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Edition 3.0 2024-09

INTERNATIONAL STANDARD

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

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

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COAXIAL COMMUNICATION CABLES –

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

FOREWORD

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- withdrawn, or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 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

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

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
$\left|\Delta\eta\right|_{\mathrm{max}}$
maximum value η_{max} minus the minimum value η_{min}

$$\Delta\eta_{\mathrm{max}} = \left|\eta_{\mathrm{max}} - \eta_{\mathrm{min}}\right| \tag{2}$$

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

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

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

$$\delta\beta = \frac{\beta_2 - \beta_1}{\beta_{\text{nom}}} \tag{4}$$

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

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

$$CT = \frac{\delta\beta}{t_2 - t_1} \tag{6}$$

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 $|\Delta\eta|_{\text{max}}$ 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

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.

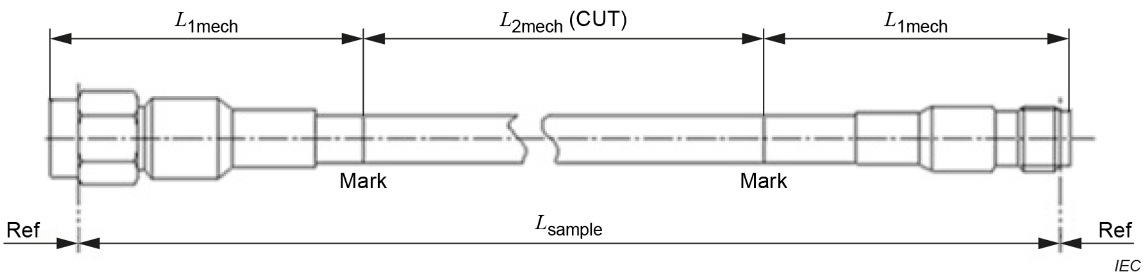


Figure 1 – Test sample (TS)

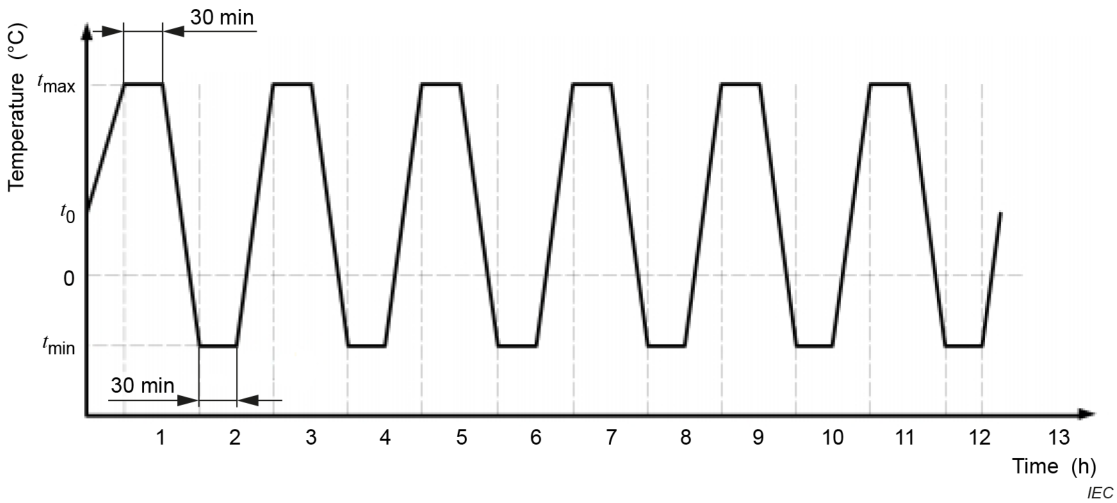
4.4 Test environment

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.

