BS EN 61189-2-719:2016

BSI Standards Publication

Test methods for electrical materials, printed boards and other interconnection structures and assemblies

Part 2-719: Test methods for materials for interconnection structures — Relative permittivity and loss tangent (500 MHz to 10 GHz)

bsi.

National foreword

This British Standard is the UK implementation of EN 61189-2-719:2016. It is identical to IEC 61189-2-719:2016.

The UK participation in its preparation was entrusted to Technical Committee EPL/501, Electronic Assembly Technology.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2016

ISBN 978 0 580 88266 1
ICS 31.180

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2016.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61189-2-719

October 2016

ICS 31.180

English Version

Test methods for electrical materials, printed boards and other interconnection structures and assemblies - Part 2-719: Test methods for materials for interconnection structures - Relative permittivity and loss tangent (500 MHz to 10 GHz) (IEC 61189-2-719:2016)

Méthode d'essai pour les matériaux électriques, les cartes imprimées et autres structures d'interconnexion et ensembles - Partie 2-719: Méthodes d'essai des matériaux pour structures d'interconnexion - Permittivité relative et tangente de perte (500 MHz à 10 GHz) (IEC 61189-2-719:2016)

Prüfverfahren für Elektromaterialien, Leiterplatten und andere Verbindungsstrukturen und Baugruppen - Teil 2-719: Prüfverfahren für Materialien von Verbindungsstrukturen - Relative Permittivität und Verlustfaktor (500 MHz bis 10 GHz) (IEC 61189-2-719:2016)

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

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European foreword

The text of document 91/1366/FDIS, future edition 1 of IEC 61189-2-719, prepared by IEC/TC 91 "Electronics assembly technology" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61189-2-719:2016.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-05-16
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2019-08-16

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The text of the International Standard IEC 61189-2-719:2016 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60194	-	Printed board design, manufacture and assembly - Terms and definitions	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 2-719: Test methods for materials for interconnection structures – Relative permittivity and loss tangent (500 MHz to 10 GHz)

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International Standard IEC 61189-2-719 has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this standard is based on the following documents:

FDIS	Report on voting
91/1366/FDIS	91/1380/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61189 series, published under the general title *Test methods for electrical materials, printed boards and other interconnection structures and assemblies*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 2-719: Test methods for materials for interconnection structures – Relative permittivity and loss tangent (500 MHz to 10 GHz)

1 Scope

This part of IEC 61189 specifies a test method of relative permittivity and loss tangent of printed board and assembly materials, expected to be determined 2 to 10 of relative permittivity and 0,001 to 0,050 of loss tangent at 500 MHz to 10 GHz.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60194, *Printed board design, manufacture and assembly – Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60194 apply.

4 Test methods

4.1 Test specimens

4.1.1 General

The requirements with respect to test specimens are as follows.

a) Specimens shall be copper clad laminate.
b) Specimens shall be cut not less than 25 mm from the edge of the sheet.
c) A minimum of four specimens shall be tested.

4.1.2 Size

The size of each specimen shall be ((200 ± 0,5) × (50 ± 1)) mm.

4.1.3 Thickness of dielectric

The dielectric thickness of each specimen shall be 0,6 mm to 1,6 mm. Typically 0,8 mm is suitable.

4.1.4 Thickness of copper foil

The copper foil thickness of each specimen should be 0,010 mm to 0,040 mm.

4.2 Test set

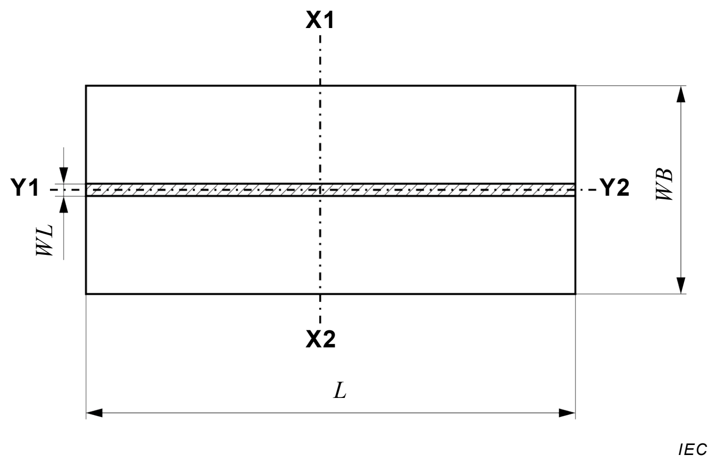
The setup of the test shall be as follows.

a) The test set consists of two boards. Board A shall be a board with a conductive line on one side and with a copper foil on another side. The width of conductive line shall be 0,9 mm ± 0,2 mm. Board B shall be a board without copper foil on one side and with a copper foil on another side. These boards shall be shown in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8.

b) Board A and board B are produced from test specimens. Copper foil on copper clad laminate shall be etched for the test set design.

c) After etching, the test set shall be etched laminate.

d) The test set shall be dried 1 h in the oven with 105 °C ± 2 °C, and kept 96 h in 20 °C /65 %RH.

