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**Wavelength-Division Multiplex Small Form Factor Pluggable (PXFP-
WDM) Optical Transmitter Module Interface Specification**

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1. Introduction

1.1. Executive Summary

Many service provider networks are fiber constrained. The cost of fiber construction is prohibitive in most applications and many service provider systems have link distances that significantly exceed 20 km. The use of a PON Extender architecture utilizing WDM optics enables multiple 10G PON links to be deployed on different wavelengths over a single fiber at distances much greater than 20 km.

WDM pluggable optics compatible with PON OLT line cards enable a multi-wavelength link between the OLT platform and a PON Repeater. This standard defines these optics for use in PON OLTs.

1.2. Scope

A PON Extender architecture utilizing WDM optics enables 10GEPON to be deployed over limited fibers and distances over 20 km. Figure 1 shows a typical system use case for a PON Extender architecture.

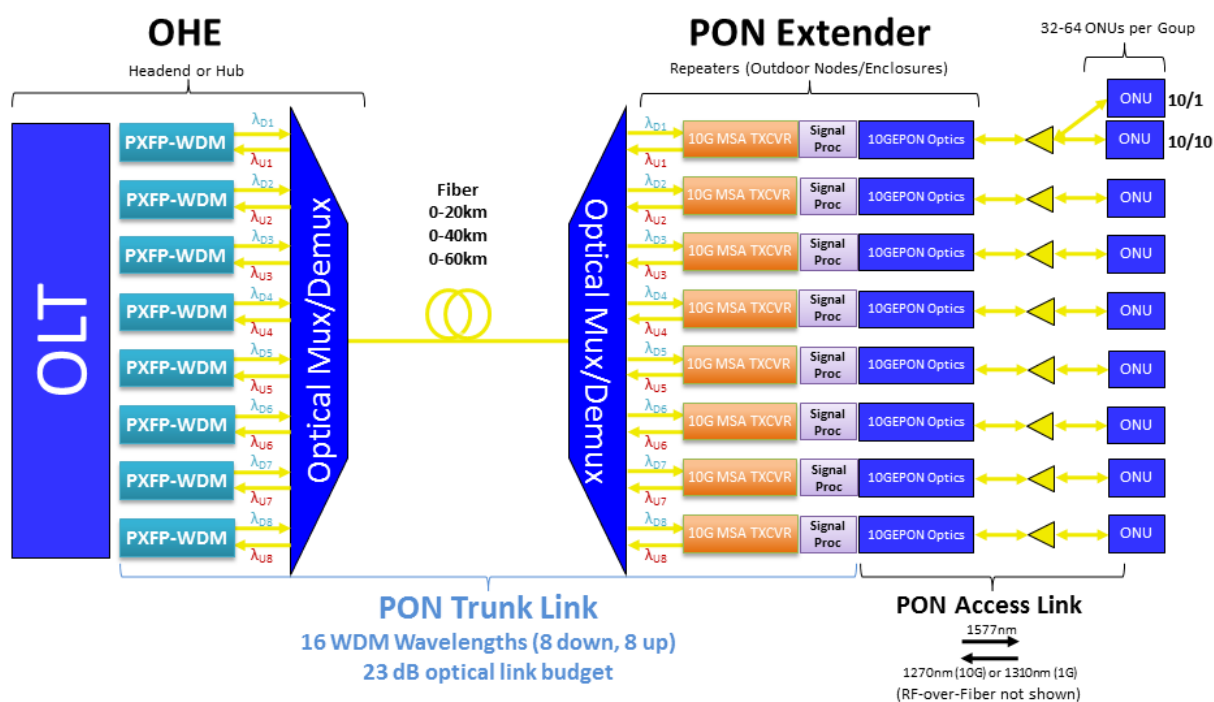


Figure 1 – Typical System Use Case for PON Extender

This specification focuses on the communications, electrical, optical, and mechanical interfaces for the Wavelength-Division Multiplex Small Form Factor Pluggable transceiver module (PXFP-WDM). PXFP-WDM is a pluggable optical transceiver module. The basic requirements are plugging into existing XFP ports in the OLT and having CWDM or DWDM 2-fiber optics (1 port for transmit and 1 port for receive). The downstream data rate is 10 Gb/s in continuous mode. The upstream data rate is a mix of 10 Gb/s and 1.25 Gb/s in continuous mode to handle co-existence of 10/10 and 10/1 ONU's in the same PON group.