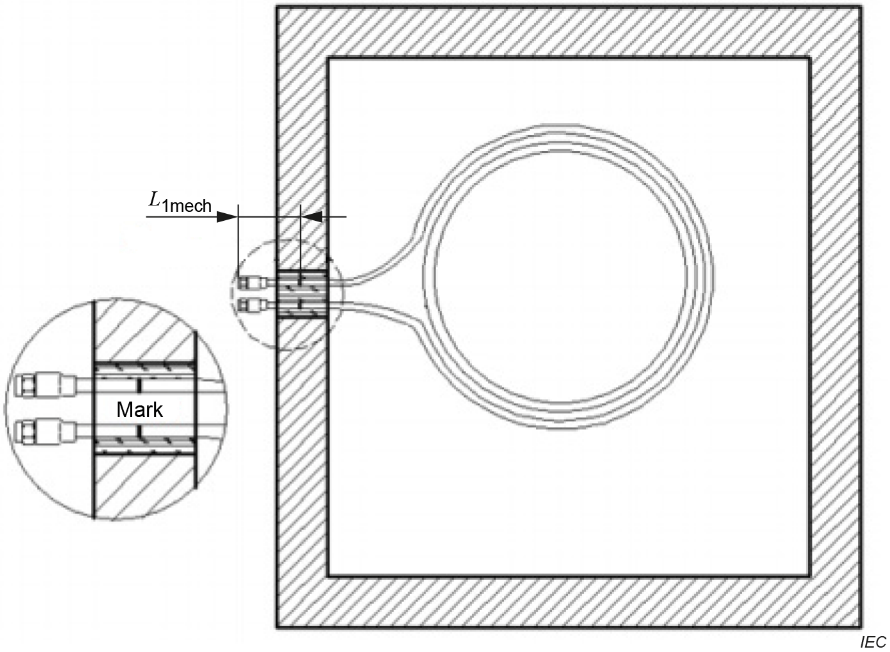


Figure 3 – TS placement diagram

c) after 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:

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

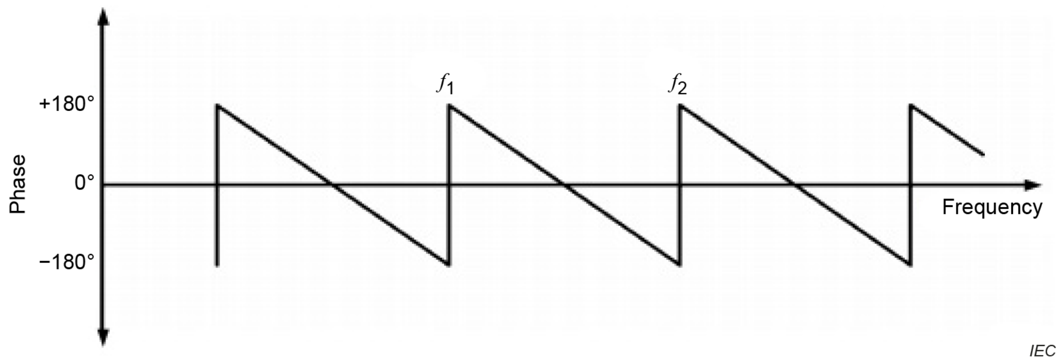


Figure 4 – Phase–Frequency graph schematic diagram

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

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:

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

where:

$\varphi_{25\ °\mathrm{C},f}$ 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 (°);

$\Phi_{25\ °\mathrm{C},f}$ 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 (°).

The phase drift of the VNA can be ignored when no higher precision is requested, and the temperature coefficient of phase $\eta_{t_i,f}$ at t_i at frequency f can be calculated with:

$$\eta_{t_i,f} = \frac{\varphi_{25\,°C,f} - \varphi_{t_i,f}}{\Phi_{25\,°C,f}} = \frac{\Delta\varphi_{t_i,f}}{\Phi_{25\,°C,f}} \quad (10)$$

4.7.2 Graph of phase temperature change

Use each $\eta_{t_i,f}$ and t_i to draw the $\eta_{t,f} - T$ (°C) graph of phase variation with temperature at specified frequency f.

4.7.3 Maximum variation value of phase variation with temperature

Use Formula (2) to calculate maximum variation value of phase variation with temperature ($\eta_{max} - \eta_{min}$).

4.7.4 Ratio of the relative phase temperature coefficient

Use Formula (3) to calculate the ratio of the relative temperature coefficient of phase PT when the relationship between phase and temperature is sufficiently linear.

4.8 Test report

The test report shall include information such as the following:

a) the preconditioning temperature ($t_{max} - t_{min}$);

b) the temperature range and test temperature points;

c) the maintaining time at each temperature;

d) the sample length;

e) the test frequency.

Annex C gives an example on how to record the testing data and calculate testing result of the phase variation as temperature change.

4.9 Requirement

The values shall meet the requirements of the relevant specification.

5 Phase constant variation with temperature

5.1 Purpose

Phase constant varies as a function of temperature. This variation can be unidirectional or multi-directional. The stability of the phase constant is characterized either by the total variation of the phase constant or by the temperature coefficient of the phase constant in a temperature range in which the relationship between phase and temperature is sufficiently linear. The phase-temperature relationship of new cables may be influenced by irreversible variations of the phase constant. These can be reduced by heat cycling.

