4.2.

4.4.5.2 Measurement of the reference values $I_{0,\max}$ and $I_{\mathrm{ref,max}}$ without CMS

The current loop shall be arranged as shown in Figure 1a and Figure 3 without CMS. A surge current of 8/20 µs impulses is injected 3 times into the excitation winding. The peak value $I_{0,\max}$ of the injected current in the excitation winding as well as the peak value $I_{\mathrm{ref,max}}$ in the current loop shall be recorded.

4.4.5.3 Measurement of the values $I_{0,\max}$ and $I_{\mathrm{sample,max}}$ with CMS

The CMS shall be arranged according to Figure 1b or Figure 1c. A surge current of 8/20 µs impulses with the same peak value $I_{0,\max}$ as in 4.4.5.2 is injected 3 times into the excitation winding. The peak value $I_{0,\max}$ of the injected current in the excitation winding as well as the peak value $I_{\mathrm{sample,max}}$ in the current loop shall be recorded.

4.4.5.4 Results

The shielding effectiveness (SE) is calculated based on the measured results according to EN 61000-5-7:

$$SE\ (dB) = 20 \times \log\left(\frac{I_{ref,\max}}{I_{sample,\max}}\right)$$

where

$I_{\text{ref,max}}$ is the averaged measured peak value in the current loop when a current with a peak value of $I_{0,\max}$ is injected in the excitation winding without CMS.

$I_{\text{sample,max}}$ is the averaged measured peak value in the current loop when a current with a peak value of $I_{0,\max}$ is injected in the excitation winding with CMS.

For both measurements (without CMS and with CMS) the peak value $I_{0,\max}$ shall be the same.

4.5 Test report

The test report shall contain:

— Client details

— Tested products – description and identification of the samples

— Performed Tests

— Basic conditions of test samples and remarks

— Test results

— Deviations

— Validation of test results

— Date and location of the test

— Test laboratory details – name and signature of test engineer and supervisor

— Details of measuring devices and test equipment used (technical data)

4.6 Possible use of the declared shielding effectiveness

Each installation requires a shielding effectiveness to guarantee an appropriate immunity level.

In an installation including parallel power cables and signal cables, shielding effectiveness has to be provided by the cables, the cable management system and the distance between power cables and data cables:

$$SE_{\text{required}}\ (\text{dB}) = SE_{\text{cables}}\ (\text{dB}) + SE_{\text{CMS}}\ (\text{dB}) + SE_{\text{distance}}\ (\text{dB})$$

For a required shielding effectiveness of the installation and for selected cables, the shielding effectiveness provided by the distance can be reduced when the shielding effectiveness of the cable management system increases.

$$SE_{\text{distance}}\ (\text{dB}) = SE_{\text{required}}\ (\text{dB}) - SE_{\text{cables}}\ (\text{dB}) - SE_{\text{CMS}}\ (\text{dB})$$

Enlarging the distance increases the shielding effectiveness provided by the distance and vice versa. Therefore, increasing the shielding effectiveness of the cable management system allows reducing the distance between parallel power cables and signal cables.

If the cable management system provides different shielding effectiveness depending on the direction (parallel or perpendicular), different distances have to be considered.

Informative Annex A includes an example of calculation of the reduction of distance required between parallel power cables and signal cables allowed by a cable management system.

EN 50174-2 requires the minimum distance between parallel power cables and signal cables for different applications depending on cables and cable management system.

NOTE CLC/TC 215 intends to revise EN 50174–2 taking into account in particular this Technical Report.

5 Transfer impedance

5.1 Introduction

The transfer impedance is an additional characteristic which can be measured to evaluate the capability of the CMS to mitigate electromagnetic disturbances.

CMS transfer impedance measures the ability of a conductive cable management system to develop a voltage drop when disturbing currents flow through this cable management system. This voltage drop is a combination of

— the voltage drop along this cable management system due to current flowing through this cable management system and

— the voltage drop along a conductor contained in this cable management system due to magnetic field arising from current flowing through this cable management system.

The CMS transfer impedance (Z_{CMS} in Ω) is defined as the ratio of the asymmetric mode voltage (V_{AS}) and the disturbance current (I_{CM}) causing it.

$$Z_{CMS} = \frac{V_{AS}}{I_{CM}}$$

If the length of the tested assembly is less than the wavelength, then the transfer impedance per meter is equal to the measured transfer impedance divided by the length of the sample

$$Z'_{CMS} = \frac{Z_{CMS}}{l} \text{ in } \Omega/\text{m}$$

NOTE Due to the 2 m long CMS test assembly, it is advised that the maximum frequency be lower than 20 MHz to avoid resonances issues. This condition is fulfilled by the 8/20 µs impulses current.

