IEC

IEC 61978-1

Edition 4.0 2024-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic dispersion compensators – Part 1: Generic specification

IEC 61978-1:2024-04 RLV(en)

IEC Secretariat
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC 61978-1

Edition 4.0 2024-04
REDLINE VERSION

INTERNATIONAL STANDARD

Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic dispersion compensators – Part 1: Generic specification

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.180.01 ISBN 978-2-8322-8788-0

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE CHROMATIC DISPERSION COMPENSATORS –

Part 1: Generic specification

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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61978-1:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61978-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fourth edition cancels and replaces the third 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) harmonization of terms and definitions with IEC TS 62627-09;

b) change of Clause 4 regarding requirements.

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

Draft	Report on voting
86B/4866/FDIS	86B/4901/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.

A list of all parts in the IEC 61978 series, published under the general title *Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic dispersion compensators*, can be found on the IEC website.

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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE CHROMATIC DISPERSION COMPENSATORS –

Part 1: Generic specification

1 Scope

This part of IEC 61978 applies to fibre optic passive chromatic dispersion compensators, all exhibiting the following features:

– they are optically passive;

– they have an optical input and an optical output for transmitting optical power;

– the ports are optical fibres or optical fibre connectors;

– they are wavelength sensitive;

– they ~~may~~ can be polarization sensitive.

This document establishes uniform requirements for the passive chromatic dispersion compensator.

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

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

IEC 60617 (all parts), *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 60793-2-50:2012, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*~~

~~IEC 60825 (all parts), *Safety of laser products*~~

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

~~IEC 61300-3-38, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-38: Examinations and measurements – Group delay, chromatic dispersion and phase ripple*~~

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC TR 61930, *Fibre optic graphical symbology*

IEC 62005 (all parts), *Reliability of fibre optic interconnecting devices and passive components*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices*

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

ISO 129-1, *Technical ~~drawings~~ product documentation (TPD) – ~~Indication~~ Presentation of dimensions and tolerances – Part 1: General principles*

~~ISO 286-1, *Geometrical product specifications (GPS) – ISO coding system for tolerances of linear sizes – Part 1: Bases of tolerances and fits*~~

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*~~

ISO 8601-1, *Date and time – Representations for information interchange – Part 1: Basic rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731 and IEC TS 62627-09 and the following 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 Basic terms~~

~~3.1.1~~
~~port~~
~~optical fibre or optical fibre connector attached to a passive component for the entry and/or exit of optical power (input and/or output port)~~

3.1 Component terms

3.1.1
passive chromatic dispersion compensator
PCDC
two-port in-line passive device used to perform chromatic dispersion compensation

Note 1 to entry: PCDCs are commonly used to compensate the chromatic dispersion of an optical path by adding the opposite sign chromatic dispersion.

Note 2 to entry: The typical optical paths comprise single-mode fibre, dispersion shifted fibre and/or non-zero dispersion shifted fibre. PCDCs have either negative or positive chromatic dispersion values depending on the chromatic dispersion sign of the optical path.

[SOURCE: IEC TS 62627-09:2016, 3.3.17]

3.1.2
dispersion compensating fibre
DCF
speciality fibre to compensate for the chromatic dispersion of an optical path

3.1.3
passive DCF based dispersion compensator
PCDC which constitutes DCF; realised by having chromatic dispersion characteristics of opposite sign to that of the optical path which are controlled the refractive index profile of the fibre

3.1.4
fibre Bragg grating
FBG
fibre type optical device which has periodically modulated refractive index profile in the core along the fibre axis

3.1.5
passive FBG based dispersion compensator
PCDC which constitutes an FBG; PCDC is realised by a chirped FBG which has gradual change in either modulation period or refractive index, or both, along the fibre axis

3.1.6
virtually imaged phased array
VIPA
optical device having a glass plate with a highly reflective mirror

Note 1 to entry: A VIPA has the same functions as a grating.

3.1.7
passive VIPA based dispersion compensator
PCDC consisting of a VIPA, focusing lens and 3-dimensional mirror

Note 1 to entry: PCDC produces both positive and negative chromatic dispersion by the movement of the 3-dimensional mirror to compensate for the chromatic dispersion of an optical path.

3.1.8
etalon
optical cavity which consists of a pair of parallel reflective mirrors

3.1.9
Gires-Tournois etalon
GT etalon
etalon having a highly reflective mirror and a half mirror

Note 1 to entry: The GT etalon is sometimes called a GT interferometer.

3.1.10
passive GT etalon based dispersion compensator
PCDC which comprises a GT etalon

3.2 Performance ~~parameter~~ terms

3.2.1
chromatic dispersion compensation
process by which a specific amount of chromatic dispersion is removed in order to mitigate the system impairment caused by unwanted dispersion

3.2.2
group delay
time by which a pulse is delayed by an optical device

Note 1 to entry: The group delay generally varies with the operating wavelength.

3.2.3
chromatic dispersion
derivative of group delay with respect to wavelength or frequency

Note 1 to entry: A typical unit is ps/nm or ps/GHz. The chromatic dispersion generally varies with the operating wavelength.

Note 2 to entry: The unit of ps/GHz are not commonly used; however, it is suitable for the evaluation of transmission system influence.

3.2.4
dispersion slope
derivative of chromatic dispersion with respect to wavelength or frequency

Note 1 to entry: A typical unit is ps/nm^2 or ps/GHz^2.The unit of ps/GHz^2 is not commonly used; however, it is suitable for the evaluation of transmission system influence.

Note 2 to entry: The dispersion slope generally varies with the operating wavelength.

3.2.5
operating wavelength
nominal wavelength λ at which a passive device operates with the specified performance

Note 1 to entry: Operating wavelength includes the wavelength to be nominally transmitted, attenuated and isolated.

3.2.6
operating wavelength range
specified range of wavelengths including all operating wavelengths

Note 1 to entry: Operating wavelength range shall include all passbands when two or more the passbands are exist.

3.2.7
figure of merit
FoM
ratio of the dispersion to the insertion loss of a PCDC at a particular operating wavelength

3.2.8
passband
wavelength range within which a passive optical ~~component~~ device is required to operate with optical attenuation less than or equal to a specified optical attenuation value

Note 1 to entry: There ~~may~~ can be one or more passbands for a PCDC.

3.2.9
passband ripple
maximum peak-to-peak variation of insertion loss in the passband

Note 1 to entry: The passband ripple of a PCDC is defined as the maximum passband ripple for all passbands.

3.2.10
group delay ripple
GDR
maximum peak-to-peak variation of the group delay approximated by a desired function of wavelength (or frequency), typically a linear fit, within a channel wavelength (or frequency) range

3.2.11
phase ripple
maximum peak-to-peak variation in measured phase spectrum when compared to a quadratic fit within a channel wavelength (or frequency) range

Note 1 to entry: Phase ripple (unit: radian) is calculated as the product of a peak-to-peak group delay ripple (unit: s) and a period of group delay ripple (unit: Hz). Refer to IEC 61300-3-38.

3.2.12
insertion loss
reduction in optical power between an input and output port of a passive ~~component~~ device

Note 1 to entry: expressed in decibels (dB).

Note 2 to entry: insertion loss is expressed as follows:

$$\cancel{a = -10\log\frac{P_a}{P_0}}$$

$$a = -10\log_{10}\frac{P_a}{P_0}$$

where

P_0 is the optical power launched into the input port;

P_a is the optical power received from the output port.

3.2.13
return loss
fraction of input power that is returned from a port of a passive ~~component~~ device expressed in decibels

Note 1 to entry: The return loss is defined as follows:

$$\cancel{RL = -10\log\frac{P_r}{P_0}}$$

$$RL = -10\log_{10}\frac{P_r}{P_0}$$

where

P_0 is the optical power launched into a port;

P_r is the optical power received back from the same port.

3.2.14
reflectance
ratio of the optical power returning back from a port to input power expressed in %

3.2.15
polarization dependent loss
PDL
maximum variation of insertion loss (attenuation) due to a variation of the state of polarization (SOP) over all the SOPs

3.2.16
wavelength dependent loss
WDL
maximum variation of the insertion loss (attenuation) over operating wavelength range

3.2.17
polarization mode dispersion
PMD
average delay of the travelling time between the two principal states of polarization (PSP), when an optical signal passes through a passive optical ~~component~~ device

4 Requirements

~~4.1 General~~

~~The requirements for PCDCs covered by this clause are intended to aid in classifying this device in a relevant specification. Additional or more severe requirements may be imposed by the relevant blank detail specification and by the detail specification.~~

4.1 Classification

~~4.2.1 General~~

~~PCDCs shall be classified as follows:~~

- ~~type;~~
- ~~style;~~
- ~~variant;~~
- ~~normative reference extensions.~~

~~4.2.2 Type~~

~~PCDCs can be categorized into different types, as follows:~~

- ~~by operating technologies (DCF, FBG, VIPA, GT etalon and so on);~~
- ~~by dispersion compensating performance (for example, wavelength dispersion compensating, dispersion slope compensating);~~
- ~~by operating wavelength range (for example, O-band, C-band, L-band);~~
- ~~by categories of transmission fibre which PCDCs are applied (for example, IEC 60793-2-50:2012, B1, B2, B4).~~

~~The application of PCDCs and the suitable operating mechanisms are summarized in Table 1.~~

~~Table 1 – Types of passive chromatic dispersion compensators~~

~~Applications~~	~~Channel number~~	~~Passbands~~	~~Technologies~~
~~TDM (Time division multiplexing)~~	~~Single channel~~	~~Narrow~~	~~Dispersion compensating fibre (DCF)~~ ~~Fibre Bragg grating (FBG)~~ ~~GT etalon~~
~~WDM (Wavelength division multiplexing)~~	~~Single channel~~	~~Narrow~~	~~FBG~~
	~~Multi-channel [a]~~	~~Narrow~~	~~FBG~~ ~~GT etalon~~ ~~Virtually imaged phased array (VIPA)~~
		~~Wide~~	~~DCF~~

~~[a] Multi-channel PCDCs can be used for a single channel use.~~

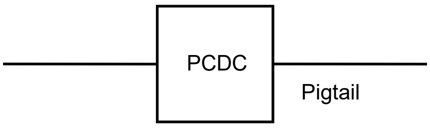
~~4.2.3 Style~~

~~4.2.3.1 General~~

~~PCDC may be classified into styles based on the fibre type(s), the connector type(s), cable type(s), housing shape, temperature control and the configuration. Style is not intended to define material or design. The configurations of PCDC ports are classified as follows.~~

~~4.2.3.2 Configuration A~~

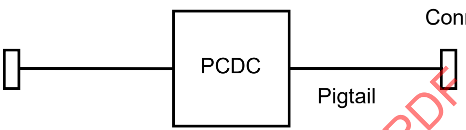
~~A device containing integral fibre optic pigtails, without connectors.~~



IEC 1687/2000

~~4.2.3.3 Configuration B~~

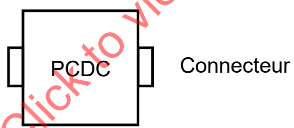
~~A device containing integral fibre optic pigtails, with a connector on each pigtail.~~



IEC 1688/2000

~~4.2.3.4 Configuration C~~

~~A device containing fibre optic connectors as an integral part of the device housing.~~



IEC 1689/2000

~~4.2.3.5 Configuration D~~

~~A device containing some combination of the interfacing features of the preceding configurations.~~

~~4.2.4 Variant~~

~~The PCDC variant identifies those common features which encompass structurally similar components.~~

~~Examples of features which define a variant include, but are not limited to, the following:~~

- ~~fibre type;~~
- ~~connector type.~~

~~4.2.5 Normative reference extensions~~

~~Normative reference extensions are used to identify integrated independent standards, specifications or other reference documents into blank detail specifications.~~

~~Unless a specified exception is noted, additional requirements imposed by an extension are mandatory. Usage is primarily intended to merge associated components to form hybrid devices,~~

~~or integrated functional application requirements that are dependent on technical expertise other than fibre optics.~~

~~Published reference documents produced by ITU consistent with the scope statements of the relevant IEC specification series may be used as an extension. Published documents produced by other regional standardization bodies such as TIA, ETSI, JIS, etc., may be referenced in a bibliography attached to the generic specification.~~

~~Some optical fibre splice configurations require special qualification provisions that shall not be imposed universally. This accommodates individual component design configurations, specialized field tooling, or specific application processes. In this case, requirements are necessary to assure repeatable performance or adequate safety, and provide additional guidance for complete product specification. These extensions are mandatory whenever used to prepare, assemble or install an optical fibre splice either for field application usage or preparation of qualification test specimens. The relevant specification shall clarify all stipulations. However, design- and style-dependent extensions shall not be imposed universally.~~

~~In the event of conflicting requirements, precedence shall be given, in descending order, as follows: generic over mandatory extension, over blank detail, over detail, over application specific extension.~~

~~Examples of requirements for normative extensions are as follows:~~

~~a) some commercial or residential building applications may require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialized locations;~~

~~b) specialized field tooling may require an extension to implement specific ocular safety, electrical shock or burn hazard avoidance requirements, or require isolation procedures to prevent potential ignition of combustible gases.~~

4.1.1 General

Fibre optic passive chromatic dispersion compensators (PCDCs) are classified either wholly or partially within the following categories:

– technology;
– type;
– wavelength band;
– categories of transmission fibre;
– interface style.

An example of a typical fibre optic PDCS classification is given in Table 1.

Table 1 – Example of a typical fibre optic PDCS classification

Items	Classification
Technology	DCF
Type	Wavelength dispersion compensating
Wavelength band	C-band
Category of transmission fibre	B-652
Interface style	Configuration D Fibre category: IEC 60793-2-50, B-652 IEC 61754-4 (SC connector)

4.1.2 Technology

PCDCs typically use the following technologies:

– dispersion compensating fibre (DCF);
– fibre Bragg grating (FBG);
– Virtual Image Phased Array (VIPA);
– GT etalon.