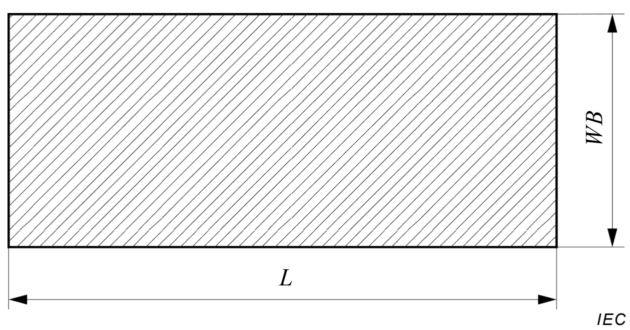


Key

WL is the width of the conductor line, in m

WB is the width of the test vehicle, in m

Figure 1 – One side of board A

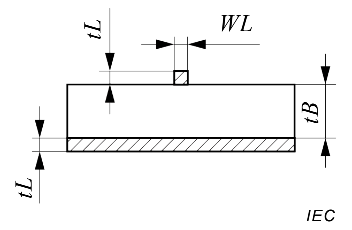


Key

L is the length of the test vehicle, in m

WB is the width of the test vehicle, in m

Figure 2 – Another side of board A



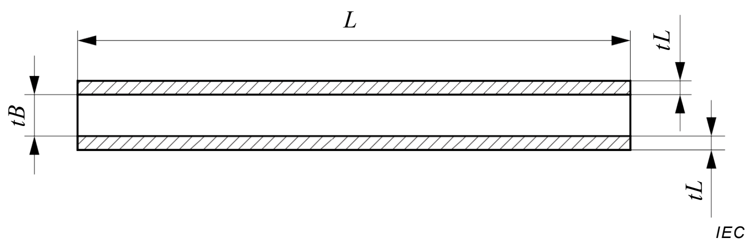
Key

WL is the width of the conductor line, in m

tL is the thickness of the conductor line, in m

tB is the thickness of the test vehicle, in m

Figure 3 – Cross section between X1 and X2 of board A



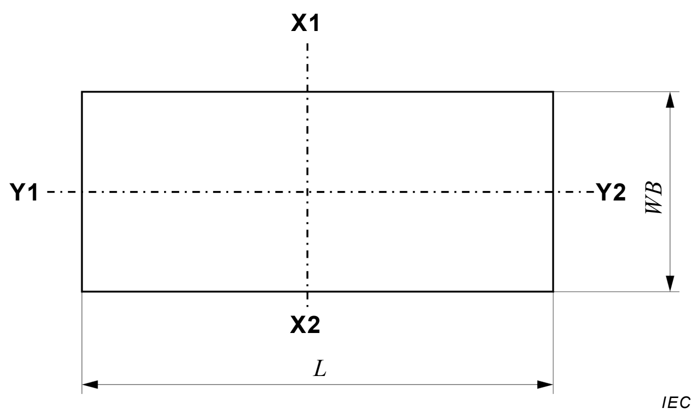
Key

L is the length of the test vehicle, in m

tB is the thickness of the test vehicle, in m

tL is the thickness of the conductor line, in m

Figure 4 – Cross section between Y1 and Y2 of board A

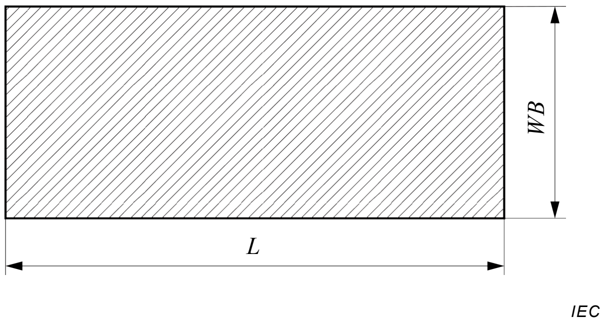


Key

L is the length of the test vehicle, in m

WB is the width of the test vehicle, in m

Figure 5 – One side of board B

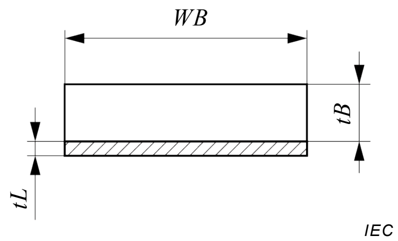


Key

L is the length of the test vehicle, in m

WB is the width of the test vehicle, in m

Figure 6 – Another side of board B



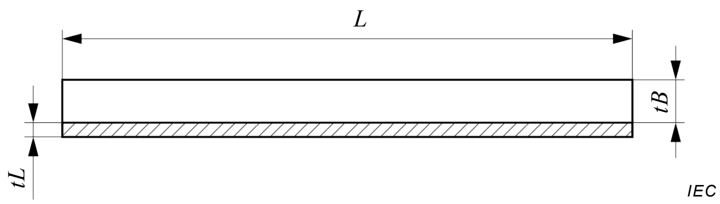
Key

WB is the width of the test vehicle, in m

tL is the thickness of the conductor line, in m

tB is the thickness of the test vehicle, in m

Figure 7 – Cross-section between X1 and X2 of board B



Key

L is the length of the test vehicle, in m

tL is the thickness of the conductor line, in m

tB is the thickness of the test vehicle, in m

Figure 8 – Cross section between Y1 and Y2 of board B

4.3 Test fixture

Test fixture shall be set up as follows and is shown in Figure 9, Figure 10, Figure 11 and Figure 12.

a) The test fixture consists of two coaxial connectors and a metallic box made of SUS (Stainless steel), etc.

b) Coaxial connectors shall be the type permitting high frequency measurement. The suitable types of connectors should be “SMA (Sub Miniature A), APC3.5 (Amphenol Precision Connector, 3,5 mm), APC7 (7 mm) or Type-N (Navy) or equivalent.

c) The thickness of the metallic board for the metallic box shall be more than 0,6 mm.

d) The distance of the gap shall be from 0,01 mm to 0,5 mm.

