IEC 63185

Edition 2.0 2025-03
REDLINE VERSION

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.120.30

ISBN 978-2-8327-0319-9

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 63185:2020. 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 63185 has been prepared by subcommittee 46F: RF and microwave passive components, 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 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.

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.

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)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63185 has been prepared by subcommittee 46F: RF and microwave passive components, 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 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.

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.

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 ≤ 170 GHz;
  - relative permittivity: 1 ≤ ε_r' ≤ 10;
  - loss tangent: $10^{-4} \leq \tan\delta \leq 10^{-2}$.

2 Normative references

There are no normative references in this document.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

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

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'IEC attire l'attention sur le fait que la mise en application du présent document peut entraîner l'utilisation d'un ou de plusieurs brevets. L'IEC ne prend pas position quant à la preuve, à la validité et à l'applicabilité de tout droit de brevet revendiqué à cet égard. À la date de publication du présent document, l'IEC n'a pas reçu notification qu'un ou plusieurs brevets pouvaient être nécessaires à sa mise en application. Toutefois, il y a lieu d'avertir les responsables de la mise en application du présent document que des informations plus récentes sont susceptibles de figurer dans la base de données de brevets, disponible à l'adresse https://patents.iec.ch. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets.

L'IEC 63185 a été établie par le sous-comité 46F: Composants passifs pour hyperfréquences et radio fréquences, du comité d'études 46 de l'IEC: Câbles, fils, guides d'ondes, connecteurs, composants passifs pour micro-onde et accessoires. Il s'agit d'une Norme internationale.

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

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

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.