

First edition
2014-04-01

Standard for Ethernet

Norme pour Ethernet



Reference number
ISO/IEC/IEEE 8802-3:2014(E)





COPYRIGHT PROTECTED DOCUMENT

© IEEE 2012

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from ISO, IEC or IEEE at the respective address below.

ISO copyright office
Case postale 56
CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
E-mail inmail@iec.ch
Web www.iec.ch

Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York
NY 10016-5997, USA
E-mail stds.ipr@ieee.org
Web www.ieee.org

Published in Switzerland

This is a preview of "ISO/IEC/IEEE 8802-3:...". [Click here to purchase the full version from the ANSI store.](#)

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.

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.

The main task of ISO/IEC JTC 1 is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is called to the possibility that implementation of this standard may require the use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. ISO/IEEE is not responsible for identifying essential patents or patent claims for which a license may be required, for conducting inquiries into the legal validity or scope of patents or patent claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance or a Patent Statement and Licensing Declaration Form, 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 ISO or the IEEE Standards Association.

ISO/IEC/IEEE 8802-3 was prepared by the LAN/MAN Standards Committee of the IEEE Computer Society (as IEEE 802.3-2012). It was adopted by Joint Technical Committee ISO/IEC JTC 1, *Information technology, Subcommittee SC 6, Telecommunications and information exchange between systems*, in parallel with its approval by the ISO/IEC national bodies, under the "fast-track procedure" defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE. IEEE is responsible for the maintenance of this document with participation and input from ISO/IEC national bodies.

This is a preview of "ISO/IEC/IEEE 8802-3:...". [Click here to purchase the full version from the ANSI store.](#)

(blank page)

IEEE Standard for Ethernet

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.3™-2012
(Revision of
IEEE Std 802.3-2008)

28 December 2012

This is a preview of "ISO/IEC/IEEE 8802-3:...". [Click here to purchase the full version from the ANSI store.](#)

IEEE Std 802.3™-2012

(Revision of
IEEE Std 802.3-2008)

IEEE Standard for Ethernet

Sponsor

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 30 August 2012

IEEE-SA Standard Board

Abstract: Ethernet local area network operation is specified for selected speeds of operation from 1 Mb/s to 100 Gb/s using a common media access control (MAC) specification and management information base (MIB). The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) MAC protocol specifies shared medium (half duplex) operation, as well as full duplex operation. Speed specific Media Independent Interfaces (MIIs) allow use of selected Physical Layer devices (PHY) for operation over coaxial, twisted-pair or fiber optic cables. System considerations for multisegment shared access networks describe the use of Repeaters that are defined for operational speeds up to 1000 Mb/s. Local Area Network (LAN) operation is supported at all speeds. Other specified capabilities include various PHY types for access networks, PHYs suitable for metropolitan area network applications, and the provision of power over selected twisted-pair PHY types.

Keywords: 10BASE; 100BASE; 1000BASE; 10GBASE; 40GBASE; 100GBASE; 10 Gigabit Ethernet; 40 Gigabit Ethernet; 100 Gigabit Ethernet; attachment unit interface; AUI; Auto Negotiation; Backplane Ethernet; data processing; DTE Power via the MDI; EPON; Ethernet; Ethernet in the First Mile; Ethernet passive optical network; Fast Ethernet; Gigabit Ethernet; GMII; information exchange; IEEE 802.3; local area network; management; medium dependent interface; media independent interface; MDI; MIB; MII; PHY; physical coding sublayer; Physical Layer; physical medium attachment; PMA; Power over Ethernet; repeater; type field; VLAN TAG; XGMII

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

Copyright © 2012 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 28 December 2012. 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 973-07381-7312-2 STD97287
Print: ISBN 973-07381-7327-6 STDPD97287

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.

Notice and Disclaimer of Liability Concerning the Use of IEEE Documents: IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. 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 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.

Use of an IEEE Standard is wholly voluntary. IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon any IEEE Standard document.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific

purpose, or that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied "AS IS."

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. 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 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.

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 the official position of IEEE or any of its committees and shall not be considered to be, nor 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 to ensure 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. Any person who would like to participate in evaluating comments or revisions to an IEEE standard is welcome to join the relevant IEEE working group at <http://standards.ieee.org/develop/wg/>.

Comments on standards should be submitted to the following address:

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

Photocopies: Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, 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.

Notice to users

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

This document is copyrighted by the IEEE. It is made available 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 this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE standards 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. 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](http://standards.ieee.org) or contact the IEEE at the address listed previously. For more information about the IEEE Standards Association or the IEEE standards development process, visit the [IEEE-SA website](http://standards.ieee.org).

