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REDLINE VERSION

INTERNATIONAL STANDARD

Coaxial communication cables –
Part 1-111: Electrical test methods – Stability of phase test methods

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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 IEC 61196-1-111:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61196-1-111 has been prepared by subcommittee 46A: Coaxial cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

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

a) addition of the list of test methods in the Scope;
b) addition of "the number of scanning points" in every test method;
c) addition of Annex A, Phase consistency test for two or more cables;
d) addition of Annex B, Phase variation with temperature test between two cables.

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

Draft	Report on voting
46A/1666/CDV	46A/1680/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61196 series, published under the general title *Coaxial communication cables*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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COAXIAL COMMUNICATION CABLES –

Part 1-111: Electrical test methods – Stability of phase test methods

1 Scope

~~This part of IEC 61196 applies to coaxial communication cables. It specifies methods for determining the stability of phase of coaxial communication cables.~~

This part of IEC 61196 provides test methods to determine the stability of phase of coaxial communication cables.

This document is applicable to RF coaxial cables. RF coaxial cable assemblies can also use this document for reference.

This part of IEC 61196 comprises following test methods:

a) phase variation with temperature (Clause 4);
b) phase constant variation with temperature (Clause 5);
c) phase stability with bending (Clause 6);
d) phase stability with twisting (Clause 7);
e) phase consistency test for two or more cables (Annex A);
f) phase variation with temperature test between two cables (Annex B).

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 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*

IEC 61196-1-108:2011, *Coaxial communication cables – Part 1-108: Electrical test methods – Test for characteristic impedance, phase and group delay, electrical length and propagation velocity*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61196-1 and the following apply.

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

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

3.1
temperature coefficient of phase
$\eta_{t,f}$
coefficient defined as at the specified frequency f, as the ratio of the phase difference $\Delta\varphi_{t,f}$ between $\varphi_{25\,°\mathrm{C},f}$ at 25 °C and $\varphi_{t,f}$ at temperature t, and the total phase $\Phi_{25\,°\mathrm{C},f}$ at 25 °C

$$\eta_{t,f} = \frac{\varphi_{25\,°\mathrm{C},f} - \varphi_{t,f}}{\Phi_{25\,°\mathrm{C},f}} = \frac{\Delta\varphi_{t,f}}{\Phi_{25\,°\mathrm{C},f}} \quad (1)$$

where:

$\varphi_{t,f}$ is the phase at temperature t and frequency f, in (°);

$\varphi_{25\,°\mathrm{C},f}$ is the phase at 25 °C and frequency f, in (°);

$\Delta\varphi_{t,f}$ is the phase difference between $\varphi_{25\,°\mathrm{C},f}$ and $\varphi_{t,f}$ at frequency f, in (°);

$\Phi_{25\,°\mathrm{C},f}$ is the total phase at 25 °C and frequency f, in (°)

3.2
maximum variation of temperature coefficient of phase
$|\Delta\eta|_{\max}$
maximum value $\eta_{\max}$ minus the minimum value $\eta_{\min}$

$$\Delta\eta_{\max} = |\eta_{\max} - \eta_{\min}| \quad (2)$$

3.3
ratio of relative temperature coefficient of phase *PT*
ratio of the relative temperature coefficient of phase PT, when the relationship between phase and temperature is sufficiently linear

$$PT = \frac{|\varphi_{t_1,f} - \varphi_{t_2,f}|}{\Phi_{25\,°\mathrm{C},f} \times (t_2 - t_1)} \quad (3)$$

where:

$\varphi_{t1,f}$ is the phase value at t_1 and frequency f, in (°);

$\varphi_{t2,f}$ is the phase value at t_2 and frequency f, in (°);

$\Phi_{25°\mathrm{C},f}$ is the total phase at 25 °C and frequency f, in (°);

t_1 and t_2 are any two temperatures within a specified temperature range in which the relationship between phase and temperature is sufficiently linear ($t_2 > t_1$), in °C

3.4
total relative variation of phase constant
total relative variation of the phase constant

$$\delta\beta = \frac{\beta_2 - \beta_1}{\beta_{\text{nom}}} \quad (4)$$

$$\delta\beta = \frac{l_{e,2} - l_{e,1}}{l_{\text{mech}}} \times v_{r,\text{nom}} = \left(\tau_{p,2} - \tau_{p,1}\right) \times c \times v_{r,\text{nom}} \quad (5)$$

where:

β_1 is the phase constant at temperature t_1, in radians/m;

β_2 is the phase constant at temperature $t_2 > t_1$, in radians/m;

β_{nom} is the nominal phase constant, in radians/m;

$\tau_{p,1}$ is the phase delay at temperature t_1, in s/m;

$\tau_{p,2}$ is the phase delay at temperature $t_2 > t_1$, in s/m;

c is the propagation velocity in free space (3×10^8 m/s);

$l_{e,1}$ is the electrical length at temperature t_1, in m;

$l_{e,2}$ is the electrical length at temperature $t_2 > t_1$, in m;

l_{mech} is the mechanical length, in m;

$v_{r,\text{nom}}$ is the nominal relative propagation velocity

Note 1 to entry: For unidirectional variation, t_1 and t_2 are the limits of a specified temperature range. In the case of changing signs of variation, t_1 and t_2 become the temperatures at which the extreme value of l_e or τ_p occur.

