DOCSIS® Provisioning of EPON Specifications
DPoEv2.0

DPoE Physical Layer Specification

DPoE-SP-PHYv2.0-I07-230322

ISSUED

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Document Status Sheet

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Key to Document Status Codes

Work in Progress An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.

Draft A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.

Issued A generally public document that has undergone Member and Technology Supplier review, cross-vendor interoperability, and is for Certification testing if applicable. Issued Specifications are subject to the Engineering Change Process.

Closed A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

Contents

Figures

Tables

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1 INTRODUCTION

DOCSIS Provisioning of EPON (DPoE) version 2.0 specifications are a joint effort of Cable Television Laboratories (CableLabs), cable operators, vendors, and suppliers to support EPON technology using existing DOCSIS-based back office systems and processes. DPoEv2.0 specifications augment the DPoE v1.0 specifications to provide requirements for additional service capabilities and corresponding provisioning and network management capabilities.

Ethernet PON (EPON) is an [802.3] standard for a passive optical network (PON). A PON is a specific type of multi-access optical network. A multi-access optical network is an optical fiber based network technology that permits more than two network elements to transmit and receive on the same fiber.

DPoE specifications are focused on DOCSIS-based provisioning and operations of Internet Protocol (IP) using DOCSIS Internet service (which is typically referred to as High Speed Data (HSD)), or IP(HSD) for short, and Metro Ethernet services as described by Metro Ethernet Forum (MEF) standards. DPoE Networks offer IP(HSD) services, functionally equivalent to DOCSIS networks, where the DPoE System acts like a DOCSIS CMTS and the DPoE System and DPoE Optical Network Unit (ONU) together act like a DOCSIS CM.

1.1 DPoE Technology Introduction

DPoE technology was established with the following common requirements already developed by operators. Each of the participant operators had previously selected 1G-EPON and 10G-EPON as the appropriate technology for one or more applications. EPON is a widely deployed technology with a sufficient and large supply of vendors offering a variety of products for each component of the access network. 2G-EPON, as described in Annex A, uses the same 1G upstream as 1G-EPON (operates at the effective rate of 1 Gbps) but provides a 2G downstream (operates at the effective rate of 2 Gbps). With the exception of requirements specified in Annex A, 2G-EPON is expected to meet all of the requirements specified for 1G-EPON. 10G-EPON technology is available and is backwards compatible with 1G-EPON. A 1G-EPON network can be incrementally upgraded to 10G-EPON, adding or replacing ONUs as business needs require. 1G-EPON and 10G-EPON are compatible with [SCTE 174].

1G-EPON and 10G-EPON, originally defined in [802.3ah] and [802.3av] respectively, support a point-to-multipoint architecture with a centralized controller called an Optical Line Terminal (OLT) and distributed low cost Layer 2 ONUs. The basic service mapping architecture in EPON is to map Ethernet (or IP) frame header information (e.g., addresses, IP Differentiated Service Code Points, Ethernet Q tag, S-VLAN/C-VLAN ID, ISID, bridge address, etc.) to a logical circuit called a Logical Link Identifier (LLID) in [802.3]. The service mapping function in DPoE specifications is similar to that used in DOCSIS specifications. Both DOCSIS and DPoE networks rely on a centralized scheduler though EPON utilizes an LLID which functions like a SID in DOCSIS to support unicast, broadcast, and multicast.

At the time when development efforts around the DPoE specifications started, there were no standard management interfaces for the ongoing operations and maintenance of the network, including fault management, performance management, security, etc. Operators already had fully working and scaled-out systems that solve these challenges for DOCSIS networks. One of the primary goals for DPoE specifications was therefore to use the existing DOCSIS back office infrastructure to scale up EPON-based business services.

1.2 Scope

This specification identifies requirements for the EPON PHY for the adaptation or additions to DOCSIS specifications that are required to support DOCSIS Provisioning of EPON.

This specification:

- Specifies interoperable implementations for various DPoE vendors; and
- Specifies additional requirements for EPON PHY layer as used in cable networks which are outside the scope of [802.3] specifications.

1.3 Goals

The DPoE PHY specification accomplishes the following objectives:

- Identify and document the requirements for Forward Error Correction
- Define requirements for optical monitoring and power control

This specification contains no additional normative requirements beyond the DPoE version 1.0 PHY specification.

1.4 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word 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 weighed before choosing a different course.
"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

1.5 DPoE Version 2.0 Specifications

A list of the specifications included in the DPoEv2.0 series is provided in Table 1. For further information please refer to http://www.cablelabs.com/specs/specification-search/?cat=dpoe&scat=dpoe-2-0.

Table 1 - DPoEv2.0 Series of Specifications

Designation	Title
DPoE-SP-ARCHv2.0	DPoE Architecture Specification
DPoE-SP-OAMv2.0	DPoE OAM Extensions Specification
DPoE-SP-PHYv2.0	DPoE Physical Layer Specification
DPoE-SP-SECv2.0	DPoE Security and Certificate Specification
DPoE-SP-IPNEv2.0	DPoE IP Network Element Requirements
DPoE-SP-MULPIv2.0	DPoE MAC and Upper Layer Protocols Interface Specification

Designation	Title
DPoE-SP-MEFv2.0	DPoE Metro Ethernet Forum Specification
DPoE-SP-OSSIv2.0	DPoE Operations and Support System Interface Specification

1.6 Reference Architecture

See Section 1.6 in [DPoE-ARCHv2.0].

1.7 DPoE Interfaces and Reference Points

See Section 1.7 in [DPoE-ARCHv2.0].

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references. At the time of publication, the editions indicated were valid. All references are subject to revision, and users of this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below. References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific. For a non-specific reference, the latest version applies.

In this specification, terms "802.1ad" and "802.1ah" are used to indicate compliance with the [802.1ad] and [802.1ah] standards, respectively, now incorporated as part of [802.1Q]. For all intents and purposes, claiming compliance to [802.1Q], [802.1ad] or [802.1ah] in the scope of this specification will be treated as claiming compliance to IEEE Std 802.1Q-2011. Unless otherwise stated, claiming compliance to 802.1Q-2005 requires a specific date reference.

[802.1] Refers to entire suite of IEEE 802.1 standards unless otherwise specified.

[802.1ah] IEEE Std 802.1ah-2008, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks – Amendment 6: Provider Backbone Bridges, January 2008. Former amendment to 802.1Q, now part of 802.1Q-2011.

[802.1Q] IEEE Std 802.1Q2018, IEEE Standard for Local and Metropolitan Area Networks – Bridges and Bridged Networks, July 2018.

[802.3] IEEE 802.3-2008, Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, released 2008.

[802.3ah] IEEE Std 802.3ah-2004, IEEE Standard for Information Technology – Telecommunications and Information Systems – Local and Metropolitan Area Networks – Specific Requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks, now part of [802.3].

[802.3av] IEEE Std 802.3av-2009, IEEE Standard for Information Technology – Telecommunications and Information Systems – Local and Metropolitan Area Networks – Specific Requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment 1: Physical Layer Specifications and Management Parameters for 10Gb/s Passive Optical Networks, now part of [802.3].

[802.3bk] IEEE 802.3bk-2013, Amendment 1: Physical Layer Specifications and Management Parameters for Extended Ethernet Passive Optical Networks.

[DPoE-ARCHv2.0] DOCSIS Provisioning of EPON, DPoE Architecture Specification, DPoE-SP-ARCHv2.0-I08-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-IPNEv2.0] DOCSIS Provisioning of EPON, IP Network Element Requirements, DPoE-SP-IPNEv2.0-I08-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-MEFv2.0] DOCSIS Provisioning of EPON, Metro Ethernet Forum Specification, DPoE-SP-MEFv2.0-I07-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-MULPIv2.0] DOCSIS Provisioning of EPON, MAC and Upper Layer Protocols Requirements, DPoE-SP-MULPIv2.0-I14-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-OAMv2.0] DOCSIS Provisioning of EPON, OAM Extensions Specification, DPoE-SP-OAMv2.0-I15-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-OSSIv2.0] DOCSIS Provisioning of EPON, Operations and Support System Interface Specification, DPoE-SP-OSSIv2.0-I13-230322, March 22, 2023, Cable Television Laboratories, Inc.

