

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

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 61280-4-4:2017 sisaldab Euroopa standardi EN 61280-4-4:2017 ingliskeelset teksti.	This Estonian standard EVS-EN 61280-4-4:2017 consists of the English text of the European standard EN 61280-4-4:2017.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 18.08.2017.	Date of Availability of the European standard is 18.08.2017.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 33.180.01

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:
Koduleht www.evs.ee; telefon 605 5050; e-post info@evs.ee

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:

Homepage www.evs.ee; phone +372 605 5050; e-mail info@evs.ee

English Version

**Fibre optic communication subsystem test procedures -
Part 4-4: Cable plants and links - Polarization mode dispersion
measurement for installed links
(IEC 61280-4-4:2017)**

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
(IEC 61280-4-4:2017)

Prüfverfahren für Lichtwellenleiter-
Kommunikationsunterssysteme - Teil 4-4: Kabelnetze und
Übertragungsstrecken - Messung der
Polarisationsmodendispersion von installierten
Übertragungsstrecken
(IEC 61280-4-4:2017)

This European Standard was approved by CENELEC on 2017-04-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 86C/1378/CDV, future edition 2 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 approved by CENELEC as EN 61280-4-4:2017.

The following dates are fixed:

- latest date by which the document has to be (dop) 2018-02-18
implemented at national level by
publication of an identical national
standard or by endorsement
- latest date by which the national (dow) 2020-08-18
standards conflicting with the
document have to be withdrawn

This document supersedes EN 61280-4-4:2006.

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

EN 61280-4-4:2017 includes the following significant technical changes with respect to EN 61280-4-4:2006:

- a) theory is removed and replaced with a reference to IEC/TR 61282-9;
- b) a new method, wavelength scanning OTDR and SOP analysis (WSOSA), is added as Annex G;
- c) a brief description of each method is added to Clause 5;
- d) Methods E and F are converted to informative Annexes E and F;
- e) a new Clause (6) on measurement configurations is added;
- f) a new Clause (7) on measurement considerations is added;
- g) Clause 10 on procedure is expanded;
- h) several of the apparatus diagrams are improved;
- i) several clarifications about what is measured and what is calculated have been made in Annex H.

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

Endorsement notice

The text of the International Standard IEC 61280-4-4:2017 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 60793-1-48:2003	NOTE	Harmonized as EN 60793-1-48:2003 ¹⁾ (not modified).
IEC 60793-1-48:2007	NOTE	Harmonized as EN 60793-1-48:2007 (not modified).
IEC 60793-2-50	NOTE	Harmonized as EN 60793-2-50.
IEC 61280-4-4:2006	NOTE	Harmonized as EN 61280-4-4:2006 (not modified).
IEC 61290-11-1	NOTE	Harmonized as EN 61290-11-1.
IEC 61290-11-2	NOTE	Harmonized as EN 61290-11-2.
IEC 61300-3-32	NOTE	Harmonized as EN 61300-3-32.

¹⁾ Superseded by EN 60793-1-48:2007 (IEC 60793-1-48:2007).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60793-1-44	-	Optical fibres - Part 1-44: Measurement methods and test procedures - Cut-off wavelength	EN 60793-1-44	-
IEC 61300-3-35	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-35: Examinations and measurements - Visual inspection of fibre optic connectors and fibre-stub transceivers	EN 61300-3-35	-
IEC/TR 61282-9	-	Fibre optic communication system design - guides - Part 9: Guidance on polarization mode dispersion measurements and theory	-	-
IEC/TR 62627-01	-	Fibre optic interconnecting devices and passive components - Part 01: Fibre optic connector cleaning methods	-	-