3.5
temperature coefficient of phase constant, *CT*
temperature coefficient of the phase constant

$$CT = \frac{\delta\beta}{t_2 - t_1} \quad (6)$$

where:

CT is the temperature coefficient of phase constant, in K^{-1};

$\delta\beta$ is the total relative variation of the phase constant;

t_1 and t_2 are any two temperatures within a specified range in which the phase constant is approximately linear, in °C

4 Phase variation with temperature

4.1 Purpose

Phase of cable varies as a function of temperature. The temperature variation will induce the change of the dielectric constant ε_r , mechanical length, and material character which will cause its phase variation. This variation can be unidirectional or multi-directional. The phase variation is characterized by the temperature coefficient of phase $\eta_{t_i,f}$ or by the ratio of relative temperature coefficient of phase PT when the relationship between phase and temperature is sufficiently linear. This method provides a test method to determine the phase variation with temperature. The maximum variation of temperature coefficient of phase $|\Delta\eta|_{max}$ is given in Formula (2).

A phase variation with temperature test to determine the difference of phase variation with temperature between two cables is given in Annex B.

4.2 Test equipment

~~A temperature chamber with sufficient precision, temperature range and volume shall meet the requirement specified in the relevant specification (for PTFE insulated cable, the temperature should be within ±2 °C).~~

~~A vector network analyzer (VNA) capable of sufficient precision is recommended.~~

Test equipment should be as follows:

a) a temperature chamber with sufficient precision within ± 2 °C;

b) a vector network analyser (VNA) with sufficient precision;

c) test clamp for fixation (if needed).

4.3 Preparation of test sample (TS)

The cable under test shall be terminated with suitable connectors at each end to make a cable assembly as a test sample (TS), as shown in Figure 1. It is suggested that a pair of screw thread connectors which suit with the vector network analyser should be used to make a TS for convenience and higher precision. Two marks should be made at each end of the TS, as shown in Figure 1. L_{1mech} shall not be less than 0,15 m and L_{2mech} of the cable under test-(CUT) shall not be less than 2,70 m.

At least two TS should be made.

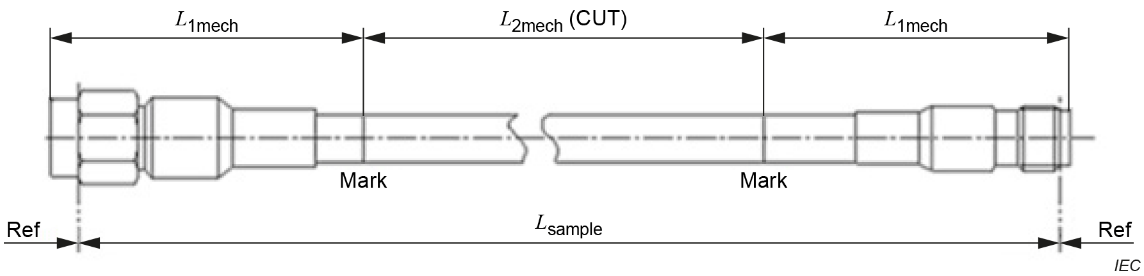


Figure 1 – Test sample (TS)

