



BSI Standards Publication

Calibration of wavelength/optical frequency measurement instruments

Part 3: Optical frequency meters internally referenced to a frequency comb (IEC 62129-3:2019)

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National foreword

This British Standard is the UK implementation of EN IEC 62129-3:2019. It is identical to IEC 62129-3:2019. It supersedes PD IEC/TS 62129-3:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/86, Fibre optics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Amendments/corrigenda issued since publication

Date	Text affected
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EUROPÄISCHE NORM

July 2019

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English Version

Calibration of wavelength/optical frequency measurement
instruments - Part 3: Optical frequency meters internally
referenced to a frequency comb
(IEC 62129-3:2019)

Étalonnage des appareils de mesure de longueur
d'onde/appareil de mesure de la fréquence optique - Partie
3: Fréquences optiques faisant référence en interne à
un peigne de fréquence
(IEC 62129-3:2019)

Kalibrierung von Messgeräten für die Wellenlänge/optische
Frequenz - Teil 3: Optisches Frequenzmessgerät mit
internem Bezug auf einen Frequenzkamm
(IEC 62129-3:2019)

This European Standard was approved by CENELEC on 2019-06-24. 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.

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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

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European foreword

The text of document 86/551/FDIS, future edition 1 of IEC 62129-3, prepared by IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62129-3:2019.

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) 2020-03-24
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-06-24

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

Endorsement notice

The text of the International Standard IEC 62129-3:2019 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 62129-1	NOTE	Harmonized as EN 62129-1
IEC 62129-2:2011	NOTE	Harmonized as EN 62129-2:2011 (not modified)
ISO/IEC 17025	NOTE	Harmonized as EN ISO/IEC 17025
IEC 61315	NOTE	Harmonized as EN IEC 61315
IEC 60359	NOTE	Harmonized as EN 60359

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Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60793-2-50	-	Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres	EN IEC 60793-2-50	-
IEC 60825-1	-	Safety of laser products - Part 1: Equipment classification and requirements	EN 60825-1	-
IEC 60825-2	-	Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCS)	EN 60825-2	-
IEC/TR 61931	-	Fibre optic - Terminology	-	-
ISO/IEC Guide 98-3	2008	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CALIBRATION OF WAVELENGTH /
OPTICAL FREQUENCY MEASUREMENT INSTRUMENTS –**

**Part 3: Optical frequency meters internally
referenced to a frequency comb**

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 62129-3 has been prepared by IEC technical committee 86: Fibre optics.

This first edition cancels and replaces IEC TS 62129-3, published in 2014.

This edition includes the following significant technical changes with respect to the previous edition:

- a) text has been added to 5.2.3 about calibration at a second optical frequency;
- b) Annex D is now normative;
- c) Subclause 4.2 has been improved;
- d) measurement method of frequency has been moved to Annex B;
- e) example of optical frequency comb has been moved to Annex C;
- f) frequency-dependence uncertainty has been moved to Annex D.

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

FDIS	Report on voting
86/551/FDIS	86/554/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 62129 series, published under the general title *Calibration of wavelength/optical frequency measurement instruments*, 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

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INTRODUCTION

It is essential for realizing fibre optic systems that optical channels are defined in the optical frequency domain, not the wavelength domain. One example: the anchor frequency of the ITU-T grid is 193,1 THz, and the channel spacings of the ITU-T grid are 12,5 GHz, 25 GHz, 50 GHz, and 100 GHz [1]¹.

ITU-T has also discussed λ -interface systems such as "black link" [2]. "Black link" includes WDM MUX/DEMUX and a transmission fibre, and provides λ -interfaces. Especially in DWDM systems (channel spacing < 100 GHz), the uncertainty in specifying optical frequency needs to be minimized.

To implement future telecom systems, it is expected that optical frequency measurements will need to be extremely precise. For example, to achieve the channel spacing of 25 GHz, signal optical frequency uncertainty ($U_{f_{\text{sig}}}$) and required measurement uncertainty ($U_{f_{\text{meas}}}$) need to be 2 GHz to 200 MHz ($U_{f_{\text{sig}}}/f = 10^{-5}$ to 10^{-6}) and 200 MHz to 2 MHz ($U_{f_{\text{meas}}}/f = 10^{-6}$ to 10^{-8}), respectively. Unfortunately, conventional wavelength meters have measurement uncertainties of 10^{-6} to 10^{-7} . The solution is to use optical frequency measurements since measurement uncertainties can be as small as 10^{-9} , which satisfies the above telecom requirement ($U_{f_{\text{meas}}}/f = 10^{-6}$ to 10^{-8}). Therefore, an optical frequency measurement scheme is necessary for the calibration of future telecom systems.

The frequency meter to calibrate with the procedure described in this document is the measurement equipment internally utilizing the optical frequency comb. In Annex A, the mathematical basis for the uncertainty of measurement is described. The measurement procedure of the frequency with the frequency meter utilizing the optical frequency comb is shown in Annex B and the example of the optical frequency comb sources are shown in Annex C. Additionally, the uncertainty depending on the frequency is shown in Annex D.

This document defines all the steps involved in the calibration process of the frequency measuring with the optical frequency meter internally utilizing an optical frequency comb: establishing the calibration conditions, carrying out the calibration, calculating the uncertainty, and reporting the uncertainty, the calibration conditions and the traceability.

¹ Numbers in square brackets refer to the Bibliography.

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CALIBRATION OF WAVELENGTH / OPTICAL FREQUENCY MEASUREMENT INSTRUMENTS –

Part 3: Optical frequency meters internally referenced to a frequency comb

1 Scope

This part of IEC 62129 describes the calibration of optical frequency meters using an optical frequency comb as an internal reference. It is applicable to instruments measuring the optical frequency emitted from sources that are typical for the fibre-optic communications industry. It is assumed that the optical radiation will be coupled to the optical frequency meter by a single-mode optical fibre. This document is part of the IEC 62129 series on the calibration of wavelength/optical frequency measurement instruments. Refer to IEC 62129-1 [3] for the calibration of optical spectrum analyzers, and refer to IEC 62129-2 [4] for calibration of Michelson interferometer single wavelength meters.

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 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

IEC TR 61931, *Fibre optic – Terminology*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TR 61931, 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>