[DPoE-SECv2.0] DOCSIS Provisioning of EPON, Security and Certificate Specification, DPoE-SP-SECv2.0-I07-230322, March 22, 2023, Cable Television Laboratories, Inc.

[SFF-8077i] SFF-8077i 10 Gigabit Small Form Factor Pluggable Module, Revision 4.0, released April 13, 2004.

[SFF-8472] SFF-8472 Specification for Diagnostic Monitoring Interface for Optical Transceivers, Revision 10.4, released January 2009.

[SFP MSA] INF 8074i Rev 1.0, Small Form-factor Pluggable Multi-Source Agreement, released 12 May 2001.

2.2 Informative References

This specification uses the following informative references.

[802.1ad] IEEE Std 802.1ad-2005, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 4: Provider Bridges, May 2006. Former amendment to 802.1Q, now part of 802.1Q-2011.

[802.1ag] IEEE Std 802.1ag-2007, IEEE Standard for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks Amendment 5: Connectivity Fault Management, December 2007.

[CMCIv3.0] Data-Over-Cable Service Interface Specifications, Cable Modem to Customer Premise Equipment Interface Specification, CM-SP-CMCIv3.0-I03-170510, May 10, 2017, Cable Television Laboratories, Inc.

[DOCSIS] Refers to entire suite of DOCSIS 3.0 specifications unless otherwise specified.

[eDOCSIS] Data-Over-Cable Service Interface Specifications, eDOCSIS Specification, CM-SP-eDOCSIS-I31-220831, August 31, 2022, Cable Television Laboratories, Inc.

[MULPIv3.0] Data-Over-Cable Service Interface Specifications, MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.

[PHYv3.0] Data-Over-Cable Service Interface Specifications, Physical Layer Specification, CM-SP-PHYv3.0-C01-171207, December 7, 2017, Cable Television Laboratories, Inc.

[RFC 2011] IETF RFC 2011, SNMPv2 Management Information Base for the Internet Protocol using SMIv2, November 1996.

[RFC 2863] IETF RFC 2863, The Interfaces Group MIB, June 2000.

[RFC 3418] IETF RFC 3418, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), June 2000.

[RFC 4188] IETF RFC 4188, Definitions of Managed Objects for Bridges, September 2005.

[RFC 4293] IETF RFC 4293, Management Information Base for the Internet Protocol (IP), April 2006.

[SCTE 174] ANSI/SCTE 174 2010, Radio Frequency over Glass Fiber-to-the-Home Specification.

2.3 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027;
  Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
- Internet Engineering Task Force (IETF) Secretariat, 48377 Fremont Blvd., Suite 117, Fremont, California 94538, USA, Phone: +1-510-492-4080, Fax: +1-510-492-4001, http://www.ietf.org
- Institute of Electrical and Electronics Engineers (IEEE), +1 800 422 4633 (USA and Canada); http://www.ieee.org
- Small Form Factor Committee (SFF), http://www.sffcommittee.com
- SCTE, Society of Cable Telecommunications Engineers Inc., 140 Philips Road, Exton, PA 19341
  Phone: +1-800-542-5040, Fax: +1-610-363-5898, Internet: http://www.scte.org/

3 TERMS AND DEFINITIONS

3.1 DPoE Network Elements

DPoE Network	This term means all the elements of a DPoE implementation, including at least one DPoE System, and one or more D-ONUs connected to that DPoE System.
DPoE System	This term refers to the set of subsystems within the hub site that provides the functions necessary to meet DPoE specification requirements.
DPoE ONU (D-ONU)	This term means a DPoE-capable ONU that complies with all the DPoE specifications. There are two logical types of D-ONUs. These are the DPoE Standalone ONU (S-ONU) and the DPoE Bridge ONU (B-ONU). Requirements specified for a D-ONU must be met by all ONUs.
DPoE Standalone ONU (S-ONU)	This term means a D-ONU that provides all the functions of a B-ONU and also provides at least one CMCI port. An S-ONU can optionally have one or more eSAFEs.
DPoE Bridge ONU (B-ONU)	This term means a D-ONU that is capable of [802.1] forwarding but cannot do all the encapsulation functions required to be an S-ONU. The B-ONU is a logical definition used by the specification for requirements that apply to all types of B-ONUs. The two types of B-ONUs are the BP-ONU and the BB-ONU.
DPoE Bridge Pluggable ONU (BP-ONU)	This term means a D-ONU that is a B-ONU which is pluggable. Pluggable BP-ONUs include devices such as an SFP-ONU (1G-EPON), SFP+ONU (10G-EPON), or XFP-ONU (10G-EPON).
DPoE Bridge Baseband ONU (BB-ONU)	This term means a D-ONU that is a B-ONU which has a baseband IEEE Ethernet interface. BB-ONUs include those with one or more [802.3] baseband PMDs. (See [DPoE-ARCHv2.0], section 7.2.6.2 for examples.)
DEMARC	Short form of "Demarcation Device." This term means the device, owned and operated by the operator that provides the demarcation (sometimes called the UNI interface) to the customer. Some architectures describe this device as the CPE (as in DOCSIS) or the NID (as in the MEF model).

