IEC 61300-3-29

Edition 2.0 2014-03

INTERNATIONAL STANDARD

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Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-29: Examinations and measurements – Spectral transfer characteristics of DWDM devices

Dispositifs d'interconnexion et composants passifs à fibres optiques – Procédures fondamentales d'essais et de mesures – Partie 3-29: Examens et mesures – Caractéristiques de transfert spectral des dispositifs DWDM

IEC 61300-3-29:2014-03(en-fr)

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International Standard IEC 61300-3-29 has been prepared by sub-committee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2005. It constitutes a technical revision.

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

– terms and definitions have been added and reconsidered in order to be harmonized with IEC 62074-1;

– characterizations of the device under test have been reviewed;

– details to be specified have been reconsidered.

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

FDIS	Report on voting
86B/3718/FDIS	86B/3758/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 list of all parts of IEC 61300 series, published under the general title, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures,* 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

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – BASIC TEST AND MEASUREMENT PROCEDURES –

Part 3-29: Examinations and measurements – Spectral transfer characteristics of DWDM devices

1 Scope

This part of IEC 61300 identifies two basic measurement methods for characterizing the spectral transfer functions of DWDM devices.

The transfer functions are the functions of transmittance dependent of wavelengths. In this standard, optical attenuations are also used.

NOTE In this standard, transfer functions are expressed by $T(\lambda)$ and optical attenuations are expressed by $A(\lambda)$.

The transfer functions can be used to produce measurements of insertion loss (IL), polarization dependent loss (PDL), isolation, centre wavelength, bandwidth (BW) and other optical performances.

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*

IEC 61300-3-2, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-2: Examinations and measurements – Polarization dependent loss in a single-mode fibre optic device*

IEC 61300-3-7, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-7: Examinations and measurements – Wavelength dependence of attenuation and return loss of single mode components*

IEC 62074-1, *Fibre optic interconnecting devices and passive components – Fibre optic WDM devices – Part 1: generic specification*

3 Terms, definitions, abbreviations and symbols

3.1 Terms and definitions

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

3.1.1
bandwidth
(linewidth)
BW
spectral width of a signal or filter

Note 1 to entry: In the case of a laser signal such as a tuneable narrowband light source, the term 'linewidth' is commonly preferred. Often defined by the width at a set power distance from the peak power level of the device (i.e. 3 dB BW or 1 dB BW). The bandwidth shall be defined as the distance between the closest crossings on either side of the centre wavelength in those cases where the spectral shape has more than 2 such points. The distance between the outermost crossings can be considered the full spectral width.

3.1.2
channel frequency range
(passband)
CFR
specified range of wavelengths (frequencies) from λ_{hmin} (f_{hmin}) to λ_{hmax} (f_{hmax}), centred about the nominal operating wavelength frequency), within which a WDM device operates to transmit less than or equal to the specified optical attenuation

Note 1 to entry: Passband is commonly used to convey the same meaning.

3.1.3
dense WDM
DWDM
WDM device intended to operate for channel spacing equal to or less than 1 000 GHz

3.1.4
polarization dependent loss
PDL
maximum variation of insertion loss due to a variation of the state of polarization (SOP) over all SOP

3.1.5
state of polarization
SOP
distribution of light energy among the two linearly independent solutions of the wave equations for the electric field

3.1.6
source spontaneous emission
SSE
broadband emissions from a laser cavity that bear no phase relation to the cavity field

Note 1 to entry: These emissions can be seen as the baseline noise on an optical spectrum analyser (OSA)

3.1.7
wavelengths division multiplexer
WDM
term frequently used as a synonym for a wavelength-selective branching device

