

# Radio frequency and coaxial cable assemblies —

## Part 1: Generic specification — General requirements and test methods

The European Standard EN 60966-1:1999 has the status of a  
British Standard

ICS 33.120.10

# National foreword

This British Standard is the English language version of EN 60966-1:1999. It is identical with IEC 60966-1:1999. It supersedes BS EN 60966-1:1993 which will be withdrawn on 2002-02-01. This standard is a harmonized specification within the IEC quality assessment system for electronic components (IECQ). In the IECQ system, this specification is numbered QC 140000.

The UK participation in its preparation was entrusted by Technical Committee EPL/46, Cables, wires, waveguides, RF connectors and accessories for comms and signalling, to Subcommittee EPL/46/1, Communication cables, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

### Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 38 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 October 1999

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English version

# Radio frequency and coaxial cable assemblies Part 1: Generic specification — General requirements and test methods

(IEC 60966-1:1999)

Ensembles de cordons coaxiaux et  
de cordons pour fréquences  
radioélectriques  
Partie 1: Spécification générique  
Généralités et méthodes d'essai  
(CEI 60966-1:1999)

Konfektionierte Koaxial- und  
Hochfrequenzkabel  
Teil 1: Fachgrundspezifikation  
Allgemeine Anforderungen und  
Prüfverfahren  
(IEC 60966-1:1999)

This European Standard was approved by CENELEC on 1999-05-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

## CENELEC

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B-1050 Brussels**

## Foreword

The text of document 46A/343/FDIS, future edition 2 of IEC 60966-1, prepared by SC 46A, Coaxial cables, of IEC TC 46, Cables, wires, waveguides, R.F. connectors, and accessories for communication and signalling, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60966-1 on 1999-05-01.

This European Standard supersedes EN 60966-1:1993.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2000-02-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2002-05-01

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex A, Annex E and Annex ZA are normative and Annex B, Annex C and Annex D are informative. Annex ZA has been added by CENELEC.

## Endorsement notice

The text of the International Standard IEC 60966-1:1999 was approved by CENELEC as a European Standard without any modification.

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## 1 Scope

This International Standard specifies requirements for radio frequency coaxial cable assemblies operating in the transverse electromagnetic mode (TEM) and establishes general requirements for testing the electrical, mechanical and environmental properties of radio frequency coaxial cable assemblies composed of cables and connectors. Additional requirements relating to specific families of cable assemblies are given in the relevant sectional specifications.

NOTE 1 The design of the cables and connectors used should preferably conform to the applicable parts of IEC 61196 and IEC 61169 respectively.

NOTE 2 This specification does not include tests which are normally performed on the cables and connectors separately. These tests are described in IEC 61196-1 and IEC 61169-1 respectively.

NOTE 3 Wherever possible, cables and connectors used in cable assemblies, even if they are not described in the IEC 61196 or IEC 61169 series are tested separately according to the tests given in the relevant generic specification.

NOTE 4 Where additional protection is applied to a cable assembly, the mechanical and environmental tests described in this standard are applicable.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60966. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60966 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60068-2-3:1969, *Environmental testing — Part 2: Tests — Test Ca: Damp heat, steady state.*

IEC 60068-2-6:1995, *Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal).*

IEC 60068-2-11:1981, *Environmental testing — Part 2: Tests — Test Ka: Salt mist.*

IEC 60068-2-14:1984, *Environmental testing — Part 2: Tests — Test N: Change of temperature.*

IEC 60068-2-27:1987, *Environmental testing — Part 2: Tests — Test Ea and guidance: Shock.*

IEC 60068-2-29:1987, *Environmental testing — Part 2: Tests — Test Eb and guidance: Bump.*

IEC 60068-2-42:1982, *Environmental testing — Part 2: Tests — Test Kc: Sulphur dioxide test for contacts and connections.*

IEC 60068-2-68:1994, *Environmental testing — Part 2: Tests — Test L: Dust and sand.*