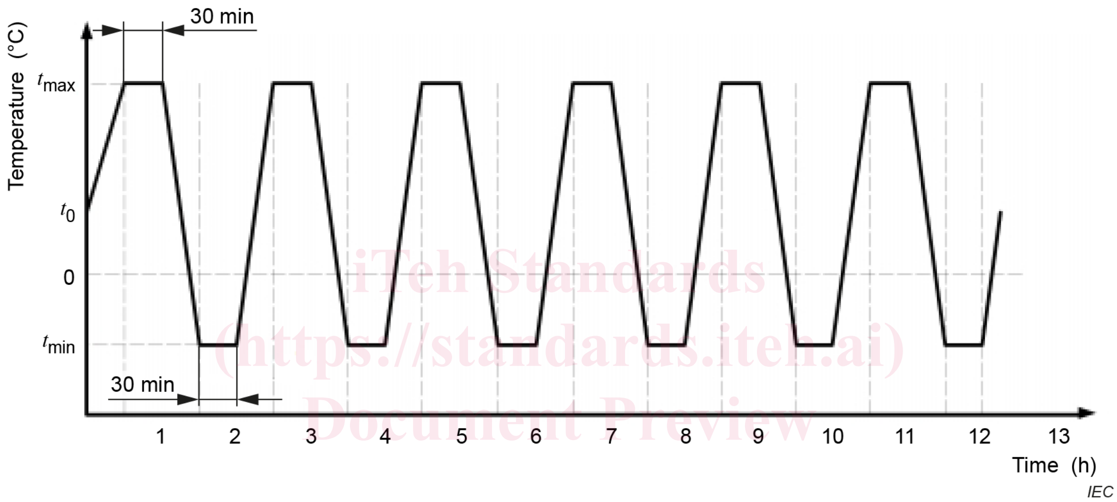
4.4 Test environment

The variation of the laboratory's ambient temperature shall be within ±2 °C. The recommended temperature is 25 °C. For a cable with PTFE dielectric, the laboratory's ambient temperature should avoid the material's sensitive temperature interval.

4.5 Preconditioning

The TS shall be put into a temperature chamber in loose coils with the diameter not less than 10 times of the cable's minimum static bending radius.

Adjust the temperature of the chamber for 6 cycles as shown in Figure 2 and maintain at least 30 min at each limit temperature (t_{max} and t_{min}) which shall be specified in the relevant specification to ensure temperature balance inside. the number of cycles may be agreed between the customer and the supplier.



Key

t_0 laboratory's ambient temperature, for example 25 °C ±2 °C;

t_{max} maximum temperature specified in the relevant specification, in °C;

t_{min} minimum temperature specified in the relevant specification, in °C.

Figure 2 – Preconditioning

4.6 Test procedure

The test procedure is as follows:

a) after preconditioning, one of the TS is picked up for calibration as a reference sample during the test. The state and position of the reference sample should not be changed during the test period to avoid any measurement error.

b) put the other TS into the temperature chamber with two ends of the TS from the marks outside the chamber and seal the chamber with thermal insulating plugs as shown in Figure 3. The marks in Figure 3 are proposed to be placed in the middle of the thermal insulating plugs. The other part of the TS in the chamber shall be placed in loose coils with the diameter not less than 10 times of the cable's minimum static bending radius.

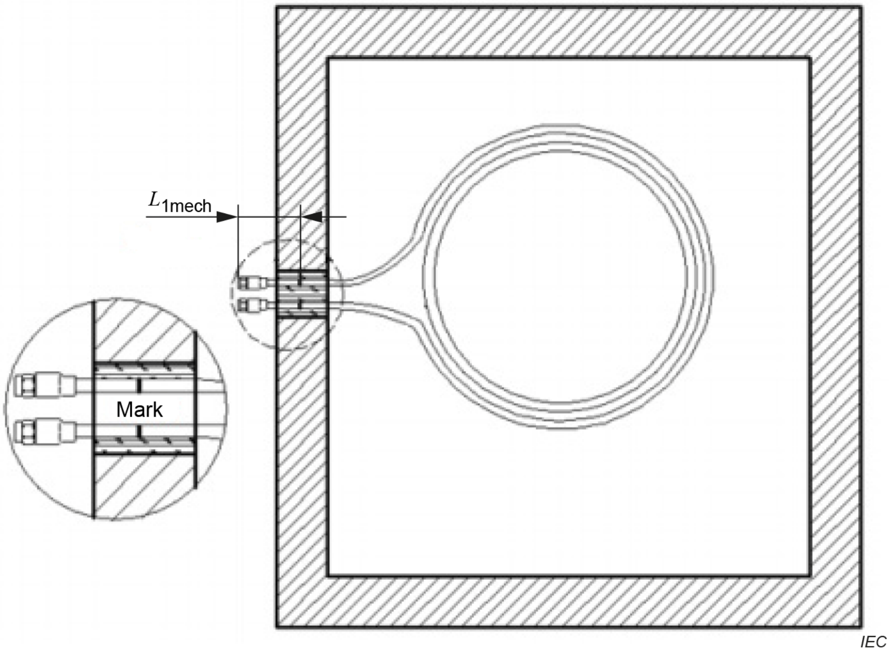


Figure 3 – TS placement diagram

c) ~~After being preheated, the VNA shall be set to S_{12} or S_{21} with the number of scanning points not less than 801. Calibrate it over the specified frequency range.~~

after the VNA is fully preheated, set the measurement frequency range and the test mode to S12 or S21. The number of scanning points shall be set according to Formula (7) and shall not be less than 801. When the value calculated according to Formula (7) exceeds the maximum number of points of the device, the highest number of points that the VNA can reach should be taken.

$$n \geq \frac{3(f_2 - f_1)l}{120} \tag{7}$$

where:

n is the number of scanning points of measurement;

f_1 is the lowest point of the frequency range, in MHz;

f_2 is the highest point of the frequency range, in MHz;

l is the physical length of the cable under test, in m.

