

IEEE Standard for Ethernet

Amendment 1: Physical Layer Specifications and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation over Backplane

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE Standard for Ethernet

Amendment 1: Physical Layer Specifications and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation over Backplane

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

Approved 27 September 2018
IEEE-SA Standards Board

Abstract: Ethernet Media Access Control (MAC) parameters, Physical Layer specifications, and management objects for the serial transfer of Ethernet format frames at 2.5 Gb/s and 5 Gb/s over electrical backplanes are defined in this amendment to IEEE Std 802.3-2018.

Keywords: 2.5 Gigabit Ethernet, 5 Gigabit Ethernet, 2.5GBASE-KX, 2.5GBASE-X, 5GBASE-KR, 5GBASE-R, amendment, AN, Auto-Negotiation, Backplane Ethernet, BASE-R, BASE-X, EEE, Energy Efficient Ethernet, Ethernet, IEEE 802.3™, IEEE 802.3cb™

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

Copyright © 2019 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 4 January 2019. 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.

PDF: ISBN 978-1-5044-5278-6 STD23391
Print: ISBN 978-1-5044-5279-3 STDPD23391

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 Notices and Disclaimers Concerning IEEE Standards Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/ipr/disclaimers.html>.

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. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups 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 Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users 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.

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 copied 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> or contact IEEE at the address listed previously. For more information about the IEEE SA or IEEE'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 P802.3cb Working Group ballot.

David J. Law, *IEEE 802.3 Working Group Chair*
Adam Healey, *IEEE 802.3 Working Group Vice-Chair*
Peter 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*

Yong Kim, *IEEE P802.3cb Task Force Chair, Phase 1**
Daniel F. Smith, *IEEE P802.3cb Task Force Chair, Phase 2*
William Lo, *IEEE P802.3cb Task Force Editor-in-Chief, Phase 1*
Daniel F. Smith, *IEEE P802.3cb Task Force Editor-in-Chief, Phase 2*
Jim Hatfield, *IEEE P802.3cb Task Force Editor, Phase 2**

Justin Abbott	John Dillard	Uyen Kashi
David Abramson	Daniel Dillow	Keisuke Kawahara
Shadi Abughazaleh	Thuyen Dinh	Yoshiaki Kawatsu
Mohammad Ahmed	Curtis Donahue	Michael Kelsen
Eric Baden	Dan Dove	Scott Kipp
Amrik Bains	Mike Dudek	Michael Klempa
Thananya Baldwin	David Dwelley	Curtis Knittle
Denis Beaudoin	Frank Effenberger	Shigeru Kobayashi
Christian Beia	Hesham Elbakoury	Daniel Koehler
Michael Bennett	David Estes	Paul Kolesar
Vipul Bhatt	John Ewen	Tom Kolze
William Bliss	Ramin Farje	Glen Kramer
Brad Booth	Shahar Feldman	Hans Lackner
Martin Bouda	James Fife	Jeffrey Lapak
Ralf-Peter Braun	Alan Flatman	Mark Laubach
Theodore Brillhart	Mathias Fricke	Han Hyub Lee
Paul Brooks	Richard Frosch	David Lewis
Alan Brown	Andrew Gardner	Jon Lewis
Matthew Brown	Claude Gauthier	Mike Peng Li
Chris Bullock	Ali Ghiasi	Jane Lim
Jairo Bustos Heredia	Joel Goergen	Dekun Liu
Adrian Butter	Volker Goetzfried	Hai-Feng Liu
Francesco Caggioni	Zhigang Gong	Miklos Lukacs
Anthony Calbone	Steven Gorshe	Kent Lusted
Clark Carty	Robert Grow	Jeffery Maki
Craig Chabot	Mark Gustlin	David Malicoat
Geoffrey Chace	Marek Hajduczenia	Yonatan Malkiman
Mandeep Chadha	Takehiro Hayashi	Arthur Marris
David Chagnosky	Yasuo Hidaka	Takeo Masuda
Jacky Chang	Rita Horner	Erdem Matoglu
Xin Chang	Bernd Horrmeyer	Naoki Matsuda
Ahmad Chini	Victor Hou	Mick McCarthy
Feng Hua Chuang	Yasuhiro Hyakutake	Brett McClellan
Christopher R. Cole	Hideki Isono	Thomas McDermott
John D'Ambrosia	Tom Issenhuth	John McDonough
Yair Darshan	Kenneth Jackson	Larry McMillan
Piers Dawe	Andrew Jimenez	Richard Mei
Fred Dawson	Chad Jones	Richard Mellitz
Wael Diab	Peter Jones	Bryan Moffitt
Eric DiBiao	Manabu Kagami	Ardeshir Mohammadian
		Paul Mooney

* Not a member of the IEEE 802.3 working group at the beginning of the working group ballot.