Each technology of PCDCs is described in Annex A to Annex D.

4.1.3 Types

– Wavelength dispersion compensation;
– Wavelength dispersion slope compensation.

4.1.4 Wavelength band

– O-band;
– S-band;
– C-band;
– L-band;
– C-band and L-band;
– other wavelength band or combination of wavelength bands above.

4.1.5 Application of PDCSs and their suitable technologies

The application of PCDCs and the suitable technologies are summarized in Table 2.

Technology dependent characteristics of PCDCs are summarized in Annex E.

Table 2 – Application, channel numbers, passband and technologies of PDCSs

Applications	Channel number	Passbands	Technologies
TDM (time division multiplexing)	Single channel	Narrow	Dispersion compensating fibre (DCF) Fibre Bragg grating (FBG) GT etalon
WDM (wavelength division multiplexing)	Single channel	Narrow	FBG
	Multi-channel [a)]	Narrow	FBG GT etalon Virtually imaged phased array (VIPA)
		Wide	DCF
[a)] Multi-channel PCDCs can be used for a single channel use.			

4.1.6 Interface style

PCDC style shall be defined based on the following elements:

– the input and output port configuration;
– the connector set type(s), if any.

NOTE Examples of interface style are provided in Annex F.

4.2 Documentation

4.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from IEC 60027 series, IEC 60617 and IEC TR 61930.

~~4.3.2 Specification system~~

~~4.3.2.1 General~~

~~This specification is part of a three-level IEC specification system. Subsidiary specifications shall consist of blank detail specifications and detail specifications. This system is shown in Table 2. There are no sectional specifications for passive dispersion compensators.~~

~~Table 2 – Three-level IEC specification structure~~

~~Specification level~~	~~Examples of information to be included~~	~~Applicable to~~
~~Basic~~	~~Inspection rules~~ ~~Optical measuring methods~~ ~~Environmental test methods~~ ~~Sampling plans~~ ~~Identification rule~~ ~~Marking standards~~ ~~Dimensional standards~~ ~~Terminology standards~~ ~~Symbol standards~~ ~~Preferred number series~~ ~~SI units~~	~~Two or more component families or subfamilies~~
~~Generic~~	~~Specific terminology~~ ~~Specific symbols~~ ~~Specific units~~ ~~Preferred values~~ ~~Marking~~ ~~Selection of tests~~	~~Component family~~
~~Blank detail~~	~~Quality conformance test schedule~~ ~~Inspection requirements~~ ~~Information common to a number of types~~	~~Groups of types having a common test schedule~~
~~Detail~~	~~Individual values~~ ~~Specific information~~ ~~Completed quality conformance test schedules~~	~~Individual type~~

~~4.3.2.2 Blank detail specifications~~

~~The blank detail specification lists all of the parameters and features applicable to a PCDC, including the type, operating characteristics, housing configurations, test methods, and performance requirements. The blank detail specification is applicable to any PCDC design and quality assessment requirement. The blank detail specification contains the preferred format for stating the required information in the detail specification.~~

~~Blank detail specifications are not, by themselves, a specification level. They are associated with the generic specification.~~

~~Each blank detail specification shall be limited to one environmental category.~~

~~Each blank detail specification shall contain~~

- ~~the minimum mandatory test schedules and performance requirements,~~
- ~~one or more assessment levels,~~
- ~~the preferred format for stating the required information in the detail specification,~~
- ~~in case of hybrid components, including connectors, addition of appropriate entry fields to show the reference normative document, document title and issue date.~~

~~4.3.2.3 Detail specifications~~

~~A specific PCDC is described by a corresponding detail specification, which is prepared by filling in the blanks of the blank detail specification. Within the constraints imposed by this generic specification, the blank detail specification may be filled in by any national committee of the IEC, thereby defining a particular PCDC as an IEC standard.~~

~~Detail specifications shall specify the following, as applicable:~~

- ~~type (see 4.2.2);~~
- ~~style (see 4.2.3);~~
- ~~variant(s) (see 4.2.4);~~
- ~~part identification number for each variant (see 4.7.1);~~
- ~~drawings, dimensions required (see 4.3.3);~~
- ~~performance requirements (see 4.6).~~

4.2.2 Drawings

4.2.2.1 General

The drawings and dimensions given in ~~detail~~ the relevant specifications shall not restrict detail construction nor ~~shall they~~ be used as manufacturing drawings.

4.2.2.2 Projection system

Either first angle or third angle projection shall be used for the drawings in documents covered by this document. All drawings within a document shall use the same projection system and the drawings shall state which system is used.

4.2.2.3 Dimensional system

All dimensions shall be given in accordance with ISO 129-1 for general information of dimensions and tolerances, ISO 286-1 for tolerances of form, orientation location and run out for information, and ISO 1101 for information interchange. The metric system shall be used in all specifications. Dimensions shall not contain more than five significant digits. When units are converted, a note shall be added in each relevant specification ~~and the conversion between systems of units shall use a factor of 25,4 mm to 1 inch~~.

4.2.3 Tests and measurements

4.2.3.1 Tests and measurements procedures

The tests and measurements procedures for optical, mechanical, climatic, and environmental characteristics of ~~passive dispersion compensators~~ fibre optic PCDCs to be used shall be defined and selected preferentially from IEC 61300 series. The size measurement method to be used shall be specified in the ~~detail specification~~ relevant IEC 61753 series performance standard or IEC 62005 series reliability standard, for dimensions which are specified within a total tolerance zone of 0,01 mm or less.

4.2.3.2 Reference components

Reference components for measurement purposes, if required, shall be specified in the relevant ~~specification~~ IEC 61300 basic test and procedure standard.

~~4.3.4.3 Gauges~~

~~Gauges, if required, shall be specified in the relevant specification.~~

4.2.4 Test ~~data sheets~~ report

~~Test data sheets shall be prepared for each test conducted as required by a relevant specification. The data sheets shall be included in the qualification report and in the periodic inspection report.~~

~~Data sheets shall contain the following information as a minimum:~~

- ~~title of test and date;~~
- ~~specimen description including the type of fibre, connector or other coupling device. The description shall also include the variant identification number (see 4.7.2);~~
- ~~test equipment used and date of latest calibration;~~
- ~~all applicable test details;~~
- ~~all measurement values and observations;~~
- ~~sufficiently detailed documentation to provide traceable information for failure analysis.~~

The test reports shall be prepared for each test conducted as required by a relevant IEC 61753 series performance standard or IEC 62005 series reliability standard. The reports shall be included in the qualification test report and in the periodic inspection report.

Test reports shall contain the following information as a minimum:

- title and date of test;
- test equipment used;
- all applicable test details;
- all measurement values and observations.

4.2.5 Instructions for use

Instructions for use, when required, shall be given by the manufacturer ~~and shall include~~.

- ~~assembly and connection instructions;~~
- ~~cleaning method;~~
- ~~safety aspects;~~
- ~~additional information as necessary.~~

4.3 Standardisation system

4.3.1 Interface standards

Refer to the proper optical connector interface of the IEC 61754 series when an optical connector is used.

4.3.2 Performance standards

Performance standards (IEC 61753 series) contain a series of tests and measurements (which ~~may or may not~~ can be grouped into a specified schedule depending on the requirements of that standards) with clearly defined conditions, severities, and pass/fail criteria. The tests are intended to be run on a one-off basis to prove the ability of any product to satisfy the performance standards requirement. Each performance standard has a different set of tests~~,~~ ~~and/or~~ severities,~~ (~~ and~~/or~~ groupings~~)~~, representing the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance~~/~~ and quality conformance programme.

~~It is possible to define a key point of the test and measurements standards when these are applied (particularly with regard to insertion loss and return loss) in conjunction with the interface standards of inter product compatibility. This ensures conformance of each individual product to this standard,~~

4.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

~~For each type of component, the following shall be identified (and appear in the standard):~~

- ~~failure modes (ways in which a component can fail);~~
- ~~failure mechanisms (causes of failure, which may be common to several components);~~
- ~~failure effects (observable, general, mechanical or optical effects of failure).~~

~~These are all related to environmental and material aspects.~~

~~Initially, just after component manufacture, there is an "infant mortality phase" during which many components would fail if they were deployed in the field. To avoid early field failure, all components may be subjected to a screening process in the factory involving environmental stresses that may be mechanical, thermal or humidity-related. This is to induce known failure mechanisms in a controlled environmental situation to occur earlier than would normally be seen in the unscreened population. For those components that survive (and are then sold), there is a reduced failure rate, since these mechanisms have been eliminated.~~

~~Screening is an optional part of the manufacturing process, rather than a test method. It will not affect the "useful life" of a component defined as the period during which it performs according to specifications. Eventually other failure mechanisms appear, and the failure rate increases beyond the defined threshold. At this point the useful life ends and the "wear-out region" begins, and the component shall be replaced.~~

~~At the beginning of useful life, performance testing on a sampled population of components may be applied by the supplier, by the manufacturer or by a third party. This is to ensure that the component meets performance specifications over the range of intended environments at this initial time. Reliability testing, on the other hand, is applied to ensure that the component meets performance specifications for at least a specified minimum useful lifetime or specified maximum failure rate. These tests are usually carried out by utilizing the performance testing, but increasing duration and severity to accelerate the failure mechanisms.~~

~~A reliability theory relates component reliability testing to component parameters and to lifetime or failure rate under testing. The theory then extrapolates these to lifetime or failure rate under less stressful service conditions. The reliability specifications include values of the component parameters needed to ensure the specified minimum lifetime or maximum failure rate in service.~~

~~4.4.3 Interlinking~~

~~Standards currently under preparation are given in Figure 1. A large number of the test and measurements standards already exist, and quality assurance qualification approval already~~

~~exists and has done so for many years. As previously mentioned, alternative methods of quality assurance/quality conformance are being developed under the headings of capability approval and technology approval which are covered in IEC Guide 102.~~

~~With regard to interface, performance and reliability standards, once all three of these standards are in place, the matrix given in Table 3 demonstrates some of the other options available for product standardization.~~

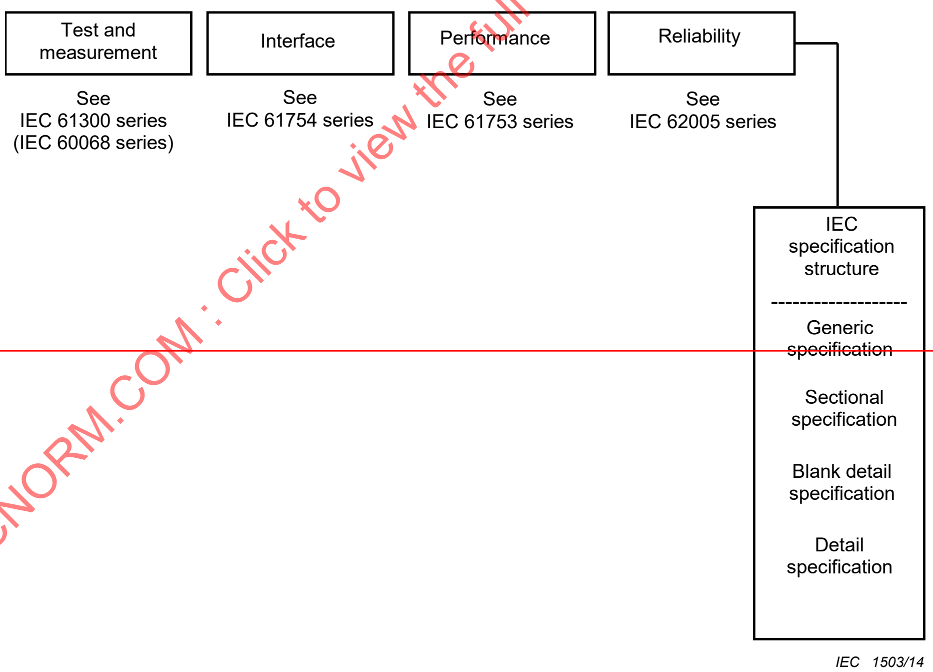
~~Product A is fully IEC standardized, having a standard interface and meeting defined performance and reliability standards.~~

~~Product B is a product with a proprietary interface but which meets a defined IEC performance and reliability standard.~~

~~Product C is a product that complies with an IEC standard interface but does not meet the requirements of either an IEC performance or reliability standard.~~

~~Product D is a product that complies with both an IEC standard interface and a performance standard but does not meet any reliability requirements.~~

~~Obviously, the matrix is more complex than shown since there will be a number of interface, performance and reliability standards which may cross-refer. In addition, the products may all be subject to a quality assurance programme that could be under IEC qualification approval, capability approval, technology approval (as Table 4 attempts to demonstrate), or even a national or company quality assurance system.~~



~~**Figure 1 – Standards currently under preparation**~~

~~**Table 3 – Standards interlink matrix**~~

~~**Product group**~~	~~**Interface standard**~~	~~**Performance standard**~~	~~**Reliability standard**~~
~~Product A~~	~~Yes~~	~~Yes~~	~~Yes~~
~~Product B~~	~~No~~	~~Yes~~	~~Yes~~
~~Product C~~	~~Yes~~	~~No~~	~~No~~

~~Product D~~	~~Yes~~	~~Yes~~	~~No~~

~~Table 4 – Quality assurance options~~

~~Product group~~	~~Company A~~			~~Company B~~			~~Company C~~		
	~~QA~~	~~CA~~	~~TA~~	~~QA~~	~~CA~~	~~TA~~	~~QA~~	~~CA~~	~~TA~~
~~Product A~~	~~X~~			~~X~~					~~X~~
~~Product B~~	~~X~~				~~X~~				~~X~~
~~Product C~~	~~X~~				~~X~~				~~X~~
~~Product D~~	~~X~~					~~X~~			~~X~~

4.4 Design and construction

4.4.1 Materials

4.4.1.1 General

~~The devices shall be manufactured with materials which meet the requirements of the detail specification. When non-flammable materials are required, the requirement shall be specified in the relevant specification, and the test of IEC 60695-11-5 shall be cited as reference.~~

All housing materials used in the construction shall be manufactured with materials which meet the requirements of the relevant IEC 61753 performance standard or IEC 62005 reliability standard.

