
**Information technology —
Telecommunications and information
exchange between systems — Local
and metropolitan area networks —
Specific requirements —**

**Part 3:
Standard for Ethernet**

**AMENDMENT 6: Physical layer
specifications and management
parameters for ethernet passive optical
networks protocol over coax**

*Technologies de l'information — Télécommunications et échange
d'information entre systèmes — Réseaux locaux et métropolitains —
Prescriptions spécifiques —*

Partie 3: Norme pour Ethernet

AMENDEMENT 6



Reference number
ISO/IEC/IEEE 8802-3:2017/Amd.6:2018(E)

Documents
© IEEE 2016
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© IEEE 2016

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO or IEEE at the respective address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Institute of Electrical and Electronics Engineers, Inc
3 Park Avenue, New York
NY 10016-5997, USA

Email: stds.ipr@ieee.org
Website: www.ieee.org

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted (see www.iso.org/directives).

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see <http://patents.iec.ch>).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see: www.iso.org/iso/foreword.html.

ISO/IEC/IEEE 8802-3:2017/Amd.6 was prepared by the LAN/MAN of the IEEE Computer Society (as IEEE Std 802.3bn-2016) and drafted in accordance with its editorial rules. It was adopted, under the “fast-track procedure” defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

A list of all parts in the ISO/IEC/IEEE 8802 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

IEEE Std 802.3bn™-2016
(Amendment to
IEEE Std 802.3™-2015
as amended by
IEEE Std 802.3bw™-2015,
IEEE Std 802.3by™-2016,
IEEE Std 802.3bq™-2016,
IEEE Std 802.3bp™-2016, and
IEEE Std 802.3br™-2016)

IEEE Standard for Ethernet

Amendment 6: Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 22 September 2016
IEEE-SA Standards Board

Abstract: Physical Layer specifications and management parameters for the operation of Ethernet Passive Optical Networks (EPON) Protocol over coaxial media is defined by this amendment to IEEE Std 802.3-2015.

Keywords: amendment, EPoC, EPON, EPON Protocol over Coax, Ethernet; Ethernet Passive Optical Networks, IEEE 802.3™, IEEE 802.3bn™, Multi-Point MAC Control (MPMC), orthogonal frequency division multiplexing (OFDM), Physical Coding Sublayer (PCS), Physical Media Attachment (PMA), Physical Medium Dependent (PMD), PON, point to multipoint (P2MP)

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2016 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 7 December 2016. Printed in the United States of America.

IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

Print: ISBN 978-1-5044-2372-4 STD21143
PDF: ISBN 978-1-5044-2373-1 STDPD21143

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at <http://ieeexplore.ieee.org/expel/standards.jsp> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IOWA's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

The following individuals were officers and members of the IEEE 802.3 Working Group at the beginning of the IEEE P802.3bn Working Group ballot. Individuals may have not voted, voted for approval, disapproval, or abstained on this amendment.

David J. Law, *IEEE 802.3 Working Group Chair*

Adam Healey, *IEEE 802.3 Working Group Vice-Chair*

Pete Anslow, *IEEE 802.3 Working Group Secretary*

Steven B. Carlson, *IEEE 802.3 Working Group Executive Secretary*

Valerie Maguire, *IEEE 802.3 Working Group Treasurer*

Mark Laubach, *IEEE P802.3bn EPON Protocol over Coax Task Force Chair*

Duane Remein, *IEEE P802.3bn EPON Protocol over Coax Task Force Editor-in-Chief*

Dale Amason	Thuyen Dinh	Manabu Kagami
J. Michael Andrewartha	Curtis Donahue	Upen Kareti
Oleksandr Babenko	Dan Dove	Keisuke Kawahara
Kwang-Hyun Baek	Mike Dudek	Yasuaki Kawatsu
Amrik Bains	Nick Duer	Michael Kelsen
Koussalya Balasubramanian	David Dwelley	Yong Kim
Thananya Baldwin	Frank Effenberger	Jonathan King
Denis Beaudoin	Hesham Elbakoury	Scott Kipp
Christian Beia	David Estes	Michael Klempa
Yakov Belopolsky	John Ewen	Curtis Knittle
Michael Bennett	Josef Faller	Shigeru Kobayashi
Vipul Bhatt	Shahar Feldman	Keisuke Kojima
William Bliss	German Feyh	Paul Kolesar
Brad Booth	Alan Flatman	Tom Kolze
Martin Bouda	Howard Frazier	Glen Kramer
David Brandt	Richard Frosch	Hans Lackner
Ralf-Peter Braun	Andrew Gardner	Brett Lane
Theodore Brillhart	Mike Gardner	Jeff Lapak
Paul Brooks	Ali Ghiasi	Efstathios Larios
David Brown	Joel Goergen	Greg Le Cheminant
Matthew Brown	Zhigang Gong	Arthur Lee
Thomas Brown	Steven Gorshe	David Lewis
Phillip Brownlee	James Graba	Jon Lewis
Juan-Carlos Calderon	Robert Grow	Lei Li
J. Martin Carroll	Mark Gustlin	Mike Peng Li
Clark Carty	Marek Hajduczenia	Shaohua Li
Mandeep Chadha	Bernie Hammond	Thomas Lichtenegger
David Chalupsky	Takehiro Hayashi	Ru Jian Lin
Jacky Chang	David Hess	Robert Lingle
Xin Chang	Yasuo Hidaka	James Iiu
David Chen	Riu Hirai	Zhenyu Liu
Wheling Cheng	Thomas Hogenmueller	William Lo
Ahmad Chini	Brian Holden	Miklos Lukacs
Golam Choudhury	Rita Horner	Kent Lusted
Keng Hua Chuang	Bernd Hormmeyer	Jeffery Maki
Peter Cibula	Victor Hou	James Malkemus
Christopher R. Cole	Liang-wei Huang	Yonatan Malkiman
Keith Conroy	Yasuhiro Hyakutake	Edwin Mallette
Eugene Dai	Scott Irwin	Arthur Marris
Shaoan Dai	Kazuhiko Ishibe	Chris Mash
John D'Ambrosia	Hideki Isono	Kirsten Matheus
Mike Darling	Tom Issenhuht	Erdem Matoglu
Yair Darshan	Kenneth Jackson	Laurence Matola
		Brett McClellan
		Thomas McDermott

John McDonough	Poldi (Pavlick) Rimboim	Alan Tipper
Richard Mei	Martin Rossbach	Pirooz Tooyserkani
Richard Mellitz	Christopher Roth	Nathan Tracy
Bryan Moffitt	Salvatore Rotolo	David Tremblay
Leo Montreuil	Hisaya Sakamoto	Albert Tretter
Paul Mooney	Vineet Salunke	Stephen Trowbridge
Andy Moorwood	Sam Sambasivan	Wen-Cheng Tseng
Thomas Mueller	Yasuo Sasaki	Yoshihiro Tsukamoto
Ron Muir	Fred Schindler	Mike Tu
Dale Murray	Stefan Schnee	Alan Ugolini
Henry Muyschondt	Peter Scruton	Ed Ulrichs
Edward Nakamoto	Alexander Seiger	Sterling A. Vaden
Gary Nicholl	Naoshi Serizawa	Stefano Valle
Paul Nikolic	Megha Shanbhag	Paul Vanderlaan
Kevin Noll	Masood Shariff	Robert Wagner
Ronald Nordin	Stephen Shellhammer	Robert Wang
Mark Nowell	Bazhong Shen	Roy Wang
David Ofelt	Mizuki Shirao	Tongtong Wang
Ichiro Ogura	Kapil Shrikhande	Xiaofeng Wang
Tom Palkert	Jeff Slavick	Xinyuan Wang
Hui Pan	Scott Sommers	Zhong Feng Wang
Sujan Pandey	Yoshiaki Sone	Markus Weber
Sesha Panguluri	Xiaolu Song	Brian Welch
Carlos Pardo	Tom Souvignier	Yang Wen
Moon Park	Bryan Sparrowhawk	Matthias Wendt
Petar Pepeljugoski	Edward Sprague	Oded Wertheim
Gerald Pepper	Peter Stassar	Martin White
Ruben Perez De Aranda Alonso	Leonard Stencil	Natalie Wienckowski
Michael Peters	Robert Stone	Ludwig Winkel
John Petrilla	Steve Swanson	Peter Wu
Rick Pimpinella	Andre Szczepanek	Yu Xu
Neven Pischl	William Szeto	Lennart Yseboodt
Rainer Poehmerer	Bharat Tailor	Ting-Fa Yu
William Powell	Akio Tajima	Liquan Yuan
Richard Prodan	Takayuki Tajima	Hayato Yuki
Rick Rabinovich	Tomoo Takahara	Garold Yurko
Saifur Rahman	Satoshi Takahashi	Andrew Zambell
Adee Ran	Kiyoto Takahata	Jin Zhang
Ram Rao	Alexander Tan	Yan Zhuang
Alon Regev	Toshiki Tanaka	George Zimmerman
Duane Remein	Mehmet Tazebay	Helge Zinner
Victor Renteria	Brian Teipen	Pavel Zivny
Michael Ressler	Geoffrey O. Thompson	Gaoling Zou

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Thomas Alexander	Osamu Ishida	Michael Peters
Pete Anslow	Atsushi Ito	Rick Pimpinella
Ralf-Peter Braun	Raj Jain	William Powell
Nancy Bravin	Adri Jovin	Adee Ran
Theodore Brillhart	Piotr Karocki	Alon Regev
Alan M. Brown	John Kay	Duane Remein
Jairo Bustos Heredia	Stuart Kerry	Maximilian Riegel
William Byrd	Scott Kipp	Robert Robinson
Steven Carlson	Tom Kolze	Benjamin Rolfe
Juan Carreon	Mark Laubach	Frank Schewe
Minho Cheong	David J. Law	Kapil Shrikhande
Keith Chow	David Lewis	Thomas Starai
Keng Hua Chuang	Jon Lewis	Peter Stassar
Charles Cook	Arthur H Light	Rene Struik
Hesham Elbakoury	Ru Lin	Walter Struppler
German Feyh	Elvis Maculuba	Mitsutoshi Sugawara
Matthew Fischer	Valerie Maguire	Geoffrey O. Thompson
Matthias Fritsche	Jeffery Maki	Mark-Rene Uchida
Yukihiro Fujimoto	Arthur Marris	Dmitri Varsanofiev
James Gilb	Thomas Mcdermott	Prabodh Varshney
Randall Groves	Michael McInnis	George Vlantis
Robert Grow	Richard Mellitz	Khurram Waheed
Marek Hajduczenia	Leo Montreuil	Roy Wang
Adam Healey	Charles Moorwood	Hung-Yu Wei
Marco Hernandez	Juichi Nakada	Oren Yuen
Shui Heung	Nick S.A. Nikjoo	Zhen Zhou
Werner Hoelzl	Satoshi Obara	Pavel Zivny
Rita Horner	Stephen Palm	
Victor Hou	Bansi Patel	
Noriyuki Ikeuchi	Arumugam Paventhan	
	Ruben Perez De Aranda Alonso	

When the IEEE-SA Standards Board approved this standard on 22 September 2016, it had the following membership:

Jean-Philippe Faure, *Chair*
Ted Burse, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Chuck Adams	Ronald W. Hotchkiss	Mehmet Ulema
Masayuki Ariyoshi	Michael Janezic	Yingli Wen
Stephen Dukes	Joseph L. Koepfinger*	Howard Wolfman
Jianbin Fan	Hung Ling	Don Wright
J. Travis Griffith	Kevin Lu	Yu Yuan
Gary Hoffman	Annette D. Reilly	Daidi Zhong
	Gary Robinson	

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 802.3bn-2016, IEEE Standard for Ethernet—Amendment 6: Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax.

IEEE Std 802.3™ was first published in 1985. Since the initial publication, many projects have added functionality or provided maintenance updates to the specifications and text included in the standard. Each IEEE 802.3 project/amendment is identified with a suffix (e.g., IEEE Std 802.3ba™-2010).

The half duplex Media Access Control (MAC) protocol specified in IEEE Std 802.3-1985 is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This MAC protocol was key to the experimental Ethernet developed at Xerox Palo Alto Research Center, which had a 2.94 Mb/s data rate. Ethernet at 10 Mb/s was jointly released as a public specification by Digital Equipment Corporation (DEC), Intel and Xerox in 1980. Ethernet at 10 Mb/s was approved as an IEEE standard by the IEEE Standards Board in 1983 and subsequently published in 1985 as IEEE Std 802.3-1985. Since 1985, new media options, new speeds of operation, and new capabilities have been added to IEEE Std 802.3. A full duplex MAC protocol was added in 1997.