A test to determine the phase consistency of two or more cables with the same length and cut from the same cable or the same batch of cables is given in Annex A.

In addition to the temperature, the phase constant depends on the pressure and the humidity of the gas enclosed within the cable. This is of particular interest in the case of cables with airtight outer conductors.

5.2 Test equipment

Test equipment is as follows:

a) a temperature chamber with sufficient precision, temperature range and volume shall meet the requirement in the relevant specification.
b) a vector network analyser (VNA) capable of sufficient precision is recommended.
c) test clamp for fixation should meet the precision requirement (if needed).

5.3 Test sample

Prepare the TS according to 4.3 or the relevant specification.

5.4 Test environment

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

5.5 Preconditioning

The TS shall be preconditioned according to 4.5.

5.6 Test procedure

The test procedure is as follows:

a) the VNA shall be calibrated according to the error correction procedure given in the manual of the VNA.
b) put the TS into the temperature chamber with two ends of TS from the marks outside the chamber and seal the chamber with thermal insulating plugs as shown in Figure 3. The other parts 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.
c) set the temperature of chamber to t_1 and maintain 30 min at least when it reaches t_1. Measure the phase $\varphi_{t_1,f}$ in radians at t_1 according to IEC 61196-1-108.
d) set the temperature of chamber to t_2 and maintain 30 min at least when it reaches t_2. Measure the phase $\varphi_{t_2,f}$ in radians at t_2 according to IEC 61196-1-108.

5.7 Test result

According to Formula (9) of IEC 61196-1-108:2011, $\beta_{t_2,f} - \beta_{t_1,f}$ is calculated as:

$$\beta_{t_2,f} - \beta_{t_1,f} = \frac{\varphi_{t_2,f}}{L_{\text{2mech}}} - \frac{\varphi_{t_1,f}}{L_{\text{2mech}}} \tag{11}$$

where:

$\beta_{t_1,f}$ is the phase constant at t_1 at frequency f, in radians/m;

$\beta_{t_2,f}$ is the phase constant at t_2 at frequency f, in radians/m;

$\varphi_{t_1,f}$ is the phase at t_1 at frequency f, in radians;

$\varphi_{t_2,f}$ is the phase at t_2 at frequency f, in radians.

The total relative variation of the phase constant is:

$$\delta\beta = \frac{\beta_{t_2,f} - \beta_{t_1,f}}{\beta_{\text{nom},f}} \tag{12}$$

where:

$\beta_{t_1,f}$ is the phase constant at t_1 at frequency f, in radians/m;

$\beta_{t_2,f}$ is the phase constant at t_2 at frequency f, in radians/m;

$\beta_{\text{nom},f}$ is the nominal phase constant at frequency f, in radians/m.

Use Formula (6) to calculate the temperature coefficient of the phase constant CT.

5.8 Test report

The test report shall include information such as the following:

a) the preconditioning temperature ($t_{\text{max}} - t_{\text{min}}$);
b) the temperature range ($t_1 - t_2$);
c) the maintaining time;
d) the sample length;
e) the test frequency;
f) the nominal phase constant;
g) the temperature coefficient of the phase constant.

5.9 Requirement

The values shall meet the requirements of the relevant specification.

6 Phase stability with bending

6.1 Purpose

The structure and electrical length of the cable will be changed when it is subjected to bending, which will induce the phase change. This method provides a test method to determine the phase variation with specified frequency when the cable is subjected to bending.

6.2 Test environment

The variation of the laboratory's ambient temperature shall be within ±2 °C. The recommended temperature is 25 °C.

6.3 Test sample

The cable under test shall be terminated with suitable connectors at each end, shown in Figure 5. It is recommended that a pair of screw thread connectors which suit with the vector network analyser is used to make a test sample for convenience and higher precision, The length L of the cable under test (CUT) shall meet the requirements shown in Figure 5.

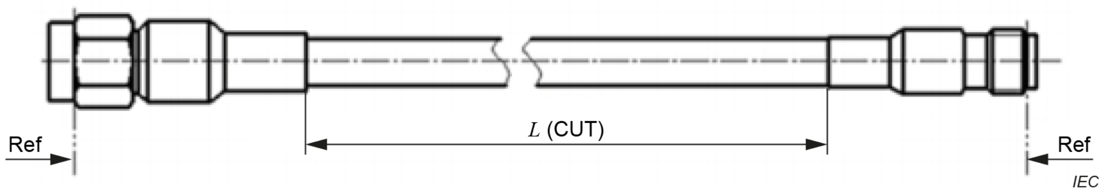


Figure 5 – Test sample (TS)

6.4 Test equipment

Test equipment is as follows:

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

b) The test clamp for fixation should meet the precision requirement (if needed).