IEC 60096-1:1986, *Radio frequency cables — Part 1: General requirements and measuring methods.*

IEC 60332-1:1993, *Tests on electric cables under fire conditions — Part 1: Test on a single vertical insulated wire or cable.*

IEC 60339 (all parts), *General purpose rigid coaxial transmission lines and their associated flange connectors.*

IEC 60512-5:1992, *Electromechanical components for electronic equipment, basic testing procedures and measuring methods — Part 5: Impact tests (free components), static load tests (fixed components), endurance tests and overload tests.*

IEC 61169-1:1992, *Radio-frequency connectors — Part 1: Generic specification — General requirements and measuring methods.*

IEC 61196-1:1995, *Radio-frequency cables — Part 1: Generic specification — General definitions, requirements and test methods.*

IEC 61726:1995, *Cable assemblies, cables, connectors and passive microwave components — Screening attenuation measurement by the reverberation chamber method.*

IEC QC 001002:1986, *Rules of procedure of the IEC quality assessment system for electronic components (IECQ).*

ISO 9000, *Quality management and quality assurance standards.*

ISO 9001:1994, *Quality systems — Model for quality assurance in design, development, production, installation and servicing.*

ISO 9002:1994, *Quality systems — Model for quality assurance in production, installation and servicing.*

## 3 Definitions

For the purpose of this part of IEC 60966, the following definitions apply.

### 3.1 cable assembly

a combination of cable(s) and connector(s) with or without any additional protection and with specified performance, used as a single unit

#### 3.1.1

#### flexible cable assembly

a cable assembly where the cable is capable of repeated flexure. The cable usually has a braid outer conductor

**3.1.2****semi-flexible cable assembly**

a cable assembly not intended for applications requiring repeated flexure of the cable in service, but bending or forming is permissible to facilitate installation

**3.1.3****semi-rigid cable assembly**

a cable assembly not intended to be bent or flexed after manufacture. Any bending or flexing during installation or use may degrade the performance of the cable assembly

**3.2****insertion loss**

the loss introduced by inserting a cable assembly into a system. In this standard, it is the ratio, expressed in decibels, of the power ( $P_1$ ) delivered to a load connected directly to a source and the power ( $P_2$ ) delivered to a load when the cable assembly is inserted between the source and the load

$$\text{Insertion loss} = 10 \times \log \left( \frac{P_1}{P_2} \right)$$

**3.3****reflection factor**

the ratio of the complex wave amplitude of the reflected wave to the complex wave amplitude of the incident wave at a port or transverse cross-section of a transmission line

**3.4****electrical length**

the equivalent free-space length of the cable assembly

**3.5****electrical length difference**

the difference in electrical length between cable assemblies

**3.6****phase difference**

the difference in phase between a transverse electromagnetic mode (TEM) wave which has traversed the cable assembly and an identical wave which has traversed another cable assembly

**3.7****propagation time**

the time taken for the propagation of a TEM wave between the reference planes of the two connectors

**3.8****minimum static bending radius**

the radius used in climatic tests. It is the minimum permissible radius for fixed installation of the cable

**3.9****dynamic bending radius**

the bending radius is used for the insertion loss stability, stability of electrical length and flexing endurance tests, and is the minimum bending radius for applications where the cable assembly is flexed. Larger bending radii will allow the increase of the maximum number of flexures

**3.10 screening effectiveness****3.10.1****transfer impedance**

the quotient of the induced voltage on the inside of the cable assembly and the inducing current outside the assembly. In practice, this is between defined points on connectors mated to the connectors of the cable assembly

**3.10.2****screening attenuation**

the ratio of the signal power inside the cable assembly to the total power that radiates outside the cable assembly

**3.11****power rating**

the input power which may be handled continuously by the cable assembly when terminated by its characteristic impedance

NOTE 1 For practical application, the maximum power that may be handled is dependent upon the return loss.

NOTE 2 Power rating is dependent on mounting details, ambient temperature, air pressure and circulation. It is normally specified at an ambient temperature of 40 °C.

