SLOVENSKI STANDARD

SIST EN 61280-4-4:2006

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Postopki preskušanja optičnega komunikacijskega podsistema – 4-4. del: Kabelske oblike in povezave – Meritve polarizacijske razpršitve v vgrajenih povezavah (IEC 61280-4-4:2006)

Fibre optic communication subsystem test procedures – Part 4-4: Cable plants and links – Polarization mode dispersion measurement for installed links (IEC 61280-4-4:2006)

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English version

Fibre optic communication subsystem test procedures Part 4-4: Cable plants and links - Polarization mode dispersion measurement for installed links

(IEC 61280-4-4:2006)

Procédures d'essai des sous-systèmes de télécommunication à fibres optiques
Partie 4-4: Installation de câbles et liens - Mesure de la dispersion de mode polarisation pour les liaisons installées
(CEI 61280-4-4:2006)

Prüfverfahren für Lichtwellenleiter-Kommunikationsuntersysteme
Teil 4-4: Kabelnetze und Übertragungsstrecken - Messung der Polarisationsmodendispersion von installierten Übertragungsstrecken
(IEC 61280-4-4:2006)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

The text of document 86C/683/FDIS, future edition 1 of IEC 61280-4-4, prepared by SC 86C, Fibre optic systems and active devices, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61280-4-4 on 2006-02-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2006-12-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-02-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61280-4-4:2006 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60793-1-48	NOTE	Harmonized as EN 60793-1-48:2003 (not modified).
IEC 61290-11-1	NOTE	Harmonized as EN 61290-11-1:2003 (not modified).
IEC 61290-11-2	NOTE	Harmonized as EN 61290-11-2:2005 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60793-1-44	- [1)]	Optical fibres Part 1-44: Measurement methods and test procedures - Cut-off wavelength	EN 60793-1-44	2002 [2)]

[1)] Undated reference.
[2)] Valid edition at date of issue.

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Procédures d'essai des sous-systèmes de télécommunication à fibres optiques –

Partie 4-4: Installation de câbles et liens – Mesure de la dispersion de mode polarisation pour les liaisons installées

Fibre optic communication subsystem test procedures –

Part 4-4: Cable plants and links – Polarization mode dispersion measurement for installed links

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 4-4: Cable plants and links – Polarization mode dispersion measurement for installed links

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.
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International Standard IEC 61280-4-4 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

The text of this standard is based on the following documents:

FDIS	Report on voting
86C/683/FDIS	86C/695RVD

Full information on the voting for the approval of this standard 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.

IEC 61280 consists of the following parts under the general title *Fibre optic communication subsystem test procedures* [1]:

Part 1: General communication subsystems [2]

Part 2: Digital systems [3]

Part 4: Cable plant and links [4]

Part 3 is in preparation.

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

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

1) The general title of the IEC 61280 series has changed. Previous parts were published under the general title *Fibre optic communication subsystem basic test procedures*

2) The title of Part 1 has changed. Parts 1-1 and 1-3 were published under the title *Test procedures for general communication subsystems*.

3) The title of Part 2 has changed. Parts 2-1, 2-2, 2-4 and 2-5 were published under the title *Test procedures for digital systems*.

4) The title of Part 4 has changed. Part 4-2 was published under the title *Fibre optic cable plant*.

FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 4-4: Cable plants and links – Polarization mode dispersion measurement for installed links

1 Scope

This part of IEC 61280 provides uniform methods of measuring polarization mode dispersion (PMD) of single-mode installed links. An installed link is the optical path between transmitter and receiver, or a portion of that optical path. These measurements may be used to assess the suitability of a given link for high bit rate applications or to provide insight on the relationships of various related transmission attributes. The principles of this document are aligned with those of the optical fibre and optical fibre cable test method, IEC 60793-1-48 (see Bibliography), which focuses on aspects related to the measurement of factory lengths. Instead, this document focuses on the measurement methods and requirements for measuring long lengths that might be installed – and that might also include other optical elements, such as amplifiers, DWDM components, multiplexers, etc.

PMD is a statistical parameter. The reproducibility of measurements depends on the particular method, but is limited also by the PMD level of the link. Gisin [3][5] derived a theoretical limit to this reproducibility, by assuming an infinite range of measured wavelengths and ideal measurement conditions.