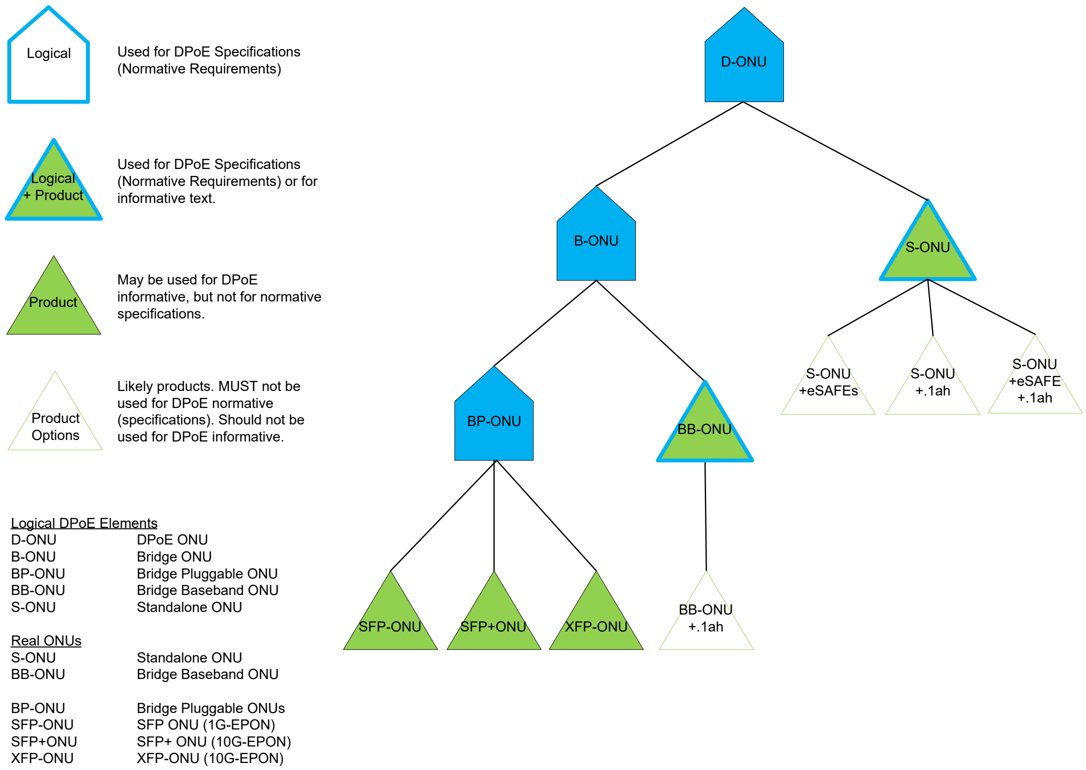


Figure 1 - D-ONU Types

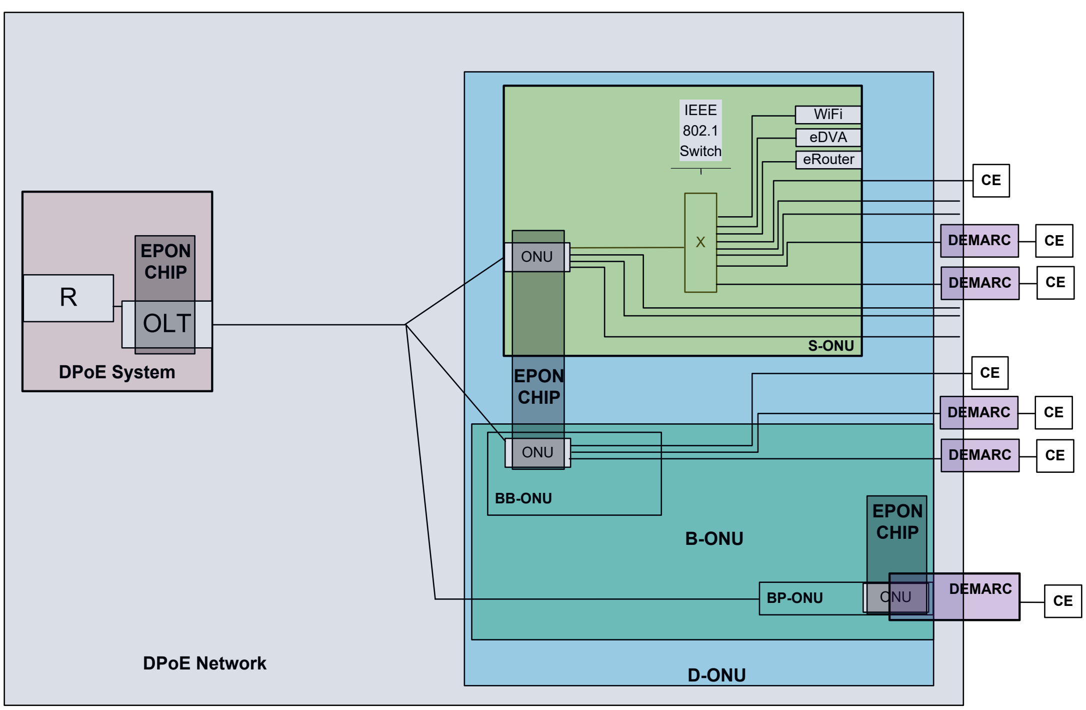


Figure 2 - DPoE Network Elements

3.2 Other Terms

1G-EPON	EPON as first defined in [802.3ah], now part of [802.3]
2G-EPON	EPON, as defined in Annex A 2G-EPON System Definition
10G-EPON	EPON as first defined in [802.3av], now part of [802.3]
Cable Modem CPE Interface	CMCI as defined in [MULPIv3.0]
Customer Premise Equipment (CPE)	Customer Premise Equipment as defined in [DOCSIS]
Ethernet Passive Optical Network (EPON)	Refers to 1G-EPON, 2G-EPON, and 10G-EPON collectively
EPON Operations and Maintenance Messaging (OAM)	EPON OAM messaging as defined in [802.3] and [DPoE-OAMv2.0]; Ethernet OAM is not the same as EPON OAM; Ethernet OAM is defined in [802.1ag]
Logical CPE Interface	LCI as defined in [eDOCSIS]
Network Interface Device (NID)	A DEMARC device in DPoE specifications

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations and acronyms:

BER	Bit error ratio
CMCI	Cable Modem CPE Interface
CoS	Class of Service
CPE	Customer Premise Equipment
DEMARC	Demarcation Device
DoS	Denial of Service
DPoE	DOCSIS Provisioning and operations of EPON
eCM	embedded Cable Modem
eDVA	embedded Digital Voice Adapter
EPON	Ethernet Passive Optical Network
EVC	Ethernet Virtual Connection
FEC	Forward error correction
IP	Internet Protocol
L2VPN	Layer 2 Virtual Private Network
LCI	Logical CPE Interface
LLID	Logical Link IDentifier
MEF	Metro Ethernet Forum
MI	MEF INNI Interface at a customer premise
MPCP	Multipoint Control Protocol
MU	MEF UNI Interface
NID	Network Interface Device
NNI	Network to Network Interface
NSI	Network Systems Interface
OAM	EPON Operations Administration and Maintenance
ODN	Optical distribution network
OLT	Optical Line Termination
ONU	Optical Network Unit
OSC	Optical Splitter Combiner
PCS	Physical Coding Sublayer
PDU	Protocol Data Units
PHY	Physical Layer
PMA	Physical Medium Attachment
PMD	Physical Media Dependent (Sublayer)
PON	Passive optical network
R	IP Router
SFP	Small Form-factor Pluggable
SFP+	Small Form-factor Pluggable Plus (+)
UNI	User Network Interface

VFI	Virtual Forwarding Instance
VSI	Virtual Switch Instance
X	IEEE Ethernet Switch (Generic)
XFP	X Form-factor Pluggable

5 EPON PHY

The specifications for the EPON PHY are defined in [802.3] [802.3bk], and Annex A in this specification. [802.3] contains specifications for optical module wavelengths, receiver sensitivity, and other parameters defining the EPON physical layer used in DPoE networks. Details of wavelength planning, supported optical budgets, and split ratios for particular deployments are outside the scope of this specification.

5.1 DPoE Additional PHY Requirements

DPoE Systems MUST support all of the Physical Media Dependent (PMD) classes defined in [802.3], Clause 60 (1G-EPON), and Clause 75 (10G-EPON), and extensions to these clauses specified in [802.3bk].

DPoE Systems SHOULD support the additional system requirements defined in Annex A 2G-EPON System Definition in this document. If a DPoE System supports these extensions, the DPoE System MUST comply with all of the required system functionality defined there.

A DPoE ONU SHOULD support the additional ONU requirements defined in Annex A 2G-EPON System Definition in this document. If a DPoE ONU supports these extensions, the DPoE ONU MUST comply with all of the required ONU functionality defined there.

5.1.1 Forward Error Correction

The DPoE System MUST support the Forward Error Correction (FEC) methods defined in [802.3], with the additional capabilities as defined in this section. The D-ONU MUST also support the Forward Error Correction (FEC) methods defined in [802.3], with the additional capabilities defined in this section.

5.1.2 1G FEC

A DPoE System MUST support FEC as defined in [802.3] for 1G EPON. A D-ONU MUST support FEC as defined in [802.3] for 1G EPON.

The DPoE System MUST support different FEC states (enabled / disabled) in the upstream and downstream directions. Correspondingly, the D-ONU MUST support different FEC states (enabled / disabled) in the upstream and downstream directions.

The DPoE System MUST support enabling FEC on a per-logical link basis. The D-ONU MUST also support enabling FEC on a per-logical link basis. FEC may be individually enabled for one or more of the logical links on the PON, may be enabled for all logical links on the PON, or may be disabled altogether, according to operator provisioning.

At the time of registration, the D-ONU MUST automatically detect the presence of FEC-encoded frames in the downstream, and set the initial state of FEC for the link to be registered in the upstream to match. The DPoE System MUST be able to enable or disable FEC encoding according to operator provisioning via OAM after the link has registered.

