

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Calibration of wavelength / optical frequency measurement instruments –
Part 3: Optical frequency meters internally referenced to a frequency comb**

**Étalonnage des appareils de mesure de longueur d'onde / appareil de mesure de
la fréquence optique –
Partie 3: Fréquencemètres optiques faisant référence en interne à un peigne de
fréquence**





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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.

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,
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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.

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>

3.1 accredited calibration laboratory

calibration laboratory authorized by the appropriate national organization to issue calibration certificates with a minimum specified uncertainty, which demonstrate traceability to national measurement standards (3.3)

3.2 calibration

set of operations that establish, under specified conditions, the relationship between the values of quantities indicated by a measuring instrument and the corresponding values realized by measurement standards

Note 1 to entry: The result of a calibration permits either the assignment of values of measurands to the indications or the determination of corrections with respect to indications.

Note 2 to entry: A calibration may also determine other metrological properties such as the effect of influence quantities.

Note 3 to entry: The result of a calibration may be recorded in a document, sometimes called a calibration certificate or a calibration report.

[SOURCE: ISO/IEC Guide 99:2007 [5], 2.39, modified – Only the first part of the definition has been used and the notes to entry have been modified.]

3.3 national measurement standard

standard recognized by a national decision to serve, in a country, as the basis for assigning values to other standards for the quantity concerned

[ISO/IEC Guide 99:2007, 5.3, modified – Some terms have been replaced with similar meaning.]

3.4 reference standard

standard, generally having the highest metrological quality available at a given location or in a given organization, from which measurements made therein are derived

Note 1 to entry: The general definition of this term is described in ISO/IEC Guide 99:2007, 5.6.

3.5 traceability

property of the result of a measurement or the value of a measurement standard whereby it can be related to stated references, usually national or international measurement standards, through an unbroken chain of comparisons all having stated uncertainties

Note 1 to entry: The general definition of this term is described in ISO/IEC Guide 99:2007, 2.41.

3.6 traceability chain

unbroken chain of comparison

Note 1 to entry: The general definition of this term is described in ISO/IEC Guide 99:2007, 2.42.

3.7 working standard

measurement standard that is used routinely to calibrate or check measuring instruments

Note 1 to entry: A working standard is usually calibrated against a reference standard.

Note 2 to entry: The general definition of this term is described in ISO/IEC Guide 99:2007, 5.7.