Some of the major additions to IEEE Std 802.3 are identified in the marketplace with their project number. This is most common for projects adding higher speeds of operation or new protocols. For example, IEEE Std 802.3u™ added 100 Mb/s operation (also called Fast Ethernet), IEEE Std 802.3z added 1000 Mb/s operation (also called Gigabit Ethernet), IEEE Std 802.3ae added 10 Gb/s operation (also called 10 Gigabit Ethernet), IEEE Std 802.3ah™ specified access network Ethernet (also called Ethernet in the First Mile) and IEEE Std 802.3ba added 40 Gb/s operation (also called 40 Gigabit Ethernet) and 100 Gb/s operation (also called 100 Gigabit Ethernet). These major additions are all now included in and are superseded by IEEE Std 802.3-2015 and are not maintained as separate documents.

At the date of IEEE Std 802.3bn-2016 publication, IEEE Std 802.3 is composed of the following documents:

IEEE Std 802.3-2015

Section One—Includes Clause 1 through Clause 20 and Annex A through Annex H and Annex 4A. Section One includes the specifications for 10 Mb/s operation and the MAC, frame formats and service interfaces used for all speeds of operation.

Section Two—Includes Clause 21 through Clause 33 and Annex 22A through Annex 33E. Section Two includes management attributes for multiple protocols and speed of operation as well as specifications for providing power over twisted pair cabling for multiple operational speeds. It also includes general information on 100 Mb/s operation as well as most of the 100 Mb/s Physical Layer specifications.

Section Three—Includes Clause 34 through Clause 43 and Annex 36A through Annex 43C. Section Three includes general information on 1000 Mb/s operation as well as most of the 1000 Mb/s Physical Layer specifications.

Section Four—Includes Clause 44 through Clause 55 and Annex 44A through Annex 55B. Section Four includes general information on 10 Gb/s operation as well as most of the 10 Gb/s Physical Layer specifications.

Section Five—Includes Clause 56 through Clause 77 and Annex 57A through Annex 76A. Clause 56 through Clause 67 and Clause 75 through Clause 77, as well as associated annexes, specify subscriber

access and other Physical Layers and sublayers for operation from 512 kb/s to 10 Gb/s, and defines services and protocol elements that enable the exchange of IEEE Std 802.3 format frames between stations in a subscriber access network. Clause 68 specifies a 10 Gb/s Physical Layer specification. Clause 69 through Clause 74 and associated annexes specify Ethernet operation over electrical backplanes at speeds of 1000 Mb/s and 10 Gb/s.

Section Six—Includes Clause 78 through Clause 95 and Annex 83A through Annex 93C. Clause 78 specifies Energy-Efficient Ethernet. Clause 79 specifies IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and value (TLV) information elements. Clause 80 through Clause 95 and associated annexes includes general information on 40 Gb/s and 100 Gb/s operation as well the 40 Gb/s and 100 Gb/s Physical Layer specifications. Clause 90 specifies Ethernet support for time synchronization protocols.

IEEE Std 802.3bw-2015

Amendment 1—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 96. This amendment adds 100 Mb/s Physical Layer (PHY) specifications and management parameters for operation on a single balanced twisted-pair copper cable.

IEEE Std 802.3by-2016

Amendment 2—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 105 through Clause 112, Annex 109A, Annex 109B, Annex 110A, Annex 110B, and Annex 110C. This amendment adds MAC parameters, Physical Layers, and management parameters for the transfer of IEEE 802.3 format frames at 25 Gb/s.

IEEE Std 802.3bq-2016

Amendment 3—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 113 and Annex 113A. This amendment adds new Physical Layers for 25 Gb/s and 40 Gb/s operation over balanced twisted-pair structured cabling systems.

IEEE Std 802.3bp-2016

Amendment 4—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 97 and Clause 98. This amendment adds point-to-point 1 Gb/s Physical Layer (PHY) specifications and management parameters for operation on a single balanced twisted-pair copper cable in automotive and other applications not utilizing the structured wiring plant.

IEEE Std 802.3br-2016

Amendment 5—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 99. This amendment adds a MAC Merge sublayer and a MAC Merge Service Interface to support for Interspersing Express Traffic over a single link.

IEEE Std 802.3bn-2016

Amendment 6—This amendment adds the Physical Layer specifications and management parameters for symmetric and/or asymmetric operation of up to 10 Gb/s on point-to-multipoint Radio Frequency (RF) distribution plants comprising either amplified or passive coaxial media. It also extends the operation of Ethernet Passive Optical Networks (EPON) protocols, such as Multipoint Control Protocol (MPCP) and Operation Administration and Management (OAM).

A companion document IEEE Std 802.3.1 describes Ethernet management information base (MIB) modules for use with the Simple Network Management Protocol (SNMP). IEEE Std 802.3.1 is updated to add management capability for enhancements to IEEE Std 802.3 after approval of the enhancements.

IEEE Std 802.3 will continue to evolve. New Ethernet capabilities are anticipated to be added within the next few years as amendments to this standard.

Acknowledgments

Grateful acknowledgment is made for portions of this standard reprinted with permission from Data-Over-Cable Service Interface Specifications DOCSIS® 3.1 Physical Layer Specification CM-SP-PHYv3.1-I01-131029 (Cable Television Laboratories, Inc. 2013), © 2013.

Contents

1. Introduction.....	25
1.2 Notation	25
1.2.7 Qm.n number format.....	25
1.3 Normative references	25
1.4 Definitions	25
1.5 Abbreviations.....	26
30. Management.....	28
30.3 Layer management for DTEs.....	28
30.3.2 PHY device managed object class	28
30.3.2.1 PHY device attributes	28
30.3.2.1.2 aPhyType	28
30.3.2.1.3 aPhyTypeList	28
30.3.5 MPCP managed object class.....	28
30.3.5.1 MPCP attributes.....	28
30.3.5.1.2 aMPCPAdminState.....	28
30.3.5.1.3 aMPCPMode.....	29
30.5 Layer management for medium attachment units (MAUs)	29
30.5.1 MAU managed object class	29
30.5.1.1 MAU attributes	29
30.5.1.1.2 aMAUType	29
45. Management Data Input/Output (MDIO) Interface.....	30
45.2 MDIO Interface Registers.....	30
45.2.1 PMA/PMD registers	30
45.2.1.4 PMA/PMD speed ability (Register 1.4).....	32
45.2.1.4.b 10GPASS-XR capable (1.4.10)	32
45.2.1.6 PMA/PMD control 2 register (Register 1.7).....	33
45.2.1.14aa EPoC PMA/PMD ability register (Register 1.17)	33
45.2.1.14aa.1 10GPASS-XR-D ability (1.17.1).....	33
45.2.1.14aa.2 10GPASS-XR-U ability (1.17.0)	33
45.2.1.130a 10GPASS-XR control and status register (Register 1.1900).....	34
45.2.1.130a.1 Time sync capable (1.1900:13).....	34
45.2.1.130a.2 US rate mismatch (1.1900:12)	34
45.2.1.130a.3 DS rate mismatch (1.1900:11)	35
45.2.1.130a.4 Link up ready (1.1900:10)	35
45.2.1.130a.5 Continuous pilot scaling factor (1.1900.9:3)	35
45.2.1.130a.6 CRC40 errored blocks (1.1900.2)	35
45.2.1.130a.7 PHY Discovery complete (1.1900.1).....	35
45.2.1.130a.8 PHY Discovery enable (1.1900.0)	35
45.2.1.130b DS OFDM control register (Register 1.1901)	35
45.2.1.130b.1 CLT tx mute (1.1901.15).....	36
45.2.1.130b.2 DS OFDM channels (1.1901.14:12)	36
45.2.1.130b.3 DS time interleaving (1.1901.11:7)	36
45.2.1.130b.4 DS windowing (1.1901.6:4)	36
45.2.1.130b.5 DS cyclic prefix (1.1901.3:0)	36
45.2.1.130c DS OFDM channel frequency control register 1 through 5 (Register 1.1902 through 1.1906).....	36

45.2.1.130c.1	DS OFDM freq ch 1 (1.1902.15:0)	37
45.2.1.130c.2	DS OFDM freq ch 2 (1.1903.15:0)	37
45.2.1.130c.3	DS OFDM freq ch 3 (1.1904.15:0)	37
45.2.1.130c.4	DS OFDM freq ch 4 (1.1905.15:0)	37
45.2.1.130c.5	DS OFDM freq ch 5 (1.1906.15:0)	37
45.2.1.130d	US OFDM control register (Register 1.1907)	38
45.2.1.130d.1	Random seed (1.1907.15:8)	38
45.2.1.130d.2	Resource Block size (1.1907.7)	38
45.2.1.130d.3	US windowing (1.1907.6:4)	38
45.2.1.130d.4	US cyclic prefix (1.1907.3:0)	38
45.2.1.130e	US OFDM channel frequency control register (Register 1.1908)	38
45.2.1.130f	US OFDMA pilot pattern register (Register 1.1909)	39
45.2.1.130f.1	Type 2 repeat (1.1909.14:12)	39
45.2.1.130f.2	Type 2 start (1.1909.11:8)	39
45.2.1.130f.3	Type 1 repeat (1.1909.6:4)	39
45.2.1.130f.4	Type 1 start (1.1909.3:0)	39
45.2.1.130g	Profile control register (Register 1.1910)	40
45.2.1.130g.1	US copy in process (1.1910.11)	40
45.2.1.130g.2	US profile copy (1.1910.10)	40
45.2.1.130g.3	US configuration ID (1.1910.9:8)	40
45.2.1.130g.4	DS copy channel ID (1.1910.6:4)	41
45.2.1.130g.5	DS copy in process (1.1910.3)	41
45.2.1.130g.6	DS profile copy (1.1910.2)	41
45.2.1.130g.7	DS configuration ID (1.1910.1:0)	41
45.2.1.130h	DS PHY Link control register (Register 1.1911)	41
45.2.1.130h.1	DS PHY Link start (1.1911.11:0)	41
45.2.1.130i	US PHY Link control register (Register 1.1912)	41
45.2.1.130i.1	US PHY Link modulation (1.1912.15:12)	41
45.2.1.130i.2	US PHY Link start (1.1912.11:0)	42
45.2.1.130j	PHY Discovery control registers (Registers 1.1913 and 1.1914)	42
45.2.1.130k	New CNU control register (Register 1.1915)	43
45.2.1.130k.1	CNU_ID assigned flag 1 (1.1915.15)	43
45.2.1.130k.2	Allowed CNU_ID (1.1915.14:0)	43
45.2.1.130l	New CNU info registers 1 through 5 (Registers 1.1916 through 1.1920)	43
45.2.1.130l.1	New CNU range (1.1916.15:0)	44
45.2.1.130l.2	New CNU MAC 0 through 2 (1.1917.15:0 through 1.1919.15:0)	44
45.2.1.130m	DS PHY Link frame counter (Register 1.1921)	44
45.2.1.130n	PMA/PMD timing offset register (Registers 1.1922 and 1.1923)	44
45.2.1.130o	PMA/PMD power offset register (Register 1.1924)	45
45.2.1.130o.1	PMA/PMD power offset (1.1924.7:0)	45
45.2.1.130p	PMA/PMD ranging offset registers (Registers 1.1925 and 1.1926)	45
45.2.1.130q	DS PMA/PMD data rate registers (Registers 1.1927, 1.1928 and 1.1929)	45
45.2.1.130r	US PMA/PMD data rate registers (Registers 1.1930, 1.1931 and 1.1932)	45
45.2.1.130s	10GPASS-XR FEC codeword counter (Registers 1.1933, 1.1934)	46
45.2.1.130t	10GPASS-XR FEC codeword success counter (Registers 1.1935 and 1.1936)	47
45.2.1.130u	10GPASS-XR FEC codeword fail counter (Registers 1.1937 and 1.1938)	47
45.2.1.130v	PHY Link EPFH counter (Register 1.1939)	47
45.2.1.130w	PHY Link EPFH error counter (Register 1.1940)	48
45.2.1.130x	PHY Link EPCH counter (Register 1.1941)	48
45.2.1.130y	PHY Link EPCH error counter (Register 1.1942)	48
45.2.1.130z	PHY Link EMB counter (Register 1.1943)	48
45.2.1.130z1	PHY Link EMB error counter (Register 1.1944)	49
45.2.1.130z2	PHY Link FPMB counter (Register 1.1945)	49
45.2.1.130z3	PHY Link FPMB error counter (Register 1.1946)	50