NOTE 1 Test methods for factory lengths of optical fibres and optical fibre cables are given in IEC 60793-1-48.

NOTE 2 Test methods for optical amplifiers are given in IEC 61290-11-1 and IEC 61290-11-2.

NOTE 3 Test methods for passive optical components are given in IEC 61300-3-32.

NOTE 4 Guidelines for the calculation of PMD for links that include components such as dispersion compensators or optical amplifiers are given in IEC 61282-3.

With the exception of Method D, all methods in this document may be used to measure the PMD in the gain band of links that include pumped optical amplifiers. For these links, amplified spontaneous emission (ASE) noise can generate depolarized spectral energy in the neighbourhood of the measurement wavelength. This will, in general, reduce the accuracy of the measurement. For Methods A, B, C, E and F, this effect can be moderated by implementing an optical or electrical filter at the receive end. However, optical filtering will not remove the ASE right under the signal spectrum. The accuracy will then be limited by a lower degree of polarization (DOP), if the spectral width of the filter cannot be sufficiently reduced as with a broadband source. Lower DOP may require the signal to be integrated longer to be meaningful or the result will become too noisy and interpretation will be erroneous.

None of the methods is suitable for measuring the PMD of links with polarization dependent loss (PDL) in excess of 10 dB. Links with PDL values less than 1 dB can be measured with reasonable accuracy. Measurement accuracy may be compromised by the presence of PDL in excess of 1 dB.

[5] Figures in square brackets refer to the bibliography.

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 60793-1-44: *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength*

3 Symbols and abbreviated terms

c	Velocity of light in vacuum (299792458 m/s)
h	Coupling length
L	Length of the link
t_c	Optical source coherence time (Method C)
$\delta\lambda$	Wavelength increment (step size)
$\delta\nu$	Optical frequency increment (step size)
$\Delta\lambda$	Optical source spectral width or linewidth (FWHM unless noted otherwise)
$\Delta\theta$	Rotation angle on Poincaré sphere
$\delta\tau$	Differential arrival times of different polarization components.
$\delta\tau_{min}$	Minimum $\delta\tau$ value that can be measured
$\Delta\tau$	Differential group delay value
$\langle\Delta\tau\rangle$	Average DGD over a wavelength range or $PMD_{average}$ value
$\langle\Delta\tau^2\rangle^{1/2}$	RMS DGD over a wavelength range or PMD_{RMS} value
$\Delta\tau_{max}$	Maximum $\delta\tau$ value that can be measured
$\Delta\omega$	Angular frequency variation in Method B
λ	Test wavelength used to measure PMD
λ_0	Central wavelength of the light source
ν	Optical light frequency
σ_R	Second moment of Fourier transform data
σ_0	RMS width of the squared autocorrelation envelope
σ_x	RMS width of the squared cross-correlation envelope
σ_ε	RMS width of interferogram
ω	Angular optical frequency
ASE	Amplified spontaneous emission
DGD	Differential group delay
DOP	Degree of polarization
DUT	Device under test
FA	Fixed analyzer

FET	Field effect transistor
FWHM	Full-width half-maximum
GINTY	General interferometric analysis
I/O	Input-output
JME	Jones matrix eigenanalysis
LED	Light emitting diode
MPS	Modulation phase shift
PDL	Polarization dependent loss
PIN (diode)	Positive insulated negative
PMD	Polarization mode dispersion
PPS	Polarization phase shift
PSA	Poincaré sphere analysis
PSP	Principal SOP
RBW	Resolution bandwidth
RMS	Root mean-square
SOP	State of polarization
SPE	Stokes parameter evaluation
TINTY	Traditional interferometric analysis

4 Background on PMD properties

PMD causes an optical pulse to spread in the time domain. This dispersion could impair the performance of a telecommunications system. The effect can be related to differential phase and group velocities and corresponding arrival times, $\delta\tau$, of different polarization components of the signal. For a sufficiently narrowband source, the effect can be related to a differential group delay (DGD), $\Delta\tau$, between pairs of orthogonally polarized principal states of polarization (PSP) at a given wavelength. For broadband transmission, the delays bifurcate and result in an output pulse that is spread out in the time domain. In this case, the spreading can be related to the root-mean square (RMS) of DGD values.