Note: The PON Extender converts the upstream data from the PON Access Link from burst-mode to continuous mode.

1.2.1. PON Extender Access Using Channel Add-Drop Mux

The point-to-point architecture in Figure 1 can be extended to a cascaded access network as shown in Figure 2, where PON extenders of single-channel or dual-channel OLTs are connected on the respective wavelength by using the WDM Channel Add-Drop Mux (CH ADM). Note that the CH ADM does not have to be incorporated into the PON Extender as depicted here, but could be external. This architecture offers the flexibility to reach more clusters of residential areas. In each area only the necessary hardware is installed and can be added on a pay-as-you-grow basis.

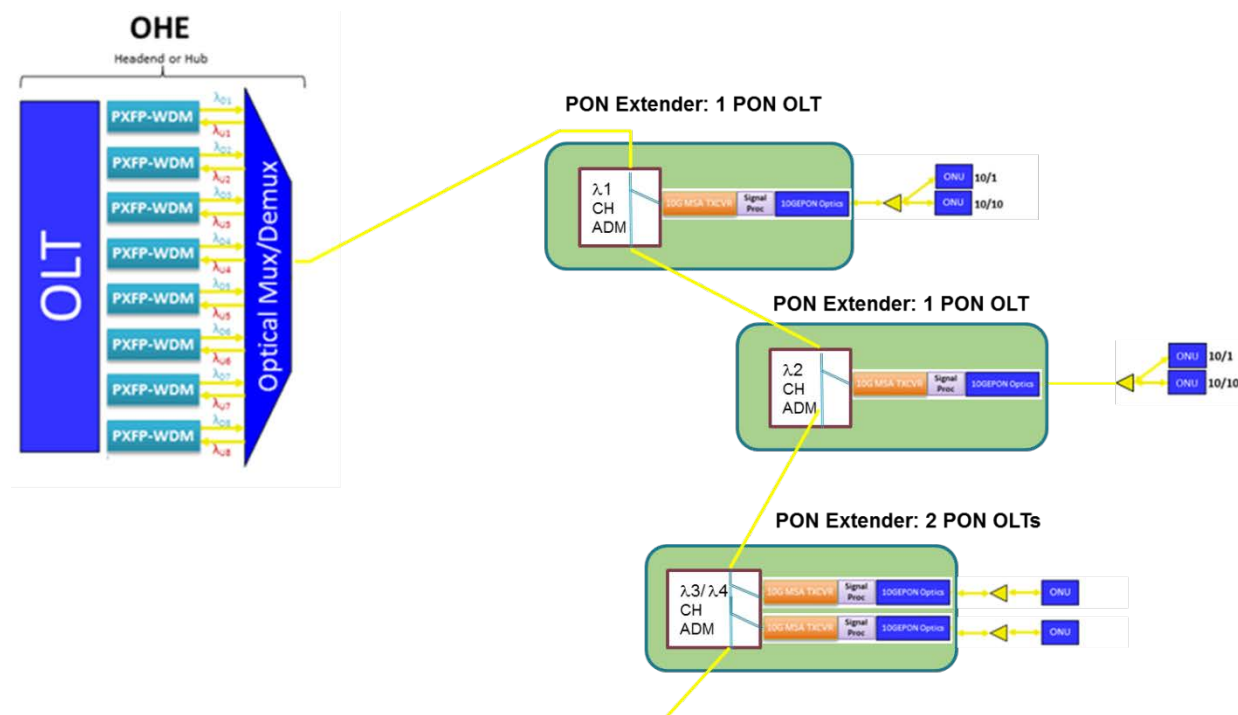


Figure 2 - PON Extender Access Using Channel Add-Drop Mux

1.3. Benefits

The benefits of a WDM-capable XFP pluggable optical interface include:

- Distance gains: XFP PON optics only support distances of up to 20 km. WDM optics support distances of up to 60 km. Coupling this capability with PON Extender devices, the service provider's optical plant can be extended well beyond what can be supported today.
- Fiber savings: XFP PON optics are fixed wavelength – a digital PON link cannot coexist on a single fiber with other digital PON links. Wave-division multiplexing allows multiple PON links to be placed on the same fiber at different wavelengths, allowing the same fiber to deliver multiple PON links.
- Commodity optics: WDM-capable optics for PON OLTs were previously only available as custom optics, increasing price and decreasing availability. This standard enables the manufacture of interoperable pluggable interfaces, reducing costs and compatibility issues.