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	10
3 Terms, definitions, symbols and abbreviated terms.....	10
3.1 Terms and definitions.....	10
3.2 Symbols and abbreviated terms	11
4 Background on PMD properties	12
5 Measurement methods	13
5.1 Methods of measuring PMD	13
5.1.1 General	13
5.1.2 Method A: Fixed analyzer with Fourier transformation (FA-FT)	14
5.1.3 Method B: Stokes parameters evaluation (SPE).....	14
5.1.4 Method C: Interferometric	15
5.1.5 Method D: Stokes parameter evaluation using back-reflected light.....	15
5.1.6 Method E: Modulated phase-shift technique.....	15
5.1.7 Method F: Polarization phase shift (PPS).....	15
5.1.8 Method G: Wavelength scanning OTDR and SOP Analysis (WSOSA).....	16
5.2 Document structure.....	16
5.3 Reference test method	16
6 Measurement configurations.....	16
6.1 Passive cabling link	16
6.2 Link including amplifiers.....	17
6.3 Link including chromatic dispersion compensating modules	17
6.3.1 General	17
6.3.2 Grating based DCM	17
6.4 Link including ROADMs	17
6.4.1 General	17
6.4.2 Multi-channel point to point configuration.....	18
6.4.3 Single channel configuration	18
7 Measurement considerations	18
7.1 General.....	18
7.2 Wavelength range	18
7.3 PMD measurement range.....	18
7.4 Measurement dynamic range	19
7.5 Fibre movement.....	19
7.6 Input and output SOP scrambling.....	19
7.6.1 General	19
7.6.2 Polarizers/scramblers	19
7.6.3 The 9-states Mueller set	20
7.6.4 Random scrambling	20
7.7 Polarization dependent loss	20
7.8 Amplifier considerations.....	20
7.8.1 General	20
7.8.2 Optical isolators.....	20
7.8.3 Wavelength range.....	20

7.8.4	Power levels	20
7.8.5	Amplified spontaneous emission (ASE) noise	21
7.9	Considerations on location of equipment	21
8	Apparatus	21
8.1	General	21
8.2	Light source and polarizers	21
8.3	Input optics	22
8.4	Cladding mode stripper	22
8.5	High-order mode filter	22
8.6	Output connection	22
8.7	Output optics	23
8.8	Detector	23
8.9	Computer or test platform	23
8.10	Means to reduce the effects of amplified spontaneous emission	23
9	Sampling and specimens	23
10	Procedure	23
11	Calculation or interpretation of results	24
12	Documentation	24
12.1	Information required for each measurement	24
12.2	Information to be available	24
13	Specification information	25
Annex A (normative)	Fixed analyzer method	26
A.1	Apparatus	26
A.1.1	Block diagrams	26
A.1.2	Light source	28
A.1.3	Analyzer	29
A.1.4	Optional polarization control at the input and output of the link under test	29
A.2	Procedure	29
A.2.1	Wavelength range and increment	29
A.2.2	Complete the scans	30
A.3	Calculations – Fourier transform	31
A.3.1	General	31
A.3.2	Data pre-processing and Fourier transformation	32
A.3.3	Transform data fitting	32
A.3.4	Spectral range	34
Annex B (normative)	Stokes parameter evaluation method	36
B.1	Apparatus	36
B.1.1	Block diagrams	36
B.1.2	Light source	37
B.1.3	Polarimeter	37
B.2	Procedure	37
B.3	Calculations	38
B.3.1	General	38
B.3.2	Jones matrix eigenanalysis (JME)	38
B.3.3	Poincaré sphere analysis (PSA) DGD calculation	40
Annex C (normative)	Interferometric method	41
C.1	General	41

C.2	Traditional analysis (TINTY).....	42
C.2.1	Apparatus.....	42
C.2.2	Procedure.....	43
C.2.3	Calculations.....	44
C.3	General analysis (GINTY).....	45
C.3.1	Benefit.....	45
C.3.2	Apparatus.....	45
C.3.3	Procedure.....	46
C.3.4	Calculations.....	47
Annex D (informative)	Stokes parameter evaluation method using back-reflected light.....	49
D.1	Utility.....	49
D.2	Apparatus.....	49
D.2.1	Block diagram.....	49
D.2.2	Directional coupler.....	49
D.2.3	Angled connector.....	49
D.2.4	Far-end termination.....	49
D.3	Procedure.....	50
D.4	Calculation and interpretation of results.....	50
Annex E (informative)	Modulation phase-shift method.....	51
E.1	Apparatus.....	51
E.1.1	Overview and block diagrams.....	51
E.1.2	Light source(s).....	52
E.1.3	Modulation.....	53
E.1.4	Polarization control.....	54
E.1.5	Input and output optics.....	54
E.1.6	Optical detector and phase detection electronics.....	55
E.1.7	Reference signal.....	55
E.2	Procedure.....	55
E.2.1	Modulation frequency.....	55
E.2.2	Scan the wavelengths and measure DGD.....	55
E.2.3	Calibration.....	58
E.3	Calculations.....	58
E.3.1	DGD calculations.....	58
E.3.2	PMD calculation.....	59
Annex F (informative)	Polarization phase shift method.....	60
F.1	Apparatus.....	60
F.1.1	Block diagram.....	60
F.1.2	Light source.....	60
F.1.3	Modulation.....	60
F.1.4	Polarization control.....	61
F.1.5	Output optics.....	61
F.1.6	Optical detectors.....	61
F.1.7	Amplitude and phase comparator.....	61
F.1.8	Reference signal.....	62
F.2	Procedure.....	62
F.2.1	Modulation frequency.....	62
F.2.2	Wavelength increment.....	62
F.2.3	Scanning wavelengths and measuring DGDs.....	62
F.2.4	Calibration.....	63