~~4.5.1.2 Corrosion resistance~~

~~All materials used in the construction of compensator sets shall be corrosion resistant or suitably finished to meet the requirements of the relevant specification.~~

4.4.1.2 Non-flammable materials

When non-flammable materials are required, the requirements shall be specified, and reference shall be made to IEC 60695-11-5. If an alternate standard is used for non-flammable materials, it shall be declared.

4.4.2 Workmanship

Components and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs, or other defects that ~~will~~ would affect life, service ability or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

4.5 Quality

Fibre optic PCDCs shall be controlled by the quality assessment procedures and declared.

4.6 Performance requirements

Fibre optic PCDCs shall meet the performance requirements specified in the relevant ~~specification~~ IEC 61753 performance standard or IEC 62005 reliability standard.

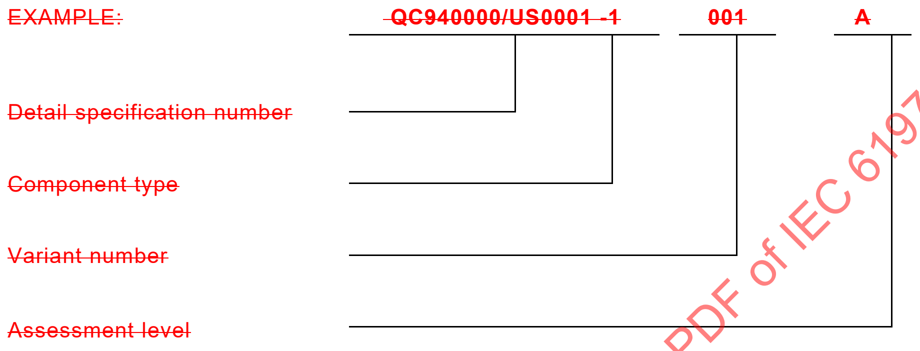
4.7 Identification and marking

4.7.1 General

Components, associated hardware and shipping packages shall be permanently and legibly identified and marked when required by the relevant ~~specification~~ IEC 61753 performance standard or IEC 62005 reliability standard.

~~4.7.2 Variant identification number~~

~~Each variant in a detail specification shall be assigned a variant identification number. The number shall consist of the number assigned to the detail specification followed by a four-digit dash number and a letter designating the assessment level. The first digit of the dash number shall be sequentially assigned to each component type covered by the detail specification. The last three digits shall be sequentially assigned to each variant of the component.~~



4.7.2 Component marking

Component marking, if required, ~~shall~~ should be specified in the ~~detail specification~~ relevant IEC 61753 performance standard or IEC 62005 reliability standard. The preferred order of marking is:

a) port identification;

b) manufacturer's part number (including serial number, if applicable);

c) manufacturer's identification mark or logo.

~~d) manufacturing date;~~

~~e) variant identification number;~~

~~f) any additional marking required by the detail specification.~~

If space does not allow for all the required marking on the component, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

4.7.3 Package marking

Several ~~PCDCs~~ devices may be ~~packed~~ packaged together for shipment.

Package marking, if required, shall be specified in the ~~detail specification~~ relevant IEC 61753 performance standard or IEC 62005 reliability standard. The preferred order of marking is:

a) manufacturer's identification mark or logo;

b) manufacturer's part number.

~~c) manufacturing date code (year/week, see ISO 8601);~~

~~d) variant identification number(s) (see 4.7.1);~~

~~e) the type designation (see 4.2.2);~~

~~f) the assessment level;~~

~~g) any additional marking required by the detail specification.~~

When applicable, individual unit packages (within the sealed package) ~~shall~~ should be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

4.8 Packaging

Packaging shall be securely without any damage to passive optical components during transportation and storage.

Packages shall include instructions for use when required by the ~~specification~~ relevant IEC 61753 performance standard or IEC 62005 reliability standard (see 4.2.5).

4.9 Storage conditions

Where short-term degradable materials, such as adhesives, are supplied with the package ~~of connector parts~~, the manufacturer shall mark these with the expiry date ~~(year and week numbers, see ISO 8601)~~ according to ISO 8601-1 together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

4.10 Safety

Fibre optic PCDCs, when used on an optical fibre transmission system and/or equipment, ~~may~~ can emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end.

The fibre optic PCDC manufacturers shall ~~make available~~ provide sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

In addition, each ~~detail specification~~ relevant IEC 61753 performance standard or IEC 62005 reliability standard shall include the following:

WARNING – Care should be taken when handling small diameter fibre to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre or an optical fibre connector when it is propagating energy is not recommended, unless prior assurance has been obtained as to the safety energy output level.

~~Reference shall be made to the IEC 60825 series, the relevant standard on safety.~~

Annex A
(informative)

Example of dispersion compensating fibre (DCF) technologies

Chromatic dispersion in optical fibre is expressed as the sum of material dispersion caused by wavelength dependence of the refractive index of the glass materials and waveguide dispersion caused by index profile of optical fibre (Figure A.1). Silica glass optical fibre material dispersion does not vary greatly. Waveguide dispersion can be controlled by changing the index profile of the optical fibre. DCFs are designed to control waveguide dispersion to achieve the desired dispersion characteristics.

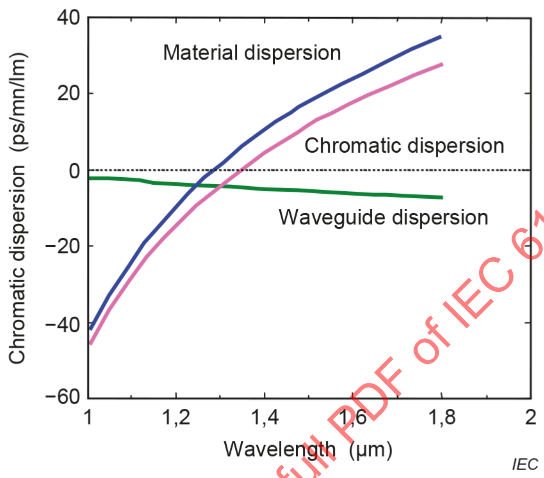


Figure A.1 – Chromatic dispersion in a standard single-mode optical fibre (SMF)

Figure A.2 shows the contour for different dispersions at a wavelength of 1,55 μm as a function of the ~~relative~~ refractive index ~~difference~~ contrast, Δ, from a pure silica cladding index value level and core diameter in a step-index profile with the germanium-doped silica core. From this figure, a DCF with a large negative chromatic dispersion can be obtained by increasing Δ and decreasing the diameter of the core.

NOTE Δ is the relative index contrast. Refer IEC IEV 731-02-20.

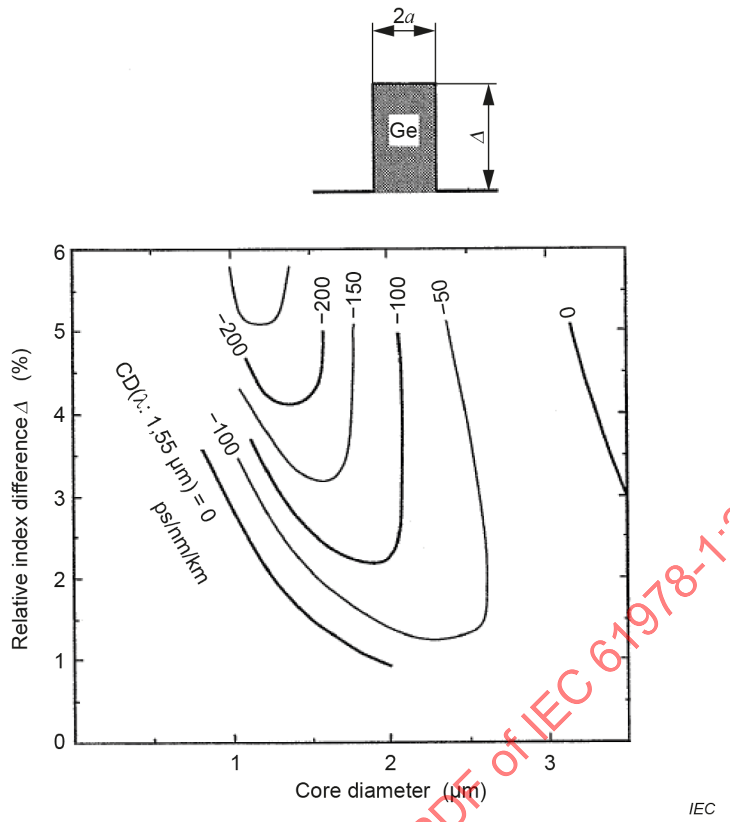
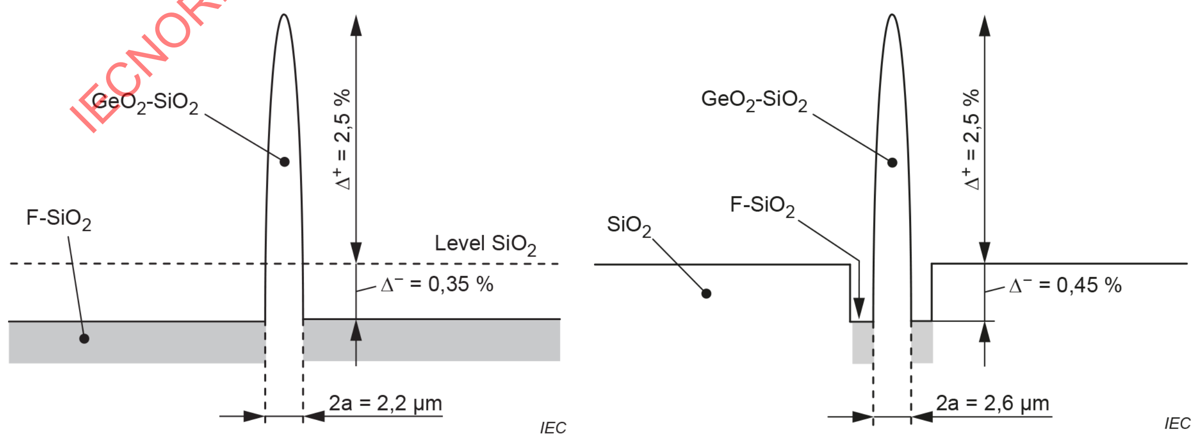


Figure A.2 – Calculated contour for different dispersion at the wavelength of 1,55 μm [CD(λ:1,55 μm)] for a step index core fibre

Figure A.3 shows two examples of refractive index profiles of DCFs. The ~~relative~~ refractive index ~~difference~~ contrast between the core and the cladding is larger and the core diameter is smaller than those of standard single-mode fibres. These design differences result in larger waveguide dispersion. As for the double-cladding type DCF, much larger waveguide dispersion can be obtained than in the case of the matched cladding type DCF.

Double cladding type DCF can give negative dispersion slope in C-band and/or L-band. Because of this, the positive dispersion slope of SMFs (IEC 60793-2-50~~:2012~~, B1 fibres) can be compensated by using this type of DCF. Dispersion slope compensation is important to achieve a uniform dispersion value over the wavelength range of a WDM transmission system.



a) **Matched cladding type** b) **Double cladding type**

Figure A.3 – Examples of refractive index profile used in DCF

Annex B
(informative)

Example of fibre Bragg grating (FBG) technologies

Fibre Bragg grating (FBG) is a fibre type optical device that has a modulated refractive index profile in the core along the longitudinal axis. A FBG functions as a reflective filter where reflection wavelength is defined in Formula (B.1). Generally, refractive index modulation is generated by using UV radiation induced refractive index change.

$$\lambda_B = 2 \times \Lambda \times n_{eff} \tag{B.1}$$

where

λ_B is the reflection wavelength (Bragg wavelength);

Λ is the refractive index modulation period;

n_{eff} is the effective refractive index.

The basic principle of dispersion compensation using a chirped FBG is shown in Figure B.1. In chirped FBG, either the grating period or effective refractive index, or both, are gradually changed, and reflection wavelength changes along the fibre axis. After travelling through the transport fibre, the signal experiences a positive chromatic dispersion so that its ~~longer~~ shorter-wavelength part arrives before its ~~shorter~~ longer-wavelength part. The chirped FBG provides more group delay for the ~~longer~~ shorter-wavelength part of the signal thus compensating for the effect of the chromatic dispersion. The slope of the group delay spectrum corresponds to the dispersion the FBG provides. To conveniently access the output signal, an optical circulator is used.

