

Fibre optic WDM devices —

Part 1: Generic specification

ICS 33.180.01; 33.180.20

National foreword

This Draft for Development is the UK implementation of IEC/PAS 62074-1:2007.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

A PAS is a Technical Specification not fulfilling the requirements for a standard, but made available to the public and established in an organization operating under a given procedure.

A review of this Draft for Development will be carried out not later than 3 years after its publication.

Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *Update Standards*. According to the replies received, the responsible BSI Committee will judge whether the validity of the PAS should be extended for a further 3 years or what other action should be taken and pass their comments on to the relevant international committee.

Observations which it is felt should receive attention before the official call for comments will be welcomed. These should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

The UK participation in its preparation was entrusted to Technical Committee GEL/86, Fibre optics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 30 November 2007

© BSI 2007

ISBN 978 0 580 60436 2

Amendments issued since publication

Amd. No.	Date	Comments



PUBLICLY AVAILABLE SPECIFICATION PRE-STANDARD

**Fibre optic WDM devices –
Part 1: Generic specification**

CONTENTS

1	Scope	4
2	Normative references	4
3	Terms and definitions	5
3.1	Basic term definitions	5
3.2	Component definitions	8
3.3	Performance parameter definitions	9
4	Requirements	22
4.1	Classification	22
4.1.1	Type	22
4.1.2	Style	22
4.1.3	Variant	23
4.1.4	Assessment level	23
4.2	Documentation	24
4.2.1	Symbols	24
4.2.2	Specification system	24
4.2.3	Drawings	25
4.2.4	Measurements	26
4.2.5	Test data sheets	26
4.2.6	Instructions for use	26
4.3	Standardization system	26
4.3.1	Performance standards	26
4.3.2	Reliability standard	27
4.3.3	Interlinking	27
4.4	Design and construction	28
4.4.1	Materials	28
4.4.2	Workmanship	28
4.5	Quality	29
4.6	Performance requirements	29
4.7	Identification and marking	29
4.7.1	Variant identification number	29
4.7.2	Component marking	29
4.7.3	Package marking	29
4.8	Safety	30
	Annex A (informative) Examples of fibre optic WDM device types	31
	Bibliography	35
	Figure 1 – Example of a six-port device, with two-input and four-output ports	5
	Figure 2 – Illustration of transfer matrix coefficient	7
	Figure 3 – Example of a six-port device, with two-input and four-output ports	8
	Figure 4 – Illustration of adjacent channel isolation	10
	Figure 5 – Illustration of a four-wavelength bidirectional system	11
	Figure 6 – Illustration of channel insertion loss variation	12

Figure 7 – Illustration of free spectral range.....	13
Figure 8 – Illustration of insertion loss	14
Figure 9 – Illustration of minimum and maximum insertion loss	14
Figure 10 – Illustration of isolation wavelength.....	15
Figure 11 – Illustration of isolation wavelength range	15
Figure 12 – Illustration of maximum adjacent channel isolation	16
Figure 13 – Illustration of non-adjacent channel isolation	17
Figure 14 – Illustration of operating wavelength	17
Figure 15 – Illustration of operating wavelength range	18
Figure 16 – Illustration of polarization dependent centre wavelength (PDCW)	18
Figure 17a – At the band edges.....	20
Figure 17b – In-band	20
Figure 17 – Illustration of ripple	20
Figure 18 – Illustration of X-dB bandwidth.....	21
Figure 19 – Wavelength-selective branching device.....	22
Figure 20 – Wavelength-selective branching device.....	23
Figure 21 – Wavelength-selective branching device.....	23
Figure 22 – Wavelength-selective branching device.....	23
Figure A.1 – Example of a wavelength multiplexer	31
Figure A.2 – Example of a wavelength demultiplexer	32
Figure A.3 – Example of a wavelength multiplexer/demultiplexer.....	32
Figure A.4 – Example of a wavelength router.....	33
Figure A.5 – Example of wavelength channel add/drop	34
Table 1 – Three-level IEC specification structure	25
Table 2 – Standards interlink matrix	28
Table 3 – Quality assurance options	28