3.2 Symbols and abbreviations

3.2.1 Symbols

δ wavelength sampling increment during the measurement

λ_h centre channel or nominal operating wavelength for a component

3.2.2 Abbreviations

APC angled physical contact

ASE amplified spontaneous emission

BBD	broadband detector
BBS	broadband light source
BW	bandwidth
CFR	channel frequency range
DOP	degree of polarization
DUT	device under test
DWDM	dense wavelengths division multiplexer
FBG	fibre Bragg grating
IL	insertion loss
OPM	optical power meter
OSA	optical spectrum analyser
PC	polarization controller
PC	physical contact
PDCW	polarization dependent centre wavelength
PDL	polarization dependent loss
PSCS	polarization state change system
PL	polarizer
RBD	reference branching devices
S	light source
SD	standard deviation
SOP	state of polarization
SSE	source spontaneous emission
TF	tracking filter
TJ	temporary joint
TLS	tuneable laser source.
TND	tuneable narrowband detector
TNLS	tuneable narrowband light source
WDL	wavelength dependent loss
WDM	wavelength division multiplexer
WM	wavelength meter

4 General description

This standard is complementary to the wavelength dependence of attenuation, and return loss (IEC 61300-3-7), and polarization dependence of attenuation (IEC 61300-3-2) for DWDM devices which channel spacing is less than or equal to 1 000 GHz (8 nm at the wavelength band of 1 550 nm).

The transfer functions can be used to produce measurements of following performance parameters:

– insertion loss (IL);
– centre wavelength and centre wavelength deviation;
– *X* dB bandwidth;
– passband ripple;
– isolation;

- crosstalk;
- polarization dependent loss (PDL) and polarization dependent centre wavelength (PDCW) ;
- channel non-uniformity;
- out-of-band attenuation.

In general, the DWDM devices have channel bandwidths less than 1 nm, filter response slopes greater than 100 dB/nm, and out-of-band rejection extending over tens of nm.

The methods described in this standard will show how to obtain the transfer function from a single input to a single output port (single conducting path). For an *M* x *N* device, it will be required to repeat this procedure using all possible combinations of input and output ports.

The methods described in this standard are intended to be applicable to any wavelength band (C, L, S, O, etc.) although examples may be shown in the C-band for illustrative purposes.

The two methods contained in this standard differ mainly in the way in which the wavelength resolution is obtained. Method A uses a tuneable narrowband light source, while Method B used a broadband light source. Method A has two branching methods; Method A.1 and Method A.2. These three measurement methods are summarized in Table 1. Method A.2 shall be considered the reference test method for DWDM devices.

Table 1 – Test methods

Method	Names	Source	Detector	Examples	Remarks
A.1	TNLS in sweep mode + BBD	TNLS in sweep mode	BBD	TNLS + DUT + OPM	Alternative
A.2	TNLS in sweep mode + TND	TNLS in sweep mode	TND	TNLS + DUT + OSA	Reference
B	BBS + TND	BBS	TND	BBS + DUT + OSA	Alternative

This standard also includes annexes that illustrate the following:

Annex A: Reflection spectrum measurements;

Annex B: Determination of wavelength increment parameter;

Annex C: Determination of a mean value using the shorth function.

5 Apparatus

5.1 Measurement set-up

The basic measurement set-up for the characterization of DWDM devices is shown in Figure 1 below.

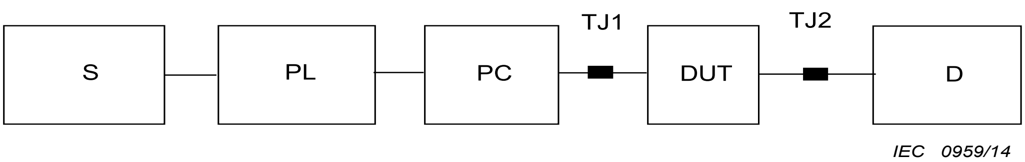

Figure 1 – Basic measurement set-up

This procedure contains three methods that differ fundamentally in the way in which the wavelength resolution is achieved. There are three key influences on the wavelength resolution: the linewidth of the source or bandwidth of the tuneable narrowband detector, the analogue bandwidth of the detection system and the rate of change of wavelength.

Having determined the wavelength resolution of the measurement, the wavelength sampling increment (δ) should be less than half the bandwidth of the system in order to accurately measure the average value of the optical attenuation.

