SLOVENSKI STANDARD
oSIST prEN IEC 61280-4-3:2022

01-februar-2022

Postopki preskušanja optičnega komunikacijskega podsistema - 4-3. del: Vgrajena pasivna optična omrežja - Meritve slabljenja in optičnih povratnih izgub

Fibre-optic communication subsystem test procedures - Part 4-3: Installed passive optical networks - Attenuation and optical return loss measurements

Ta slovenski standard je istoveten z: **prEN IEC 61280-4-3:2021**

ICS:

33.180.01	Sistemi z optičnimi vlakni na splošno	Fibre optic systems in general

oSIST prEN IEC 61280-4-3:2022 **en**

86C/1749A/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 61280-4-3 ED1**	
DATE OF CIRCULATION: (2021-12-03) **2021-12-17**	CLOSING DATE FOR VOTING: **2022-02-25***
SUPERSEDES DOCUMENTS: **86C/1733/CD, 86C/1748/CC**	

IEC SC 86C : FIBRE OPTIC SYSTEMS AND ACTIVE DEVICES

SECRETARIAT: United States of America	SECRETARY: Mr Fred Heismann
OF INTEREST TO THE FOLLOWING COMMITTEES: SC 86B,ISO/IEC JTC 1/SC 25	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	
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TITLE:

Fibre-optic communication subsystem test procedures – Part 4-3: Installed passive optical networks – Attenuation and optical return loss measurements

PROPOSED STABILITY DATE: 2025

NOTE FROM TC/SC OFFICERS:

Please note: This revised CDV is being circulate to include a software supplement. There are no other changes to this document

*The closing date for voting remains unchanged

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIBRE-OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 4-3: Installed passive optical networks – Attenuation and optical return loss measurements

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IEC 61280-4-3 has been prepared by subcommittee SC86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is an International Standard.

This publication contains an attached file titled "Supplemental Data" in the form of an Excel spread sheet. This file is intended to be used as a complement and does not form an integral part of the standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

201 The language used for the development of this International Standard is English.

202 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
203 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
204 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
205 described in greater detail at www.iec.ch/standardsdev/publications.

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

209 • reconfirmed,
210 • withdrawn,
211 • replaced by a revised edition, or
212 • amended.

213

214

INTRODUCTION

IEC has developed a large set of standards for measurement of fibre optic cable plants. These standards are applicable to passive optical networks (PON) if specifics of these networks are known and understood. This document provides dedicated procedures for attenuation measurements in PONs as well as additional information.

For the purpose of this document, a PON is a point-to-multipoint network that includes optical line terminals (OLTs), optical network terminals (ONTs), and an optical fibre infrastructure that is entirely passive and is represented by a single-rooted point-to-multipoint tree of optical fibres with splitters, combiners, filters, and other passive components.

PONs are commonly used in fibre-to-the-home (FTTH) and fibre-to-the-building (FTTB) optical access networks (OAN). In addition, the measurement principles described in this document may also apply to PONs used in other applications, like passive optical local area networks (PO-LANs).

FIBRE-OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 4-3: Installed passive optical networks – Attenuation and optical return loss measurements

1 Scope

This part of IEC 61280-4 describes the measurement of attenuation, optical return loss and optical power in installed passive optical networks (PON) using single-mode fibre**.**

This document specifies two methods for measuring the attenuation before activation of the PON:

- Method A: One-cord method using a light source and a power meter (LSPM);
- Method B: Optical time-domain reflectometer (OTDR) method in upstream direction only, with reduction of uncertainties due to the variation of backscatter coefficient.

In addition, method C, which is described in informative Annex C, provides an estimate of the attenuation after partial activation of the PON by using a U band filtered optical time-domain reflectometer (FOTDR) in an upstream direction.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 61280-1-3, *Fibre-optic communication subsystem test procedures – Part 1-3: General communication subsystems – Measurement of central wavelength, spectral width and additional spectral characteristics*

IEC 61280-4-2, *Fibre-optic communication subsystem test procedures – Part 4-2: Installed cable plant – Single-mode attenuation and optical return loss measurement*

IEC TR 61282-14:2019, *Fibre optic communication system design guidelines – Part 14: Determination of the uncertainties of attenuation measurements in fibre plants*

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*

IEC 61315, *Calibration of fibre-optic power meters*

IEC 61746-1:2009, *Calibration of optical time-domain reflectometers (OTDR) – Part 1: OTDR for single-mode fibres*

IEC 61753-1, *Fibre optic interconnecting devices and passive components – Performance standard – Part 1: General and guidance*

IEC TR 62316, *Guidance for the interpretation of OTDR backscattering traces for single-mode fibres*

IEC TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*

3 Terms, definitions, and abbreviated terms

3.1 Definitions

For the purposes of this document, the following terms and definitions apply.

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

3.1.1
attenuation
L
reduction of optical power induced by transmission through a medium such as cabling

$$L_{dB} = 10 \log_{10}(P_{in}/P_{out})$$

where

P_{in} and P_{out} are the power, typically measured in mW, into and out of the cabling

Note 1 to entry: Attenuation is expressed in dB.

Note 2 to entry: Loss and attenuation are equivalent

3.1.2
coexistence element
CoEx
bidirectional functional element used to connect different PON systems, as defined in different ITU-T Recommendation series, to the same ODN

[SOURCE: ITU-T G.989, modified for use in this document]

3.1.3
light source power meter
LSPM
test system consisting of a light source (LS), power meter (PM) and associated test cords used to measure the attenuation of installed cable plant

3.1.4
non-wavelength-selective branching device
(optical) coupler
(optical) splitter
bidirectional passive component with three or more optical fibre or optical connector ports that operates as a passive component in that it contains no optoelectronic or other transducing elements

Note 1 to entry: There are three or more ports for the entry and/or exit of optical power, which is shared among these ports in a pre-determined fashion.