45.2.1.130z4	US PHY Link response time register (Register 1.1947)	50
45.2.1.130z5	10GPASS-XR modulation ability register (Register 1.1948)	50
45.2.1.130z5.1	US modulation ability (1.1948.9:8)	51
45.2.1.130z5.2	DS OFDM channel ability (1.1948.7:5)	51
45.2.1.130z5.3	DS modulation ability (1.1948.4:0)	51
45.2.1.130z6	PHY Discovery Response power control register (Register 1.1949)	51
45.2.1.130z6.1	PHY Discovery Response power step (1.1949.15:8)	51
45.2.1.130z6.2	PHY Discover Response initial power (1.1949.7:0)	51
45.2.1.130z7	US target receive power register (Register 1.1950)	51
45.2.1.130z8	DS transmit power registers (Registers 1.1951 through 1.1955)	52
45.2.1.130z8.1	DS transmit power Ch1 (1.1951.8:0)	52
45.2.1.130z8.2	DS transmit power Ch2 (1.1952.8:0)	52
45.2.1.130z8.3	DS transmit power Ch3 (1.1953.8:0)	53
45.2.1.130z8.4	DS transmit power Ch4 (1.1954.8:0)	53
45.2.1.130z8.5	DS transmit power Ch5 (1.1955.8:0)	53
45.2.1.130z9	US receive power measurement registers (1.1956 through 1.1957)	53
45.2.1.130z9.1	US receive power valid (1.1956.15)	53
45.2.1.130z9.2	US receive power measurement (1.1956.8:0)	53
45.2.1.130z9.3	US receive power CNU (1.1957.14:0)	54
45.2.1.130z10	Reported power register (1.1958)	54
45.2.1.130z10.1	Reported power (1.1958.8:0)	54
45.2.7a	OFDM PMA/PMD registers	54
45.2.7a.1	10GPASS-XR DS OFDM channel ID register (Register 12.0)	55
45.2.7a.1.1	DS OFDM channel ID (12.0.2:0)	55
45.2.7a.2	10GPASS-XR DS profile descriptor control 1 through 1023 (Registers 12.1 through 12.1023)	55
45.2.7a.2.1	DS modulation type SC7 (12.1.15:12)	56
45.2.7a.2.2	DS modulation type SC6 (12.1.11:8)	56
45.2.7a.2.3	DS modulation type SC5 (12.1.7:4)	56
45.2.7a.2.4	DS modulation type SC4 (12.1.3:0)	56
45.2.7a.3	10GPASS-XR US profile descriptor control 0 through 1023 registers (Registers 12.1024 through 12.2047)	56
45.2.7a.3.1	US modulation type SC3 (12.1024.15:12)	57
45.2.7a.3.2	US modulation type SC2 (12.1024.11:8)	57
45.2.7a.3.3	US modulation type SC1 (12.1024.7:4)	57
45.2.7a.3.4	US modulation type SC0 (12.1024.3:0)	57
45.2.7a.4	10GPASS-XR US pre-equalizer coefficients 0 through 4095 (Registers 12.2048 through 12.10239)	57
45.2.7a.4.1	Real pre-equalizer coefficient SC0 (12.2048.15:0)	58
45.2.7a.4.2	Imaginary pre-equalizer coefficient SC0 (12.2049.15:0)	58
45.2.7a.5	10GPASS-XR receive MER control registers (Registers 12.10240 and 12.10241)	58
45.2.7a.5.1	MER measurement valid (12.10240.3)	58
45.2.7a.5.2	Receive MER Channel ID (12.10240.2:0)	58
45.2.7a.5.3	Receive MER CNU ID (12.10241.14:0)	58
45.2.7a.6	10GPASS-XR receive MER measurement registers (Registers 12.10242 through 12.12287)	59
45.2.7a.6.1	Receive MER SC5 (12.10242.15:8)	59
45.2.7a.6.2	Receive MER SC4 (12.10242.7:0)	59
45.5	Protocol implementation conformance statement (PICS) proforma for Clause 45, Management Data Input/Output (MDIO) Interface	60
45.5.3	Major capabilities/options	60
45.5.3.2	PMA/PMD MMD options	60
45.5.3.13a	OFDM management functions	60

56. Introduction to Ethernet for subscriber access networks	62
56.1 Overview.....	62
56.1.2 Summary of P2MP sublayers	62
56.1.2.1 Multipoint MAC Control Protocol (MPCP)	62
56.1.2.2 Reconciliation Sublayer (RS) and media independent interfaces.....	63
56.1.3 Physical Layer signaling systems	63
56.1.5 Unidirectional transmission	65
67. System considerations for Ethernet subscriber access networks	67
67.1 Overview.....	67
67.2 Discussion and examples of EFM P2MP topologies.....	67
67.2.1 Trade off between link span and split ratio for P2MP PON architecture	67
67.2.2 Single splitter topology for P2MP PON architecture	68
67.2.3 Tree-and-branch topology for P2MP PON architecture	68
67.6 Operations, Administration, and Maintenance	68
67.6.1 Unidirectional links.....	68
67.6.3 Link status signaling in P2MP networks	68
76. Reconciliation Sublayer, Physical Coding Sublayer, and Physical Media Attachment for 10G-EPON	69
76.2 Reconciliation Sublayer (RS) for 10G-EPON	69
76.2.6 Mapping of XGMII and GMII signals to PLS service primitives	69
76.2.6.1 Functional specifications for multiple MACs.....	69
76.2.6.1.3 RS Receive function	69
100. Physical Medium Dependent (PMD) sublayer, and medium for coaxial distribution networks, type 10GPASS-XR	70
100.1 Overview.....	70
100.1.1 Terminology and conventions	70
100.1.2 Positioning of the PMD sublayer within the IEEE 802.3 architecture	70
100.1.3 PMD types	70
100.1.4 Mapping of PMD variables.....	70
100.2 PMD functional specification	74
100.2.1 PMD service interface	74
100.2.1.1 PMD_UNITDATA.request.....	75
100.2.1.2 PMD_UNITDATA.indication	75
100.2.1.3 PMD_SIGNAL.request.....	75
100.2.2 Delay constraints.....	75
100.2.3 PMD transmit function	76
100.2.4 PMD receive function	76
100.2.5 PMD transmit enable function.....	76
100.3 PMD operational requirements.....	76
100.3.1 CLT and CNU modulation formats	76
100.3.2 Data rates	77
100.3.2.1 Downstream PHY data rate	77
100.3.2.2 Upstream PHY data rate	78
100.3.2.3 PHY Link managed variables	79
100.3.3 CLT transmitter requirements.....	80
100.3.3.1 OFDM channel power definitions	80
100.3.3.2 CLT output electrical requirements	81

100.3.3.2.1	PHY Link managed variables	83
100.3.3.3	Phase noise requirements	83
100.3.3.4	Power per OFDM channel for CLT	83
100.3.3.5	Out-of-band noise and spurious requirements for the CLT	84
100.3.3.6	CLT transmitter output requirements	88
100.3.4	CNU transmitter requirements	88
100.3.4.1	Burst timing convention	88
100.3.4.2	Transmit power requirements	88
100.3.4.3	OFDMA transmit power calculations	89
100.3.4.3.1	PHY Link managed variables	90
100.3.4.4	OFDMA fidelity requirements	90
100.3.4.4.1	Spurious emissions	90
100.3.4.4.2	Spurious emissions in the upstream frequency range	92
100.3.4.4.3	Adjacent channel spurious emissions	94
100.3.4.4.4	Spurious emissions during burst on/off transients	95
100.3.4.5	Transmit MER requirements	95
100.3.4.5.1	Definitions	96
100.3.4.5.2	Requirements	97
100.3.4.6	CNU Transmitter output requirements	97
100.3.4.7	CNU RF power amplifier requirements	98
100.3.5	CLT receiver requirements	99
100.3.5.1	CLT receiver input power requirements	99
100.3.5.1.1	PHY Link managed variables	100
100.3.5.2	CLT receiver error performance in AWGN channel	100
100.3.5.3	CLT upstream receive modulation error ratio requirements	101
100.3.5.3.1	PHY Link managed variables	101
100.3.6	CNU receiver requirements	102
100.3.6.1	Input signal characteristics at CNU receiver	102
100.3.6.2	CNU error performance in AWGN channel	102
100.3.6.3	Receive modulation error ratio requirements	103
100.3.7	Channel band rules	105
100.3.7.1	Downstream channel bandwidth rules	105
100.3.7.2	Downstream exclusion band rules	105
100.3.7.3	Upstream channel bandwidth rules	106
100.3.7.4	Upstream exclusions and unused subcarriers rules	106
100.4	Test requirements and measurement methods	106
100.4.1	CLT RF output muting requirement	106
100.4.2	CNU receive modulation error ratio testing	107
100.4.3	Upstream channel power	107
100.4.3.1	PHY Link managed variables	108
100.4.4	Guidelines for verifying compliance with downstream phase noise requirements	108
100.4.4.1	Test mode 1	109
100.4.4.2	Test mode 2	109
100.5	Environmental, safety, and labeling	110
100.5.1	General safety	110
100.5.2	Installation	110
100.5.3	Environment	110
100.5.4	PMD labeling	110
100.5.4.1	Frequency plan	110
100.5.4.1.1	Downstream frequency plan	110
100.5.4.1.2	Upstream frequency plan	110
100.6	EEE capability	110

100.7	Protocol implementation conformance statement (PICS) proforma for Clause 100, Physical Medium Dependent (PMD) sublayer and medium for coaxial cable distribution networks, type 10GPASS-XR	111
100.7.1	Identification	111
100.7.1.1	Implementation identification	111
100.7.1.2	Protocol summary	111
100.7.2	Major capabilities/options	112
100.7.3	PICS proforma tables for Physical Medium Dependent (PMD) sublayer for coax cable distribution networks, type 10GPASS-XR.....	113
100.7.3.1	PMD functional specifications	113
100.7.3.2	Definition of parameters and measurement methods	116
100.7.3.3	Environmental specifications	116
101.	Reconciliation Sublayer, Physical Coding Sublayer, and Physical Media Attachment for EPoC	117
101.1	Overview.....	117
101.1.1	Conventions	117
101.1.2	Constraints for delay through RS, PCS, and PMA	117
101.1.3	Mapping of PCS, and PMA variables.....	117
101.1.4	Functional blocks supporting 10GPASS-XR PCS, PMA, and PMD sublayers	117
101.2	Reconciliation Sublayer (RS) for EPoC	125
101.3	Physical Coding Sublayer (PCS) for EPoC	125
101.3.1	Overview.....	125
101.3.2	PCS transmit function	127
101.3.2.1	Idle deletion process	127
101.3.2.1.1	Constants.....	127
101.3.2.1.2	Variables	128
101.3.2.1.3	Counters.....	129
101.3.2.1.4	Functions.....	129
101.3.2.1.5	State diagrams.....	129
101.3.2.2	64B/66B Encoder.....	131
101.3.2.3	CRC40	132
101.3.2.4	Low Density Parity Check (LDPC) Forward Error Correction (FEC) codes.....	132
101.3.2.4.1	LDPC matrix definition	133
101.3.2.5	FEC Encoder and Data Detector processes	134
101.3.2.5.1	Data Detector process	134
101.3.2.5.2	LDPC encode process	136
101.3.2.5.3	LDPC codeword transmission order.....	136
101.3.2.5.4	Upstream FEC encoding	139
101.3.2.5.5	Constants.....	139
101.3.2.5.6	Variables	139
101.3.2.5.7	Functions.....	141
101.3.2.5.8	State diagrams.....	144
101.3.3	PCS receive function	146
101.3.3.1	FEC Decoder.....	147
101.3.3.1.1	Upstream FEC decoding	147
101.3.3.1.2	LDPC decoding process within CNU (downstream).....	147
101.3.3.1.3	LDPC decoding process within CLT upstream	149
101.3.3.1.4	Codeword error monitor	149
101.3.3.1.5	Constants.....	149
101.3.3.1.6	Variables	150
101.3.3.1.7	Functions.....	151
101.3.3.1.8	State diagrams.....	152
101.3.3.2	64B/66B Decoder	154

101.3.3.3	Idle control character insertion process	154
101.3.3.3.1	Constants	155
101.3.3.3.2	Variables	155
101.3.3.3.3	Functions	156
101.3.3.3.4	Messages	156
101.3.3.3.5	State diagrams	156
101.4	10GPASS-XR PMA	157
101.4.1	Overview	157
101.4.2	PMA Service Interface	158
101.4.2.1	PMA_UNITDATA.request	158
101.4.2.1.1	Semantics of the service primitive	158
101.4.2.1.2	When generated	158
101.4.2.1.3	Effect of receipt	159
101.4.2.2	PMA_UNITDATA.indication	159
101.4.2.2.1	Semantics of the service primitive	159
101.4.2.2.2	When generated	159
101.4.2.2.3	Effect of receipt	159
101.4.3	Downstream PMA transmit function	159
101.4.3.1	Overview	159
101.4.3.2	Time and frequency synchronization	160
101.4.3.3	Subcarrier clocking	161
101.4.3.4	Subcarrier configuration and bit loading	162
101.4.3.4.1	Nullled subcarriers	162
101.4.3.4.2	Continuous pilots	162
101.4.3.4.3	Bit loaded subcarriers	162
101.4.3.4.4	Excluded subcarriers	163
101.4.3.4.5	PHY Link managed variables	163
101.4.3.5	Framing	164
101.4.3.6	Pilot map	164
101.4.3.6.1	Scattered pilots	165
101.4.3.6.2	Continuous pilots	167
101.4.3.6.3	Predefined continuous pilots around the PHY Link	167
101.4.3.6.4	Continuous pilot placement defined by PHY Link message	167
101.4.3.6.5	PHY Link managed variables	169
101.4.3.7	Scrambler	169
101.4.3.8	Symbol mapper	170
101.4.3.8.1	Introduction	170
101.4.3.8.2	Transmitter bit loading for symbol mapping	171
101.4.3.8.3	Bit loading	172
101.4.3.8.4	FCP calculation	173
101.4.3.9	Time and frequency interleaver	174
101.4.3.9.1	Overview	174
101.4.3.9.2	Time interleaving	174
101.4.3.9.3	Frequency interleaving	175
101.4.3.9.4	Interleaving impact on continuous pilots, scattered pilots, PHY Link and excluded spectral region	178
101.4.3.9.5	PHY Link managed variables	179
101.4.3.10	Pilot insertion	179
101.4.3.10.1	Pilot boosting	180
101.4.3.11	Inverse Discrete Fourier Transform (IDFT)	180
101.4.3.11.1	PHY Link managed variables	180
101.4.3.12	Cyclic prefix and windowing	180
101.4.3.12.1	PHY Link managed variables	184
101.4.3.13	OFDM channel requirements	184

