

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Calibration of wavelength/optical frequency measurement instruments –
Part 1: Optical spectrum analyzers**

**Étalonnage des appareils de mesure de longueur d'onde/appareil de mesure de
la fréquence optique –
Partie 1: Analyseurs de spectre optique**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Calibration of wavelength/optical frequency measurement instruments –
Part 1: Optical spectrum analyzers**

**Étalonnage des appareils de mesure de longueur d'onde/appareil de mesure de
la fréquence optique –
Partie 1: Analyseurs de spectre optique**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.140; 33.180.01

ISBN 978-2-8322-3123-4

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Preparation for calibration	12
4.1 Organization	12
4.2 Traceability	12
4.3 Preparation	12
4.4 Reference calibration conditions	12
5 Wavelength calibration	13
5.1 Overview.....	13
5.2 Wavelength calibration under reference conditions	13
5.2.1 General	13
5.2.2 Equipment for wavelength calibration under reference conditions	14
5.2.3 Procedure for wavelength calibration under reference conditions.....	14
5.2.4 Calculations of wavelength uncertainty under reference conditions.....	14
5.3 Wavelength calibration for operating conditions	15
5.3.1 General	15
5.3.2 Wavelength dependence	15
5.3.3 Temperature dependence.....	16
5.4 Calculation of expanded uncertainty	17
6 Power level calibration.....	18
6.1 Overview.....	18
6.2 Power level calibration under reference conditions.....	19
6.2.1 General	19
6.2.2 Equipment for power level calibration under reference conditions	19
6.2.3 Procedure for power level calibration under reference conditions.....	19
6.2.4 Calculation of power level uncertainty under reference conditions	20
6.3 Power level calibration for operating conditions	21
6.3.1 General	21
6.3.2 Wavelength dependence	21
6.3.3 Polarization dependence	23
6.3.4 Linearity	24
6.3.5 Temperature dependence	26
6.4 Calculation of expanded uncertainty	27
7 Resolution bandwidth (spectral resolution) test.....	28
7.1 Overview.....	28
7.2 Resolution bandwidth (spectral resolution) test	28
7.2.1 General	28
7.2.2 Equipment for resolution bandwidth (spectral resolution) test	28
7.2.3 Test procedure for resolution bandwidth (spectral resolution)	29
8 Documentation	30
8.1 Measurement conditions	30
8.2 Measurement data and uncertainty	30
Annex A (normative) Mathematical basis	31

A.1	General.....	31
A.2	Type A evaluation of uncertainty	31
A.3	Type B evaluation of uncertainty	32
A.4	Determining the combined standard uncertainty.....	32
A.5	Reporting	33
Annex B (informative)	Examples of calculation of calibration uncertainty.....	34
B.1	General.....	34
B.2	Wavelength calibration.....	34
B.2.1	Uncertainty under reference conditions: $u_{D_{\lambda_{ref}}}$	34
B.2.2	Uncertainty under operating conditions	35
B.2.3	Expanded uncertainty calculation	36
B.3	Power level calibration	37
B.3.1	Uncertainty under reference conditions: $u_{D_{Pref}}$	37
B.3.2	Uncertainty under operating conditions	38
B.3.3	Expanded uncertainty calculation	41
Annex C (informative)	Using the calibration results	42
C.1	General.....	42
C.1.1	Overview	42
C.1.2	Parameters	42
C.1.3	Restrictions	42
C.2	Additive corrections	42
C.2.1	Parameters.....	42
C.2.2	Measurements close to a calibration reference wavelength.....	43
C.2.3	Measurements at other wavelengths.....	43
C.3	Multiplicative corrections.....	44
C.3.1	Parameters.....	44
C.3.2	Measurements close to a calibration reference wavelength.....	44
C.3.3	Measurements at other wavelengths.....	44
C.4	OSA calibration results (additive correction)	45
Annex D (informative)	Wavelength references	48
D.1	General.....	48
D.2	Gas laser lines.....	48
D.3	Noble gas reference lines	48
D.4	Molecular absorption lines	49
Bibliography.....		53
Figure 1	– Setup using a gas laser whose wavelength is known.....	13
Figure 2	– Setup using a broadband source with a transmission device	13
Figure 3	– Setup using an LD with an unknown wavelength	13
Figure 4	– Test configuration for determining the temperature dependence of wavelength uncertainty	17
Figure 5	– Setup for calibration of power level under reference conditions	19
Figure 6	– Test configuration for determining the wavelength dependence of power level uncertainty	21
Figure 7	– Test configuration for determining the polarization dependence of power level uncertainty	23
Figure 8	– Configuration for testing linearity error of power level uncertainty	24