Errata

Errata, if any, for this and all other standards can be accessed 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 <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 nondiscriminatory. 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 of the IEEE 802.3 working group at the beginning of the working group ballot of this revision:

David J. Law, *Working Group Chair*
Wael William Diab, *Working Group Vice-Chair*
Adam Healey, *Working Group Secretary*
Steven B. Carlson, *Working Group Executive Secretary*
Valerie Maguire, *Working Group Treasurer*

Wael William Diab, *IEEE P802.3 (802.3bh) Task Force Chair and Chief Editor*
Valerie Maguire, *IEEE P802.3 (802.3bh) Task Force Recording Secretary and Clause Editor*
Peter Anslow, *IEEE P802.3 (802.3bh) Task Force Section Editor*
Marek Hajduczenia, *IEEE P802.3 (802.3bh) Task Force Section Editor*

Historical participants

The following individuals participated in the IEEE 802.3 working group during various stages of the standard's development. Since the initial publication, many IEEE standards have added functionality or provided updates to material included in this standard. Included is a historical list of participants who have dedicated their valuable time, energy, and knowledge to the creation of this material:

IEEE Std 802.3 document	Date approved by IEEE and ANSI	Officers at the time of working group ballot
IEEE Std 802.3-1985, Original 10 Mb/s standard, MAC, PLS, AUI, 10BASE5	23 June 1983 (IEEE) 31 December 1984 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i>
IEEE Std 802.3a-1988 (Clause 10), 10 Mb/s MAU 10BASE2	15 November 1985 (IEEE) 28 December 1987 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Alan Flatman , <i>Task Force Chair</i>
IEEE Std 802.3b-1985 (Clause 11), 10 Mb/s Broad-band MAU, 10BROAD36	19 September 1985 (IEEE) 28 February 1986 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Menachem Abraham , <i>Task Force Chair</i>
IEEE Std 802.3c-1985 (9.1–9.8), 10 Mb/s Baseband Repeater	12 December 1985 (IEEE) 4 June 1986 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Geoffrey O. Thompson , <i>Task Force Chair</i>
IEEE Std 802.3d-1987 (9.9), 10 Mb/s Fiber MAU, FOIRL	10 December 1987 (IEEE) 9 February 1989 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Steven Moustakas , <i>Task Force Chair</i>
IEEE Std 802.3e-1987 (Clause 12), 1 Mb/s MAU and Hub 1BASE5	11 June 1987 (IEEE) 15 December 1987 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Robert Galin , <i>Task Force Chair</i>
IEEE Std 802.3h-1990 (Clause 5), 10 Mb/s Layer Management, DTEs	28 September 1990 (IEEE) 11 March 1991 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Andy J. Luque , <i>Task Force Chair</i>
IEEE Std 802.3i-1990 (Clauses 13 and 14), 10 Mb/s UTP MAU, 10 BASE-T	28 September 1990 (IEEE) 11 March 1991 (ANSI)	Donald C. Loughry , <i>Working Group Chair</i> Patricia Thaler , <i>Task Force Chair (initial)</i> Richard Anderson , <i>Task Force Chair (final)</i>

