

TECHNICAL SPECIFICATION



**Calibration of wavelength/optical frequency measurement instruments –
Part 3: Optical frequency meters using optical frequency combs**



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Calibration of wavelength/optical frequency measurement instruments – Part 3: Optical frequency meters using optical frequency combs

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CALIBRATION OF WAVELENGTH/OPTICAL
FREQUENCY MEASUREMENT INSTRUMENTS –****Part 3: Optical frequency meters using optical frequency combs**

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 62129-3, which is a technical specification, has been prepared by IEC technical committee 86: Fibre optics.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
86/461/DTS	86/465/RVC

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

This publication 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 publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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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 [2]¹.

ITU-T has also discussed λ -interface systems such as “black link” [3]. “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^{-15} to 10^{-16} , 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.

Optical frequency measurement technology is progressing rapidly. Many fundamental papers have examined the use of equally-spaced “optical frequency comb” lines (spacing of up to 50 GHz) from an optical frequency comb as a “ruler” for optical frequency measurement [4-15]. For example, mode-locked lasers with carrier-envelope phase locked enable ultra-low measurement uncertainties of 10^{-15} to 10^{-16} . Some examples of practical optical frequency combs are shown in Annex B (mode-locked fibre laser + carrier-envelope phase lock, stabilized laser + electro-optical modulator, and stabilized laser + supercontinuum source). Frequency measurements provide more accurate values than interferometric wavelength measurements in air by eliminating the effects of refractive indices. Furthermore, they allow the measurement devices to be significantly smaller than wavelength meters.

¹ Numbers between square brackets refer to the Bibliography.

CALIBRATION OF WAVELENGTH/OPTICAL FREQUENCY MEASUREMENT INSTRUMENTS –

Part 3: Optical frequency meters using optical frequency combs

1 Scope

This part of IEC 62129, which is a technical specification, describes the calibration of optical frequency meters. 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.

2 Normative references

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

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC/TR 61931, as well as the following terms and definitions, apply.

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

3.2

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, 2.39, modified] [16]

3.3

national (measurement) standard

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

[SOURCE: ISO/IEC Guide 99:2007, 5.3 modified]

3.4

national standards laboratory

laboratory which maintains the national measurement standard

3.5

reference standard

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

[SOURCE: ISO/IEC Guide 99:2007, 5.6 modified]

3.6

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

[SOURCE: ISO/IEC Guide 99:2007, 2.41 modified]

3.7

traceability chain

unbroken chain of comparison

[SOURCE: ISO/IEC Guide 99:2007, 2.42 modified]

3.8

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.

[SOURCE: ISO/IEC Guide 99:2007, 5.7 modified]

4 Calibration test requirements

4.1 Preparation

The following recommendations apply.

The calibration laboratory should satisfy requirements of ISO/IEC 17025.