5.1.3 10G FEC

A DPoE System MUST support FEC as defined in [802.3] for 10G EPON. A D-ONU MUST support FEC as defined in [802.3] for 10G EPON.

A DPoE System MAY support disabling FEC for all 10G-EPON DPoE ONUs connected to the given TUL interface. Note that due to the stream-based nature of FEC in 10G-EPON, there is no way to support disabling or enabling FEC on per logical link basis.

If the FEC disabling function is supported, the operator is responsible for making sure that the FEC for the given TUL interface is disabled only when selected or all connected DPoE ONUs have sufficient power budget margin to achieve error-free operation with FEC disabled. Given that changing FEC state (enabling or disabling) for 10G-EPON TUL interface is service affecting, the operator needs to account for the DPoE ONU re-registration process when changes to the FEC state are made.

A 10G-EPON DPoE ONU MAY support disabling FEC, if configured appropriately by the DPoE System. A 10G-EPON DPoE ONU MAY automatically detect the presence of an FEC encoded downstream, and set the initial state of its upstream FEC to match.

5.2 Raman Interference Mitigation

The DPoE System MUST provide means for reducing Raman interference of the EPON downstream with other optical wavelengths by replacing [802.3] IDLE time by randomized frames as defined in this section.

Standard 1 Gbit/s Ethernet transmission features transmission of an IDLE pattern (comprising an alternating sequence of 1s and 0s) when there is no subscriber data to be transmitted. The high frequency component of such a data pattern produces interference affecting other optical wavelengths. In the [802.3] based DPoE Network, the downstream optical channel transmitted at the central wavelength of 1490 nm (digital data) produces a power spike at the optical channel transmitted at the central wavelength of 1550 nm (RF video). The Raman mitigation technique reduces this interference by minimizing the power transmitted in the high frequency component, as shown in Figure 3 below.

The standard Ethernet IDLE is replaced by an Ethernet frame carrying a payload with a random pattern, spreading transmitted optical power over a wider spectrum, and reducing the interference at specific other wavelengths.

Figure 3 - Interference Spectra Without and With Raman Mitigation

The DPoE System MUST always transmit actual network data in the downstream if such is available.

If the DPoE System detects a sufficiently long idle period on the NNI interface, with the size equal to a minimum Ethernet frame (64 bytes plus 8 bytes of preamble and 12 bytes of IPG), the DPoE System MUST replace this IDLE frame with an internally generated Ethernet frame with a random payload, as described above. This frame MUST be sent on a unicast LLID that is not connected to any D-ONU on the particular DPoE System TU (PON) interface, ensuring thus that no D-ONU can receive such a frame. The DPoE System MUST generate a payload for this frame such that it comprises a sequence of uniformly distributed random values.

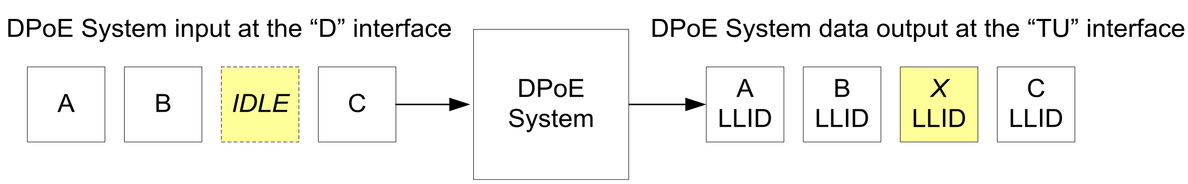


Figure 4 - IDLE Pattern Replacement Function

5.3 Optical Monitoring

A DPoE System MUST support all optical monitoring values as specified in [SFF-8472], including monitoring received optical power, transmit power, transmit bias current, internal voltage, and temperature. Similarly the D-

ONU MUST support all optical monitoring values as specified in [SFF-8472], including monitoring received optical power, transmit power, transmit bias current, internal voltage, and temperature.

A DPoE System MUST be able to report received optical power on a per-logical link basis, as well as reporting received optical power during idle time on the PON upstream.

5.4 D-ONU Optical Power Control

One possible failure mode for a D-ONU is for the laser driver to remain in the enabled state outside of the assigned transmission slot, continually generating light into the PON, interfering with transmissions of other D-ONUs in the upstream. The DPoE System MUST be able to isolate such failed D-ONUs from the PON by disabling their transmitter until the D-ONU can be replaced. The DPoE System disables a D-ONU laser by means of a specialized DPoE OAM message. A D-ONU MUST support an optical power disable command from the [DPoE-OAMv2.0].

A D-ONU MUST be able to disconnect the power supply from the optical module under software control. A D-ONU MUST be able to separately control the power supplies to the transmit and receive paths of the optical module. A DPoE System MUST be able to send an OAM message to the D-ONU to signal optical power shutdown. If the DPoE System sends such a message, the D-ONU MUST turn off or disconnect the power to the optical module. Once the optical module is disconnected, the DPoE System cannot signal the D-ONU to turn on the power. Therefore, a D-ONU that implements such a feature MUST retain this setting when it is rebooted or power-cycled (in non-volatile storage). The D-ONU MAY remove this setting if it is reset by means other than a software reboot or power-cycle (for example, a RESET button or similar means).

A B-ONU that complies with the [SFP MSA] SHOULD be able to disconnect the power supply from the optical module (within the SFP module) under software control. A B-ONU that complies with the [SFP MSA] SHOULD be able to separately control the power supplies to the transmit and receive paths of the optical module within the SFP module. These requirements apply to the optical module within the B-ONU and do not apply to the SFP module itself, because the transmit and received power pins for the SFP module supply power (in parallel) to both the optical and Layer 2 subsystems within the SFP ONU.

The procedure used to detect malfunctioning D-ONUs, and the decision whether to disable them or not, is outside the scope of this specification. In general, network error statistics are used to detect any transmission problems, and malfunctioning D-ONUs are distinguished from working D-ONUs by disabling their lasers temporarily. Once the specific D-ONU has been identified as the source of the problem, it is permanently disabled using the DPoE OAM.

A DPoE System MUST provide the operator the capability to turn on or off such a rogue D-ONU detection function for each PON and for an entire DPoE System.

6 D-ONU UNI "S" INTERFACE

The S interface is the User to Network Interface (UNI). D-ONUs support two types of S interfaces. These are either physical or logical interfaces. Although logical interfaces do not necessarily connect to the CPE, the transport of services to logical and physical interfaces is the same. Any S interface that is configured as a CMCI, MI, or MU interface is a physical interface.

6.1 Physical Interfaces

S-ONUs and B-ONUs that do not comply with the [SFP MSA] MUST support standard Ethernet interfaces for the S interfaces configured as (CMCI, MI, or MU) physical interfaces, as defined in [802.3].

A B-ONU that complies with the [SFP MSA] MUST support the standard SFP interface defined in the [SFP MSA]. A B-ONU that complies with the [SFP MSA] MUST also support the digital management interface defined in [SFF-8472].

6.2 Logical Interfaces

In addition to a physical interface, a D-ONU MAY have a logical Ethernet [802.3] interface. This interface could be used to provide an Ethernet transport across the PON from the DPoE System to a real physical interface within the D-ONU package. This interface could be a sub-interface to a switch or bridge group within the D-ONU, or a sub-interface on an [802.3] interface of a real Physical Interface as in Section 6.1 above. Additionally, the logical interface may be terminated on an internal management entity within the D-ONU, e.g., a management client.