IEEE Std 802.3 document	Date approved by IEEE and ANSI	Officers at the time of working group ballot
IEEE Std 802.3j-1993 (Clauses 15–18), 10 Mb/s Fiber MAUs 10BASE-FP, 10BASE-FB, and 10BASE-FL	15 September 1993 (IEEE) 15 March 1994 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Keith Amundsen , <i>Task Force Chair (initial)</i> Frederick Scholl , <i>Task Force Chair (final)</i> Michael E. Lee , <i>Technical Editor</i>
IEEE Std 802.3k-1993 (Clause 19), 10 Mb/s Layer Management, Repeaters	17 September 1992 (IEEE) 8 March 1993 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Joseph S. Skorupa , <i>Task Force Chair</i> Geoffrey O. Thompson , <i>Vice Chair and Editor</i>
IEEE Std 802.3l-1992 (14.10), 10 Mb/s PICS Proforma 10BASE-T MAU	17 September 1992 (IEEE) 23 February 1993 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Mike Armstrong , <i>Task Force Chair and Editor</i> Paul Nikolich , <i>Vice Chair</i> William Randle , <i>Editorial Coordinator</i>
IEEE Std 802.3m-1995, Maintenance 2	21 September 1995 (IEEE) 16 July 1996 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3n-1995, Maintenance 3	21 September 1995 (IEEE) 4 April 1996 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3p-1993 (Clause 20), Management, 10 Mb/s Integrated MAUs	17 June 1993 (IEEE) 4 January 1994 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Joseph S. Skorupa , <i>Task Force Chair</i> Geoffrey O. Thompson , <i>Vice Chair and Editor</i>
IEEE Std 802.3q-1993 (Clause 5), 10 Mb/s Layer Management, GDMO Format	17 June 1993 (IEEE) 4 January 1994 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Joseph S. Skorupa , <i>Task Force Chair</i> Geoffrey O. Thompson , <i>Vice Chair and Editor</i>
IEEE Std 802.3r-1996 (8.8), Type 10BASE5 Medium Attachment Unit PICS proforma	29 July 1996 (IEEE) 6 January 1997 (ANSI)	Patricia Thaler , <i>Working Group Chair</i> Imre Juhász , <i>Task Force Chair</i> William Randle , <i>Task Force Editor</i>
IEEE Std 802.3s-1995, Maintenance 4	21 September 1995 (IEEE) 8 April 1996 (ANSI)	Geoffrey O. Thompson , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3t-1995, 120 Ω informative annex to 10BASE-T	14 June 1995 (IEEE) 12 January 1996 (ANSI)	Geoffrey O. Thompson , <i>Working Group Chair</i> Jacques Christ , <i>Task Force Chair</i>
IEEE Std 802.3u-1995 (Clauses 21–30), Type 100BASE-T MAC param- eters, Physical Layer, MAUs, and Repeater for 100 Mb/s Operation	14 June 1995 (IEEE) 4 April 1996 (ANSI)	Geoffrey O. Thompson , <i>Working Group Chair</i> Peter Tarrant , <i>Task Force Chair (Phase 1)</i> Howard Frazier , <i>Task Force Chair (Phase 2)</i> Paul Sherer , <i>Task Force Editor-in-Chief (Phase 1)</i> Howard Johnson , <i>Task Force Editor-in-Chief (Phase 2)</i> Colin Mick , <i>Task Force Comment Editor</i>
IEEE Std 802.3v-1995, 150 Ω informative annex to 10BASE-T	12 December 1995 (IEEE) 16 July 1996 (ANSI)	Geoffrey O. Thompson , <i>Working Group Chair</i> Larry Nicholson , <i>Task Force Chair</i>
IEEE Std 802.3x-1997 and IEEE Std 802.3y-1997 (Revi- sions to IEEE Std 802.3, Clauses 31 and 32), Full- Duplex Operation and Type 100BASE-T2	20 March 1997 (IEEE) 5 September 1997 (ANSI)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Rich Seifert , <i>Task Force Chair and Editor (802.3x)</i> J. Scott Carter , <i>Task Force Chair (802.3y)</i> Colin Mick , <i>Task Force Editor (802.3y)</i>
IEEE Std 802.3z-1998 (Clauses 34–39, 41–42), Type 1000BASE-X MAC Param- eters, Physical Layer, Repeater, and Management Parameters for 1000 Mb/s Operation	25 June 1998 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Howard M. Frazier, Jr. , <i>Task Force Chair</i> Howard W. Johnson , <i>Task Force Editor</i>
IEEE Std 802.3aa-1998, Maintenance 5	25 June 1998 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> Colin Mick , <i>Task Force Editor</i>

IEEE Std 802.3 document	Date approved by IEEE and ANSI	Officers at the time of working group ballot
IEEE Std 802.3ab-1999 (Clause 40), Physical Layer Parameters and Specifications for 1000 Mb/s Operation Over 4 Pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T	26 June 1999 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> George Eisler , <i>Task Force Chair</i> Colin Mick , <i>Task Force Editor</i>
IEEE Std 802.3ac-1998, Frame Extensions for Virtual Bridged Local Area Network (VLAN) Tagging on IEEE 802.3 Networks	16 September 1998 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Andy J. Luque , <i>Working Group Secretary</i> Ian Crayford , <i>Task Force Chair</i> Rich Seifert , <i>Task Force Editor</i>
IEEE Std 802.3ad-2000 (Clause 43), Aggregation of Multiple Link Segments	30 March 2000 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> Steven Haddock , <i>Task Force Chair</i> Tony Jeffree , <i>Task Force Co-Editor</i> Rich Seifert , <i>Task Force Co-Editor</i>
IEEE Std 802.3-2002 (IEEE 802.3ag, Maintenance 6, Revision of the base), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	14 January 2002 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i>
IEEE Std 802.3ae-2002, (Clauses 44–53) Media Access Control (MAC) Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation	13 June 2002 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> R. Jonathan Thatcher , <i>Task Force Chair</i> Stephen Haddock , <i>Task Force Vice Chair</i> Bradley J. Booth , <i>Task Force Editor</i> Lacreshia Laningham , <i>Task Force Assistant Editor</i> Benjamin Brown , <i>Logic Track Chair</i> Walter Thirion , <i>Optical Track Chair</i>
IEEE Std 802.3af-2003, (Clause 33) Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI)	12 June 2003 (IEEE)	Geoffrey O. Thompson , <i>Working Group Chair (Phase 1)</i> Robert M. Grow , <i>Working Group Chair (Phase 2)</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary (Phase 1)</i> Steven B. Carlson , <i>Working Group Secretary (Phase 2)</i> Steven B. Carlson , <i>Task Force Chair</i> Michael S. McCormack , <i>Task Force Editor (Phase 1)</i> John J. Jetzt , <i>Task Force Editor (Phase 2)</i> Chad M. Jones , <i>Task Force Comment Editor</i>
IEEE Std 802.3ah-2004, Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks	6 April 2005 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Howard Frazier , <i>Task Force Chair</i> Wael W. Diab , <i>Task Force Editor-in-Chief</i> Hugh Barrass , <i>Task Force Vice-Chair</i> Scott Simon , <i>Task Force Recording Secretary</i> Behrooz Rezvani , <i>Task Force Executive Secretary</i>
IEEE Std 802.3aj-2003, Maintenance 7	11 September 2003 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Catherine K. N. Berger , <i>Task Force Editor</i>
IEEE Std 802.3ak-2004, Physical Layer and Management Parameters for 10Gb/s Operation, Type 10GBASE-CX4	9 February 2004 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Daniel J. Dove , <i>Task Force Chair</i> Howard A. Baumer , <i>Task Force Editor</i>