**3.12****artificial ageing**

a process used to improve the stability of phase attenuation and expansion with temperature. This process normally consists of submitting the complete cable assembly to a number of temperature cycles. Unless otherwise specified in the relevant detail specification, submitting the complete cable assembly to artificial ageing is optional, at the discretion of the supplier

**4 Design and manufacturing requirements****4.1 Cable design and construction**

Cables in accordance with, or conforming to, IEC 61196 shall be specified wherever possible. Where cable designs deviating from IEC 61196 are required, these cables shall comply with the requirements of the relevant detail specification.

## 4.2 Connector design and construction

Connector types conforming to the relevant part of IEC 61169 shall be specified wherever possible, but where a special connector design is required, the interface shall conform to the relevant part of IEC 61169, where available, and the connector construction shall comply with the requirements of the relevant detail specification.

## 4.3 Outline and interface dimensions

- a) Outline dimensions shall be in accordance with the relevant detail specification of the cable assembly.
- b) Interface dimensions shall be in accordance with the relevant detail specification.

## 5 Workmanship, marking and packaging

### 5.1 Workmanship

There shall be no observable defects in the cable assembly; it shall be clean and in good condition.

### 5.2 Marking

Marking shall be legible and in accordance with the relevant detail specification; it shall identify the manufacturer of the cable assembly.

### 5.3 End caps

Unless otherwise specified in the relevant detail specification, disposable end caps of suitable material for transport and storage shall be fitted to the connectors to protect at least each interface from damage and dirt.

### 5.4 Packaging and labelling

Packaging and labelling shall be in accordance with the relevant detail specification, unless otherwise specified.

## 6 Quality assessment

A guide for quality assurance including capability approval as well as qualification approval is given in Annex E.

## 7 Test methods — General

### 7.1 Standard atmospheric conditions for testing

Unless otherwise specified, all tests shall be carried out under the conditions specified in IEC 60068.

Before the measurements are made, the cable assemblies shall be stored at the measuring temperature for a time sufficient to allow the entire cable assembly to reach this temperature. When measurements are made at a temperature other than the standard temperature, the result shall, where necessary, be corrected to the standard temperature.

NOTE Where it is impracticable to carry out tests under the standard atmospheric conditions for testing, a note to this effect, stating the actual conditions of tests, should be added to the test report.

### 7.2 Visual inspection

The specimen shall be visually examined to ensure that:

- a) the condition, workmanship and finish are satisfactory;
- b) the marking is in accordance with 5.2 of this specification;
- c) there is no mechanical damage, undesired movement or displacement of parts;
- d) no pitting or flaking of materials or finishes is apparent.

Examination may generally be carried out using an instrument with up to three times magnification.

### 7.3 Dimensions inspection

#### 7.3.1 Interface dimensions

The interface dimensions shall be tested for compliance with the relevant detail specification with the appropriate test equipment.

Where connectors conforming to IEC 61169 are used, inspection of interface dimensions may be limited to those features likely to vary as a result of incorrect assembly, for example the axial dimensions from reference plane to dielectric, and to inner contact features.

Where other connectors are used or where special requirements exist, details shall be given in the relevant detail specification.

#### 7.3.2 Outline dimensions

Any special requirements for the measurement of cable assembly outline dimensions shall be given in the relevant detail specification.

## 8 Electrical tests

### 8.1 Reflection properties

#### 8.1.1 Object

To determine the amount of signal that is reflected back to the signal source by the cable assembly under test in a matched system. The reflection behaviour is preferably expressed in terms of “dB return loss”.

### 8.1.2 Procedure

The return loss of a cable assembly should be measured with a suitable network analyser.

For the measurement of the reflection characteristics of cable assemblies, special care must be given to the following:

- ensure that the sweep speed is slow enough for the reflected signal to remain in the centre of the IF-filter of the receiver system. The longer the cable, the slower the sweep speed that must be chosen;
- cable assemblies might have narrow return loss spikes. For continuous network analyser-systems, the sweep rate shall be low enough and for digital network analyser-systems, the number of measurement points shall be high enough for resolving eventual return loss spikes.

