IEC 60512-23-3

Edition 2.0 2018-12
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

~~Electromechanical components~~ Connectors for electrical and electronic equipment – ~~Basic testing procedures and measuring methods~~ – Tests and measurements –
Part 23-3: Screening and filtering tests – Test 23c: Shielding effectiveness of connectors and accessories – Line injection method

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INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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~~ELECTROMECHANICAL COMPONENTS~~ CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – ~~BASIC TESTING PROCEDURES AND MEASURING METHODS~~ TESTS AND MEASUREMENTS –

Part 23-3: Screening and filtering tests – Test 23c: Shielding effectiveness of connectors and accessories – Line injection method

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60512-23-3 has been prepared by subcommittee 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

This second edition cancels and replaces the first edition, published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) an introduction has been added to provide some guidance to this document in view of concurrent test method 23g in the same family;
b) the frequency range for which this test method is considered reliable moved from 1 GHz to 3 GHz, to be consistent with Figure 7 (unchanged) and current industry practice and need;
c) update to IEC 62153-4-6:2017 of former normative reference IEC 60096-4-1:1990, withdrawn and incorrect (should have been IEC 61196-1:1995, also withdrawn);
d) update to current subclause numbers of IEC 62153-4-6:2017 what were the previous subclause numbers referenced in IEC 61196-1:1995 (wrongly attributed to IEC 60096-4-1:1990). For immediate understanding the title of these subclauses has been added;
e) alignment of title to the current scope of SC 48B (connectors) and inclusion of electrical equipment as target application of said connectors (per current scope of TC 48) and explicit reference to the method – line injection – for the measurement of transfer impedance;
f) symbols SE for shielding effectiveness and Z_T for surface transfer impedance added throughout the document;
g) list of connectors to which the test method is applicable – previously in 3.1 – moved in scope;
h) former name of AECMA organization changed to the current ASD-STAN;
i) “specimen” used instead of “sample” throughout the document;
j) clarification in the title of what transfer impedance is described in Table 3 and editorial improvement of the same;
k) “dielectric constant” changed into the updated term “relative permittivity”;
l) added a note to warn about the fact that this test method requires in 6.6 a TDR with more stringent rise time of less than 100 ps than the value of less than 350 ps specified both in IEC 62153-4-6 and in EN 50289-1-6 for the similar line injection method applied to screened cables, whereas test 23g of IEC 60512-23-7 specifies for the same purpose a TDR with a rise time of less than 200 ps;
m) adoption of term “*connector housing*” [IEV 581-27-10] instead of “*shell*” to address the connector accessory providing the shielding;
n) title “Transfer impedance Z_T [Ω]” added to the ordinate axis on the left side of double log diagram of Figure 7;
o) explanatory note to clarify the conversion formula for SE from Z_T added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
48B/2631/CDV	48B/2670/RVC

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

A list of all parts in the IEC 60512 series, published under the general title *Connectors for electrical and electronic equipment – Tests and measurements*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document is part of the IEC 60512 series within the group of standards identified as *Part 23: Screening and filtering tests*.

It covers a method to measure the shielding (screening) effectiveness of shielded connectors or of shielding accessories for connectors that are non-inherently shielded, e.g. connector shielded housings and/or connector EMC cable glands, by measurement of the surface transfer impedance Z_T (Ω) as a function of the frequency. By using a formula, Z_T is then converted in shielding effectiveness SE (dB).

In Part 23 there is another document, IEC 60512-23-7, *Connectors for electronic equipment – Tests and measurements – Part 23-7 – Screening and filtering tests – Test 23g: Effective transfer impedance of connectors*, that provides test 23g.

The first difference between the method described in this document and test 23g is that here in test 23c, in the measurement of the transfer impedance Z_T the capacitive coupling phenomena covered by the capacity coupling impedance Z_F are considered negligible, while test 23g includes these effects to measure the effective surface transfer impedance Z_{TE}.

This test 23c is applicable to a wide range of applications: it covers circular connectors, rectangular connectors and connectors for PCBs, as well as connector shielding accessories, i.e. those accessories such as connector shielded housings and/or metal shielding plates, providing shielding properties to a non-inherently shielded connector.

Test 23g is a variant of the triaxial test method for screened cables of IEC 62153-4-7, it addresses more specifically non-circular screened (shielded) connectors, it requires as DUT a complete cable assembly, i.e. a short piece of screened cable terminated by two connectors to be tested, and it requires also two adaptors plus a specific test jig.

More differences will be clear by a comparative read of the two test methods (this test 23c and test 23g) for the choice of the most suitable test to be indicated by the connector (or accessory) product detail specification or the manufacturer specification.

For further guidance regarding EMC testing of connectors and cable assemblies with screened cables and connectors, see also IEC TS 62513-4-1.

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Part 23-3: Screening and filtering tests – Test 23c: Shielding effectiveness of connectors and accessories – Line injection method

1 Scope ~~and object~~

This part of IEC 60512 defines a standard test method for measuring the shielding effectiveness SE of a shielded connector, or of a connector not provided with integral shield once fitted with a shielding accessory and terminated with a screened cable.

The complete assembly has a continuous 360° shielding capability throughout its length.

NOTE 1 Practically, continuous 360° shielding is not always achievable based on the geometry of the connector.

NOTE 2 Shielding" is used in this document with the same meaning as "screening".

This test method can be applied to shielded connectors and to connector accessories with ~~outer~~ shielding capability. The following different connector designs can be tested:

– circular connectors;
– rectangular connectors;
– connectors for printed boards;
– connector shielding accessories.

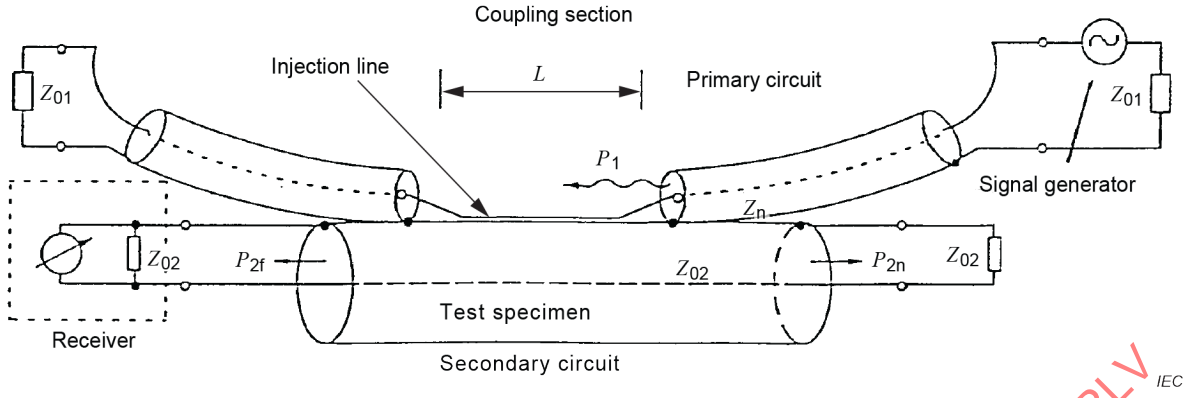
NOTE 3 For the definition of "accessory" see IEV 581-24-10. A shielding accessory i.e. an accessory that confers shielding to a non-inherently shielded connector, may be a suitable set of shielded housings providing electrical continuity, along the mated connector set, between the screen of the (screened) cable at the cable outlet of the free cable connector housing and the metallic mounting surface for the fixed connector housing. The free connector housing is provided with a cable screen clamp.

This test method utilizes the principle that the intrinsic shielding property of the connector/accessory/cable assembly is its surface transfer impedance Z_T which can be expressed as the longitudinal voltage inside the shield, relative to the current flow on the outside shell.

This test method is based on two impedance-matched circuits. See Figure 1 for the measurement principle. The connector specimen under test is integrated into the secondary circuit 02. The impedance-matched injection line of the primary circuit 01, which activates the electromagnetic field, runs parallel to the surface of the ~~test sample~~ specimen under test.

This test is also suitable for measuring the shielding effectiveness of a connector fitted with triaxial contacts terminated with shielded, twisted pair cables, as used in data bus systems.

NOTE 4 This standard has been adopted by ASD-STAN (formerly known as AECMA) as EN 2591-212 ~~and, as such, should not be amended without direct consultation and liaison with the AECMA organization~~.



Key

Z_{01} characteristic impedance, primary circuit
Z_{02} characteristic impedance, secondary circuit
L length of coupling section
P_1 power, primary circuit
P_{2f} power, far end, secondary circuit
P_{2n} power, near end, secondary circuit

Figure 1 – Principle of line injection method

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60096-4-1:1990, *Radio-frequency cables – Part 4: Specification for superscreened cables – Section 1: General requirements and test methods*~~

IEC 60050-581, *International Electrotechnical Vocabulary - Part 581: Electromechanical components for electronic equipment*

IEC 60512-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 1: Generic specification*

IEC 62153-4-6:2017, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-581 and in IEC 60512-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Test method

4.1 Test requirements

This method is based on ~~IEC 60096-4-1~~ IEC 62153-4-6:2017 and the ~~sample~~ specimen under test shall be tested with the cables installed. However, reference to ~~12.1.6.1 and 12.1.6.3~~ 7.2.1 (reduced primary current) and 7.2.3 (inhomogeneities of cable screens around the circumference) of IEC 62153-4-6:2017 shall be made to ensure that an electrically short length is maintained and that a minimum of four points around the circumference of the specimen under test are measured.