Set the temperature chamber to 25 °C and maintain at least 10 min when it reaches the temperature. Connect the TS with the VNA and read the frequencies f_1 and f_2 which are the adjacent peak wave or valley wave as shown in Figure 4. The frequencies f_1 and f_2 should be near the value of f. The total phase of the CUT at frequency f at 25 °C is:

$$\Phi_{25\,°\mathrm{C},f} = 360° \times \frac{f}{f_2 - f_1} \times \frac{L_{2mech}}{L_{sample}} \tag{8}$$

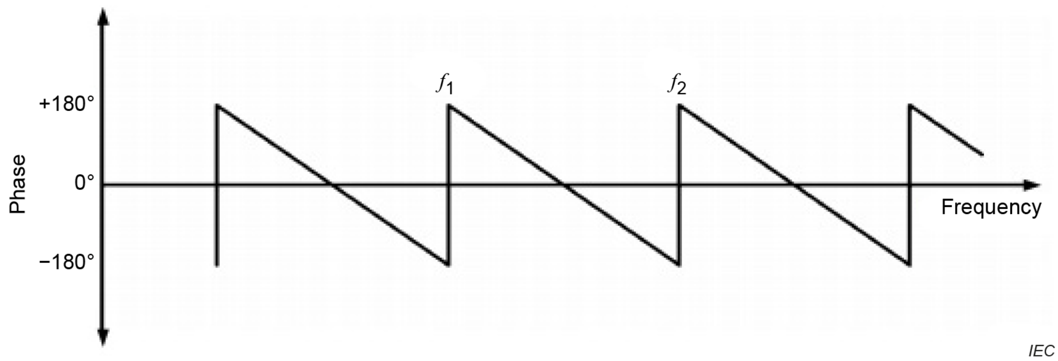


Figure 4 – Phase–Frequency graph schematic diagram

d) at 25 °C, use the reference sample to calibrate VNA, then connect the TS with the VNA and record the phase value $\varphi_{25\,°\text{C},f}$ at frequency f. Connect the reference sample with the VNA again and record its phase drift $\delta_{25\,°\text{C},f}$

e) adjust the temperature of the chamber to the lowest temperature t_1 and maintain for enough time that the CUT becomes balanced in temperature (see NOTE 1). Repeat the steps of 4.6, paragraph 5 and record the phase value $\varphi_{t_1,f}$ and phase drift $\delta_{1,f}$ at test frequency f at t_1.

f) adjust the temperature of the chamber to each higher temperature t_i (see NOTE 2) until it reaches the maximum temperature of the cable and repeat the steps of 4.6, paragraph 6 and record the phase value $\varphi_{t_i,f}$ and phase drift $\delta_{i,f}$ at frequency f at t_i.

NOTE 1 Different cables differ in maintaining time. When the outer diameter of cables is less than 6 mm, the maintaining time is at least 30 minutes or as specified in the relevant specification; when the outer diameter of cables is more than 6 mm, the maintaining time is increased or as specified in the relevant specification.

NOTE 2 For cables with PTFE dielectric, the testing temperature point between –20 °C to 25 °C is increased so as to get a more accurate result.

4.7 Test result

4.7.1 Calculation of temperature coefficient of phase

Use Formula (1) to calculate the temperature coefficient of phase $\eta_{t_i,f}$ at t_i at frequency f:

$$\eta_{t_i,f} = \frac{\varphi_{25\,°\text{C},f} - \varphi_{t_i,f} - \delta_{i,f}\,/\,2}{\Phi_{25\,°\text{C},f}} = \frac{\Delta\varphi_{t_i,f}}{\Phi_{25\,°\text{C},f}} \tag{9}$$

where:

$\varphi_{25\,°\text{C},f}$ is the phase at 25 °C at frequency f, in (°);

$\varphi_{t_i,f}$ is the phase at t_i at frequency f, in (°);

$\delta_{i,f}$ is the VNA phase drift at each temperature point during test, in (°);

$\Phi_{25\,°\text{C},f}$ is the total phase at 25 °C and frequency f, in (°);

$\Delta\varphi_{t_i,f}$ is the phase difference between $\varphi_{25℃,f}$ and $\varphi_{t_i,f}$ at frequency f, in (°).