Dale Murray
 Henry Muysshondt
 James Nadolny
 Edward Nakamoto
 Gary Nicholl
 Kevin Noll
 Mark Nowell
 David Ofelt
 Thomas Palkert
 Hui Pan
 Sesha Panguluri
 Vasu Parthasarathy
 Petar Pepeljugoski
 Gerald Pepper
 Ruben Perez De Aranda Alonso
 Michael Peters
 Phong Pham
 Jean Picard
 William Powell
 Rick Rabinovich
 Adee Ran
 Alon Regev
 Duane Remein
 Victor Renteria
 Christopher Roth
 Salvatore Rotolo
 Toshiaki Sakai
 Jorge Salinger

Sam Sambasivan
 Edward Sayre
 Dieter Schicketanz
 Fred Schindler
 Hossein Sedarat
 Naoshi Serizawa
 Masood Shariff
 Ramin Shirani
 Tom Skaar
 Jeff Slavick
 Scott Sommers
 Yoshiaki Sone
 Tom Souvignier
 Peter Stassar
 Heath Stewart
 Robert Stone
 David Stover
 Junqing Sun
 Ken-Ichi Suzuki
 Steve Swanson
 Andre Szczepanek
 William Szeto
 Bharat Tailor
 Takayuki Tajima
 Satoshi Takahashi
 Kohichi Tamura
 Brian Teipen
 Geoffrey Thompson

Pirooz Toyserkani
 Albert Tretter
 Stephen Trowbridge
 Yoshihiro Tsukamoto
 Ed Ulrichs
 Alexander Umnov
 Sterling A. Vaden
 Stefano Valle
 Paul Vanderlaan
 Robert Wagner
 Dylan Walker
 Haifei Wang
 Roy Wang
 Tongtong Wang
 Xinyuan Wang
 Matthias Weadt
 Oded Werth
 Natalie Wienckowski
 Ludwig Winkel
 Peter Wu
 Jun Xu
 Yu Xue
 Jun Yang
 Lennart Yseboodt
 Hayato Yuki
 Andrew Zambell
 Yan Zhuang
 George Zimmerman

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

Shadi Abughazaleh
 Thomas Alexander
 Peter Anslow
 Butch Anton
 Amrik Bains
 Ralf-Peter Braun
 Nancy Bravin
 Theodore Brillhart
 Matthew Brown
 Demetrio Bucaneg
 Jairo Bustos Heredia
 William Byrd
 Steven B. Carlson
 Juan Carreon
 Mandeep Chadda
 Keith Chow
 Keng Hua Chuang
 Charles Cook
 Rodney Cummings
 Sourav Dutta
 Michael Fischer
 Matthias Fritsche
 Yoshihiro Fujimoto
 Zhigang Gong
 James Graba
 Eric W. Gray
 Randall Groves
 Robert Grow
 Michael Gundlach
 Marek Hajduczenia
 Adam Healey

Marco Hernandez
 David Hess
 Werner Hoelzl
 Robert Horner
 Tom Hundley
 Noriyuki Ikeuchi
 Tsunehiko Ito
 Raj Jain
 SangKwon Jeong
 Piotr Karocki
 Stuart Kerry
 Yong Kim
 Mark Laubach
 David J. Law
 Jon Lewis
 Mike Peng Li
 Elvis Maculuba
 Valerie Maguire
 Jeffery Maki
 Arthur Marris
 Mick McCarthy
 Brett McClellan
 Thomas McDermott
 Larry McMillan
 Richard Mellitz
 Charles Moorwood
 Michael Newman
 Nick S. A. Nikjoo
 Paul Nikolich
 Satoshi Obara

Thomas Palkert
 Bansi Patel
 Arumugam Paventhan
 Michael Peters
 Rick Pimpinella
 Adee Ran
 Alon Regev
 Maximilian Riegel
 Robert Robinson
 Benjamin Rolfe
 Daniel F. Smith
 Thomas Starai
 Walter Struppeler
 Mitsutoshi Sugawara
 Junqing Sun
 Geoffrey Thompson
 Michael Thompson
 Steven Tilden
 David Tremblay
 Mark-Rene Uchida
 Alexander Umnov
 Paul Vanderlaan
 George Vlantis
 Khurram Waheed
 Lisa Ward
 Karl Weber
 Andreas Wolf
 Peter Wu
 Jun Xu
 Oren Yuen
 Zhen Zhou

When the IEEE-SA Standards Board approved this amendment on 27 September 2018, it had the following membership:

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

Ted Burse
Guido R. Hiertz
Christel Hunter
Joseph L. Koepfinger*
Thomas Koshy
Hung Ling
Dong Liu

Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Paul Nikolich
Ronald C. Petersen
Annette D. Reilly

Robby Robson
Dorothy Stanley
Mehmet Ulema
Phil Wennblom
Philip Winston
Howard Wolfman
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 802.3cb-2018, IEEE Standard for Ethernet—Amendment 1: Physical Layer Specifications and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation over Backplane.

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 802.3-2018 and are not maintained as separate documents.

At the date of publication for IEEE Std 802.3cb-2018, IEEE Std 802.3 was composed of the following documents:

IEEE Std 802.3-2018

Section One—Includes Clause 4 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.

