

Fibre optic communication system design guides —

Part 5: Accommodation and compensation of dispersion

ICS 33.180.01

National foreword

This Published Document reproduces verbatim IEC TR 61282-5:2002.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/3, Fibre optic systems and active devices, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

This Published Document, having been prepared under the direction of the Electrotechnical Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 6 September 2002

Summary of pages

This document comprises a front cover, an inside front cover, the IEC TR title page, pages 2 to 20, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

© BSI 6 September 2002

ISBN 0 580 40327 0

**RAPPORT
TECHNIQUE
TECHNICAL
REPORT**

**CEI
IEC**

TR 61282-5

Première édition
First edition
2002-04

**Guides de conception des systèmes
de communications à fibres optiques –**

**Partie 5:
Adaptation et compensation de la dispersion**

**Fibre optic communication system
design guides –**

**Part 5:
Accommodation and compensation
of dispersion**



Numéro de référence
Reference number
CEI/IEC/TR 61282-5:2002

CONTENTS

FOREWORD.....	3
INTRODUCTION.....	4
1 Scope and object.....	5
2 Reference documents.....	5
3 Chromatic dispersion limitations	6
3.1 Chromatic dispersion of dispersion-unshifted fibre.....	6
3.2 Pulse broadening	7
3.3 Dispersion-limited length	8
4 Types of dispersion compensation.....	10
4.1 Passive compensation along the optical path	10
4.2 Compensation and accommodation by the transmitter or receiver	11
4.3 Active compensation along the optical path	12
4.4 Compensation by dispersion management.....	12
5 Passive dispersion compensator parameters	12
5.1 Operating wavelength range.....	12
5.2 Chromatic dispersion.....	12
5.3 Dispersion compensation rate	14
5.4 Insertion loss.....	14
5.5 Reflectance	15
5.6 Polarization	15
5.6.1 Polarization-mode dispersion.....	15
5.6.2 Polarization-dependent loss.....	16
5.7 Optical non-linearity	16
6 Dispersion compensator applications.....	16
6.1 Higher bit-rates	16
6.2 Longer unrepeated spans	17
6.3 Multiwavelength transmission	17
7 System parameters for passive dispersion compensators	18
Annex A List of acronyms	19
Bibliography.....	20
Figure 1 – Extremes of the dispersion coefficient for B1 fibre.....	6
Figure 2 – Summing the dispersions of a B1 fibre and a DCF-based PDC over the OA window	10
Figure 3 – Reflectivity and time-delay characteristics of an FBG-based PDC (dispersion is the slope of the line)	11
Figure 4 – Passive dispersion compensators placed at one location	16
Figure 5 – PDCs placed before transmitter booster OAs (protect circuit not shown)	17
Figure 6 – Two-band WDM with an OA and a PDC in the upper band	17
Figure 7 – Multichannel WDM in the OA band	18
Table 1 – Calculated length limits (in km) between regenerators as determined by attenuation and dispersion at 1 550 nm	9
Table 2 – Transmission length ranges with a PDC designed to compensate typical lengths of B1 fibre.....	13

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 5: Accommodation and compensation of dispersion

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this technical report may be the subject of patent rights. The 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 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.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86C/291/CDV	86C/347/RVC

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 3.

This document, which is purely informative, is not to be regarded as an International Standard.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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

INTRODUCTION

Dispersion compensation is usually used in conjunction with optical amplification. Currently optical amplification is most practical utilizing erbium-doped fibre amplifiers operating in the 1 550 nm region. Such systems are used to extend the spacings between regenerative repeaters and to increase the power budget for higher bit-rate/bandwidth applications. Passive dispersion compensators (PDCs) have intrinsic losses that are overcome by the optical amplifiers (OAs). Future OAs in the 1 310 nm region may not require dispersion compensation of B1 fibre.

PDCs may be used in the interoffice and subscriber loop plant environment, for analogue or digital transmission, in unidirectional and bidirectional transmission, in single-wavelength or wavelength-division-multiplexed transmission, and with an OA external to it. The PDC will have single-mode optical fibre ports that may be ports with coated fibres, buffered fibres, fibre cable, or with integral optical connectors and no fibres. Alternatively, one or more PDCs may be used with one or more OAs as part of an integrated component.

In this technical report, the PDC will be discussed as a "black box" which performs certain input-to-output transforms, without regard to the particular technologies that may be employed within the PDC.

FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 5: Accommodation and compensation of dispersion

1 Scope and object

This part of IEC 61282, which is a technical report, applies to the accommodation and compensation of dispersion in fibre optic communication systems.

Generally, dispersion compensation and accommodation is used in the 1 550 nm region with cables incorporating conventional (dispersion-unshifted) single-mode category B1 fibre as shown in IEC 60793-1 and IEC 60793-2. In this wavelength region, the fibre has a positive dispersion coefficient that averages at about 17 ps/nm–km. There are two subcategories of such fibre. The cutoff wavelength of B1 fibre is low enough for the fibre to be used in either the 1 310 nm or the 1 550 nm region. Such fibre makes up the vast majority of installed fibre optic cable world wide. The cutoff wavelength of B1.2 fibre is high enough for the fibre to be used in the 1 550 nm region only. Such fibre is used in some submarine systems.