Figure 9 – Test configuration for determining the temperature dependence of power level uncertainty 26

Figure C.1 – Calibration of OSA wavelength scale using krypton emission lines; 95 % confidence intervals shown 47

Figure D.1 – Absorption of LED light by acetylene ($^{12}\text{C}_2\text{H}_2$) 50

Figure D.2 – Absorption of LED light by hydrogen cyanide ($\text{H}^{13}\text{C}^{14}\text{N}$) 52

Table 1 – Recommended light sources 29

Table C.1 – OSA calibration results 46

Table C.2 – Summary of OSA calibration parameters 46

Table D.1 – Vacuum wavelengths (nm) of selected gas laser lines 46

Table D.2 – Vacuum wavelengths (nm) of noble gas reference lines 49

Table D.3 – Vacuum wavelengths (nm) for the $\nu_1+\nu_3$ band of acetylene $^{12}\text{C}_2\text{H}_2$ absorption lines [21-23] 50

Table D.4 – Vacuum wavelengths (nm) for the $\nu_1+\nu_3$ band of acetylene $^{13}\text{C}_2\text{H}_2$ absorption lines [21-23] 51

Table D.5 – Vacuum wavelengths (nm) of selected hydrogen cyanide ($\text{H}^{13}\text{C}^{14}\text{N}$) absorption lines [24] 51

currently in preview, click buy full version

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CALIBRATION OF WAVELENGTH/OPTICAL
FREQUENCY MEASUREMENT INSTRUMENTS –****Part 1: Optical spectrum analyzers**

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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, accept IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62129-1 has been prepared by IEC technical committee 86: Fibre optics.

This third edition of IEC 62129-1 cancels and replaces the first edition of IEC 62129, published in 2006. This edition constitutes a technical revision.

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

- a) update of term and definitions;
- b) update of calibration conditions;
- c) calculation change of uncertainties related to wavelength temperature dependence, power linearity, power level temperature dependence;
- d) move of Annex E to the bibliography.

The text of this standard is based on the following documents:

CDV	Report on voting
86/477/CDV	86/483/RVC

Full information on the voting for the approval of this standard 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 measurements 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 website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication 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.

CALIBRATION OF WAVELENGTH/OPTICAL FREQUENCY MEASUREMENT INSTRUMENTS –

Part 1: Optical spectrum analyzers

1 Scope

This part of IEC 62129 specifies procedures for calibrating an optical spectrum analyzer that is developed for use in fibre-optic communications and designed to measure the power distribution of an optical spectrum. It does not apply to an optical wavelength meter that measures only centre wavelengths, a Fabry-Perot interferometer or a monochromator that has no display unit.

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 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication* (available at <http://www.electropedia.org>),

IEC 60793-2 (all parts), *Optical fibres – Part 2: Product specifications*

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

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

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 60050-731 and the following apply.

3.1

accredited calibration laboratory

calibration laboratory authorized by an appropriate national organization to issue calibration certificates that demonstrates traceability to national 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 standards

Note 1 to entry: The results of a calibration permit either the assignment of measurand values to the indications or the determination of corrections with respect to the indications.