FIBRE OPTIC WDM DEVICES –

Part 1: Generic specification

1 Scope

This PAS applies to fibre optic wavelength division multiplexing (WDM) devices. These have all of the following general features:

- They are passive, in that they contain no optoelectronic or other transducing elements; but they may use temperature control but only with the purpose of stabilizing device characteristics; they exclude any optical switching function.
- They have three or more ports for the entry and/or exit of optical power, and share optical power among these ports in a predetermined fashion depending on the wavelength.
- The ports are optical fibres or optical fibre connectors.

This document establishes uniform requirements for the following:

- Optical, mechanical and environmental properties.
- Measurement and test procedures for quality assessment.

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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050(731): *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

IEC 60617, *International Standard Database Snapshot – Graphical symbols for diagrams*

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

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

IEC 61300-1 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

IECQ 01, *IEC Quality Assessment System for Electronic Components (IECQ) – Basic Rules*

IECQ 001002 (all parts), *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure*

IEC Guide 102, *Electronic components – Specification structures for quality assessment (Qualification approval and capability approval)*

ISO 129, *Technical drawings – Indication of dimensions and tolerances – General principles*

ISO 286 (all parts), *ISO system of limits and fits*

ISO 370, *Toleranced dimensions - Conversion from inches into millimetres and vice versa*

ISO 1101, *Geometrical Product Specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ITU-T Recommendation G.671:2005, *Transmission characteristics of optical components and subsystems*

ITU-T Recommendation G.692:1998, *Optical interfaces for multichannel systems with optical amplifiers*

3 Terms and definitions

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

3.1 Basic term definitions

3.1.1

port

optical fibre or optical fibre connector attached to a passive component for the entry and/or exit of the optical power (input and/or output port)

3.1.2

transfer matrix

The optical properties of a fibre optic wavelength-selective branching device can be defined in terms of an $n \times n$ matrix of coefficients, where n is the number of ports, and the coefficients represent the fractional optical power transferred between designated ports. Figure 1 shows the one example of six port device which has two input ports and four output ports. The ports are numbered sequentially. So, the possible combinations of two ports are six by six, total 36 combinations. These 36 combinations are expressed by a matrix.

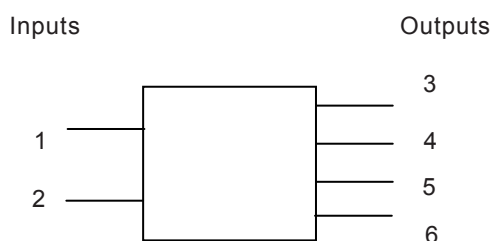


Figure 1 – Example of a six-port device, with two-input and four-output ports

In general, the transfer matrix T is :

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & \cdot & \cdot & t_{1n} \\ t_{21} & & & & & \\ \cdot & & & & & \\ \cdot & & t_{ij} & & & \\ \cdot & & & & & \\ t_{n1} & & & & & t_{nn} \end{bmatrix}$$

where

t_{ij} is the ratio of the optical power P_{ij} transferred out of port j (output port) with respect to input power P_i into port i (input port), that is:

$$t_{ij} = P_{ij}/P_i$$

t_{ij} is a number more than zero, and less than or equal to one ($0 \leq t_{ij} \leq 1$). In a wavelength-selective branching device the coefficient t_{ij} is a function of the wavelength and may be a function of the input polarization or modal power distribution.

Single-mode fibre optic WDM devices may operate in a coherent fashion with respect to multiple inputs. Consequently, the transfer coefficients may be affected by the relative phase and intensity of simultaneous coherent optical power inputs at two or more ports.