6.5 Test procedure

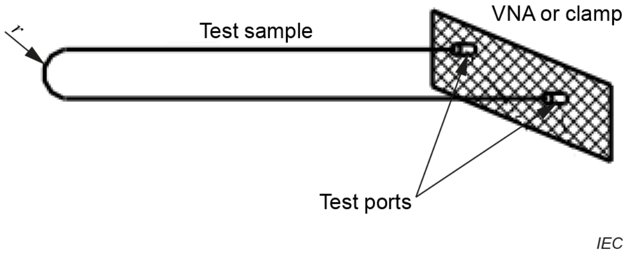
The test procedure is as follows:

a) After being preheated, the VNA shall be set to S12 or S21 with the number of scanning points according to 4.6c), Calibrate it over the specified frequency range.

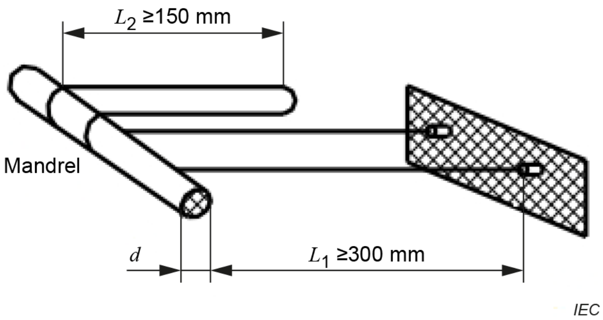
b) Connect the TS with the VNA and bend the CUT to U shape with the minimum bending radius r specified in relevant specification as shown in Figure 6a). Calibrate the phase of the VNA to zero.

c) Put a mandrel with the specified diameter d on C and bend the CUT around the mandrel for 180° as shown in Figure 6b). Record curve 1 of the phase variation with frequency in the VNA shown in Figure 8. Bending should be very carefully performed and stable in order to reduce its effect on the test result.

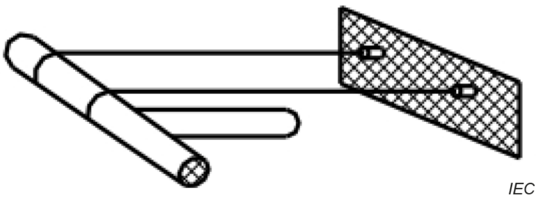
d) Straighten CUT back to the initial position shown in Figure 6a). Put the mandrel under the CUT, and then bend the CUT around the mandrel for 180° in a reversed way as shown in Figure 6c). Record curve 2 of the phase variation with frequency in the VNA shown in Figure 8.



a) Initial position



b) First bend



c) Second bend

Figure 6 – Bending test

6.6 Test report

The test report shall include information such as the following:

a) the bending radius *r* of the U shape; normally *r* shall not be less than the minimum dynamic bending radius;

b) the diameter *d* of the mandrel, which is usually 10 times of the cable's outer diameter;

c) the test frequency;

d) the result of the test: curve 1 and curve 2.

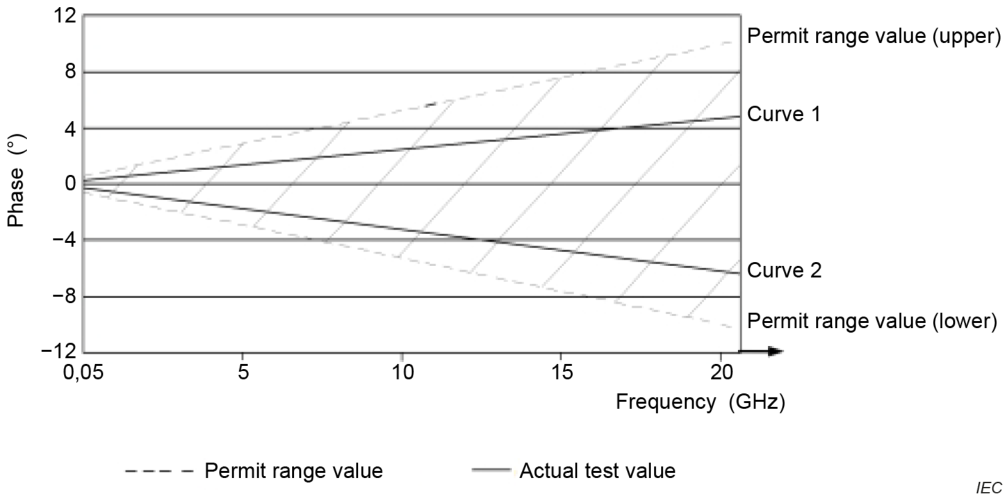


Figure 7 – Test graph schematic diagram

6.7 Requirement

The result of the test (curve 1 and curve 2) shall meet the requirement in the relevant specification shown as permit range value in Figure 7.

