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2002-08

PRE-STANDARD

Fibre optic interconnecting devices and passive components – Basic test and measurement procedures –

Part 3-29: Examinations and measurements – Measurement techniques for characterizing the amplitude of the spectral transfer function of DWDM components

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3-29: Examinations and measurements – Measurement techniques for characterizing the amplitude of the spectral transfer function of DWDM components

FOREWORD

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public.

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

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:
Draft PAS	**Report on voting**
86B/1699/PAS	86B/1748/RVD

Following publication of this PAS, the technical committee or subcommittee concerned will investigate the possibility of transforming the PAS into an International Standard.

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5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

IEC 61300 consists of the following parts, under the general title: *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures:*

– Part 1: General and guidance

– Part 2: Tests

– Part 3: Examinations and measurements.

This PAS shall remain valid for no longer than 3 years starting from 2002-08. The validity may be extended for a single 3-year period, following which it shall be revised to become another type of normative document, or shall be withdrawn.

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

Part 3-29: Examinations and measurements – Measurement techniques for characterizing the amplitude of the spectral transfer function of DWDM components

1 Scope

The purpose of this document is to identify two basic measurement methods for characterising the spectral transfer functions of DWDM filter components as defined in IEC 62074-1. The transfer functions can be used to produce measurements of attenuation (A), polarisation dependent loss (PDL), isolation, centre wavelength, and bandwidth (BW).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61300. All normative documents are subject to revision and parties to agreements based on this part of IEC 61300 are recommended to apply the most recent edition. A catalogue of current IEC and ISO standards can be found on http://www.iec.ch/ and http://www.iso.ch/ respectively.

IEC 62074-1: *Fibre Optic WDM devices – Part 1 Generic specification*

IEC 61300-3-2: *Fibre optic interconnecting devices and passive components – Polarisation dependence of attenuation for single mode fibre optic devices*

IEC 61300-3-5: *Fibre optic interconnecting devices and passive components – Wavelength dependence of attenuation*

IEC 61300-3-7: *Fibre optic interconnecting devices and passive components – Wavelength dependence of attenuation and return loss*

IEC 61300-3-12: *Fibre optic interconnecting devices and passive components – Polarisation of a single-mode fibre optic component: Matrix calculation method*

3 General description

This document is complementary to the wavelength dependence of attenuation (IEC 61300-3-5), the wavelength dependence of attenuation and return loss (IEC 61300-3-7), polarisation dependence of attenuation (IEC 61300-3-2), and the polarisation dependence of attenuation using matrix methods (IEC 61300-3-12) test procedures. It is meant to cover any DWDM devices described by IEC 62074-1. In general, these 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 procedure will show how to obtain the transfer function from a single input to a single output port (single conducting path). For an m × n device, it will be required to repeat this procedure using all possible combinations of input and output ports.

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The methods described in this procedure 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 procedure differ mainly in the way in which the wavelength resolution is obtained. Method A uses a tuneable laser source and a broad band detector, while Method B uses a broad band source and a tuneable receiver. Method A shall be considered the reference test method for DWDM devices. This procedure also includes appendixes that illustrate the following:

A. Reflection spectrum measurements

B. Determination of wavelength increment parameter

C. Determination of a mean value using the shorth function

D. Precautions in using IEC 61300-3-7 for DWDM devices

3.1 Terms and abbreviations

Many of the terms and abbreviations in this document are described in the IEC generic standard 60050-731 and the IEC WDM component standard 62074-1. Some terms and abbreviations specific to this measurement technique are included below.

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ASE Amplified spontaneous emissions

BW Bandwidth: The spectral width of a signal or filter. In case of a laser signal such as a tuneable laser 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). Must be defined as the distance between the closest crossings on either side of the centre wavelength in the cases where the spectral shape has more than 2 such points. The distance between the outermost crossings can be considered the full spectral width.

δ Wavelength sampling increment during the measurement.

λ_h Centre channel or nominal operating wavelength for a component

OWR Operating wavelength range. The specified range of wavelengths from λ_{hmin} to λ_{hmax} centred about the nominal operating wavelength, within which a WDM device operates.

SSE Source spontaneous emission: Broad band emissions from a laser cavity that bear no phase relation to the cavity field. These emissions can be seen as the baseline noise on an optical spectrum analyzer.

TLS Tuneable laser source.

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4 Apparatus

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

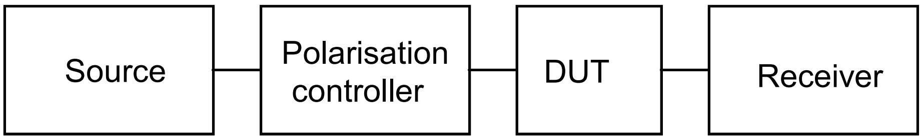

Figure 1 – Basic measurement apparatus

As mentioned in the general discussion, this procedure contains two distinct 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 receiver, 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 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 receiver. Practical constraints may result in smaller or larger bandwidths than recommended. Two cautions with smaller bandwidths; first, coherent interference effects can lead to additional measurement errors, and second undersampling 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.