Z_{CMS} can be experimentally determined by injecting a disturbing current and measuring the resulting asymmetric mode voltage.

The results of these measurements give a way to compare the influence of different CMS. Lower transfer impedance means that a current flowing in the CMS has a lower effect on the victim wired equipment.

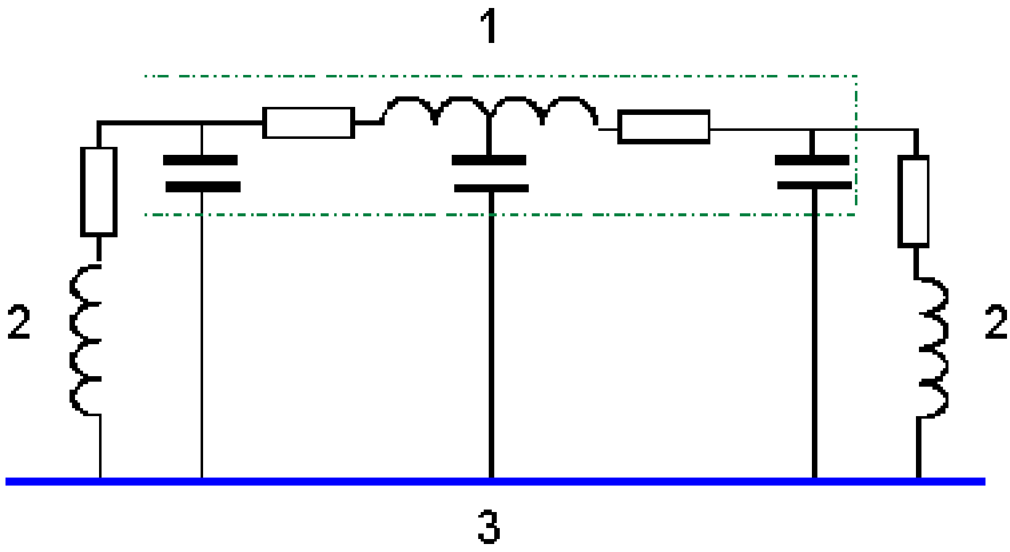
However, compared to shielding effectiveness covered in Clause 4, transfer impedance is generally associated with more difficulties for reliable measurements and for using these measurements.

The set-up and the installation conditions are very important to have meaningful and reproducible measurements.

To date, a lot of EMC tests have been performed to compare the influence of different metallic Cabling Management Systems (CMS). Nevertheless, the test results were similar because the high impedance of the bonding connection lengths between the CMS and the earthing / grounding reference hided the real difference between CMS (See Figure 5 and Figure 6).

The impedance of the bonding connection to the ground plan was much higher than the impedance of the CMS sections. The impedance of the bonding connections hided the lower impedance of the different CMS and as a consequence their influence.

Therefore, a new test arrangement is proposed as shown in Figure 7.



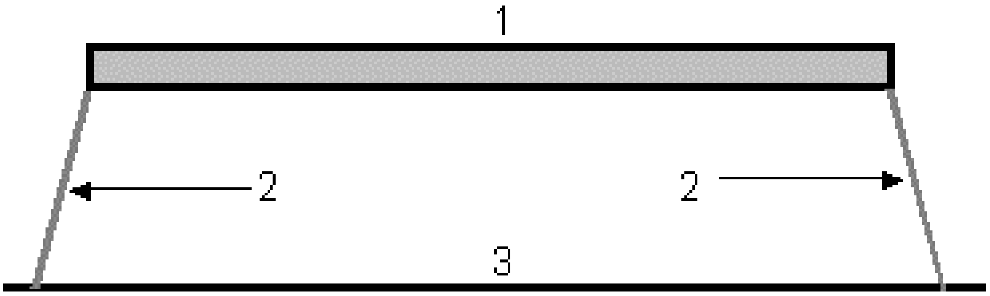
Key

1 cable Management System impedance

2 bonding impedance

3 ground plane

Figure 5 — Simplified system impedance



Key

1 cable Management System

2 very long bonding connections

3 ground plane

Figure 6 — Existing test installation

5.2 Declaration

Under consideration.

5.3 Test arrangement

This test arrangement is intended for time domain measurements (using a pulse) but can be used as base for frequency domain measurements (carried out at various frequencies).

The test arrangement is shown in Figure 7.

