Superconductivity - Part 17: Electronic characteristic measurements - Local critical current density and its distribution in large-area superconducting films (IEC 61788-17:2013)

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION

EESTI STANDARDI EESSÕNA	NATIONAL FOREWORD
See Eesti standard EVS-EN 61788-17:2013 sisaldab Euroopa standardi EN 61788-17:2013 ingliskeelset teksti.	This Estonian standard EVS-EN 61788-17:2013 consists of the English text of the European standard EN 61788-17:2013.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 05.04.2013.	Date of Availability of the European standard is 05.04.2013.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 17.220.20, 29.050

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61788-17

April 2013

ICS 17.220.20; 29.050

English version

Superconductivity -
Part 17: Electronic characteristic measurements -
Local critical current density and its distribution in large-area superconducting films
(IEC 61788-17:2013)

Supraconductivité -
Partie 17: Mesures de caractéristiques électroniques -
Densité de courant critique local et sa distribution dans les films supraconducteurs de grande surface
(CEI 61788-17:2013)

Supraleitfähigkeit -
Teil 17: Messungen der elektronischen Charakteristik -
Lokale kritische Stromdichte und deren Verteilung in großflächigen supraleitenden Schichten
(IEC 61788-17:2013)

This European Standard was approved by CENELEC on 2013-02-20. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

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

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 61788-17:2013 E

Foreword

The text of document 90/310/FDIS, future edition 1 of IEC 61788-17, prepared by IEC TC 90, "Superconductivity" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61788-17:2013.

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)	2013-11-20
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-02-20

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61788-17:2013 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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	Series	International electrotechnical vocabulary	-	-

CONTENTS

INTRODUCTION

Over twenty years after their discovery in 1986, high-temperature superconductors are now finding their way into products and technologies that will revolutionize information transmission, transportation, and energy. Among them, high-temperature superconducting (HTS) microwave filters, which exploit the extremely low surface resistance of superconductors, have already been commercialized. They have two major advantages over conventional non-superconducting filters, namely: low insertion loss (low noise characteristics) and high frequency selectivity (sharp cut) [1][1]. These advantages enable a reduced number of base stations, improved speech quality, more efficient use of frequency bandwidths, and reduced unnecessary radio wave noise.

Large-area superconducting thin films have been developed for use in microwave devices [2]. They are also used for emerging superconducting power devices, such as, resistive-type superconducting fault-current limiters (SFCLs) [3–5], superconducting fault detectors used for superconductor-triggered fault current limiters [6, 7] and persistent-current switches used for persistent-current HTS magnets [8, 9]. The critical current density J_c is one of the key parameters that describe the quality of large-area HTS films. Nondestructive, AC inductive methods are widely used to measure J_c and its distribution for large-area HTS films [10–13], among which the method utilizing third-harmonic voltages $U_3\cos(3\omega t+\theta)$ is the most popular [10, 11], where ω, t and θ denote the angular frequency, time, and initial phase, respectively. However, these conventional methods are not accurate because they have not considered the electric-field E criterion of the J_c measurement [14, 15] and sometimes use an inappropriate criterion to determine the threshold current I_{th} from which J_c is calculated [16]. A conventional method can obtain J_c values that differ from the accurate values by 10 % to 20 % [15]. It is thus necessary to establish standard test methods to precisely measure the local critical current density and its distribution, to which all involved in the HTS filter industry can refer for quality control of the HTS films. Background knowledge on the inductive J_c measurements of HTS thin films is summarized in Annex A.

In these inductive methods, AC magnetic fields are generated with AC currents $I_0\cos\omega t$ in a small coil mounted just above the film, and J_c is calculated from the threshold coil current I_{th}, at which full penetration of the magnetic field to the film is achieved [17]. For the inductive method using third-harmonic voltages U_3, U_3 is measured as a function of I_0, and the I_{th} is determined as the coil current I_0 at which U_3 starts to emerge. The induced electric fields E in the superconducting film at $I_0 = I_{th}$, which are proportional to the frequency f of the AC current, can be estimated by a simple Bean model [14]. A standard method has been proposed to precisely measure J_c with an electric-field criterion by detecting U_3 and obtaining the n-value (index of the power-law E-J characteristics) by measuring I_{th} precisely at various frequencies [14, 15, 18, 19]. This method not only obtains precise J_c values, but also facilitates the detection of degraded parts in inhomogeneous specimens, because the decline of n-value is more remarkable than the decrease of J_c in such parts [15]. It is noted that this standard method is excellent for assessing homogeneity in large-area HTS films, although the relevant parameter for designing microwave devices is not J_c, but the surface resistance. For application of large-area superconducting thin films to SFCLs, knowledge on J_c distribution is vital, because J_c distribution significantly affects quench distribution in SFCLs during faults.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the determination of the E-J characteristics by inductive J_c measurements as a function of frequency, given in the Introduction, Clause 1, Clause 4 and 5.1.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he is willing to negotiate licenses free of charge with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with the IEC. Information may be obtained from:

1 Numbers in square brackets refer to the Bibliography.

Name of holder of patent right:
National Institute of Advanced Industrial Science and Technology

Address:
Intellectual Property Planning Office, Intellectual Property Department
1-1-1, Umezono, Tsukuba, Ibaraki Prefecture, Japan

Attention is drawn to the possibility that some of the elements of this document may be subject to patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

ISO (www.iso.org/patents) and IEC (http://patents.iec.ch) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

SUPERCONDUCTIVITY –

Part 17: Electronic characteristic measurements – Local critical current density and its distribution in large-area superconducting films

1 Scope

This part of IEC 61788 describes the measurements of the local critical current density (J_c) and its distribution in large-area high-temperature superconducting (HTS) films by an inductive method using third-harmonic voltages. The most important consideration for precise measurements is to determine J_c at liquid nitrogen temperatures by an electric-field criterion and obtain current-voltage characteristics from its frequency dependence. Although it is possible to measure J_c in applied DC magnetic fields [20, 21][2], the scope of this standard is limited to the measurement without DC magnetic fields.

This technique intrinsically measures the critical sheet current that is the product of J_c and the film thickness *d*. The range and measurement resolution for $J_c d$ of HTS films are as follows:

– $J_c d$: from 200 A/m to 32 kA/m (based on results, not limitation);
– Measurement resolution: 100 A/m (based on results, not limitation).

2 Normative reference

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

3 Terms and definitions

For the purposes of this document, the definitions given in IEC 60050-815:2000, some of which are repeated here for convenience, apply.

3.1
critical current
I_c
maximum direct current that can be regarded as flowing without resistance

Note 1 to entry: I_c is a function of magnetic field strength and temperature.

[SOURCE: IEC 60050-815:2000, 815-03-01]

---

2 Numbers in square brackets refer to the Bibliography.