The line injection method provides a means of obtaining two ~~balanced and~~ impedance-matched transmission lines. This is achieved by selecting as the first transmission line an inner pick-up line through the ~~sample~~ specimen under test, said line being adjusted to provide an impedance match as close as possible to 50 Ω relative to the ~~sample~~ specimen under test. The second outer transmission line is achieved by laying an injection wire along the length of the ~~sample~~ specimen under test, this line also being adjusted to provide an impedance match as close as possible to 50 Ω relative to the ~~sample~~ specimen under test.

It ~~is~~ shall be ~~important to~~ ensured that there is no earth loop between the signal source and the measuring equipment.

~~**3.2 Test screen diameter**~~

~~The surface transfer impedance of the screen installed for the test shall comply with the requirements of table 1 and shall have an outside diameter of not less than 90 % of the inside diameter of the cable accessory outlet.~~

~~**Table 1 – Requirements for transfer impedance**~~

~~Test screen diameter~~ ~~mm~~	~~Maximum surface transfer impedance of screen~~ ~~mΩ/m at 30 MHz~~
~~2 – 4,9~~	~~70~~
~~5 – 9,9~~	~~45~~
~~10 – 17,9~~	~~35~~
~~18 – 23,9~~	~~20~~
~~24 – 29,9~~	~~10~~
~~30 – 40+~~	~~5~~
~~NOTE These values have been chosen in order that the leakage of the shield is not dominant in the overall result.~~	

4.2 Applicable frequency range

The applicable frequency range is 10 kHz up to ~~1~~ 3 GHz. The maximum applicable frequency is dependent on the test set-up and the dimensions of the ~~sample~~ specimen under test.

The ~~upper~~ maximum applicable frequency ~~limit~~ can be calculated as:

$$f = \frac{c}{\pi \times L \times \left| \sqrt{\varepsilon_{r2}} - \sqrt{\varepsilon_{r1}} \right|} \quad (1)$$

where

c = 3 × 10^8 m/s (speed of light in vacuum);

L is the length of the ~~sample~~ coupling section of the specimen under test in m (see Figure 1);

ε_{r1} is the ~~dielectric constant~~ relative permittivity of the primary circuit;

ε_{r2} is the ~~dielectric constant~~ relative permittivity of the secondary circuit.

5 Test equipment

The test and measuring equipment shall consist of (see Figure 2):

– a vector network analyser or alternatively a signal generator with the same characteristic impedance as the line injection circuit and with a power amplifier if necessary for very low transfer impedance and a receiver with a calibrated step attenuator and complemented with a low noise amplifier for very low transfer impedance;

– a power splitter (as required);

– attenuators (as required);

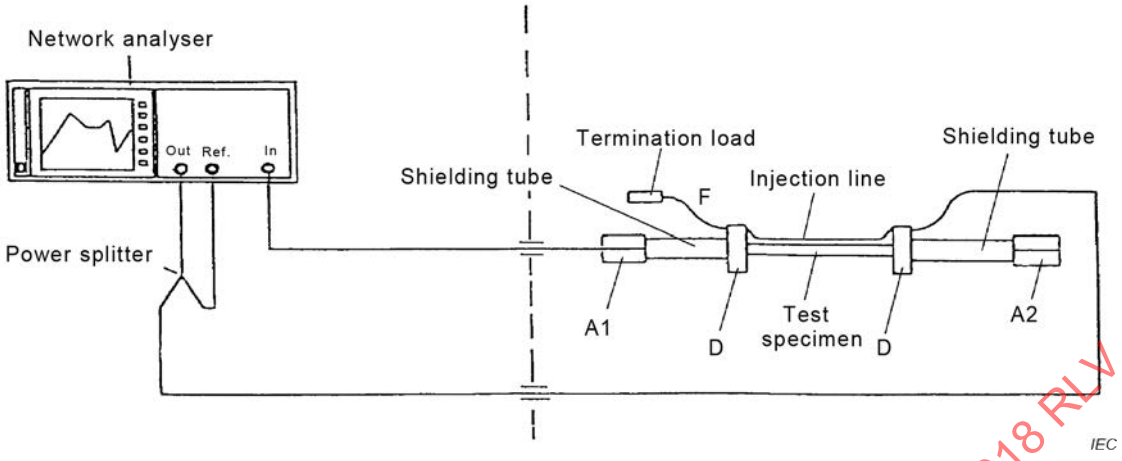
– termination loads matching the impedance of the vector network analyzer ports;

– test adapter;

– a time domain reflectometer (TDR) with rise time of less than 100 ps or a vector network analyser (at least 3 GHz) performing a return loss measurement transformed into the time domain (see 6.6);

– an insulated copper foil or a multi-conductor ribbon cable for the injection line construction.

NOTE This test method specifies the use of a TDR with rise time of less than 100 ps (see 6.5.3), whereas test 23g of IEC 60512-23-7 specifies for the same test equipment a rise time of less than 200 ps and the standards covering line injection method for screened cables IEC 62153-4-6 and EN 50289-1-6 specify for the TDR a rise time of less than 350 ps.



Key

A1 Coupling box

A2 Termination box

D Launchers for injection line

F Feeding cables for primary circuit

Figure 2 – Installation of test set-up

6 Preparation of the test ~~sample under test~~ specimen

6.1 General

In all applications when testing accessories, the shielding tube is ~~subsituted~~ replaced with the accessory to be tested.

NOTE The term "accessories" means here e.g. "EMC cable glands". The connector shielded housings (which are also "accessories" in this document) do not replace the shielding tube.

6.2 Circular connectors

~~The connector shells are mounted on the r.f. proof-shielding tubes.~~

The r.f. proof shielding tubes are mounted on the connector housings.

The total length l of the ~~sample~~ specimen under test acts as the coupling section.

Figure 3 shows an example of a test set-up for shielded circular connectors. The coupling of the injection line is carried out by semi-rigid coaxial cables with appropriate termination load for the feeding cable of the signal generator. The outer conductor of the semi-rigid cable and the shielding tube are connected by soldering.

The injection line shall be isolated from the conductive surfaces of the connector ~~shells~~ housings. Therefore, for impedance matching, a suitable dielectric has to be chosen.

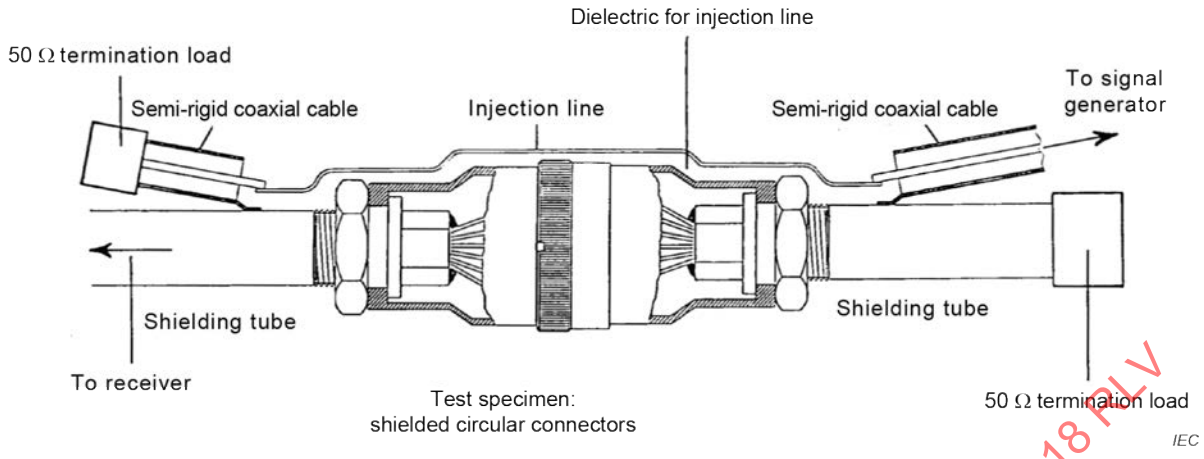


Figure 3 – Example of test set-up for shielded circular connectors

6.3 Rectangular connectors

For rectangular connectors in shielded ~~shells~~ housings, the shielding tubes or equivalent shielded cables are coupled to the cable retention (cable screen clamp) of the connector ~~shells~~ shielded housings which is r.f. proof.

The coupling section extends over the total length L of both ~~shells~~ housings in the direction of the signal path.

If the connector interface is mounted to a shielded ~~shell~~ housing only on one side, the adaptor shall have a separate outer shielding.

In Figure 4, an example of a test set-up for shielded rectangular connectors is shown. Semi-rigid coaxial cables are used for coupling of the injection line, which is isolated from the ~~sample~~ specimen under test by a suitable dielectric, if necessary.

