TECHNICAL REPORT

IEC TR 61282-7

First edition
2003-01

Fibre optic communication system design guides –

Part 7: Statistical calculation of chromatic dispersion

Guides de conception des systèmes de communications à fibres optiques –

Partie 7: Calcul statistique de la dispersion chromatique

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FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 7: Statistical calculation of chromatic 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.
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IEC 61282-7, 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/429/DTR	86C/468/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 2.

The committee has decided that the contents of this publication will remain unchanged until 2009-12. At this date, the publication will be

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- withdrawn;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

FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDES –

Part 7: Statistical calculation of chromatic dispersion

1 Scope

This part of IEC 61282 is a guideline providing methods of representing the process statistics of the chromatic dispersion of optical fibres and related components that may be combined in a link.

Chromatic dispersion (ps/nm) is the derivative, with respect to wavelength, of the group delay (ps) induced by the spectral content of light propagating through an optical element or fibre. Chromatic dispersion is normally a function of wavelength and can be either positive (group delay increasing with wavelength) or negative (group delay decreasing with wavelength).

The presence of chromatic dispersion can induce distortions in signals leading to bit errors depending on

– source spectral width;
– source chirp;
– bit period;
– distance.

In addition, chromatic dispersion is interactive with the effects of non-linear optical effects and second order polarisation mode dispersion (PMD). The above system impairments are beyond the scope of this technical report.

When different components or fibres are combined, the chromatic dispersion of the combination is the total of the chromatic dispersion values of the individuals, on a wavelength-by-wavelength basis. A section with high chromatic dispersion will be balanced by sections with lower values. The variation in the total dispersion of links will therefore be dependent on the distributions of the products that are used in the link. This document provides methods to calculate the distribution statistics of concatenated links based on information on the distributions of different fibre or component populations.

NOTE In the clauses that follow, examples are given for particular fibre and component types. These examples are not necessarily broadly representative.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-42*: Optical fibres – Part 1-42: Measurement methods and test procedures – Chromatic dispersion*

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

ITU-T Recommendation G.652: *Characteristics of a single-mode optical fibre cable*

ITU-T Recommendation G.655: *Characteristics of a non-zero dispersion shifted single-mode optical fibre cable*

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

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

3 Characterisation of chromatic dispersion coefficient versus wavelength

This clause outlines the characterisation of dispersion as a function of wavelength – for a given wavelength range. This function is often represented as a formula that includes parameters that can vary from fibre to fibre for a given fibre design. Characterisations of these formulas should give an indication of the wavelength range over which the formula applies. Extrapolation beyond these ranges can result in error.

For optical fibre, chromatic dispersion coefficient, D, can vary with wavelength, λ, according to a variety of formula types that are found in IEC 60793-1-42. The simplest is the linear representation which has just two parameters, zero-dispersion wavelength, λ_0, and zero-dispersion slope, S_0, as:

$$D(\lambda) = S_0(\lambda - \lambda_0) \quad \text{(ps/nm·km)} \tag{1}$$

Measurements are based either on fitting differential group delays (DGD) or by fitting the integral to the measured group delay.

Other forms defined in 60793-1-42 are the three-term Sellmeier (Equation (2)), and the five-term Sellmeier (Equation (3)). Note that for the five-term Sellmeier, parameters, C_j, different from the zero-dispersion wavelength and slope must be fitted.

$$D(\lambda) = \frac{S_0\lambda}{4}\left(1 - \left(\frac{\lambda_0}{\lambda}\right)^4\right) \tag{2}$$

$$D(\lambda) = 2C_1\lambda - 2C_2\lambda^{-3} + 4C_3\lambda^3 - 4C_4\lambda^{-5} \tag{3}$$

For components, similar types of expressions can be used to characterise the chromatic dispersion value, d, as a function of wavelength. For components, however, the units are most often given as ps/nm (unadjusted for length). [The use of the term “coefficient,” for fibre indicates a length normalisation.]

