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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radio-frequency connectors –
Part 1-2: Electrical test methods – Insertion loss

Connecteurs pour fréquences radioélectriques –
Partie 1-2: Méthodes d'essai électrique – Perte d'insertion

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RADIO-FREQUENCY CONNECTORS –

Part 1-2: Electrical test methods – Insertion loss

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International Standard IEC 61169-1-2 has been prepared by subcommittee 46F: RF and microwave passive components, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories.

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

FDIS	Report on voting
46F/466/FDIS	46F/480/RVD

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.

A list of all parts of the IEC 61169 series, under the general title *Radio-frequency connectors*, 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

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RADIO-FREQUENCY CONNECTORS –

Part 1-2: Electrical test methods – Insertion loss

1 Scope

This part of IEC 61169 provides test methods for the insertion loss of radio-frequency (RF) connectors.

This document is applicable to cable RF connectors, microstrip RF connectors and RF connector adapters. It is also applicable to RF channels in multi-RF channel connectors and hybrid connectors which contain any combination of coaxial contact, optical fibres contact, and current-carrying electrical contact element.

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.

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IEC 61169-1, *Radio frequency connectors – Part 1: Generic specification – General requirements and measuring methods*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61169-1 and the following apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
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3.1
insertion loss
loss of power resulting from the insertion of a connector or similar device into a transmission line, expressed by formula (1), in decibels:

$$IL = -10\lg\left(\frac{P_2}{P_1}\right) \tag{1}$$

where

IL is the insertion loss, in dB;

P_1 is the input power into the RF connector, transmitted by the signal source;

P_2 is the output power from the RF connector to the load, transmitted by the signal source.

4 Preparation of test sample (DUT)

4.1 Cable RF connector

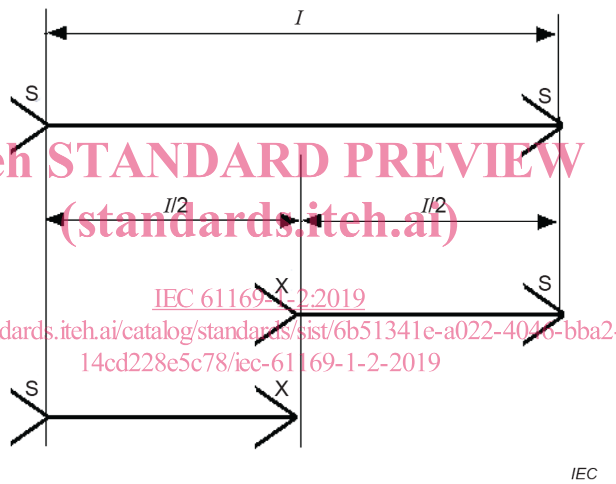
4.1.1 Method 1

Cable RF connectors should be tested by making a connector-cable assembly as follows:

a) First, make a standard cable assembly for calibrating the test system by using a section of pre-selected uniform cable with uniform characteristic impedance and at its both ends connecting two standard test connectors which can directly connect and match to the two ports of the test equipment.

b) Then cut the standard cable assembly in the middle without making it shorter, and connect respectively to the connector pair under test, as shown in Figure 1. The connector pair under test shall be mated together for the test. The test result is the insertion loss of the connector pair under test.

c) When needed, insertion loss of a single connector is about 1/2 of the test result (assuming the insertion losses of the pin connector and the socket connector are equal).



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NOTE When no standard test connector is available, verified coaxial connectors can be used.