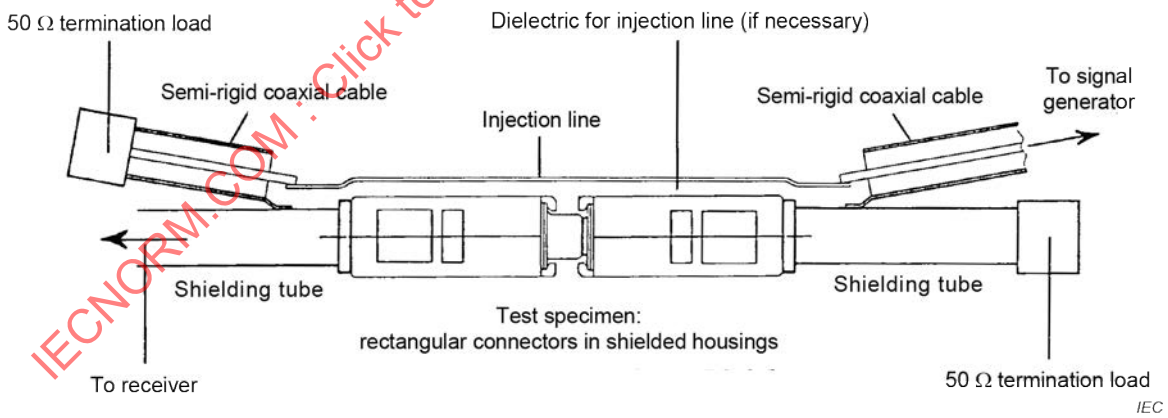


Figure 4 – Example of test set-up for shielded rectangular connectors

6.4 Connectors for printed boards

Connectors for printed boards can only be tested with the aid of the line injection method, if there are additional outer shielding structures for the PCBs. These can be achieved by a suitable shielded box, printed boards with shielding on both sides or equivalent constructions.

Figure 5 shows a test set-up for shielded printed board connectors. The injection line with suitable dielectric for ~~isolation~~ insulation and impedance-matching is coupled to the semi-rigid

coaxial cable. For termination, a 50 Ω SMD resistor is used, which is mounted on the printed board beyond the coupling section.

Instead of the shielding tube, a multilayer printed board is used with shielding on both sides and impedance-matched stripline technology.

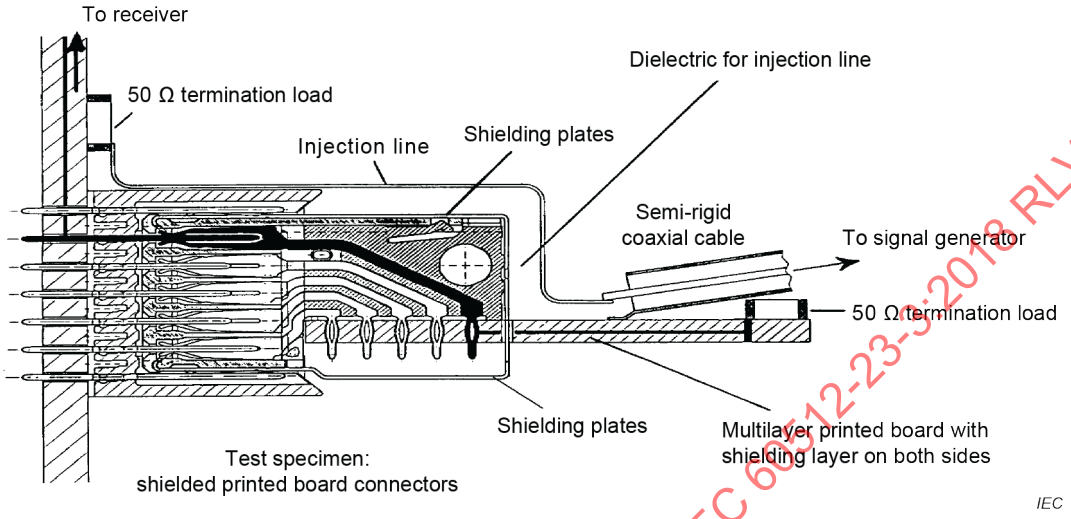


Figure 5 – Example of test set-up for shielded printed board connectors

6.5 Impedance matching of primary and secondary circuits

6.5.1 General

The contact(s) or contact group(s) under test (secondary circuit) and the injection line (primary circuit) shall be chosen and arranged, so that the impedance value is in the range of 50 Ω ± 10 Ω.

For frequencies below 1 MHz, higher tolerance values are permissible (50 Ω ± 20 Ω).

6.5.2 Preparation of the secondary circuit

The contact(s) under test are given by the detail specification. The other contacts are not connected. For the measurement of the impedance ~~along the injection line~~ of the inner pick-up line through the specimen (secondary circuit), the TDR is used.

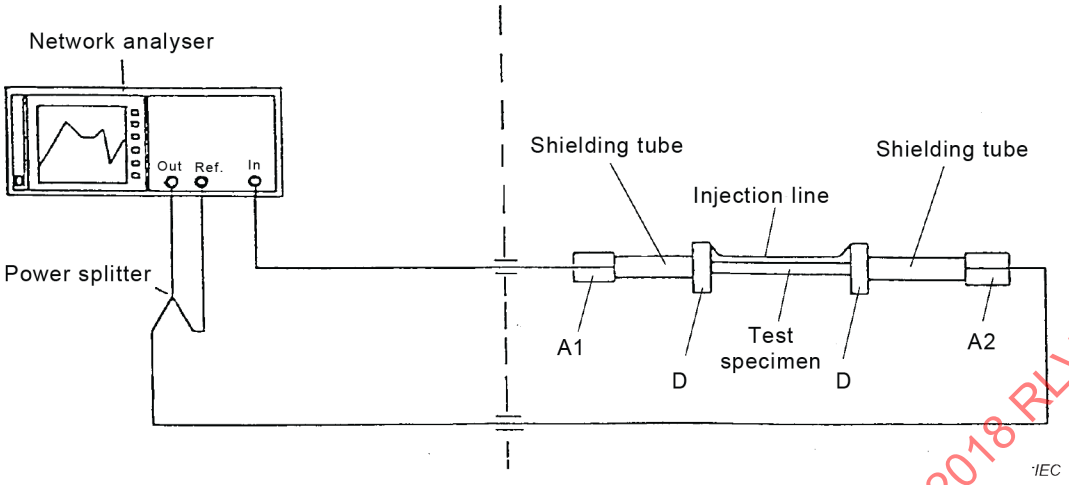
6.5.3 Adaptation of the primary circuit

The required impedance for the specified frequency range of the injection line (primary circuit) can be realized by suitable design of a copper foil or the right conductor number of a ribbon cable. Simultaneously, the impedance matching is measured with a TDR (rise time less than 100 ps). The injection line ~~has to~~ shall run parallel to the selected contact(s) of the connector.

The distance between the connector contact(s) and the injection line shall be as short as possible. The coupling section shall be restricted to the length L of the test ~~sample under test~~ specimen.

6.6 Calibration of test set-up

For the calibration procedure, see the test set-up according to Figure 6. For the short-circuit calibration procedure, the output signal of the network analyser is connected to the input channel via the ~~sample under~~ test specimen.



Key

A1 Coupling box

A2 ~~Termination~~ Coupling box

D Launchers for injection line

Figure 6 – Calibration test set-up

7 Measurement of shielding effectiveness

7.1 Measurement

For the measurement, a test set-up according to Figures 2 to 5 and in accordance with ~~12.1.6.3 of IEC 60096-4-1 is used~~ 7.2.3 (inhomogeneities of cable screen around the circumference) of IEC 62153-4-6:2017 shall be used.

7.2 Method of calculating shielding effectiveness SE (attenuation) from surface transfer impedance Z_T

The surface transfer impedance Z_T and the shielding effectiveness SE can be calculated from the following relationships:

Surface transfer impedance:

$$Z_T = 100 \times \frac{V_{receiver}}{V_{generator}} \quad \Omega/m \tag{2}$$

NOTE 1 The value 100 Ω is the sum of the two 50 Ω termination loads. The injected current is $V_{generator}/100$.

For the specimen under test (a shielded connector or a connector shielding accessory) Z_T shall be an absolute value. As the test specimen is not of unit length (1 m), it shall be necessary to correct the Z_T result of formula (2) multiplying it by the coupling length L of the test specimen expressed in m.

Shielding effectiveness:

$$SE = 40 - 20 \log_{10} Z_T \quad dB \tag{3}$$

~~NOTE The value Z_T will be an absolute value for the sample under test; if the sample under test is a cable which is not of unit length, it will be necessary to correct the result.~~

NOTE 2 The first term, 40 dB, derives from 20 $\log_{10}$ (100) = 20 • 2 (dB), where 100 is the value in Ω of the circuit impedance, sum of the two 50 Ω termination loads. The shielding effectiveness SE is the ratio of the power induced without shield to the power induced with shield, i.e. their logarithmic difference. Expressed in decibel SE becomes 20 $\log_{10}$ ($V_{\text{without shield}}$ / $V_{\text{with shield}}$) = 20 $\log_{10}$ $V_{\text{without shield}}$ – 20 $\log_{10}$ $V_{\text{with shield}}$, hence the correlation between SE and Z_T.

The measurement results are visualized in Figure 7 as a linear curve in a double logarithmic scale. In the axis of ordinate on the left the relative shielding effectiveness SE (attenuation) is shown, on the right the transfer impedance Z_T is shown, and in the abscissa the frequency is shown.