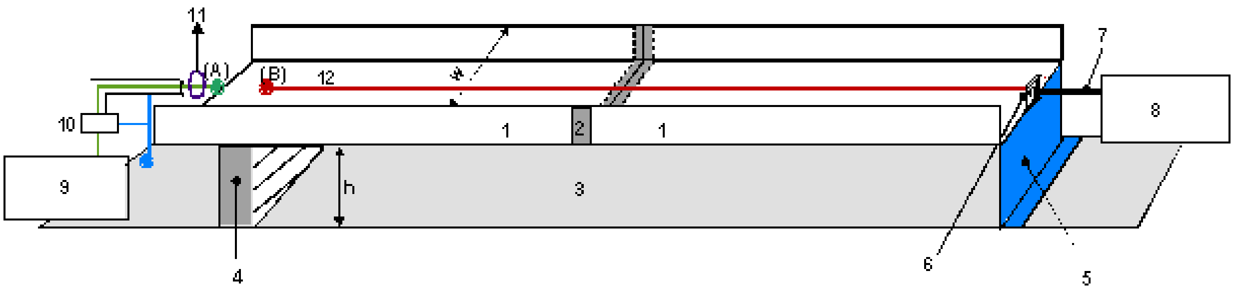


Figure 7a — Test configuration

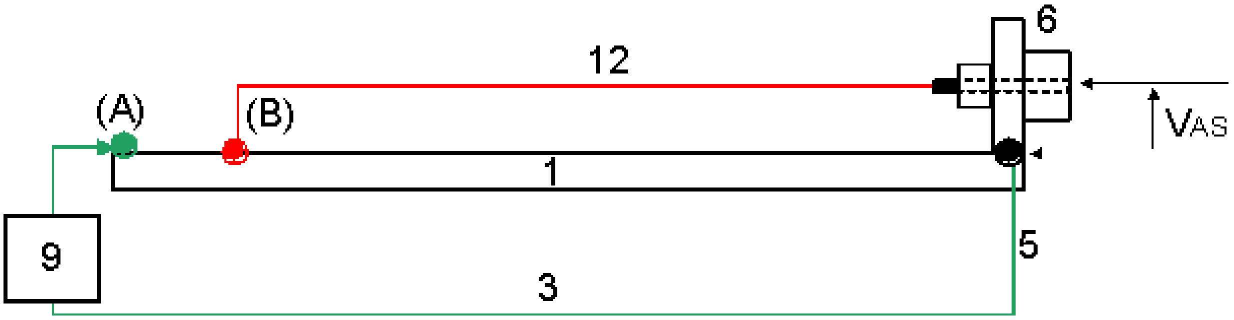


Figure 7b — Details of the connection of VAS measurement points

Key

1	piece of Cable Management System
2	junction between the 2 two pieces within the test assembly
3	ground plane foil
4	isolated wedge
5	large bonding connection
6	coaxial connector
7	coaxial cable
8	VAS measurement
9	Surge current generator
10	50 Ω coaxial maximum 6 dB attenuator to be used only for frequency domain measurements
11	current probe for measurement of ICM
12	insulated conductor
h	height of the test assembly above the ground plane foil
w	width of the Cable Management System
(A)	injection point
(B)	measurement point

Figure 7 — Test configuration

The test assembly shall be placed on a ground plane in accordance with the following conditions:

1) The ground plane is a copper foil at least 0,1 mm thick. Its width is at least 3 times the width of the tested CMS. Its length is at least 1,5 times the length of the test assembly.

NOTE A ground plane of 3 × 2 m is a good compromise for all CMS width.

2) The height (h) between the ground plane and the bottom of the test assembly is the half of the width w of the tested CMS width a tolerance of ± 10 mm.

3) The test assembly varies between both following tested configurations:

— Configuration 1: The test assembly is made of one single piece of 2000 mm ± 3 mm.

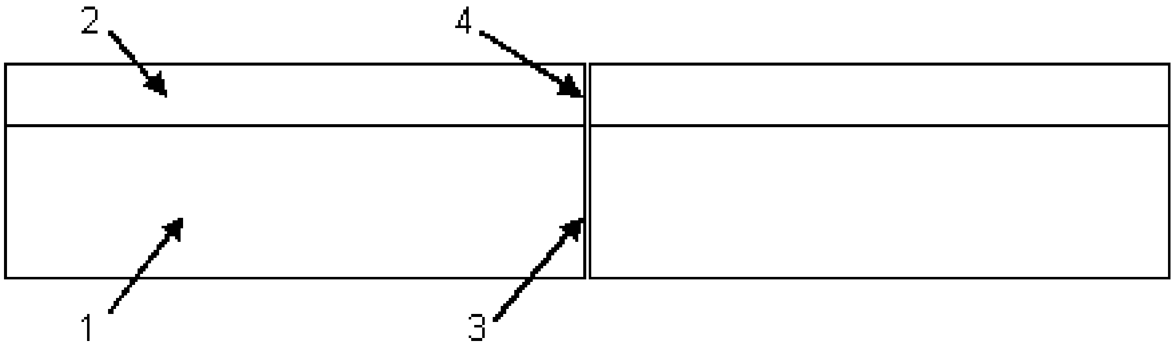
- Configuration 2: To assess the impact of the interconnection joints, the test assembly is composed of two pieces of 1000 mm ± 3 mm each, with one joint to connect the two pieces.