Section Seven—Includes Clause 96 through Clause 115 and Annex 97A through Annex 115A. Clause 96 through Clause 98, Clause 104, and associated annexes, specify Physical Layers and optional features for 100 Mb/s and 1000 Mb/s operation over a single twisted pair. Clause 100 through Clause 103, as well as associated annexes, specify Physical Layers for the operation of the EPON protocol over coaxial distribution networks. Clause 105 through Clause 114 and associated annexes include general information on 25 Gb/s operation as well as 25 Gb/s Physical Layer specifications. Clause 99 specifies a MAC merge sublayer for the interspersing of express traffic. Clause 115 and its associated annex specify a Physical Layer for 1000 Mb/s operation over plastic optical fiber.

Section Eight—Includes Clause 116 through Clause 126 and Annex 119A through Annex 120E. Clause 116 through Clause 124 and associated annexes include general information on 200 Gb/s and 400 Gb/s operation as well the 200 Gb/s and 400 Gb/s Physical Layer specifications. Clause 125 and Clause 126 include general information on 2.5 Gb/s and 5 Gb/s operation as well as 2.5 Gb/s and 5 Gb/s Physical Layer specifications.

IEEE Std 802.3cb-2018

Amendment 1—This amendment includes changes to IEEE Std 802.3-2018 and its amendments, and adds Clause 127 through Clause 130, Annex 127A, Annex 128A, Annex 128B, and Annex 130A. This amendment adds new Physical Layers for operation at 2.5 Gb/s and 5 Gb/s over electrical backplanes.

Two companion documents exist, IEEE Std 802.3.1 and IEEE Std 802.3.2. IEEE Std 802.3.1 describes Ethernet management information base (MIB) modules for use with the Simple Network Management Protocol (SNMP). IEEE Std 802.3.2 describes YANG data models for Ethernet. IEEE Std 802.3.1 and IEEE Std 802.3.2 are updated to add management capability for enhancements to IEEE Std 802.3 after approval of those 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.

Contents

1. Introduction.....	23
1.3 Normative references.....	23
1.4 Definitions	23
1.5 Abbreviations.....	24
30. Management.....	25
30.3 Layer management for DTEs.....	25
30.3.2 PHY device managed object class	25
30.3.2.1 PHY device attributes	25
30.3.2.1.2 aPhyType	25
30.3.2.1.3 aPhyTypeList.....	25
30.3.2.1.5 aSymbolErrorDuringCarrier	25
30.5 Layer management for medium attachment units (MAUs).....	26
30.5.1 MAU managed object class	26
30.5.1.1 MAU attributes	26
30.5.1.1.2 aMAUType.....	26
30.6 Management for link Auto-Negotiation	26
30.6.1 Auto-Negotiation managed object class	26
30.6.1.1 Auto-Negotiation attributes	26
30.6.1.1.5 aAutoNegLocalTechnologyAbility	26
45. Management Data Input/Output (MDIO) Interface.....	27
45.2 MDIO Interface Registers.....	27
45.2.1 PMA/PMD registers	27
45.2.1.1 PMA/PMD control 1 register (Register 1.0).....	27
45.2.1.1.5 PMA local loopback (1.0.0).....	27
45.2.1.6 PMA/PMD control 2 register (Register 1.7).....	27
45.2.1.7 PMA/PMD status 2 register (Register 1.8).....	28
45.2.1.7.4 Transmit fault (1.8.11).....	28
45.2.1.7.5 Receive fault (1.8.10).....	28
45.2.1.8 PMD transmit disable register (Register 1.9)	28
45.2.1.18 2.5G/5G PMA/PMD extended ability register (Register 1.21)	29
45.2.1.18.a 5GBASE-KR ability (1.21.3).....	29
45.2.1.18.b 2.5GBASE-KX ability (1.21.2)	29
45.2.1.89 BASE-R PMD control register (Register 1.150)	29
45.2.1.89.3 Transmitter equalizer disable (1.150.2)	30
45.2.1.97 1000BASE-KX/2.5GBASE-KX control register (Register 1.160)	30
45.2.1.97.1 PMD transmit disable (1.160.0).....	30
45.2.1.98 1000BASE-KX/2.5GBASE-KX status register (Register 1.161).....	30
45.2.1.98.6 1000BASE-KX/2.5GBASE-KX signal detect (1.161.0).....	31
45.2.1.140 Test-pattern ability (Register 1.1500).....	31
45.2.3 PCS registers.....	31
45.2.3.1 PCS control 1 register (Register 3.0).....	31
45.2.3.1.2 Loopback (3.0.14).....	31
45.2.3.6 PCS control 2 register (Register 3.7).....	32
45.2.3.8 PCS status 3 register (Register 3.9).....	32
45.2.3.8.a 5GBASE-R capable (3.9.3)	32
45.2.3.8.b 2.5GBASE-X capable (3.9.2)	32