A detailed explanation of the various components of this system and their functions is contained below. Apparatuses for both the Tuneable Laser and the Tuneable Receiver procedures are shown in Figures 2 and 3.

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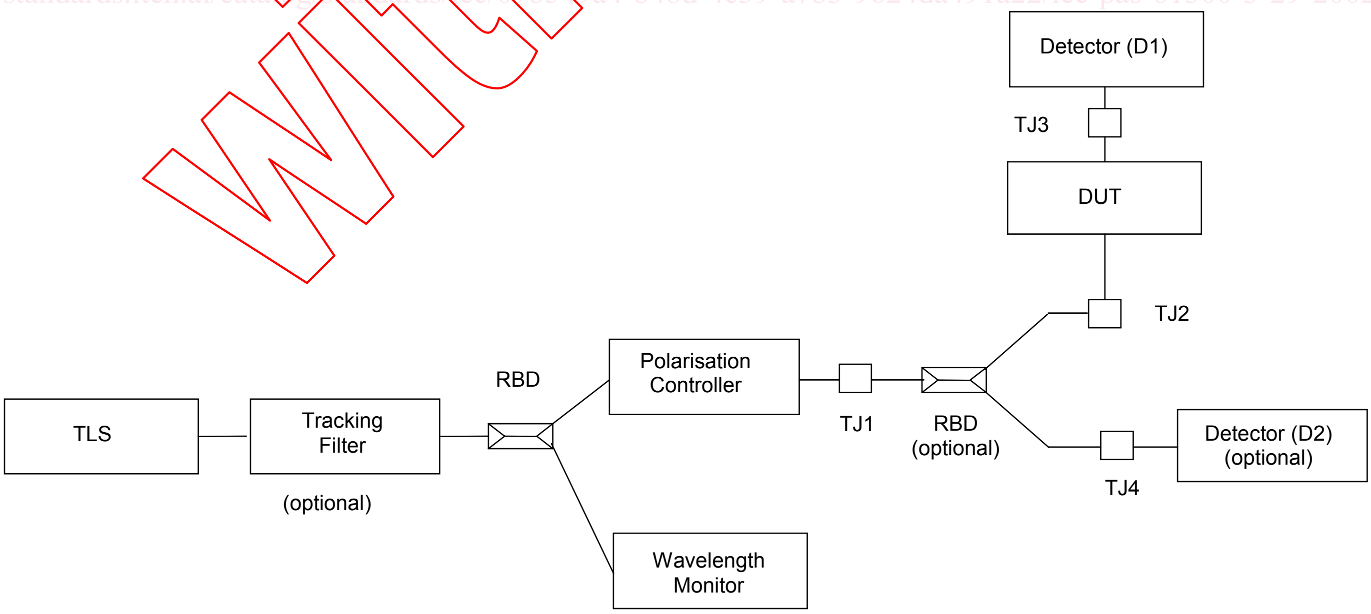

Figure 2 – Measurement apparatus for tuneable laser system

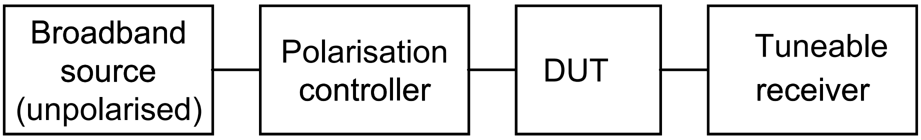

Figure 3 – Measurement apparatus for tuneable receiver system

4.1 Source

4.1.1 Tuneable laser, Method A

This method uses a polarised tuneable laser source (TLS) 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 better than +/– 0,01dB over the measuring period. This stability can be obtained using the optional detector D2 in Figure 2 as a reference detector. If D2 is synchronised with D1, 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 more dynamic range 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).

The wavelength accuracy of the TLS shall be approximately an order of magnitude better than the step size for each point in the measuring range. This accuracy 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 tuneable laser source should be sufficient to provide an order of magnitude greater signal to noise ratio 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 50GHz from 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 –60dBc.

4.1.1.1 Tracking filter

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 must 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.

4.1.1.2 Reference branching device (RBD)

The configuration of the RBD is 1x2 or 2x2. If its configuration is 2x2, one port of the RBD shall be terminated to have a back reflection <-50dB. The splitting ratio of the RBD shall be stable with wavelength. It shall also be insensitive to polarisation. The polarisation sensitivity of transmission attenuation shall be less than one tenth of the wavelength dependency of attenuation to be measured. The Polarisation Mode Dispersion of the RBD shall be less

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than ½ of the coherence time of the source so as not to depolarise 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.