Unless otherwise specified in this test description, manufacturer's instructions for mounting shall be followed. In case of lack in manufacturer's instructions, provisions from the relevant products standard shall apply.

This applies for example to tightening torques.

For CMS which includes base and cover, the following additional conditions apply:

When manufacturer's instructions do not require shifting the junction between covers from the junction between bases, the test shall be made with the worst case condition: junction between covers in correspondence with the junction between bases as shown in Figure 8.

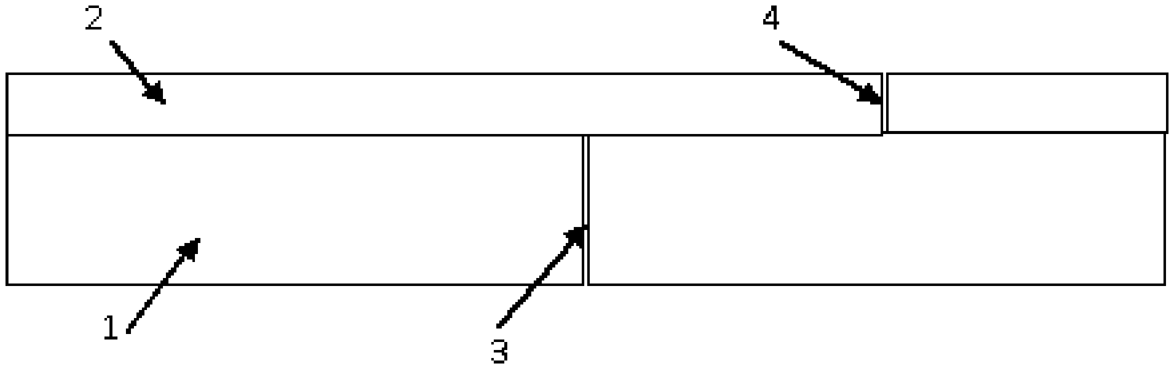


Key

1 base
2 cover
3 junction between bases
4 junction between covers

Figure 8 — Test assembly when manufacturer's instructions do not require shifting the junction between covers from the junction between bases

When manufacturer's instructions require shifting the junction between covers from the junction between bases, the test shall be made with two pieces of cover, one 1500 mm ± 3 mm long and the other 500 mm ± 3 mm long, mounted on two pieces of base, each one 1000 mm ± 3 mm long as shown in Figure 9.



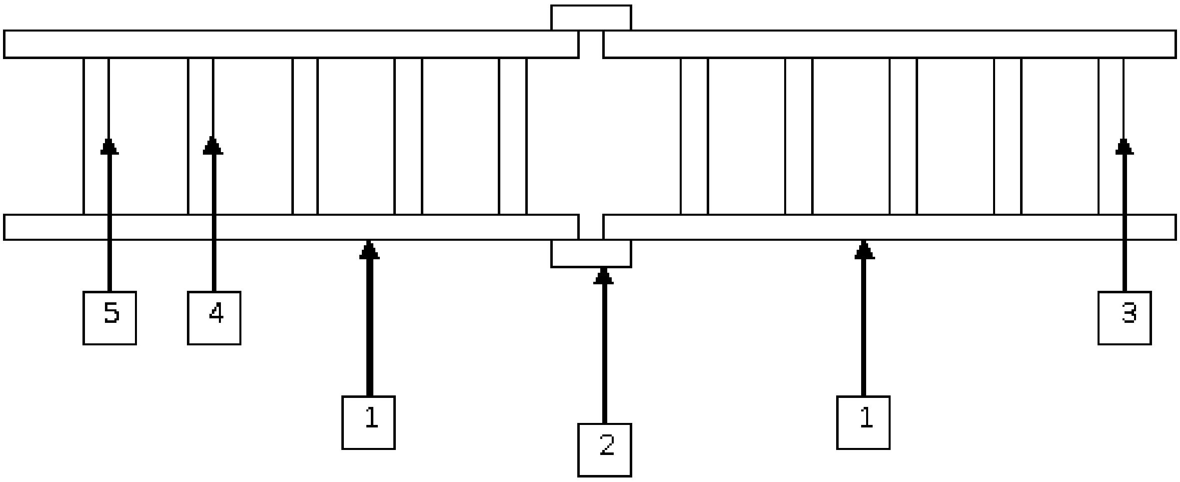
Key

1 base
2 cover
3 junction between bases
4 junction between covers shifted from the junction between bases

Figure 9 — Test assembly when manufacturer's instructions require shifting the junction between covers from the junction between bases

4) The bonding connection between the test assembly and the ground plane shall be made with a copper foil at least 0,05 mm thick on the complete width of the tested assembly.