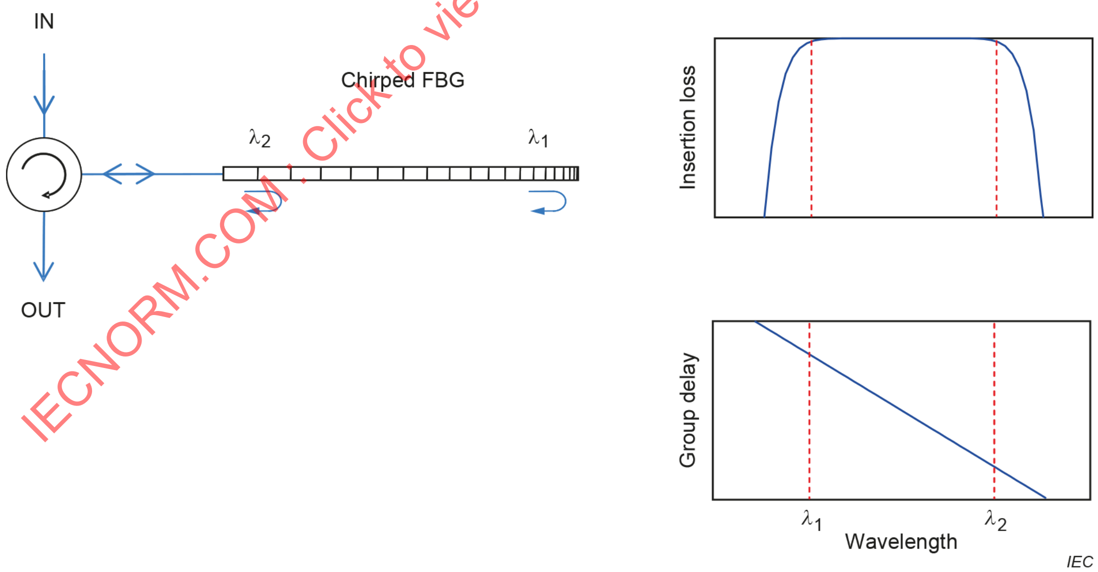
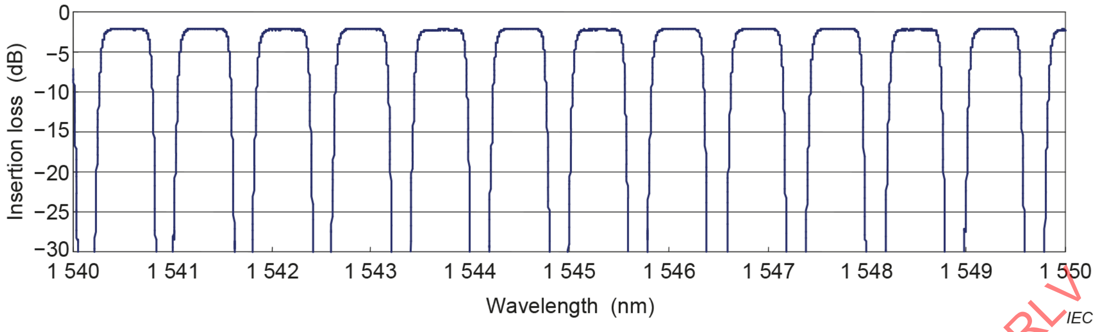
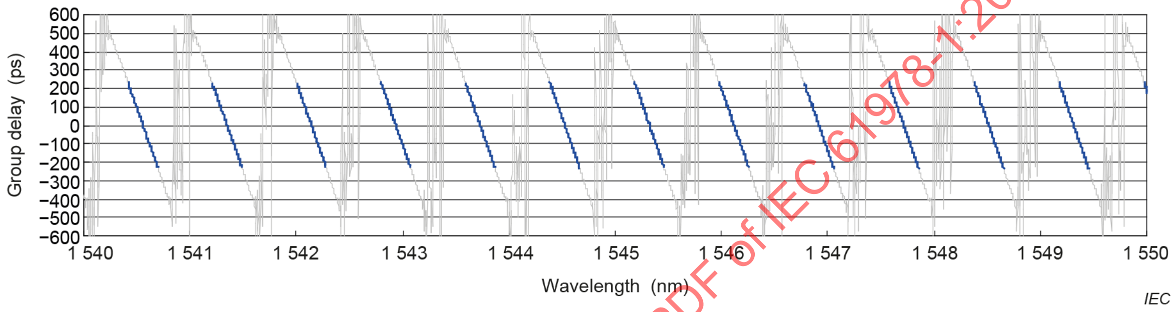


Figure B.1 – Illustration of the use of a chirped fibre Bragg grating for chromatic dispersion compensation

The FBG can be made multi-channel, allowing for a simultaneous compensation of the chromatic dispersion accumulated in all channels of a WDM system. The multi-channel character of the FBG is typically obtained through a sampling approach, i.e. a spatial modulation of its physical properties. As an example, Figure B.2 shows an expanded view over 10 nm of the spectral characteristics of a multi-channels FBG tailored for compensating the chromatic dispersion accumulated over 100 km of single-mode fibre, specified in IEC 60793-2-50~~:2012~~, category B1.



a) Insertion loss (attenuation) including the optical circulator



b) Group delay spectrum

Figure B.2 – Expanded view over 10 nm of the insertion loss (attenuation) spectrum of a multi-channel FBG

Annex C
(informative)

Example of virtually imaged phased array (VIPA) technologies

Figure C.1 shows the structure of a virtually imaged phased array (VIPA). The input light from a single-mode fibre is line-focused into a glass plate. The glass plate is coated on both surfaces and collimated light is emitted from the reverse side of the glass plate after multiple reflections between the coated surfaces. The light from the glass plate is then focused onto a curved mirror. The reflected light travels back to the glass plate and is finally coupled back into the fibre.

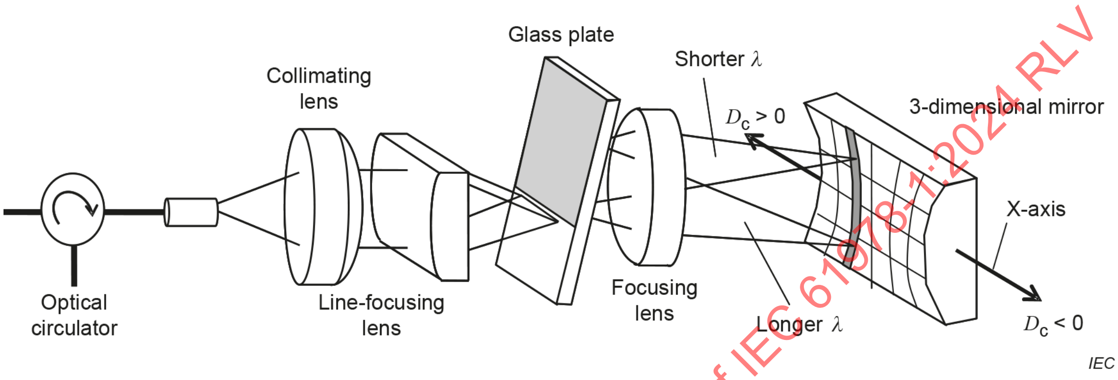


Figure C.1 – Structure of virtually imaged phased array (VIPA)

Figure C.2 shows the detailed light path. Each time that the light is reflected at the right-angle surface of the glass plate, a small percentage of the power passes through the partially reflecting coating. This creates multiple beams that diverge from the corresponding beam waist in the virtual image. The interference of these diverging beams generates collimated light. This collimated light travels at an angle from the optical axis which varies with the wavelength. Chromatic dispersion, i.e. the wavelength dependence of distance travelled, is determined by the wavelength dependence of the pointing angle of collimated light from the glass plate and the surface profile of the reflection mirror. The convex portion of the mirror produces negative chromatic dispersion, and the concave portion of the mirror produces positive chromatic dispersion. Figure C.1 shows that the collimated light (grey line area on the surface of the 3-D mirror) reflects along the concave mirror surface which produces positive chromatic dispersion. By shifting the position of the 3-D mirror along the X-axis, the collimated light can also reflect off the convex mirror surface, which produces negative chromatic dispersion. If the surface profile of the 3-D mirror is designed such that the curvature of the mirror's surface is gradually changed along the X-axis, the chromatic dispersion can be readily changed by shifting the 3-D mirror's position along the X-axis.

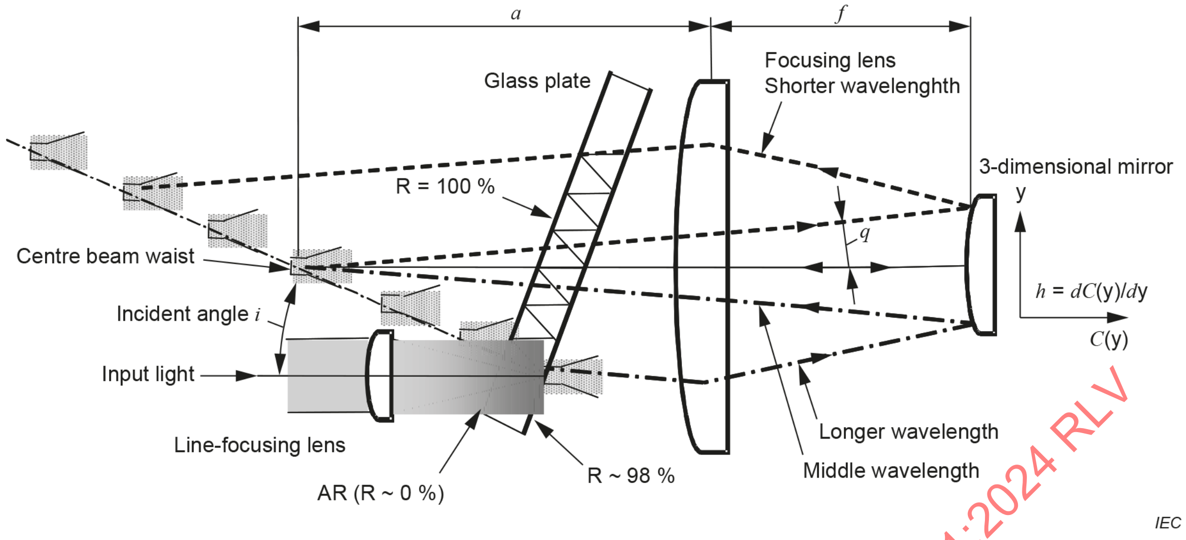


Figure C.2 – Detailed light path and mechanism of generating chromatic dispersion

Annex D
(informative)

Example of GT etalon technologies

An etalon is an optical cavity which consists of a pair of parallel reflective mirrors. Multiple reflection interference between two ~~filters~~ mirrors gives cyclic spectrum and dispersion characteristics. The period of cyclic spectrum is called free spectral range (FSR). Operating wavelength and FSR can be adjusted by changing optical distance between the two mirrors.

There are mainly two types of etalons: Fabry-Perot (FP) etalon and Gires-Tournois (GT) etalon. The GT etalon (Figure D.1) is suitable for dispersion compensation. The GT etalon is an optical cavity that consists of mirrors having different reflectivity. Generally, the front mirror has low reflectivity and rear mirror has high reflectivity. In this case, the reflection power spectrum is relatively smooth, although the phase of the reflected light depends strongly on the wavelength. Using a multiple cavity etalon with optimized design, higher order dispersion can be compensated. Sometimes a GT etalon is called a GT interferometer.

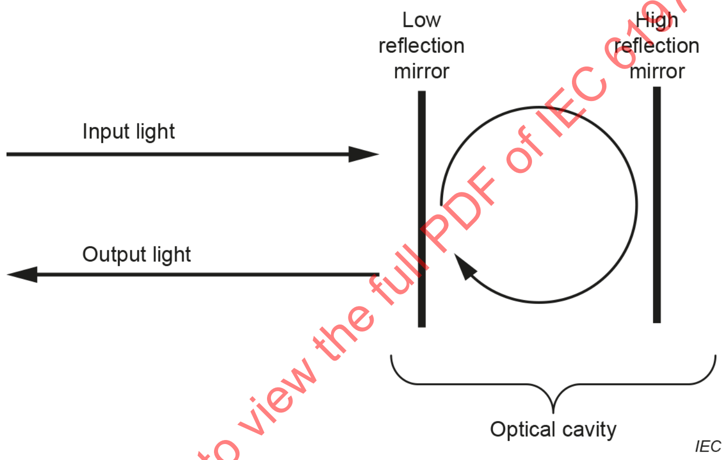


Figure D.1 – Gires-Tournois etalon

Annex E
(informative)

Technology dependent characteristics of PCDCs

As described in Annex A to Annex D, primarily, four technologies are used for PCDCs. Table E.1 shows the summary of technology-dependent characteristics of PCDCs.

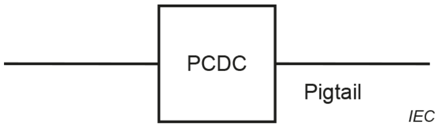
Table E.1 – Summary of technology dependent characteristics of PCDCs

	DCF	**FBG**	**VIPA**	**Etalon**
Passband	Wide	Relatively narrow	Narrow/periodical	Narrow/periodical or wide
GDR period	No GDR	Typically approx. 10 pm	Typically approx. 2 pm	Typically approx. 30 pm
Loss dependency on dispersion	Yes	No	No	No
Non linearity	Yes	No	No	No
Tuneable function	No	Yes	Yes	Yes

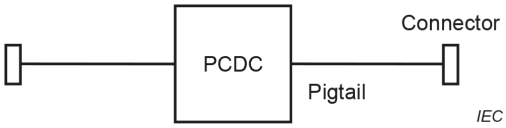
Annex F
(informative)

Example of interface style

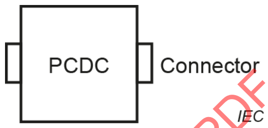
The four examples of interface style for fibre optic PDCSs are shown in Figure F.1 a) to Figure F.1 d).