45.2.3.11	EEE control and capability 2 register (Register 3.21)	33
45.2.3.11.a	5GBASE-KR EEE supported (3.21.8).....	33
45.2.3.11.b	2.5GBASE-KX EEE supported (3.21.7)	33
45.2.3.15	BASE-R and MultiGBASE-T PCS status 1 register (Register 3.32)	33
45.2.3.15.1	BASE-R and MultiGBASE-T receive link status (3.32.12)	33
45.2.3.15.4	BASE-R and MultiGBASE-T PCS high BER (3.32.1)	34
45.2.3.15.5	BASE-R and MultiGBASE-T PCS block lock (3.32.0)	34
45.2.3.16	BASE-R and MultiGBASE-T PCS status 2 register (Register 3.33)	34
45.2.3.16.1	Latched block lock (3.33.15)	34
45.2.3.16.2	Latched high BER (3.33.14)	34
45.2.3.16.3	BER(3.33.13:8).....	34
45.2.3.16.4	Errored blocks (3.33.7:0)	35
45.2.3.17	5/10/25GBASE-R PCS test pattern seed A (Registers 3.34 through 3.37)	35
45.2.3.18	5/10/25GBASE-R PCS test pattern seed B (Registers 3.38 through 3.41).....	35
45.2.7	Auto-Negotiation registers.....	35
45.2.7.2	AN status (Register 7.1).....	35
45.2.7.2.1	Parallel detection fault (7.1.9).....	35
45.2.7.12	Backplane Ethernet, BASE-R copper status (Register 7.48).....	36
45.2.7.12.3	Negotiated Port Type (7.48.1, 7.48.2, 7.48.3, 7.48.5, 7.48.6, 7.48.8, 7.48.9, 7.48.10, 7.48.11, 7.48.12, 7.48.13, 7.48.14, 7.48.15)	36
45.2.7.15	EEE advertisement 2 (Register 7.62).....	36
45.2.7.15.a	5GBASE-KR EEE (7.62.3)	37
45.2.7.15.b	2.5GBASE-KX EEE (7.62.2)	37
45.2.7.16	EEE link partner ability 2 (Register 7.63)	37
45.5	Protocol implementation conformance statement (PICS) proforma for Clause 45, Management Data Input/Output (MDIO) interface	38
45.5.3	PICS proforma tables for the Management Data Input Output (MDIO) interface	38
45.5.3.2	PMA/PMD MMD options	38
45.5.3.3	PMA/PMD management functions.....	38
45.5.3.6	PCS options.....	38
46.	Reconciliation Sublayer (RS) and 10 Gigabit Media Independent Interface (XGMII).....	39
46.3	XGMII functional specifications	39
46.3.3	Error and fault handling	39
46.3.3.3	Response to received invalid frame sequences	39
69.	Introduction to Ethernet operation over electrical backplanes	40
69.1	Overview.....	40
69.1.1	Scope.....	40
69.1.2	Relationship of Backplane Ethernet to the ISO OSI reference model.....	40
69.2	Summary of Backplane Ethernet Sublayers	41
69.2.3	Physical Layer signaling systems	41
69.3	Delay constraints.....	42
69.5	Protocol implementation conformance statement (PICS) proforma.....	42
70.	Physical Medium Dependent sublayer and baseband medium, type 1000BASE-KX	43
70.5	PMD MDIO function mapping.....	43
73.	Auto-Negotiation for backplane and copper cable assembly	44
73.2	Relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model	44

73.6	Link codeword encoding	44
73.6.4	Technology Ability Field.....	44
73.7	Receive function requirements	45
73.7.4	Arbitration function requirements	45
73.7.4.1	Parallel Detection function	45
73.7.6	Priority Resolution function.....	45
73.10	State diagrams and variable definitions	46
73.10.1	State diagram variables.....	46
73.10.2	State diagram timers	46
73.11	Protocol implementation conformance statement (PICS) proforma for Clause 73, Auto-Negotiation for backplane and copper cable assembly.....	47
73.11.4	PICS proforma tables for Auto-Negotiation for backplane and copper cable assembly	47
73.11.4.4	Receive function requirements	47
78.	Energy-Efficient Ethernet (EEE).....	48
78.1	Overview.....	48
78.1.1	LPI Signaling	48
78.1.4	PHY types optionally supporting EEE	48
78.2	LPI mode timing parameters description.....	48
78.5	Communication link access latency.....	49
125.	Introduction to 2.5 Gb/s and 5 Gb/s networks	50
125.1	Overview.....	50
125.1.2	Relationship of 2.5 Gigabit and 5 Gigabit Ethernet to the ISO OSI reference model.....	50
125.1.3	Nomenclature.....	50
125.1.4	Physical Layer signaling systems	51
125.2	Summary of 2.5 Gigabit and 5 Gigabit Ethernet sublayers	52
125.2.2	Physical coding sublayer (PCS).....	52
125.2.3	Physical Medium Attachment sublayer (PMA).....	52
125.2.4	Auto-Negotiation, type BASE-T	52
125.2.4.1	Auto-Negotiation, type BASE-T	52
125.2.4.2	Auto-Negotiation, type Backplane	53
125.3	Delay Constraints.....	53
127.	Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer for 2.5 Gb/s 8B/10B 2.5GBASE-X	54
127.1	Overview.....	54
127.1.1	Scope.....	54
127.1.2	Relationship of 2.5GBASE-X to other standards	54
127.1.3	Summary of 2.5GBASE-X sublayers	54
127.1.3.1	Physical Coding Sublayer (PCS).....	54
127.1.3.2	Physical Medium Attachment (PMA) sublayer.....	54
127.1.3.3	Physical Medium Attachment (PMA) service interface rates	55
127.1.4	Inter-sublayer interfaces	55
127.1.5	Functional block diagram	56
127.2	Physical Coding Sublayer (PCS)	56
127.2.1	PCS Interface (XGMII)	56
127.2.2	Functions within the PCS	57
127.2.3	PCS used with 2.5GBASE-KX PMD	57
127.2.4	Use of code-groups	58
127.2.5	XGMII to 2.5GPII mapping.....	58