The following special principles shall apply for CMS providing discontinuous support, such as cable ladder system or wire mesh cable tray system, as illustrated in Figure 10:



Key

1 supporting side member
2 junction between two cable ladder lengths
3 last rung where bonding connection between the test assembly and the ground plane is made
4 "measurement rung", where the insulated conductor used for the measurement is connected, corresponding to point (B) in Figure 7
5 "injection rung", where the current is injected, corresponding to point (A) in Figure 7

Figure 10 — Principles for testing a cable ladder system

— The bonding connection between the test assembly and the ground plane shall be made on the last rung of the cable ladder (or transversal wire of the wire mesh cable tray);

— The junction between the two pieces shall be made approximately at a distance of 1 m from this final rung of the cable ladder (or transversal wire of the wire mesh cable tray);

— The insulated conductor used for the measurement shall be connected on the “measurement rung” of the cable ladder (or transversal wire of the wire mesh cable tray) which is the closest rung from the last rung which is at least 2 m far from this last rung;

— The current shall be injected on the “injection rung” of the cable ladder (or transversal wire of the wire mesh cable tray) which is further from the last rung and is the closest rung from this measurement rung spaced from this measurement rung of at least one third of the width w of the tested CMS.

5) An insulated conductor shall be prepared and used as follows. This insulated conductor is made from a RG8U coaxial cable AWG 10, after removal of its external sheath and screen. One extremity of the conductor is connected to the test assembly at point (B) and the other extremity is connected to a coaxial cable through a coaxial connector.

6) The insulated conductor is placed in the middle (lengthwise) of the test assembly and maintained straight in this place and in direct contact with the test assembly along its whole length with adhesive tape.

NOTE “maintained straight” implies that when the lengthwise section of the product is not straight (example: cable tray with embossed base, cable ladder…), the insulated conductor is “straight” and therefore only locally in direct contact with the test assembly.

Special dispensation for conduit: maintaining the insulated conductor with adhesive tape is not required.

For CMS with integral divider(s), the insulated conductor shall be placed in the middle of the widest compartment.

7) The distance between the injection point (A) and the measurement point (B) as shown in Figure 7 shall be one third of the width w of the tested CMS.

8) Unless required by the manufacturer’s instructions, usual junctions shall not be de-greased.

NOTE De-greasing the whole product to improve the test repeatability is under consideration.

5.4 Test method

One objective of this time domain test method is to optimize the test by measuring the virtual transfer impedance with only one measurement instead of the various measurements at distinct frequencies required in frequency test methods. Another advantage of the time domain test method is to inject heavier current (a tenth of Amps) inside the test assembly and stimulate its magnetic property.

The test shall be carried out with a hybrid surge current generator of 8/20 µs impulses according to EN 61000-4-5 with 2 Ω output impedance and capable of generating a wave shape with a peak current between 10 A and 100 A.

Voltage and current evolutions versus time shall be recorded.

The voltage V_{AS} shall be measured with an oscilloscope with a bandwidth of at least 50 MHz. The uncertainty in measurement shall be less than 3 %.

The disturbing current shall be measured with a probe.

The bandwidth of the probe shall be at least 50 MHz. The uncertainty in measurement of the scaling factor shall be less than 3 %.

When using Hall effect probe, it is necessary to degauss the current probe at each measurement to avoid any unwanted offset.

The lower cut off frequency shall be lower than 1 kHz and the upper cut off frequency shall be greater than 50 MHz in order to measure the current correctly and within 3 % accuracy. This requirement originates from the spectra of an 8/20 µs impulses current as shown in Figure 4.

To avoid any disturbing couplings, the measurement equipment shall be installed inside a shielded enclosure.