For example, for digital systems, the number of points should be:

$$n \geq 3(f_2 - f_1) L / (120)$$

where

- $n$  is the number of sampling points in the frequency range  $f_1$  to  $f_2$  forming the response curve;
- $f_1$  is the lowest frequency in the range, in MHz;
- $f_2$  is the highest frequency in the range, in MHz;
- $L$  is the physical length of the test specimen, in m.

Failing to apply these criteria may result in too wide a distance between the frequency sampling points, thus leading to considerable measuring failures.

The return loss of cable assemblies is not necessarily symmetrical for both sides, and measurements from both sides might be required. Unless otherwise stated in the relevant detail specification, the worse case has to be within the specification.

The system has to be calibrated with the appropriate connector types. If these are not available, then adapters have to be used. The adapters will give a deterioration in the measured return loss, but, the result shall not be corrected for the adapters. The combined return loss, including the adapters, shall be within the specification.

Other techniques for measuring the reflection characteristics of a cable assembly may be used if agreed by the customer.

### 8.1.3 Requirements

The measured return loss values shall be within the specified limits.

#### 8.1.4 Information to be given in the detail specification

- a) Minimum return loss, as a function of frequency, if appropriate.
- b) Frequency range.
- c) Required frequency resolution.

Measurements to be made from one or both ends.

### 8.2 Uniformity of impedance

#### 8.2.1 Object

To determine the variation of local characteristic impedance of the cable assembly.

#### 8.2.2 Procedure

Measurement is made using a time domain reflectometer (TDR) with input step applied to the cable assembly through an air line acting as an impedance reference. Impedance variation along the assembly shall be observed.

Alternatively, a system using frequency domain to time domain conversion may be used.

#### 8.2.3 Requirements

To be as specified in the relevant detail specification.

#### 8.2.4 Information to be given in the detail specification

- a) Rise time of the TDR system.
- b) Limits of impedance variation.

### 8.3 Insertion loss

#### 8.3.1 Procedure

The insertion loss shall be inspected in accordance with Annex A.

#### 8.3.2 Requirements

The insertion loss shall not exceed the specified limits at any frequency within the frequency band indicated in the relevant detail specification.

#### 8.3.3 Information to be given in the detail specification

- a) Maximum insertion loss, if appropriate, as a function of frequency.
- b) Frequency range.

### 8.4 Insertion loss stability

#### 8.4.1 Object

To determine the change of attenuation at a given frequency when the cable assembly is subjected to dynamic bending.

### 8.4.2 Procedure

During insertion loss measurement according to 8.3, the cable is wound on a mandrel of radius equal to the dynamic bending radius and using the number of turns indicated in the relevant detail specification.

### 8.4.3 Requirements

During and after the test, the specified change of insertion loss given in the relevant detail specification shall not be exceeded.

### 8.4.4 Information to be given in the detail specification

- Dynamic bending radius of the cable (radius of the mandrel).
- Number of turns and portion of the cable assembly on the mandrel.
- Test frequencies.
- Maximum change of insertion loss.

## 8.5 Propagation time

### 8.5.1 Procedure

The propagation time is inspected in accordance with Annex B.

### 8.5.2 Requirements

The propagation time shall not exceed the limits indicated in the relevant detail specification.

### 8.5.3 Information to be given in the detail specification

- Frequency band in which the measurement is carried out (see clause B.1) or rise time of the system (see clause B.2).
- Propagation time and tolerance.

## 8.6 Stability of electrical length

### 8.6.1 Object

To determine the change of phase caused by the change in electrical length when the cable assembly is subjected either to bending or twisting.