127.2.5.1	2.5 Gb/s PCS Internal Interface (2.5GPIL).....	58
127.2.5.2	Word Encode	59
127.2.5.3	Word-to-Octets	61
127.2.5.4	Octets-to-Word	61
127.2.5.5	Word Decode	62
127.2.6	8B/10B transmission code	62
127.2.6.1	Notation conventions	62
127.2.6.2	Transmission order	62
127.2.6.3	Generating code-groups and checking the validity of received code	64
127.2.6.4	Ordered sets	64
127.2.6.5	Comma considerations.....	65
127.2.6.6	Sequence (/Q/)	65
127.2.6.7	Data (/D/)	65
127.2.6.8	IDLE (/I/)	65
127.2.6.9	Low Power Idle (/LI/).....	65
127.2.6.10	Start_of_Packet delimiter (SPD)	65
127.2.6.11	End_of_Packet delimiter (EPD)	66
127.2.6.12	Error_Propagation (/V/).....	66
127.2.7	Detailed functions and state diagrams	66
127.2.7.1	State variables	66
127.2.7.1.1	Notation conventions	66
127.2.7.1.2	Constants.....	66
127.2.7.1.3	Variables	67
127.2.7.1.4	Functions.....	72
127.2.7.1.5	Counters	73
127.2.7.1.6	Messages	74
127.2.7.1.7	Timers	75
127.2.7.2	State diagrams.....	76
127.2.7.2.1	Word Encode and Word-to-Octets	76
127.2.7.2.2	Transmit	76
127.2.7.2.3	Synchronization	80
127.2.7.2.4	Receive.....	80
127.2.7.2.5	Octets-to-Word and Decode	80
127.2.7.2.6	LPI state diagram	86
127.2.7.2.7	LPI status and management	87
127.3	Physical Medium Attachment (PMA) sublayer.....	87
127.3.1	Service Interface	87
127.3.1.1	PMA_UNITDATA.request.....	87
127.3.1.1.1	Semantics of the service primitive.....	87
127.3.1.1.2	When generated	87
127.3.1.1.3	Effect of receipt	87
127.3.1.2	PMA_UNITDATA.indication	88
127.3.1.2.1	Semantics of the service primitive.....	88
127.3.1.2.2	When generated	88
127.3.1.2.3	Effect of receipt	88
127.3.2	Functions within the PMA	88
127.3.2.1	Data delay	88
127.3.2.2	PMA transmit function	88
127.3.2.3	PMA receive function.....	89
127.3.2.4	Code-group alignment	89
127.3.3	Loopback mode.....	89
127.3.3.1	Receiver considerations	89
127.3.3.2	Transmitter considerations.....	89
127.3.4	Test functions.....	89

127.3.4.1	PMA PRBS9 test pattern (optional).....	90
127.4	Compatibility considerations	90
127.5	Delay constraints.....	90
127.6	Environmental specifications.....	90
127.7	Protocol implementation conformance statement (PICS) proforma for Clause 127, Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer for 2.5 Gb/s 8B/10B 2.5GBASE-X.....	91
127.7.1	Introduction.....	91
127.7.2	Identification	91
127.7.2.1	Implementation identification.....	91
127.7.2.2	Protocol summary	91
127.7.3	Major capabilities/options.....	92
127.7.4	PICS proforma tables for the PCS and PMA sublayer, type 2.5GBASE-X.....	92
127.7.4.1	PCS	92
127.7.4.2	Code-group functions	93
127.7.4.3	EEE	93
127.7.4.4	PMA functions.....	94
127.7.4.5	Compatibility considerations	94
128.	Physical Medium Dependent sublayer and baseband medium, type 2.5GBASE-KX.....	95
128.1	Overview.....	95
128.2	Physical Medium Dependent (PMD) service interface	95
128.2.1	PMD_UNITDATA.request.....	96
128.2.1.1	Semantics of the service primitive.....	96
128.2.1.2	When generated	96
128.2.1.3	Effect of receipt	96
128.2.2	PMD_UNITDATA.indication	96
128.2.2.1	Semantics of the service primitive.....	96
128.2.2.2	When generated	96
128.2.2.3	Effect of receipt	96
128.2.3	PMD_SIGNAL.indication	96
128.2.3.1	Semantics of the service primitive.....	96
128.2.3.2	When generated	97
128.2.3.3	Effect of receipt	97
128.2.4	PMD_RXQUIET.request.....	97
128.2.4.1	Semantics of the service primitive.....	97
128.2.4.2	When generated	97
128.2.4.3	Effect of receipt	97
128.2.5	PMD_TXQUIET.request.....	97
128.2.5.1	Semantics of the service primitive.....	97
128.2.5.2	When generated	97
128.2.5.3	Effect of receipt	98
128.3	PCS requirements for Auto-Negotiation (AN) service interface.....	98
128.4	Delay constraints.....	98
128.5	PMD MDIO function mapping.....	98
128.6	PMD functional specifications.....	99
128.6.1	Link block diagram.....	99
128.6.2	PMD transmit function	100
128.6.3	PMD receive function.....	100
128.6.4	PMD signal detect function	100
128.6.5	PMD transmit disable function	100
128.6.6	Loopback mode.....	100
128.6.7	PMD fault function	101

