

**Calibration of wavelength/optical frequency
measurement instruments - Part 2: Michelson
interferometer single wavelength meters**

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

Käesolev Eesti standard EVS-EN 62129-2:2011 sisaldab Euroopa standardi EN 62129-2:2011 ingliskeelset teksti.

Standard on kinnitatud Eesti Standardikeskuse 29.07.2011 käskkirjaga ja jõustub sellekohase teate avaldamisel EVS Teatajas.

Euroopa standardimisorganisatsioonide poolt rahvuslikele liikmetele Euroopa standardi teksti kättesaadavaks tegemise kuupäev on 08.07.2011.

Standard on kättesaadav Eesti standardiorganisatsioonist.

This Estonian standard EVS-EN 62129-2:2011 consists of the English text of the European standard EN 62129-2:2011.

This standard is ratified with the order of Estonian Centre for Standardisation dated 29.07.2011 and is endorsed with the notification published in the official bulletin of the Estonian national standardisation organisation.

Date of Availability of the European standard text 08.07.2011.

The standard is available from Estonian standardisation organisation.

ICS 33.180.30

Standardite reprodutseerimis- ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonilisse süsteemi või edastamine ükskõik millises vormis või millisel teel on keelatud ilma Eesti Standardikeskuse poolt antud kirjaliku loata.

Kui Teil on küsimusi standardite autorikaitse kohta, palun võtke ühendust Eesti Standardikeskusega:
Aru str 10 Tallinn 10317 Eesti; www.evs.ee; Telefon: 605 5050; E-post: info@evs.ee

Right to reproduce and distribute belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without permission in writing from Estonian Centre for Standardisation.

If you have any questions about standards copyright, please contact Estonian Centre for Standardisation:
Aru str 10 Tallinn 10317 Estonia; www.evs.ee; Phone: 605 5050; E-mail: info@evs.ee

**Calibration of wavelength/optical frequency measurement instruments -
Part 2: Michelson interferometer single wavelength meters
(IEC 62129-2:2011)**

Etalonnage des appareils de mesure de
longueur d'onde/appareil de mesure de la
fréquence optique -
Partie 2: Appareils de mesure de longueur
d'onde unique à interféromètre de
Michelson
(CEI 62129-2:2011)

Kalibrierung von Messgeräten für die
Wellenlänge/optische Frequenz -
Teil 2: Michelson-Interferometer-
Einzelwellenlängen-Messgeräte
(IEC 62129-2:2011)

This European Standard was approved by CENELEC on 2011-06-30. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 86/395/FDIS, future edition 1 of IEC 62129-2, prepared by IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62129-2 on 2011-06-30.

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

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2012-03-30
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2014-06-30

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62129-2:2011 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 60793-1-1	NOTE	Harmonized as EN 60793-1-1.
IEC 60825-1	NOTE	Harmonized as EN 60825-1.
IEC 60825-2	NOTE	Harmonized as EN 60825-2.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-300	2001	International Electrotechnical Vocabulary - Electrical and electronic measurements and measuring instruments - Part 311: General terms relating to measurements - Part 312: General terms relating to electrical measurements - Part 313: Types of electrical measuring instruments - Part 314: Specific terms according to the type of instrument	-	-
IEC 61315	2005	Calibration of fibre-optic power meters	EN 61315	2006
IEC/TR 61931	1998	Fibre optic - Terminology	-	-
ISO/IEC 17025	2005	General requirements for the competence of testing and calibration laboratories	EN ISO/IEC 17025	2005
ISO/IEC Guide 99	2007	International vocabulary of metrology - Basic and general concepts and associated terms (VIM)	-	-
ISO/IEC Guide 98-3	2008	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions	7
4 Preparation for calibration	11
4.1 Organization	11
4.2 Traceability.....	11
4.3 Advice for measurements and calibrations	11
4.4 Recommendations to customers	12
5 Single wavelength calibration	12
5.1 General	12
5.2 Establishing calibration conditions.....	12
5.3 Calibration procedure	13
5.3.1 General	13
5.3.2 Measurement configuration	13
5.3.3 Detailed procedure.....	15
5.3.4 Stability test (if necessary)	15
5.3.5 "On/Off repeatability" measurement (optional if a specification is available).....	16
5.3.6 Wavelength dependence measurement (optional)	18
5.3.7 Connector repeatability measurement (optional).....	19
5.4 Calibration uncertainty	20
5.5 Reporting the results	21
6 Absolute power calibration	21
Annex A (normative) Mathematical basis	22
Annex B (informative) Rejection of outliers	25
Annex C (informative) Example of a single wavelength calibration	27
Annex D (informative) ITU wavelength bands	30
Annex E (informative) Atomic and molecular reference transitions	31
Annex F (informative) Reference locked laser example.....	42
Annex G (informative) Balance between accuracy and calibration time.....	44
Bibliography	46
Figure 1 – Example of a traceability chain.....	10
Figure 2 – Wavelength meter measurement using a lock quality monitor signal.....	14
Figure 3 – Wavelength meter measurement using a reference wavelength meter	14
Figure F.1 – Typical measurement arrangement to lock laser to gas absorption line.....	43
Table 1 – Typical parameters to calculate the "On/Off repeatability" measurement duration	17
Table B.1 – Critical values Z_c as a function of sample size N	26
Table C.1 – Type A uncertainty contributions for a stability measurement	27
Table C.2 – Uncertainty contributions for a "On/Off repeatability" measurement	28