7 Phase stability with twisting

7.1 Purpose

The structure and electrical length of the cable will be changed when it is subjected to twisting, which will induce the phase change. This method provides a test method to determine the phase variation with specified frequency when the cable is subjected to twisting.

7.2 Test environment

The variation of the laboratory's ambient temperature shall be within ±2 °C. The recommended temperature is 25 °C.

7.3 Test sample

The cable under test shall be terminated with suitable connectors at each end, as shown in Figure 5. A pair of screw thread connectors which suit with the vector network analyser should be used to make a test sample for convenience and higher precision. The length L of the cable under test should be:

$$L = \frac{360°}{\theta} \tag{13}$$

where:

L is the length of CUT, in m;

θ is the permitting maximum twist angle per length specified in the relevant specification, in °/m.

7.4 Test equipment

Test equipment is as follows:

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

b) the test clamp for fixation should meet the precision requirement (if needed).

7.5 Test procedure

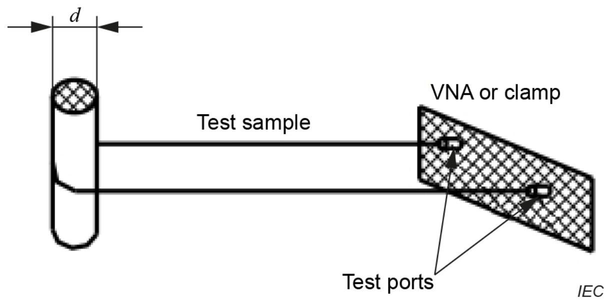
The test procedure is as follows:

a) After being preheated, the VNA shall be set to S12 or S21 with the number of scanning points according to 4.6c),Calibrate it over the specified frequency range.

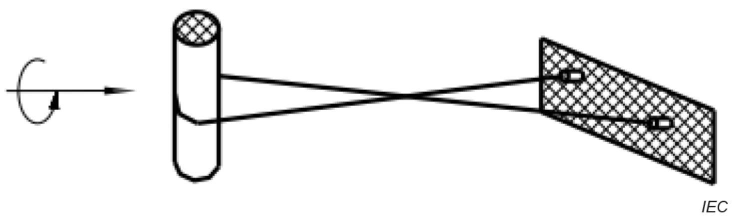
b) Connect the TS with the VNA and bend the CUT to U shape around a mandrel with the specified diameter *d* as shown in Figure 8a). Calibrate the phase of the VNA to zero.

c) Rotate the mandrel to 180° as shown in Figure 8b) and record curve 3 of the phase variation with frequency in the VNA shown in Figure 9. Twisting should be very carefully performed and stable in order to reduce its effect on the test result.

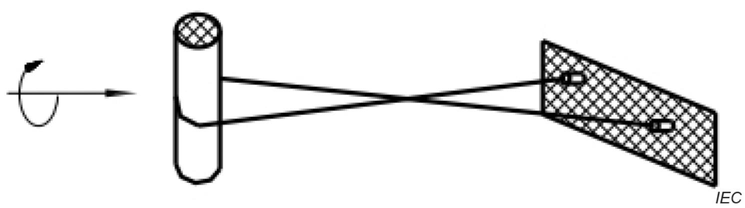
d) Return the mandrel to the initial position shown in Figure 8a). Then rotate the mandrel to 180° in the reverse way as shown in Figure 8c). Record curve 4 of the phase variation with frequency in the VNA shown in Figure 9.



a) Initial position



b) First twist



c) Second twist

Figure 8 – Twist test

7.6 Test report

The test report shall include information such as the following:

a) the diameter d of the mandrel, which is usually 10 times of the cable's outer diameter;
b) the test frequency range;
c) the maximum twist angle per length;
d) the result of test: curve 3 and curve 4.