[SOURCE: IEC 60875-1]

3.1.5
optical access network
OAN
set of access links sharing the same network-side interfaces and supported by optical access transmission systems

Note 1 to entry: The OAN can include a number of ODNs connected to the same OLT.

3.1.6
optical distribution network
ODN
point-to-multipoint optical fibre infrastructure

Note 1 to entry: A simple ODN is entirely passive and is represented by a single-rooted point-to-multipoint tree of optical fibres with splitters, combiners, filters, and possibly other passive optical components.

3.1.7
optical return loss
ORL
R_{ORL}
ratio of the input power (P_{in}) of the cabling under test to the backward power (P_r) reflected by the cabling under test:

$$R_{ORL} = 10 \log_{10}(P_{in} / P_r)$$

Note 1 to entry: R_{ORL} is expressed in dB.

Note 2 to entry: R_{ORL} is a positive number.

3.1.8
optical time-domain reflectometer
OTDR
test system consisting of an optical time-domain reflectometer and associated test cords used to characterize and measure the attenuation and optical return loss of installed cable plant and specific elements within that cable plant

3.1.9
point-to-point wavelength division multiplexing passive optical network
PtP WDM PON
multiple wavelength PON solution that provides a dedicated wavelength per optical network unit (ONU) in both downstream and upstream directions

Note 1 to entry: The defining characteristic of a PtP WDM PON is that each ONU is served by one or more dedicated wavelengths.

3.1.10
passive optical network
PON
combination of network elements in an ODN-based optical access network that includes an OLT and one or more ONUs and implements a particular coordinated suite of physical medium dependent layer, transmission convergence layer, and management protocols

3.1.11
reference test method
RTM
test method for measuring a given characteristic strictly according to the definition of this characteristic, and giving results which are accurate, reproducible, and relatable to practical use

[SOURCE: IEC TR 61931:1998, 2.8.1, modified – The words in brackets, "for optical fibres", have been omitted from the term.]

3.1.12
reflectance
R
ratio of the reflected power (in watts), to the incident power (in watts), at a discrete location in a fibre optic component

Note 1 to entry: R is expressed in dB.

Note 2 to entry: R is given by the following formula:

$$R = 10 \log_{10}\left(\frac{P_{\text{refl}}}{P_{\text{inc}}}\right)$$

Note 3 to entry: Reflectance values are negative.

3.1.13
time and wavelength division multiplexing passive optical network
TWDM PON
multiple wavelength PON solution in which each wavelength is shared between multiple optical network units (ONUs) by employing time division multiplexing and multiple access mechanisms

3.1.14
wavelength-selective branching device
wavelength division multiplexer / de-multiplexer
WDM device
passive component with three or more ports that shares optical power among its ports in a predetermined fashion, without any amplification or other active modulation, and only depending on wavelength, in the sense that at least two different wavelength ranges are nominally transferred between two different pairs of ports

[SOURCE: IEC 62074-1]

3.2 Abbreviated terms

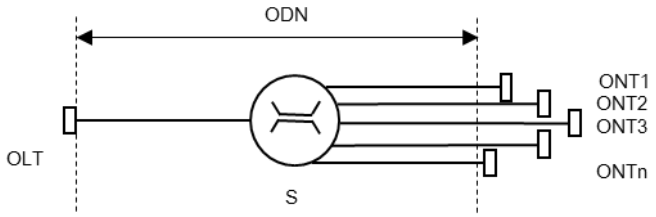
APC	angled physical contact (description of connector style)
ATM	alternative test method
CW	continuous wave
FTTB	fibre-to-the-building
FTTH	fibre-to-the-home
LSA	least squares approximation
LS	light source
OLT	optical line terminal
ONT	optical network terminal
ONU	optical network unit
PC	physical contact (description of connector style that is not angled)
PDL	polarization-dependent loss
PLC	planar lightwave circuit
PM	power meter
RTM	reference test method
TWDM	time wavelength division multiplexing.

WDM wavelength division multiplexing

4 Basic PON architecture

Figure 1 shows the basic architecture of a PON. Refer to Annex D for more details on PON configurations.

Directions are defined as “downstream direction” when the signal is transmitted from the OLT to the ONT, and “upstream direction” when the signal is transmitted from the ONT to the OLT.



Key:

OLT optical line terminal

ODN optical distribution network

ONT optical network terminal

S non-wavelength-selective branching device

Figure 1 – Single stage conventional ODN structure

5 Attenuation measurement

5.1 General

Measuring the attenuation in a PON is more challenging than measuring attenuation in installed point-to-point cable plants for the following reasons:

- PONs often do not follow the traditional installation sequence of point-to-point cable plants, so that some parts of the PON can be still under construction while other parts are already in service;
- the particular structure of PONs makes the use of certain traditional measurement techniques, like OTDR measurements in the downstream direction, more complicated;
- the wavelengths to be used for attenuation measurements should be as close as possible to the wavelengths used by the transmission equipment, which can be different from the basic 1 310 nm and 1 550 nm wavelengths used in measurements of point-to-point cable plants.

To accommodate these constraints, various amendments to conventional attenuation measurement methods are needed.

5.2 Methods

Two attenuation measurement methods are designated:

– Method A: optical light source and power meter (LSPM) one-cord method using a light source at common wavelengths and a power meter;

– Method B: optical time-domain reflectometer (OTDR) method in upstream direction only, with controlled backscattered coefficient of test cords to reduce uncertainties.

Method A uses an optical light source and power meter to measure input and output power levels of the PON under test to determine the attenuation. It requires a separate reference