Table C.3 – Uncertainty budget for wavelength dependence	28
Table C.4 – Uncertainty budget for the wavelength meter calibration.....	29
Table D.1 – The ITU-T bands in different units	30
Table E.1 – Helium-neon laser lines	32
Table E.2 – Centre vacuum wavelengths for Acetylene $^{12}\text{C}_2\text{H}_2$	33
Table E.3 – Frequency and vacuum wavelength values for the $\nu_1 + \nu_3$ and $\nu_1 + \nu_2 + \nu_4 + \nu_5$ bands of $^{13}\text{C}_2\text{H}_2$	35
Table E.4 – List of H^{13}CN transitions.....	38
Table E.5 – List of $^{12}\text{C}^{16}\text{O}$ transitions.....	40
Table E.6 – Excited state optogalvanic transitions	41
Table G.1 – Summary of choices	45

This document is a preview generated by EVS

INTRODUCTION

Wavelength meters, often based on the Michelson interferometer, are designed to measure the wavelength of an optical source as accurately as possible. Although the wavelength meters contain an internal absolute reference, typically a Helium-Neon laser, calibration is required to achieve the highest accuracies. The instrument is typically used to measure wavelengths other than that of the internal reference. Corrections are made within the instrument for the refractive index of the surrounding air. A precise description of the calibration conditions must therefore be an integral part of the calibration.

This international standard defines all of the steps involved in the calibration process: establishing the calibration conditions, carrying out the calibration, calculating the uncertainty, and reporting the uncertainty, the calibration conditions and the traceability.

The calibration procedure describes how to determine the ratio between the value of the input reference wavelength (or the optical frequency) and the wavelength meter's result. This ratio is called *correction factor*. The measurement uncertainty of the correction factor is combined following Annex A from uncertainty contributions from the reference meter, the test meter, the setup and the procedure.

The calculations go through detailed characterization of individual uncertainties. It is important to know that:

- a) estimations of the individual uncertainties are acceptable;
- b) a detailed uncertainty analysis is only necessary once for each wavelength meter type under test, and that all subsequent calibrations can be based on this one-time analysis;
- c) some of the individual uncertainties can simply be considered to be part of a checklist, with an actual value which can be neglected.

A number of optical frequency references can be used to provide a traceable optical frequency. These are based on absorption by gas molecules under low pressure and using excited-state opto-galvanic transitions in atoms. Annex E lists the lines.

CALIBRATION OF WAVELENGTH/OPTICAL FREQUENCY MEASUREMENT INSTRUMENTS –

Part 2: Michelson interferometer single wavelength meters

1 Scope

This part of IEC 62129 is applicable to instruments measuring the vacuum wavelength or optical frequency emitted from sources that are typical for the fibre-optic communications industry. These sources include Distributed Feedback (DFB) laser diodes, External Cavity lasers and single longitudinal mode fibre-type sources. It is assumed that the optical radiation will be coupled to the wavelength meter by a single-mode optical fibre. The standard describes the calibration of wavelength meters to be performed by calibration laboratories or by wavelength meter manufacturers. This standard is part of the IEC 62129 series on the calibration of wavelength/optical frequency measurement instruments. Refer to IEC 62129 for the calibration of optical spectrum analyzers.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-300:2001, *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical instruments – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

IEC 61315 :2005, *Calibration of fibre-optic power meters*

IEC/TR 61931:1998, *Fibre optic – Terminology*

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

ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

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 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 standards*