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Measurement of the complex permittivity for low-loss dielectric substrates balanced-type circular disk resonator method

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MEASUREMENT OF THE COMPLEX PERMITTIVITY FOR LOW-LOSS DIELECTRIC SUBSTRATES BALANCED-TYPE CIRCULAR DISK RESONATOR METHOD

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This second edition cancels and replaces the first edition published in 2020. This edition constitutes a technical revision.

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

a) the upper limit of the applicable frequency range has been extended from 110 GHz to 170 GHz;
b) circular disk resonators used for the measurements now include one with waveguide interfaces;
c) in calculating the complex permittivity from the measured resonant properties, the fringing fields are now accurately taken into account based on the mode-matching analysis.

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

Draft	Report on voting
46F/699/FDIS	46F/702/RVD

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.

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MEASUREMENT OF THE COMPLEX PERMITTIVITY FOR LOW-LOSS DIELECTRIC SUBSTRATES BALANCED-TYPE CIRCULAR DISK RESONATOR METHOD

1 Scope

This document relates to a measurement method for complex permittivity of dielectric substrates at microwave and millimeter-wave frequencies. This method has been developed to evaluate the dielectric properties of low-loss materials used in microwave and millimeter-wave circuits and devices. It uses higher-order modes of a balanced-type circular disk resonator and provides broadband measurements of dielectric substrates by using one resonator, where the effect of excitation holes and that of fringing fields are taken into account accurately on the basis of the mode-matching analysis.

In comparison with the conventional method described in IEC 62810 and IEC 61338-1-3, this method has the following characteristics:

- the values of the relative permittivity ε_r' and loss tangent $\tan\delta$ normal to dielectric plate samples can be measured accurately and non-destructively;
- this method presents broadband measurements by using higher-order modes by one resonator;
- this method is applicable for the measurements under the following conditions:
  - frequency: 10 GHz ≤ f ≤ ~~110~~ 170 GHz;
  - relative permittivity: 1 ≤ ε_r' ≤ 10;
  - loss tangent: $10^{-4} \leq \tan\delta \leq 10^{-2}$.

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 61338-1-3:1999, *Waveguide type dielectric resonators – Part 1-3: General information and test conditions – Measurement method of complex relative permittivity for dielectric resonator materials at microwave frequency*~~

~~*IEC 62810:2015, Cylindrical cavity method to measure the complex permittivity of low-loss dielectric rods*~~

There are no normative references in this document.

IEC 63185

Edition 2.0 2025-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Measurement of the complex permittivity for low-loss dielectric substrates balanced-type circular disk resonator method

Méthode du résonateur symétrique à disque circulaire pour mesurer la permittivité complexe des substrats diélectriques à faible perte



IEC 63185:2025-03(en-fr)

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2 Normative references

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MÉTHODE DU RÉSONATEUR SYMÉTRIQUE À DISQUE CIRCULAIRE POUR MESURER LA PERMITTIVITÉ COMPLEXE DES SUBSTRATS DIÉLECTRIQUES À FAIBLE PERTE

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Cette deuxième édition annule et remplace la première édition parue en 2020. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) la limite supérieure de la plage de fréquences applicable a été étendue de 110 GHz à 170 GHz;

b) les résonateurs à disque circulaire utilisés pour le mesurage comprennent désormais un résonateur avec des interfaces de guide d'ondes;

c) lors du calcul de la permittivité complexe à partir des propriétés de résonance mesurées, les champs de franges sont désormais pris en compte précisément par un ajustement d'analyse modale.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
46F/699/FDIS	46F/702/RVD

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MÉTHODE DU RÉSONATEUR SYMÉTRIQUE À DISQUE CIRCULAIRE POUR MESURER LA PERMITTIVITÉ COMPLEXE DES SUBSTRATS DIÉLECTRIQUES À FAIBLE PERTE

1 Domaine d'application

Le présent document traite d'une méthode de mesure de la permittivité complexe des substrats diélectriques aux fréquences micro-ondes et millimétriques. Cette méthode a été élaborée pour évaluer les propriétés diélectriques des matériaux à faible perte utilisés dans les circuits et dispositifs aux fréquences micro-ondes et millimétriques. Cette méthode utilise les modes d'ordre supérieur d'un résonateur symétrique à disque circulaire, et permet d'effectuer le mesurage large bande de substrats diélectriques à l'aide d'un résonateur qui, sous l'effet des ports d'excitation, produit un champ de franges qui sont prises en compte précisément par un ajustement d'analyse modale.

En comparaison avec la méthode conventionnelle décrite dans l'IEC 62810 et l'IEC 61338-1-3, cette méthode présente les caractéristiques suivantes:

- elle permet de mesurer avec exactitude et de manière non destructive les valeurs de la permittivité relative, ε_r', et de la tangente de l'angle de pertes, $\tan\delta$, perpendiculaire aux échantillons de plaques diélectriques;
- elle permet des mesurages à large bande à l'aide de modes d'ordre supérieur d'un résonateur;
- elle est applicable pour effectuer des mesurages dans les conditions suivantes:
  - fréquence: 10 GHz ≤ f ≤ 170 GHz;
  - permittivité relative: $1 \leq \varepsilon_r' \leq 10$;
  - tangente de l'angle de pertes: $10^{-4} \leq \tan\delta \leq 10^{-2}$.

2 Références normatives

Le présent document ne contient aucune référence normative.