IEEE Std 802.3 document	Date approved by IEEE and ANSI	Officers at the time of working group ballot
IEEE Std 802.3-2005 (IEEE 802.3REVam, Revision of the base). Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	9 June 2005 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Wael W. Diab , <i>Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Piers Dawe , <i>Review Editor</i>
IEEE Std 802.3an-2006, Physical Layer and Management Parameter for 10 Gb/s Operation, Type 10GBASE-T	8 June 2006 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Task Force Chair</i> Sanjay Kasturia , <i>Task Force Editor-in-Chief</i> George Eisler , <i>Task Force Recording Secretary</i>
IEEE Std 802.3ap-2007, Ethernet Operation over Electrical Backplanes	22 March 2007 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice-Chair</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Adam Healey , <i>Task Force Chair</i> John D'Ambrosia , <i>Task Force Secretary</i> Schelto vanDoorn , <i>Task Force Editor-in-Chief (Phase 1)</i> Ilango S. Ganga , <i>Task Force Editor-in-Chief (Phase 2)</i>
IEEE Std 802.3aq-2006, Physical Layer and Management Parameters for 10 Gb/s Operation, Type 10GBASE-LRM	15 September 2006 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> David G. Cunningham , <i>Task Force Chair</i> Nick Weiner , <i>Task Force Editor</i> Piers Dawe , <i>Task Force Contributing Editor</i>
IEEE Std 802.3as-2006, Frame format extensions	15 September 2006 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Kevin Q Daines , <i>Task Force Chair</i> Glenn W. Parsons , <i>Task Force Editor</i>
IEEE Std 802.3-2005/Cor 1-2006 (IEEE 802.3au), DTE Power via MDI Isolation corrigendum	8 June 2006 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Editor</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i>
IEEE Std 802.3-2005/Cor 2-2007 (IEEE 802.3aw), 10GBASE-T corrigendum	7 June 2007 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Editor</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i>
IEEE Std 802.3-2008 (IEEE 802.3ay), Maintenance #9 (Revision of the base), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	26 September 2008 (IEEE)	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Editor</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i>
IEEE Std 802.3at-2009 Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements	11 September 2009 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Mike McCormack , <i>Task Force Chair</i> D. Matthew Landry , <i>Task Force Chief Editor</i> Chad Jones , <i>Task Force Comment Editor</i>

IEEE Std 802.3 document	Date approved by IEEE and ANSI	Officers at the time of working group ballot
IEEE Std 802.3av-2009 Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks	11 September 2009 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Glen Kramer , <i>Task Force Chair</i> Duane Remoin , <i>Task Force Chief Editor</i> Marek Hajduczenia , <i>Task Force Assistant Editor</i>
IEEE Std 802.3az-2010 Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet	30 September 2010 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Michael Bennett , <i>Task Force Chair</i> Sanjay Kasturia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3ba Media Access Control Parameters, Physical Layers, and Management Parameters for 40 Gb/s and 100 Gb/s Operation	17 June 2010 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> John D'Ambrosia , <i>Task Force Chair</i> Ilango S. Ganga , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3-2008/Cor 1-2009 (IEEE 802.3bb) Pause Reaction Delay Corrigendum.	9 December 2009 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i>
IEEE Std 802.3bc-2009 Ethernet Organizationally Specific Type, Length, Value (TLVs)	11 September 2009 (IEEE)	David J. Law , <i>Working Group Chair and Task Force Editor</i> Wael W. Diab , <i>Working Group Vice Chair, Task Force Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i>
IEEE Std 802.3bd-2011 MAC Control Frame for Priority-based Flow Control	16 June 2011 (IEEE)	Tony Jeffrey , <i>IEEE 802.1 Working Group Chair</i> Paul Congdon , <i>IEEE 802.1 Working Group Vice Chair</i> David J. Law , <i>IEEE 802.3 Working Group Chair</i> Wael W. Diab , <i>IEEE 802.3 Working Group Vice Chair</i> Pat Thaler , <i>Data Center Bridging Task Group Chair</i>
IEEE Std 802.3bf-2011 Media Access Control (MAC) Service Interface and Management Parameters to Support Time Synchronization Protocols	16 May 2011 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Steven B. Carlson , <i>Task Force Chair</i> Marek Hajduczenia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bg-2011 Physical Layer and Management Parameters for Serial 40 Gb/s Ethernet Operation Over Single-Mode Fiber	31 March 2011 (IEEE)	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Mark Nowell , <i>Task Force Chair</i> Pete Anslow , <i>Task Force Editor-in-Chief</i>

