IEC 61169-1-4

Edition 1.0 2020-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Radio-frequency connectors –
Part 1-4: Electrical test methods – Voltage standing wave ratio, return loss and reflection coefficient

Connecteurs pour fréquences radioélectriques –
Partie -4: Méthodes d’essai électriques – Rapport d’ondes stationnaires en tension, affaiblissement de réflexion et coefficient de réflexion

IEC 61169-1-4:2020-07(en-fr)

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FOREWORD

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International Standard IEC 61169-1-4 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/505/FDIS	46F/510/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

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- withdrawn,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

RADIO-FREQUENCY CONNECTORS –

Part 1-4: Electrical test methods – Voltage standing wave ratio, return loss and reflection coefficient

1 Scope

This part of IEC 61169 provides test methods for the voltage standing wave ratio, return loss and reflection coefficient of RF connectors, including frequency domain method, time domain method, and gating.

This document is applicable to cable RF connectors, microstrip RF connectors and RF adapters. It is also suitable to RF channels in multi-RF channel connectors and hybrid connectors.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61169-1 and the following definitions 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

3.1
reflection coefficient
ratio of the normalized complex wave amplitude of the reflected wave to that of the incident wave at a port or transverse cross-section of a transmission line, expressed as the following:

$$\Gamma = \frac{V_\mathrm{r}}{V_\mathrm{i}} = \frac{Z_\mathrm{L} - Z_0}{Z_\mathrm{L} + Z_0} \tag{1}$$

where

Γ is the reflection coefficient in complex number;

V_i is the incident voltage in complex number;

V_r is the reflection voltage in complex number;

Z_0 is the characteristic impedance of a transmission line;

Z_L is the impedance of the termination in complex number.

3.2
voltage standing wave ratio
VSWR
ratio, along a transmission line, of a maximum of the voltage to an adjacent minimum magnitude of the voltage of a standing wave, expressed as the following:

$$VSWR = \frac{|V_{\text{max}}|}{|V_{\text{min}}|} = \frac{|V_{\text{i}} + V_{\text{r}}|}{|V_{\text{i}} - V_{\text{r}}|} = \frac{1 + |\varGamma|}{1 - |\varGamma|} \tag{2}$$

where

$VSWR$ is the voltage standing wave ratio;

V_{max} is the maximum magnitude of the voltage;

V_{min} is the minimum magnitude of the voltage;

V_{i} is the incident voltage;

V_{r} is the reflection voltage;

$\varGamma$ is the reflection coefficient in complex number.

3.3
return loss
RL
ratio of the power of the reflected wave to the power of the incident wave at a specified port or transverse cross-section of a transmission line, expressed as follows:

$$RL = -10\log_{10}\frac{P_{\text{r}}}{P_{\text{i}}} = -20\log_{10}|\varGamma| \tag{3}$$

where

RL is the return loss;

P_{i} is the power of incident wave;

P_{r} is the power of reflected wave;

$\varGamma$ is the reflection coefficient in complex number.

4 Preparation of test sample (DUT)

4.1 Cable RF connector

Use two cable connectors under test to make a dual-connector assembly as a test sample (DUT) by connecting a section of pre-selected uniform cable with accurate characteristic impedance or a simulated cable which is designed as a coaxial airline, as shown in Figure 1, with following requirements:

a) The length l of the cable or the simulated cable shall at least have two wave nodes in the frequency range being tested. That is:

$$I > \frac{v}{2(f_2 - f_1)} \tag{4}$$

where

v is the wave velocity in the cable or the simulated cable;

f_1 and f_2 are the minimum and maximum frequency being test respectively within the tested frequency domain.

b) The ratio of the diameters of the inner and outer conductors of the simulated cable should use the typical value if possible and is suitable for the connector under test. The axial length of the inner conductor is related to the electric length, so its structure and dimension accuracy should without axial movement.

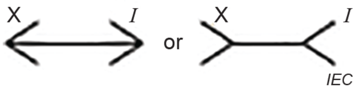


Figure 1 – Dual-connector assembly test sample (DUT)

4.2 Microstrip connector

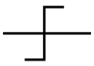
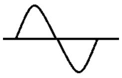
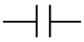
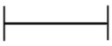
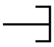
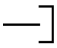
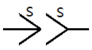
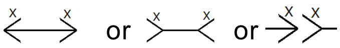
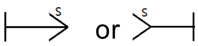
The microstrip connector shall be tested by using an appropriate test fixture on the microstrip end, and the microstrip connector with test fixture as a whole should be treated as the test sample (DUT). Test fixture which should be specified in relevant specification.

4.3 Adapter

An adapter shall be tested directly when it can connect to the test system or to connect to test system by using standard test adapter when it cannot connect to the test system directly.

5 Typical graphical symbols

The typical graphical symbols used are as follows:

	Time domain reflect meter equipment
	Frequency domain vector network analyser
	Mated precision hermaphroditic connectors
	Standard airline
	Precision termination
	Short
	Open
	Interface of standard test connector
	Interface of connector under test interface of pin, interface of socket
	Adapter from hermaphroditic interface to standard test connector
	Interface of pin connector
	Interface of socket connector
	Interface of hermaphroditic connector

6 Test condition

Test shall be conducted under room ambient conditions or as specified in the relevant specification.