128.6.8	PMD transmit fault function	101
128.6.9	PMD receive fault function.....	101
128.6.10	PMD LPI function	101
128.7	2.5GBASE-KX electrical characteristics.....	102
128.7.1	Transmitter characteristics	102
128.7.1.1	Test fixtures	102
128.7.1.2	Test fixture characteristics	102
128.7.1.3	Signaling speed	103
128.7.1.4	Output amplitude	103
128.7.1.5	Differential output return loss.....	104
128.7.1.6	Common-mode output return loss	104
128.7.1.7	Transition time	105
128.7.1.8	Transmit jitter test requirements	105
128.7.1.9	Transmit jitter	105
128.7.2	Receiver characteristics	106
128.7.2.1	Receiver interference tolerance	106
128.7.2.2	Signaling speed range	106
128.7.2.3	AC-coupling.....	106
128.7.2.4	Input signal amplitude	107
128.7.2.5	Differential input return loss.....	107
128.8	Interconnect characteristics.....	107
128.9	Environmental specifications.....	107
128.9.1	General safety	107
128.9.2	Network safety.....	107
128.9.3	Installation and maintenance guidelines	107
128.9.4	Electromagnetic compatibility.....	107
128.9.5	Temperature and humidity.....	107
128.10	Protocol implementation conformance statement (PICS) proforma for Clause 128, Physical Medium Dependent sublayer and baseband medium, type 2.5GBASE-KX	108
128.10.1	Introduction.....	108
128.10.2	Identification	108
128.10.2.1	Implementation identification.....	108
128.10.2.2	Protocol summary	108
128.10.3	Major capabilities/options.....	109
128.10.4	PICS proforma tables for Clause 128, Physical Medium Dependent (PMD) sublayer and baseband medium, type 2.5GBASE-KX.....	109
128.10.4.1	PMD functional specifications.....	109
128.10.4.2	Management functions.....	110
128.10.4.3	Transmitter electrical characteristics	111
128.10.4.4	Receiver electrical characteristics.....	112
128.10.4.5	Environmental and safety specifications	112
129.	Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer for 5 Gb/s 64B/66B, type 5GBASE-R	113
129.1	Overview.....	113
129.1.1	Scope.....	113
129.1.2	Relationship of 5GBASE-R to other standards	113
129.1.3	Summary of 5GBASE-R sublayers	114
129.1.3.1	Physical Coding Sublayer (PCS).....	114
129.1.3.2	Physical Medium Attachment (PMA) sublayer.....	114
129.1.4	Inter-sublayer interfaces	115
129.2	Physical Coding Sublayer (PCS)	115
129.2.1	Functions within the PCS	115

129.2.2	Notation conventions	116
129.2.3	Transmission order	116
129.2.4	Low Power Idle.....	117
129.2.5	PCS used with 5GBASE-KR PMD	118
129.3	Physical Medium Attachment (PMA) sublayer.....	118
129.3.1	Service Interface	118
129.3.2	Functions within the PMA	118
129.3.2.1	PMA transmit function	119
129.3.2.2	PMA receive function.....	119
129.3.3	PMA loopback mode (optional)	119
129.4	Compatibility considerations	119
129.5	Delay constraints.....	119
129.6	Environmental specifications.....	119
129.7	Protocol implementation conformance statement (PICS) proforma for Clause 129, Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer for 5 Gb/s 64B/66B, type 5GBASE-R	120
129.7.1	Introduction.....	120
129.7.2	Identification.....	120
129.7.2.1	Implementation identification.....	120
129.7.2.2	Protocol summary	120
129.7.3	Major capabilities/options.....	121
129.7.4	PICS Proforma Tables for PCS, type 5GBASE-R	121
129.7.4.1	Coding rules.....	121
129.7.4.2	Scrambler and Descrambler.....	121
129.7.5	Test-pattern modes.....	122
129.7.5.1	Bit order	122
129.7.6	Management.....	122
129.7.6.1	State diagrams.....	123
129.7.6.2	Loopback	123
129.7.6.3	Delay Constraints.....	123
129.7.6.4	Auto-Negotiation for Backplane Ethernet functions	123
129.7.6.5	LPI functions.....	124
130.	Physical Medium Dependent sublayer and baseband medium, type 5GBASE-KR.....	125
130.1	Overview.....	125
130.2	Physical Medium Dependent (PMD) service interface	125
130.2.1	PMD_UNITDATA.request.....	126
130.2.1.1	Semantics of the service primitive.....	126
130.2.1.2	When generated	126
130.2.1.3	Effect of receipt	126
130.2.2	PMD_UNITDATA.indication	126
130.2.2.1	Semantics of the service primitive.....	126
130.2.2.2	When generated	126
130.2.2.3	Effect of receipt	126
130.2.3	PMD_SIGNAL.indication	126
130.2.3.1	Semantics of the service primitive.....	126
130.2.3.2	When generated	127
130.2.3.3	Effect of receipt	127
130.2.4	PMD_RX_MODE.request.....	127
130.2.4.1	Semantics of the service primitive.....	127
130.2.4.2	When generated	127
130.2.4.3	Effect of receipt	127
130.2.5	PMD_TX_MODE.request	127