The wavelength dependency of the transfer matrix coefficient should be considered. A matrix coefficient may be expressed as t_{ijk} , where k is the wavelength number, λ_k . For a more generic expression, the transfer matrix is shown as follows:

$$T = \begin{matrix} & \begin{matrix} \text{Wavelength number} \\ \begin{matrix} 1 & 2 & \dots & k & \dots & n \end{matrix} \end{matrix} \\ \begin{matrix} \text{Send port number} \\ \begin{matrix} 1 \\ 2 \\ \vdots \\ n \end{matrix} \end{matrix} & \begin{bmatrix} \begin{matrix} t_{111} & t_{121} & \dots & t_{1n1} \\ t_{211} & t_{221} & \dots & t_{2n1} \\ \vdots & \vdots & \ddots & \vdots \\ t_{n11} & t_{n21} & \dots & t_{nn1} \end{matrix} & \begin{matrix} \begin{matrix} t_{112} & t_{122} & \dots & t_{1n2} \\ t_{212} & t_{222} & \dots & t_{2n2} \\ \vdots & \vdots & \ddots & \vdots \\ t_{n12} & t_{n22} & \dots & t_{nn2} \end{matrix} & \dots & \begin{matrix} t_{11k} & t_{12k} & \dots & t_{1nk} \\ t_{21k} & t_{22k} & \dots & t_{2nk} \\ \vdots & \vdots & \ddots & \vdots \\ t_{n1k} & t_{n2k} & \dots & t_{nnk} \end{matrix} \end{matrix} \end{bmatrix} \end{matrix}$$

3.1.3

transfer matrix coefficient

an element t_{ij} of the transfer matrix (refer to Figure 2 below)

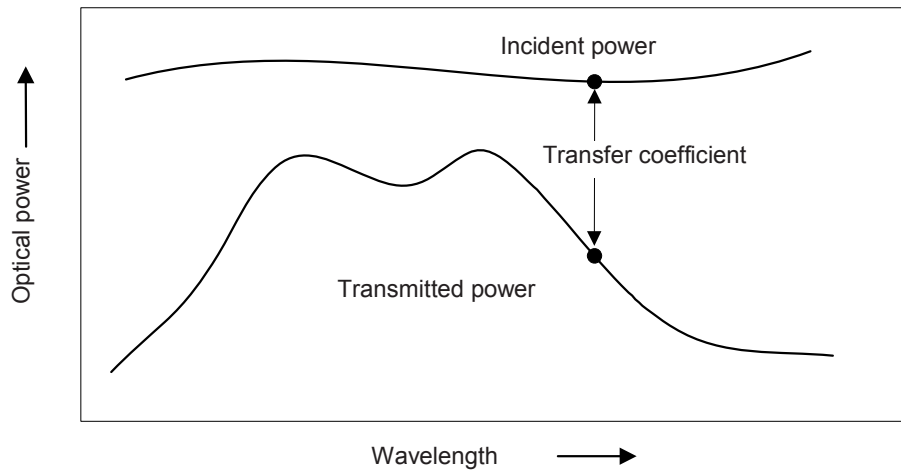


Figure 2 – Illustration of transfer matrix coefficient

3.1.4

logarithmic transfer matrix

in general, the logarithmic transfer matrix is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdot & \cdot & \cdot & a_{1n} \\ a_{21} & & & & & \\ \cdot & & & & & \\ \cdot & & & a_{ij} & & \\ \cdot & & & & & \\ a_{n1} & & & & & a_{nn} \end{bmatrix}$$

where

a_{ij} is the optical power reduction in decibels out of port j with unit power into port i , that is:

$$a_{ij} = -10 \log t_{ij}$$

where

t_{ij} is the transfer matrix coefficient.

