

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Calibration of tuneable laser sources

Étalonnage des sources laser accordables



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 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 Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.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 once a month by email.

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: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

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 une fois par mois par email.

Service Clients - webstore.iec.ch/csc

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

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.



IEC 62522

Edition 2.0 2024-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Calibration of tuneable laser sources

Étalonnage des sources laser accordables

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.260, 33.180.01

ISBN 978-2-8322-9034-7

**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.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms, definitions, and abbreviated terms	7
3.1 Terms and definitions.....	7
3.2 Abbreviated terms.....	10
4 Preparation for calibration	10
4.1 Organization	10
4.2 Traceability	10
4.3 Preparation	10
4.4 Reference calibration conditions	11
5 Wavelength calibration	11
5.1 Overview.....	11
5.2 Wavelength calibration at reference conditions	12
5.2.1 Set-up	12
5.2.2 Calibration equipment.....	12
5.2.3 Procedure for wavelength calibration	12
5.2.4 Dependence on conditions.....	13
5.2.5 Uncertainty at reference conditions.....	15
5.3 Wavelength calibration at operating conditions	16
5.3.1 General	16
5.3.2 Optical power dependence	16
5.3.3 Uncertainty at operating conditions	17
6 Optical power calibration	18
6.1 Overview.....	18
6.2 Optical power calibration at reference conditions	18
6.2.1 Set-up	18
6.2.2 Calibration equipment.....	19
6.2.3 Procedure for power calibration at reference conditions.....	19
6.2.4 Dependence on conditions.....	20
6.2.5 Uncertainty at reference conditions.....	23
6.3 Optical power calibration at operating conditions	23
6.3.1 General	23
6.3.2 Wavelength dependence	24
6.3.3 Uncertainty at operating conditions	25
7 Documentation	25
7.1 Calibration data and uncertainty.....	25
7.2 Calibration conditions	26
Annex A (normative) Mathematical basis for measurement uncertainty calculations.....	27
A.1 General.....	27
A.2 Type A evaluation of uncertainty	27
A.3 Type B evaluation of uncertainty	28
A.4 Determining the combined standard uncertainty.....	29
A.5 Reporting.....	29
Annex B (informative) Other testing	30

B.1	General.....	30
B.2	Wavelength tuning resolution	30
B.2.1	Set-up	30
B.2.2	Testing equipment	30
B.2.3	Testing procedure for determining wavelength resolution.....	30
B.3	Optical power tuning resolution	31
B.3.1	Set-up	31
B.3.2	Testing equipment	31
B.3.3	Testing procedure for optical power resolution.....	31
B.4	Signal-to-source spontaneous emission ratio	32
B.4.1	General	32
B.4.2	Set-up	32
B.4.3	Testing equipment	32
B.4.4	Testing procedure for determining signal-to-source spontaneous emission ratio	32
B.5	Side-mode suppression ratio.....	33
B.5.1	General	33
B.5.2	Set-up	33
B.5.3	Testing equipment	34
B.5.4	Testing procedure for determining the side-mode suppression ratio.....	34
Annex C (informative)	Linear to dB scale conversion of uncertainties.....	37
C.1	Definition of decibel	37
C.2	Conversion of relative uncertainties	37
Bibliography	39
Figure 1	– Measurement set-up for wavelength calibration.....	12
Figure 2	– Measurement set-up for temperature dependence.....	13
Figure 3	– Measurement set-up for wavelength stability	14
Figure 4	– Measurement set-up for optical power dependence.....	16
Figure 5	– Measurement set-up for intrinsic optical power calibration.....	18
Figure 6	– Measurement set-up for temperature dependence.....	20
Figure 7	– Measurement set-up for optical power stability.....	21
Figure 8	– Measurement set-up for connection repeatability/reproducibility.....	22
Figure 9	– Measurement set-up for wavelength dependence.....	24
Figure B.1	– Measurement set-up for wavelength resolution	30
Figure B.2	– Measurement set-up for optical power resolution setting test	31
Figure B.3	– Measurement set-up for signal to total source spontaneous emission ratio	32
Figure B.4	– Measurement of the signal to spontaneous emission ratio.....	33
Figure B.5	– Measurement set-up for the side-mode suppression ratio test.....	33
Figure B.6	– Optical spectrum of tuneable laser source	35
Figure B.7	– Measurement set-up for SMSR	35
Table 1	– Source of uncertainty for wavelength calibration.....	11
Table 2	– Source of uncertainty for optical power calibration.....	18

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALIBRATION OF TUNEABLE LASER SOURCES

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, access to 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62522 has been prepared by IEC technical committee 86: Fibre optics. It is an International Standard.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

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

- a) addition of references to IEC 61315;
- b) addition of Table 1 and Table 2 on uncertainties;
- c) clarification of the reference power meter settings in 6.2.3 and 6.3.2.3.

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

Draft	Report on voting
86/639/FDIS	86/643/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

Wavelength-division multiplexing (WDM) transmission systems have been deployed in optical trunk lines. ITU-T Recommendations in the G.694 series describe the frequency and wavelength grids for WDM applications. For example, the frequency grid of ITU-T Recommendation G.694.1 supports a variety of channel spacing ranging from 12,5 GHz to 100 GHz and wider. WDM devices, such as arrayed waveguide grating (AWG), thin film filter or grating based multiplexers (MUX), and demultiplexers (DMUX) with narrow channel spacing are incorporated in the WDM transmission systems. When measuring the characteristics of such devices, wavelength tuneable laser sources are commonly used and are required to have well-calibrated performances; wavelength uncertainty, wavelength tuning repeatability, wavelength stability, and output optical power stability are important parameters.

The tuneable laser source (TLS) is generally equipped with the following features:

- a) the output wavelength is continuously tuneable in a wavelength range starting at 1 260 nm or higher and ending at less than 1 675 nm (the output should excite only the fundamental LP01 fibre mode);
- b) an output port for optical fibre connectors.

The envelope of the spectrum is a single longitudinal mode with a full-width at half-maximum (FWHM) of at most 0,1 nm. Any adjacent modes are at least 20 dB lower than the main spectral mode (for example, a distributed feedback laser diode (DFB-LD), external cavity laser, etc.).

CALIBRATION OF TUNEABLE LASER SOURCES

1 Scope

This document provides a stable and reproducible procedure to calibrate the wavelength and power output of a tuneable laser against reference instrumentation such as optical power meters and optical wavelength meters (including optical frequency meters) that have been previously traceably calibrated.

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 (OFCSs)*

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

IEC 62129-2, *Calibration of wavelength/optical frequency measurement instruments – Part 2: Michelson interferometer single wavelength meters*

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

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1.1

accredited calibration laboratory

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