Ali Abaye	Phil L. Arst	James Binder	Maurice Caldwell
Fazal Abbas	Doug Artman	Larry Birenbaum	Richard Cam
Ghani Abbas	Jean-Pierre Astorg	Jeff E. Bisberg	Bob Campbell
John S. Abbott	Mehran Ataee	Michel Bohbot	Peter Campbell
Justin Abbott	Ilan Atias	Mark Bohrer	Robert R. Campbell
Hamlet Abedmamoore	Steve Augusta	Jean-Michel Bonnamy	Luigi Canavese
Joe Abler	Phil Auld	Bradley J. Booth	James T. Carlo
Menachem Abraham	Siamack Ayandeh	Paul Booth	Craig Carlson
Shadi AbuGhazaleh	Kameran Azadet	Paul Bottorff	Steven B. Carlson
Martin Adams	Joseph N. Babanezhad	Thomas J. Boucino	Dan Carnine
Luc Adriaennsens	Chet Babla	Samuel Bourche	J. Martin Carroll
Don Aelmore	Gerard E. Bachand	David Bourque	J. Scott Carter
Puneet Agarwal	Guna Bala	Gary Bourque	Andrew Castellano
Akira Agata	R. V. Balakrishnam	Sidney Bouzaglo	Ron Cates
Oscar Agazzi	Koussalya Balasubramanian	Kirk Bovill	Jeffrey D. Catlin
John R. Agee	Vittal Balasubramanian	John Bowerman	Mandeep Chadha
Nand Aggarwal	Andy Baldman	Richard Bowers	David Chalupsky
Paul Ahrens	Thananya Baldwin	Peter Bradshaw	Edward Chang
Youichi Akasaka	Keith Balmer	Al Braga	Edward G. Chang
Vish Akella	Mogens Cash Balsby	Richard Brand	Edward S. Chang
Reza Alavi	Bruce Bandali	Rudolf Brandner	Frank Chang
Alan Albrecht	Jaya Bandyopadhyay	Ralf-Peter Braun	Justin Chang
Keith Albright	Majid Barazande-Pour	Richard S. Brehove	Kiwon Chang
Don Alderrou	Ozdal Barkan	Dirk Breuer	Luke Chang
Jan Alexander	Ian Barker	Steve Brewer	Samuel Chang
Thomas Alexander	Eyal Barnea	Robert F. Bridge	Sun-Hyok Chang
Abe Ali	Barry Barnett	Vince Bridgers	Thomas Chantrell
Brad Allen	Jim Barnette	Dave Brier	Howard Charney
David Allen	Hugh Barrass	Andrew Brierley-Green	Jian Chen
John Allen	Bob Barrett	Rhett Brikovskis	Xiaopeng Chen
Zehavit Alon	Scott Barrick	Charles Brill	Zinan (Nan) Chen
Arne Alping	Meir Bartur	Robert D. Brink	Linda Cheng
Michael Altman	Yoram Barzilai	Rick Brooks	Weiyong Cheng
Yehuda Alush	Howard Baumer	Alan M. Brown	Kok-Wui Cheong
Karen Amavisca	Denis Beaudoin	Benjamin Brown	Giovanni Cherubini
Andrew Ambrose	Michaël Beck	Daniel J. Brown	Rao Cherukuri
Khaled Amer	Jonathan Beckwith	Dave Brown	Albert Chiang
Nitish Amin	Christian Beia	Jack Brown	David Chin
Keith Amundsen	Edward Beili	Kevin Brown	Hon Wah Chin
Ole Christian Andersen	Alexei Beliaev	Matthew Brown	Jae hun Cho
Arlan J. Anderson	William Belknap	Suzy Brown	Francis Choi
Eric Anderson	Eran Bello	Phillip Brownlee	Jin-Seek Choi
Jon Anderson	Yakov Belopolsky	Brian Brunn	Rahul Chopra
Paul Anderson	Randy J. Below	Robert Brunner	Joseph Chou
Richard Anderson	Vincent Bemmell	Steve F. Buck	Golam Choudhury
Stephen D. Anderson	Michael Bennett	Lisa Buckman	Jacky Chow
Stephen J. Anderson	Richard Bennett	Mark Bugg	Kuen Chow
Tony Anderson	Miles Benson	Juan Bulnes	Henry Choy
Ralph Andersson	Sidney Berglund	Bill Bunch	Chris Christ
Jack S. Andresen	Ernest E. Bergmann	James Burgess	Jacques Christ
Peter Anslow	April Bergstrom	Scott Burton	George Chu
Ekkehard Antz	David J. Berman	Robert A. Busse	Hwan-Seok Chung
Ken-ichi Arai	Roberto Bertoldi	Thomas T. Butler	Yue-Der Chzh
Bert Armijo	John L. Bestel	Roy Bynum	Albert Claessen
Mike Armstrong	Dave Bethune	Ed Cady	Guss Claessen
Susie Armstrong	Vipul Bhatt	Luca Cafiero	G. J. Clancy
Brian Arnold	Sudeep Bhoja	John Cagle	Brice Clark
Lewis B. Aronson	Harmeet Bhugra	Jeffrey C. Cain	Susan Roden Clarke
Simcha Aronson	Jan Bialkowski	Donald Caldwell	George Claseman