7 Test methods

7.1 Frequency-domain method

7.1.1 Test theory

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

It is assuming 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 the signal b_1; 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 test sample can be represented by the S-parameter in Figure 3.

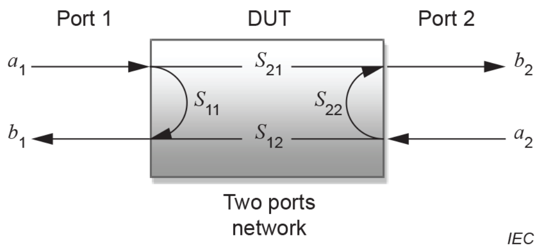


Figure 3 – S-parameter representing transmission and reflection characteristics

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

$$b_1 = a_1 S_{11} + a_2 S_{12}$$

$$b_2 = a_1 S_{21} + a_2 S_{22}$$

When the end of test sample is terminated on a precision load, a_2 = 0 and the input reflection coefficient can be calculated as following formulae:

$$S_{11} = \frac{b_1}{a_1}$$

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.

Due to inhomogeneity and manufacturing error of the internal structure of the connector, it is necessary to test the reflection characteristics of the test sample from two directions.

7.1.2 Test equipment

The test equipment is as follows.

a) A vector network analyser (VNA).

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

7.1.3 Test procedure

7.1.3.1 One-port measurement

The one-port measurement procedure is as follows.

a) After the vector network analyser is warmed up, set the measurement frequency range and other related parameters, and then set its test mode to measure the voltage standing wave ratio or return loss or reflection coefficient.

b) System calibration: use the open, short, load calibration standards separately to calibrate the vector network analyser test system, as shown in Figure 4.

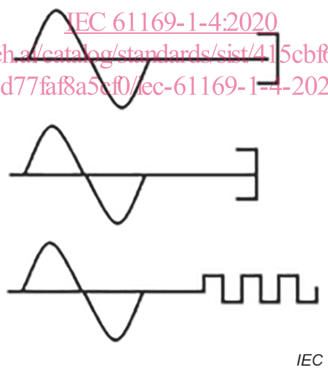


Figure 4 – System calibration outline

c) System calibration with standard test adaptor when needed: when the test port of the vector network analyser cannot directly connect with the test sample, the standard test adaptors are needed. In that case, the standard test adaptors are needed to be inserted in system and calibrated, shown as Figure 5.

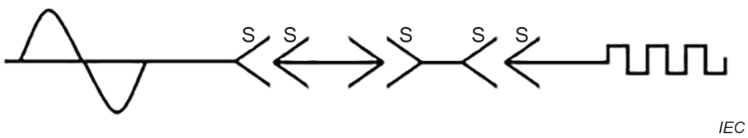


Figure 5 – Outline of system calibration and verification when standard test adapter is used

d) Connect the DUT to the test system as shown in Figure 6 as an example and record the S_{11} graph. Turn DUT around and test the DUT in other direction and record the other S_{11} graph.

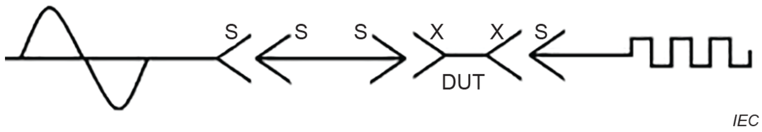


Figure 6 – DUT test outline

7.1.3.2 Two-port measurement

The two-port measurement procedure is as follows.

a) After the vector network analyser is warmed up, set the measurement frequency range and other related parameters, and then set its test mode to measure the voltage standing wave ratio or return loss or reflection coefficient.

b) System calibration: use the open, short, load and straight through calibration standards to calibrate the vector network analyser test system completely or use the electronic calibration to calibrate the vector network analyser test system directly.

c) Standard test adaptor calibration and verification when needed: when the test port of the vector network analyser cannot directly connect with the test sample, the standard test adaptors are needed. In that case, the standard test adaptors are needed to be calibrated and verified, shown as Figure 7.

Figure 7 – Standard test adaptor calibration and verification outline

d) DUT measurement: connect the DUT to the test system as shown in Figure 8 as an example and record the S_{11} and S_{22} graphs.

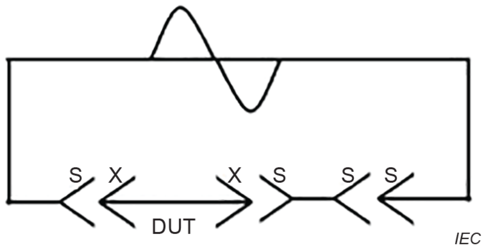


Figure 8 – DUT test arrangement example

7.2 Time-domain method

7.2.1 Test theory

When a step function signal is sent to DUT and the signal pass through the test point of DUT, part of the energy is reflected. The distance (L) from the input end to the test point can be calculated by measuring the total signal traveling time (t) as Figure 9. The reflection coefficient of the position can be calculated by measuring the amplitude of the incident signal and the reflected signal, as shown in Figure 9.