SLOVENSKI STANDARD
SIST EN 62810:2015

01-oktober-2015

Metoda s valjasto votlino za merjenje kompleksne permitivnosti (dielektrične konstante) nizkoizgubnih dielektričnih palic (IEC 62810:2015)

Cylindrical cavity method to measure the complex permittivity of low-loss dielectric rods (IEC 62810:2015)

Zylindrisches Hohlraumverfahren zur Messung der komplexen Permittivität von verlustarmen dielektrischen Stäben (IEC 62810:2015)

Mesure de la permitivité complexe des barreaux diélectriques à faibles pertes par la méthode de la cavité cylindrique (IEC 62810:2015)

Ta slovenski standard je istoveten z: **EN 62810:2015**

ICS:

33.120.30	Radiofrekvenčni konektorji (RF)	R.F. connectors

SIST EN 62810:2015 **en**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 62810

May 2015

ICS 33.120.30

English Version

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 62810:2015 E

Foreword

The text of document 46F/242/CDV, future edition 1 of IEC 62810, prepared by SC 46F, "R.F. and microwave passive components", of IEC TC 46, "Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62810:2015.

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)	2015-12-24
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-03-24

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In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60556 NOTE Harmonised as EN 60556.

IEC 62810

Edition 1.0 2015-02

INTERNATIONAL STANDARD

colour
inside

Cylindrical cavity method to measure the complex permittivity of low-loss dielectric rods

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CYLINDRICAL CAVITY METHOD TO MEASURE THE COMPLEX PERMITTIVITY OF LOW-LOSS DIELECTRIC RODS

FOREWORD

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International Standard IEC 62810 has been prepared by subcommittee 46F: R.F. and microwave passive components, of IEC technical committee 46: Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories.

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

CDV	Report on voting
46F/242/CDV	46F/260/RVC

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.

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.

A bilingual version of this publication may be issued at a later date.

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.

CYLINDRICAL CAVITY METHOD TO MEASURE THE COMPLEX PERMITTIVITY OF LOW-LOSS DIELECTRIC RODS

1 Scope

This International Standard relates to a measurement method for complex permittivity of a dielectric rod at microwave frequency. This method has been developed to evaluate the dielectric properties of low-loss materials in coaxial cables and electronic devices used in microwave systems. It uses the TM_{010} mode in a circular cylindrical cavity and presents accurate measurement results of a dielectric rod sample, where the effect of sample insertion holes is taken into account accurately on the basis of the rigorous electromagnetic analysis.

In comparison with the conventional method described in IEC 60556 [2][1], this method has the following characteristics:

- the values of the relative permittivity ε' and loss tangent $\tan\delta$ of a dielectric rod sample can be measured accurately and non-destructively;
- the measurement accuracy is within 1,0 % for ε' and within 20 % for $\tan\delta$;
- the effect of sample insertion holes is corrected using correction charts presented;
- this method is applicable for the measurements on the following condition:
  - frequency: 1 GHz $\leqq f \leqq$ 10 GHz;
  - relative permittivity: 1 $\leqq \varepsilon' \leqq$ 100;
  - loss tangent: $10^{-4} \leqq \tan\delta \leqq 10^{-1}$.

2 Normative references

Void.

3 Measurement parameters

The measurement parameters are defined as follows:

$$\varepsilon_r = \varepsilon' - j\varepsilon'' \tag{1}$$

$$\tan\delta = \varepsilon''/\varepsilon' \tag{2}$$

where ε' and ε'' are the real and imaginary parts of the complex relative permittivity ε_r.

4 Theory and calculation equations

A resonator structure used in these measurements is shown in Figure 1. A cavity, made with copper, with diameter D and height H has sample insertion holes with diameter d_2 and depth g oriented coaxially. A dielectric rod sample of diameter d_1 having ε' and $\tan\delta$ is inserted into the holes.

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[1] Figures in square brackets refer to the Bibliography.

The TM_{010} mode, where the electric field component in the cavity is parallel to the sample rod, is used for the measurement. Taking account of the effect of sample insertion holes calculated on the basis of the rigorous electromagnetic field analysis, ε' and $\tan\delta$ are determined from the measured values of the resonant frequency f_0 and the unloaded Q-factor Q_u. To avoid the tedious numerical calculation and make the measurements easy, the following process is taken in this measurement:

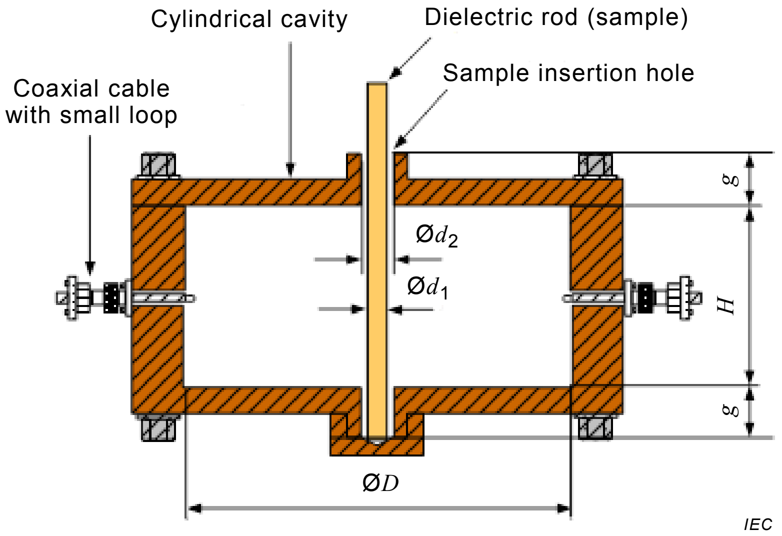


Figure 1 – Structure of a cylindrical cavity resonator

The following steps shall be taken:

1) At the first step, obtain approximate values ε_p and $\tan\delta_\text{p}$ from the f_0 and Q_u values by using the simple perturbation formulas, where the effect of sample insertion holes is neglected. The subscript p denotes the calculated values using the following perturbation formulas:

$$\varepsilon_\text{p} = \frac{1}{\alpha}\frac{f_0 - f_1}{f_1}\left(\frac{D}{d_1}\right)^2 + 1 \tag{3}$$

$$\tan\delta_\text{p} = \frac{1}{2\alpha\varepsilon_\text{p}}\left(\frac{D}{d_1}\right)^2\left(\frac{1}{Q_\text{u1}} - \frac{1}{Q_\text{u0}}\right) \tag{4}$$

where $\alpha = 1/J_1(x_{01})^2 = 1{,}855$.

$J_\text{n}(x)$ is the Bessel function of order n of first kind and $x_{01} = 2{,}405$ is the first root of $J_0(x) = 0$. f_0 and Q_u0 are the resonant frequency and unloaded Q-factor measured for the cavity without a sample, respectively. f_1 and Q_u1 are ones measured for the cavity with a sample.

2) In the second step, obtain accurate values ε' and $\tan\delta$ from ε_p and $\tan\delta_\text{p}$ values by using the following equations with correction factors calculated based on the rigorous analysis:

$$\varepsilon' = C_1\,\varepsilon_\text{p} \tag{5}$$

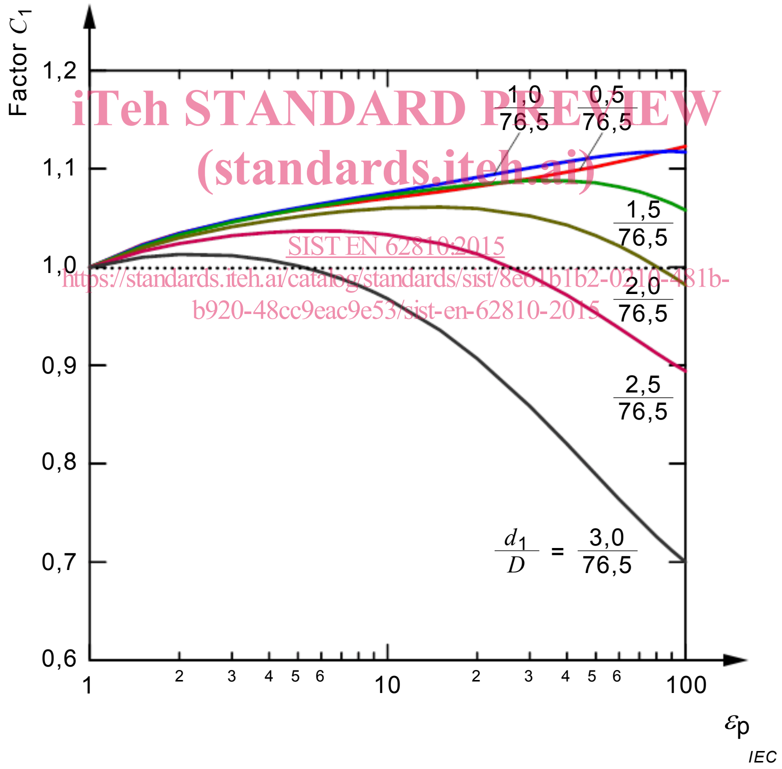
$$\tan\delta = C_2 \tan\delta_\text{p} \tag{6}$$

where correction factors C_1 and C_2, due to the sample insertion holes and errors included in the perturbation formulas, are calculated numerically by using the Ritz-Galerkin method [3][5], as shown in Figure 2 and Figure 3, and the corresponding data are listed in detail in Table 1, 2, and 3. The missing data of C_1 and C_2 can be obtained by interpolation or extrapolation from the tables. The correction factors shown in these figures are calculated for the cavity with D = 76,5 mm, H = 20,0 mm, d_2 = 3,0 mm, and g = 10,0 mm, where the resonant frequency is about 3 GHz. C_1 is also used for a cavity having the same aspect ratios as H/D, d_2/D and g/D.

It is found from the analysis for a cavity with insertion holes which constitute a cut-off TM_{01} mode cylindrical waveguide that f_0 converges to a constant value for g>10 mm and d_2 = 3 mm. Therefore, the correction factors shown in Figure 2 and Figure 3 are applicable to a dielectric sample rod with d_1<3 mm and ε' below the value calculated by the following equation for the measured value of the resonant frequency:

$$\varepsilon' \le \left(\frac{x_{01}c}{\pi d_2 f_0}\right)^2 \tag{7}$$

where c is the velocity of light in a vacuum (c = 2,9 979 × 108 m/s).



Assumptions

D	76,5 mm	d_2	3,0 mm
H	20,0 mm	g	10,0 mm

Figure 2 – Correction factor C_1 for ε'