Terry Cobb	Bernard O. Debbasch	Herman Eiliya	Richard Froke
Michael Coden	Michael deBie	George Eisler	Ingrid Fromm
Kelly B. Coffey	Tom Debiec	Martin Elhøj	Richard Frosch
Larry Cohen	John DeCramer	David Elie-Dit-Cosaque	Hongyan Fu
Christopher R. Cole	Joel Dedrick	Kevin M. Elliff	Judy Fuess
Doug Coleman	Steve Deffley	Michael Elswick	Yukihiro Fujimoto
Régis Colla	Dave Delaney	Paul "Skip" Ely	Atsuhisa Fukuoka
Kevin Cone	Moshe De-Leon	Richard Ely	John Fuller
Herbert V. Congdon	Bill Delveaux	Kent English	Darrell Furlong
Paul Congdon	Ralph DeMent	Gregory Ennis	Mel Gable
Patrick Conlon	Joe DeNicholas	Gianfranco Enrico	Robert D Gaglianella
Don Connor	Tazio M. DeNicolo	Brian S. Ensign	Justin Gaither
Robert Conte	Sanjay Desai	Norman Erbacher	Robert Galin
Charles I. Cook	Claudio Desanti	Tooraj Esmailian	Sharad Gandhi
Ronald J. Cooper	Peter Desaulniers	Nick Esser	Tom Gandy
Stephen Cooper	Mark Devon	Daniel Essig	Ilango S. Ganga
Neil Coote	Sanjay Dhawan	David Estes	Robin Gangopadhyaya
Edward Cornejo	Chris Di Minico	Judith Estrin	Xiao Ming Gao
Ronald Crane	Wael William Diab	Jim Everitt	Clete Gardenhour
George Cravens	Patrick Diamond	Steve Evitts	Geoffrey M. Garner
Ian Crayford	Erik Dickens	John F. Ewen	Denton Gentry
John Creigh	Bryan Dietz	Richard Fabbri	John George
J. Francois Crepin	Chris DiMinico	Siavash Fallahi	Floyd H. Gerhardt
Bill Cronin	Thomas J. Dineen	Sabina Fanfoni	Keith Gerhardt
Peter Cross	Zheming Ding	Janos Farkas	Mark Gerhold
Richard Cross	Sean Dingman	Rebecca Farley	Anoop Ghanwani
Brian Cruikshank	Thuyen Dinh	Donald Fedyk	Ali Ghiasi
Diego Crupnicoff	Hans Peter Dittler	Eldon Feist	Sajol Ghoshal
Kai Cui	Hamish Dobson	Daniel Feldman	Dimitrios Giannakopoulos
David Cullerot	David W. Dolfi	Dongning Feng	Giorgio Giaretta
Chris Cullin	Mark Donhowe	Feifei (Felix) Feng	Pat Gilliland
David G. Cunningham	Hank (H. N.) Dorris	Severn Ferdun	George Gintis
Joe Curcio	Daniel Dove	Jean-Loup Ferrant	Joel Goergen
Robert A. Curtis	James Doyle	Mark Feuerstraeter	Franz Goetz
Simon Cushin	Daniel S. Draper	Jens Fiedler	Adi Golbert
Dariusz Dabiri	Scott Dredge	Julien Fiere	Glenn Golden
Robert Dahlgren	Brian Drever	Dave Fifield	Moty Goldis
Saleem Dahmouh	Steve Dreyer	Norival Figueira	Matthew Goldman
Fumio Daido	John Dring	Juan Figueroa	Timothy D. Goodman
Bernard Daines	Michael Dudek	Robert G. Finch	Steve Goody
Kevin Q Daines	Marcus Duell	Norman Finn	Rich Graham
John Dallesasse	Richard Dugan	Farzin Firoozmand	Russ Granger
John D'Ambrosia	Raymond S. Duley	David Fischer	Eric B. Grann
Nabil Damouny	Linda Dunbar	Thomas Fischer	Tom Grasmehr
Rupert S. Dance	Joseph E. Dupuis	John Fitzgerald	C. Thomas Gray
Mark Darby	Marc R. Dupuis	Alan Flatman	Eric Gray
Yair Darshan	David Dwelley	Steve Flickinger	Larry Green
Peter Dartnell	J. Craig Easley	Norbert Folkens	Martin Green
Subrata Datta	Paul Eastman	Christian G. Folting	Jonathan E. Greenlaw
John Davidson	Jeff Ebeling	Harry Forbes	Bryan Gregory
David Davies	Peter Ecclesine	Brian Ford	Richard Grenier
Edward Davis	Edward J. Eckert	Richard Fransen	Karanvir Grewal
Peter Dawe	Clay Eddings	Roger Fraser	Michael R. Grimwood
Piers Dawe	Phil Edholm	Howard M. Frazier	Edward Grivna
John De Andrea	Tom Edsall	Robert Frazier	Robert M. Grow
Kathryn de Graaf	Dean Edwards	Ladd Freitag	Robert Gudz
Gerald de Grace	Gareth Edwards	Ken Friedenbach	Andreas Gulle
Michael de la Garrigue	Frank J. Effenberger	Scott Fritz	Karunakar Gulukota
Moshe De Leon	John Egan	Krister Frojdh	Ajay Gummalla

