SLOVENSKI STANDARD
SIST EN IEC 61788-22-3:2022

01-december-2022

Superprevodnost - 22-3. del: Superprevodni tračni fotonski detektor - Brezfotonska pogostost (IEC 61788-22-3:2022)

Superconductivity - Part 22-3: Superconducting strip photon detector - Dark count rate (IEC 61788-22-3:2022)

Supraleitfähigkeit – Teil 22-3: Supraleitender Streifen-Photonendetektor - Dunkelzählrate (IEC 61788-22-3:2022)

Supraconductivité - Partie 22-3: Détecteur de photons à bande supraconductrice - Taux de comptage en obscurité (IEC 61788-22-3:2022)

Ta slovenski standard je istoveten z: EN IEC 61788-22-3:2022

<u>ICS:</u>

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 IEC 61788-22-3:2022 en

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 61788-22-3

September 2022

ICS 29.050

English Version

Superconductivity - Part 22-3: Superconducting strip photon detector - Dark count rate (IEC 61788-22-3:2022)

Supraconductivité - Partie 22-3: Détecteur de photons à bande supraconductrice - Taux de comptage en obscurité (IEC 61788-22-3:2022)

Supraleitfähigkeit - Teil 22-3: Supraleitender Streifen-Photonendetektor - Dunkelzählrate (IEC 61788-22-3:2022)

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN IEC 61788-22-3:2022 E

European foreword

The text of document 90/489/FDIS, future edition 1 of IEC 61788-22-3, prepared by IEC/TC 90 "Superconductivity" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61788-22-3:2022.

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)	2023-06-23
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2025-09-23

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Endorsement notice

The text of the International Standard IEC 61788-22-3:2022 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61788-22-1 NOTE Harmonized as EN 61788-22-1

ISO/TS 80004-2:2015 NOTE Harmonized as CEN ISO/TS 80004-2:2017 (not modified)

IEC 61788-22-3

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Part 22-3: Superconducting strip photon detector – Dark count rate

Supraconductivité –
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FOREWORD

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IEC 61788-22-3 has been prepared by IEC technical committee 90: Superconductivity. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
90/489/FDIS	90/491/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/standardsdev/publications.

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 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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 61788-22 (all parts) is a series of International Standards on superconductor electronic devices. Superconductivity enables ultra-sensitive sensing or detection of a variety of measurands. IEC 61788-22-1 [1][1] lists various types of superconductor sensors and detectors. The strip type in this document is one of them.

A typical fundamental structure of strip type detectors is a meander superconductor line, for example, with a thickness of less than 10 nm, a width of less than 100 nm or a few 100 nm, and a length of a few mm. The structure is in the nanoscale. ISO TS 80004-2:2015 [2] defines the nanoscale as a length range approximately from 1 nm to 100 nm. Because nano-objects have one or two dimensions in the nanoscale, superconductor meander lines are categorized as a nano-object.

The term "nanowire" is frequently used for superconductor meander lines, but it is not recommended in this document. In the ISO vocabulary, a nanowire is defined as an electrically conducting or semi-conducting nanofibre with two external dimensions in the nanoscale, with the third dimension being significantly larger. The two external dimensions of the nanowires are in the nanoscale range, approximately from 1 nm to 100 nm. When the first two dimensions differ significantly, a "nanoplate," "nanoribbon," or "nanotape" shall be used for the meander line shape. However, in the field of electronics, these terms are not common. In addition to the ISO definition of nano-objects, the shape of the superconductor meander lines may not fit the shape of common wires that have a round cross-section. Although there are cases in which a superconductor line shape falls into the category of nanowire (e.g. a superconductor line with a thickness of 10 nm and a width of 100 nm), the theoretical treatment of single photon detection mechanisms still requires "strip" rather than "nanowire": the width is wider than coherence length and thus the superconductor line has a two-dimensional nature. Therefore, IEC 61788-22-1 assigns the word "strip" or "nanostrip" to the meander line shape. According to the nomenclature of the standard, the strip type detector is called superconductor strip photon detector (SSPD) or superconductor nanostrip photon detector (SNSPD). The abbreviated term SSPD is used in this document.

SSPDs are usually cooled down to a temperature well below the critical temperature and current-biased with a bias value close to, but smaller than, its switch current. The photon detection mechanisms can be described by Cooper-pair breaking, leading to hotspot formation or vortex motion, followed by electrothermal feedback creating a resistive region [3], [4]. Although an exact detection model has not been established yet, it is true that photon absorption leads to Cooper pair breaking that creates quasiparticles because the photon energy in a telecommunication wavelength band (~ 1 eV) is typically 2 to 3 orders of magnitude higher than the binding energy of a Cooper pair (~ meV). The photon absorption may create a normal-conducting local-hotspot in the nanostrip. With an electrothermal feedback process, the normal conducting domain expands across the width of the nanostrip and along the current flow direction, leading to a voltage drop in the superconductor nanostrip. Other possible models are vortex-antivortex depairing, in which two vortices move toward the opposite strip edges, and single vortex crossing. Such vortex motion also creates a voltage drop, which can be followed by resistive domain creation with the same electrothermal feedback mechanism. Because of the resistive domain in the strip, the bias current is diverted to a readout circuit. The normal conducting region will be cooled down rapidly and finally disappear. The above process produces a voltage pulse which corresponds to an event of single photon absorption.

Typical application areas of SSPDs include quantum information, laser communication, light detection and ranging, fluorescence spectroscopy and quantum computing. The SSPDs outperform such single photon detectors as photomultipliers and avalanche photodiodes in performance measures listed in the next paragraph. Due to the increasing needs for ultra-sensitive photon detection in a range of visible to mid-infrared wavelengths, the SSPD market

1 Figures in square brackets refer to the Bibliography.

is growing quickly. The standardization of SSPDs is beneficial to not only the industrial application, but also detector development.

For photon detection, there are fundamental parameters, such as detection efficiency, timing jitter, dead time and dark count rate. The dark count rate affects the measurement of other parameters. For this reason, priority is given to the dark count rate. This document (IEC 61788-22-3) defines a measurement method of dark count rate (DCR).