Even for the products for which the linear representation of Equation (1) is appropriate for each individual fibre, the combination of the distributions of the zero-dispersion wavelength and slope will normally not lead to a very clear understanding of the distribution of chromatic dispersion. Figure 1 shows such a combined distribution that illustrates a correlation between the dispersion parameters.

Figure 1 – Distribution of dispersion parameters

4 Characterisation of the chromatic dispersion coefficient statistics versus wavelength

This clause outlines the technique used to characterise the distribution of a single population of fibres. Similar approaches can be applied to components.

The fibre distribution shown in Figure 1 was intended for use in the wavelength range of 1 530 nm to 1 560 nm – a B4 type fibre (ITU-T G.655), see IEC 60793-2-50. The chromatic dispersion values for the lower end of this range are affected more by the variation of slope values for high zero-dispersion wavelength than for low zero dispersion wavelength. The combined contributions are therefore difficult to evaluate without some other means.

The characterisation methodology suitable for use in concatenation statistics for this distribution alone, or for combination with other distributions is to calculate the dispersion coefficient for each of the wavelengths in the range of the application – for each individual fibre. This creates a distribution of dispersion coefficient values for each wavelength. Figures 2 and 3 show these distributions at two selected wavelengths for the distribution shown in Figure 1.

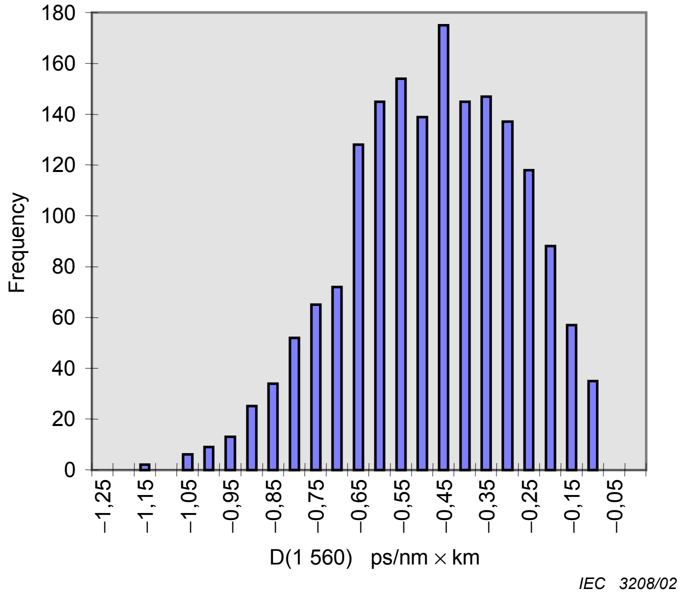

Figure 2 – Histogram of values at 1 560 nm

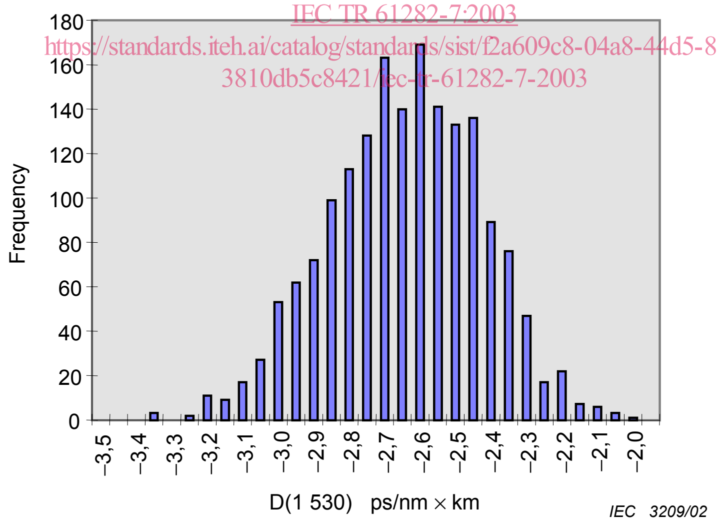

Figure 3 – Histogram of values at 1 530 nm

The distribution for each wavelength is characterised with an average and a standard deviation value. These statistics are then plotted versus wavelength. Figures 4 and 5 show the relationships.