7 DPOE SYSTEM D INTERFACE AND TU INTERFACE

The 1G/2G-EPON DPoE System SHOULD support SFP ([SFF-8472]-compliant) pluggable 1G/2G-EPON optics at the TU interface. The DPoE System supporting SFP pluggable 1G/2G-EPON optics MUST support third-party optics subject to power requirements of the SFP cage. In practical terms, this means that a DPoE System supporting pluggable 1G/2G-EPON optics is expected to accept 1G/2G-EPON pluggable third-party vendors, as long as the power, thermal, and other requirements of the SFP cage are met.

The 10G-EPON DPoE System SHOULD support SFP+ ([SFF-8077i]-compliant) or XFP ([SFF-8077i]-compliant) pluggable 10G-EPON optics at the TU interface. The DPoE System supporting SFP+ or XFP pluggable 10G-EPON optics MUST support third-party optics subject to power requirements of the SFP+ or XFP cage. In practical terms, this means that a DPoE System supporting pluggable 10G-EPON optics is expected to accept 10G-EPON pluggable third-party vendors, as long as the power, thermal, and other requirements of the SFP+ or XFP cage are met.

The 10G-EPON DPoE System SHOULD support SFP ([SFF-8472]-compliant), SFP+ ([SFF-8077i]-compliant), or XFP ([SFF-8077i]-compliant), or other pluggable optics at the D/MN interface. The DPoE System supporting such pluggable optics at the D/MN interface MUST support third-party optics subject to power requirements of the selected pluggable cage. In practical terms, this means that a DPoE System supporting pluggable optics at the D/MN is expected to accept pluggable third-party vendors, as long as the power, thermal, and other requirements of the selected pluggable cage are met.

Annex A 2G-EPON System Definition (Normative)

A.1 Overall Requirements for the System

A DPoE System that supports 2G-EPON MUST meet all 1G-EPON DPoE requirements, except where specified differently in this annex.

A DPoE ONU that supports 2G-EPON MUST meet all 1G-EPON DPoE ONU requirements, except where specified differently in this annex.

A.1.1 Coding and Rate

The 2G-EPON DPoE System supports two rate modes in the downstream:

- 1G Mode
- 2G Mode

When a DPoE System that supports 2G-EPON operates in 1G Mode, it uses the same 8B/10B coding as a DPoE System that supports 1G-EPON. When a DPoE System that supports 2G-EPON works in 2G Mode, its internal data width is 16 bits, using double 8B/10B coding (i.e., low 8-bit and high 8-bit respectively use 8B/10B coding independently).

The 2G-EPON downstream can support 2.5 Gbps rate (after double 8B/10B coding), its upstream supports 1.25Gbps rate (after 8B/10B coding). The line rate of 2.5 Gbps corresponds to double 8B/10B coding of 2 Gbps.

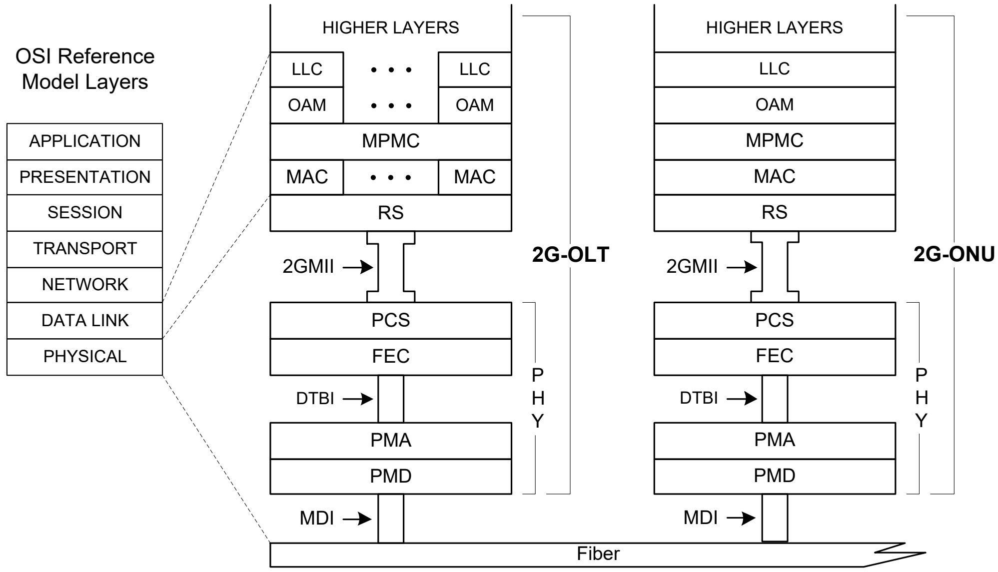
A DPoE System that supports 2G-EPON MUST meet the 2G-EPON downstream rate requirements in Table 2.

Table 2 - 2G-EPON Downstream Rate Requirements

EPON system	Coding	Line rate (GBd)	Bit rate (Gbps)	Mode of Operation
1G-EPON	8B/10B	1.25	1	NA
2G-EPON	Double 8B/10B	2.5	2	2G Mode
	8B/10B	1.25	1	1G Mode
Note1: Bit rate means the transmitter’s rate before 8B/10B coding, corresponding to the rate at 2GMII and GMII interface of protocol stack. Note 2: 1G-EPON rate is used for comparison reference.				

A.1.2 Protocol Stack

Figure 5 illustrates the 2G-EPON protocol stack and the relationship between the protocol stack and the ISO/IEC OSI reference model.



2GMII– 2 Gb/S Media Independent Interface
2G-OLT – 2 Gb/S Optical Line Terminal
2G-ONU – 2 Gb/S Optical Network Unit
DTBI – Dual Ten-Bit Interface
FEC – Forward Error Correction
MAC – Media Access Control
MDI – Medium Dependent Interface
MPMC – Multi-Point MAC Control
OAM – Operations, Administration & Maintenance
PCS – Physical Coding Sublayer
PHY – Physical Layer Device
PMA – Physical Medium Attachment
PMD – Physical Medium Dependent
RS – Reconciliation Sublayer

Figure 5 - Relationship between the 2G-EPON Protocol Stack and OSI Reference Model

A.1.3 2GMII Overview

2GMII provides the media-independent interface between the 2G-EPON MAC layer and PHY layer. It is located between the RS sublayer and the PCS sublayer and supports the following features:

- Full duplex data transmitting and receiving operation.
- Full duplex transmitting and receiving with downstream 2 Gbps and upstream 1 Gbps, or full duplex transmitting and receiving with downstream 1 Gbps and upstream 1 Gbps.
- Data and delimiting sync with reference clock.
- In 2 Gbps rate mode, provide independent downstream 16 bit-width data and upstream 8-bit width data. In 1 Gbps rate mode, provide independent downstream 8-bit width data and independent upstream 8-bit width data.

The definitions of 2GMII signals at the OLT are shown in Figure 6; the definitions of these signals are the same as those in GMII.

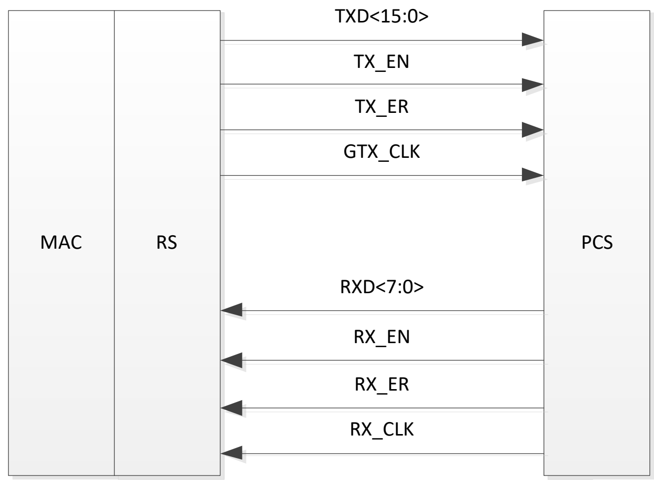


Figure 6 - 2GMII Signal Definitions at OLT

The definitions of 2GMII signals at the ONU are shown in Figure 7; the definitions of these signals are the same as those in GMII.