101.4.4 Upstream PMA transmit function.....	185
101.4.4.1 Overview.....	185
101.4.4.2 Time and frequency synchronization.....	185
101.4.4.2.1 OFDM channel frequency accuracy	185
101.4.4.2.2 OFDM channel timing accuracy.....	185
101.4.4.2.3 Modulation timing jitter.....	185
101.4.4.3 Frame timing.....	186
101.4.4.3.1 RB Superframe configuration and burst transmission.....	186
101.4.4.3.2 OFDMA transmission burst start.....	186
101.4.4.3.3 OFDMA transmission internal to a burst.....	187
101.4.4.3.4 OFDMA transmission burst end.....	187
101.4.4.3.5 Variables	187
101.4.4.3.6 State diagram	188
101.4.4.4 Subcarrier configuration and bit loading	189
101.4.4.4.1 Nulled subcarriers.....	189
101.4.4.4.2 Bit loaded subcarriers	189
101.4.4.4.3 Excluded subcarriers.....	189
101.4.4.4.4 PHY Link managed variables.....	189
101.4.4.5 Upstream symbol mapper.....	190
101.4.4.5.1 Variables	190
101.4.4.5.2 Functions.....	193
101.4.4.5.3 State diagrams.....	194
101.4.4.5.4 Minimum gap time and burst marker overhead.....	197
101.4.4.6 Pilot patterns	197
101.4.4.6.1 variables.....	198
101.4.4.7 Staging and pilot insertion	198
101.4.4.7.1 Staging	198
101.4.4.7.2 Pilot insertion.....	199
101.4.4.8 Burst markers.....	199
101.4.4.8.1 Introduction.....	199
101.4.4.8.2 Burst marker start and stop sequences.....	199
101.4.4.8.3 Burst marker B element encoding	201
101.4.4.9 Pre-equalization and Inverse Discrete Fourier Transform (IDFT).....	204
101.4.4.9.1 Pre-equalization coefficients.....	204
101.4.4.9.2 PHY Link managed variables.....	205
101.4.4.10 Cyclic prefix and windowing.....	205
101.4.4.10.1 PHY Link managed variables.....	206
101.4.5 Constellation structure and mapping	207
101.4.5.1 One dimensional Gray mapping for m-tuple binary bits.....	207
101.4.5.2 Constellation structure and mapping of BPSK.....	207
101.4.5.3 Constellation structure and mapping of 22n-QAM.....	208
101.4.5.4 Constellation structure and mapping of 22n+1-QAM (n>0).....	209
101.4.5.4.1 Constellation structure and mapping of 8-QAM.....	209
101.4.5.4.2 Constellation structure and mapping of 22n+1-QAM with n > 1	210
101.4.5.5 QAM constellation scaling	211
101.4.6 PMA testing	212
101.4.6.1 Pre-equalization testing.....	212
101.4.6.2 OFDM channel frequency accuracy test.....	213
101.5 Applicability of Clause 90 and IEEE Std 802.1AS, Clause 13 for EPoC time transport	213
101.5.1 CLT PHY asymmetry correction of future time transmitted by the CLT to CNU _i	213
101.5.2 CNU PHY asymmetry correction of future time received by CNU _i	213
101.6 Protocol implementation conformance statement (PICS) proforma for Clause 101, Reconciliation Sublayer, Physical Coding Sublayer, and Physical Media Attachment for EPoC	215

101.6.1	Introduction.....	215
101.6.2	Identification.....	215
101.6.2.1	Implementation identification	215
101.6.2.2	Protocol summary	215
101.6.3	Major capabilities/options	216
101.6.4	PICS proforma tables for Reconciliation Sublayer, Physical Coding Sublayer, and Physical Media Attachment for EPoC	216
101.6.4.1	General specifications	216
101.6.4.2	Transmission functions	217
101.6.4.3	OFDM Configuration functions	217
101.6.4.4	OFDM Timing	218
101.6.4.5	Data Detector functions	219
101.6.4.6	IDLE insertion and deletion functions	219
101.6.4.7	FEC functions	220
101.6.4.8	Encoding functions	220
101.6.4.9	Pilots	221
101.6.4.10	Equalization	222
102.	EPoC PHY Link.....	223
102.1	PHY Link overview and architecture	223
102.1.1	PHY Link frame structure and protocol	223
102.1.2	PHY Link block diagram.....	225
102.1.3	PHY Link Message Engine.....	226
102.1.4	PHY Link FEC encoder.....	227
102.1.4.1	LDPC (480, 288) mother code.....	227
102.1.4.2	LDPC (160, 80) mother code.....	227
102.1.4.3	Shortening and puncturing encoders.....	227
102.1.4.3.1	LDPC (384, 288) puncturing encoder.....	228
102.1.4.3.2	LDPC (128, 80) puncturing encoder.....	228
102.1.5	PHY Link scrambler	229
102.1.6	PHY Link symbol map and constellation mapping	229
102.1.7	Interleaving.....	230
102.1.8	Mapping of PHY Link variables.....	230
102.2	Downstream PHY Link	234
102.2.1	Downstream PHY Link Physical Layer.....	234
102.2.1.1	Resource allocation.....	234
102.2.1.2	Downstream PHY Link modulation	234
102.2.1.3	Downstream PHY Link subcarrier block interleaving	235
102.2.2	Downstream preamble	236
102.2.3	Downstream frame.....	237
102.2.3.1	Downstream EPoC PHY Frame Header.....	238
102.2.3.1.1	Configuration ID and profile activation.....	238
102.2.3.1.2	Response Frame ID.....	238
102.2.3.1.3	PHY Link DA	239
102.2.3.1.4	PHY Timestamp	240
102.2.3.2	EPoC Probe Control Header message block.....	240
102.2.3.2.1	Probe Scheduling type Probe Control fields.....	241
102.2.3.2.2	Broadcast PHY Discovery type Probe Control fields.....	241
102.2.3.2.3	Unicast PHY Discovery type Probe Control fields	241
102.2.3.2.4	PHY Link managed variables	242
102.2.3.3	Downstream EPoC message block	242
102.2.3.4	Downstream padding	243
102.2.3.5	Downstream FEC Parity message block.....	243

102.2.4	Downstream PHY Link FEC	243
102.2.5	Downstream PHY Link response time	243
102.2.6	PHY Link managed variables	243
102.2.7	Downstream state diagrams	244
102.2.7.1	Constants	244
102.2.7.2	Counters	244
102.2.7.3	Variables	245
102.2.7.4	Functions	247
102.2.7.5	State diagrams	247
102.3	Upstream PHY Link	249
102.3.1	Upstream PHY Link Physical Layer	249
102.3.1.1	Upstream resource allocation	249
102.3.1.2	Upstream PHY Link modulation	249
102.3.1.3	Upstream PHY Link transmission	249
102.3.2	Upstream PHY Link frame	249
102.3.2.1	Upstream EPoC PHY Frame Header	249
102.3.2.2	Upstream EPoC message block	249
102.3.2.2.1	Padding	251
102.3.3	Upstream PHY Link FEC	251
102.3.4	Upstream PHY Link pilot pattern	251
102.3.5	Upstream state diagrams	251
102.3.5.1	Constants	251
102.3.5.2	Counters	252
102.3.5.3	Variables	252
102.3.5.4	Functions	253
102.3.5.5	State diagrams	253
102.4	PHY Link applications	254
102.4.1	PHY Discovery	255
102.4.1.1	Overview of PHY Discovery	255
102.4.1.2	PHY Link acquisition	255
102.4.1.3	PHY Discovery window opening	256
102.4.1.4	PHY Link Discovery Response	256
102.4.1.5	PHY Discovery preamble	258
102.4.1.6	CNU_ID allocation	259
102.4.1.7	PHY Discovery completion	260
102.4.1.8	PHY Link managed variables	260
102.4.1.9	PHY Discovery state diagrams	261
102.4.1.9.1	Constants	261
102.4.1.9.2	Variables	261
102.4.1.9.3	Counters	262
102.4.1.9.4	Functions	262
102.4.1.9.5	State diagrams	263
102.4.2	Upstream Wideband Probing	263
102.4.2.1	Introduction	263
102.4.2.2	Probing symbol pilots	264
102.4.2.3	Probing symbol scheduling	264
102.4.2.4	Probing sequence	266
102.4.2.5	Probe symbol repetition	267
102.4.2.6	Wide Band Probing state diagrams	267
102.4.2.6.1	Constants	267
102.4.2.6.2	Variables	267
102.4.2.7	Counters	268
102.4.2.8	Functions	268
102.4.2.9	State diagrams	269

102.4.3	Link-up declaration.....	270
102.4.4	Link-down declaration.....	271
102.4.4.1	CNU PHY self declared link-down.....	272
102.4.4.2	CLT declared link-down.....	272
102.4.4.3	Upper layer declared link-down.....	272
102.4.5	OFDM Profile descriptors.....	272
102.4.5.1	PHY Link managed variables.....	273
102.5	Protocol implementation conformance statement (PICS) proforma for Clause 102, EPoC	
	PHY Link.....	274
102.5.1	Introduction.....	274
102.5.2	Identification.....	274
102.5.2.1	Implementation identification.....	274
102.5.2.2	Protocol summary.....	274
102.5.3	Major capabilities/options.....	275
102.5.4	PICS proforma tables for EPoC PHY Link.....	275
102.5.4.1	PHY Link general specifications.....	275
102.5.4.2	PHY Link timing.....	277
102.5.4.3	Downstream framing.....	277
102.5.4.4	DS Encoding and transmission.....	278
102.5.4.5	Downstream OFDM.....	278
102.5.4.6	Upstream encoding and transmission.....	279
102.5.4.7	Upstream framing.....	279
102.5.4.8	Upstream OFDM.....	279
102.5.4.9	Communication Protocol.....	280
102.5.4.10	PHY Discovery.....	280
102.5.4.11	Probes.....	281
103.	Multipoint MAC Control for EPoC.....	282
103.1	Overview.....	282
103.1.1	Position of Multipoint MAC Control within the IEEE 802.3 hierarchy.....	284
103.1.2	Functional block diagram.....	286
103.1.3	Service interfaces.....	287
103.1.4	State diagram conventions.....	287
103.1.5	Other conventions.....	287
103.2	Multipoint MAC Control operation.....	287
103.2.1	Principles of Multipoint MAC Control.....	287
103.2.1.1	Ranging and timing process.....	287
103.2.2	Multipoint transmission control, Control Parser, and Control Multiplexer.....	288
103.2.2.1	Constants.....	290
103.2.2.2	Counters.....	291
103.2.2.3	Variables.....	291
103.2.2.4	Functions.....	293
103.2.2.5	Timers.....	295
103.2.2.6	Messages.....	295
103.2.2.7	State diagrams.....	295
103.3	Multipoint Control Protocol (MPCP).....	302
103.3.1	Principles of Multipoint Control Protocol.....	302
103.3.2	Compatibility considerations.....	302
103.3.2.1	PAUSE operation.....	302
103.3.2.2	Optional Shared LAN emulation.....	302
103.3.2.3	Multicast and single copy broadcast support.....	302
103.3.2.4	Delay requirements.....	302
103.3.3	Discovery processing.....	302