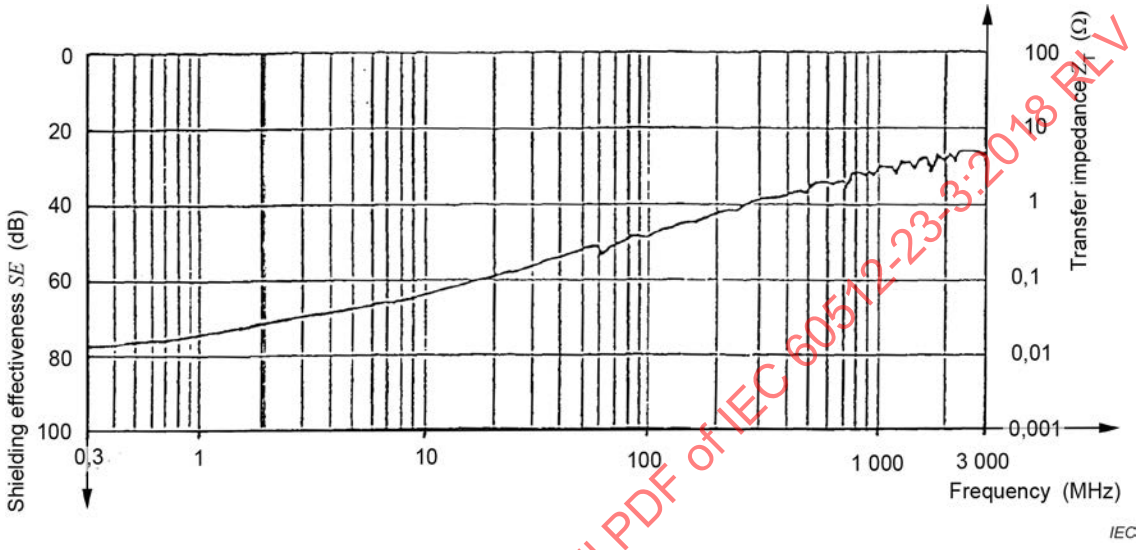


Figure 7 – Example of a shielding attenuation (shielding effectiveness) plot

8 Requirements

The surface transfer impedance Z_T of the connector (see formula (2) above) expressed in milliohms (mΩ), or converted to shielding effectiveness SE expressed in decibels (dB) (see formula (3) above), shall not exceed (in the case of Z_T), or be lower than (in the case of SE), the value(s) specified in the product detail specification.

9 Details to be specified

a) Contact(s) or contact group(s) to be tested.

b) Minimum value of the shielding effectiveness (SE) in dB or maximum value of the transfer impedance (Z_T).

c) Frequency or frequency range.

~~d) Outside diameter of screen of cable used in test.~~

d) Any deviation from the standard test ~~procedure~~ method.

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IEC TS 62153-4-1:2014, *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic screening measurements*

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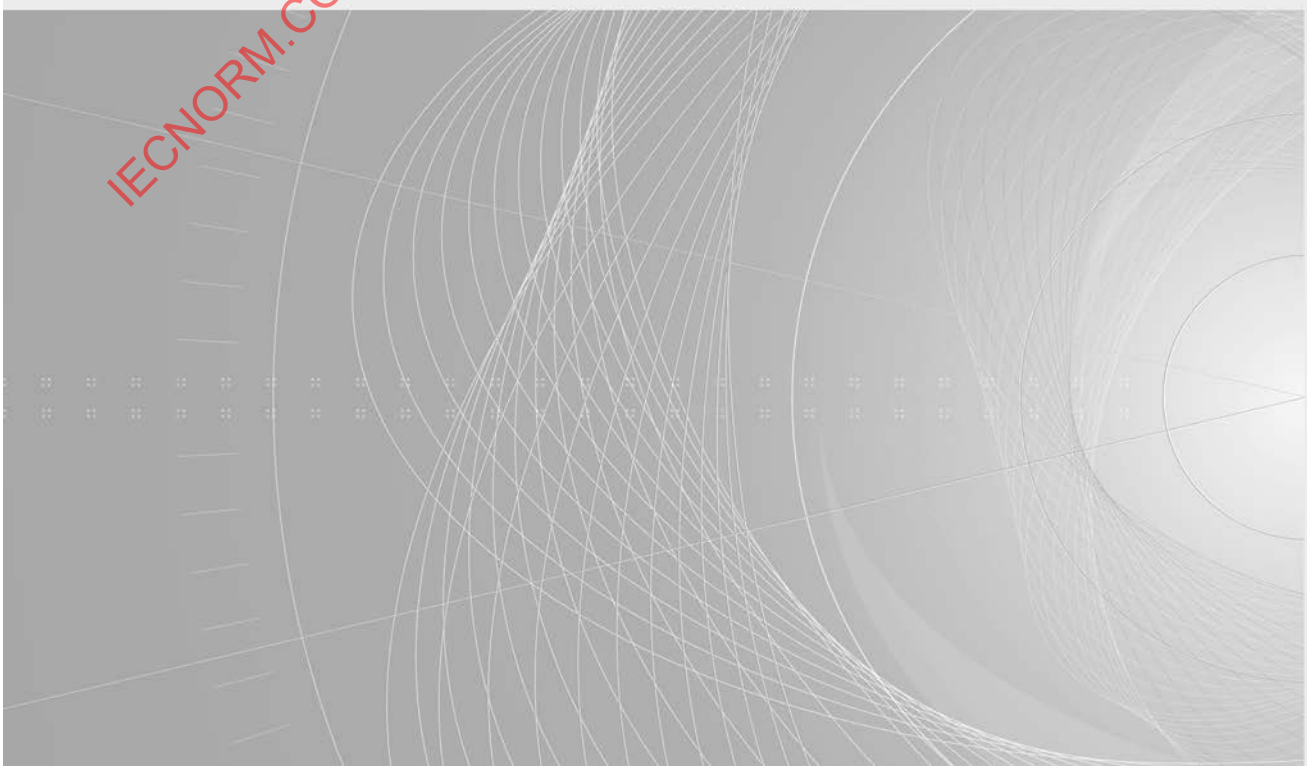

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Part 23-3: Screening and filtering tests – Test 23c: Shielding effectiveness of connectors and accessories – Line injection method

FOREWORD

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International Standard IEC 60512-23-3 has been prepared by subcommittee 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

This second edition cancels and replaces the first edition, published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) an introduction has been added to provide some guidance to this document in view of concurrent test method 23g in the same family;

b) the frequency range for which this test method is considered reliable moved from 1 GHz to 3 GHz, to be consistent with Figure 7 (unchanged) and current industry practice and need;
c) update to IEC 62153-4-6:2017 of former normative reference IEC 60096-4-1:1990, withdrawn and incorrect (should have been IEC 61196-1:1995, also withdrawn);
d) update to current subclause numbers of IEC 62153-4-6:2017 what were the previous subclause numbers referenced in IEC 61196-1:1995 (wrongly attributed to IEC 60096-4-1:1990). For immediate understanding the title of these subclauses has been added;
e) alignment of title to the current scope of SC 48B (connectors) and inclusion of electrical equipment as target application of said connectors (per current scope of TC 48) and explicit reference to the method – line injection – for the measurement of transfer impedance;
f) symbols SE for shielding effectiveness and Z_T for surface transfer impedance added throughout the document;
g) list of connectors to which the test method is applicable – previously in 3.1 – moved in scope;
h) former name of AECMA organization changed to the current ASD-STAN;
i) “specimen” used instead of “sample” throughout the document;
j) clarification in the title of what transfer impedance is described in Table 3 and editorial improvement of the same;
k) “dielectric constant” changed into the updated term “relative permittivity”;
l) added a note to warn about the fact that this test method requires in 6.6 a TDR with more stringent rise time of less than 100 ps than the value of less than 350 ps specified both in IEC 62153-4-6 and in EN 50289-1-6 for the similar line injection method applied to screened cables, whereas test 23g of IEC 60512-23-7 specifies for the same purpose a TDR with a rise time of less than 200 ps;
m) adoption of term “*connector housing*” [IEV 581-27-10] instead of “*shell*” to address the connector accessory providing the shielding;
n) title “Transfer impedance Z_T [Ω]” added to the ordinate axis on the left side of double log diagram of Figure 7;
o) explanatory note to clarify the conversion formula for SE from Z_T added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
48B/2631/CDV	48B/2670/RVC

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

A list of all parts in the IEC 60512 series, published under the general title *Connectors for electrical and electronic equipment – Tests and measurements*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This document is part of the IEC 60512 series within the group of standards identified as *Part 23: Screening and filtering tests*.

It covers a method to measure the shielding (screening) effectiveness of shielded connectors or of shielding accessories for connectors that are non-inherently shielded, e.g. connector shielded housings and/or connector EMC cable glands, by measurement of the surface transfer impedance Z_T (Ω) as a function of the frequency. By using a formula, Z_T is then converted in shielding effectiveness SE (dB).

In Part 23 there is another document, IEC 60512-23-7, *Connectors for electronic equipment – Tests and measurements – Part 23-7 – Screening and filtering tests – Test 23g: Effective transfer impedance of connectors*, that provides test 23g.