a_{ij} is a positive number larger than or equal to zero. The same as the transfer matrix coefficient. A more generic expression of the logarithmic transfer matrix is shown as follows:

$$A = \begin{matrix} & \begin{matrix} \text{Wavelength number} \\ \begin{matrix} 1 & 2 & \dots & k & \dots & n \end{matrix} \end{matrix} \\ \begin{matrix} \text{Receive port number} \\ \begin{matrix} 1 & 2 & \dots & n \end{matrix} \end{matrix} & \begin{bmatrix} \begin{matrix} a_{111} & a_{121} & \cdot & a_{1n1} \\ a_{211} & a_{221} & \cdot & a_{2n1} \\ \cdot & \cdot & \cdot & \cdot \\ a_{n11} & a_{n21} & \cdot & a_{nn1} \end{matrix} & \begin{matrix} a_{112} & a_{122} & \cdot & a_{1n2} \\ a_{212} & a_{222} & \cdot & a_{2n2} \\ \cdot & \cdot & \cdot & \cdot \\ a_{n12} & a_{n22} & \cdot & a_{nn2} \end{matrix} & \dots & \begin{matrix} a_{11k} & a_{12k} & \cdot & a_{1nk} \\ a_{21k} & a_{22k} & \cdot & a_{2nk} \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1k} & a_{n2k} & \cdot & a_{nnk} \end{matrix} \end{bmatrix} \end{matrix} \end{matrix}$$

3.1.5**conducting ports**

two ports i and j between which t_{ij} is nominally greater than zero at a specified wavelength.

3.1.6**input/output port pair**

conducting ports i and j (t_{ij} nominally greater than zero) that are isolated from any other ports j (a_{ij} nominally infinite)

NOTE Figure 3 below shows an example of a six-port device, with two input ports and four output ports. The ports are numbered sequentially, so that the transfer matrix is developed to show all ports and all possible combinations. The port numbering is arbitrary.

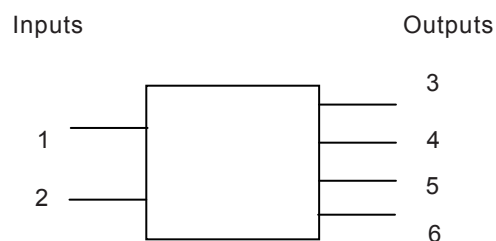


Figure 3 – Example of a six-port device, with two-input and four-output ports

For the example shown, if there are four operating wavelengths, then the resulting transfer matrix becomes a $6 \times 6 \times 4$ matrix: loss at λ_1 from port 1 to port 6 would use a_{161} . Reflectance of port 2 at λ_4 would use a_{224} . Loss from port 5 to port 2 at λ_3 would use a_{523} .

3.1.7**isolated ports**

two ports i and j between which t_{ij} is nominally zero, and a_{ij} is nominally infinite at a specified wavelength

3.1.8**channel**

another term for operating wavelength (or frequency)

3.1.9**channel spacing**

centre-to-centre differences in frequency or wavelength between adjacent channels in a WDM device

3.2 Component definitions**3.2.1****wavelength-selective branching device**

passive component possessing three or more ports which shares optical power among its ports in a predetermined fashion, without any amplification, switching, or other active modulation but only depending on the wavelength, in the sense that at least two different wavelength ranges are nominally transferred between two different couples of ports

3.2.2

wavelength division multiplexer

WDM

term frequently used as a synonym for a wavelength-selective branching device

NOTE Depending on the spectral response, a WDM device may be defined either as :

- DWDM (dense WDM) device, if it is intended to operate for channel spacing equal or less than 1 000 GHz;
- CWDM (coarse WDM) device, if it is intended to operate for channel spacing less than 50 nm and greater than 1 000 GHz (about 8 nm at 1 550 nm and 5,7 nm at 1 310 nm);
- WWDM (Wide WDM) device, if it is intended to operate for channel spacing equal or greater than 50 nm.