The bandwidth of the system is determined by the convolution of the effective source bandwidth with the rate of change of wavelength over the time constant of the detector. Practical constraints may result in smaller or larger bandwidths than recommended. Two cautions should be noted with smaller bandwidths: first, coherent interference effects can lead to additional measurement errors, and second, under-sampling of the device could lead to misrepresentations of the reconstructed transfer function. If larger bandwidths are used, the reconstructed transfer function could smear out fine structures and distort response slopes. As the response slopes may exceed 100 dB/nm, small uncertainties in wavelength may result in large amplitude response errors. In general, the resolution bandwidth of the system needs to be chosen based on the device characteristics and noted in the details to be specified.

As explained in Table 1, there are three measurement methods. Figures 2, 3, and 4 show the typical set-ups for Methods A.1, A.2 and B.

Figure 2 – Measurement set-up for tuneable narrowband light source (TNLS) system

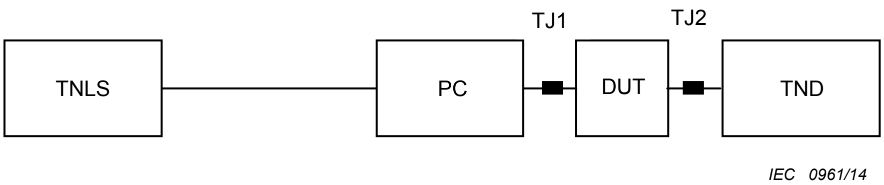

Figure 3 – Measurement set-up for TNLS and tuneable narrowband detector (TND) system

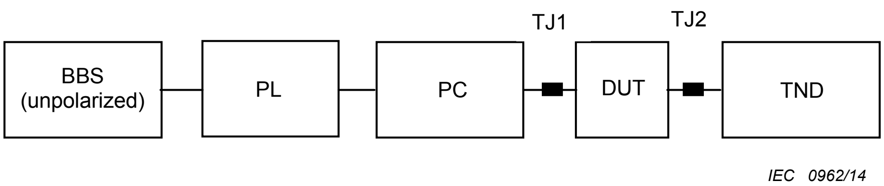

Figure 4 – Measurement set-up for BBS and tuneable narrowband detector (TND) system

5.2 Light source, S

5.2.1 Tuneable narrowband light source (TNLS) – Method A

This method uses a polarized tuneable narrowband light source (TNLS) that can select a specific output wavelength and can be tuned across a specified wavelength range. The "source" could also include a tracking filter, reference branching device (RBD), and wavelength monitor as shown in Figure 2. These additions are optional as they relate to the measurement requirements and the TLS specifications.

The power stability at any of the operating wavelengths shall be less than ±0,01 dB over the measuring period. This stability can be obtained using the optional detector BBD2 in Figure 2 as a reference detector. If BBD2 is synchronized with BBD1, then the variations in power can be cancelled. It should be noted that the dynamic response of the two power meters should have the same electrical bandwidth. The output power of the TLS shall be sufficient to provide the apparatus with an order of magnitude range more dynamic than the device exhibits (i.e. the measurement apparatus should be able to measure a 50 dB notch if the device is a 40 dB notch filter).

The wavelength uncertainty of the TLS shall be approximately an order of magnitude smaller than the step size for each point in the measuring range. This uncertainty may be obtained by having the wavelength monitor feedback to the TLS. The tuning range of the TLS shall cover the entire spectral region of the DWDM device and the source shall also be free of mode hopping over that tuning range.

The side mode suppression ratio and the SSE of the TLS should be sufficient to provide a signal to noise ratio one order of magnitude greater than is required for the measurement, or the use of a tracking filter shall be required for notch filter measurements. The SSE can be measured on an optical spectrum analyser using a 0,1 nm resolution bandwidth. The measured points should be taken at half the distance between possible DWDM channels (i.e. at 50 GHz from the centre frequency for a 100 GHz DWDM device). As an example, if the system needs to measure 50 dB of attenuation, the SSE should be –60 dB.

