SLOVENSKI STANDARD
SIST EN 61788-7:2002

01-september-2002

Superconductivity - Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies

Superconductivity -- Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies

Supraleitfähigkeit -- Teil 7: Charakteristische elektronische Messungen - Oberflächenwiderstand von Supraleitern bei Frequenzen im Mikrowellenbereich

Supraconductivité -- Partie 7: Mesures des caractéristiques électroniques - Résistance de surface des supraconducteurs aux hyperfréquences

Ta slovenski standard je istoveten z: EN 61788-7:2002

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.050	Superprevodnost in prevodni materiali	Superconductivity and conducting materials

SIST EN 61788-7:2002 en

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61788-7

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English version

Superconductivity
Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies
(IEC 61788-7:2002)

Supraconductivité
Partie 7: Mesures des caractéristiques électroniques -
Résistance de surface des supraconducteurs aux hyperfréquences
(CEI 61788-7:2002)

Supraleitfähigkeit
Teil 7: Charakteristische elektronische Messungen -
Oberflächenwiderstand von Supraleitern bei Frequenzen im Mikrowellenbereich
(IEC 61788-7:2002)

This European Standard was approved by CENELEC on 2002-03-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 61788-7:2002 E

Foreword

The text of document 90/111/FDIS, future edition 1 of IEC 61788-7, prepared by IEC TC 90, Superconductivity, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61788-7 on 2002-03-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2002-12-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2005-03-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annex A is informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61788-7:2002 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

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

Publication	Year	Title	EN/HD	Year
IEC 60050-815	- [1)]	International Electrotechnical Vocabulary (IEV) Chapter 815: Superconductivity	-	-

1) Undated reference.

INTERNATIONAL STANDARD

IEC 61788-7

First edition
2002-01

Superconductivity –

Part 7: Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies

Supraconductivité –

Partie 7:
Mesures des caractéristiques électroniques – Résistance de surface des supraconducteurs aux hyperfréquences

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SUPERCONDUCTIVITY –

Part 7: Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61788-7 has been prepared by IEC technical committee 90: Superconductivity.

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

FDIS	Report on voting
90/111/FDIS	90/117/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.

Annex A is for information only.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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

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

INTRODUCTION

Since the discovery of some Perovskite-type Cu-containing oxides, extensive R & D work on high-temperature oxide superconductors has been, and is being, made worldwide, and its application to high-field magnet machines, low-loss power transmission, electronics and many other technologies is in progress.

In various fields of electronics, especially in telecommunication fields, microwave passive devices such as filters using oxide superconductors are being developed and are undergoing on-site testing [1,2] [1].

Superconductor materials for microwave resonators, filters, antenna and delay lines have the advantage of very low loss characteristics. Knowledge of this parameter is of primary importance for the development of new materials on the supplier side and for the design of superconductor microwave components on the customer side. The parameters of superconductor materials needed for the design of microwave components are the surface resistance R_s and the temperature dependence of the surface resistance.

Recent advances in high Tc superconductor (HTS) thin films with R_s several orders of magnitude lower than that of normal metals have increased the need for a reliable characterization technique to measure this property [3,4]. Traditionally, the R_s of Nb or any other low temperature superconducting material was measured by first fabricating an entire three dimensional resonant cavity and then measuring its Q-value. The R_s could be calculated by solving the EM field distribution inside the cavity. Another technique involves placing a small sample inside a larger cavity. This technique has many forms but usually involves the uncertainty introduced by extracting the loss contribution due to the HTS films from the experimentally measured total loss of the cavity.

The best HTS samples are epitaxial films grown on flat crystalline substrates and no high quality films have been grown on any curved surface so far. What is needed is a technique that: can use these small flat samples; requires no sample preparation; does not damage or change the film; is highly repeatable; has great sensitivity (down to 1/1 000th the R_s of copper); has great dynamic range (up to the R_s of copper); can reach high internal powers with only modest input powers; and has broad temperature coverage (4,2 K to 150 K).

The dielectric resonator method is selected among several methods [5,6,7] to determine the surface resistance at microwave frequencies because it is considered to be the most popular and practical at present. Especially, the sapphire resonator is an excellent tool for measuring the R_s of HTS materials [8].