The first difference between the method described in this document and test 23g is that here in test 23c, in the measurement of the transfer impedance Z_T the capacitive coupling phenomena covered by the capacity coupling impedance Z_F are considered negligible, while test 23g includes these effects to measure the effective surface transfer impedance Z_{TE}.

This test 23c is applicable to a wide range of applications: it covers circular connectors, rectangular connectors and connectors for PCBs, as well as connector shielding accessories, i.e. those accessories such as connector shielded housings and/or metal shielding plates, providing shielding properties to a non-inherently shielded connector.

Test 23g is a variant of the triaxial test method for screened cables of IEC 62153-4-7, it addresses more specifically non-circular screened (shielded) connectors, it requires as DUT a complete cable assembly, i.e. a short piece of screened cable terminated by two connectors to be tested, and it requires also two adaptors plus a specific test jig.

More differences will be clear by a comparative read of the two test methods (this test 23c and test 23g) for the choice of the most suitable test to be indicated by the connector (or accessory) product detail specification or the manufacturer specification.

For further guidance regarding EMC testing of connectors and cable assemblies with screened cables and connectors, see also IEC TS 62513-4-1.

CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

Part 23-3: Screening and filtering tests – Test 23c: Shielding effectiveness of connectors and accessories – Line injection method

1 Scope

This part of IEC 60512 defines a standard test method for measuring the shielding effectiveness SE of a shielded connector, or of a connector not provided with integral shield once fitted with a shielding accessory and terminated with a screened cable.

The complete assembly has a continuous 360° shielding capability throughout its length.

NOTE 1 Practically, continuous 360° shielding is not always achievable based on the geometry of the connector.

NOTE 2 Shielding" is used in this document with the same meaning as "screening".

This test method can be applied to shielded connectors and to connector accessories with shielding capability. The following different connector designs can be tested:

– circular connectors;
– rectangular connectors;
– connectors for printed boards;
– connector shielding accessories.

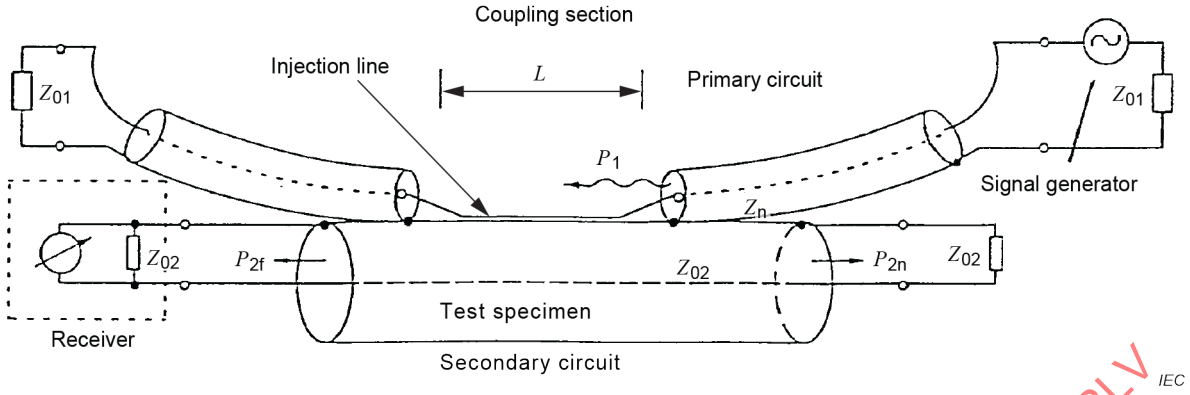
NOTE 3 For the definition of "accessory" see IEV 581-24-10. A shielding accessory i.e. an accessory that confers shielding to a non-inherently shielded connector, may be a suitable set of shielded housings providing electrical continuity, along the mated connector set, between the screen of the (screened) cable at the cable outlet of the free cable connector housing and the metallic mounting surface for the fixed connector housing. The free connector housing is provided with a cable screen clamp.

This test method utilizes the principle that the intrinsic shielding property of the connector/ accessory/cable assembly is its surface transfer impedance Z_T which can be expressed as the longitudinal voltage inside the shield, relative to the current flow on the outside shell.

This test method is based on two impedance-matched circuits. See Figure 1 for the measurement principle. The connector specimen under test is integrated into the secondary circuit 02. The impedance-matched injection line of the primary circuit 01, which activates the electromagnetic field, runs parallel to the surface of the specimen under test.

This test is also suitable for measuring the shielding effectiveness of a connector fitted with triaxial contacts terminated with shielded, twisted pair cables, as used in data bus systems.

NOTE 4 This standard has been adopted by ASD-STAN (formerly known as AECMA) as EN 2591-212 .



Key

Z_{01} characteristic impedance, primary circuit
Z_{02} characteristic impedance, secondary circuit
L length of coupling section
P_1 power, primary circuit
P_{2f} power, far end, secondary circuit
P_{2n} power, near end, secondary circuit

Figure 1 – Principle of line injection method

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-581, *International Electrotechnical Vocabulary - Part 581: Electromechanical components for electronic equipment*

IEC 60512-1, *Connectors for electrical and electronic equipment – Tests and measurements – Part 1: Generic specification*

IEC 62153-4-6:2017, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-581 and in IEC 60512-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Test method

4.1 Test requirements

This method is based on IEC 62153-4-6:2017 and the specimen under test shall be tested with the cables installed. However, reference to 7.2.1 (reduced primary current) and 7.2.3 (inhomogeneities of cable screens around the circumference) of IEC 62153-4-6:2017 shall be made to ensure that an electrically short length is maintained and that a minimum of four points around the circumference of the specimen under test are measured.

The line injection method provides a means of obtaining two impedance-matched transmission lines. This is achieved by selecting as the first transmission line an inner pick-up line through the specimen under test, said line being adjusted to provide an impedance match as close as possible to 50 Ω relative to the specimen under test. The second outer transmission line is achieved by laying an injection wire along the length of the specimen under test, this line also being adjusted to provide an impedance match as close as possible to 50 Ω relative to the specimen under test.

It shall be ensured that there is no earth loop between the signal source and the measuring equipment.

4.2 Applicable frequency range

The applicable frequency range is 10 kHz up to 3 GHz. The maximum applicable frequency is dependent on the test set-up and the dimensions of the specimen under test.

The maximum applicable frequency can be calculated as:

$$f = \frac{c}{\pi \times L \times \left| \sqrt{\varepsilon_{r2}} - \sqrt{\varepsilon_{r1}} \right|} \quad (1)$$

where

c = 3 × 10^8 m/s (speed of light in vacuum);

L is the length of the coupling section of the specimen under test in m (see Figure 1);

ε_{r1} is the relative permittivity of the primary circuit;

ε_{r2} is the relative permittivity of the secondary circuit.

5 Test equipment

The test and measuring equipment shall consist of (see Figure 2):

– a vector network analyser or alternatively a signal generator with the same characteristic impedance as the line injection circuit and with a power amplifier if necessary for very low transfer impedance and a receiver with a calibrated step attenuator and complemented with a low noise amplifier for very low transfer impedance;

– a power splitter (as required);

– attenuators (as required);

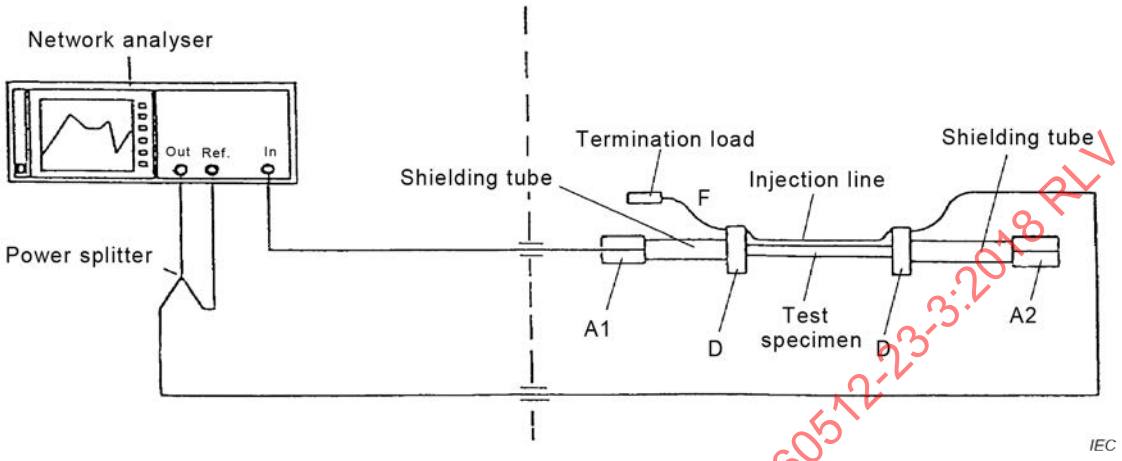
– termination loads matching the impedance of the vector network analyzer ports;

– test adapter;

– a time domain reflectometer (TDR) with rise time of less than 100 ps or a vector network analyser (at least 3 GHz) performing a return loss measurement transformed into the time domain (see 6.6);

– an insulated copper foil or a multi-conductor ribbon cable for the injection line construction.