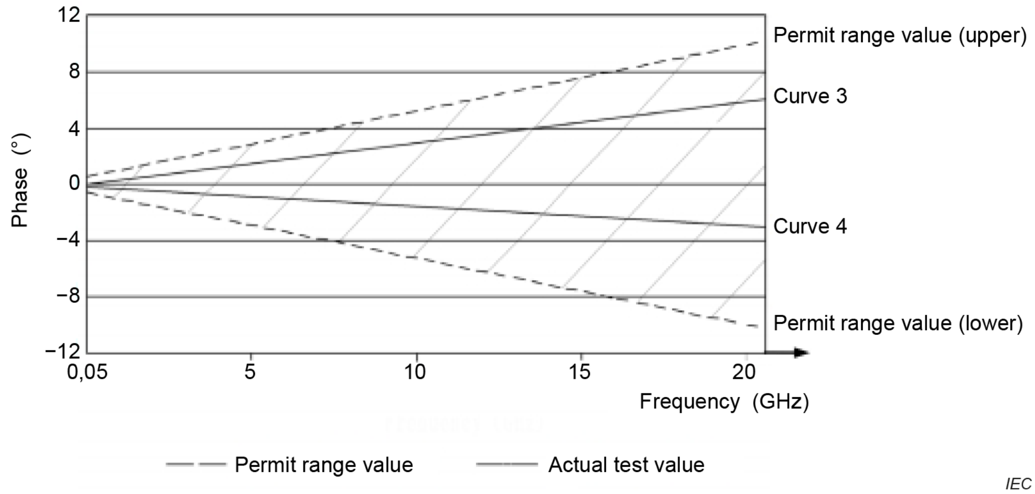


Figure 9 – Test graph schematic diagram

7.7 Requirement

The result of test (curve 3 and curve 4) shall meet the requirements in the relevant specification shown as permit range value in Figure 9.

Annex A
(normative)

Phase consistency test for two or more cables

A.1 Purpose

The change of cable dielectric constant can cause the phase change. This test is to determine the phase consistency of two or more cables with same length and cut from a same cable or same batch of cables in the specified frequency range.

A.2 Test equipment

Test equipment should be as follows:

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

b) test clamp for fixation (if needed).

A.3 The preparation of test sample (TS)

Cut two or more pieces of cables with same length l from a cable under test (CUT) as shown in Figure A.1.

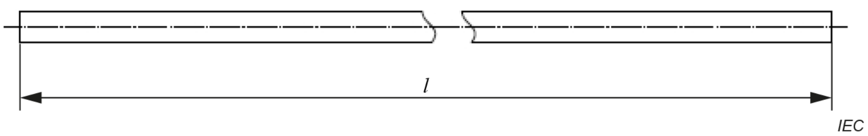


Figure A.1 – Cable

Each piece of cable shall be terminated with a suitable pair of connectors with same model and specification and quality, to make a cable assembly as a test sample (TS), as shown in Figure A.2.

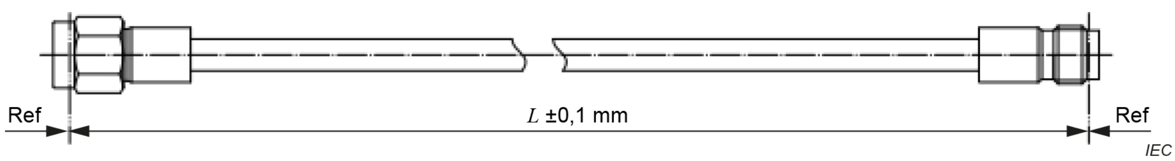


Figure A.2 – Cable assembly (TS)

It is recommended that a pair of screw thread connectors which suit with the vector network analyser (VNA) should be used to make a test sample for convenience and higher precision.

To improve the test precision, the difference between the pairs of suitable connectors should be small, and the phase difference can be ignored.

A.4 Test environment

The variation of the laboratory's ambient temperature shall be within ±2 °C. The recommended temperature is 25 °C.

A.5 Test procedure

The test procedure is as follows:

a) After 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 4.6c);

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

c) Connect one TS (or user specified TS) with VNA, calibrate the phase of the VNA to zero.

d) Connect another TS into the VNA and measure and record the phase and find the maximum value of phase difference $\Delta\varphi$ in the specified frequency range.

e) According to formula (A.1), calculate the phase consistency:

$$\delta = \frac{\Delta\delta}{l} \tag{A.1}$$

where:

δ is the phase consistency of the cable, in °/m;

$\Delta\delta$ is the maximum phase difference in the specified frequency range, in (°);

l is the physical length of cable, in m.