### 8.6.2 Procedures

#### 8.6.2.1 Bending

##### Method 1

A cable assembly which is of a U shape has to be connected to a suitable network analyser (NWA), (see Figure 1a). During recording of the phase of the transmitting signal, the cable is wound around the mandrel for  $180^\circ$  (see Figure 1b), unwound to the starting position, wound counter-clockwise for  $180^\circ$  around the mandrel (see Figure 1c) and again unwound to its starting position. The initial position of the mandrel shall be chosen so that only the straight parts of the U will be bent during the test.

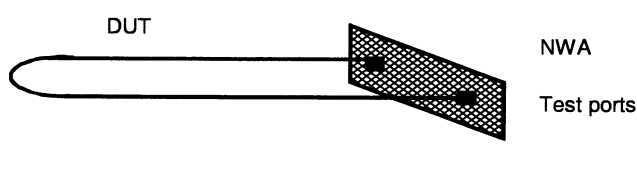


Figure 1a — Start position

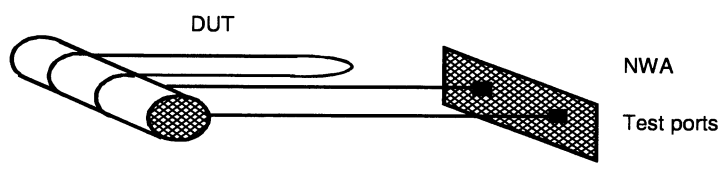


Figure 1b — First bend

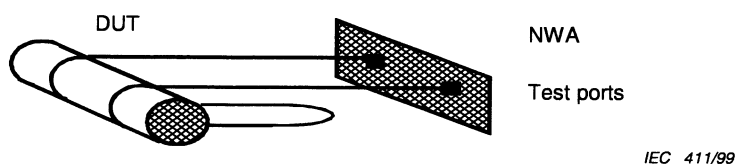


Figure 1c — Second bend

Figure 1 — Bending test: U shape assembly

## Method 2

A cable assembly which is of a straight shape (see Figure 2a) has to be terminated by a short at one end and connected to a suitable network analyser at the other end. During the recording of the phase of the reflected signal, the cable is first wound clockwise around the mandrel for one half turn (see Figure 2b), released to the starting position then wound anti-clockwise around the mandrel (see Figure 2c) and again released to its starting position.

8.6.2.2 *Twisting*

A cable assembly which is of a U shape has to be connected to a suitable network analyser (see Figure 3a). During the recording of the phase of the transmitting signal the mandrel in the middle of the cable is first twisted in a clockwise direction for  $180^\circ$  (see Figure 3b) then released to the starting position, twisted counter-clockwise for  $180^\circ$  (see Figure 3c) and again released to its starting position.

NOTE Depending on the torsional rigidity and the maximum permissible torque at the cable connectors interface, the maximum twist angle may have to be restricted.

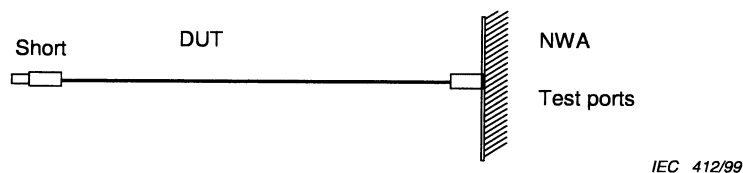


Figure 2a — Start position

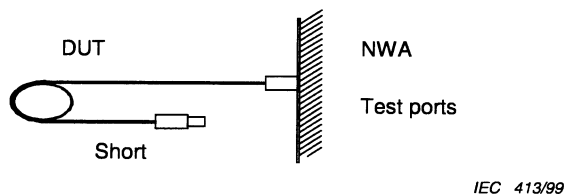


Figure 2b — First bend

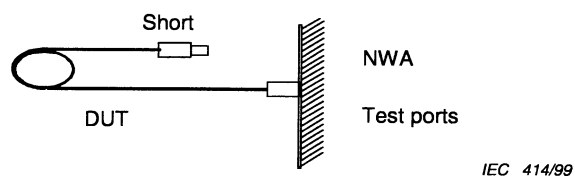


Figure 2c — Second bend

Figure 2 — Bending test: straight assembly