103.3.3.1	Constants.....	304
103.3.3.2	Variables.....	304
103.3.3.3	Timers.....	305
103.3.3.4	Messages.....	305
103.3.3.5	State diagrams.....	308
103.3.4	Report Processing.....	313
103.3.5	Gate Processing.....	313
103.3.5.1	Constants.....	313
103.3.5.2	Variables.....	313
103.3.5.3	Functions.....	315
103.3.5.4	Timers.....	316
103.3.5.5	Messages.....	316
103.3.5.6	State diagrams.....	317
103.3.6	MPCPDU structure and encoding.....	321
103.3.6.1	GATE description.....	321
103.3.6.2	REPORT description.....	321
103.3.6.3	REGISTER_REQ description.....	321
103.3.6.4	REGISTER description.....	322
103.3.6.5	REGISTER_ACK description.....	323
103.4	Protocol implementation conformance statement (PICS) proforma for Clause 103, Multipoint MAC Control for EPoC.....	324
103.4.1	Introduction.....	324
103.4.2	Identification.....	324
103.4.2.1	Implementation identification.....	324
103.4.2.2	Protocol summary.....	324
103.4.3	Major capabilities/options.....	325
103.4.4	PICS proforma tables for Multipoint MAC Control.....	325
103.4.4.1	Compatibility considerations.....	325
103.4.4.2	Multipoint MAC Control.....	326
103.4.4.3	State diagrams.....	327
103.4.4.4	MPCP.....	328
Annex A (informative).	Bibliography.....	330
Annex 31A (normative)	MAC Control opcode assignments.....	331
Annex 100A (normative)	EPoC OFDM channel model.....	332
100A.1	Topology.....	332
100A.2	Downstream channel parameters.....	333
100A.3	Upstream channel parameters.....	335
100A.4	Protocol implementation conformance statement (PICS) proforma for Annex 100A, EPoC OFDM channel model.....	338
100A.4.1	Introduction.....	338
100A.4.2	Identification.....	338
100A.4.2.1	Implementation identification.....	338
100A.4.2.2	Protocol summary.....	338
100A.4.3	Major capabilities/options.....	339

IEEE Standard for Ethernet

Amendment 6: Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.¹

The editing instructions are shown in **bold italic**. Four editing instructions are used: change, delete, insert, and replace. **Change** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strike through~~ (to remove old material) and underscore (to add new material). **Delete** removes existing material. **Insert** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. **Replace** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

Cross references that refer to clauses, tables, equations, or figures not covered by this amendment are highlighted in green.

¹Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

1. Introduction

1.2 Notation

Insert a new 1.2.7 after 1.2.6 “Accuracy and resolution of numerical quantities” as follows:

1.2.7 Qm.n number format

The Qm.n number format is a fixed-point number format where the number of fractional bits is specified by n and optionally the number of integer bits is specified by m. For example, a Q14 number has 14 fractional bits; a Q2.14 number has 2 integer bits and 14 fractional bits. Preceding the “Q” with a “U” indicates an unsigned number.

1.3 Normative references

Insert the following references in alphanumeric order:

CFR 76, Code of Federal Regulations, Title 47, Part 76, October 2005.

IEC 61169-24:2009, Radio-frequency connectors—Part 24: Sectional specification—Radio frequency coaxial connectors with screw coupling, typically for use in 75 Ω cable networks (type F).

IEEE Std 802.1AS™-2011, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

SCTE 02 2006, Specification for “F” Port, Female, Indoor.

1.4 Definitions

Insert the following definition after 1.4.49 “10GBASE-X” as follows:

1.4.49a 10GPASS-XR: A collection of IEEE 802.3 EPON Protocol over Coax (EPoC) Physical Layer specifications for up to 10 Gb/s downstream and up to 1.6 Gb/s upstream point-to-multipoint link over a coax cable distribution network. (See IEEE Std 802.3, Table 56–1, Clause 100, Clause 101, Clause 102, and Clause 103.)

Change the definition of 1.4.134 as modified by IEEE Std 802.3by-2016 as follows:

1.4.134 channel: In 10BROAD36 and 10GPASS-XR, a band of frequencies dedicated to a certain service transmitted on the broadband medium. Otherwise, a defined path along which data in the form of an electrical or optical signal passes. (For 10BROAD36, see IEEE Std 802.3, [Clause 11](#), for 10GPASS-XR see [Clause 100](#), [Clause 101](#), and [Clause 102](#).)

Insert the following definitions after 1.4.144 “Clocked Violation LO (CVL)” as follows:

1.4.144a coax cable distribution network (CCDN): A radio frequency (RF) distribution plant composed of either amplified or passive coaxial media.

1.4.144b coax line terminal (CLT): The network-end DTE for a coaxial access network. The CLT is the master entity in a P2MP EPoC network with regard to the MPCP protocol.

1.4.144c coax network unit (CNU): The subscriber-end DTE to a coaxial access network. A CNU is a slave entity in a P2MP EPoC network with regard to the MPCP protocol.

Insert the following definition after 1.4.170 “cross connect” as follows:

1.4.170a cyclic prefix (CP): A redundant set of samples prepended to an OFDM symbol.

Insert the following definition after 1.4.277 “mixing segment” and before 1.4.277a (as inserted by IEEE Std 802.3bq-2016) as follows:

1.4.277aa modulation error ratio (MER): The ratio of average signal constellation power to average constellation error power—that is, digital complex baseband signal-to-noise ratio—expressed in decibels.

Insert the following definition after 1.4.294 “OAM Discovery” as follows:

1.4.294a OFDM channel: See orthogonal frequency division multiplexing (OFDM) channel.

Insert the following definition after 1.4.296 “Operations, Administration, and Maintenance (OAM)” as follows:

1.4.296a optical distribution network (ODN): An optical distribution plant composed of fiber optic cabling and a passive optical splitter or cascade of splitters.

Insert the following definition after 1.4.306 “Organizationally Unique Identifier (OUI)” as follows:

1.4.306a orthogonal frequency division multiplexing (OFDM) channel: A data transmission channel in which the transmitted data is carried over a number of orthogonal subcarriers.

Change the definition of 1.4.331 “Point-to-Multipoint network (P2MP)” as follows:

1.4.331 Point-to-Multipoint network (P2MP): ~~A passive optical network providing transport of Ethernet frames. A network topology based on a centralized station connected to a number of end stations. Frames transit the network between the central station and the end stations and do not transit directly from end station to end station.~~ (See IEEE Std 802.3, [Clause 64](#), ~~and~~ [Clause 65](#), [Clause 76](#), [Clause 77](#), [Clause 101](#), and [Clause 103](#)).

Insert the following definition after 1.4.348 “quad” as follows:

1.4.348a quadrature amplitude modulation (QAM) symbol: The amplitude-phase representation of the bits of data that modulate a carrier signal or that modulate each of the subcarriers in OFDM.

Change the note in 1.4.400 as follows:

NOTE—See [Clause 64](#), ~~and~~ [Clause 77](#), ~~and~~ [Clause 103](#). The value of time_{quantum} is defined in 64.2.2.1.

1.5 Abbreviations

Insert the following new abbreviations into the list, in alphabetical order:

CCDN	coax cable distribution network
CLT	coax line terminal
CNU	coax network unit
CP	cyclic prefix

IEEE Std 802.3bn-2016
Amendment 6: Physical Layer Specifications and Management Parameters for Ethernet Passive
Optical Networks Protocol over Coax

EPoC	EPON protocol over coax
HFC	hybrid fiber coax
MER	modulation error ratio
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
QAM	quadrature amplitude modulation
RF	radio frequency
RTT	round trip time

30. Management

30.3 Layer management for DTEs

30.3.2 PHY device managed object class

30.3.2.1 PHY device attributes

30.3.2.1.2 aPhyType

Insert after 10/1GBASE-PRX a single line for “10GPASS-XR” type into the APPROPRIATE SYNTAX list of 30.3.2.1.2 aPhyType (as modified by IEEE Std 802.3bw-2015, IEEE Std 802.3by-2016, IEEE Std 802.3bq-2016, and IEEE Std 802.3bp-2016) as follows:

...	10GPASS-XR	Clause 101 PCS up to 10 Gb/s 64B/66B OFDM downstream and up to 1.6 Gb/s 64B/66B OFDMA upstream
...		

30.3.2.1.3 aPhyTypeList

Insert after 10/1GBASE-PRX a single line for “10GPASS-XR” type into the APPROPRIATE SYNTAX list of 30.3.2.1.3 aPhyTypeList (as modified by IEEE Std 802.3bw-2015, IEEE Std 802.3by-2016, IEEE Std 802.3bq-2016, and IEEE Std 802.3bp-2016) as follows:

...	10GPASS-XR	Clause 101 PCS up to 10 Gb/s 64B/66B OFDM downstream and up to 1.6 Gb/s 64B/66B OFDMA upstream
...		

30.3.5 MPCP managed object class

Change the capitalization of the title for 30.3.5.1 as follows:

30.3.5.1 MPCP Attributes

30.3.5.1.2 aMPCPAdminState

Change the description for “BEHAVIOUR DEFINED AS” section of 30.3.5.1.2 aMPCPAdminState to add Clause 103 to the list of cross references as follows:

....
 BEHAVIOUR DEFINED AS:
 A read-only value that identifies the operational state of the Multipoint MAC Control sublayer. An interface that can provide the Multipoint MAC Control sublayer functions specified in [Clause 64](#), ~~or Clause 77~~, or [Clause 103](#) is enabled to do so when this attribute has the enumeration “enabled”. When this attribute has the enumeration “disabled”, the interface acts as it would if it had no Multipoint MAC Control sublayer. The operational state of the Multipoint MAC Control sublayer can be changed using the acMPCPAdminControl action.;

30.3.5.1.3 aMPCPMode

Change the description for “APPROPRIATE SYNTAX” and “BEHAVIOUR DEFINED AS” section of 30.3.5.1.3 aMPCPMode as follows:

...

APPROPRIATE SYNTAX:

An ENUMERATED VALUE that has the following entries:

OLT

ONU

CLT

CNU

BEHAVIOUR DEFINED AS:

A read-only value that identifies the operational mode of the Multipoint MAC Control sublayer.

An interface that can provide the Multipoint MAC Control sublayer functions specified in Clause 64, ~~or Clause 77, or Clause 103. When operates as an OLT when~~ this attribute has the enumeration “OLT”, the interface acts as an OLT. When this attribute has the enumeration “ONU”, the interface acts as an ONU. When this attribute has the enumeration “CLT”, the interface acts as a CLT. When this attribute has the enumeration “CNU”, the interface acts as a CNU.

30.5 Layer management for medium attachment units (MAUs)

30.5.1 MAU managed object class

30.5.1.1 MAU attributes

30.5.1.1.2 aMAUType

Insert after 10GBASE-T a single line for “10GPASS-XR” type into the APPROPRIATE SYNTAX list of 30.5.1.1.2 aMAUType (as modified by IEEE Std 802.3bw-2015, IEEE Std 802.3by-2016, IEEE Std 802.3bq-2016, and IEEE Std 802.3bp-2016) as follows:

...

10GBASE-XR	Coax cable distribution network PHY continuous downstream/burst mode upstream PHY as specified in Clause 100 and Clause 101
------------	---

...

45. Management Data Input/Output (MDIO) Interface

45.2 MDIO Interface Registers

Change reserved row 12 through 28 of Table 45–1 and insert a new row 12 as follows (unchanged rows are not shown):

Table 45–1—MDIO Manageable Device addresses

Device address	MMD name
<u>12</u>	<u>OFDM PMA/PMD</u>
13 through 28	Reserved

Change the identified reserved row in Table 45–2 and insert a new row for OFDM devices immediately below the changed row as follows (unchanged rows and footnotes not shown):

Table 45–2—Devices in package registers bit definitions

Bit(s)	Name	Description	R/W
m.5.15: 12 <u>13</u>	Reserved	Value always 0	RO
m.5.12	OFDM	1 = OFDM present in package 0 = OFDM not present in package	RO

45.2.1 PMA/PMD registers

Change the reserved row for 1.17 in Table 45–3 (as inserted by IEEE Std 802.3bw-2015) as follows (unchanged rows not shown):

Table 45–3—PMA/PMD registers

Register address	Register name	Subclause
1.17	Reserved EPoC PMA/PMD ability	<u>45.2.1.14aa</u>

IEEE Std 802.3bn-2016
Amendment 6: Physical Layer Specifications and Management Parameters for Ethernet Passive
Optical Networks Protocol over Coax

Change Table 45–3 (as inserted by IEEE Std 802.3bw-2015) as follows (unchanged rows not shown):