During the phase consistency test, the states of the coils, connector with instrument and the connector on tightening torque of the tested sample and zero calibration sample should be consistent, and should be tested in natural stable environment to avoid shaking.

A.6 Test report

The test report should include the following information:

a) the length l of the cable;

b) the length L of the cable assembly;

c) the test frequency range;

d) the test result.

A.7 Requirement

The values shall meet the requirements of the relevant specification.

Annex B
(normative)

Phase variation with temperature test between two cables

B.1 Purpose

The purpose of this test is to determine the difference of phase variation with temperature between two cables with same length and cut from the same cable or same batch of cables at the same frequency and same temperature.

B.2 Preparation of test sample

Cut two pieces of cables with same length l from a same cable under test (CUT) and made two or more TS according to 4.3.

B.3 Test environment

See 4.4.

B.4 Preconditioning

See 4.5.

B.5 Test procedure

Test every TS separately according to 4.6.

B.6 Test results

a) calculate all the temperature coefficient of phase $\eta_{ti,f}$ of each TS at temperature t_i and frequency f according to 4.7.1.

b) draw the $\eta_{t,f} - T$ (°C) graph of phase variation with temperature at specified frequency f of each TS according to 4.7.2, as shown in Figure B.1.

c) use formula to calculate maximum difference $\Delta\beta_{max}$ of the two TS, as shown in Figure B.1.

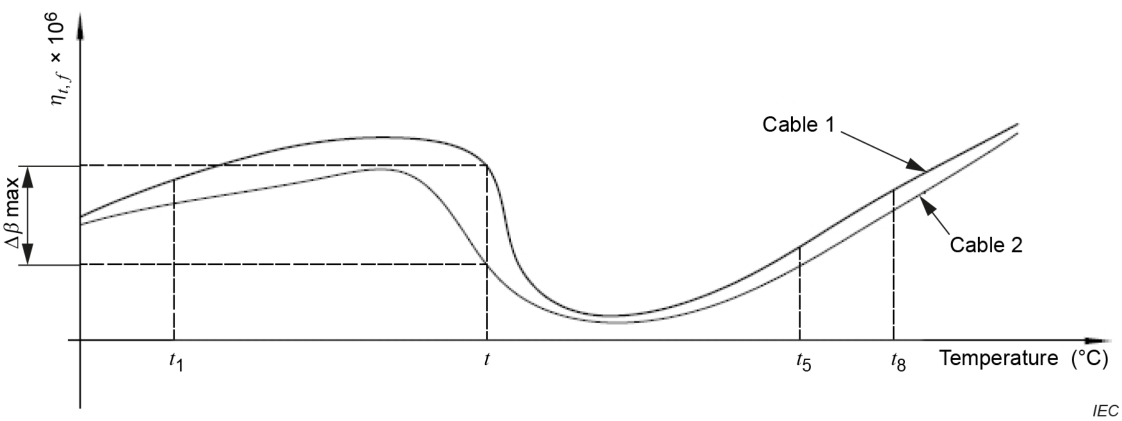


Figure B.1 – $\eta_{t,f} - T$ (°C) contrast graph

B.7 Test report

The test report should include the following information:

a) the preconditioning temperature (t_{max} – t_{min});
b) the temperature range and test temperature points;
c) the maintaining time at each temperature;
d) the sample length;
e) the test frequency;
f) Test result.

B.8 Requirement

The $\Delta\beta_{max}$ shall not exceed the requirements of the relevant specification.

Annex C
(informative)

Example for recording and calculating the phase variation with temperature

C.1 Purpose

In this Annex C, an example for recording and calculating of the phase variation with temperature is given.

C.2 Test sample

2 pieces of cable of 3 m long with SMA connectors terminated in both ends.

C.3 Test conditions

Laboratory's temperature: 25 °C ± 2 °C

Preconditioning temperature:

– t_{max}: 100 °C

– t_{min}: −40 °C

Test frequency f: 5 GHz;

Test temperature points: –50 °C, –25 °C , 0 °C, 15 °C, 20 °C, 25 °C, 50 °C, 75 °C, 100 °C;

Maintaining time: 30 min;

Record: f_1 = 5,296 37 GHz; f_2 = 5,379 85 GHz; $\varphi_{25\,°C,f}$ = –106,39°

C.4 Test record and calculation

According to Formula (8): $\Phi_{25\,°C,f} = 360° \times \frac{f}{f_2 - f_1} \times \frac{L_{2mech}}{L_{sample}}$,

calculate the total phase $\Phi_{25\,°C,f}$ = 19 405,8° at 25 °C;

calculate the temperature coefficient of phase $\eta_{t_i,f}$ at temperature t_i and fill in Table C.1.

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

Table C.1 – Test record and calculation

No.	t °C	$\varphi_{t_i,f}$	$\delta_{i,f}$	$\Delta\varphi_{t_i,f} = \varphi_{25\,°C,f} - \varphi_{t_i,f} - \delta_{i,f}/2$	$\eta_{t_i,f} = \frac{\Delta\varphi_{t_i,f}}{\Phi_{25\,°C,f}}$
0	25	–106,39	0	-	-
1	–50	–111,87	0,20	5,380	$277,24 \times 10^{-6}$
2	–25	–115,23	0,17	8,755	$451,15 \times 10^{-6}$
3	0	–117,32	0,16	10,850	$559,11 \times 10^{-6}$
4	15	–115,64	0,16	9,170	$472,54 \times 10^{-6}$
5	20	–109,52	0,17	3,045	$156,91 \times 10^{-6}$
6	25	–105,78	0,12	–0,670	$–34,53 \times 10^{-6}$
7	50	–107,42	0,21	0,925	$47,67 \times 10^{-6}$
8	75	–112,96	0,38	6,380	$328,77 \times 10^{-6}$
9	100	–118,02	0,48	11,390	$586,94 \times 10^{-6}$

Drawing as shown in Figure C.1:

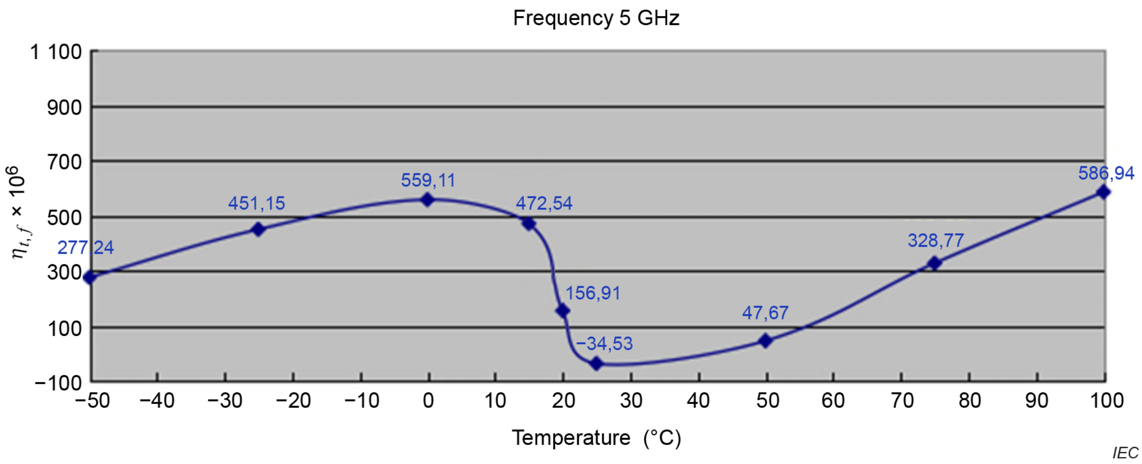


Figure C.1 – $\eta_{t,f} - T$ (°C) graph

C.5 Test result calculation

a) maximum phase variation with temperature $\left|\Delta\eta\right|_{\text{max}}$

According to Figure C.1:

η_{max} : 586,94 × 10^{-6}

η_{min} : –34,53 × 10^{-6}

According to Formula (2):

$$\left|\Delta\eta\right|_{\text{max}} = \left|\eta_{\text{max}} - \eta_{\text{min}}\right| = \left|586{,}94\ \text{x}10^{-6} - \left(-34{,}53\,x10^{-6}\right)\right| = 621{,}47\,x10^{-6}$$

b) ratio of relative temperature coefficient of phase PT

According to Figure C.1, the relationship between phase and temperature is linear between 25 °C and 100 °C.

According to Figure C.1: $\varphi_{25\,°\text{C},f}$: –105,78

$\varphi_{100\,°\text{C},f}$: –118,02

According to Formula (3):

$$PT = \frac{\left|\varphi_{25\,°\text{C},f} - \varphi_{100\,°\text{C},f}\right|}{\Phi_{25\,°\text{C},f} \times (t_2 - t_1)} = \frac{\left|-105{,}78-(-118{,}02)\right|}{19\,405{,}8\times(100-25)} = 8{,}41\times10^{-6}$$

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