The test method given in this standard can be also applied to other superconductor bulk plates including low Tc material.

This standard is intended to provide an appropriate and agreeable technical base for the time being to engineers working in the fields of electronics and superconductivity technology.

The test method covered in this standard is based on the VAMAS (Versailles Project on Advanced Materials and Standards) pre-standardization work on the thin film properties of superconductors.

[1] Numbers in brackets refer to the bibliography.

SUPERCONDUCTIVITY –

Part 7: Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies

1 Scope

This part of IEC 61788 describes measurement of the surface resistance of superconductors at microwave frequencies by the standard two-resonator method. The object of measurement is the temperature dependence of R_s at the resonant frequency.

The applicable measurement range of surface resistances for this method is as follows:

– Frequency: 8 GHz < f < 30 GHz

– Measurement resolution: 0,01 mΩ at 10 GHz

The surface resistance data at the measured frequency, and that scaled to 10 GHz, assuming the f^2 rule (f < 30 GHz) for comparison, shall be reported.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-815, *International Electrotechnical Vocabulary – Part 815: Superconductivity*

3 Terms and definitions

For the purposes of this standard, the definitions given in IEC 60050-815 apply.

In general, surface impedance Z_s for conductors, including superconductors, is defined as the ratio of the electric field E_t to the magnetic field H_t, tangential to a conductor surface:

$$Z_s = E_t / H_t = R_s + jX_s$$

where R_s is the surface resistance and X_s is the surface reactance.

4 Requirements

The surface resistance R_s of a superconductor film shall be measured by applying a microwave signal to a dielectric resonator with the superconductor film specimen and then measuring the attenuation of the resonator at each frequency. The frequency shall be swept around the resonant frequency as the centre, and the attenuation – frequency characteristics shall be recorded to obtain Q-value, which corresponds to the loss.

The target precision of this method is a coefficient of variation (standard deviation divided by the average of the surface resistance determinations) that is less than 20 % for the measurement temperature range from 30 K to 80 K.

It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

Hazards exist in this type of measurement. The use of a cryogenic system is essential to cool the superconductors to allow transition into the superconducting state. Direct contact of skin with cold apparatus components can cause immediate freezing, as can direct contact with a spilled cryogen. The use of an r.f.-generator is also essential to measure high-frequency properties of materials. If its power is too high, direct contact to human bodies can cause an immediate burn.

5 Theory and calculation equations

Figure 1 shows the configuration of the TE_{0mp} mode resonator, which is used to eliminate the air-gap effects. A cylindrical dielectric rod with diameter, d, and height, h, is short-circuited at both ends by surfaces of two parallel superconductor films deposited on dielectric substrates with diameter, d', thus constituting a resonator. These superconductor films are required to have the same value of R_s. The value of R_s is calculated from the measured resonant frequency f_0 and unloaded quality factor Q_u for the TE_{0mp} resonance mode. When the two superconductor films have different values of R_s, the measured R_s value corresponds to the average value of these two films.

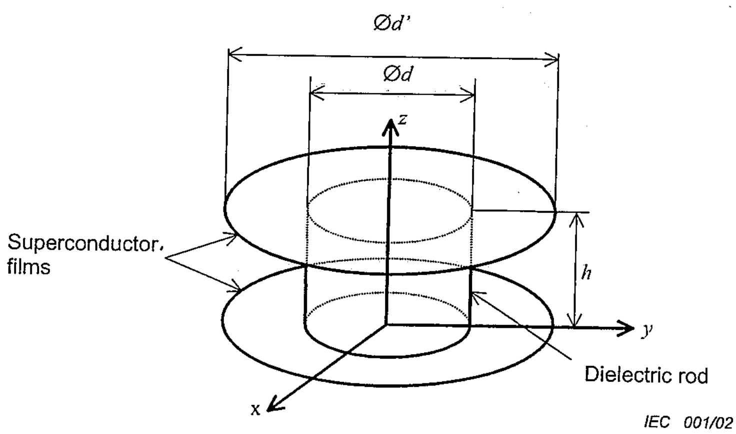

Figure 1 – Configuration of a cylindrical dielectric rod resonator short-circuited at both ends by two parallel superconductor films deposited on dielectric substrates