The virtual transfer impedance is calculated as follow:

$$Z_v = \frac{V_{AS\max}}{I_{CM\max}}$$

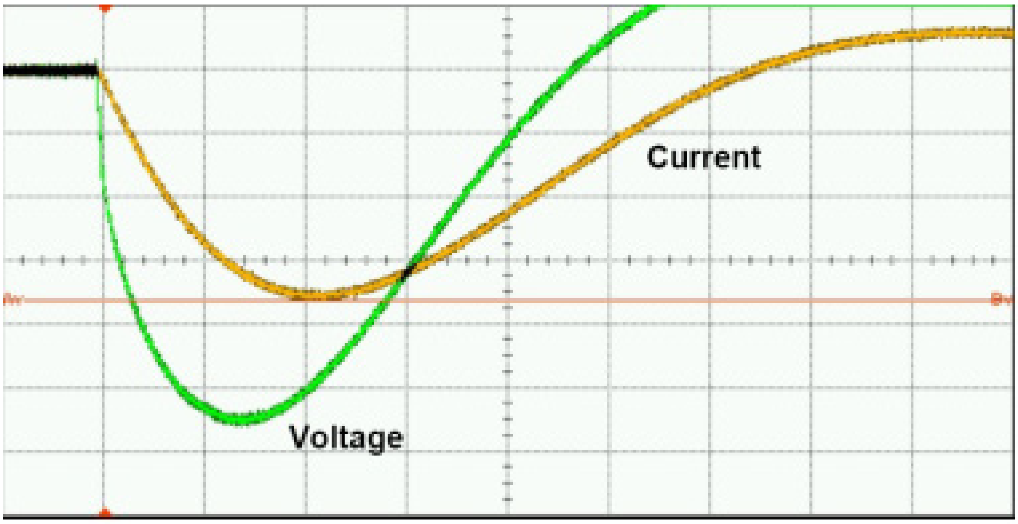


Figure 11 — Example of voltage and current versus time

On each tested assembly:

— 10 shots shall be carried out with at least 1 s between one shot and the following one.

NOTE high current may modify the contacts and therefore the transfer impedance.10 shots on the same assembly are supposed to be enough to verify the trend in damaging contacts.

5.5 Test report

The test report shall include:

— The 10 corresponding values of virtual transfer impedance and chronologically recorded.

— Virtual transfer impedance minimum value, maximum value, average value and standard deviation.

— Virtual transfer impedance per meter minimum value, maximum value, average value and standard deviation. Virtual transfer impedance per meter is the virtual transfer impedance divided by the cohabitation length, the length of the test assembly excluding AB distance.

5.6 Possible use of the test declared CMS Transfer impedance

CMS transfer impedance measures the ability of a conductive cable management system to develop a voltage drop when a disturbing current flows through this cable management system. This voltage drop is a combination of

— the voltage drop along this cable management system due to current flowing through this cable management system and

— the voltage drop along a conductor contained in this cable management system due to the magnetic field arising from the current flowing through this cable management system.

As an example, a test result of virtual transfer impedance per meter of 1 mΩ/m would mean that a current of 20 kA in the cable management system would develop approximately a voltage drop of 20 V/m.

These currents are not usually created by power cables but, for example, by lightning discharges, short-circuit currents or other disturbing currents coming from the earthing circuit.

For this reason, there is not a direct relationship between the transfer impedance and the distance between information or communication cables and power cables.

Annex A
(informative)

Example of calculation of the reduction of distance required between parallel power cables and signal cables provided by a cable management system

Two situations are considered:

First situation: without cable management system, requiring a distance d_1

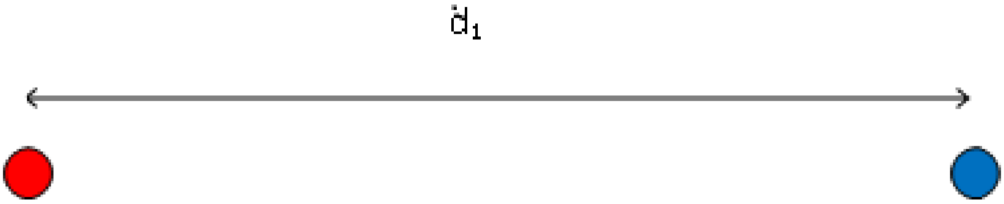


Figure A.1 — Required distance without cable management system

Second situation: with cable management system containing the victim cable, requiring a lower distance d_2

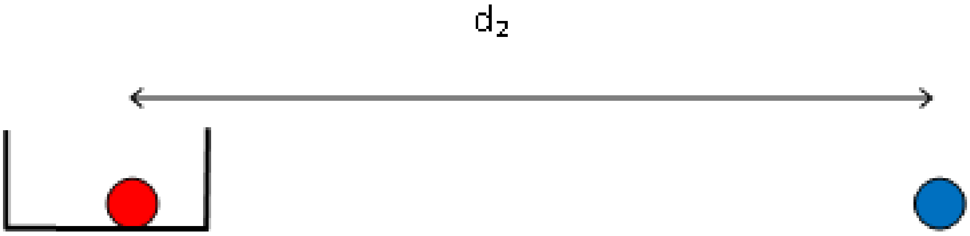


Figure A.2 — Required distance with cable management system

The approach is considering that the magnetic field on the victim cable is the same in the two situations.