130.2.5.1	Semantics of the service primitive.....	127
130.2.5.2	When generated	127
130.2.5.3	Effect of receipt	128
130.3	PCS requirements for Auto-Negotiation (AN) service interface.....	128
130.4	Delay constraints.....	128
130.5	PMD MDIO function mapping.....	128
130.6	PMD functional specifications.....	129
130.6.1	Link block diagram.....	129
130.6.2	PMD transmit function	129
130.6.3	PMD receive function.....	129
130.6.4	PMD signal detect function	129
130.6.5	PMD transmit disable function	130
130.6.6	Loopback mode.....	130
130.6.7	PMD_fault function	131
130.6.8	PMD transmit fault function	131
130.6.9	PMD receive fault function.....	131
130.6.10	PMD LPI function	131
130.7	5GBASE-KR electrical characteristics	132
130.7.1	Transmitter characteristics	132
130.7.1.1	Test fixture.....	132
130.7.1.2	Test fixture characteristics	133
130.7.1.3	Signaling speed	133
130.7.1.4	Output amplitude	133
130.7.1.5	Differential output return loss.....	134
130.7.1.6	Common-mode output return loss	135
130.7.1.7	Transition time	135
130.7.1.8	Transmit jitter test requirements	135
130.7.1.9	Transmit jitter	136
130.7.1.10	Transmitter output waveform	136
130.7.2	Receiver characteristics	137
130.7.2.1	Receiver interference tolerance	138
130.7.2.2	Signaling speed range	138
130.7.2.3	AC-coupling.....	138
130.7.2.4	Input signal amplitude	138
130.7.2.5	Differential input return loss.....	138
130.8	Interconnect characteristics.....	139
130.9	Environmental specifications.....	139
130.9.1	General safety	139
130.9.2	Network safety.....	139
130.9.3	Installation and maintenance guidelines	139
130.9.4	Electromagnetic compatibility.....	139
130.9.5	Temperature and humidity.....	139
130.10	Protocol implementation conformance statement (PICS) proforma for Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium, type 5GBASE-KR.....	140
130.10.1	Introduction.....	140
130.10.2	Identification	140
130.10.2.1	Implementation identification.....	140
130.10.2.2	Protocol summary	140
130.10.3	Major capabilities/options.....	141
130.10.4	PICS proforma tables for Clause 130, Physical Medium Dependent (PMD) sublayer and baseband medium, type 5GBASE-KR.....	141
130.10.4.1	PCS requirements for AN service interface.....	141
130.10.4.2	PMD functional specifications.....	142
130.10.4.3	Management functions.....	143

130.10.4.4 PMD Transmitter electrical characteristics.....	143
130.10.4.5 Receiver electrical characteristics.....	144
130.10.4.6 Environmental specifications.....	144
Annex 31B (normative) MAC Control PAUSE operation	145
31B.3 Detailed specification of PAUSE operation.....	145
31B.3.7 Timing considerations for PAUSE operation	145
31B.4 Protocol implementation conformance statement (PICS) proforma for MAC Control PAUSE operation	146
31B.4.3 Major capabilities/options.....	146
31B.4.6 PAUSE command MAC timing considerations	146
Annex 69A (normative) Interference tolerance testing	147
69A.1 Introduction.....	147
69A.2 Test setup	147
69A.2.1 Pattern generator	147
69A.2.2 Test channel	148
69A.2.4 Transmitter control	148
69A.3 Test methodology.....	148
Annex 69B (normative) Interconnect characteristics	149
69B.4 Channel parameters.....	149
69B.4.1 Overview.....	149
69B.4.2 Fitted attenuation	149
69B.4.3 Insertion loss	151
69B.4.4 Insertion loss deviation	153
69B.4.5 Return loss	155
69B.4.6 Crosstalk	156
69B.4.6.4 Insertion loss to crosstalk ratio (ICR).....	156
Annex 127A (informative) Compatibility of 2.5GBASE-X PCS/PMA with 1000BASE-X PCS/PMA running 2.5 times faster	158
Annex 128A (normative) 2.5 Gb/s Storage Enclosure Interface (2.5GSEI).....	159
128A.1 Overview.....	159
128A.1.1 Bit error ratio	161
128A.2 2.5GSEI compliance point definitions	161
128A.3 2.5GSEI electrical characteristics	164
128A.3.1 2.5GSEI host output characteristics.....	164
128A.3.1.1 Signaling rate and range	164
128A.3.1.2 Signaling levels.....	165
128A.3.1.3 Output return loss.....	165
128A.3.1.4 Transmit jitter test requirements	166
128A.3.1.5 Transmit jitter	166
128A.3.1.6 Transmitter output noise and distortion	166
128A.3.2 2.5GSEI host input characteristics.....	167
128A.3.2.1 Input differential return loss	167
128A.3.2.2 Receiver interference tolerance	167
128A.3.2.3 Receiver jitter tolerance	169
128A.3.3 2.5GSEI drive output characteristics	170

