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)

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 It also gives information on projects, replaced and withdrawn publications.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.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 33.180.01

ISBN 978-2-8322-8702-6

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