In long fibre spans, DGD varies randomly both in time and wavelength since it depends on the details of the birefringence along the entire fibre length. It is also sensitive to time-dependent temperature and mechanical perturbations on the fibre. For this reason, a useful way to characterize PMD in long fibres is in terms of the expected value, $\langle\Delta\tau\rangle$, or the mean DGD over wavelength. In principle, the expected value $\langle\Delta\tau\rangle$ does not undergo large changes for a given fibre from day to day or from source to source, unlike the parameters $\delta\tau$ or $\Delta\tau$. In addition, $\langle\Delta\tau\rangle$ is a useful predictor of transmission performance.

The term "PMD" is used both in the general sense of two polarization modes having different group velocities (one having the fastest velocity and corresponding earliest arrival time and the other the slowest velocity and corresponding latest arrival time, the difference between the two arrival times being the DGD), and in the specific sense of the expected value $\langle\Delta\tau\rangle$. The latter gives us the strict definition of PMD for the purposes of this document. The DGD $\Delta\tau$ or pulse broadening $\delta\tau$ can be averaged over wavelength, yielding $\langle\Delta\tau\rangle_\lambda$, or frequency, yielding $\langle \Delta\tau \rangle_\nu$, or time, yielding $\langle \Delta\tau \rangle_t$, or temperature, yielding $\langle \Delta\tau \rangle_T$. For most purposes, it is not necessary to distinguish between these various options for obtaining $\langle \Delta\tau \rangle$.

$$PMD_{\mathrm{AVG}} = \langle \Delta\tau \rangle \tag{1a}$$

The expression in Equation (1a) is sometimes called the linear average of the DGD values. It is reported for the purposes of specifying optical fibre cables and many other components. Another metric, the RMS of the DGD values is also reported by some measurement instruments, particularly those based on Method C. It is defined as:

$$PMD_{\mathrm{RMS}} = \langle \Delta\tau^2 \rangle^{1/2} \tag{1b}$$

For many links, the DGD values are randomly distributed closely as a Maxwell distribution. Under the assumption of a perfect fit with a Maxwell distribution, the linkage between the two metrics, linear average DGD and RMS DGD is given by Equation (1c).

$$< \Delta\tau > = \left(\frac{8}{3\pi} \right)^{1/2} < \Delta\tau^2 >^{1/2} \tag{1c}$$

NOTE 1 Equation (1c) applies if the distribution of DGD values is Maxwellian. This assumption may not be valid if there are highly birefringent elements (relative to the rest of the link) in the optical path. A multiplier of from 3 to 3,7 (see IEC 61282-3), depending on probability limits accepted by the link owner, is applied to the PMD_{AVG} value to determine the maximum DGD, which is specified for ITU-T compliant links. This multiplier is based on a Maxwell assumption and reflects a very long tail of that distribution. If the link includes a highly birefringent element, both the PMD_{AVG} and PMD_{RMS} metrics will increase relative to the actual tail of the DGD distribution (implying that a reduced multiplier could be used), but Equation (1c) may not be maintained because the DGD distribution will begin to resemble one based on the square root of a non-central chi-square distribution with three degrees of freedom. In these cases, the PMD_{RMS} value will generally be larger relative to the PMD_{AVG} value indicated by Equation (1c). This condition is indicated by "flat tops" on the fringe envelopes from the time domain measurement methods such as Method C and by bimodal DGD distributions from the frequency domain measurement methods such as Method B.

The expected value operator in the above equations refers to the long term expected value across all wavelengths. In practice, a finite wavelength range at a particular point of time and condition are sampled and some form of mean of the data is calculated. The expected value of these calculated means is equal to the long-term expected values, assuming ergodicity over time, wavelength, and condition. If this assumption is not valid, the result will vary depending on the particular wavelengths that are sampled. For ergodic conditions, the reproducibility of the measurement will vary with wavelength range and PMD level [3][6].

NOTE 2 Ergodic: of or relating to a process in which every sequence or sizable sample is equally representative of the whole.

5 Measurement methods

5.1 Methods of measuring PMD

Six basic methods of measuring PMD are given. Details specific to each are given in normative annexes. The methods are listed below in order of their introduction. For some methods, multiple approaches of analyzing the measured results are also provided.

[6] Figures in square brackets refer to the bibliography.