$H_{withoutCMS,d1} = H_{withCMS,d2}$ which means that the ratio is equal to one:

$$1 = \frac{H_{without,d_1}}{H_{with,d_2}}$$

$$1 = \frac{H_{without,d_1}}{H_{with,d_2}} = \frac{H_{without,d_1}}{H_{without,d_2}} \times \frac{H_{without,d_2}}{H_{with,d_2}} = \textit{Influence of the distance x Influence of the CMS}$$

Tests using an 8/20 µs impulses current supports the assumption that the magnetic field around a perturbing power cable is proportional to $\frac{1}{d^2}$ (where *d* is the distance to the centre of the cable).

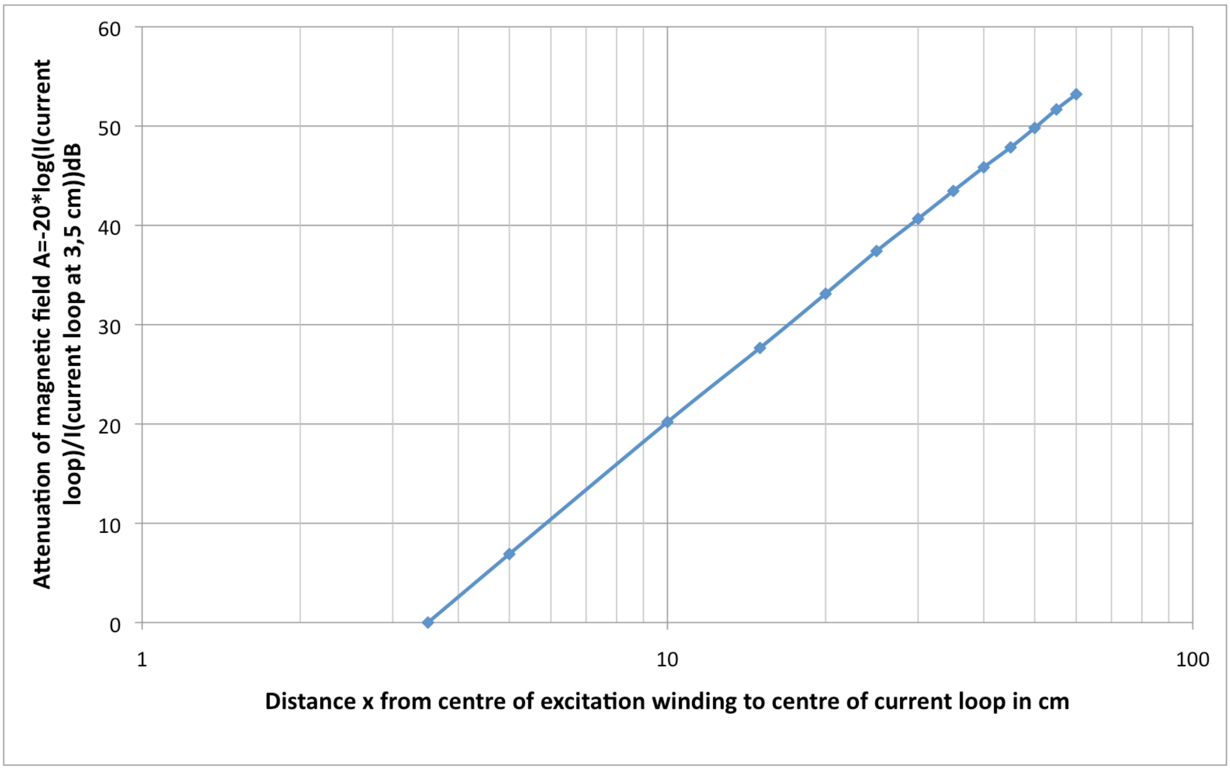


Figure A.3— Variation of the magnetic field with the distance to a perturbing power cable

$$1 = \frac{H_{without,d_1}}{H_{with,d_2}} = \frac{H_{without,d_1}}{H_{without,d_2}} \times \frac{H_{without,d_2}}{H_{with,d_2}} = \frac{d_2^2}{d_1^2} \times 10^{\frac{SE}{20}}$$