Table 45–3—PMA/PMD registers

Register address	Register name	Subclause
1.1809 through 1.1899 ²⁰⁹⁹	Reserved	
<u>1.1900</u>	<u>10GPASS-XR control and status</u>	<u>45.2.1.130a</u>
<u>1.1901</u>	<u>DS OFDM control</u>	<u>45.2.1.130b</u>
<u>1.1902 through 1.1906</u>	<u>DS OFDM channel frequency control</u>	<u>45.2.1.130c</u>
<u>1.1907</u>	<u>US OFDM control</u>	<u>45.2.1.130d</u>
<u>1.1908</u>	<u>US OFDM channel frequency control</u>	<u>45.2.1.130e</u>
<u>1.1909</u>	<u>US OFDMA pilot pattern</u>	<u>45.2.1.130f</u>
<u>1.1910</u>	<u>Profile control</u>	<u>45.2.1.130g</u>
<u>1.1911</u>	<u>DS PHY Link control</u>	<u>45.2.1.130h</u>
<u>1.1912</u>	<u>US PHY Link control</u>	<u>45.2.1.130i</u>
<u>1.1913 and 1.1914</u>	<u>PHY Discovery control</u>	<u>45.2.1.130j</u>
<u>1.1915</u>	<u>New CNU control</u>	<u>45.2.1.130k</u>
<u>1.1916 through 1.1920</u>	<u>New CNU info</u>	<u>45.2.1.130l</u>
<u>1.1921</u>	<u>DS PHY Link frame counter</u>	<u>45.2.1.130m</u>
<u>1.1922 and 1.1923</u>	<u>PMA/PMD timing offset</u>	<u>45.2.1.130n</u>
<u>1.1924</u>	<u>PMA/PMD power offset</u>	<u>45.2.1.130o</u>
<u>1.1925 and 1.1926</u>	<u>PMA/PMD ranging offset</u>	<u>45.2.1.130p</u>
<u>1.1927 through 1.1929</u>	<u>DS PMA/PMD data rate</u>	<u>45.2.1.130q</u>
<u>1.1930 through 1.1932</u>	<u>US PMA/PMD data rate</u>	<u>45.2.1.130r</u>
<u>1.1933 and 1.1934</u>	<u>10GPASS-XR FEC codeword counter</u>	<u>45.2.1.130s</u>
<u>1.1935 and 1.1936</u>	<u>10GPASS-XR FEC codeword success counter</u>	<u>45.2.1.130t</u>
<u>1.1937 and 1.1938</u>	<u>10GPASS-XR FEC codeword fail counter</u>	<u>45.2.1.130u</u>
<u>1.1939</u>	<u>PHY Link EPFH counter</u>	<u>45.2.1.130v</u>
<u>1.1940</u>	<u>PHY Link EPFH error counter</u>	<u>45.2.1.130w</u>
<u>1.1941</u>	<u>PHY Link EPCH counter</u>	<u>45.2.1.130x</u>

Table 45–3—PMA/PMD registers (continued)

Register address	Register name	Subclause
<u>1.1942</u>	<u>PHY Link EPCH error counter</u>	<u>45.2.1.130y</u>
<u>1.1943</u>	<u>PHY Link EMB counter</u>	<u>45.2.1.130z</u>
<u>1.1944</u>	<u>PHY Link EMB error counter</u>	<u>45.2.1.130z1</u>
<u>1.1945</u>	<u>PHY Link FPMB counter</u>	<u>45.2.1.130z2</u>
<u>1.1946</u>	<u>PHY Link FPMB error counter</u>	<u>45.2.1.130z3</u>
<u>1.1947</u>	<u>US PHY Link response time</u>	<u>45.2.1.130z4</u>
<u>1.1948</u>	<u>10GPASS-XR modulation ability</u>	<u>45.2.1.130z5</u>
<u>1.1949</u>	<u>PHY Discovery Response power control</u>	<u>45.2.1.130z6</u>
<u>1.1950</u>	<u>US target receive power</u>	<u>45.2.1.130z7</u>
<u>1.1951 through 1.1955</u>	<u>DS transmit power</u>	<u>45.2.1.130z8</u>
<u>1.1956 and 1.1957</u>	<u>US receive power measurement</u>	<u>45.2.1.130z9</u>
<u>1.1958</u>	<u>Reported power</u>	<u>45.2.1.130z10</u>
<u>1.1959 through 1.2099</u>	<u>Reserved</u>	

45.2.1.4 PMA/PMD speed ability (Register 1.4)

Change the reserved row for 1.4.10 in Table 45–6 as inserted by IEEE Std 802.3by-2016 as follows (unchanged rows not shown):

Table 45–6—PMA/PMD speed ability register bit definitions

Bit(s)	Name	Description	R/W ^a
1.4.10	<u>Reserved</u> <u>10GPASS-XR capable</u>	<u>Value always 0</u> <u>1 = PMA/PMD is capable of operating as 10GPASS-XR</u> <u>0 = PMA/PMD is not capable of operating as</u> <u>10GPASS-XR</u>	RO

^aRO = Read only

Insert 45.2.1.4.b after 45.2.1.4.a (as inserted by IEEE Std 802.3by-2016) as follows:

45.2.1.4.b 10GPASS-XR capable (1.4.10)

When read as one, bit 1.4.10 indicates that the PMA/PMD is able to operate as 10GPASS-XR. When read as zero, bit 1.4.10 indicates that the PMA/PMD is not able to operate as 10GPASS-XR.

45.2.1.6 PMA/PMD control 2 register (Register 1.7)

Change the PMA/PMD type selection row in Table 45–7 to add 10GPASS-XR PMDs as follows (only Bits, Name, added Description text, and R/W is shown). Change “reserved” line(s) as appropriate for values defined by this and other approved amendments.

Table 45–7—PMA/PMD control 2 register bit definitions

Bit(s)	Name	Description	R/W ^a
1.7.5:0	PMA/PMD type selection	<u>1 1 0 0 1 1 = 10GPASS-XR-U PMA/PMD</u> <u>1 1 0 0 1 0 = 10GPASS-XR-D PMA/PMD</u>	R/W

^aR/W = Read/Write, RO = Read only

Insert 45.2.1.14aa and Table 45–17aa before 45.2.1.14a as inserted by IEEE Std 802.3bw-2015 as follows:

45.2.1.14aa EPoC PMA/PMD ability register (Register 1.17)

The assignment of bits in the EPoC PMA/PMD ability register is shown in Table 45–17aa. All of the bits in the EPoC PMA/PMD ability register are read only; a write to the EPoC PMA/PMD ability register shall have no effect.

Table 45–17aa—EPoC PMA/PMD ability register bit definitions

Bit(s)	Name	Description	R/W ^a
1.17.15:2	Reserved	Value always 0	RO
1.17.1	10GPASS-XR-D ability	1 = PMA/PMD is able to perform 10GPASS-XR-D 0 = PMA/PMD is not able to perform 10GPASS-XR-D	RO
1.17.0	10GPASS-XR-U ability	1 = PMA/PMD is able to perform 10GPASS-XR-U 0 = PMA/PMD is not able to perform 10GPASS-XR-U	RO

^aRO = Read only

45.2.1.14aa.1 10GPASS-XR-D ability (1.17.1)

When read as one, bit 1.17.1 indicates that the PMA/PMD is able to operate as a 10GPASS-XR-D PMA/PMD type. When read as zero, bit 1.17.1 indicates that the PMA/PMD is not able to operate as a 10GPASS-XR-D PMA/PMD type.

45.2.1.14aa.2 10GPASS-XR-U ability (1.17.0)

When read as one, bit 1.17.0 indicates that the PMA/PMD is able to operate as a 10GPASS-XR-U PMA/PMD type. When read as zero, bit 1.17.0 indicates that the PMA/PMD is not able to operate as a 10GPASS-XR-U PMA/PMD type.

Insert 45.2.1.130a through 45.2.1.130z10 after 45.2.1.130 as follows:

45.2.1.130a 10GPASS-XR control and status register (Register 1.1900)

The assignment of bits in the 10GPASS-XR control and status register is shown in Table 45–98aa.

Table 45–98aa—10GPASS-XR control and status register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1900.15:14	Reserved	Value always 0	RO
1.1900.13	Time synch capable	1 = The CNU supports time synchronization variables 0 = The CNU does not support time synchronization variables	RO
1.1900.12	US rate mismatch	1 = the upstream rate calculated at the CNU and the CLT matches within 10 b/s 0 = the upstream rate calculated at the CNU and the CLT is mismatched by greater than 10 b/s	RO
1.1900.11	DS rate mismatch	1 = the downstream rate calculated at the CNU and the CLT matches within 10 b/s 0 = the downstream rate calculated at the CNU and the CLT is mismatched by greater than 10 b/s	RO
1.1900.10	Link up ready	1 = the CNU is ready to enter the Link-Up state 0 = the CNU is not ready to enter the Link-Up state	R/W
1.1900.9:3	Continuous pilot scaling factor	Number of continuous pilots in the downstream OFDM channels	R/W
1.1900.2	CRC40 errored blocks	1 = 65-bit blocks with detected CRC40 errors are labeled as errored 0 = 65-bit blocks with detected CRC40 errors are not labeled as errored	R/W
1.1900.1	PHY Discovery complete	1 = The PMA/PMD has completed PHY Discovery on the coaxial cable distribution network 0 = The PMA/PMD has not completed PHY Discovery on the coaxial cable distribution network	R/W
1.1900.0	PHY Discovery enable	1 = PMA/PMD is permitted to transmit on the media 0 = PMA/PMD is not permitted to transmit on the media	R/W

^aRO = Read only, R/W = Read/Write

45.2.1.130a.1 Time synch capable (1.1900:13)

When read as one, bit 1.1900:13 indicates that the 10G-PASS-XR PMA/PMD is capable of supporting the time synchronization variables PHY differential delay and PHY differential delay tolerance reflected in registers 1.1949 and 1.1950. This bit is a reflection of the *TimeSyncCapable* variable defined in 101.6.

45.2.1.130a.2 US rate mismatch (1.1900:12)

When read as one, bit 1.1900:12 indicates that the upstream rate calculated at the CNU and the CLT is mismatched by greater than 10 b/s. This bit is defined in 10GPASS-XR-U PMA/PMD only, in 10GPASS-XR-D always read as zero. This bit is a reflection of the *US_RateMatchFail* variable defined in 100.3.2.3.

45.2.1.130a.3 DS rate mismatch (1.1900:11)

When read as one, bit 1.1900.11 indicates that the downstream rate calculated at the CNU and the CLT is mismatched by greater than 10 b/s. This bit is defined in 10GPASS-XR-U PMA/PMD only, in 10GPASS-XR-D always read as zero. This bit is a reflection of the *DS_RateMatchFail* variable defined in 100.3.2.3.

45.2.1.130a.4 Link up ready (1.1900:10)

Bit 1.1900.10 indicates that the CNU is ready for the link-up state. This bit is a reflection of the *LinkUpRdy* variable defined in 102.4.1.9.2.

45.2.1.130a.5 Continuous pilot scaling factor (1.1900.9:3)

Bits 1.1900.9:3 form an unsigned integer that is used to determine the number of continuous pilots in the downstream OFDM channels. These bits are a reflection of the variable *CntPltSF* defined in 101.4.3.6.5.

45.2.1.130a.6 CRC40 errored blocks (1.1900.2)

Bit 1.1900.2 is used to control whether 65-bit blocks with detected CRC40 errors are labeled as errored before being passed higher layers as described in 101.3.3.1.4. This bit is a reflection of the variable *CRC40ErrCtrl* defined in 101.3.3.1.6.

45.2.1.130a.7 PHY Discovery complete (1.1900.1)

When read as one, bit 1.1900.1 indicates that the 10GPASS-XR PMA/PMD has completed PHY Discovery (see 102.4.1) on the coaxial cable distribution network. When read as zero, bit 1.1900.1 indicates that the PMA/PMD has not completed PHY Discovery on the coaxial cable distribution network. This bit is defined in 10GPASS-XR-U PMA/PMD only, in 10GPASS-XR-D always read as one. This bit is a reflection of the variable *PhyDiscCmplt* defined in 102.4.1.9.2.

The default value for bit 1.1900.1 is zero.

45.2.1.130a.8 PHY Discovery enable (1.1900.0)

When read as one, bit 1.1900.0 indicates that the 10GPASS-XR PMA/PMD is permitted to transmit on the media. When read as zero, bit 1.1900.0 indicates that the PMA/PMD is not permitted to transmit on the media. This bit is a reflection of the variable *PD_Enable* defined in 102.2.7.3.

The default value for bit 1.1900.0 is zero.

45.2.1.130b DS OFDM control register (Register 1.1901)

The assignment of bits in the DS OFDM control register is shown in Table 45–98ab.

Table 45–98ab—DS OFDM control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1901.15	CLT tx mute	1 = CLT PHY muted state for test purposes 0 = CLT PHY not muted (normal operation)	R/W

Table 45–98ab—DS OFDM control register bit definitions (continued)

Bit(s)	Name	Description	R/W ^a
1.1901.14:12	DS OFDM channels	Indicates the number of OFDM channels the PMA/PMD is operating in the downstream direction	R/W
1.1901.11:7	DS time interleaving	Indicates the number of OFDM symbols the PMA/PMD is time interleaving in the downstream direction	R/W
1.1901.6:4	DS windowing	Indicates the size of the windowing control for the PMA/PMD in the downstream direction	R/W
1.1901.3:0	DS cyclic prefix	Indicates the size of the cyclic prefix for the PMA/PMD in the downstream direction	R/W

^aR/W = Read/Write

45.2.1.130b.1 CLT tx mute (1.1901.15)

When bit 1.1901.15 is set to one, the CLT PMD transmitter enters the test mode and it is muted. When bit 1.1901.15 is set to a zero, the CLT PMD enters the normal operating state. This bit has no effect in the CNU. This bit is a reflection of the variable *CLT_TxMute* defined in 100.4.1.