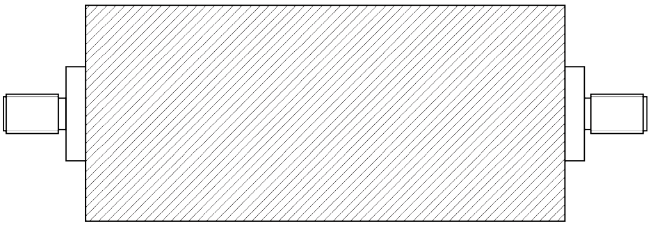
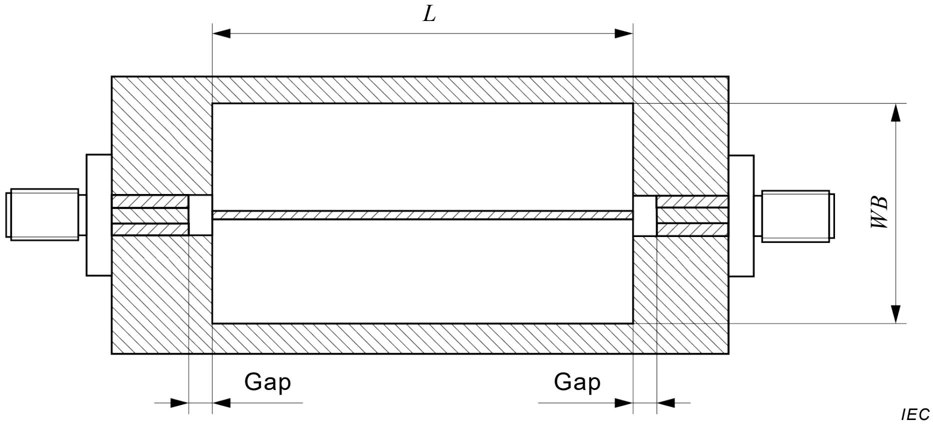


Figure 9 – Top view of test fixture



Key

L is the length of test vehicle, in m

WB is the width of test vehicle, in m

Figure 10 – Horizontal cross section of test fixture with test set

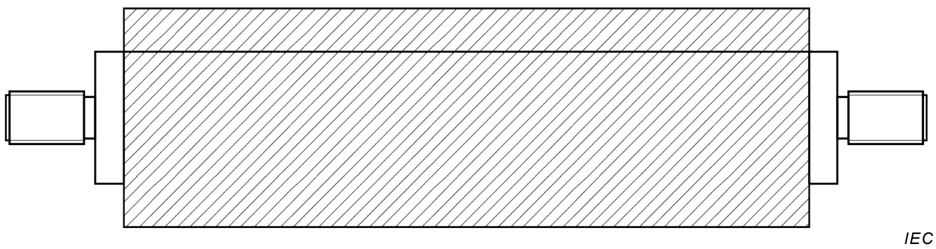


Figure 11 – Side view of test fixture

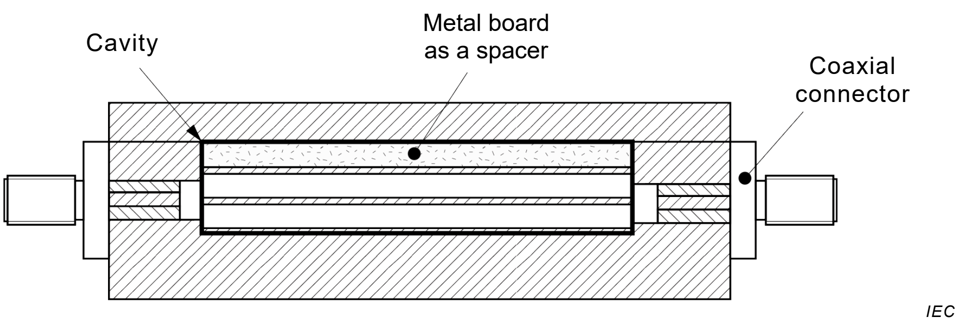


Figure 12 – Vertical cross-section of test fixture with test set

4.4 Test equipment

The test equipment includes the following.

a) A vector network analyser (VNA) shall be used.
b) Thy dynamic range of the VNA shall be more than 50 dB.
c) The frequency range of the VNA shall be from 100 MHz to over 10 GHz.

4.5 Procedure

4.5.1 Measurements

4.5.1.1 Electrical measurements

The following requirements apply to electrical measurements.

a) Electrical measurements shall be carried out by using VNA and fixture.
b) Measurement conditions shall be set in VNA, such as frequency, measurement point, averaging number and smoothing level. On the VNA, measurement conditions should be set as follows. Smoothing should be turned off. The number of the data points used should be enough to capture the amplitude of the peaks of the resonances accurately. Averaging may be set to improve signal to noise.
c) VNA shall be calibrated with coaxial cables in the range of the measurement frequency. A full two-port calibration is needed.
d) Coaxial connectors of the test fixture shall be connected with coaxial cables.
e) The test set shall be set facing the conductive line side of board A and the dielectric side of board B in the test fixture box.
f) The dummy board and top board of the test fixture shall be set on the test set. The dummy board is tightened to the cavity with screws by typically 0,90 Nm, which is also a typical torque to tighten coaxial cables, so that board A and B are in contact with each other.
g) The resonation figure of S21 shall be checked on the monitor of VNA. The example is shown in Figure 13. The S21 response should be inspected on the display of the VNA (see Figure 13) to ensure that all relevant information is captured across the required frequency range. In particular, faithful capture of the amplitude of the peaks of the resonances should be checked.
h) The data of S21 should be stored in a suitable digital device and should be used for calibration.

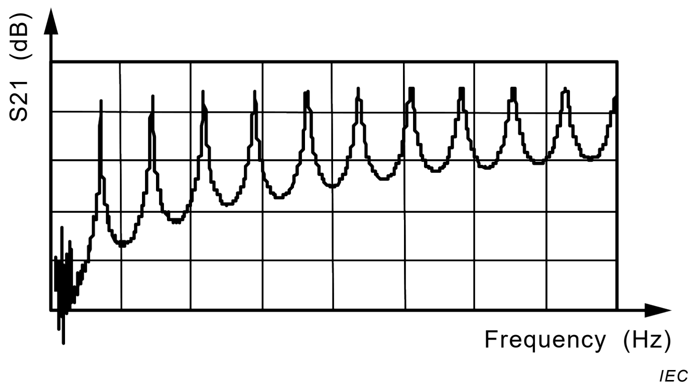


Figure 13 – Example of VNA raw data

4.5.1.2 Measurements of line length

The line length should be measured with an uncertainty of ±0,1 mm.

4.5.1.3 Measurements of thickness

The thickness of the dielectric and conductor of test specimens shall be measured with a ±0,001 mm tolerance.

4.5.2 Calculations

4.5.2.1 Relative permittivity

Relative permittivity (ε_r) shall be calculated as follows:

$$\varepsilon_r = \left[\frac{\lambda_0}{\lambda}\right]^2 = \left[\frac{c}{f_m}\cdot\frac{m}{2(L+\Delta L)}\right]^2 \quad m = 1,2,3... \qquad (1)$$

where

λ_0 is the wavelength in vacuum;

λ is the wavelength of the dielectric when it is tested;

c is the speed of light (2,997 8 × 10^9 m/s);

m is a number (1, 2, 3...);

f_m is the resonant frequency at number m in Hz;

L is the line length of test set in m;

ΔL is the total effective increase length of the resonator in m (negligible).

4.5.2.2 Loss tangent

The following requirements apply to the loss tangent.

a) The maximal and minimal envelope shall be calculated from raw data.

b) Attenuation factor (α) shall be calculated as follows:

$$\alpha = \frac{1}{2}\ln\left[\frac{1+U}{1-U}\right]\frac{1}{L+\Delta L}\times 8{,}686 \quad \text{(dB/m)} \qquad (2)$$

$$U = 10^{\frac{P}{20}} \qquad (3)$$

where

P is the difference of maximal envelope and minimal envelope in dB.

An example of P data is shown in Figure 14.

c) Because α is the sum of the conductive loss factor (α_{c}) and the dielectric loss factor (α_{d}), α_{d} shall be calculated as follows:

$$\alpha_{\mathrm{d}} = \alpha - \alpha_{\mathrm{c}} \quad \text{(dB/m)} \tag{4}$$

α_{c} shall be calculated as follows:

$$\alpha_{\mathrm{c}} = \frac{0{,}0231\, R_{\mathrm{s}} \varepsilon_{\mathrm{r}} Z_0}{30\pi\left(tB - tL\right)}\left[1 + \frac{2WL}{tB - tL} + \frac{1}{\pi}\cdot\frac{tB + tL}{tB - tL}\ln\left[\frac{2tB - tL}{tL}\right]\right] \quad \text{(dB/m)} \tag{5}$$

$$R_{\mathrm{s}}\sqrt{\pi\mu_0 f_m \rho} \quad (\Omega) \tag{6}$$

$$Z_0 = \frac{30\pi}{\sqrt{\varepsilon_{\mathrm{r}}}}\cdot\frac{1 - tL/tB}{WL/tB + C_f/\pi} \quad (\Omega) \tag{7}$$

$$C_f = 2\ln\left[\frac{1}{1 - tL/tB} + 1\right] - \frac{tL}{tB}\ln\left[\frac{1}{(1 - tL/tB)^2} - 1\right] \tag{8}$$

where

R_{s} is the surface resistance in Ω;

Z_0 is the characteristic impedance of test set in Ω;

tB is the thickness of the dielectric in m;.

tL is the thickness of the conductor line in m;

WL is the width of the conductor line in m;

μ_0 is the magnetic permeability in vacuum, $4\pi \times 10^{-7}$ H/m;

ρ is the resistivity of copper, $1{,}72 \times 10^{-8}$ Ωm. In the case of special copper foil, ρ shall be the specific value used.

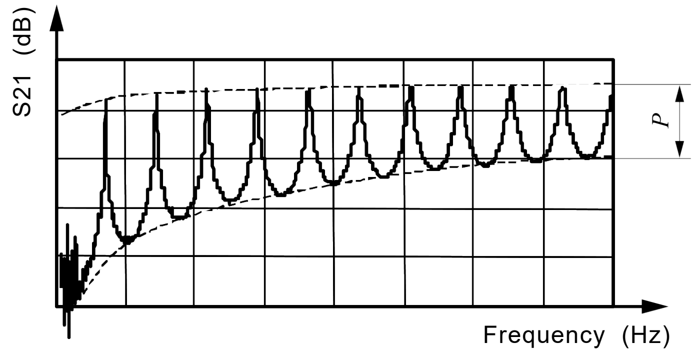
d) α_{d} shall be calculated as follows:

$$\alpha_{\mathrm{d}} = \frac{8{,}686\pi f_m \sqrt{\varepsilon_{\mathrm{r}}}}{c}\tan\delta \quad \text{(dB/m)} \tag{9}$$

$\tan\delta$ is the loss tangent.

e) $\tan\delta$ shall be calculated as follows:

$$\tan\delta = \frac{(\alpha - \alpha_{\mathrm{c}})c}{8{,}686\pi f_m \sqrt{\varepsilon_{\mathrm{r}}}} \tag{10}$$



Key

P is the actual data acquired from VNA raw data as shown in this figure.

Figure 14 – Envelopes of raw data from VNA measurement

5 Report

The report shall include:

a) the test number and revision;
b) the identification and description of the material tested;
c) the relative permittivity and the average in each frequency;
d) the loss tangent and the average in each frequency;
e) the date of the test;
f) temperature and humidity under test (for reference);
g) any deviation from the test method;
h) the name of the person conducting the test.

6 Additional information

6.1 Accuracy

Relative permittivity: $\Delta\varepsilon/\varepsilon$ / = ±0,05

Loss tangent: $\Delta\tan\delta/\tan\delta$ = ±0,1

6.2 Additional information concerning fixtures and results

An example of a test fixture and test result is shown in Annex A.

Annex A
(informative)

Example of test fixture and test results

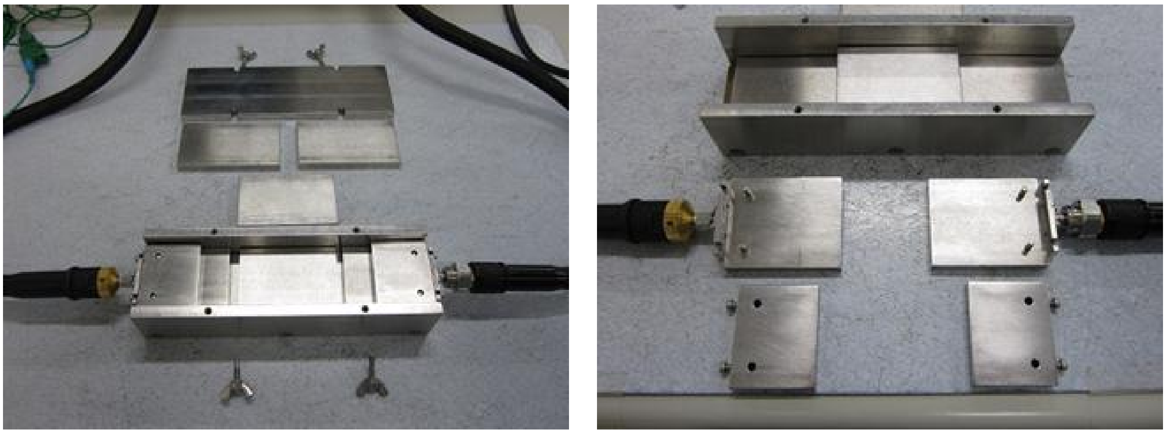
A.1 Dimension example of a test fixture

Figure A.1 shows an example of dimensions in detail for each part of the test fixture.

Figure A.2 shows the construction of the test fixture that is using the parts shown in Figure A.1.

Figure A.3 shows the connector attachments. The hole sizes of the connector attachments depend on the selected connector.

Figure A.4 shows an attachment with a connector.



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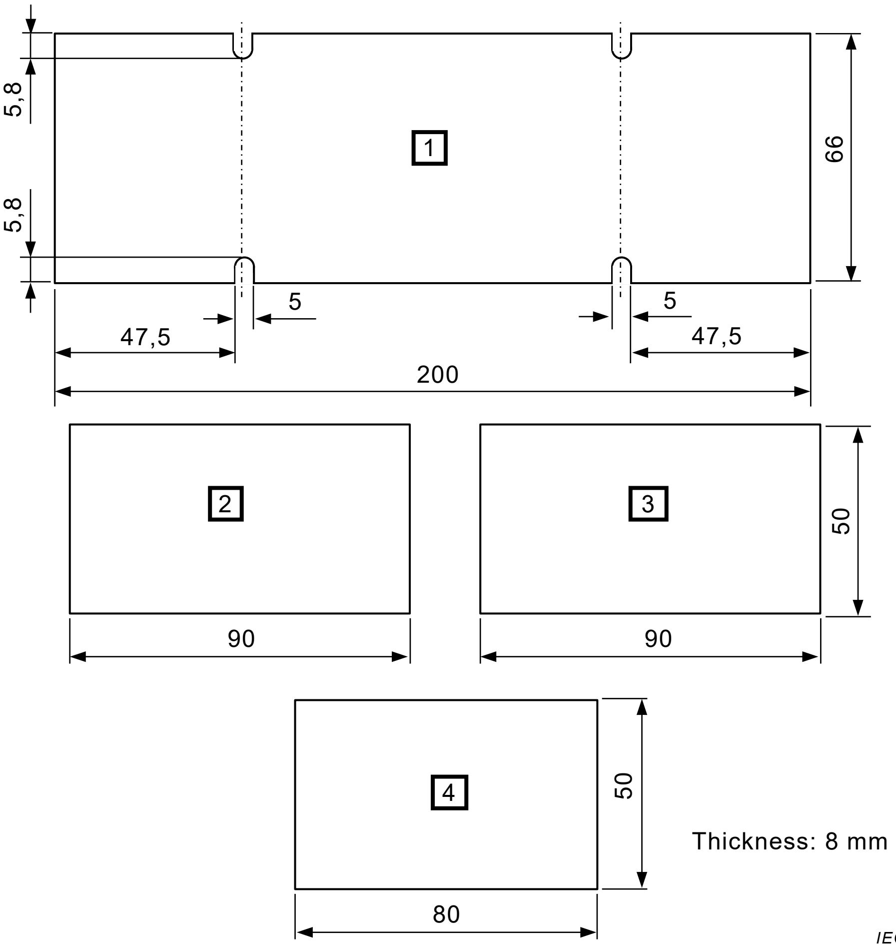
Dimensions in millimetres



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Dimensions in millimetres

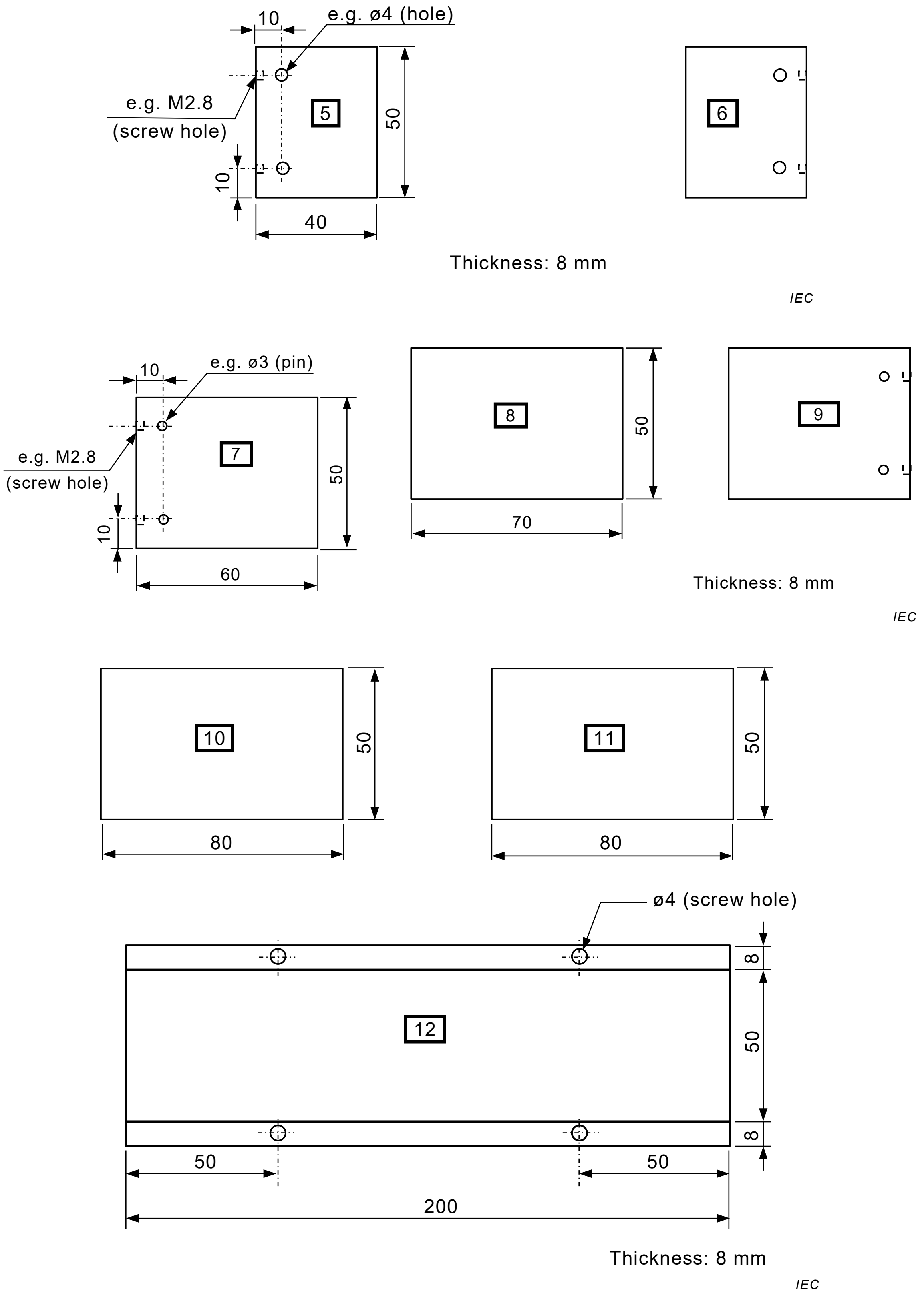


Figure A.1 – Parts of test fixture

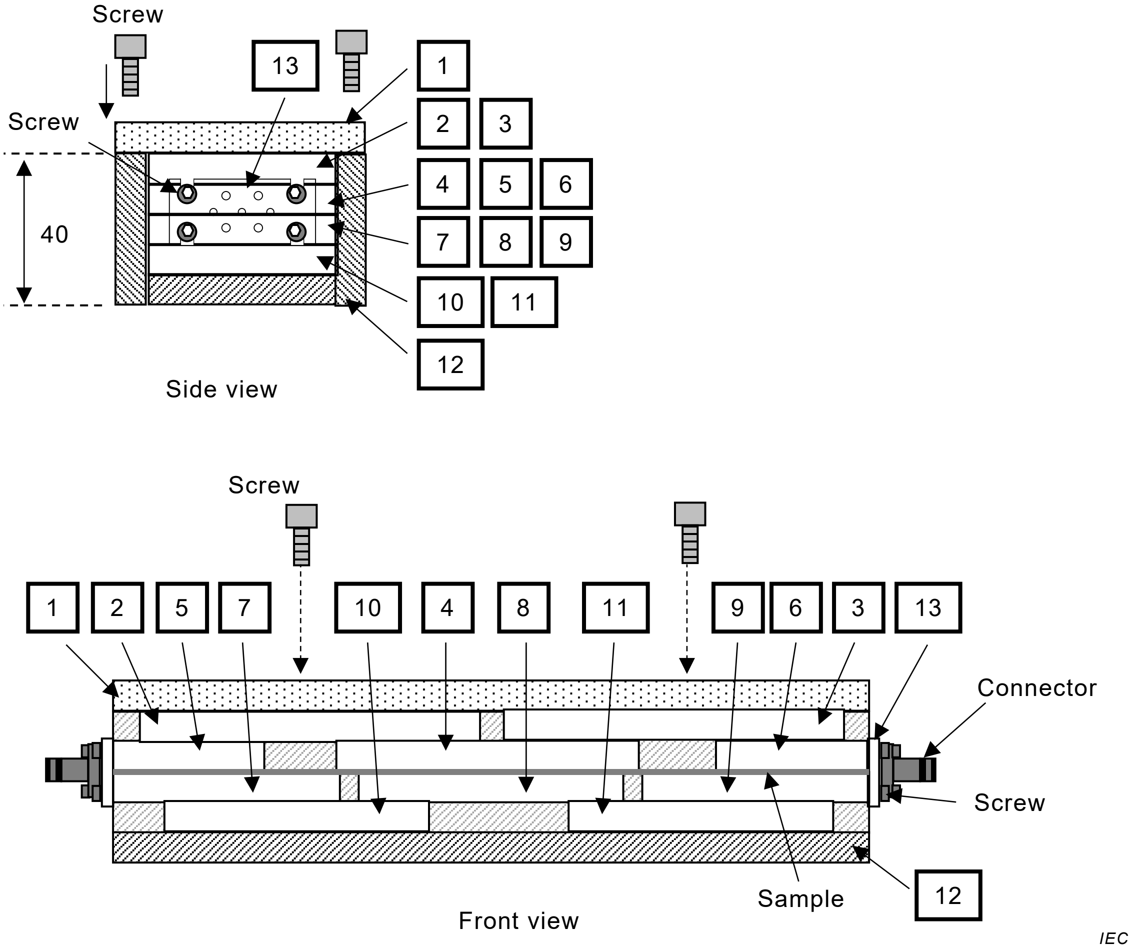


Figure A.2 – Construction of parts

Dimensions in millimetres

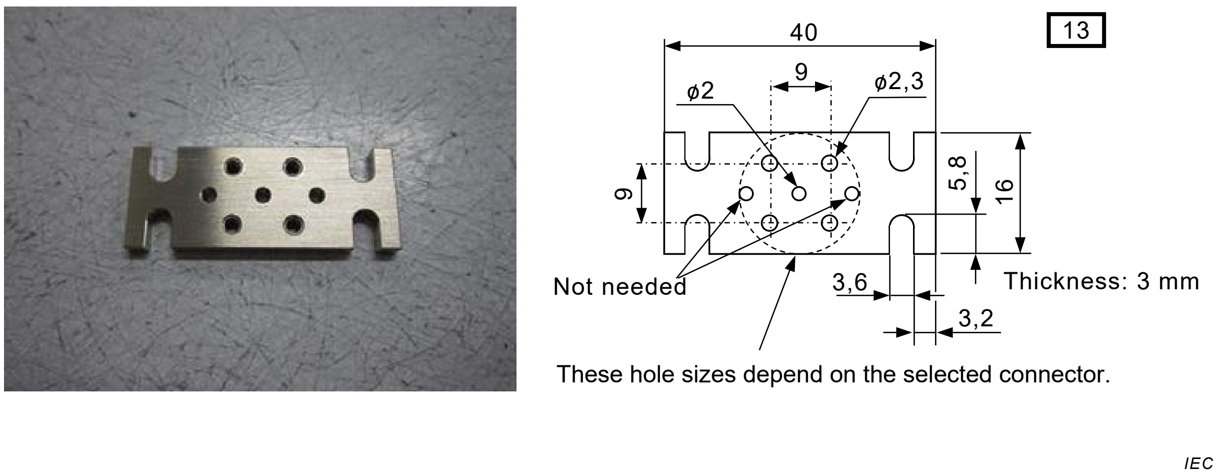
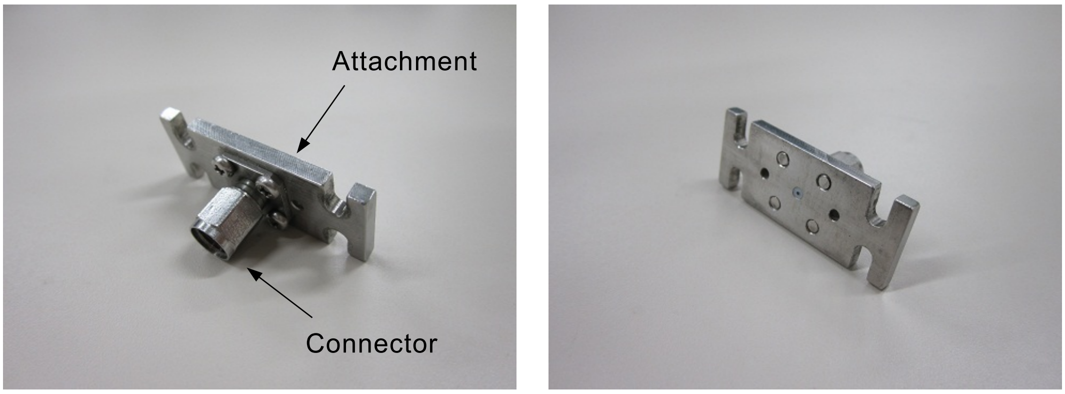


Figure A.3 – Part for connector attachment



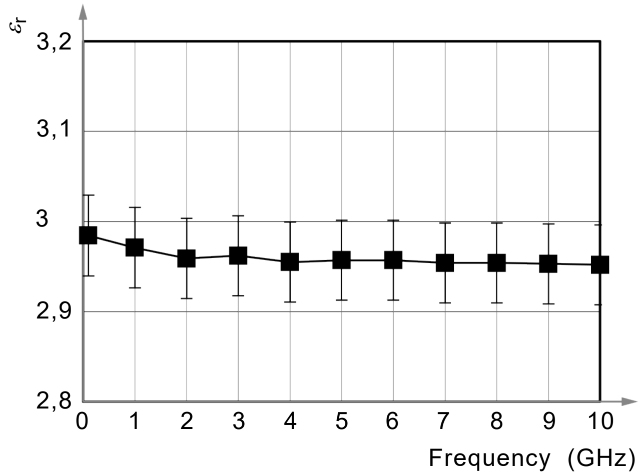
IEC

e.g. SGMC Microwave: 311-32-00-000 (2,4 mm MALE (4) HOLE FLANGE RECEPTACLE)

Figure A.4 – Attachment with connector

A.2 Example of test results

Figure A.5 and Figure A.6 show typical measurement result of 0,8 mm thickness of PTFE CCL with 35 μm of copper thickness.



IEC

Figure A.5 – An example of measured ε_r data, PTFE CCL

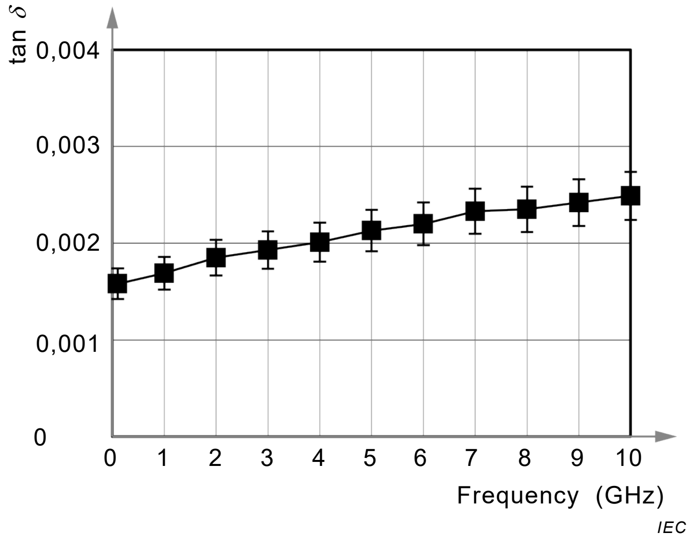


Figure A.6 – An example of measured tanδ data, PTFE CCL

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