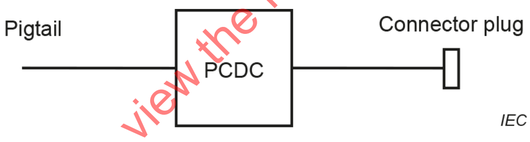
a) Configuration A – Device integral fibre pigtails without a connector



b) Configuration B – Device containing integral fibre optic pigtails with a connector plug on each port



c) Configuration C – Device containing connector receptacles as an integral port of the device housing



d) Configuration D – Example – Device containing some combination of the interfacing feature of the preceding configurations

Figure F.1 – Examples of interface style for fibre optic PCDCs

Bibliography

IEC 60068 (all parts), *Environmental testing*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

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

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60869-1, *Fibre optic interconnecting devices and passive components – Fibre optic passive power control devices – Part 1: Generic specification*

IEC 60874 (all parts), *Fibre optic interconnecting devices and passive components – Connectors for optical fibres and cables*

IEC 60974 (all parts), *Arc welding equipment*

IEC 61073-1, *Fibre optic interconnecting devices and passive components – Mechanical splices and fusion splice protectors for optical fibres and cables – Part 1: Generic specification*

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-2 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2: Tests*

IEC 61300-3 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3: Examinations and measurements*

IEC 61300-3-38, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-38: Examinations and measurements – Group delay, chromatic dispersion and phase ripple*

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC 61754 (all parts), *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces*

IEC 61754-4, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 4: Type SC connector family*

IEC 61754-13, ~~*Fibre optic interconnecting devices and passive components –*~~ *Fibre optic connector interfaces – Part 13: Type FC-PC connector*

IEC 61754-15, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 15: Type LSH connector family*

IEC TR 61931, *Fibre optic – Terminology*

~~IEC 62005 (all parts), *Reliability of fibre optic interconnecting devices and passive components*~~

IEC 61978-1

Edition 4.0 2024-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic dispersion compensators –
Part 1: Generic specification

Dispositifs d'interconnexion et composants passifs fibroniques – Compensateurs de dispersion chromatique passifs fibroniques –
Partie 1 : Spécification générique

IEC 61978-1:2024-04(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE CHROMATIC DISPERSION COMPENSATORS –

Part 1: Generic specification

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 61978-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This fourth edition cancels and replaces the third 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) harmonization of terms and definitions with IEC TS 62627-09;
b) change of Clause 4 regarding requirements.

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

Draft	Report on voting
86B/4866/FDIS	86B/4901/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.

A list of all parts in the IEC 61978 series, published under the general title *Fibre optic interconnecting devices and passive components – Fibre optic passive chromatic dispersion compensators*, can be found on the IEC website.

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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

FIBRE OPTIC INTERCONNECTING DEVICES
AND PASSIVE COMPONENTS – FIBRE OPTIC PASSIVE
CHROMATIC DISPERSION COMPENSATORS –

Part 1: Generic specification

1 Scope

This part of IEC 61978 applies to fibre optic passive chromatic dispersion compensators, all exhibiting the following features:

– they are optically passive;
– they have an optical input and an optical output for transmitting optical power;
– the ports are optical fibres or optical fibre connectors;
– they are wavelength sensitive;
– they can be polarization sensitive.

This document establishes uniform requirements for the passive chromatic dispersion compensator.

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

IEC 60050-731, *International Electrotechnical Vocabulary – Chapter 731: Optical fibre communication*

IEC 60617 (all parts), *Graphical symbols for diagrams*

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

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC TR 61930, *Fibre optic graphical symbology*

IEC 62005 (all parts), *Reliability of fibre optic interconnecting devices and passive components*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices*

ISO 129-1, *Technical product documentation (TPD) – Presentation of dimensions and tolerances – Part 1: General principles*

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

ISO 8601-1, *Date and time – Representations for information interchange – Part 1: Basic rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-731 and IEC TS 62627-09 and the following 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 Component terms

3.1.1
passive chromatic dispersion compensator
PCDC
two-port in-line passive device used to perform chromatic dispersion compensation

Note 1 to entry: PCDCs are commonly used to compensate the chromatic dispersion of an optical path by adding the opposite sign chromatic dispersion.

Note 2 to entry: The typical optical paths comprise single-mode fibre, dispersion shifted fibre and/or non-zero dispersion shifted fibre. PCDCs have either negative or positive chromatic dispersion values depending on the chromatic dispersion sign of the optical path.

[SOURCE: IEC TS 62627-09:2016, 3.3.17]

3.1.2
dispersion compensating fibre
DCF
speciality fibre to compensate for the chromatic dispersion of an optical path

3.1.3
passive DCF based dispersion compensator
PCDC which constitutes DCF; realised by having chromatic dispersion characteristics of opposite sign to that of the optical path which are controlled the refractive index profile of the fibre

3.1.4
fibre Bragg grating
FBG
fibre type optical device which has periodically modulated refractive index profile in the core along the fibre axis

3.1.5
passive FBG based dispersion compensator
PCDC which constitutes an FBG; PCDC is realised by a chirped FBG which has gradual change in either modulation period or refractive index, or both, along the fibre axis

3.1.6
virtually imaged phased array
VIPA
optical device having a glass plate with a highly reflective mirror

Note 1 to entry: A VIPA has the same functions as a grating.

3.1.7
passive VIPA based dispersion compensator
PCDC consisting of a VIPA, focusing lens and 3-dimensional mirror

Note 1 to entry: PCDC produces both positive and negative chromatic dispersion by the movement of the 3-dimensional mirror to compensate for the chromatic dispersion of an optical path.

3.1.8
etalon
optical cavity which consists of a pair of parallel reflective mirrors

3.1.9
Gires-Tournois etalon
GT etalon
etalon having a highly reflective mirror and a half mirror

Note 1 to entry: The GT etalon is sometimes called a GT interferometer.

3.1.10
passive GT etalon based dispersion compensator
PCDC which comprises a GT etalon

3.2 Performance terms

3.2.1
chromatic dispersion compensation
process by which a specific amount of chromatic dispersion is removed in order to mitigate the system impairment caused by unwanted dispersion

3.2.2
group delay
time by which a pulse is delayed by an optical device

Note 1 to entry: The group delay generally varies with the operating wavelength.

3.2.3
chromatic dispersion
derivative of group delay with respect to wavelength or frequency

Note 1 to entry: A typical unit is ps/nm or ps/GHz. The chromatic dispersion generally varies with the operating wavelength.

Note 2 to entry: The unit of ps/GHz are not commonly used; however, it is suitable for the evaluation of transmission system influence.

3.2.4
dispersion slope
derivative of chromatic dispersion with respect to wavelength or frequency

Note 1 to entry: A typical unit is ps/nm^2 or ps/GHz^2.The unit of ps/GHz^2 is not commonly used; however, it is suitable for the evaluation of transmission system influence.

Note 2 to entry: The dispersion slope generally varies with the operating wavelength.

3.2.5
operating wavelength
nominal wavelength λ at which a passive device operates with the specified performance

Note 1 to entry: Operating wavelength includes the wavelength to be nominally transmitted, attenuated and isolated.

3.2.6
operating wavelength range
specified range of wavelengths including all operating wavelengths

Note 1 to entry: Operating wavelength range shall include all passbands when two or more the passbands are exist.

3.2.7
figure of merit
FoM
ratio of the dispersion to the insertion loss of a PCDC at a particular operating wavelength

3.2.8
passband
wavelength range within which a passive optical device is required to operate with optical attenuation less than or equal to a specified optical attenuation value

Note 1 to entry: There can be one or more passbands for a PCDC.

3.2.9
passband ripple
maximum peak-to-peak variation of insertion loss in the passband

Note 1 to entry: The passband ripple of a PCDC is defined as the maximum passband ripple for all passbands.

3.2.10
group delay ripple
GDR
maximum peak-to-peak variation of the group delay approximated by a desired function of wavelength (or frequency), typically a linear fit, within a channel wavelength (or frequency) range

3.2.11
phase ripple
maximum peak-to-peak variation in measured phase spectrum when compared to a quadratic fit within a channel wavelength (or frequency) range

Note 1 to entry: Phase ripple (unit: radian) is calculated as the product of a peak-to-peak group delay ripple (unit: s) and a period of group delay ripple (unit: Hz). Refer to IEC 61300-3-38.

3.2.12
insertion loss
reduction in optical power between an input and output port of a passive device

Note 1 to entry: expressed in decibels (dB).

Note 2 to entry: insertion loss is expressed as follows:

$$a = -10\log_{10}\frac{P_a}{P_0}$$

where

P_0 is the optical power launched into the input port;

P_a is the optical power received from the output port.

3.2.13
return loss
fraction of input power that is returned from a port of a passive device expressed in decibels

Note 1 to entry: The return loss is defined as follows:

$$RL = -10\log_{10}\frac{P_r}{P_0}$$

where

P_0 is the optical power launched into a port;

P_r is the optical power received back from the same port.

3.2.14
reflectance
ratio of the optical power returning back from a port to input power expressed in %

3.2.15
polarization dependent loss
PDL
maximum variation of insertion loss (attenuation) due to a variation of the state of polarization (SOP) over all the SOPs

3.2.16
wavelength dependent loss
WDL
maximum variation of the insertion loss (attenuation) over operating wavelength range

3.2.17
polarization mode dispersion
PMD
average delay of the travelling time between the two principal states of polarization (PSP), when an optical signal passes through a passive optical device

4 Requirements

4.1 Classification

4.1.1 General

Fibre optic passive chromatic dispersion compensators (PCDCs) are classified either wholly or partially within the following categories:

– technology;
– type;
– wavelength band;
– categories of transmission fibre;
– interface style.

An example of a typical fibre optic PDCS classification is given in Table 1.

Table 1 – Example of a typical fibre optic PDCS classification

Items	Classification
Technology	DCF
Type	Wavelength dispersion compensating
Wavelength band	C-band
Category of transmission fibre	B-652
Interface style	Configuration D Fibre category: IEC 60793-2-50, B-652 IEC 61754-4 (SC connector)

4.1.2 Technology

PCDCs typically use the following technologies:

– dispersion compensating fibre (DCF);
– fibre Bragg grating (FBG);
– Virtual Image Phased Array (VIPA);
– GT etalon.

Each technology of PCDCs is described in Annex A to Annex D.

4.1.3 Types

– Wavelength dispersion compensation;
– Wavelength dispersion slope compensation.

4.1.4 Wavelength band

– O-band;
– S-band;
– C-band;
– L-band;
– C-band and L-band;
– other wavelength band or combination of wavelength bands above.

4.1.5 Application of PDCSs and their suitable technologies

The application of PCDCs and the suitable technologies are summarized in Table 2.

Technology dependent characteristics of PCDCs are summarized in Annex E.

Table 2 – Application, channel numbers, passband and technologies of PDCSs

Applications	Channel number	Passbands	Technologies
TDM (time division multiplexing)	Single channel	Narrow	Dispersion compensating fibre (DCF) Fibre Bragg grating (FBG) GT etalon
WDM (wavelength division multiplexing)	Single channel	Narrow	FBG
	Multi-channel [a)]	Narrow	FBG GT etalon Virtually imaged phased array (VIPA)
		Wide	DCF

a) Multi-channel PCDCs can be used for a single channel use.

4.1.6 Interface style

PCDC style shall be defined based on the following elements:

– the input and output port configuration;
– the connector set type(s), if any.

NOTE Examples of interface style are provided in Annex F.

4.2 Documentation

4.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from IEC 60027 series, IEC 60617 and IEC TR 61930.

4.2.2 Drawings

4.2.2.1 General

The drawings and dimensions given in the relevant specifications shall not restrict detail construction nor be used as manufacturing drawings.

4.2.2.2 Projection system

Either first angle or third angle projection shall be used for the drawings in documents covered by this document. All drawings within a document shall use the same projection system and the drawings shall state which system is used.

4.2.2.3 Dimensional system

All dimensions shall be given in accordance with ISO 129-1 for general information of dimensions and tolerances, ISO 286-1 for tolerances of form, orientation location and run out for information, and ISO 1101 for information interchange. The metric system shall be used in all specifications. Dimensions shall not contain more than five significant digits. When units are converted, a note shall be added in each relevant specification.

4.2.3 Tests and measurements

4.2.3.1 Tests and measurements procedures

The tests and measurements procedures for optical, mechanical, climatic, and environmental characteristics of fibre optic PCDCs to be used shall be defined and selected preferentially from

IEC 61300 series. The size measurement method to be used shall be specified in the relevant IEC 61753 series performance standard or IEC 62005 series reliability standard, for dimensions which are specified within a total tolerance zone of 0,01 mm or less.

4.2.3.2 Reference components

Reference components for measurement purposes, if required, shall be specified in the relevant IEC 61300 basic test and procedure standard.

4.2.4 Test report

The test reports shall be prepared for each test conducted as required by a relevant IEC 61753 series performance standard or IEC 62005 series reliability standard. The reports shall be included in the qualification test report and in the periodic inspection report.

Test reports shall contain the following information as a minimum:

– title and date of test;
– test equipment used;
– all applicable test details;
– all measurement values and observations.

4.2.5 Instructions for use

Instructions for use, when required, shall be given by the manufacturer.

4.3 Standardisation system

4.3.1 Interface standards

Refer to the proper optical connector interface of the IEC 61754 series when an optical connector is used.

4.3.2 Performance standards

Performance standards (IEC 61753 series) contain a series of tests and measurements (which can be grouped into a specified schedule depending on the requirements of that standards) with clearly defined conditions, severities, and pass/fail criteria. The tests are intended to be run on a one-off basis to prove the ability of any product to satisfy the performance standards requirement. Each performance standard has a different set of tests severities, and groupings, representing the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance and quality conformance programme.

4.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

4.4 Design and construction

4.4.1 Materials

4.4.1.1 General

All housing materials used in the construction shall be manufactured with materials which meet the requirements of the relevant IEC 61753 performance standard or IEC 62005 reliability standard.

4.4.1.2 Non-flammable materials

When non-flammable materials are required, the requirements shall be specified, and reference shall be made to IEC 60695-11-5. If an alternate standard is used for non-flammable materials, it shall be declared.

4.4.2 Workmanship

Components and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs, or other defects that would affect life, service ability or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

4.5 Quality

Fibre optic PCDCs shall be controlled by the quality assessment procedures and declared.

4.6 Performance requirements

Fibre optic PCDCs shall meet the performance requirements specified in the relevant IEC 61753 performance standard or IEC 62005 reliability standard.