45.2.1.130b.2 DS OFDM channels (1.1901.14:12)

Bits 1.1901.14:12 indicate the integer number of downstream OFDM channels in use. The number is between 1 and 5; where bit 1.1901.12 is the LSB and bit 1.1901.14 is the MSB. These bits are a reflection of the counter *DS_ChCnt* defined in 100.3.2.3.

45.2.1.130b.3 DS time interleaving (1.1901.11:7)

Bits 1.1901.11:7 indicate the integer number of time interleaved OFDM symbols in the downstream direction. The number is between 1 and 32; where bit 1.1901.7 is the LSB and bit 1.1901.11 is the MSB. These bits are a reflection of the variable *DS_TmIntrlv* defined in 101.4.3.9.5.

45.2.1.130b.4 DS windowing (1.1901.6:4)

Bits 1.1901.6:4 indicate the size, in OFDM Clock periods (1/204.8 MHz), of the windowing control for the 10GPASS-XR PMA/PMD in the downstream direction. These bits are a reflection of the variable *DSNrp* defined in 101.4.3.12.1 with bits 1.1901.6:4 mapping to bits 2:0 of *DSNrp*, respectively.

45.2.1.130b.5 DS cyclic prefix (1.1901.3:0)

Bits 1.1901.3:0 indicate the size, in OFDM Clock periods (1/204.8 MHz), of the cyclic prefix control for the 10GPASS-XR PMA/PMD in the downstream direction. These bits are a reflection of the variable *DSNcp* defined in 101.4.3.12.1 with bits 1.1901.3:0 mapping to bits 3:0 of *DSNcp*, respectively.

45.2.1.130c DS OFDM channel frequency control register 1 through 5 (Register 1.1902 through 1.1906)

The assignment of bits in the DS OFDM channel frequency control register 1 through 5 is shown in Table 45–98ac.

Table 45–98ac—DS OFDM channel frequency control register 1 through 5 bit definitions

Bit(s)	Name	Description	R/W ^a
1.1902.15:0	DS OFDM freq ch 1	This register specifies the center frequency of subcarrier 0 of downstream OFDM channel number 1.	R/W
1.1903.15:0	DS OFDM freq ch 2	This register specifies the center frequency of subcarrier 0 of downstream OFDM channel number 2.	R/W
1.1904.15:0	DS OFDM freq ch 3	This register specifies the center frequency of subcarrier 0 of downstream OFDM channel number 3.	R/W
1.1905.15:0	DS OFDM freq ch 4	This register specifies the center frequency of subcarrier 0 of downstream OFDM channel number 4.	R/W
1.1906.15:0	DS OFDM freq ch 5	This register specifies the center frequency of subcarrier 0 of downstream OFDM channel number 5.	R/W

^aR/W = Read/Write

45.2.1.130c.1 DS OFDM freq ch 1 (1.1902.15:0)

Register 1.1902 specifies the center frequency for OFDM channel number 1 in units of 50 kHz. This register is a reflection of the variable *DS_FreqCh(1)* defined in 100.3.2.3.

45.2.1.130c.2 DS OFDM freq ch 2 (1.1903.15:0)

Register 1.1903 specifies the center frequency of OFDM channel number 2 in units of 50 kHz. This register is a reflection of the variable *DS_FreqCh(2)* defined in 100.3.2.3.

45.2.1.130c.3 DS OFDM freq ch 3 (1.1904.15:0)

Register 1.1904 specifies the center frequency of OFDM channel number 3 in units of 50 kHz. This register is a reflection of the variable *DS_FreqCh(3)* defined in 100.3.2.3.

45.2.1.130c.4 DS OFDM freq ch 4 (1.1905.15:0)

Register 1.1905 specifies the center frequency of OFDM channel number 4 in units of 50 kHz. This register is a reflection of the variable *DS_FreqCh(4)* defined in 100.3.2.3.

45.2.1.130c.5 DS OFDM freq ch 5 (1.1906.15:0)

Register 1.1906 specifies the center frequency of OFDM channel number 5 in units of 50 kHz. This register is a reflection of the variable *DS_FreqCh(5)* defined in 100.3.2.3.

45.2.1.130d US OFDM control register (Register 1.1907)

The assignment of bits in the US OFDM control register is shown in Table 45–98ad.

Table 45–98ad—US OFDM control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1907.15:8	Random seed	Random back-off seed for PHY Discovery	R/W
1.1907.7	Resource Block size	1 = 16 OFDMA symbols in the upstream OFDMA Resource Block 0 = 8 OFDMA symbols in the upstream OFDMA Resource Block	R/W
1.1907.6:4	US windowing	Indicates the size of the windowing control for the PMA/PMD in the upstream direction	R/W
1.1907.3:0	US cyclic prefix	Indicates the size of the cyclic prefix for the PMA/PMD in the upstream direction	R/W

^aR/W = Read/Write

45.2.1.130d.1 Random seed (1.1907.15:8)

Bits 1.1907.15:8 form an 8-bit integer that is used by the CNU for the seed of the PHY Discovery back-off algorithm. These bits are a reflection of the *Rnd* variable defined in 102.4.1.9.2.

45.2.1.130d.2 Resource Block size (1.1907.7)

Bit 1.1907.7 indicates the number of OFDM symbols in a Resource Block in the upstream direction. This bit is a reflection of the variable *RBsize* defined in 101.4.4.3.5.

45.2.1.130d.3 US windowing (1.1907.6:4)

Bits 1.1907.6:4 indicate the size, in units of OFDM Clock periods (1/204.8 MHz), of the windowing control for the 10GPASS-XR PMA/PMD in the upstream direction. These bits are a reflection of the variable *USNrp* defined in 101.4.4.10.1 with bits 1.1907.6:4 mapping to bits 2:0 of *USNrp*, respectively.

45.2.1.130d.4 US cyclic prefix (1.1907.3:0)

Bits 1.1907.3:0 indicate the size, in units of OFDM Clock periods (1/204.8 MHz), of the cyclic prefix control for the 10GPASS-XR PMA/PMD in the upstream direction. These bits are a reflection of the variable *USNcp* defined in 101.4.4.10.1 with bits 1.1907.3:0 mapping to bits 3:0 of *USNcp*, respectively.

45.2.1.130e US OFDM channel frequency control register (Register 1.1908)

The assignment of bits in the US OFDM channel frequency control register is shown in Table 45–98ae.

Register 1.1908 indicates the center frequency, in units of 50 kHz, of subcarrier 0 for the upstream OFDM channel. This register is a reflection of the variable *US_FreqCh1* defined in 100.3.2.3.

Table 45–98ae—US OFDM channel frequency control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1908.15:0	US OFDM freq	This specifies the center frequency of subcarrier 0 of the upstream OFDM channel.	R/W

^aR/W = Read/Write**45.2.1.130f US OFDMA pilot pattern register (Register 1.1909)**

The assignment of bits in the US OFDMA pilot pattern register is shown in Table 45–98af. For additional information on the use of the parameters in this register see 101.4.4.6.

Table 45–98af—US OFDMA pilot pattern register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1909.15	Reserved	Value always 0	RO
1.1909.14:12	Type 2 repeat	Indicates the number of subcarriers between Type 2 Pilots	R/W
1.1909.11:8	Type 2 start	Indicates the number of the subcarrier on which the Type 2 Pilot pattern starts	R/W
1.1909.7	Reserved	Value always 0	RO
1.1909.6:4	Type 1 repeat	Indicates the number of subcarriers between Type 1 Pilots	R/W
1.1909.3:0	Type 1 start	Indicates the number of the subcarrier on which the Type 1 Pilot pattern starts	R/W

^aRO = Read only, R/W = Read/Write**45.2.1.130f.1 Type 2 repeat (1.1909.14:12)**

Bits 1.1909.14:12 indicate the number of subcarriers between repeating Type 2 Pilots. Additional information on pilot patterns and encoding for these bits is located in 101.4.4.6 and Table 101–14. These bits are a reflection of the variable *Type2_Repeat* defined in 101.4.4.6.1.

45.2.1.130f.2 Type 2 start (1.1909.11:8)

Bits 1.1909.11:8 indicate the number of the first subcarrier designated as a Type 2 Pilot. These bits are a reflection of the variable *Type2_Start* defined in 101.4.4.6.1.

45.2.1.130f.3 Type 1 repeat (1.1909.6:4)

Bits 1.1909.6:4 indicate the number of subcarriers between repeating Type 1 Pilots. Additional information on pilot patterns and encoding for these bits is located in 101.4.4.6 and Table 101–14. These bits are a reflection of the variable *Type1_Repeat* defined in 101.4.4.6.1.

45.2.1.130f.4 Type 1 start (1.1909.3:0)

Bits 1.1909.3:0 indicate the number of the first subcarrier designated as a Type 1 Pilot. These bits are a reflection of the variable *Type1_Start* defined in 101.4.4.6.1.

45.2.1.130g Profile control register (Register 1.1910)

The assignment of bits in the Profile control register is shown in Table 45–98ag. See 102.4.5 for additional information on the profile copy functionality.

Table 45–98ag—Profile control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1910.15:12	Reserved	Value always 0	RO
1.1910.11	US copy in process	1 = the active upstream profile is being copied to the off-line profile 0 = the upstream off-line profile is not being modified by a profile copy	RO
1.1910.10	US profile copy	1 = initiates a copy of the active upstream profile to the off-line profile 0 = no copy initiated	R/W, SC
1.1910.9:8	US configuration ID	Controls switching the active upstream profile	RO
1.1910.7	Reserved	Value always 0	RO
1.1910.6:4	DS copy channel ID	Indicates which of the 5 downstream OFDM channel profiles is to be copied	
1.1910.3	DS copy in process	1 = the active downstream profile is being copied to the off-line profile 0 = the downstream off-line profile is not being modified by a profile copy	RO
1.1910.2	DS profile copy	1 = initiates a copy of the active downstream profile to the off-line profile 0 = normal	R/W, SC
1.1910.1:0	DS configuration ID	Controls switching the active downstream profile	RO

^aR/W = Read/Write, RO = Read only, SC = Self-clearing

45.2.1.130g.1 US copy in process (1.1910.11)

When read as one, bit 1.1910.11 indicates that a copy of the currently active upstream profile to the inactive profile is in process, writes to all upstream profile descriptors and their reflective registers (see 45.2.7a.3 and 102.4.5) are ignored, and switching between profiles (see 102.2.3.1.1) is prohibited. This bit is a reflection of the variable *US_CpyInP* defined in 102.4.5.1.

45.2.1.130g.2 US profile copy (1.1910.10)

When bit 1.1910.10 is set to one, a copy of the currently active upstream profile to the inactive profile is initiated and will continue to completion. This bit is set to zero by the PMA/PMD on or before completion of the profile copy. This bit is a reflection of the variable *US_ProfICpy* defined in 102.4.5.1.

45.2.1.130g.3 US configuration ID (1.1910.9:8)

Bits 1.1910.9:8 indicate the value of the most recently received upstream Configuration ID bits (see 102.2.3.1). These bits are a reflection of the variable *US_CID* defined in 102.2.3.1.1.

45.2.1.130g.4 DS copy channel ID (1.1910.6:4)

Bits 1.1910.6:4 indicate which one of the five downstream ODFM channel profiles is to be copied. These bits are a reflection of the *DS_CpyCh* variable defined in 102.4.5.1.

45.2.1.130g.5 DS copy in process (1.1910.3)

When read as one, bit 1.1910.3 indicates that a copy of the currently active downstream profile to the inactive profile is in process, writes to all downstream profile descriptors and their reflective registers (see 45.2.7a.2 and 102.4.5) are ignored, and switching between profiles (see 102.2.3.1) is prohibited. This bit is a reflection of the variable *DS_CpyInP* defined in 102.4.5.1.

45.2.1.130g.6 DS profile copy (1.1910.2)

When bit 1.1910.2 is set to one, a copy of the currently active downstream profile to the inactive profile is initiated and will continue to completion. This bit is set to zero by the PMA/PMD on or before completion of the profile copy. This bit is a reflection of the variable *UDS_PrfICpy* defined in 102.4.5.1.

45.2.1.130g.7 DS configuration ID (1.1910.1:0)

Bits 1.1910.1:0 indicate the value of the most recently received downstream Configuration ID bits (see 102.2.3.1). These bits are a reflection of the variable *DS_CID* defined in 102.2.7.3.