NOTE This test method specifies the use of a TDR with rise time of less than 100 ps (see 6.5.3), whereas test 23g of IEC 60512-23-7 specifies for the same test equipment a rise time of less than 200 ps and the standards covering line injection method for screened cables IEC 62153-4-6 and EN 50289-1-6 specify for the TDR a rise time of less than 350 ps.



Key

A1 Coupling box

A2 Termination box

D Launchers for injection line

F Feeding cables for primary circuit

Figure 2 – Installation of test set-up

6 Preparation of the test specimen

6.1 General

In all applications when testing accessories, the shielding tube is replaced with the accessory to be tested.

NOTE The term “accessories” means here e.g. “EMC cable glands”. The connector shielded housings (which are also “accessories” in this document) do not replace the shielding tube.

6.2 Circular connectors

The r.f. proof shielding tubes are mounted on the connector housings.

The total length L of the specimen under test acts as the coupling section.

Figure 3 shows an example of a test set-up for shielded circular connectors. The coupling of the injection line is carried out by semi-rigid coaxial cables with appropriate termination load for the feeding cable of the signal generator. The outer conductor of the semi-rigid cable and the shielding tube are connected by soldering.

The injection line shall be isolated from the conductive surfaces of the connector housings. Therefore, for impedance matching, a suitable dielectric has to be chosen.

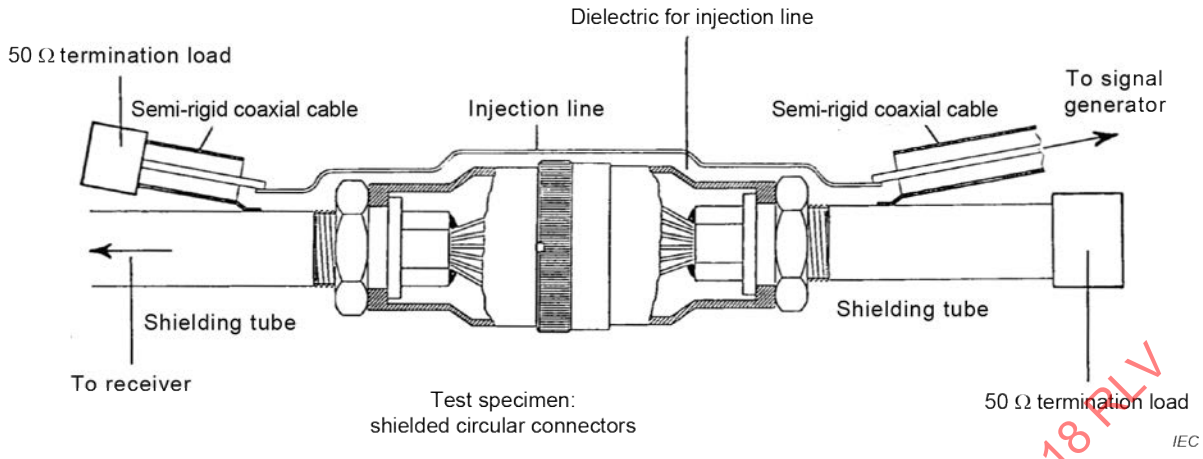


Figure 3 – Example of test set-up for shielded circular connectors

6.3 Rectangular connectors

For rectangular connectors in shielded housings, the shielding tubes or equivalent shielded cables are coupled to the cable retention (cable screen clamp) of the connector shielded housings which is r.f. proof.

The coupling section extends over the total length L of both housings in the direction of the signal path.

If the connector interface is mounted to a shielded housing only on one side, the adaptor shall have a separate outer shielding.

In Figure 4, an example of a test set-up for shielded rectangular connectors is shown. Semi-rigid coaxial cables are used for coupling of the injection line, which is isolated from the specimen under test by a suitable dielectric, if necessary.

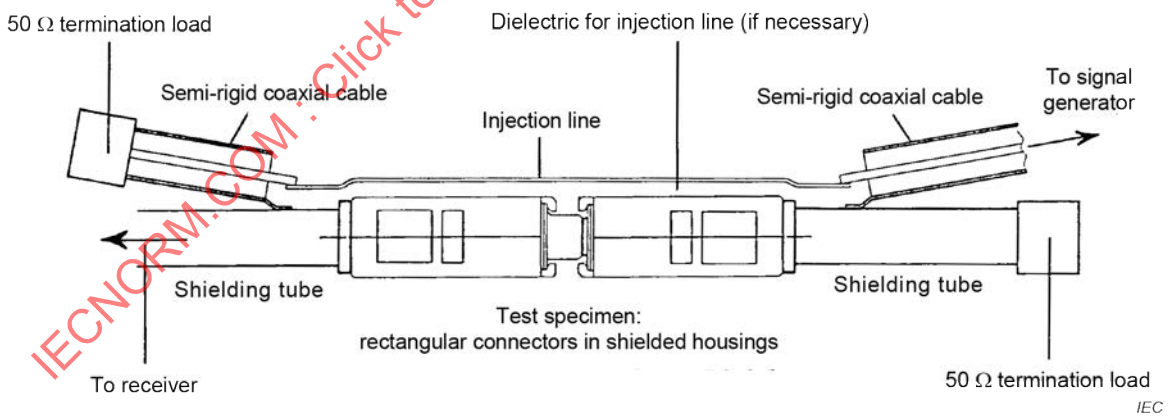


Figure 4 – Example of test set-up for shielded rectangular connectors

6.4 Connectors for printed boards

Connectors for printed boards can only be tested with the aid of the line injection method, if there are additional outer shielding structures for the PCBs. These can be achieved by a suitable shielded box, printed boards with shielding on both sides or equivalent constructions.

Figure 5 shows a test set-up for shielded printed board connectors. The injection line with suitable dielectric for insulation and impedance-matching is coupled to the semi-rigid coaxial

cable. For termination, a 50 Ω SMD resistor is used, which is mounted on the printed board beyond the coupling section.

Instead of the shielding tube, a multilayer printed board is used with shielding on both sides and impedance-matched stripline technology.

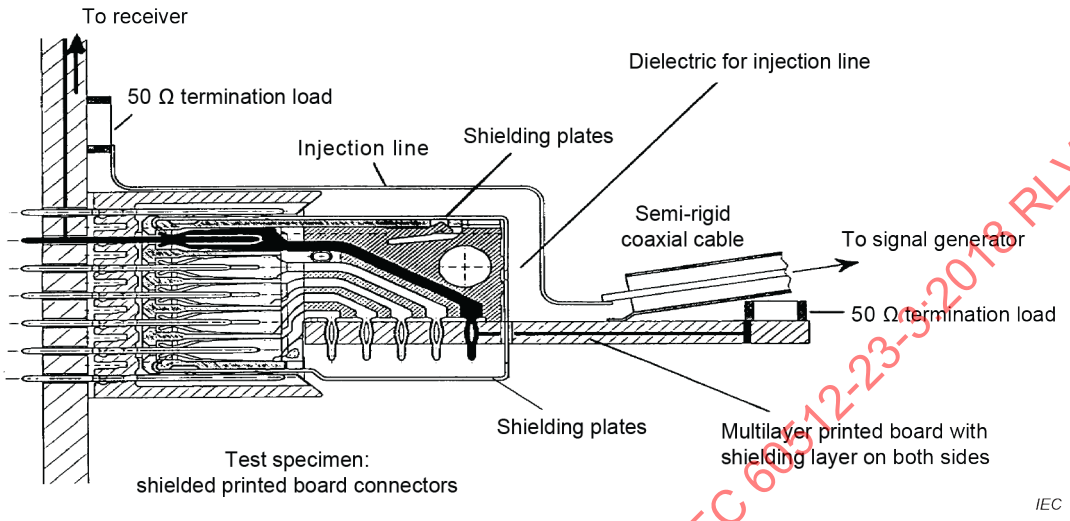


Figure 5 – Example of test set-up for shielded printed board connectors

6.5 Impedance matching of primary and secondary circuits

6.5.1 General

The contact(s) or contact group(s) under test (secondary circuit) and the injection line (primary circuit) shall be chosen and arranged, so that the impedance value is in the range of 50 Ω ± 10 Ω.

For frequencies below 1 MHz, higher tolerance values are permissible (50 Ω ± 20 Ω).

6.5.2 Preparation of the secondary circuit

The contact(s) under test are given by the detail specification. The other contacts are not connected. For the measurement of the impedance of the inner pick-up line through the specimen (secondary circuit), the TDR is used.