3.2.3

wavelength multiplexer

MUX

WDM (DWDM, CWDM or WWDM) which has n input ports and one output port, and whose function is to combine n different optical signals differentiated by wavelength from n corresponding input ports on to a single output port

3.2.4

wavelength demultiplexer

DEMUX

WDM (DWDM, CWDM or WWDM) which has one input port and n output ports, and whose function is to separate n different optical signals differentiated by wavelength from a single input port to n corresponding output ports

3.2.5

interleaver

bidirectional DWDM which has three ports, and whose function is to separate n different optical signals differentiated by wavelength from a single input port to odd channel signal to one output port and even channel signal to the other output port alternately

3.3 Performance parameter definitions

3.3.1

crosstalk

(for WDM devices) value of the ratio between the optical power of the specified signal and all noises

3.3.2

isolation

(for WDM devices) value of the ratio between the optical power of the specified signal and the specified noise

3.3.3

add-drop isolation

value of the optical power reduction in decibels a_{ij} between an input i , and an output port j , that is isolated at every wavelength (or frequency for a dense WDM (DWDM) device)

NOTE a_{ij} is defined in 3.1.4.

3.3.4

adjacent channel isolation

adjacent channel crosstalk

unidirectional (far-end) isolation with the restriction that x , the isolation wavelength number, is restricted to the channels immediately adjacent to the (channel) wavelength number associated with port o .

NOTE This is illustrated in Figure 4 below. The adjacent channel crosstalk has the same meaning as adjacent channel isolation.

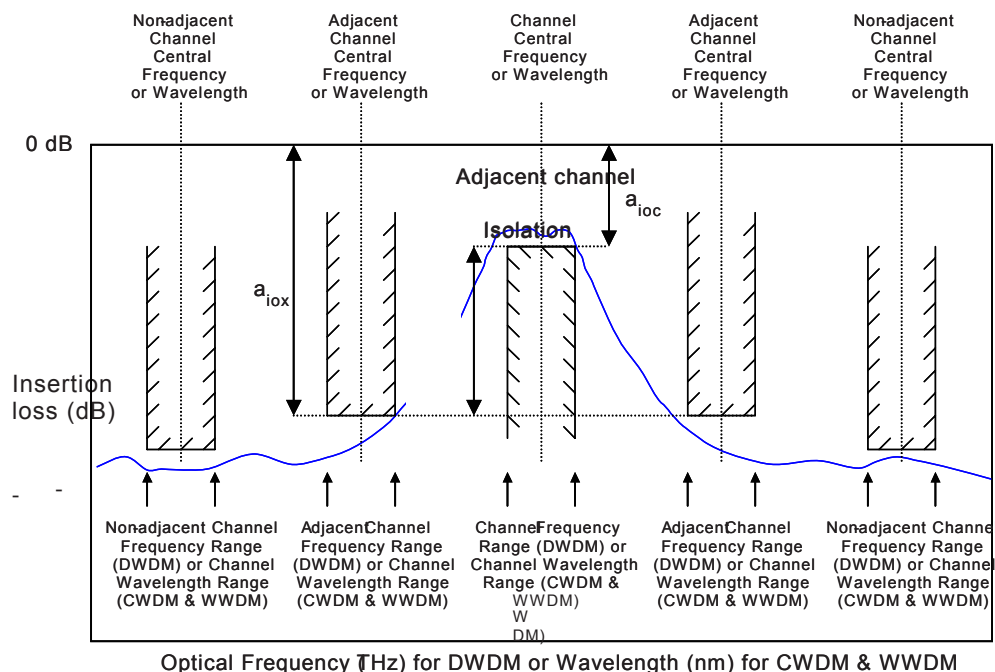


Figure 4 – Illustration of adjacent channel isolation

3.3.5

bidirectional (near-end) crosstalk attenuation

in a bidirectional WDM multiplexer (MUX)/demultiplexer (DMUX) device, the bidirectional (near-end) crosstalk attenuation is defined to be:

$$BCA = a_{mox}$$

where

a_{mox} is an element of the logarithmic transfer matrix;

m is the MUX input port number;

o is the DMUX output port number;

x is the wavelength number associated with port m .

3.3.6

bidirectional (near-end) isolation

because bidirectional WDM-MUX/DMUX devices have both input channels and output channels at the same side of the device, input light for one direction can appear on the output port for the other direction

In the example given below of a four-wavelength bidirectional system, wavelengths 1 and 2 travel from left to right and wavelengths 3 and 4 from right to left (see Figure 5).