128A.3.4	2.5GSEI drive input characteristics	171
128A.3.4.1	Input differential return loss	171
128A.3.4.2	Receiver interference tolerance	171
128A.3.4.3	Receiver jitter tolerance	172
128A.4	Protocol implementation conformance statement (PICS) proforma for Annex 128A, 2.5 Gb/s Storage Enclosure Interface (2.5GSEI)	174
128A.4.1	Introduction.....	174
128A.4.2	Identification.....	174
128A.4.2.1	Implementation identification.....	174
128A.4.2.2	Protocol summary	174
128A.4.3	Major capabilities/options.....	175
128A.4.4	PICS proforma tables for 2.5 Gb/s Storage Enclosure Interface (2.5GSEI).....	175
128A.4.4.1	Host output functions.....	175
128A.4.4.2	Host input functions.....	175
128A.4.4.3	Drive output functions	176
128A.4.4.4	Drive input functions	176
Annex 128B (normative)	Test fixtures for 2.5 Gb/s and 5 Gb/s Storage Enclosure Interfaces.....	177
128B.1	Host and drive compliance boards	177
128B.1.1	Test fixture return loss	177
128B.1.2	Test fixture insertion loss.....	177
128B.2	Mated test fixtures.....	178
128B.2.1	Mated test fixtures insertion loss	179
128B.2.2	Mated test fixtures return loss.....	179
128B.2.3	Mated test fixtures integrated crosstalk noise.....	180
128B.2.3.1	Mated test fixture near-end crosstalk (NEXT) loss	180
128B.3	Protocol implementation conformance statement (PICS) proforma for Annex 128B, Test fixtures for 2.5 Gb/s and 5 Gb/s Storage Enclosure Interfaces.....	182
128B.3.1	Introduction.....	182
128B.3.2	Identification.....	182
128B.3.2.1	Implementation identification.....	182
128B.3.2.2	Protocol summary	182
128B.3.3	Major capabilities/options.....	183
128B.3.4	PICS proforma tables for test fixtures	183
128B.3.4.1	Management functions.....	183
Annex 130A (normative)	5 Gb/s Storage Enclosure Interface (5GSEI).....	184
130A.1	Overview.....	184
130A.1.1	Bit error ratio	186
130A.2	5GSEI compliance point definitions	186
130A.3	5GSEI electrical characteristics	189
130A.3.1	5GSEI host output characteristics.....	189
130A.3.1.1	Signaling rate and range	189
130A.3.1.2	Signaling levels.....	190
130A.3.1.3	Output return loss.....	190
130A.3.1.4	Transmitter output waveform	191
130A.3.1.4.1	Linear fit to the measured waveform.....	191
130A.3.1.4.2	Steady-state voltage and linear fit pulse peak.....	191
130A.3.1.4.3	Pre-cursor coefficient.....	191
130A.3.1.5	Transmit jitter test requirements	192
130A.3.1.6	Transmit jitter	192
130A.3.1.7	Transmitter output noise and distortion	192

130A.3.2	5GSEI host input characteristics	193
130A.3.2.1	Input differential return loss	193
130A.3.2.2	Receiver interference tolerance	193
130A.3.2.3	Receiver jitter tolerance	195
130A.3.3	5GSEI drive output characteristics	196
130A.3.3.1	Linear fit to the measured waveform	197
130A.3.3.2	Steady-state voltage and linear fit pulse peak	197
130A.3.3.3	Precursor coefficient	197
130A.3.3.4	Transmitter output noise and distortion	197
130A.3.4	5GSEI drive input characteristics	198
130A.3.4.1	Input differential return loss	198
130A.3.4.2	Receiver interference tolerance	198
130A.3.4.3	Receiver jitter tolerance	200
130A.4	Protocol implementation conformance statement (PICS) proforma for Annex 130A, 5 Gb/s Storage Enclosure Interface (5GSEI)	202
130A.4.1	Introduction	202
130A.4.2	Identification	202
130A.4.2.1	Implementation identification	202
130A.4.2.2	Protocol summary	202
130A.4.3	Major capabilities/options	203
130A.4.4	PICS proforma tables for 5 Gb/s Storage Enclosure Interface (5GSEI)	203
130A.4.4.1	Host output functions	203
130A.4.4.2	Host input functions	203
130A.4.4.3	Drive output functions	204
130A.4.4.4	Drive input functions	204

IEEE Standard for Ethernet

Amendment 1: Physical Layer Specifications and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation over Backplane

[This amendment is based on IEEE Std 802.3™-2018.]

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.

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 ~~striketrough~~ (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.¹

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