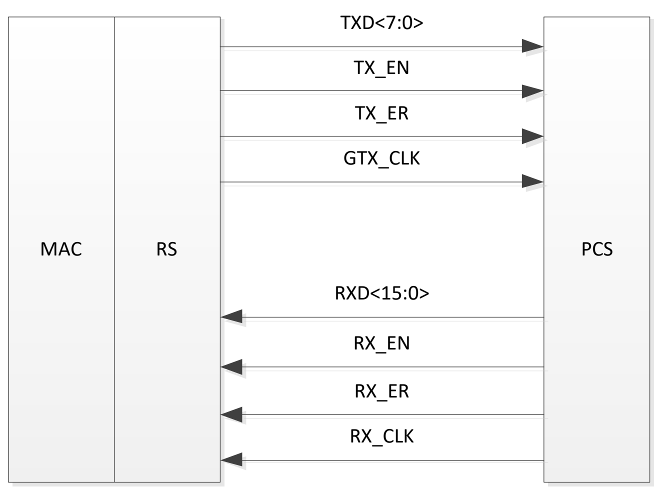


Figure 7 - Definitions of 2GMII signals at ONU

When a DPoE system or ONU that supports 2G-EPON is in 1G Mode, 2GMII only uses low 8-bit data group (bits <7:0>), and its operation mode is the same as GMII.

A.1.4 Dual Ten-Bit Interface (DTBI) Requirements

The 2G-EPON DTBI is located between the PCS and the PMA and supports full duplex data code group transmission. Therefore, the data bit number that the OLT sends is double 10-bit, and the data bit number that it receives is 10-bit. The data bit number that the ONU sends is 10-bit, and the data bit number that the ONU receives is double 10-bit.

Each group of 10-bit data bus is the same as the 10-bit data bus of the TBI in 1G-EPON and denotes one 8B/10B code group data with a clock frequency of 125 MHz. The dual ten-bit interface is illustrated in Figure 8. See the 1G-EPON requirements in [802.3] for further details.

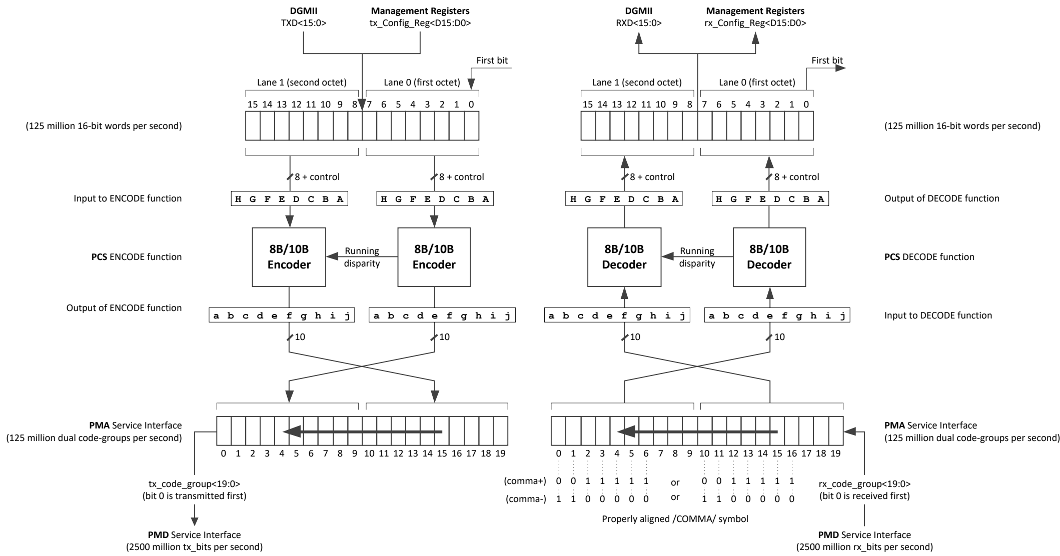


Figure 8 - Dual Ten-Bit Interface

When 2G-EPON operates in 1G Mode, the DTBI uses the first group of 10-bit data bus (i.e., the low 10-bit), and its operation mode is the same as TBI.

A.2 PON Interface Protocol Stack and Requirements

A.2.1 PMD Sublayer

A.2.1.1 PMD Sublayer Basic Requirements

The PMD sublayer of a DPoE System that supports 2G-EPON SHOULD support the following power classes:

- 2000BASE-PX10
- 2000BASE-PX20
- 2000BASE-PX30
- 2000BASE-PX40

The PMD sublayer of a DPoE ONU that supports 2G-EPON SHOULD support the following power classes:

- 2000BASE-PX10
- 2000BASE-PX20
- 2000BASE-PX30
- 2000BASE-PX40

These power classes are collectively referred to as 2000BASE-PX[1].

2000BASE-PX has the following features:

- P2MP fiber transmission
- In single-mode fiber, 2000 Mbps or 1000 Mbps rate for downstream; 1000 Mbps rate for upstream. The transmission range is 20 km.

[1] The 2000BASE-PX PMD is not defined in [802.3]. It is the 1000BASE-X PMD operating at twice the bit rate of 1000BASE-PX; the functionality of individual sublayers is unchanged.

- At the physical layer service interface, BER is not more than 10^{-12}.

The single downstream PMD (D-PMD) in the 2G-EPON system sends data to multiple upstream PMDs (U-PMDs) via broadcasting mode in the downstream direction (D-PMD to U-PMD) and receives bursty data from multiple U-PMDs in the upstream direction. Upstream and downstream share the same single fiber.

One end of 2000BASE-PX uses 2000BASE-PX-U PMD, and the other end uses 2000BASE-PX-D PMD, as shown in Figure 9. The suffix "U" and "D" respectively are used to denote the receiving and transmitting direction at the link's opposite end. If the network uses FEC, it can increase split ratio or transmission range. The max transmission range is not restricted by this standard.

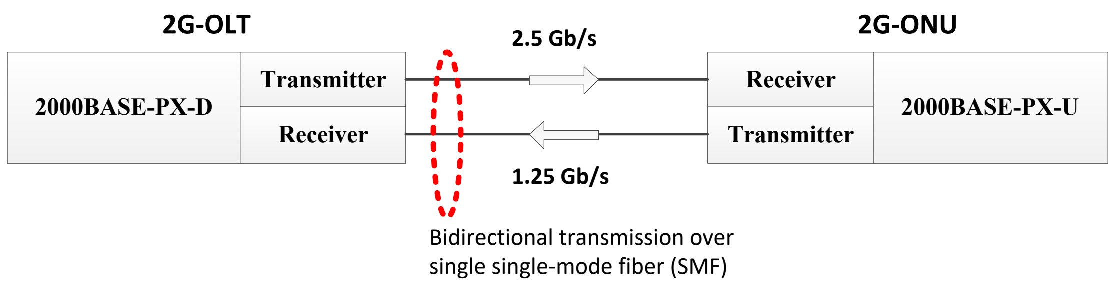


Figure 9 - D-PMD and U-PMD Illustration

Table 3 defines the basic PMD types for 2G-EPON.