4.7 Identification and marking

4.7.1 General

Components, associated hardware and shipping packages shall be permanently and legibly identified and marked when required by the relevant IEC 61753 performance standard or IEC 62005 reliability standard.

4.7.2 Component marking

Component marking, if required, should be specified in the relevant IEC 61753 performance standard or IEC 62005 reliability standard. The preferred order of marking is:

a) port identification;

b) manufacturer's part number (including serial number, if applicable);

c) manufacturer's identification mark or logo.

If space does not allow for all the required marking on the component, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

4.7.3 Package marking

Several devices may be packaged together for shipment.

Package marking, if required, shall be specified in the relevant IEC 61753 performance standard or IEC 62005 reliability standard. The preferred order of marking is:

a) manufacturer's identification mark or logo;

b) manufacturer's part number.

When applicable, individual unit packages (within the sealed package) should be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

4.8 Packaging

Packaging shall be securely without any damage to passive optical components during transportation and storage.

Packages shall include instructions for use when required by the relevant IEC 61753 performance standard or IEC 62005 reliability standard (see 4.2.5).

4.9 Storage conditions

Where short-term degradable materials, such as adhesives, are supplied with the package, the manufacturer shall mark these with the expiry date according to ISO 8601-1 together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

4.10 Safety

Fibre optic PCDCs, when used on an optical fibre transmission system and/or equipment, can emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end.

The fibre optic PCDC manufacturers shall provide sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

In addition, each relevant IEC 61753 performance standard or IEC 62005 reliability standard shall include the following:

WARNING – Care should be taken when handling small diameter fibre to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre or an optical fibre connector when it is propagating energy is not recommended, unless prior assurance has been obtained as to the safety energy output level.

Annex A
(informative)

Example of dispersion compensating fibre (DCF) technologies

Chromatic dispersion in optical fibre is expressed as the sum of material dispersion caused by wavelength dependence of the refractive index of the glass materials and waveguide dispersion caused by index profile of optical fibre (Figure A.1). Silica glass optical fibre material dispersion does not vary greatly. Waveguide dispersion can be controlled by changing the index profile of the optical fibre. DCFs are designed to control waveguide dispersion to achieve the desired dispersion characteristics.

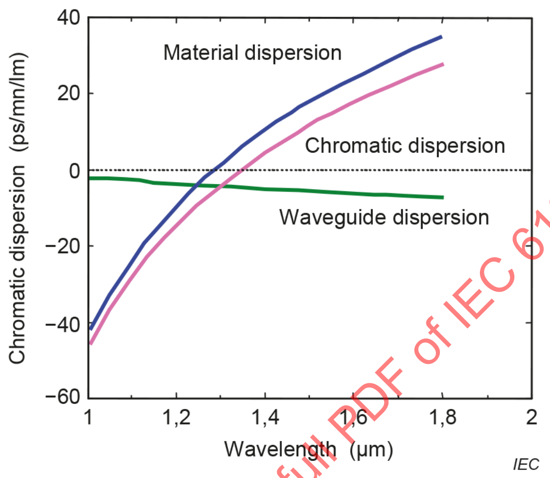


Figure A.1 – Chromatic dispersion in a standard single-mode optical fibre (SMF)

Figure A.2 shows the contour for different dispersions at a wavelength of 1,55 μm as a function of the refractive index contrast, Δ, from a pure silica cladding index value level and core diameter in a step-index profile with the germanium-doped silica core. From this figure, a DCF with a large negative chromatic dispersion can be obtained by increasing Δ and decreasing the diameter of the core.

NOTE Δ is the relative index contrast. Refer IEC IEV 731-02-20.

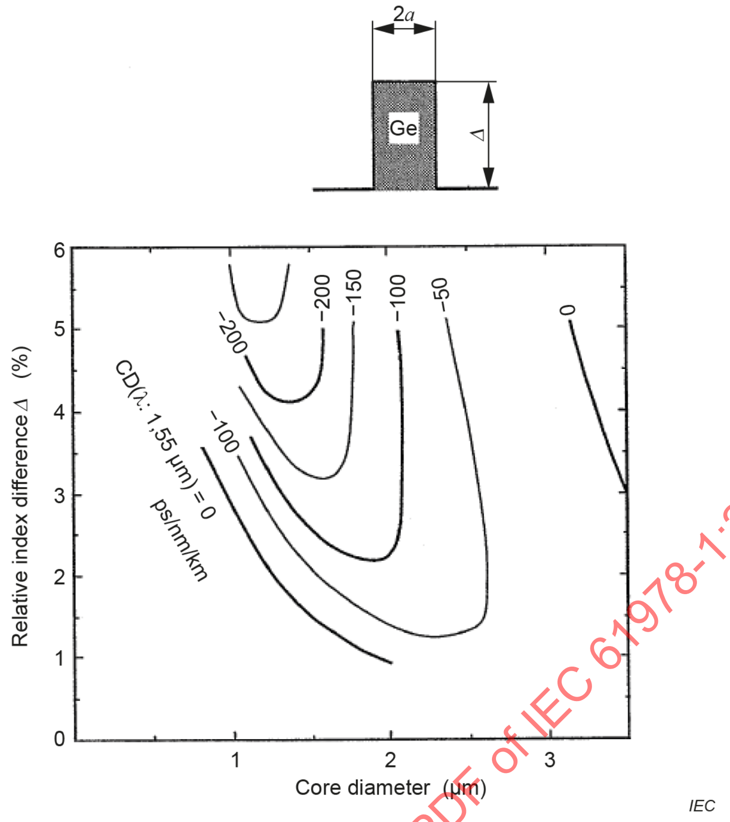
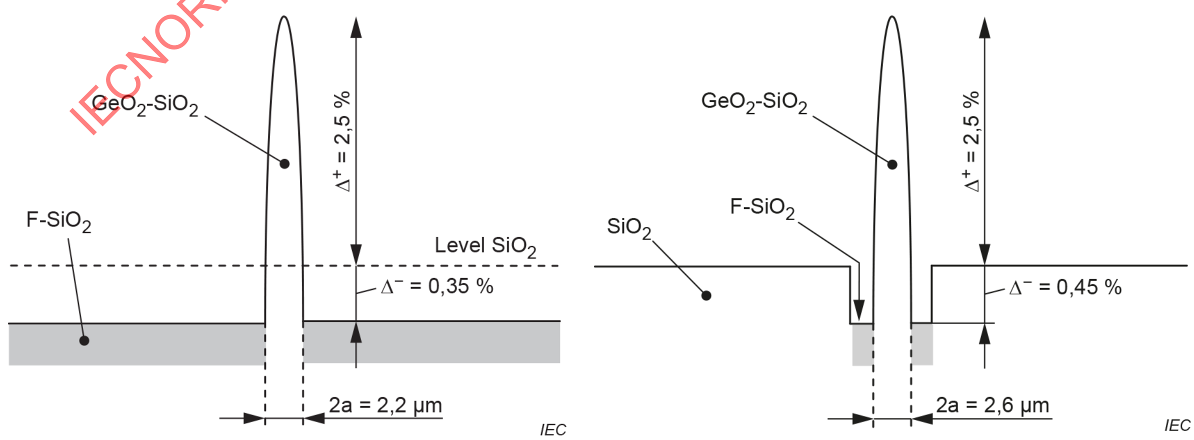


Figure A.2 – Calculated contour for different dispersion at the wavelength of 1,55 μm [CD(λ:1,55 μm)] for a step index core fibre

Figure A.3 shows two examples of refractive index profiles of DCFs. The refractive index contrast between the core and the cladding is larger and the core diameter is smaller than those of standard single-mode fibres. These design differences result in larger waveguide dispersion. As for the double-cladding type DCF, much larger waveguide dispersion can be obtained than in the case of the matched cladding type DCF.

Double cladding type DCF can give negative dispersion slope in C-band and/or L-band. Because of this, the positive dispersion slope of SMFs (IEC 60793-2-50, B1 fibres) can be compensated by using this type of DCF. Dispersion slope compensation is important to achieve a uniform dispersion value over the wavelength range of a WDM transmission system.



a) Matched cladding type **b) Double cladding type**

Figure A.3 – Examples of refractive index profile used in DCF

Annex B
(informative)

Example of fibre Bragg grating (FBG) technologies

Fibre Bragg grating (FBG) is a fibre type optical device that has a modulated refractive index profile in the core along the longitudinal axis. A FBG functions as a reflective filter where reflection wavelength is defined in Formula (B.1). Generally, refractive index modulation is generated by using UV radiation induced refractive index change.

$$\lambda_B = 2 \times \Lambda \times n_{eff} \tag{B.1}$$

where

λ_B is the reflection wavelength (Bragg wavelength);

Λ is the refractive index modulation period;

n_{eff} is the effective refractive index.

The basic principle of dispersion compensation using a chirped FBG is shown in Figure B.1. In chirped FBG, either the grating period or effective refractive index, or both, are gradually changed, and reflection wavelength changes along the fibre axis. After travelling through the transport fibre, the signal experiences a positive chromatic dispersion so that its shorter-wavelength part arrives before its longer-wavelength part. The chirped FBG provides more group delay for the shorter-wavelength part of the signal thus compensating for the effect of the chromatic dispersion. The slope of the group delay spectrum corresponds to the dispersion the FBG provides. To conveniently access the output signal, an optical circulator is used.

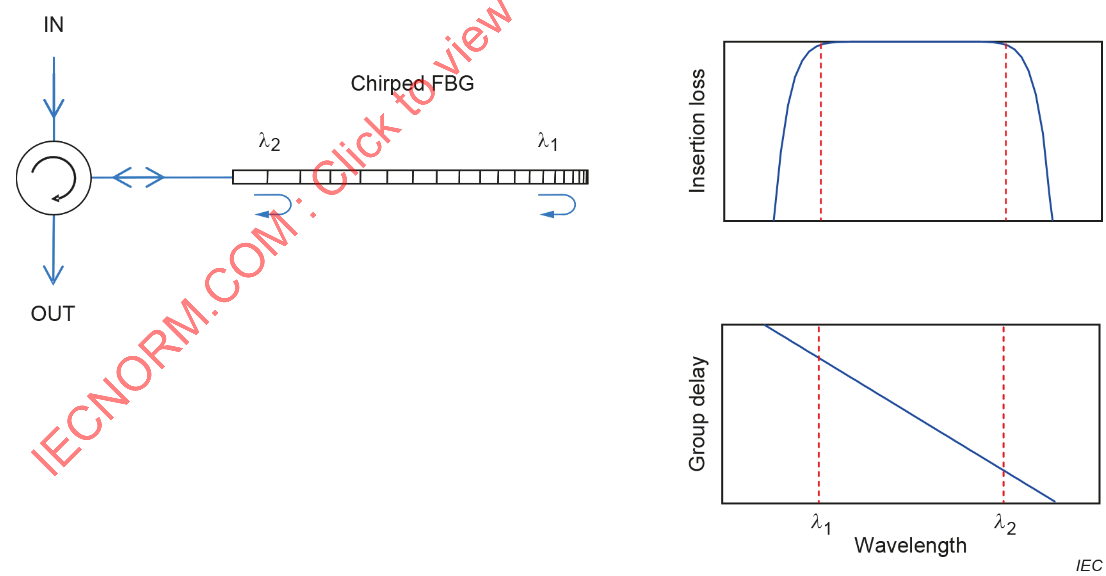
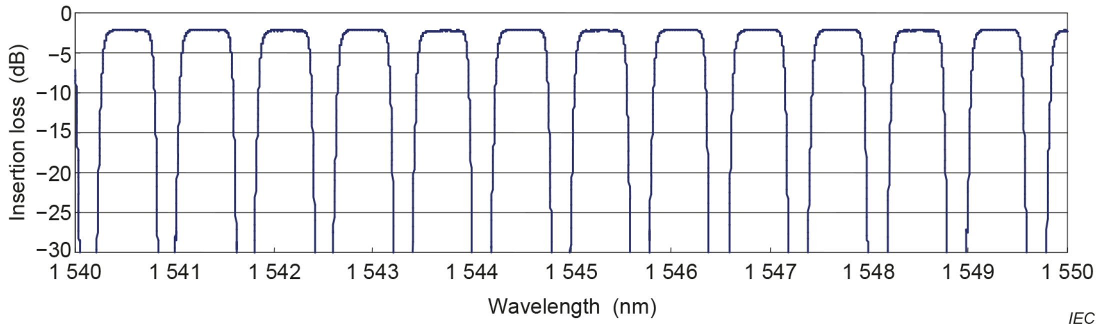
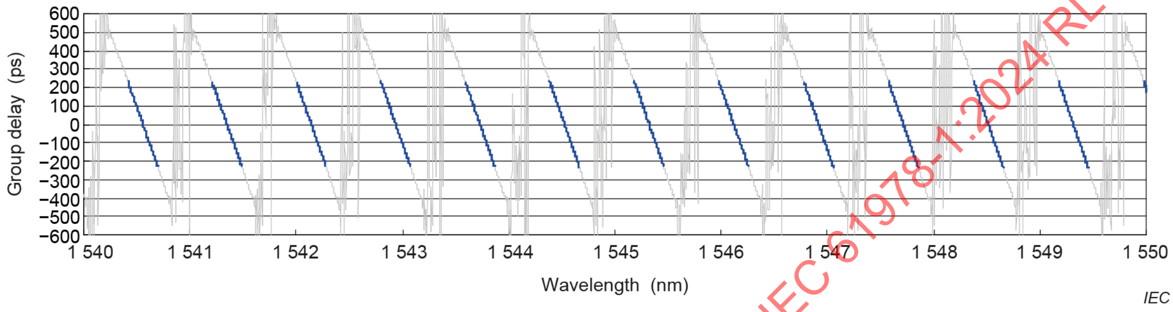


Figure B.1 – Illustration of the use of a chirped fibre Bragg grating for chromatic dispersion compensation

The FBG can be made multi-channel, allowing for a simultaneous compensation of the chromatic dispersion accumulated in all channels of a WDM system. The multi-channel character of the FBG is typically obtained through a sampling approach, i.e. a spatial modulation of its physical properties. As an example, Figure B.2 shows an expanded view over 10 nm of the spectral characteristics of a multi-channels FBG tailored for compensating the chromatic dispersion accumulated over 100 km of single-mode fibre, specified in IEC 60793-2-50, category B1.



a) Insertion loss (attenuation) including the optical circulator



b) Group delay spectrum

Figure B.2 – Expanded view over 10 nm of the insertion loss (attenuation) spectrum of a multi-channel FBG

Annex C
(informative)

Example of virtually imaged phased array (VIPA) technologies

Figure C.1 shows the structure of a virtually imaged phased array (VIPA). The input light from a single-mode fibre is line-focused into a glass plate. The glass plate is coated on both surfaces and collimated light is emitted from the reverse side of the glass plate after multiple reflections between the coated surfaces. The light from the glass plate is then focused onto a curved mirror. The reflected light travels back to the glass plate and is finally coupled back into the fibre.