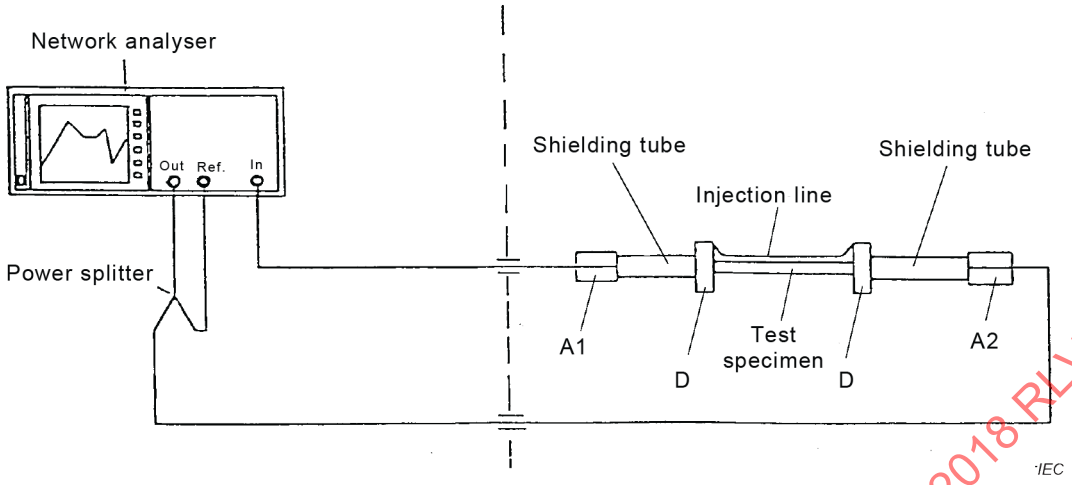
6.5.3 Adaptation of the primary circuit

The required impedance for the specified frequency range of the injection line (primary circuit) can be realized by suitable design of a copper foil or the right conductor number of a ribbon cable. Simultaneously, the impedance matching is measured with a TDR (rise time less than 100 ps). The injection line shall run parallel to the selected contact(s) of the connector.

The distance between the connector contact(s) and the injection line shall be as short as possible. The coupling section shall be restricted to the length L of the test specimen.

6.6 Calibration of test set-up

For the calibration procedure, see the test set-up according to Figure 6. For the short-circuit calibration procedure, the output signal of the network analyser is connected to the input channel via the test specimen.



Key

A1 Coupling box

A2 Coupling box

D Launchers for injection line

Figure 6 – Calibration test set-up

7 Measurement of shielding effectiveness

7.1 Measurement

For the measurement, a test set-up according to Figures 2 to 5 and in accordance with 7.2.3 (inhomogeneities of cable screen around the circumference) of IEC 62153-4-6:2017 shall be used.

7.2 Method of calculating shielding effectiveness SE (attenuation) from surface transfer impedance Z_T

The surface transfer impedance Z_T and the shielding effectiveness SE can be calculated from the following relationships:

Surface transfer impedance:

$$Z_T = 100 \times \frac{V_{receiver}}{V_{generator}} \quad \Omega/m \tag{2}$$

NOTE 1 The value 100 Ω is the sum of the two 50 Ω termination loads. The injected current is $V_{generator}/100$.

For the specimen under test (a shielded connector or a connector shielding accessory) Z_T shall be an absolute value. As the test specimen is not of unit length (1 m), it shall be necessary to correct the Z_T result of formula (2) multiplying it by the coupling length L of the test specimen expressed in m.

Shielding effectiveness:

$$SE = 40 - 20 \log_{10} Z_T \quad dB \tag{3}$$

NOTE 2 The first term, 40 dB, derives from 20 $\log_{10}$ (100) = 20 • 2 (dB), where 100 is the value in Ω of the circuit impedance, sum of the two 50 Ω termination loads. The shielding effectiveness SE is the ratio of the power induced

without shield to the power induced with shield, i.e. their logarithmic difference. Expressed in decibel SE becomes $20 \log_{10} (V_{\text{without shield}} / V_{\text{with shield}}) = 20 \log_{10} V_{\text{without shield}} - 20 \log_{10} V_{\text{with shield}}$, hence the correlation between SE and Z_T.

The measurement results are visualized in Figure 7 as a linear curve in a double logarithmic scale. In the axis of ordinate on the left the relative shielding effectiveness SE (attenuation) is shown, on the right the transfer impedance Z_T is shown, and in the abscissa the frequency is shown.

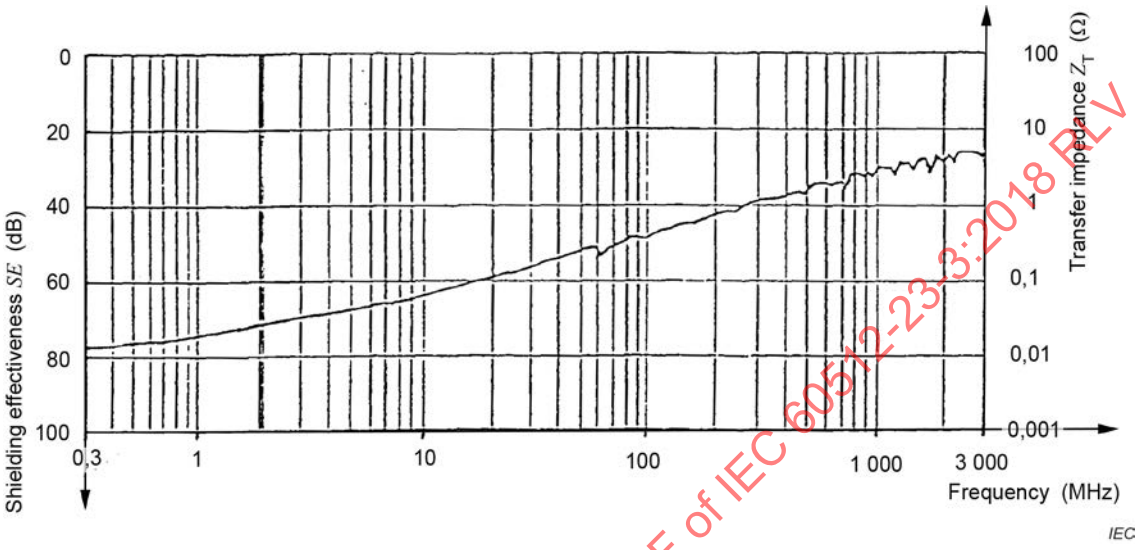


Figure 7 – Example of a shielding attenuation (shielding effectiveness) plot

8 Requirements

The surface transfer impedance Z_T of the connector (see formula (2) above) expressed in milliohms (mΩ), or converted to shielding effectiveness SE expressed in decibels (dB) (see formula (3) above), shall not exceed (in the case of Z_T), or be lower than (in the case of SE), the value(s) specified in the product detail specification.

9 Details to be specified

a) Contact(s) or contact group(s) to be tested.

b) Minimum value of the shielding effectiveness (SE) in dB or maximum value of the transfer impedance (Z_T).

c) Frequency or frequency range.

d) Any deviation from the standard test method.

Bibliography

IEC TS 62153-4-1:2014, *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic screening measurements*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONNECTEURS POUR ÉQUIPEMENTS ÉLECTRIQUES ET ÉLECTRONIQUES – ESSAIS ET MESURES –

Partie 23-3: Essais d'écrantage et de filtrage – Essai 23c: Efficacité de blindage des connecteurs et des accessoires – Méthode de la ligne d'injection

AVANT-PROPOS

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La Norme internationale IEC 60512-23-3 a été établie par le sous-comité 48B: Connecteurs électriques, du comité d'études 48 de l'IEC: Connecteurs électriques et structures mécaniques pour les équipements électriques et électroniques.

Cette deuxième édition annule et remplace la première édition, parue en 2000. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) ajout d'une introduction visant à donner des recommandations dans le présent document relatives à la méthode d'essai parallèle 23g, figurant dans la même famille;

b) modification de la plage de fréquences pour laquelle la présente méthode d'essai est considérée fiable, dont la limite supérieure passe de 1 GHz à 3 GHz, afin d'assurer l'homogénéité avec la Figure 7 (inchangée) et les pratiques et besoins actuels de l'industrie;

c) mise à jour de l'ancienne référence normative IEC 60096-4-1:1990, retirée et incorrecte (la référence normative à spécifier aurait dû être l'IEC 61196-1:1995, depuis elle aussi retirée), qui devient l'IEC 62153-4-6:2017;

d) mise à jour des numéros de paragraphe actuels pour refléter ceux de l'IEC 62153-4-6:2017, qui étaient auparavant les numéros de paragraphe de l'IEC 61196-1:1995 (attribués par erreur à l'IEC 60096-4-1:1990). Dans un souci de clarification, le titre de ces paragraphes a été ajouté;

e) alignement du titre sur le domaine d'application actuel du SC 48B (connecteurs) et inclusion des équipements électriques comme application cible desdits connecteurs (selon le domaine d'application actuel du TC 48), et référence explicite à la méthode (ligne d'injection) utilisée pour la mesure de l'impédance de transfert;

f) ajout dans l'ensemble du document des symboles SE pour l'efficacité de blindage, et Z_T pour l'impédance de transfert de surface;

g) déplacement dans le domaine d'application de la liste des connecteurs auxquels s'applique la méthode d'essai, auparavant indiquée en 3.1;

h) modification de l'ancien nom de l'organisation AECMA pour refléter son nom actuel, l'ASD-STAN;

i) utilisation du terme «éprouvette» à la place d'«échantillon» dans l'ensemble du document;

j) clarification dans le titre de l'impédance de transfert décrite dans le Tableau 3 et amélioration éditoriale du titre;

k) utilisation de l'expression actualisée «permittivité relative» à la place de l'expression «constante diélectrique»;

l) ajout d'une note de mise en garde spécifiant que cette méthode d'essai exige en 6.6 un réflectomètre temporel avec un temps de montée inférieur à 100 ps, plus rigoureux que la valeur maximale de 350 ps spécifiée dans l'IEC 62153-4-6 et dans l'EN 50289-1-6 pour la méthode analogue de ligne d'injection appliquée aux câbles écrantés, tandis que l'essai 23g de l'IEC 60512-23-7 spécifie dans ce même contexte un RDT avec un temps de montée inférieur à 200 ps;

m) utilisation de l'expression «*boîtier de connecteurs*» [IEV 581-27-10] à la place du terme «*capot*», pour décrire l'accessoire de connecteur assurant le blindage;

n) ajout de la légende «Impédance de transfert Z_T [Ω]» sur l'axe des ordonnées, en partie droite du schéma à double échelle logarithmique de la Figure 7;

o) ajout d'une note explicative visant à clarifier la formule de conversion permettant d'obtenir SE à partir de Z_T.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
48B/2631/CDV	48B/2670/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Les futures normes de cette série porteront dorénavant le nouveau titre général cité ci-dessus. Le titre des normes existant déjà dans cette série sera mis à jour lors de leur prochaine édition.