Table 3 - 2G-EPON PMD Type Definitions

Description	2000BASE-PX10-U	2000BASE-PX10-D	2000BASE-PX20-U	2000BASE-PX20-D	2000BASE-PX30-U	2000BASE-PX30-D	2000BASE-PX40-U	2000BASE-PX40-D	Unit
Fiber type	IEC 60793–2 B1.1, B1.3 SMF				IEC 60793–2 B1.1, B1.3 SMF, ITU–T G.652, G.657 SMF				--
Number of Fibers	1								--
Rated Transmitting Wavelength			1310	1490	1310	1490	1310	1490	nm
Transmitting Direction	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	
Min Range (Note 1)	0.5 m – 10 km		0.5 m – 20 km						
Max Channel Insertion Loss (Note 2)	20	19.5	24	23.5	29	29	33	33	dB
Min Channel Insertion Loss	5		10	10	15	15	18	18	dB
Note 1: In a FEC enabled link, the minimum range may be increased, or, links with a higher channel insertion loss may be used. Note 2: At nominal transmit wavelength.									

A.2.1.2 Transceiver PMD to MDI Optical Specifications for 2000BASE-PX10-D and 2000BASE-PX10U

A.2.1.2.1 Transmitter Optical Specifications

DPoE System 2000BASE-PX10-D transmitters MUST meet the specifications defined in Table 60–3 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX10-D transmitters MUST meet the Wavelength Range specification defined in Table 4.

DPoE ONU 2000BASE-PX20-U transmitters MUST meet the specifications defined in Table 60–6 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX20-U transmitters MUST meet the Wavelength Range specification defined in Table 4

Table 4 - 2000BASE-PX10-D and 2000BASE-PX10-U Transmitter Characteristics

Parameter	2000BASE-PX10-D Transmitter	2000BASE-PX10-U Transmitter	Unit
Wavelength Range (Note 1)	1480 – 1500	1300 – 1320	nm
Note 1: Represents ±1σ range of RMS spectral width central wavelength.			

A.2.1.2.2 Receiver Optical Specifications

DPoE System 2000BASE-PX10-U receivers MUST meet the specifications defined Table 60–5 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX10-U receivers MUST meet the Wavelength Range specification defined in Table 5.
DPoE ONU 2000BASE-PX20-D receivers MUST meet the specifications defined Table 60–8 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX20-D receivers MUST meet the Wavelength Range specification defined in Table 5.

DPoE ONU 2000BASE-PX10-D receivers MUST meet the specifications defined Table 60–5 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX10-D receivers MUST meet the Wavelength Range specification defined in Table 5
DPoE ONU 2000BASE-PX20-D receivers MUST meet the specifications defined Table 60–8 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX20-D receivers MUST meet the Wavelength Range specification defined in Table 5.

Table 5 - 2000BASE-PX10-D and 2000BASE-PX10-U Receiver Characteristics

Description	2000BASE-PX10-D Receiver	2000BASE-PX10-U Receiver	Unit
Wavelength Range	1300 – 1320	1480 – 1500	nm

A.2.1.3 Transceiver PMD to MDI Optical Specifications for 2000BASE-PX20-D and 2000BASE-PX20U

A.2.1.3.1 Transmitter Optical Specifications

DPoE System 2000BASE-PX20-D transmitters MUST meet the specifications defined in Table 60–6 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX20-D transmitters MUST meet the Wavelength Range specification defined in Table 6.

DPoE ONU 2000BASE-PX20-U transmitters MUST meet the specifications defined in Table 60–6 of [802.3bk], with the exception of the Wavelength Range parameter. DPoE ONU 2000BASE-PX20-U transmitters MUST meet the Wavelength Range specification defined in Table 6.

Table 6 - 2000BASE-PX20-D and 2000BASE-PX20-U Transmitter Characteristics

Parameter	2000BASE-PX20-D Transmitter	2000BASE-PX20-U Transmitter	Unit
Wavelength Range (Note 1)	1480 – 1500	1300 – 1320	nm
Note 1: Represents ±1σ range of RMS spectral width central wavelength.			

A.2.1.3.2 Receiver Optical Specifications

DPoE System 2000BASE-PX20-U receivers MUST meet the specifications defined Table 60–8 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX20-U receivers MUST meet the Wavelength Range specification defined in Table 7.

DPoE ONU 2000BASE-PX20-D receivers MUST meet the specifications defined Table 60–8 of [802.3bk], with the exception of the Wavelength Range parameter. DPoE ONU 2000BASE-PX20-D receivers MUST meet the Wavelength Range specification defined in Table 7.

DPoE ONU 2000BASE-PX20-D receivers MUST meet the specifications defined Table 60–8 of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX20-D receivers MUST meet the Wavelength Range specification defined in Table 7.

Table 7 - 2000BASE-PX20-D and 2000BASE-PX20-U Receiver Characteristics

Description	2000BASE-PX20-D Receiver	2000BASE-PX20-U Receiver	Unit
Wavelength Range	1300 – 1320	1480 – 1500	nm

A.2.1.4 Transceiver PMD to MDI Optical Specifications for 2000BASE-PX30-D and 2000BASE-PX30-U

A.2.1.4.1 Transmitter Optical Specifications

DPoE System 2000BASE-PX30-D transmitters MUST meet the specifications defined in Table 60–8a of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX30-D transmitters MUST meet the Wavelength Range specification defined in Table 8.

DPoE ONU 2000BASE-PX30-U transmitters MUST meet the specifications defined in Table 60–8a of [802.3bk], with the exception of the Wavelength Range parameter. DPoE ONU 2000BASE-PX30-U transmitters MUST meet the Wavelength Range specification defined in Table 8.

DPoE ONU 2000BASE-PX30-U transmitters MUST meet the specifications defined in Table 60–8a of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX30-U transmitters MUST meet the Wavelength Range specification defined in Table 8.

Table 8 - 2000BASE-PX30-D and 2000BASE-PX30-U Transmitter Characteristics

Parameter	2000BASE-PX30-D Transmitter	2000BASE-PX30-U Transmitter	Unit
Wavelength Range (Note 1)	1480 – 1500	1300 – 1320	nm
Note 1: Represents ±1σ range of RMS spectral width central wavelength.			

A.2.1.4.2 Receiver Optical Specifications

DPoE System 2000BASE-PX30-U receivers MUST meet the specifications defined in Table 60–8c of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX30-U receivers MUST meet the Wavelength Range specification defined in Table 9.

DPoE ONU 2000BASE-PX30-D receivers MUST meet the specifications defined in Table 60–8c of [802.3bk], with the exception of the Wavelength Range parameter. DPoE ONU 2000BASE-PX30-D receivers MUST meet the Wavelength Range specification defined in Table 9.

DPoE ONU 2000BASE-PX30-D receivers MUST meet the specifications defined in Table 60–8c of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX30-D receivers MUST meet the Wavelength Range specification defined in Table 9.

Table 9 - 2000BASE-PX30-D and 2000BASE-PX30-U Receiver Characteristics

Description	2000BASE-PX30-D Receiver	2000BASE-PX30-U Receiver	Unit
Wavelength Range	1300 – 1320	1480 – 1500	nm

A.2.1.5 Transceiver PMD to MDI Optical Specifications for 2000BASE-PX40-D and 2000BASE-PX40-U

A.2.1.5.1 Transmitter Optical Specifications

DPoE System 2000BASE-PX40-D transmitters MUST meet the specifications defined in Table 60–8d of [802.3bk].

DPoE ONU 2000BASE-PX40-U transmitters MUST meet the specifications defined in Table 60–8d of [802.3bk].

A.2.1.5.2 Receiver Optical Specifications

DPoE System 2000BASE-PX40-U receivers MUST meet the specifications defined in Table 60–8e of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE System 2000BASE-PX40-U receivers MUST meet the Wavelength Range specification defined in Table 10.

DPoE ONU 2000BASE-PX40-D receivers MUST meet the specifications defined in Table 60–8e of [802.3bk], with the exception of the Wavelength Range parameter.

DPoE ONU 2000BASE-PX40-D receivers MUST meet the Wavelength Range specification defined in Table 10.

DPoE ONU 2000BASE-PX40-D receivers MUST meet the specifications defined in Table 60–8e of [802.3bk], with the exception of the Wavelength Range parameter. DPoE ONU 2000BASE-PX40-D receivers MUST meet the Wavelength Range specification defined in Table 10.