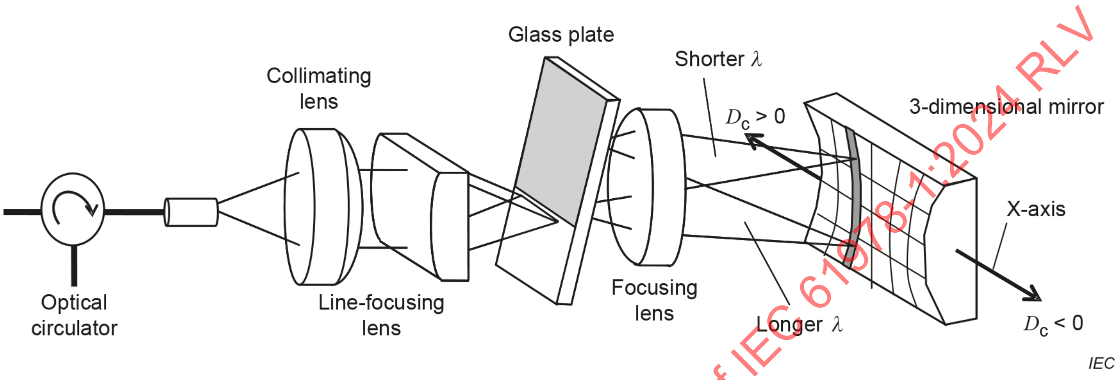


Figure C.1 – Structure of virtually imaged phased array (VIPA)

Figure C.2 shows the detailed light path. Each time that the light is reflected at the right-angle surface of the glass plate, a small percentage of the power passes through the partially reflecting coating. This creates multiple beams that diverge from the corresponding beam waist in the virtual image. The interference of these diverging beams generates collimated light. This collimated light travels at an angle from the optical axis which varies with the wavelength. Chromatic dispersion, i.e. the wavelength dependence of distance travelled, is determined by the wavelength dependence of the pointing angle of collimated light from the glass plate and the surface profile of the reflection mirror. The convex portion of the mirror produces negative chromatic dispersion, and the concave portion of the mirror produces positive chromatic dispersion. Figure C.1 shows that the collimated light (grey line area on the surface of the 3-D mirror) reflects along the concave mirror surface which produces positive chromatic dispersion. By shifting the position of the 3-D mirror along the X-axis, the collimated light can also reflect off the convex mirror surface, which produces negative chromatic dispersion. If the surface profile of the 3-D mirror is designed such that the curvature of the mirror's surface is gradually changed along the X-axis, the chromatic dispersion can be readily changed by shifting the 3-D mirror's position along the X-axis.

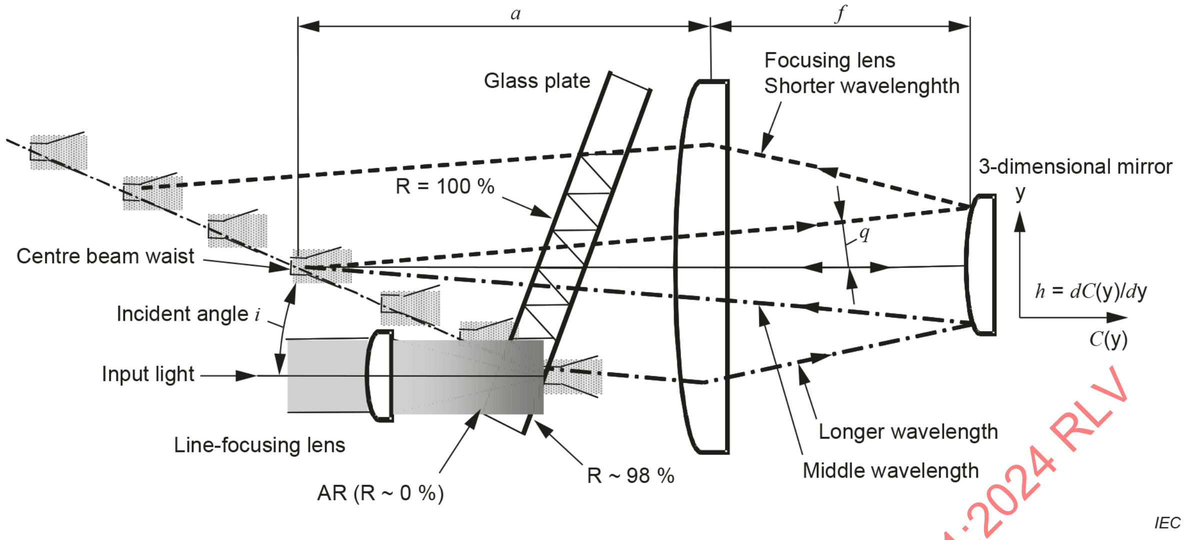


Figure C.2 – Detailed light path and mechanism of generating chromatic dispersion

Annex D
(informative)

Example of GT etalon technologies

An etalon is an optical cavity which consists of a pair of parallel reflective mirrors. Multiple reflection interference between two mirrors gives cyclic spectrum and dispersion characteristics. The period of cyclic spectrum is called free spectral range (FSR). Operating wavelength and FSR can be adjusted by changing optical distance between the two mirrors.

There are mainly two types of etalons: Fabry-Perot (FP) etalon and Gires-Tournois (GT) etalon. The GT etalon (Figure D.1) is suitable for dispersion compensation. The GT etalon is an optical cavity that consists of mirrors having different reflectivity. Generally, the front mirror has low reflectivity and rear mirror has high reflectivity. In this case, the reflection power spectrum is relatively smooth, although the phase of the reflected light depends strongly on the wavelength. Using a multiple cavity etalon with optimized design, higher order dispersion can be compensated. Sometimes a GT etalon is called a GT interferometer.

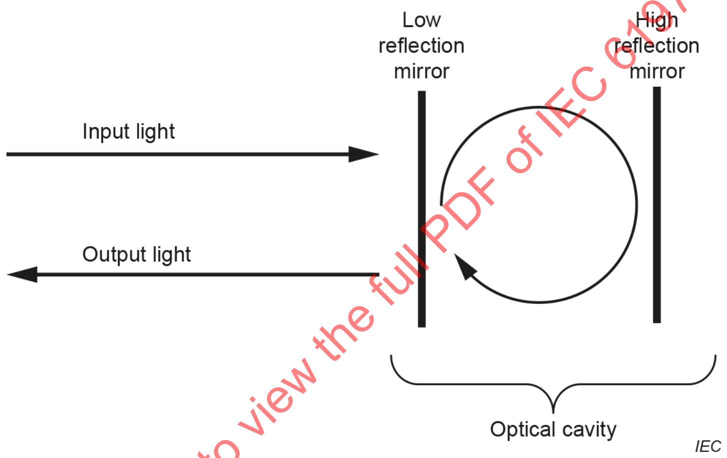


Figure D.1 – Gires-Tournois etalon

Annex E
(informative)

Technology dependent characteristics of PCDCs

As described in Annex A to Annex D, primarily, four technologies are used for PCDCs. Table E.1 shows the summary of technology-dependent characteristics of PCDCs.

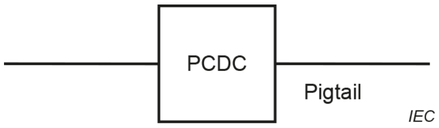
Table E.1 – Summary of technology dependent characteristics of PCDCs

	DCF	FBG	VIPA	Etalon
Passband	Wide	Relatively narrow	Narrow/periodical	Narrow/periodical or wide
GDR period	No GDR	Typically approx. 10 pm	Typically approx. 2 pm	Typically approx. 30 pm
Loss dependency on dispersion	Yes	No	No	No
Non linearity	Yes	No	No	No
Tuneable function	No	Yes	Yes	Yes

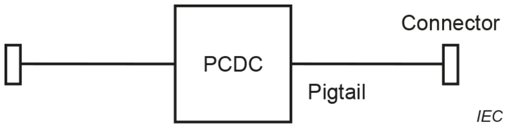
Annex F
(informative)

Example of interface style

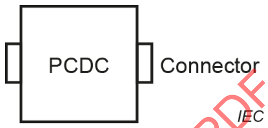
The four examples of interface style for fibre optic PDCSs are shown in Figure F.1 a) to Figure F.1 d).



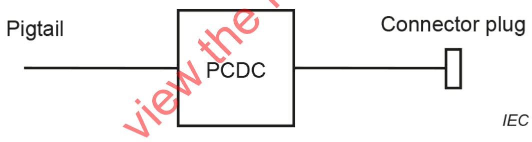
a) Configuration A – Device integral fibre pigtails without a connector



b) Configuration B – Device containing integral fibre optic pigtails with a connector plug on each port



c) Configuration C – Device containing connector receptacles as an integral port of the device housing



d) Configuration D – Example – Device containing some combination of the interfacing feature of the preceding configurations

Figure F.1 – Examples of interface style for fibre optic PCDCs

Bibliography

IEC 60068 (all parts), *Environmental testing*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

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

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60869-1, *Fibre optic interconnecting devices and passive components – Fibre optic passive power control devices – Part 1: Generic specification*

IEC 60874 (all parts), *Fibre optic interconnecting devices and passive components – Connectors for optical fibres and cables*

IEC 60974 (all parts), *Arc welding equipment*

IEC 61073-1, *Fibre optic interconnecting devices and passive components – Mechanical splices and fusion splice protectors for optical fibres and cables – Part 1: Generic specification*

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-2 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2: Tests*

IEC 61300-3 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3: Examinations and measurements*

IEC 61300-3-38, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-38: Examinations and measurements – Group delay, chromatic dispersion and phase ripple*

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC 61754 (all parts), *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces*

IEC 61754-4, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 4: Type SC connector family*

IEC 61754-13, *Fibre optic connector interfaces – Part 13: Type FC-PC connector*

IEC 61754-15, *Fibre optic interconnecting devices and passive components – Fibre optic connector interfaces – Part 15: Type LSH connector family*

IEC TR 61931, *Fibre optic – Terminology*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

____

DISPOSITIFS D’INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – COMPENSATEURS DE DISPERSION CHROMATIQUE PASSIFS FIBRONIQUES –

Partie 1: Spécification générique

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l’ensemble des comités électrotechniques nationaux (Comités nationaux de l’IEC). L’IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l’électricité et de l’électronique. À cet effet, l’IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l’IEC"). Leur élaboration est confiée à des comités d’études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l’IEC, participent également aux travaux. L’IEC collabore étroitement avec l’Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l’IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l’IEC intéressés sont représentés dans chaque comité d’études.
3) Les Publications de l’IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l’IEC. Tous les efforts raisonnables sont entrepris afin que l’IEC s’assure de l’exactitude du contenu technique de ses publications; l’IEC ne peut pas être tenue responsable de l’éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d’encourager l’uniformité internationale, les Comités nationaux de l’IEC s’engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l’IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l’IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L’IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d’évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l’IEC. L’IEC n’est responsable d’aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s’assurer qu’ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l’IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d’études et des Comités nationaux de l’IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l’utilisation de cette Publication de l’IEC ou de toute autre Publication de l’IEC, ou au crédit qui lui est accordé.
8) L’attention est attirée sur les références normatives citées dans cette publication. L’utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L’IEC attire l’attention sur le fait que la mise en application du présent document peut entraîner l’utilisation d’un ou de plusieurs brevets. L’IEC ne prend pas position quant à la preuve, à la validité et à l’applicabilité de tout droit de propriété revendiqué à cet égard. À la date de publication du présent document, l’IEC [avait/n’avait pas] reçu notification qu’un ou plusieurs brevets pouvaient être nécessaires à sa mise en application. Toutefois, il y a lieu d’avertir les responsables de la mise en application du présent document que des informations plus récentes sont susceptibles de figurer dans la base de données de brevets, disponible à l’adresse https://patents.iec.ch. L’IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevet.

L’IEC 61978-1 a été établie par le sous-comité 86B: Dispositifs d’interconnexion et composants passifs à fibres optiques, du comité d’études 86 de l’IEC: Fibres optiques. Il s’agit d’une Norme internationale.

Cette quatrième édition annule et remplace la troisième édition parue en 2014. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) harmonisation des termes et définitions avec l'IEC TS 62627-09;
b) modification de l'Article 4 concernant les exigences.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
86B/4866/FDIS	86B/4901/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 61978, publiées sous le titre général *Dispositifs d'interconnexion et composants passifs fibroniques – Compensateurs de dispersion chromatique passifs fibroniques*, se trouve sur le site Web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site Web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé, ou
- révisé.

IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture de ce document indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

DISPOSITIFS D'INTERCONNEXION ET COMPOSANTS PASSIFS FIBRONIQUES – COMPENSATEURS DE DISPERSION CHROMATIQUE PASSIFS FIBRONIQUES –

Partie 1: Spécification générique

1 Domaine d'application

La présente partie de l'IEC 61978 s'applique aux compensateurs de dispersion chromatique passifs fibroniques qui présentent les caractéristiques suivantes:

– ils sont passifs au niveau optique;

– ils possèdent une entrée optique et une sortie optique pour la transmission de la puissance optique;

– les ports sont des fibres optiques ou des connecteurs optiques;

– ils sont sensibles aux longueurs d'onde;

– ils peuvent être sensibles à la polarisation.

Le présent document établit des exigences uniformes pour les compensateurs de dispersion chromatique passifs.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027 (toutes les parties), *Symboles littéraux à utiliser en électrotechnique*

IEC 60050-731, *Vocabulaire Électrotechnique International – Chapitre 731: Télécommunications par fibres optiques*

IEC 60617 (toutes les parties), *Symboles graphiques pour schémas*

IEC 61300 (toutes les parties), *Dispositifs d'interconnexion et composants passifs fibroniques – Procédures fondamentales d'essais et de mesures*

IEC 61753 (toutes les parties), *Dispositifs d'interconnexion et composants passifs fibroniques – Norme de performance*

IEC TR 61930, *Symbologie des graphiques de fibres optiques*

IEC 62005 (toutes les parties), *Dispositifs d'interconnexion et composants passifs à fibres optiques - Fiabilité*

IEC TS 62627-09, *Fibre optic interconnecting devices and passive components – Vocabulary for passive optical devices* (disponible en anglais seulement)

ISO 129-1, *Documentation technique de produits – Représentation des dimensions et tolérances – Partie 1: Principes généraux*

ISO 1101, *Spécification géométrique des produits (GPS) – Tolérancement géométrique – Tolérancement de forme, orientation, position et battement*

ISO 8601-1, *Date et heure – Représentations pour l'échange d'information – Partie 1: Règles de base*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60050-731 et de l'IEC TS 62627-09 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

3.1 Termes concernant les composants

3.1.1
compensateur de dispersion chromatique passif
PCDC
dispositif passif à deux ports alignés utilisé pour réaliser une compensation de dispersion chromatique

Note 1 à l'article: Les PCDC sont couramment utilisés pour compenser la dispersion chromatique d'un trajet optique en ajoutant la dispersion chromatique de signe opposé.

Note 2 à l'article: Les trajets optiques types comportent des fibres unimodales, des fibres à dispersion décalée et/ou des fibres à dispersion décalée non nulle. Les PCDC présentent des valeurs de dispersion chromatique négatives ou positives en fonction du signe de dispersion chromatique du trajet optique.

Note 3 à l'article: L'abréviation "PCDC" est dérivée du terme anglais développé correspondant "Passive Chromatic Dispersion Compensator".

[SOURCE: IEC TS 62627-09:2016, 3.3.17]

3.1.2
fibre de compensation de dispersion
DCF
fibre spéciale destinée à compenser la dispersion chromatique d'un trajet optique

Note 1 à l'article: L'abréviation "DCF" est dérivée du terme anglais développé correspondant "Dispersion Compensating Fibre".

3.1.3
compensateur de dispersion passif basé sur DCF
Le PCDC est réalisé par l'obtention de caractéristiques de dispersion chromatique de signe opposé à celle du trajet optique, qui sont obtenues par le profil d'indice de réfraction de la fibre

3.1.4
réseau de Bragg sur fibre
FBG
dispositif optique de type fibre disposant d'un profil d'indice de réfraction modulé périodiquement au niveau du cœur, le long de l'axe de la fibre

Note 1 à l'article: L'abréviation "FBG" est dérivée du terme anglais développé correspondant "Fibre Bragg Grating".

3.1.5
compensateur de dispersion passif basé sur FBG
Le PCDC est réalisé par un FBG à pas variable dont la période de modulation ou l'indice de réfraction, ou les deux, varient progressivement le long de l'axe de la fibre

3.1.6
réseau de phase à images virtuelles
VIPA
dispositif optique constitué d'une lame de verre avec un miroir à haute réflexion

Note 1 à l'article: Un VIPA a les mêmes fonctions qu'un réseau.

Note 2 à l'article: L'abréviation "VIPA" est dérivée du terme anglais développé correspondant "Virtually Imaged Phased Array".

3.1.7
compensateur de dispersion passif basé sur VIPA
PCDC constitué d'un VIPA, d'une lentille de focalisation et d'un miroir à trois dimensions

Note 1 à l'article: Un PCDC génère une dispersion chromatique positive et négative par le déplacement du miroir à trois dimensions, permettant ainsi de compenser la dispersion chromatique d'un trajet optique.

3.1.8
étalon
cavité optique constituée d'une paire de miroirs réfléchissants parallèles

3.1.9
étalon Gires-Tournois
étalon GT
étalon constitué d'un miroir à haute réflexion et d'un demi-miroir

Note 1 à l'article: L'étalon GT est parfois appelé interféromètre GT.

3.1.10
compensateur de dispersion passif basé sur étalon GT
PCDC comportant un étalon GT

3.2 Termes concernant les performances

3.2.1
compensation de dispersion chromatique
procédé par lequel une quantité spécifique de dispersion chromatique est éliminée afin de limiter la dégradation du système du fait de dispersions non désirées

3.2.2
temps de propagation de groupe
temps par lequel une impulsion est retardée par un dispositif optique

Note 1 à l'article: Le temps de propagation de groupe varie généralement avec la longueur d'onde de fonctionnement.

3.2.3
dispersion chromatique
dérivée du temps de propagation de groupe par rapport à la longueur d'onde ou la fréquence

Note 1 à l'article: L'unité type est exprimée en ps/nm ou ps/GHz. La dispersion chromatique varie généralement avec la longueur d'onde de fonctionnement.

Note 2 à l'article: L'unité ps/GHz n'est pas couramment utilisée; elle est néanmoins adaptée à l'évaluation de l'influence du système de transmission.

3.2.4
pente de dispersion
dérivée de la dispersion chromatique par rapport à la longueur d'onde ou la fréquence

Note 1 à l'article: L'unité type est exprimée en ps/nm^2 ou ps/GHz^2. L'unité ps/GHz^2 n'est pas couramment utilisée; elle est néanmoins adaptée à l'évaluation de l'influence du système de transmission.

Note 2 à l'article: La pente de dispersion varie généralement avec la longueur d'onde de fonctionnement.

3.2.5
longueur d'onde de fonctionnement
longueur d'onde nominale λ à laquelle fonctionne un dispositif passif avec les performances spécifiées

Note 1 à l'article: La longueur d'onde de fonctionnement consiste en la longueur d'onde à transmettre nominalement, affaiblie et isolée.

3.2.6
plage de longueurs d'onde de fonctionnement
plage de longueurs d'onde spécifiée contenant toutes les longueurs d'onde de fonctionnement

Note 1 à l'article: La plage de longueurs d'onde de fonctionnement doit comprendre toutes les bandes passantes lorsqu'il existe au moins deux bandes passantes.

3.2.7
facteur de mérite
FoM
rapport de la dispersion à la perte d'insertion d'un PCDC à une longueur d'onde de fonctionnement particulière

Note 1 à l'article: L'abréviation "FoM" est dérivée du terme anglais développé correspondant "Figure of Merit".

3.2.8
bande passante
plage de longueurs d'onde dans laquelle il est exigé qu'un dispositif optique passif fonctionne avec un affaiblissement optique inférieur ou égal à une valeur d'affaiblissement optique spécifiée

Note 1 à l'article: Il peut y avoir une ou plusieurs bandes passantes pour un PCDC.

3.2.9
ondulation de la bande passante
variation crête à crête maximale de la perte d'insertion dans la bande passante

Note 1 à l'article: L'ondulation de la bande passante d'un PCDC est définie comme l'ondulation maximale de la bande passante, pour toutes les bandes passantes.

3.2.10
ondulation du temps de propagation de groupe
GDR
variation crête à crête maximale du temps de propagation de groupe, approchée par une fonction souhaitée en fonction de la longueur d'onde (ou de la fréquence), généralement une approximation linéaire, dans une plage de longueurs d'onde (ou de fréquences) du canal

Note 1 à l'article: L'abréviation "GDR" est dérivée du terme anglais développé correspondant "Group Delay Ripple".

3.2.11
ondulation de phase
variation crête à crête maximale dans le spectre de phase mesuré, lors d'une comparaison avec une interpolation quadratique dans une plage de longueurs d'onde (ou de fréquences)

Note 1 à l'article: L'ondulation de phase (unité: radian) est calculée comme le produit d'une ondulation du temps de propagation de groupe crête à crête (unité: s) et d'une période d'ondulation du temps de propagation de groupe (unité: Hz). Voir l'IEC 61300-3-38.

3.2.12
perte d'insertion
réduction de la puissance optique entre un port d'entrée et un port de sortie d'un dispositif passif

Note 1 à l'article: La perte d'insertion est exprimée en décibels (dB).

Note 2 à l'article: La perte d'insertion est exprimée comme suit:

$$a = -10\log_{10}\frac{P_a}{P_0}$$

où

P_0 est la puissance optique injectée dans le port d'entrée;

P_a est la puissance optique reçue du port de sortie.

3.2.13
affaiblissement de réflexion
fraction de la puissance d'entrée qui est réfléchie par un port d'un dispositif passif, exprimée en décibels

Note 1 à l'article: L'affaiblissement de réflexion est défini comme suit:

$$RL = -10\log_{10}\frac{P_r}{P_0}$$

où

P_0 est la puissance optique injectée au niveau d'un port;

P_r est la puissance optique réfléchie par ce même port.

3.2.14
réflectance
rapport de la puissance optique réfléchie par un port sur la puissance d'entrée, exprimée en %

3.2.15
perte dépendant de la polarisation
PDL
variation maximale de la perte d'insertion (affaiblissement) due à une variation de l'état de polarisation (SOP, State Of Polarization) sur tous les SOP

Note 1 à l'article: L'abréviation "PDL" est dérivée du terme anglais développé correspondant "Polarization Dependent Loss".

3.2.16
perte dépendant de la longueur d'onde
WDL
variation maximale de la perte d'insertion (affaiblissement) sur la plage de longueurs d'onde de fonctionnement

Note 1 à l'article: L'abréviation "WDL" est dérivée du terme anglais développé correspondant "Wavelength Dependent Loss".

3.2.17
dispersion de mode de polarisation
PMD
temps moyen de passage entre les deux états de polarisation principaux (PSP, Principal State of Polarization), lorsqu'un signal optique traverse un dispositif optique passif

Note 1 à l'article: L'abréviation "PMD" est dérivée du terme anglais développé correspondant "Polarization Mode Dispersion".

4 Exigences

4.1 Classification

4.1.1 Généralités

Les compensateurs de dispersion chromatique passifs fibroniques (PCDC) sont classés selon les critères suivants, soit dans leur intégralité, soit en partie:

– Technologie;
– type;
– bande de longueurs d'onde;
– catégorie de fibre de transmission;
– modèle d'interface.

Un exemple de classification type de PCDC fibronique est donné dans le Tableau 1.

Tableau 1 – Exemple de classification type de PCDC fibronique

Critère	Classification
Technologie	DCF
Type	Compensation de la dispersion de longueur d'onde
Bande de longueurs d'onde	Bande C
Catégorie de fibre de transmission	B-652
Modèle d'interface	Configuration D Catégorie de fibre: IEC 60793-2-50, B-652 IEC 61754-4 (connecteur de type SC)

4.1.2 Technologie

Les PCDC utilisent généralement les technologies suivantes:

– fibre de compensation de dispersion (DCF);
– réseau de Bragg sur fibre (FBG);
– réseau de phase à images virtuelles (VIPA);
– étalon GT.

Chaque technologie de PCDC est décrite dans les annexes, de l'Annexe A à l'Annexe D.

4.1.3 Types

– Compensation de la dispersion de longueur d'onde
– Compensation de pente de dispersion de longueur d'onde

4.1.4 Bande de longueurs d'onde

– Bande O
– Bande S
– Bande C
– Bande L
– Bande C et bande L
– Autre bande de longueurs d'onde, ou combinaison de bandes de longueurs d'onde ci-dessus

4.1.5 Application des PCDC et de leurs technologies appropriées

L'application des PCDC et des technologies appropriées est résumée dans le Tableau 2.

Les caractéristiques liées à la technologie des PCDC sont résumées dans l'Annexe E.

Tableau 2 – Application, nombre de canaux, bande passante et technologies des PCDC

Applications	Nombre de canaux	Bande passante	Technologies
Multiplexage par répartition dans le temps (TDM, Time Division Multiplexing)	Monocanal	Étroite	Fibre de compensation de dispersion (DCF) Réseau de Bragg sur fibre (FBG) Étalon GT
Multiplexage par répartition en longueur d'onde (MRL)	Monocanal	Étroite	FBG
	Multicanal [a]	Étroite	FBG Étalon GT Réseau de phase à images virtuelles (VIPA)
		Large	DCF
[a] Un PCDC multicanal peut être utilisé pour un seul canal.			

4.1.6 Modèle d'interface

Le modèle du PCDC doit être défini sur la base des éléments suivants:

– la configuration du port d'entrée et du port de sortie;
– le ou les types de jeux de connecteurs, le cas échéant.

NOTE Des exemples de modèle d'interface sont donnés à l'Annexe F.

4.2 Documentation

4.2.1 Symboles

Les symboles graphiques et littéraux doivent, dans la mesure du possible, être issus de la série IEC 60027, de l'IEC 60617 et de l'IEC TR 61930.

4.2.2 Dessins

4.2.2.1 Généralités

Les schémas et les dimensions indiqués dans les spécifications applicables ne doivent ni réduire les détails de construction, ni être utilisés en tant que schémas de fabrication.