EESTI STANDARD

EVS-EN 61788-7:2007

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

EESTI STANDARDIKESKUS

EESTI STANDARDI EESSÕNA	NATIONAL FOREWORD
Käesolev Eesti standard EVS-EN 61788-7:2007 sisaldab Euroopa standardi EN 61788-7:2006 ingliskeelset teksti. Käesolev dokument on jõustatud 17.01.2007 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes. Standard on kättesaadav Eesti standardiorganisatsioonist.	This Estonian standard EVS-EN 61788-7:2007 consists of the English text of the European standard EN 61788-7:2006. This document is endorsed on 17.01.2007 with the notification being published in the official publication of the Estonian national standardisation organisation. The standard is available from Estonian standardisation organisation.

Käsitlusala:	**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 Rs at the resonant frequency.	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 Rs at the resonant frequency.

ICS 17.220, 29.050

Võtmesõnad: definition, definitions, electrical engineering, measurement, superconductivity, superconductors, surface insulation resistance, testing

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61788-7

December 2006

ICS 17.220; 29.050

Supersedes EN 61788-7:2002

English version

Superconductivity
Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies
(IEC 61788-7:2006)

Supraconductivité
Partie 7: Mesures des caractéristiques électroniques -
Résistance de surface des supraconducteurs aux hyperfréquences
(CEI 61788-7:2006)

Supraleitfähigkeit
Teil 7: Charakteristische elektronische Messungen -
Oberflächenwiderstand von Supraleitern bei Frequenzen im Mikrowellenbereich
(IEC 61788-7:2006)

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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.

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CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the 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

Foreword

The text of document 90/193/FDIS, future edition 2 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 2006-11-01.

This European Standard supersedes EN 61788-7:2002.

Examples of technical changes made are:

– closed type resonators are recommended from the viewpoint of the stable measurements;

– uniaxial-anisotropic characteristics of sapphire rods are taken into consideration for designing the size of the sapphire rods;

– recommended measurement frequency of 18 GHz and 22 GHz are added to 12 GHz described in EN 61788-7:2002.

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)	2007-08-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-11-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61788-7:2006 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 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.

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) Part 815: Superconductivity	-	-

[1] Undated reference.

INTERNATIONAL STANDARD

IEC 61788-7

Second edition
2006-10

Superconductivity –

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

Reference number
IEC 61788-7:2006(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

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- **IEC Web Site (www.iec.ch)**
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INTERNATIONAL STANDARD

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Superconductivity –

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

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Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SUPERCONDUCTIVITY –

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

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

This second edition cancels and replaces the first edition, published in 2002, of which it constitutes a technical revision. Examples of technical changes made are: 1) closed type resonators are recommended from the viewpoint of the stable measurements, 2) uniaxial-anisotropic characteristics of sapphire rods are taken into consideration for designing the size of the sapphire rods, and 3) recommended measurement frequency of 18 GHz and 22 GHz are added to 12 GHz described in the first edition.

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

FDIS	Report on voting
90/193/FDIS	90/198/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.

IEC 61788 consists of the following parts, under the general title *Superconductivity*:

Part 1: Critical current measurement – DC critical current of Cu/Nb-Ti composite superconductors

Part 2: Critical current measurement – DC critical current of Nb_3Sn composite superconductors

Part 3: Critical current measurement – DC critical current of Ag- and/or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductors

Part 4: Residual resistance ratio measurement – Residual resistance ratio of Nb-Ti composite superconductors

Part 5: Matrix to superconductor volume ratio measurement – Copper to superconductor volume ratio of Cu/Nb-Ti composite superconductors

Part 6: Mechanical properties measurement – Room temperature tensile test of Cu/Nb-Ti composite superconductors

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

Part 8: AC loss measurements – Total AC loss measurement of Cu/Nb-Ti composite superconducting wires exposed to a transverse alternating magnetic field by a pickup coil method

Part 9: Measurements for bulk high temperature superconductors – Trapped flux density of large grain oxide superconductors

Part 10: Critical temperature measurement – Critical temperature of Nb-Ti, Nb_3Sn, and Bi-system oxide composite superconductors by a resistance method

Part 11: Residual resistance ratio measurement – Residual resistance ratio of Nb_3Sn composite superconductors

Part 12: Matrix to superconductor volume ratio measurement – Copper to non-copper volume ratio of Nb_3Sn composite superconducting wires

Part 13: AC loss measurements – Magnetometer methods for hysteresis loss in Cu/Nb-Ti multifilamentary composites

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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.

INTRODUCTION

Since the discovery of some Perovskite-type Cu-containing oxides, extensive research and development (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 low loss 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 [8,9].

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.

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1) Figures in square 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 for comparison, are 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 (IEV) – Part 815: Superconductivity*

3 Terms and definitions

For the purposes of this document, the terms and 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.