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

IEC 60512-23-3:2018-12 RLV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.220.01

ISBN 978-2-8322-6360-0

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

~~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

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

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.

~~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

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.

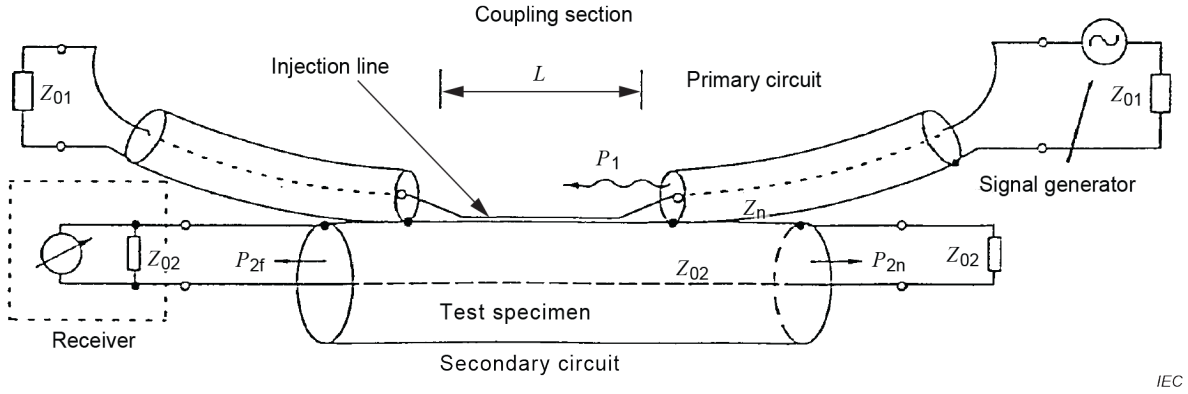
NOTE 3 For the definition of "accessory" see IEV 581-24-10. A shielding accessory i.e. an accessory that confers shielding to a non-inherently shielded connector, may be a suitable set of shielded housings providing electrical continuity, along the mated connector set, between the screen of the (screened) 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:

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

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);

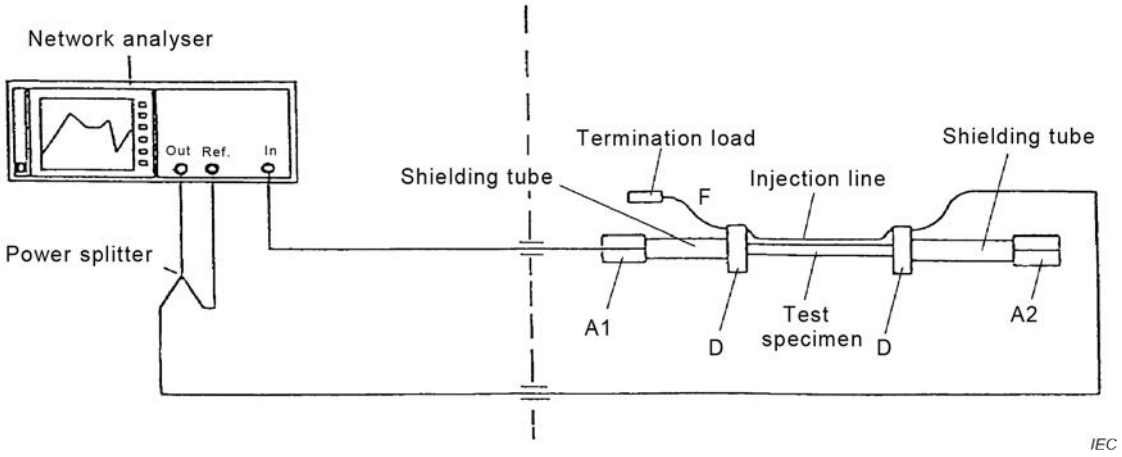
– termination loads matching the impedance of the vector network analyzer ports;

– 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.

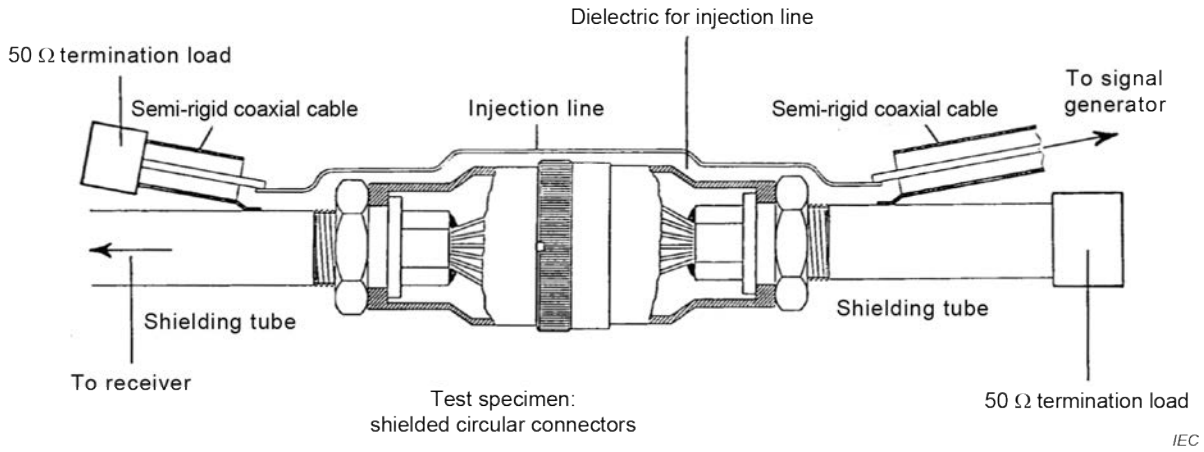


Figure 3 – Example of test set-up for shielded circular connectors

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.

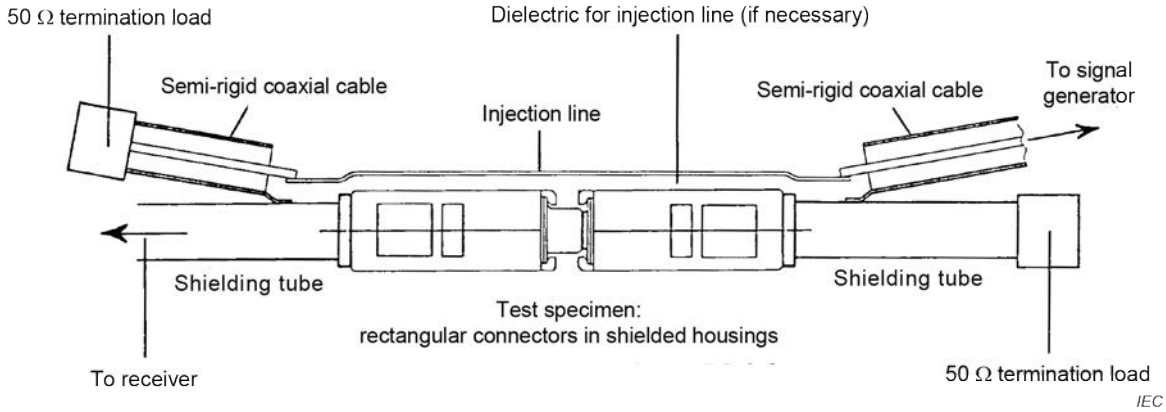


Figure 4 – Example of test set-up for shielded rectangular connectors

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