5.2.2 Broadband source (BBS) – Method B

This method uses an unpolarized broadband light source such as an LED or an amplified spontaneous emission (ASE) source. The source spectrum shall provide sufficient optical power over the full wavelength range of the DUT. This factor is especially important in the measurement of notch filters where the dynamic resolution of the system needs to be high (typically >50 dB) for accurate measurements.

The optical power of the light source shall either be stable over the duration of the test or normalized in a wavelength-specific fashion by means of a reference path (possibly consisting of a RBD and a synchronized TND).

5.3 Tracking filter (TF)

The tracking filter is required if the dynamic range of the TLS and the detector does not allow for measuring a depth of at least 10 dB greater than required due to the shape of the DUT and the broadband SSE of the TLS. The filter shall track the TLS so as to provide the maximum SSE suppression and the maximum transmitted power as the TLS is scanned across the measurement region. It should be noted that the spectral shape of the filter will affect the effective linewidth of the system.

5.4 Reference branching device (RBD)

The configuration of the RBD is 1 × 2 or 2 × 2. If its configuration is 2 × 2, one port of the RBD shall be terminated to have a back reflection of less than –50 dB. The splitting ratio of the RBD shall be stable with wavelength. It shall also be insensitive to polarization. The polarization sensitivity of transmission attenuation shall be less than one-tenth of the wavelength dependency of attenuation to be measured. The polarization mode dispersion of the RBD shall be less than one half of the coherence time of the source so as not to depolarize the input signal. The split ratio shall be sufficient to provide the dynamic range for the measurement of the transfer function and the power necessary for the wavelength meter to operate correctly.

5.5 Wavelength meter (WM)

In this test procedure, the wavelength uncertainty of the source needs to be extremely small and closely monitored. If the tuning uncertainty of the TLS is not sufficient for the measurement, the wavelength monitor shall be required. For this measurement method it is necessary to measure the spectral peak of any input signal within the device bandwidth to an uncertainty approximately one order of magnitude greater than the step size. Therefore, acceptable wavelength monitors include an optical wavelength meter or a gas absorption cell (such as an acetylene cell). If a gas absorption cell is used, the wavelength uncertainty of the TLS shall be sufficient to resolve the absorption lines.

Regarding the wavelength repeatability of the TLS and the monitor, it should be understood that if the test apparatus has 0,1 dB of ripple with a 30 pm period, then a random 3 pm wavelength variation from reference scan to device scan can result in as much as 0,03 dB of attenuation error.

5.6 Polarizer (PL)

For the BBS method (Method B), the polarizer shall be put after the BBS. A polarization extinction ratio of polarizer shall be more than or equal to 20 dB.

5.7 Polarization controller (PC)

The polarization controller is used to control the input state of polarization (SOP). The details of polarization controller are defined as PSCS in IEC 61300-3-2. That standard defines two types of PSCS, for all polarization methods and the Mueller matrix method. In the event of a polarization dependent measurement, the controller will be used to generate four known polarization states for testing purposes. The states shall be distinct and well known in order to achieve accurate PDL measurements. The return loss on the input to the controller shall be greater than 50 dB, so as not to return any polarized light back to the TLS cavity for Method A. This may also be achieved using an isolator to protect the TLS.

5.8 Device under test (DUT)

5.8.1 General

The device under test shall be DWDM devices. For the purposes of this standard, the test ports shall be a single “input-output” path. The method described herein can be extrapolated upon to obtain a single measurement system capable of handling even an *M* x *N* DWDM device. It is noted that these measurements are very sensitive to reflections, and that precautions shall be taken to ensure that reflection cavities are not introduced in the test set-up.

In many cases, the characteristics of DWDM devices are temperature dependent. This measurement procedure assumes that any such device is held at a constant temperature throughout the procedure. The absolute uncertainty of the measurement may be limited by the uncertainty of any heating or cooling device used to maintain a constant temperature. For example, if a device is known to have a temperature dependence of 0,01 nm/°C, and the temperature during the procedure is held to a set temperature ± 1 °C; then any spectral results obtained are known to have an uncertainty of 0,02 nm due to temperature.