Une liste de toutes les parties de la série IEC 60512, publiées sous le titre général *Connecteurs pour équipements électriques et électroniques – Essais et mesures*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Le présent document fait partie de la série IEC 60512 et appartient au groupe de normes identifié par le titre secondaire *Partie 23: Essais d'écrantage et de filtrage*.

Il couvre une méthode de mesure de l'efficacité de blindage (d'écrantage) de connecteurs blindés, ou d'accessoires de blindage destinés à des connecteurs non intrinsèquement blindés, par exemple des boîtiers de connecteurs blindés et/ou des presse-étoupes CEM pour connecteur, en mesurant l'impédance de transfert de surface Z_T (Ω) en fonction de la fréquence. En utilisant une formule, Z_T est ensuite convertie en efficacité de blindage SE (dB).

La Partie 23 englobe un autre document, l'IEC 60512-23-7, *Connecteurs pour équipements électroniques – Essais et mesures – Partie 23-7: Essais d'écrantage et de filtrage – Essai 23g: Impédance de transfert efficace des connecteurs*, qui spécifie l'essai 23g.

La première différence entre la méthode décrite dans le présent document et l'essai 23g est que dans le présent essai 23c, pour la mesure de l'impédance de transfert Z_T, les phénomènes de couplage capacitif couverts par *l'*impédance de couplage capacitif Z_F sont considérés comme étant négligeables, tandis que l'essai 23g intègre ces effets pour mesurer *l'*impédance de transfert de surface effective Z_{TE}.

Le présent essai 23c s'applique à une large gamme d'applications: il englobe les connecteurs circulaires, les connecteurs rectangulaires et les connecteurs pour cartes de circuit imprimé, ainsi que les accessoires de blindage pour connecteurs, c'est-à-dire les accessoires tels que les boîtiers de connecteurs blindés et/ou les plaques de blindage métalliques, qui fournissent des propriétés de blindage à un connecteur non intrinsèquement blindé.

L'essai 23g est une variante de la méthode d'essai triaxiale pour les câbles écrantés spécifiée dans l'IEC 62153-4-7; il porte plus spécifiquement sur des connecteurs écrantés (blindés) non circulaires, et il exige en tant que dispositif soumis à essai (DUT, Device Under Test) un câble assemblé complet, c'est-à-dire une petite longueur de câble écranté équipé à chacune de ses deux extrémités d'un connecteur à soumettre à essai, et il exige également deux adaptateurs ainsi qu'un gabarit d'essai spécifique.

Les autres différences seront plus évidentes par une lecture comparative des deux méthodes d'essai (le présent essai 23c et l'essai 23g), préalablement au choix de l'essai le plus approprié à indiquer dans la spécification particulière du connecteur (ou de l'accessoire) ou dans la spécification du fabricant.

Pour d'autres recommandations concernant les essais CEM des connecteurs et des ensembles de câble avec câbles et connecteurs écrantés, voir aussi l'IEC TS 62513-4-1.

CONNECTEURS POUR ÉQUIPEMENTS ÉLECTRIQUES ET ÉLECTRONIQUES – ESSAIS ET MESURES –

Partie 23-3: Essais d'écrantage et de filtrage – Essai 23c: Efficacité de blindage des connecteurs et des accessoires – Méthode de la ligne d'injection

1 Domaine d'application

La présente partie de l'IEC 60512 définit une méthode d'essai normalisée pour mesurer l'efficacité de blindage SE d'un connecteur blindé, ou d'un connecteur sans blindage intégré et équipé d'un accessoire de blindage, et raccordé à un câble écranté.

Le câble assemblé présente un blindage continu sur 360° sur toute sa longueur.

NOTE 1 Le blindage continu à 360° n'est pas toujours réalisable dans la pratique, en raison de la géométrie du connecteur.

NOTE 2 Le terme «blindage» est utilisé dans le présent document comme synonyme du terme «écrantage».

La présente méthode d'essai peut être appliquée aux connecteurs blindés et aux accessoires de connecteur ayant un blindage. Les différentes conceptions de connecteur ci-après peuvent être soumises à essai:

– connecteurs circulaires,
– connecteurs rectangulaires,
– connecteurs pour cartes de circuit imprimé,
– accessoires de blindage pour connecteur.

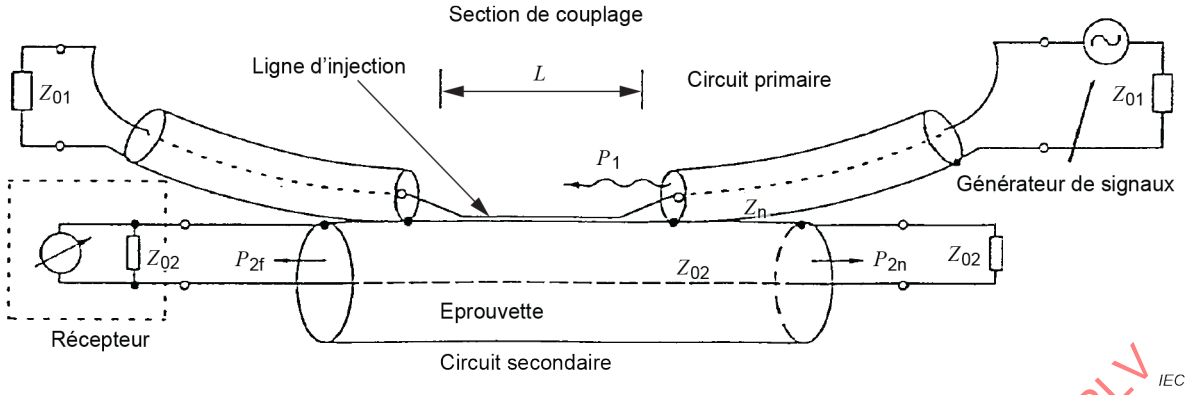
NOTE 3 Pour la définition du terme «accessoire», voir la référence IEV 581-24-10. Un accessoire de blindage, c'est-à-dire un accessoire qui confère un blindage à un connecteur non intrinsèquement blindé, peut être un ensemble approprié de boîtiers blindés assurant la continuité électrique, le long de l'ensemble de connecteurs accouplés, entre l'écran du câble (écranté) à la sortie du boîtier des fiches, et la surface de montage métallique pour le boîtier des embases. Le boîtier de connecteurs libre est fourni avec un serre-écran de câble.

La présente méthode d'essai part du principe que la propriété intrinsèque du blindage de l'ensemble connecteur/accessoire/câble est son impédance de transfert de surface Z_T, qui peut être exprimée par la tension longitudinale à l'intérieur du blindage, en fonction du courant parcourant le boîtier extérieur.

La présente méthode d'essai est basée sur deux circuits adaptés en impédance. La Figure 1 représente le principe de mesure. L'éprouvette de connecteur est intégrée au circuit secondaire 02. La ligne d'injection adaptée en impédance du circuit primaire 01, qui active le champ électromagnétique, chemine parallèlement à la surface de l'éprouvette.

Le présent essai est également adapté à la mesure de l'efficacité de blindage d'un connecteur équipé de contacts triaxiaux raccordés à des câbles blindés à paires torsadées, comme ceux utilisés dans les systèmes pour bus de données.

NOTE 4 La présente norme a été adoptée par l'ASD-STAN (anciennement l'AECMA) sous la référence EN 2591-212.



Légende

Z_{01} impédance caractéristique du circuit primaire
Z_{02} impédance caractéristique du circuit secondaire
L longueur de section de couplage
P_1 puissance du circuit primaire
P_{2f} puissance à l'extrémité éloignée du circuit secondaire
P_{2n} puissance à l'extrémité proche du circuit secondaire

Figure 1 – Principe de la méthode de la ligne d'injection

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-581, *Vocabulaire Electrotechnique International - Partie 581: Composants électromécaniques pour équipements électroniques*

IEC 60512-1, *Connecteurs pour équipements électriques et électroniques – Essais et mesures – Partie 1: Spécification générique*

IEC 62153-4-6:2017, *Metallic cables and other passive components test methods – Part 4-6: Electromagnetic compatibility (EMC) – Surface transfer impedance – Line injection method* (disponible en anglais seulement)

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60050-581 et de l'IEC 60512-1 s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp