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Umerjanje analizatorjev optičnega spektra (IEC 62129:2006)

Calibration of optical spectrum analyzers (IEC 62129:2006)

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(IEC 62129:2006)

Etalonnage des analyseurs
de spectre optique
(CEI 62129:2006)

Kalibrierung von optischen
Spektrumanalysatoren
(IEC 62129:2006)

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Foreword

The text of document 86/245/FDIS, future edition 1 of IEC 62129, prepared by IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62129 on 2006-02-01.

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– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-02-01

This European Standard makes reference to International Standards. Where the International Standard referred to has been endorsed as a European Standard or a home-grown European Standard exists, this European Standard shall be applied instead. Pertinent information can be found on the CENELEC web site.

Endorsement notice

The text of the International Standard IEC 62129:2006 was approved by CENELEC as a European Standard without any modification.

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Etalonnage des analyseurs de spectre optique

Calibration of optical spectrum analyzers

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CALIBRATION OF OPTICAL SPECTRUM ANALYZERS

FOREWORD

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

IEC 62129 cancels and replaces IEC/PAS 62129, published in 2004, and constitutes a technical revision.

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

FDIS	Report on voting
86/245/FDIS	86/250/RVD

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.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

CALIBRATION OF OPTICAL SPECTRUM ANALYZERS

1 Scope

This International Standard provides procedures for calibrating an optical spectrum analyzer designed to measure the power distribution of an optical spectrum. This analyzer is equipped with an input port for use with a fibre-optic connector.

An optical spectrum analyzer is equipped with the following minimum features:

a) the ability to present a display of an optical spectrum with respect to absolute wavelength;

b) a marker/cursor that displays the optical power and wavelength at a point on the spectrum display.

NOTE This standard applies to optical spectrum analyzers developed for use in fibre-optic communications, and is limited to equipment that can directly measure the optical spectrum output from an optical fibre, where the optical fibre is connected to an input port installed in the optical spectrum analyzer through a fibre-optic connector.

In addition, an optical spectrum analyzer can measure the spectral power distribution with respect to the absolute wavelength of the tested light and display the results of such measurements. It will not include an optical wavelength meter that measures only centre wavelengths, a Fabry-Perot interferometer or a monochromator that has no display unit.

The procedures outlined in this standard are considered to be mainly performed by users of optical spectrum analyzers. The document, therefore, does not include correction using the calibration results in the main body. The correction procedures are described in Annex C. Of course, this standard will be useful in calibration laboratories and for manufacturers 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 60050-731, *International Electrotechnical Vocabulary (IEV) – Chapter 731: Optical fibre communication*

IEC 60359, *Electrical and electronic measurement equipment – Expression of performance*

IEC 60793-1 (all parts), *Optical fibres – Part 1: Measurement methods and test procedures*

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

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems*

IEC 61290-3-1, *Optical amplifiers – Test methods – Part 3-1: Noise figure parameters – Optical spectrum analyzer method*

BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML:1993, *International vocabulary of basic terms in metrology (VIM)*

BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML, *Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050-731 and the following terms and definitions apply.

3.1
calibration
set of operations which establishes, under specified conditions, the relationship between the values indicated by the measuring instrument and the corresponding known values of that quantity (see also VIM, definition 6.11)

3.2
calibration under reference conditions
calibration which includes the evaluation of the test analyzer uncertainty under **reference conditions** (3.17)

3.3
calibration for operating conditions
the calibration for operating conditions of an **optical spectrum analyzer** (3.16) including the evaluation of the test analyzer operational uncertainty

3.4
centre wavelength
λ_{centre}
the power-weighted mean wavelength of a light source in a vacuum, in nanometers (nm)

For a continuous spectrum the centre wavelength is defined as:

$$\lambda_{centre} = (1 / P_{total}) \int \rho(\lambda)\, \lambda \, d\lambda \qquad (1)$$

For a spectrum consisting of discrete lines, the centre wavelength is defined as:

$$\lambda_{centre} = \sum_i P_i \lambda_i \; / \sum_i P_i \qquad (2)$$

where

$\rho(\lambda)$ is the power spectral density of the source, for example in W/nm;

λ_i is the i^{th} discrete wavelength;

P_i is the power at λ_i, for example, in watts;

P_{total} is ΣP_i = total power, for example, in watts.

NOTE The above integrals and summations theoretically extend over the entire spectrum of the light source.