Smaller values of dispersion are attainable with dispersion-shifted category B2 fibre and with non-zero-dispersion category B4 fibre. Dispersion accommodation or compensation may sometimes be used with these fibre types as well, but only category B1 fibres will be discussed in this technical report.

Compensation refers to techniques or components that reduce the value of the dispersion or the dispersion slope of a fibre optic link to enable transmission at digital bit-rates and at analogue frequencies higher than would be possible without these techniques. Effectively, the cumulative zero-dispersion wavelength of the optical path is moved from the 1 310 nm region to somewhere in the 1 550 nm region. A link of dispersion-unshifted B1 fibre and an in-line dispersion compensator can be made to resemble, in some cumulative respects, a link of dispersion-shifted B2 fibre. Examples of passive dispersion compensating components include dispersion-compensating fibre, fibre Bragg gratings, and etalons.

Accommodation refers to techniques or components that utilize dispersion to enable transmission at digital bit-rates and at analogue frequencies higher than would be possible without these techniques. Examples of active dispersion accommodation include optical or electrical prechirping at the transmitter, dispersion-assisted transmission, midspan spectral inversion, and receiver signal processing. Accommodation will be treated in future revisions of this technical report.

Management referring to techniques that vary the dispersion coefficient along the optical path (both sign and magnitude) remains under study.

2 Reference documents

IEC 60793-1 (all parts), *Optical fibres – Part 1: Generic specification*

IEC 60793-2, *Optical fibres – Part 2: Product specifications*

IEC/TR 61282-3, *Fibre optic communication system design guides – Part 3: Calculation of PMD in fibre optic systems* ¹⁾

IEC/TR 61282-4, *Fibre optic communication system design guides – Part 4: Accommodation and utilization of non-linear effects in single-mode fibre optic systems* ¹⁾

ITU-T Recommendation G.691, *Optical interfaces for single-channel STM-64, STM-256 and other SDH systems with optical amplifiers*

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

ITU-T Recommendation G.957, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*

3 Chromatic dispersion limitations

3.1 Chromatic dispersion of dispersion-unshifted fibre

As discussed above, dispersion compensators are needed when category B1 fibre is used in conjunction with OAs, especially in the C-band (1 530 nm to 1 565 nm). Figure 1 shows the limiting chromatic dispersion coefficients characteristic of B1 fibre.

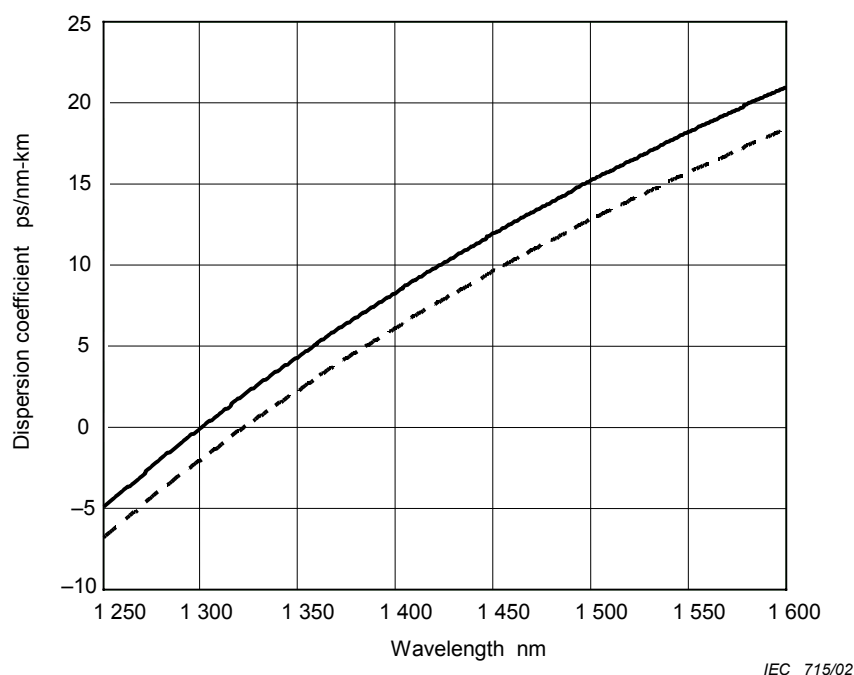


Figure 1 – Extremes of the dispersion coefficient for B1 fibre

To accommodate manufacturing tolerances, while still satisfying user needs, the specifications for B1 fibre allow a range for the values of fibre zero-dispersion wavelength λ_0 , with a maximum value of the zero-dispersion slope coefficient S_0 at 1 310 nm. The lowest allowed value of λ_0 with the maximum allowed value of S_0 results in the solid curve in figure 1; the highest allowed value of λ_0 with a typical low value of S_0 results in the dashed curve. These give the highest and lowest values respectively of the dispersion coefficient at 1 550 nm: about 18,2 ps/nm–km and under 16 ps/nm–km. Acceptable fibres will lie between these limits.

¹⁾ To be published.

¹⁾ Under consideration.