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INTERNATIONAL STANDARD

Superconductivity –
Part 22-1: Superconducting electronic devices – Generic specification for sensors and detectors

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SUPERCONDUCTIVITY –

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FOREWORD

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International Standard IEC 61788-22-1 has been prepared by IEC technical committee 90: Superconductivity.

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

FDIS	Report on voting
90/388/FDIS	90/391/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61788 series, published under the general title *Superconductivity*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document 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- withdrawn,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

Superconductivity offers various possibilities for the realization of sensing and detection of a variety of measurands. Several sensors and detectors have been developed, exploiting features like superconducting energy gaps, sharp normal-superconducting transition, nonlinear I–V characteristics, superconducting coherent states, and quantization of magnetic flux. All these properties can be influenced by the interaction with electromagnetic fields, photons, ions, etc. Superconducting sensors and detectors have extremely high performance for energy resolution, time response, and low noise, most of which cannot be realized by any other phenomena.

The word "sensor" is normally used for measuring stationary or slowly changing electromagnetic fields, physical quantities such as current and temperature. On the other hand, the word "detector" is normally used for single quanta such as photons from infrared to γ-rays and individual particles. However, the boundary between "sensor" and "detector" is ambiguous. In this document, therefore, both "sensor" and "detector" are used. Additionally, a detector using a sensor is possible, for example, X-ray detector using transition edge sensor (TES) that measures temperature rise due to the deposition of measurand energy. In this document, for example, the terminology "transition edge sensor X-ray detector" is used for X-ray detection using TES.

Superconducting sensors and detectors have been applied to a variety of fields including medical diagnosis, telecommunications, mineral exploration, astronomical instruments, quantum information processing, and analytical instruments. For users, IEC standardization is necessary because there is confusing terminology, there are no graphical symbols for diagrams, and no test methods.

SUPERCONDUCTIVITY –

Part 22-1: Superconducting electronic devices – Generic specification for sensors and detectors

1 Scope

This part of IEC 61788-22-1 describes general items concerning the specifications for superconducting sensors and detectors, which are the basis for specifications given in other parts of IEC 61788 for various types of sensors and detectors. The sensors and detectors described are basically made of superconducting materials and depend on superconducting phenomena or related phenomena. The objects to be measured (measurands) include magnetic fields, electromagnetic waves, photons of various energies, electrons, ions, α-particles, and others.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050-815, *International Electrotechnical Vocabulary – Part 815: Superconductivity*

IEC 60417, *Graphical symbols for use on equipment* (available at: http://www.graphical-symbols.info)

IEC 60617, *Graphical symbols for diagrams* (available at: http://std.iec.ch/iec60617)

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols* (available at: http://www.graphical-symbols.info)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-815 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
additional positive feedback
APF
method enhancing voltage-flux transformation ratio by using resistance and coupling coil to SQUID ring

3.2
critical current modulation parameter
β_L
parameter defined by $2LI_c/\Phi_0$, where L is the SQUID washer inductance, I_c is the critical current of a Josephson junction, for DC SQUIDs, and a parameter defined by $2\pi LI_c/\Phi_0$ for RF SQUIDs

Note 1 to entry: The term "shielding parameter" can also be used.

3.3
Stewart-McCumber parameter
β_C
parameter defined by $2\pi I_c R_n{}^2 C/\Phi_0$, where R_n is the normal state resistance of a Josephson junction, and C is the capacitance of a Josephson junction

3.4
bridge junction
junction formed from two superconductors connected by a superconducting bridge of small section

Note 1 to entry: The term "microbridge" can also be used.

3.5
critical current
I_c
maximum direct current that can be regarded as flowing through a Josephson junction without resistance

3.6
critical current density
J_c
critical current divided by the cross-section of the conductor or the junction area of the Josephson junction

3.7
feedback coil
coil that is inductively coupled to a SQUID operated in the flux locked loop (FLL) mode

3.8
flux locked loop
FLL
method that improves linearity and dynamic range of a SQUID by using negative feedback to keep the constant flux number in the SQUID ring

3.9
gradiometer
configuration of superconducting loops coupled to a SQUID magnetometer, or of multiple SQUID magnetometers that are arranged so as to be insensitive to homogenous magnetic fields or to be sensitive to magnetic field gradients

3.10
metallic magnetic calorimetric detector
type of superconducting device that the temperature increase of a metallic absorber is measured by sensing the magnetization change of the absorber because of measurand energy deposition

3.11
microwave kinetic inductance detector
type of superconducting device that uses the microwave surface impedance change of a superconducting strip because of measurand energy deposition

3.12
normal state resistance
resistance of a superconductor or a Josephson junction at a normal state

Note 1 to entry: In a superconductor or a TES, it is the resistance at a temperature just above the superconducting transition.

Note 2 to entry: In a Josephson junction, it is the tunnelling resistance at a bias voltage well above $2\Delta/e$.

3.13
planar gradiometer
kind of configuration of the flux pickup loop that measures a magnetic field gradient in the plane of the flux pickup loop coupled to a SQUID

3.14
quasiparticle
excitation combining properties of an electron and a hole that is created by breaking a Cooper pair in a superconductor

3.15
superconducting hot electron bolometric mixer
type of superconducting device that uses heterodyne mixing with the resistive transition from the superconducting state to the normal state in a superconducting microbridge because of measurand energy deposition

3.16
superconducting quantum interference device sensor
SQUID sensor
type of superconducting device that uses quantum interference occurring in a closed electrical circuit containing one or more Josephson junctions

Note 1 to entry: Every measurand, for example magnetic fields or electric currents, that is transformed into a change of magnetic flux threading the superconducting structure can be sensed by a SQUID.

3.17
SQUID array
SQA
device consisting of series and/or parallel arrays of multiple SQUIDs

3.18
nano-SQUID
device whose largest loop dimension is less than 500 nm

3.19
SQUID ring
multiply superconducting structure that contains one or more Josephson junctions

Note 1 to entry: The term "SQUID loop" can also be used.