Figure 1 – Preparation of cable RF connector test sample (DUT)

4.1.2 Method 2

Cable RF connectors should be tested by making a connector-cable assembly as follows:

a) First, make a long cable assembly to measure the attenuation of the cable by using a section of pre-selected uniform cable with uniform characteristic impedance with the connector under test at one end and the mating connector at the other end. The length of the cable shall be sufficiently long (its RF transmission loss shall be not less than 2 dB at 2 GHz) so that the insertion loss of connectors can be ignored. The cable length in the test sample is defined as the distance from face to face of the cable dielectric of the stripped cable for the connectors. The attenuation of the cable shall be calculated as follows.

$$\alpha = \frac{IL_1}{L_1} \qquad (2)$$

where

α is the attenuation of the cable, in dB/m;

IL_1 is the insertion loss of the long cable assembly, in dB;

L_1 is the length of the long cable, in m.

b) Then, make a short cable assembly by cutting the long cable assembly near the connector under test and connecting the mating connector at the cable end. The short cable assembly should be such as to minimize the loss due to the cable alone and sufficiently long so that its characteristic impedance remains unchanged at least during the cable stripping and connector assembly procedure. The insertion loss of the connector pair under test can be calculated as follows.

$$IL = IL_2 - \alpha \times L_2 \tag{3}$$

where

IL is the insertion loss of the connector pair under test;

α is the attenuation of the cable, in dB/m;

IL_2 is the insertion loss of the short cable assembly, in dB;

L_2 is the length of the short cable, in m.

c) When needed, a single connector insertion loss is about 1/2 of the test result (assuming the insertion losses of the pin connector and the socket connector are equal).

4.2 Microstrip connector

The microstrip connector shall be tested by using an appropriate test fixture at the microstrip end, and the microstrip connector with the test fixture as a whole should be treated as the test sample (DUT). The insertion loss result from the test fixture shall be as small as possible.

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When possible, two identical microstrip connectors may be connected back-to-back as a test sample by using an applicable test fixture. In that case, the insertion loss of each microstrip connector is about 1/2 of the test result (assuming the insertion loss of the test fixture is ignored).

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4.3 Adapter

An adapter shall be tested directly when it can be connected to test equipment or by using standard test adapters when it cannot be connected to test equipment.

5 Test methods

5.1 Test theory

At lower frequencies, the physical length of the test sample is less than $\lambda/10$, and the test values of the voltage/current on the test sample are independent of the test position. At higher frequencies, the physical length of the test sample is bigger than $\lambda/10$, and the characteristic impedance reflects its transmission characteristics. The voltage/current on the test sample differs at different positions.

It is assumed that the shielding effect of the test sample is good enough with no interference from outside and no signal leaking out. The input signal a_1 of the test sample will transmit one part of signal b_2 to the load and also a portion of signal b_1 and a_2 is reflected back at both the input port 1 and the output load port 2 respectively, as shown in Figure 2.

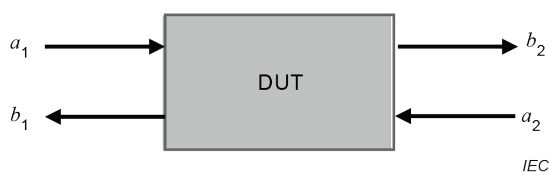

Figure 2 – Illustration of signal transmission and reflection in DUT

The signal transmission and reflection characteristics in the test sample can be represented by the S-parameter in Figure 3.

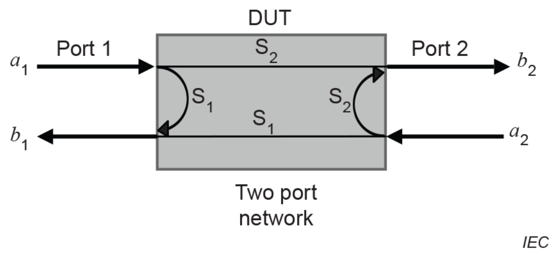

Figure 3 – S-parameter representing transmission and reflection characteristics

The definition of S-parameter is based on ratio of the signal voltages which are vectors:

$$b_1 = a_1 \mathrm{S}_{11} + a_2 \mathrm{S}_{12}$$

$$b_2 = a_1 \mathrm{S}_{21} + a_2 \mathrm{S}_{22}$$

The vector network analyser is based on the above principle to measure the S-parameter of the connector, cable and cable assemblies, and these S-parameters reflect the transmission and reflection characteristics of the connector, cable and cable assemblies in the frequency domain. S_{21} and S_{12} represent the forward and reverse insertion loss. As connectors are normally very short, S_{21} and S_{12} are the same in principle, and only one direction insertion loss needs to be measured unless both S_{21} and S_{12} are required in the relevant specifications.