4.1.1.3 Wavelength monitor

In this test procedure, the wavelength accuracy of the source needs to be extremely accurate and closely monitored. If the tuning accuracy 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 accuracy 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 accuracy of the TLS must be sufficient to resolve the absorption lines.

Regarding the wavelength repeatability of the TLS + 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.

4.1.2 Broad band source (BBS), Method B

This method uses an unpolarised broadband light source such as an LED or an amplified spontaneous emission (ASE) source. The source spectrum must 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.

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The optical power of the light source must 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 synchronised tuneable receiver).

The degree of polarization (DOP) of the source should be less than 10 percent to avoid biasing those measurements that require unpolarised light. Care should be taken to ensure that the narrow width of the tuneable filter does not increase the effective DOP beyond this limit.

In some instances, the tuneable filter used for this method could be placed after the BBS creating an unpolarised TLS. In this instance, the filter characteristics should be as described in the tuneable receiver section (2.4.2).

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4.2 Polarisation controller

The polarisation controller is used to control the input state of polarisation (SOP). In the event of a polarisation dependent measurement, the controller will be used to generate four known polarisation states for testing purposes. The states must be distinct and well known in order to achieve accurate PDL measurements. The return loss on the input to the controller shall be >50dB, so as not to return any polarised light back to the TLS cavity for Method A.

For the BBS method (B), the controller is optional if polarisation dependent measurements are not required. If it is used in this set-up, it must provide an extinction ratio of at least 20 dB.

4.3 Device under test (DUT)

The device under test shall be a DWDM component as defined in IEC 62074-1. For the purposes of this document, 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 × n DWDM device. It is noted that these measurements are very sensitive to reflections, and that precautions must be taken to ensure that reflection cavities are not introduced in the test set-up.

In many cases, the characteristics of DWDM components are temperature dependent. This measurement procedure assumes that any such device is held at a constant temperature throughout the procedure. The absolute accuracy of the measurement may be limited by the accuracy 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.

4.3.1 Device input optics

Use an optical lens system or fibre pigtail to excite the test device. If a lens system is used, couple the power into the test device so it is insensitive to the position of the input end face. This can be done with a launch beam that spatially and angularly overfills the test port. In the case of fibre pigtailed devices, use a device that extracts cladding modes. The fibre coating will typically perform this function.

If fibre connectors or fibre butt coupling are employed, use physical contact connectors or index matching fluid to avoid interference effects.

4.3.2 Device output optics

Use an optical lens system or fibre pigtail to couple light from the test device to the receiver. If fibre connectors or fibre butt coupling are employed, use physical contact connectors or index matching fluid to avoid interference effects.

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4.4 Receiver system

4.4.1 Broad band detectors (D1,D2), Method A

The detectors used for this method consist of a broad band optical detector, the associated electronics, and a means of connecting to an optical fibre. The optical connection may be a receptacle for an optical connector, a fibre pigtail, or a bare fibre adapter. The back reflection from detectors D1 and D2 should be minimised with any precautions available. The preferred options would be to use either an APC connector, or a PC connector in conjunction with an optical isolator. It should be noted that the use of an APC connector will contribute approximately 0.03 dB of PDL to the measurement.

The dynamic range and sensitivity of the detectors should be sufficient to measure the noise floor required by the test system and the DUT. In general, it is required to have a dynamic range approximately 10 dB wider than the measurable isolation of the device, with a sensitivity at least 5 dB below the expected stop band attenuation at the test system power level. For instance if the maximum device isolation is 40 dB, the maximum device loss is 5 dB, and the test system optical power is –5 dBm, then the detectors would need to have a sensitivity of at least –55 dBm, and a dynamic range of at least 50 dB (i.e. should not saturate at –5 dBm).

The detectors should have a resolution of 0,001 dB and linearity better than 0,02 dB over the pass band wavelength range. The stability of the power detectors should exceed 0.01 dB over the measurement period in the pass band as well. For polarisation dependent measurements, the polarisation dependence of the detector should be < 0,01 dB.

Where during the sequence of measurements a detector shall be disconnected and reconnected the coupling efficiency for the two measurements shall be maintained. Use of a large area detector to capture all of the light emanating from the fibre is recommended, but care should be taken to ensure that the stability of the detector parameters are not affected by variations in detection uniformity over the active area of the detector. It is also recommended that the face of the detector be placed at an angle other than orthogonal to the incoming light source to reduce back reflections while ensuring that polarisation effects are minimised.