



BSI Standards Publication

# Fibre optic communication system design guidelines

---

Part 5: Accommodation and compensation of chromatic dispersion

## National foreword

This Published Document is the UK implementation of IEC TR 61282-5:2019. It supersedes PD IEC TR 61282-5:2002, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/86/3, Fibre optic systems and active devices.

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

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

© The British Standards Institution 2019  
Published by BSI Standards Limited 2019

ISBN 978 0 539 01119 7

ICS 33.180.01

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 July 2019.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---



# TECHNICAL REPORT

---

**Fibre optic communication system design guidelines –  
Part 5: Accommodation and compensation of chromatic dispersion**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 33.180.01

ISBN 978-2-8322-7131-5

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD .....	4
1 Scope .....	6
2 Normative references .....	6
3 Terms, definitions and abbreviated terms .....	6
3.1 Terms and definitions.....	6
3.2 Abbreviated terms.....	6
4 Background .....	7
5 Impact of chromatic dispersion .....	8
5.1 Dependence on fibre type .....	8
5.2 Dispersion-unshifted fibres .....	8
5.3 Dispersion-shifted fibres .....	10
5.4 Pulse broadening .....	11
5.5 Pulse narrowing and signal peaking .....	13
5.6 Dispersion-limited transmission distance.....	14
6 Compensation and accommodation of dispersion .....	16
6.1 Passive dispersion compensation along the optical path .....	16
6.1.1 General .....	16
6.1.2 Dispersion compensating fibre.....	16
6.1.3 Chirped fibre Bragg grating.....	17
6.1.4 Etalon filter .....	18
6.2 Dispersion management .....	18
6.3 Accommodation of dispersion .....	20
6.4 Pre-distortion of the transmitted signal.....	20
6.5 Electrical accommodation in the receiver .....	21
6.6 Dispersion-assisted transmission.....	22
6.7 Mid-span spectral inversion .....	23
7 Passive dispersion compensator parameters .....	24
7.1 Compensated fibre length .....	24
7.2 Operating wavelength range .....	24
7.3 Chromatic dispersion .....	24
7.4 Dispersion slope .....	25
7.5 Insertion loss .....	25
7.6 Wavelength-dependent loss .....	25
7.7 Phase ripple.....	26
7.8 Reflectance.....	26
7.9 Polarization-mode dispersion .....	26
7.10 Polarization-dependent loss.....	27
7.11 Optical nonlinearity .....	27
7.12 Latency.....	27
8 Passive dispersion compensator applications .....	28
8.1 Unamplified fibre spans .....	28
8.2 Fibre links with in-line optical amplifiers .....	28
8.3 Multi-channel WDM transmission systems.....	29
8.4 Hybrid transmission systems.....	30
8.5 Multi-band WDM transmission systems .....	30

9 System parameters for passive dispersion compensators .....	30
Bibliography.....	32
Figure 1 – Range of the dispersion coefficient for B-652.D fibres .....	9
Figure 2 – Distortions in a 10 Gbit/s NRZ signal at various amounts of CD .....	14
Figure 3 – Summing the dispersions of a B-652 fibre and a DCF over the C-band.....	17
Figure 4 – Reflectivity and time delay of an FBG-based PDC .....	18
Figure 5 – Periodic dispersion map with span-by-span compensation .....	19
Figure 6 – Transmitter for generating pre-compensated optical signals .....	21
Figure 7 – Coherent optical receiver with electrical CD post-compensation .....	22
Figure 8 – Spectral inversion of a modulated signal via four-wave mixing .....	23
Figure 9 – Passive dispersion compensators placed at the receiver .....	28
Figure 10– PDCs placed before optical booster amplifiers at the transmitter .....	28
Figure 11 – PDCs placed after pre-amplifiers at the receiver.....	28
Figure 12 – Optically amplified link with in-line PDCs .....	29
Figure 13 – Optically amplified WDM communication link with in-line PDCs .....	29
Figure 14 – WDM link with individual compensation of residual dispersion .....	30
Figure 15 – Two-band WDM link with OA and PDC in the C-band .....	30
Table 1 – Single-mode fibre types and range of dispersion coefficients at 1 550 nm .....	11
Table 2 – Dispersion-limited transmission distances over B-652 fibre at 1 550 nm .....	15
Table 3 – Primary system parameters for DCF-based PDCs .....	31
Table 4 – Primary system parameters for FBG-based PDCs .....	31

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDELINES –****Part 5: Accommodation and compensation of chromatic dispersion**

## 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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 61282-5, which is a Technical Report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition, published in 2002, and constitutes a technical revision.

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

- a) extends the application space for dispersion compensation and accommodation to communication systems that employ non-zero dispersion-shifted fibres;
- b) adds a discussion on the suitability of fibre types for long-haul transmission of wavelength-multiplexed signals;
- c) updates the dispersion coefficient limits for dispersion-unshifted fibres;

- d) adds information on the dispersion coefficients of dispersion-shifted fibres;
- e) updates the naming of the fibre types to the revised naming conventions defined in IEC 60793-2-50:2018;
- f) updates Table 2 to include the dispersion tolerance of phase-shift-keyed modulation formats used for the transmission of 40 Gbit/s and 100 Gbit/s signals;
- g) adds information on dispersion management in terrestrial and submarine communication systems;
- h) extends the description of passive dispersion compensators based on fibre Bragg gratings and etalons;
- i) adds information on electronic dispersion accommodation in coherent communication systems (including transmitters and receivers);
- j) updates the description of optical accommodation techniques to include soliton transmission and mid-span spectral inversion;
- k) extends the list of system parameters for passive dispersion compensators to include wavelength-dependent loss, phase ripple, and latency;
- l) updates the description of dispersion compensator applications in long-haul communication systems.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
86C/1573/DTR	86C/1581/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61282 series, published under the general title *Fibre optic communication system design guidelines*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

## FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDELINES –

### Part 5: Accommodation and compensation of chromatic dispersion

#### 1 Scope

This part of IEC 61282, which is a Technical Report, describes various techniques for accommodation and compensation of chromatic dispersion in fibre optic communication systems. These techniques include dispersion compensation with passive optical components, advanced dispersion management, and electronic accommodation of dispersion in the transmitters and receivers.

#### 2 Normative references

There are no normative references in this document.

#### 3 Terms, definitions and abbreviated terms

##### 3.1 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

##### 3.2 Abbreviated terms

ADC	analogue-to-digital converter
BER	bit-error ratio
CD	chromatic dispersion
CW	continuous wave
DAC	digital-to-analogue converter
DCF	dispersion-compensating fibre
DCM	dispersion compensation module
DGD	differential group delay
DPSK	differential phase-shift keying
DQPSK	differential quaternary phase-shift keying
DSF	dispersion-shifted fibre
DWDM	dense wavelength-division multiplexing
FBG	fibre Bragg grating
FWM	four-wave mixing
<i>I</i>	in-phase component
IL	insertion loss
ITU	International Telecommunication Union