F.3	Calculations	63
F.3.1	Results overview	63
F.3.2	DGD determination	64
F.3.3	PMD calculation.....	65
Annex G (normative) Wavelength scanning OTDR and SOP analysis (WSOSA) PMD test method.....		66
G.1	General.....	66
G.2	Apparatus	66
G.2.1	Block diagram.....	66
G.2.2	Light source.....	67
G.2.3	Launch polarization	67
G.2.4	Polarization scrambling.....	68
G.2.5	Input/output optics	68
G.3	Specimen stability.....	68
G.4	Procedure	68
G.4.1	Set instrument parameters.....	68
G.4.2	Action of the instrument after measurement initiation.....	69
G.5	Calculations	71
G.5.1	Power normalisation	71
G.5.2	Transmission differences	72
G.5.3	Mean-square transmission difference and round trip PMD	73
G.5.4	Determination of PMD.....	74
G.6	Procedures for measuring PMD on installed aerial links	74
G.6.1	Instability compensation	74
G.6.2	Approaches to reducing the effects of instabilities	75
Annex H (informative) PMD determination by Method C		77
H.1	General.....	77
H.2	Traditional analysis	77
H.3	General analysis	79
Bibliography.....		81
Figure 1 – Typical passive cabling link configuration		16
Figure 2 – Example configuration of link including amplifiers.....		17
Figure A.1 – Block diagrams for fixed analyzer		28
Figure A.2 – Example of the R-function for the fixed analyzer method.....		31
Figure A.3 – A chirped sine wave.....		33
Figure A.4 – PMD by Fourier analysis		34
Figure B.1 – Block diagram for Method B using a narrowband (tuneable laser) source.....		36
Figure B.2 – Block diagram for Method B using a broadband (ASE) source.....		36
Figure C.1 – Generic set-up for Method C (INTY).....		41
Figure C.2 – Schematic diagram for Method C (TINTY).....		42
Figure C.3 – Typical data obtained by Method C (TINTY).....		44
Figure C.4 – Schematic diagram for Method C (GINTY)		45
Figure C.5 – Typical random-mode-coupling data obtained by Method C (GINTY)		47
Figure C.6 – Typical mixed-mode-coupling data obtained by Method C (GINTY)		47
Figure D.1 – Layout for Method D		49
Figure E.1 – Basic apparatus		51

Figure E.2 – Apparatus layout for polarization modulation.....	52
Figure E.3 – Mueller states on Poincaré sphere	57
Figure E.4 – DGD versus wavelength.....	58
Figure E.5 – DGD in histogram format	58
Figure F.1 – Block diagram for Method F (polarization phase shift method).....	60
Figure F.2 – DGD versus wavelength for a random mode coupling device	64
Figure G.1 – Illustration of the frequency domain and parameters for WSOSA	66
Figure G.2 – Typical generic experimental implementation for WSOSA.....	67
Figure G.3 – Typical power measurement results.....	71
Figure G.4 – Typical $s(\omega)$ for random I/O-SOP	72
Figure G.5 – Typical transmission difference for a frequency pair and I/O-SOP	73
Figure G.6 – Example of 2-pulse implementation in presence of instabilities.....	76
Table E.1 – Example of Mueller set.....	57

INTRODUCTION

Polarization mode dispersion (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 and the accessible wavelength range. Gisin [1]¹ derived a theoretical limit to this reproducibility independent of the measurement method by assuming ideal measurement conditions.

Originally, the principles of IEC 61280-4-4:2006 were closely aligned with those of IEC 60793-1-48:2003 on optical fibre and optical fibre cable test method, which focuses on aspects related to the measurement of factory lengths. However, IEC 60793-1-48:2007 removed some of the test methods that are no longer of interest to fibre and cable manufacturers. These have been retained as informative Annexes D, E, and F in this document, and a new test method G has been added.

This document also updates test methods A, B and C and adds more information applicable to testing of installed cabling.

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 (OAs) 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 TR 61282-3.

NOTE 5 Further general guidance on PMD measurements and background theory is contained in IEC TR 61282-9.

¹ Figures in square brackets refer to the Bibliography.