Table 10 - 2000BASE-PX40-D and 2000BASE-PX40-U Receiver Characteristics

Description	2000BASE-PX40-D Receiver	2000BASE-PX40-U Receiver	Unit
Wavelength Range	1300 – 1320	1480 – 1500	nm

A.2.1.6 Receiver Wavelength Filtering

The minimum optical sensitivity of 2G-EPON receivers have to be met while interference signals exist. Interference signals are caused by other PON types or services such as video signals in the enhancement band. To minimize the effect of interference signals, 2G-EPON receivers need to isolate interference signals using an appropriate wavelength blocking filter (WBF) and WDM filter.

DPoE System 2000BASE-PX receivers SHOULD support filtering wavelength bands outside of the specified wavelength range, such that signals on other wavelengths do not cause any harmful interference to the reception of signals within the operating wavelength range.

DPoE ONU 2000BASE-PX receivers SHOULD support filtering wavelength bands outside of the specified wavelength range, such that signals on other wavelengths do not cause any harmful interference to the reception of signals within the operating wavelength range.

It is expected that 36 dB of optical isolation will be required to meet this requirement.

A.2.1.7 Transceiver Jitter at TP1 to TP4 (Reference Definition)

The high-frequency jitter and the jitter transfer function for the 2000BASE-PX transceiver is defined in Clause 60.6 of [802.3bk]. The 2000BASE-PX test points match those of 1000BASE-PX, illustrated in Figure 60-2 of [802.3].

A.2.1.8 PMD sublayer service interface

The PMD Sublayer Service Interface is defined in clause 60 of [802.3]. Note that for 2G-EPON, the PMA sends the stream of bits to the PMD at the nominal rate of either 2.5 GBd or 1.25 GBd, depending upon the mode of operation.

A.2.1.9 PMD Delay Constraints

PMD delay constraints are defined in [802.3].

A.2.2 PMA Sublayer

The 2G-EPON system PMA sublayer is similar to 1G-EPON system and mainly implements the following functions:

1. Map the codes from or to the PCS sublayer and the signal definition to the DTBI definition;
2. Either implement serial/parallel conversion for codes and forward them to the PMD sublayer or implement serial/parallel conversion for received codes from PMD sublayer.
3. Recover clock from 8B/10B code the from PMD sublayer.
4. Map bit stream from/to the PMD sublayer.
5. Support implementing data loopback at the PMD service interface.

The clock frequency used by the PMA sublayer is 125 MHz, and when the 2G-EPON system works in 2 Gbps mode, the downstream rate between the PMA sublayer and the PMD sublayer is 2.5 Gbps. When the 2G-EPON system works in 1 Gbps mode, the downstream rate between the PMA sublayer and the PMD sublayer is 1.25 Gbps.

A.2.3 PCS Sublayer

The 2G-EPON system uses a PCS sublayer that is similar to the 1G-EPON system. When the 2G-EPON system is in downstream 1.25 Gbps rate mode, it uses the same 8B/10B coding as the 1G-EPON system. When the 2G-EPON system is in downstream 2 Gbps rate mode, the bus bit width is 16 bit, using double 8B/10B coding (i.e., low 8-bit and high 8-bit respectively use 8B/10B coding independently). The 2G-EPON DPoE system MUST support the FEC codec function. A DPoE System that supports 2G-EPON SHOULD be able to enable/disable FEC functions based on the ONU. The FEC function of a DPoE System that supports 2G-EPON SHOULD meet the FEC coding requirement specified in [802.3].

A.2.4 RS Sublayer

The 2G-EPON system uses the same RS sublayer as the 1G-EPON system. Refer to the 1G-EPON system requirements in [802.3] for further details.

A.2.5 OAM Sublayer

A DPoE System that supports 2G-EPON MUST support the EPON Mode (D7/00 14) OAM message per [DPoE-OAMv2.0].

A DPoE ONU that supports 2G-EPON MUST support the EPON Mode (D7/00 14) OAM message per [DPoE-OAMv2.0].

A.2.6 Multipoint MAC Control (MPMC) Sublayer

The MPMC sublayer uses MPCP and defines the P2MP optical network MAC control mechanism.

The 2G-EPON system use the same MPCP and state machine as the 1G-EPON system. Refer to the 1G-EPON system requirements in [802.3] for further details.

Appendix I Acknowledgments

On behalf of our industry, we would like to thank the following individuals for their contributions to the development of this specification, listed in alphabetical order of company affiliation.

Contributor	Company Affiliation
John Dickinson, Edwin Mallette	Bright House Networks
Howard Abramson, Ed Boyd, Andrew Chagnon, Drew Davis, Andrew Dellow, James Fletcher, Paul Gray, Matt Hartling, Ricki Li, Niki Pantelias, Paul Runcy	Broadcom
Mike Holmes, Wen Li, Fulin Pan, Jianhui Zhou	Broadway Networks
Chris Donley, Brian Hedstrom, Stuart Hoggan, Curtis Knittle, Bob Lund, Glenn Russell, Karthik Sundaresan, Greg White	CableLabs
Shamim Akhtar, Philip Chang, Jason Combs, Doug Jones, Saif Rahman, Matt Scully, Rashid Siddiqui Mehmet Toy, Bin Wen	Comcast
Vladimir Bronstein, James Chen, Hesham ElBakoury, Dylan Ko, Jeff Stribling, Guru Yeleswarapu, Simon Zhu	Hitachi Communication Technologies America
Victor Blake	Independent Consultant
Matt Cannon, Ron daSilva, Robert Harris, Shan Huang, Mike Kelsen, Tushar Nakhre, Karen Rice, Ashish Sardesai	Time Warner Cable
David Chen, Dick Chen, Marek Hajduczenia, Nevin Jones, Zang Meiyan, Stove Li Zhang	ZTE

Appendix II Revision History

II.1 Engineering Change incorporated into DP0E-SP-PHYv2.0-I02-130328

ECN	ECN Date	Summary	Author
PHYv2.0-N-13.0061-1	11/29/2012	Removal of optional requirement for 10G-EPON FEC	Marek Hajduczenia

II.2 Engineering Change incorporated into DPoE-SP-PHYv2.0-I03-140327

ECN	ECN Date	Summary	Author
PHYv2.0-N-14.0120-1	02/27/2014	Support for third party pluggable optics in DPoE System	Marek Hajduczenia

II.3 Engineering Changes incorporated into DPoE-SP-PHYv2.0-I04-140807

ECN	ECN Date	Summary	Author
PHYv2.0-N-14.0175-1	7/3/2014	Alignment and cleanup of 802.3 references	Marek Hajduczenia
PHYv2.0-N-14.0190-1	7/10/2014	DPoEv1 PHY Edits to support 2G EPON	Lane Johnson

II.4 Engineering Changes incorporated into DPoE-SP-PHYv2.0-I05-160602

ECN	ECN Date	Summary	Author
PHYv2.0-N-15.0230-1	12/31/15	Remove DEMARC Specification References and Attributes	Steve Burroughs
PHYv2.0-N-16.0241-1	3/31/16	DPoE 2.0 PHY - Retire SOAM Specification	Steve Burroughs

II.5 Engineering Change incorporated into DPoE-SP-PHYv2.0-I06-180228

ECN	ECN Date	Summary	Author
PHYv2.0-N-18.0266-1	2/8/2018	S/S1/S2 interface alignment and simplification	Marek Hajduczenia

II.6 Engineering Change incorporated into DPoE-SP-PHYv2.0-I07-230322

ECN	ECN Date	Summary	Author
PHYv2.0-N-23.0284-1	3/2/2023	Remove reference to IEEE 802.1d	Steve Burroughs

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