Richard Gumpertz	Susan Hennenfent	Woo-Hyuk Jang	Harold W. Katz
Craig Gunther	Ken Herrity	Stephen Janshego	Boris Katzenberg
Bin Guo	Pierre Herve	Jonathan Jedwab	Dave Kaufman
Sandeep Gupta	James H. Hesson	Tony Jeffree	Sumesh Kaul
Sudhir Gupta	John Hickey	George D. Jelatis	Yasuaki Kawatsu
Tanmay Gupta	Chip Hicks	Ernie Jensen	Kevin Kayser
Mitch Gusat	Tetsuya Higuchi	John J. Jetzt	Hal Keen
Jonas Gustafsson	Olli-Pekka Hiironen	Jack L. Jewell	Paul Kellam
Mark Gustlin	John Hill	Pankaj Jha	N. Patrick Kelly
Paul J. Gyugyi	Tricia Hill	Jessica Xin Jiang	Joe Kennedy
Russ Gyurek	Sammy Hindi	Qiaofeng Jiang	John J. Kenny
Steven Haas	William Hingston	Wenbin Jiang	Scott Kesler
Michael Hackert	Henry Hinrichs	Ni Jie	Dawson Kesling
Tariq Haddad	David Hinzel	Andrew C. Jimenez	Lior Khernmash
Stephen Haddock	Kengo Hirano	Robert Jin	Tuan Khuu
Atikem Haile-Mariam	Ryan Hirth	Thomas K. Joergensen	Gary Kidwell
Marek Hajduczenia	Charlie Hochstedler	Clarence Joh	Keti Kilcrease
Sharam Hakimi	Charles Hoffner	Michael D. Johas Teener	Bob Kilgore
Clive Hallatt	Jay Hoge	Richard John	Chan Kim
Hiroshi Hamano	Brian Holden	Donald C. Johnson	Dae Young Kim
Farid Hamidy	Bryan Hoover	Howard Johnson	Jin H. Kim
Kevin Hamilton	Gregory Hopkins	Mize Johnson	Seung-Hwan Kim
Bernie Hammond	Keith Hopwood	Scott Johnson	Su-Hyung Kim
Benny Hanigal	Rita Horner	Cristopher Jolly	Yongbum Kim
Greg Hankins	Steven E. Horowitz	Chad M. Jones	Marc Kimpe
G. Y. Hanna	Michael Horvat	Nick Jones	Mitsunobu Kimura
Chris Hansen	Yoshifumi Hotta	William W. Jones	John Kincaid
Johannes Hansen	Stanley Hronik	Ulf Jonsson	Bill Kind
Mogens Hansen	Henry Hsiaw	Bheom-Soon Joo	Jonathan P. King
Del Hanson	Jacob Hsu	Seong-Soon Joo	Neal King
Onn Haran	Fred Huang	Anthony Jordan	Scott G. Kipp
Hacene Hariti	Xi Huang	Thomas K. Jørgensen	Paul Kish
Guy Harkins	Charles Hudson	Juan Jover	Tadayoshi Kitayama
Milton C. Harper	Chuck Hudson	Imre Juhász	Philippe Klein
Doug Harshbarger	Todd Hudson	Jason Julyan	Richard Knight
G. R. Hartley	Michael Hughes	Kwi-Yung Jung	Mike Ko
Lloyd Hasley	Walter K. Hurwitz	Dieter W. Junkers	Hiroshi Kobayashi
Marwan Hassoun	Dean Huumala	Paul Jury	Shoukei Kobayashi
Mehdi Hatamian	Thong Huynh	David Kabal	Satoshi Kodama
W. B. Hatfield	David W. Hyer	Jayant Kadambi	Henriecus Koeman
Tom Hatley	Haruhiko Ichino	Vic Kairis	David J. Koenen
Stephen Haughey	Hiroki Ikeda	Shinkyō Kaku	Christine Koenig
Haw Ming Haung	Nicholas Ilyadis	Omer Kal	David E. Kohl
Kirk Hayden	James Innis	Mohan Kalkunte	Srinivas Kola
Claude Hayek	Romain Insler	Amrit Kalla	Paul F. Kolesar
Robert Hays	Kazuhiko Ishibe	Joel S. Kalman	Steven Koller
Carl G. Hayssen	Osamu Ishida	Matt Kaltenbach	Kishan Rao Konda
Asif Hazarika	Hideki Isono	Puru Kamat	Masashi Kono
Adam Healey	Hirotake Iwadate	Ron Kao	David Kooistra
Jeffrey Heath	Steve Jackson	Hadriel Kaplan	Derek Koonce
Gaby Hecht	Krista S Jacobsen	Rainer Kaps	Paul Kopera
Jim Heckroth	Michael R. Jacobson	Roger Karam	Leonid Koshevoy
Chris Heegard	Mike Jacobson	Abhay Karandikar	Josef Kosilek
Gopal Hegde	Ajit Jadeja	Jaime Kardontchik	Donald E. Kotas
Wolfgang Heidasch	John M. Jaeger	Yuji Kasai	William F. Kous
Ronen Heldman	Brent Jaffa	Allen Kasey	Tetsu Koyama
David Helster	Raj Jain	Prakash Kashyap	Seiji Kozaki
Ariel Hendel	David V. James	Sanjay Kasturia	Josef Kozilek
Itzik Hendel	Eric Jang	Toyoyuki Kato	Glen Koziuk