$$\frac{d_2}{d_1} = 10^{\frac{-SE}{20x2}} = 10^{\frac{-SE}{40}}$$

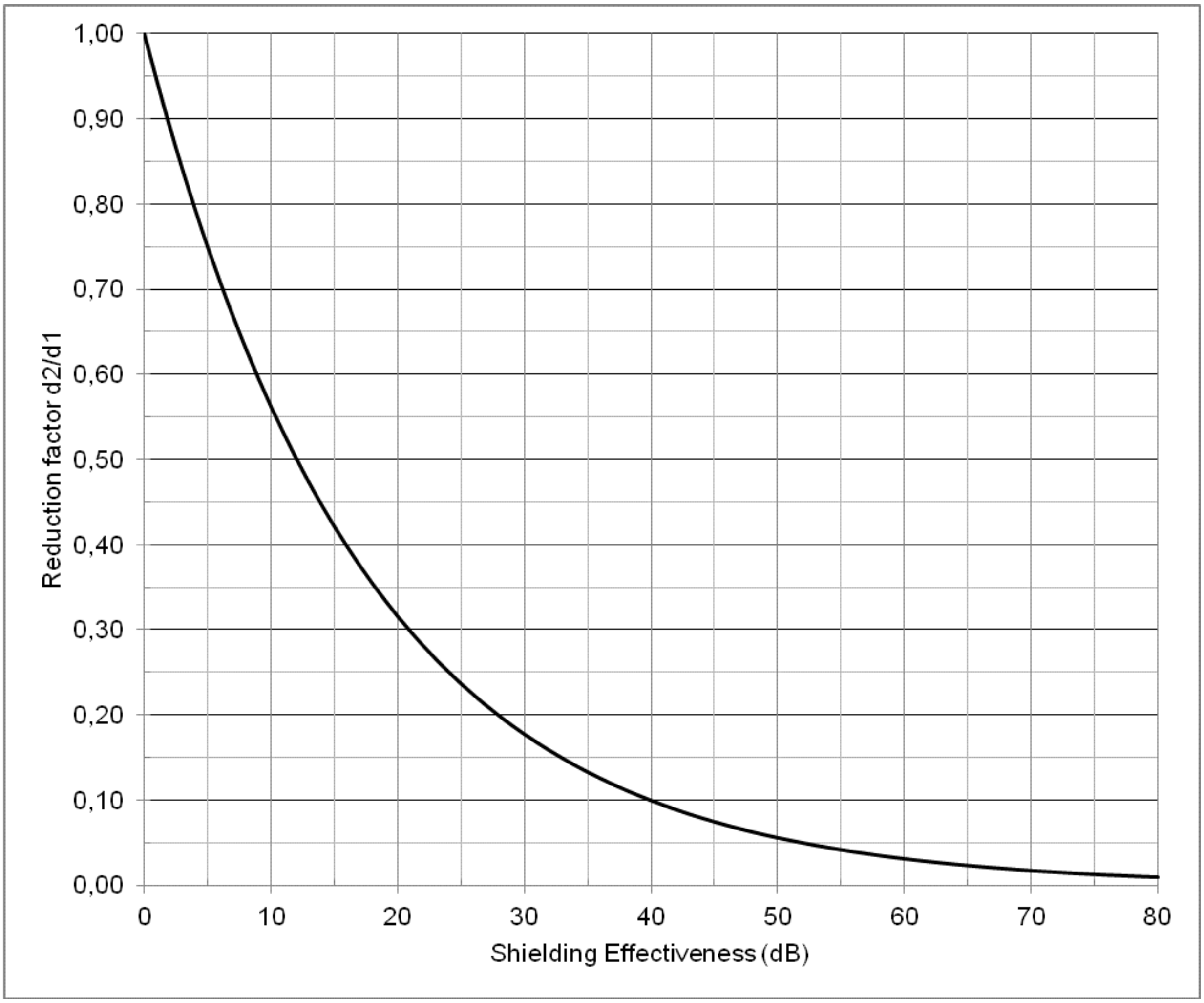


Figure A.4 — Reduction of required distance according to the Shielding Effectiveness of the cable management system

Table A.1 — Examples of reduction factor for CMS

Declaration according 4.2	SE (dB)	Reduction factor	Comment
EM A-37–20–09-XX	37	0,12	CMS with cover running in a plane parallel to the plane of the excitation winding (Figure 2a)
	20	0,32	Same CMS, without cover, running in a plane parallel to the plane of the excitation winding (Figure 2b)
	09	0,60	Same CMS, with cover, running in a plane perpendicular to the plane of the excitation winding (Figure 2c)
	XX	SE being not declared, the reduction factor is unknown and shall be taken as 1	Same CMS, without cover, running in a plane perpendicular to the plane of the excitation winding (Figure 2d)

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[6] EN 61537, *Cable management - Cable tray systems and cable ladder systems (IEC 61537)*

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