1.4. Intended Audience

This specification is intended for optics vendors and provides detailed requirements to allow the manufacture of interoperable, standardized pluggable optical interfaces for this use case.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

- No normative references are applicable.

2.2. Standards from Other Organizations

Reference	Description
[DWDM]	ITU G.698.1, November, 2009, Series G: Transmission Systems and Media, Digital Systems and Networks, Transmission media and optical systems characteristics – Characteristics of optical systems, Multichannel DWDM applications with single-channel optical interfaces.
[DWDM-GRID]	ITU G.694.1, February, 2012, Series G: Transmission Systems and Media, Digital Systems and Networks, Transmission media and optical systems characteristics – Characteristics of optical systems, Spectral Grids for WDM applications: DWDM frequency grid.
[FINISH]	IEC 61300-3-35, ed. 1.0, November 20, 2009, Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-35: Examinations and measurements - Fibre optic connector endface visual and automated inspection, IEC Sub-committee 86B
[IEC 61754-20]	IEC 61754-20:2012 □Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 20: Type LC connector family
[IEC 61755-3-1]	IEC 61755-3-1:2006, ed. 1.0, July 1, 2006, Fibre optic connector optical interfaces – Part 3-1: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia PC ferrule, single mode fibre. IEC Sub-committee 86B
[XFP MSA]	INF-8077i, Revision 4.5, August 31, 2005, 10 Gigabit Small Form Factor Pluggable Module, SFF Committee
[SFF-8477]	SFF-8477, Revision 1.4, December 4, 2009, Tunable XFP for ITU Frequency Grid Applications, SFF Committee

2.3. Published Materials

Reference	Description
[UM10204]	UM10204, Version 4.0, February 13 2012, The I2C-Bus specification and user manual, NXP Semiconductors

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

- No informative references are applicable.

3.2. Standards from Other Organizations

Reference	Description
[IEEE 802.3]	IEEE Standard for Information Technology-Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, IEEE 802.3-2012

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

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<i>shall not</i>	This phrase means that the item is an absolute prohibition of this document.
<i>forbidden</i>	This word means the value specified shall never be used.
<i>should</i>	This word or the adjective “ <i>recommended</i> ” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
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5. Abbreviations

Abbreviation	Term
APD	avalanche photodiode
BOL	beginning of life
CDR	clock data recovery
DWDM	Dense Wavelength Division Multiplexing

Abbreviation	Term
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMI	Electromagnetic Interference
EOL	end of life
I ² C	two-wire communications interface
LOS	loss of signal
MSA	multi-source agreement
OHE	optical headend
OLT	optical line terminal
ONU	optical network unit
PCB	printed circuit board
PON	Passive Optical Network
Rx	receive
SCL	serial clock
SDA	serial data
SERDES	serializer/deserializer
SFP	small form factor pluggable module
Tx	transmit
UPC	Ultra Physical Contact connector end-face
WDM	Wavelength Division Multiplexing
XFP	10 gigabit small form factor pluggable module
PXFP-WDM	A WDM-capable transceiver module with an XFP form factor

6. Management Interface

2-Wire Communications (I²C) for the PXFP-WDM module are based upon [XFP MSA]. I²C is an implementation of the NXP (formerly Philips) I²C [UM10204] specification with mapped memory address locations (also known as “well-known addresses”) for diagnostics and operations. The SFF Committee specifies the I²C common memory mapping in [XFP MSA] and [SFF-8477] for SFP and XFP, as well as additional physical layer requirements. This specification uses the same well-known memory map locations (addresses) for functions that are the same or substantially similar. Some memory map fields from [XFP MSA] and [SFF-8477] are re-allocated or not used; in addition, some memory map fields have been added.

The PXFP-WDM module **shall** implement the I²C requirements specified in [XFP MSA], except where specified differently in the following sections.

6.1. Summary of 2-Wire Communications Requirements

In [XFP MSA] 2-wire communication requirements are spread across several sections, including Section 4.2 and Table 26, Section 2.6 and Table 3. The following bullets summarize the requirements in [XFP MSA]; refer to [XFP MSA] for complete details.

- I²C communications *may* not be available for up to 300 ms after power up or reset
- The I²C interface bus of the PXFP-WDM module is not a shared one, in contrast to that of the XFP module, as it does not have a Mod_DeSel pin.
- There must be at least 20 μ s between the STOP signal and the next START signal for a particular module.
- The clock rate can be as high as 400 kHz (I²C fast mode).