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5.2 Test equipment

Test equipment is as follows:

a) an applicable vector network analyser (VNA);

b) calibration standards including open, short, precision terminal load, standard test adapter, and electronic calibration may also be used. The frequency range of the standard parts should cover the entire test frequency range.

5.3 Test procedure

5.3.1 Cable RF connector

The insertion loss of the cable connectors can be measured by using one of the following methods:

a) Method 1: The test procedure is as follows:

   1) After the vector network analyser is run in, set the measurement frequency range and other related parameters.

   2) System calibration: Full two port calibration shall be performed at the ends of the test cables.

   3) Set the test mode to measure the insertion loss and connect the standard cable assembly to the two test ports of the vector network analyser and store the result.

   4) Maintain the test equipment with no change and take the standard cable assembly off. Then cut the standard cable assembly in the middle and connect respectively to the connector pair under test (DUT) as shown in Figure 1.

   5) Mate connectors under test and reconnect them to the two test ports of the vector network analyser. Then measure the insertion loss and subtract the stored values got at above item 3) and then get the insertion loss of the connector pair under test and record the result (the maximum value for specified frequency range).

6) The insertion loss of a single connector under test is 1/2 of the test result.

b) Method 2: The test procedure is as follows:

1) After the vector network analyser is run in, set the measurement frequency range and other related parameters.

2) System calibration: full two port calibration shall be performed at the ends of test cables.

3) Set the test mode to measure the insertion loss and connect the long cable assembly (its length is L_1) to the two test ports of the vector network analyser and measure its insertion loss IL_1.

4) Maintain the test equipment with no change and take the long cable assembly off. Then cut the long cable assembly and make a short cable assembly as specified in 4.1.2.

5) Connect the short cable assembly (its length is L_2) to the two test ports of the vector network analyser and measure its insertion loss IL_2.

6) Assuming the attenuation of the cable is a constant within its length range, the insertion loss IL of the connector pair under test can be calculated by using equations (2) and (3).

7) The insertion loss of a single connector under test is 1/2 of the result.

5.3.2 Microstrip connector

The insertion loss of the microstrip connectors can be measured as follows:

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a) After the vector network analyser is run in, set the measurement frequency range and other related parameters.

b) System calibration: full two port calibration shall be performed at the ends of test cables.

c) Set the test mode to measure the insertion loss.

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d) When the two test ports of the vector network analyser can be connected directly to the test sample of the microstrip connectors (see 4.2), connect the test sample of the microstrip connectors (see 4.2) to the two test ports of the vector network analyser and measure its insertion loss IL, which is the insertion loss of the microstrip connectors under test (DUT).

e) If the two test ports of the vector network analyser cannot be connected directly to the test sample of the microstrip connectors, standard test adapters and calibration are needed. Remove one of adapters, change it for the standard test adapter with the same electrical length and sex, then connect the test sample of the microstrip connectors for insertion loss measurement and record the test result.

f) The insertion loss of a single connector under test is 1/2 of the result.

5.3.3 Adapter

The insertion loss of adapters can be measured as follows:

a) After the vector network analyser is run in, set the measurement frequency range and other related parameters.

b) System calibration: full two port calibration shall be performed at the ends of the test cables.

c) Set the test mode to measure the insertion loss.

d) When the two test ports of the vector network analyser can be connected directly to the adapters under test, connect the adapters under test directly to the two test ports of the vector network analyser and measure its insertion loss IL, which is the insertion loss of the adapters under test (DUT).