3.5
confidence level
an estimation of the probability that the true value of a measured parameter lies in the given range (see **expanded uncertainty** (3.11))

3.6
coverage factor
k
the coverage factor, k, is used to calculate the **expanded uncertainty** (3.11) U from the **standard uncertainty** (3.21), σ (see 3.11)

3.7
displayed power level
DPL
the power level indicated by an **optical spectrum analyzer** (3.16) undergoing **calibration** (3.1) at a specified wavelength resolution setting

NOTE With an **optical spectrum analyzer**, the power level for a set resolution is measured and displayed.

3.8
displayed power level deviation
Δ*P*
the difference between the displayed power level measured by the test analyzer, P_{OSA}, and the corresponding reference power, P_{ref}, divided by the reference power

$$\Delta P = (P_{OSA} - P_{ref}) \;/\; P_{ref} = P_{OSA} \;/\; P_{ref} - 1 \tag{3}$$

3.9
displayed power level uncertainty
$\boldsymbol{\sigma_{\Delta P}}$
the **standard uncertainty** (3.21) of the displayed power level deviation

$$\sigma_{\Delta P} = \sigma(P_{OSA} \;/\; P_{ref} - 1) \tag{4}$$

NOTE In the above formula, σ is to be understood as the **standard uncertainty** (3.21).

3.10
displayed wavelength range
the complete wavelength range shown in an **optical spectrum analyzer** (3.16) display for a particular **instrument state** (3.12)

3.11
expanded uncertainty
U
confidence interval
the expanded uncertainty, U, is the range of values within which the measurement parameter, at the stated **confidence level** (3.5), can be expected to lie. It is equal to the **coverage factor** (3.6), k, times the combined **standard uncertainty** (3.21) σ:

$$U = k\,\sigma \tag{5}$$

NOTE When the distribution of uncertainties is assumed to be normal and a large number of measurements are made, then **confidence levels** (3.5) of 68,3 %, 95,5 % and 99,7 % correspond to k values of 1, 2 and 3 respectively.

The measurement uncertainty of an **optical spectrum analyzer** (3.16) should be specified in the form of expanded uncertainty, U.

3.12
instrument state
a complete description of the measurement conditions and state of an **optical spectrum analyzer** (3.16) during the calibration process

NOTE Typical parameters of the instrument state are the **displayed wavelength range** (3.10) in use, the **resolution bandwidth (spectral resolution)** (3.18), the display mode (watt or dBm), warm-up time and other instrument settings.

3.13
measurement result
the displayed or electrical output of any **optical spectrum analyzer** (3.16) in wavelength, in units of nm or µm, and in power level, in units of mW or dBm, after completing all operations suggested by the operating instructions, for example warm-up

3.14
measurement wavelength range
the wavelength range of injected light over which an **optical spectrum analyzer** (3.16) performance is specified

3.15
operating conditions
all conditions of the measured and influential qualities, and other important requirements which the **expanded uncertainty** (3.11) of an **optical spectrum analyzer** (3.16) is intended to be met

[VIM, definition 5.5 modified]

3.16
optical spectrum analyzer
OSA
an optical instrument for measuring the power distribution of a spectrum with respect to wavelength (frequency)

NOTE An OSA is equipped with an input port for use with a fibre-optic connector, and the spectrum is obtained from light injected into the input port; the instrument also includes a screen-display function.

3.17
reference conditions
an appropriate set of influencing parameters, their nominal values and their tolerance bands, with respect to which the uncertainty at reference conditions is specified

[IEC 60359, definition 3.3.10 modified]

NOTE Each tolerance band includes both the possible uncertainty of the condition and the uncertainty in measuring the condition.

The reference conditions normally include the following parameters and, if necessary, their tolerance bands: reference date, reference temperature, reference humidity, reference atmospheric pressure, reference light source, reference **displayed power level** (3.7), reference fibre, reference connector-adapter combination, reference wavelength, reference (spectral) bandwidth and **resolution bandwidth (spectral resolution)** (3.18) set.

3.18
resolution bandwidth
R
spectral resolution
full width at half maximum (FWHM) of the displayed spectrum obtained by the test analyzer when using a source whose **spectral bandwidth** (3.20) is sufficiently narrow, that is, very much less than the resolution bandwidth being measured

3.19
side-mode suppression ratio
SMSR
the peak power ratio between the main mode spectrum and the largest side mode spectrum in a single-mode laser diode such as a DFB-LD

NOTE The side-mode suppression ratio is usually described in dB.

3.20
spectral bandwidth
B
for the purpose of this standard, the FWHM of the spectral width of the source

If the source exhibits a continuous spectrum, then the spectral bandwidth, *B*, is the FWHM of the spectrum.

If the source is a laser diode with a multiple-longitudinal mode spectrum, then the FWHM spectral bandwidth B is the RMS spectral bandwidth, multiplied by 2,35 (assuming the source has a Gaussian envelope):

$$B = 2{,}35\ [\{(1\ /\ P_{total}) \times \left[\sum_i P_i \lambda_i^{\ 2}\right]\} - \lambda_{centre}^{\ 2}]^{1/2} \qquad (6)$$

where

λ_{centre} is the **centre wavelength** (3.4) of laser diode, in nm;

P_{total} is $\sum P_i$ = total power, in watts;

P_i is the power of i^{th} longitudinal mode, in watts;

λ_i is the wavelength of i^{th} longitudinal mode, in nm.

3.21
standard uncertainty
σ
uncertainty of a measurement result expressed as a standard deviation

NOTE For further information, see Annex A and the ISO/IEC Guide to the Expression of Uncertainty in Measurement (ISO/IEC GUIDE EXPRES).

3.22
uncertainty type A
type of uncertainty obtained by a statistical analysis of a series of observations, such as when evaluating certain random effects of measurement (see ISO/IEC GUIDE EXPRES)

3.23
uncertainty type B
type of uncertainty obtained by means other than a statistical analysis of observations, for example an estimation of probable sources of uncertainty, such as when evaluating systematic effects of measurement (see ISO/IEC GUIDE EXPRES)

NOTE Other means may include previous measurement data, experience with or general knowledge of the behaviour and properties of relevant materials, instruments, manufacturers' specifications, data provided in calibration and other certificates, and uncertainties assigned to reference data taken from handbooks.

3.24
wavelength deviation
Δ*λ*
the difference between the **centre wavelength** (3.4) measured by the test analyzer, λ_{OSA}, and the reference wavelength, λ_{ref}, in nm or µm

$$\Delta\lambda = \lambda_{OSA} - \lambda_{ref} \qquad (7)$$

3.25
wavelength uncertainty
$\boldsymbol{\sigma_{\Delta\lambda}}$
the **standard uncertainty** (3.21) of the **wavelength deviation** (3.24), in nm or µm

4 Calibration test requirements

4.1 Preparation

The following recommendations apply.

Calibrations should be carried out in facilities that are separate from other functions of the organization. This separation should include laboratory accommodation and measurement equipment.

The calibration laboratory should operate a quality control system appropriate to the range of measurement it performs (for example ISO 9000), when the calibration is performed in calibration laboratories. There should be independent scrutiny of the measurement results, intermediary calculations and preparation of calibration certificates.

The environmental conditions shall be commensurate with the degree of uncertainty that is required for calibration:

a) the environment shall be clean;

b) temperature monitoring and control is required;

c) all laser sources shall be safely operated (refer to IEC 60825-1).

Perform all tests at an ambient room temperature of (23 ± 3) °C with a relative humidity of (50 ± 20) % unless otherwise specified. Give the test equipment a minimum of 2 h prior to testing to reach equilibrium with its environment. Allow the optical spectrum analyzer a warm-up period in accordance with the manufacturer's instructions.

4.2 Reference test conditions

The reference test conditions usually include the following parameters and, if necessary, their tolerance bands: date, temperature, relative humidity, displayed power level, wavelength, light source, fibre, connector-adapter combination, (spectral) bandwidth and resolution bandwidth (spectral resolution) set. Unless otherwise specified, use a single-mode optical fibre input pigtail as prescribed by the IEC 60793-1 series, having a length of at least 2 m.

Operate the optical spectrum analyzer in accordance with the manufacturer's specifications and operating procedures. Where practical, select a range of test conditions and parameters which emulate the actual field operating conditions of the analyzer under test. Choose these parameters so as to optimize the analyzer's accuracy and resolution capabilities, as specified by the manufacturer's operating procedures.

Document the conditions as specified in Clause 8.

The calibration results only apply to the set of test conditions used in the calibration process. Because of the potential for hazardous radiation, be sure to establish and maintain conditions of laser safety. Refer to IEC 60825-1 and IEC 60825-2.

4.3 Traceability

Make sure that any test equipment which has a significant influence on the calibration results is calibrated in an unbroken chain to the appropriate national standard or natural physical constant. Upon request, specify this test equipment and its calibration chain(s). The re-calibration period(s) shall be defined and documented.