45.2.1.130h DS PHY Link control register (Register 1.1911)

The assignment of bits in the DS PHY Link control register is shown in Table 45–98ah.

Table 45–98ah—DS PHY Link control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1911.15:12	Reserved	Value always 0	RO
1.1911.11:0	DS PHY Link start	DS PHY Link starting subcarrier	R/W

^aRO = Read only, R/W = Read/Write

45.2.1.130h.1 DS PHY Link start (1.1911.11:0)

Bits 1.1911.11:0 set the starting subcarrier number of the downstream 10GPASS-XR PHY Link. They indicate the lowest frequency subcarrier of the downstream PHY Link used to carry PHY Link information bits. See 102.2 for additional details on the downstream PHY Link. These bits are a reflection of the variable *DS_PhyLinkStrt* defined in 102.2.7.3.

45.2.1.130i US PHY Link control register (Register 1.1912)

The assignment of bits in the US PHY Link control register is shown in Table 45–98ai.

45.2.1.130i.1 US PHY Link modulation (1.1912.15:12)

Bits 1.1912.15:12 are used to set the modulation type of the upstream PHY Link. These bits are a reflection of the *US_PhyLinkMod* variable defined in 102.3.5.3 with bits 1.1912.15:12 mapping to bits 3:0 of *US_PhyLinkMod*, respectively.

Table 45–98ai—US PHY Link control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1912.15:12	US PHY Link modulation	US PHY Link modulation type	R/W
1.1912.11:0	US PHY Link start	US PHY Link starting subcarrier	R/W

^aR/W = Read/Write

45.2.1.130i.2 US PHY Link start (1.1912.11:0)

Bits 1.1912.11:0 set the starting subcarrier number of the upstream 10GPASS-XR PHY Link. They indicate the lowest frequency subcarrier of the upstream PHY Link used to carry PHY Link information bits. See 102.3 for additional details on the upstream PHY Link. These bits are a reflection of the variable *US_PhyLinkStrt* defined in 102.3.5.3.

45.2.1.130j PHY Discovery control registers (Registers 1.1913 and 1.1914)

The PHY Discovery process is used to bring up new CNUs on the EPoC coax cable distribution network. Registers 1.1913 and 1.1914 indicate when the next PHY Discovery window is opened relative to the downstream Timestamp with bit 1.1913.0 being the LSB and bit 1.1914.15 being the MSB. Setting the PHY Discovery start parameter to zero disables the PHY Discovery window. The PHY Discovery control registers direct this process, which is described in 102.4.1. The assignment of bits in the PHY Discovery control registers is shown in Table 45–98aj. These registers are a reflection of the *DiscStrt* variable defined in 102.2.3.2.4

Table 45–98aj—PHY Discovery control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1913.15:0	PHY Discovery start lower	Time of next open PHY Discovery window bits [15:0]	R/W, MW
1.1914.15:0	PHY Discovery start upper	Time of next open PHY Discovery window bits [31:16]	R/W, MW

^a R/W = Read/Write, MW = Multi-word

45.2.1.130k New CNU control register (Register 1.1915)

The assignment of bits in the New CNU control register is shown in Table 45–98ak. Additional information on the use of the New CNU control register can be found in 102.4.1.6 and 102.4.3.

Table 45–98ak—New CNU control register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1915.15	CNU_ID assigned flag	1 = the allowed CNU_ID value has been assigned to a CNU 0 = the allowed CNU_ID value has not been assigned to a CNU	R/W
1.1915.14:0	Allowed CNU_ID	A new CNU may be assigned this value for CNU_ID if the CNU_ID assigned flag is FALSE	R/W

^aR/W = Read/Write

45.2.1.130k.1 CNU_ID assigned flag 1 (1.1915.15)

Bit 1.1915.15 indicates if the associated CNU_ID value has been assigned to a CNU by the PHY. When this bit is set to one, the associated CNU_ID has been assigned to a CNU. When this bit is set to zero the associated CNU_ID has not been assigned. See 102.4.1.6 and 102.4.3 for additional details on the use of this flag. This bit is a reflection of the variable *AssgndCNU_ID* defined in 102.4.1.9.2.

45.2.1.130k.2 Allowed CNU_ID (1.1915.14:0)

Bits 1.1915.14:0 indicate to the 10GPASS-XR PHY a valid CNU_ID value. The value may be assigned to a new CNU when the CNU_ID assigned flag (bit 1.1915.15) is set to zero, when the flag is set to one it is an indication that this value has already been assigned to a CNU and it should not be use for another CNU. These bits are a reflection of the *AlldCNU_ID* variable defined in 102.4.1.9.2.

45.2.1.130l New CNU info registers 1 through 5 (Registers 1.1916 through 1.1920)

The assignment of bits in the New CNU info registers 1 through 5 is shown in Table 45–98al. Additional information on the use of the New CNU info registers see 102.4.3.

Table 45–98al—New CNU info registers 1 through 5 bit definitions

Bit(s)	Name	Description	R/W ^a
1.1916.15:0	New CNU range	The range of the CNU corresponding to Allowed CNU_ID	RO
1.1917.15:0	New CNU MAC 0	MAC address bits [15:0] of the CNU corresponding to Allowed CNU_ID	RO, MW
1.1918.15:0	New CNU MAC 1	MAC address bits [31:16] of the CNU corresponding to Allowed CNU_ID	RO, MW
1.1919.15:0	New CNU MAC 2	MAC address bits [47:32] of the CNU corresponding to Allowed CNU_ID	RO, MW
1.1920.15:0	Reserved	Value always 0	RO

^aRO = Read only, MW = Multi-word

45.2.1.130l.1 New CNU range (1.1916.15:0)

Register 1.1916 forms an integer that indicates the range of the CNU corresponding to Allowed CNU_ID (see 102.4.1.6) in units of OFDM Clock periods (1/204.8 MHz). This register is a reflection of the variable *NewCNU_Rng* defined in 102.4.1.9.2.

45.2.1.130l.2 New CNU MAC 0 through 2 (1.1917.15:0 through 1.1919.15:0)

Registers 1.1917 through 1.1919 hold the MAC address of the CNU, as determined by the PHY Discovery process, corresponding to Allowed CNU_ID (see 45.2.1.130k) with bit 1.1917.0 being the LSB and 1.1919.15 being the MSB. These registers are a reflection of the variable *New_MAC* defined in 102.4.1.9.2.

45.2.1.130m DS PHY Link frame counter (Register 1.1921)

Register 1.1921 represents the DS PHY Link frame count. This counter is incremented at the beginning of the PHY Link frame and, on terminal count, rolls over to zero. The assignment of bits in the DS PHY Link frame counter is shown in Table 45–98am.

Table 45–98am—DS PHY Link frame counter bit definitions

Bit(s)	Name	Description	R/W ^a
1.1921.15:0	PHY Link frame counter	Counter that indicates the PHY Link frame currently being processed by the PHY. This counter rolls over to zero and is incremented at the beginning of each PHY Link frame	RO

^aRO = Read only

45.2.1.130n PMA/PMD timing offset register (Registers 1.1922 and 1.1923)

The assignment of bits in the PMA/PMD timing offset registers is shown in Table 45–98an. Registers 1.1923 and 1.1922 form an offset, in units of OFDM Clock periods (1/204.8 MHz), used to align the CNU to the upstream OFDM timing. For more information on the use of this register see 102.4.1.6. These registers are a reflection of the variable *PhyTimingOffset* defined in 102.4.1.9.2.

Table 45–98an—PMA/PMD timing offset register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1922.15:0	PMA/PMD timing offset lower	Transmit timing offset [15:0]	R/W, MW
1.1923.15:0	PMA/PMD timing offset upper	Transmit timing offset [31:16]	R/W, MW

^aR/W = Read/Write, MW = Multi-word

45.2.1.130o PMA/PMD power offset register (Register 1.1924)

The assignment of bits in the PMA/PMD power offset register is shown in Table 45–98ao.

Table 45–98ao—PMA/PMD power offset register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1924.15:8	Reserved	Value always 0	RO
1.1924.7:0	PMA/PMD power offset	TX Power offset	R/W

^a RO = Read Only, R/W = Read/Write

45.2.1.130o.1 PMA/PMD power offset (1.1924.7:0)

Bits 1.1924.7:0 represent a power offset, in units of 0.25 dB, the CNU is to make in order that transmissions arrive at the CLT at the desired power level. For more information on the use of these bits see 102.4.1.6. These bits are a reflection of the variable *PhyPowerOffset* defined in 102.4.1.9.2.

45.2.1.130p PMA/PMD ranging offset registers (Registers 1.1925 and 1.1926)

Registers 1.1925 and 1.1926 represent the PMA/PMD ranging offset parameter, in units of OFDM Clock periods (1/204.8 MHz). The assignment of bits in the PMA/PMD ranging offset register is shown in Table 45–98ap. These registers are a reflection of the variable *PhyRngOffset* defined in 102.4.1.9.2.

Table 45–98ap—PMA/PMD ranging offset registers bit definitions

Bit(s)	Name	Description	R/W ^a
1.1925.15:0	PMA/PMD ranging offset lower	PMA/PMD ranging offset register bits [15:0]	R/W, MW
1.1926.15:0	PMA/PMD ranging offset upper	PMA/PMD ranging offset register bits [31:16]	R/W, MW

^aR/W = Read/Write, MW = Multi-word

45.2.1.130q DS PMA/PMD data rate registers (Registers 1.1927, 1.1928 and 1.1929)

Registers 1.1927, 1.1928, and 1.1929 represent the downstream data rate, in units of b/s. Bit 1.1929.4 is the MSB and bit 1.1927.0 is the LSB of the value. The bit assignments for the DS Data Rate registers is illustrated in Table 45–98aq. These registers are a reflection of the variable *DS_DataRate* defined in 100.3.2.3.

45.2.1.130r US PMA/PMD data rate registers (Registers 1.1930, 1.1931 and 1.1932)

Registers 1.1930, 1.1931, and 1.1932 represent the upstream data rate in units of b/s. Bit 1.1932.4 is the MSB and bit 1.1930.0 is the LSB of the value. The bit assignments for the US Data Rate registers is illustrated in Table 45–98ar. These registers are a reflection of the variable *US_DataRate* defined in 100.3.2.3.

Table 45–98aq—DS PMA/PMD data rate register bit definitions

Bit(s)	Name	Description	R/W ^a
1.1927.15:3	DS PMA/PMD data rate lower	The downstream PMA/PMD data rate bits [15:3] of a UQ34.3 formatted number	RO, MW
1.1927.2:0	DS PMA/PMD data rate fractional	The downstream PMA/PMD data rate bits [2:0] of a UQ34.3 formatted number	RO, MW
1.1928.15:0	DS PMA/PMD data rate mid	The downstream PMA/PMD data rate bits [31:16] of a UQ34.3 formatted number	RO, MW
1.1929.15:5	Reserved	Value always 0	RO
1.1929.4:0	DS PMA/PMD data rate upper	The downstream PMA/PMD data rate bits [36:32] of a UQ34.3 formatted number	RO, MW

^aRO = read only, MW = Multi-word**Table 45–98ar—US PMA/PMD data rate register bit definitions**

Bit(s)	Name	Description	R/W ^a
1.1930.15:3	US PMA/PMD data rate lower	The upstream PMA/PMD data rate bits [15:3] of a UQ34.3 formatted number	RO, MW
1.1930.2:0	US PMA/PMD data rate fractional	The upstream PMA/PMD data rate bits [2:0] of a UQ34.3 formatted number	RO, MW
1.1931.15:0	US PMA/PMD data rate mid	The upstream PMA/PMD data rate bits [31:16] of a UQ34.3 formatted number	RO, MW
1.1932.15:5	Reserved	Value always 0	RO
1.1932.4:0	US PMA/PMD data rate upper	The upstream PMA/PMD data rate bits [36:32] of a UQ34.3 formatted number	RO, MW

^aRO = read only, MW = Multi-word**45.2.1.130s 10GPASS-XR FEC codeword counter (Registers 1.1933, 1.1934)**

The assignment of bits in the 10GPASS-XR FEC codeword counter is shown in Table 45–98as. Registers 1.1933 and 1.1934 are used to read the value of a 32-bit counter. When registers 1.1933 and 1.1934 are used to read the 32-bit counter value, the register 1.1933 is read first, the value of the register 1.1934 is latched when (and only when) register 1.1933 is read and reads of register 1.1934 return the latched value rather than the current value of the counter. These registers are a reflection of the variable *FecCodeWordCount* defined in 101.3.3.1.6.

Table 45–98as—10GPASS-XR FEC codeword counter bit definitions

Bit(s)	Name	Description	R/W ^a
1.1933.15:0	FEC codeword counter lower	Total FEC codewords counter [15:0]	RO, MW
1.1934.15:0	FEC codeword counter upper	Total FEC codewords counter [31:0]	RO, MW

^aRO = Read only, MW = Multi-word