Glen Kramer	Hyeong Ho Lee	Meilissa R. Lum	Jim McGrath
Daniel Krent	Jack Lee	Andy J. Luque	Chris McGugan
Subi Krishnamurthy	Kyusang Lee	Kent Lusted	Alan McGuire
Lars Paul Krolner	Michael E. Lee	Sharon Lutz	James McIntosh
Joerg-R Kropp	Wesley Lee	Jeffrey Lynch	Keith McKechnie
Simon Kropveld	Ying Lee	Mark Lynn	Donna McMaster
George Kubovcik	Vincent Lefebvre	Eric R. Lynskey	Tim McShane
Pankaj Kumar	Richard Lefkowitz	Ian Lyon	Greg McSorley
Vinod Kumar	Amir Lehr	Henning Lysdal	James D. McVey
Ted Kummert	Brian E. Lemoff	Gael Mace	Grahame Measor
Aniruddha Kundu	John Lemon	Ben Mack-Crane	Mounir Meghelli
David Kung	Richard Lena	Brian MacLeod	Mukesh Mehta
Jeffrey Kuo	Andreas Lenkisch	Kenneth MacLeod	Richard Y. Mei
David Kurcharczyk	Lisa Leo	Sam Madani	Vince Melendy
Christopher Kurker	Robert H. Leonowich	Anthony Magee	Richard Mellitz
Yasuyuki Kuroda	Michael Lerer	Joseph Maggiolino	Avraham Menachem
Hidetsune Kurokawa	Warayot Lertniphonphun	Randall Magliozzi	Menucher Menuchery
Toshihiko Kusano	Amir Leshem	Valerie Maguire	Mark Merrill
Gerard Kuyt	Raymond W. K. Leung	Ariel Maislos	John Messenger
Bengt Kvist	Tommy Leung	Rabih Makarem	Jo Beth Metzger
Bruce Kwan	Avinoam Levy	Jeffery J. Maki	Steve Metzger
Alan Kwentus	Van Lewing	Trey Malpass	Jeffrey Meyer
Lee LaBarre	David Lewis	Daniel Maltbie	Yossi Meyouhas
Adel Henry Labib	Richard Lewis	Jeff Mandin	Amir Mezer
Richard LaCerte	Mike Peng Li	Jim Mangin	Tremont Miao
Hans Lackner	Sam Liang	Bob Marchetti	Joseph Micallef
Gadi Lahat	William P. Lidinsky	Luciano Marchitto	Thomas Michaelis
Kari Laihonen	Seyoun Lim	Carlo Mariotti	Richard Michalowski
Ashvin Lakshmikantha	John O. Limb	Arthur Marris	Colin Mick
Lowell D. Lamb	Chan-De Lin	Charles Marsh	Martin R. Milbury
Lawrence J. Lamers	George Lin	Robert Marshall	Jim Millar
Erik Lander	Ray Lin	Robert A. Marsland	Bruce D. Miller
D. Matthew Landry	Ru Jian Lin	Arlen Martin	C. Kenneth Miller
William Lane	Yoseph L. Linde	Arlon Martin	Larry D. Miller
Gordon Langlands	Wayne Lindquist	David W. Martin	Brian Misk
Daun Langston	Thomas A. Lindsay	Jeff Martin	Jacob (Kobi) Mizrahi
Jeff Lapak	Laurie Lindsey	Koichiro Mashiko	Fanny Mlinarsky
Ed Lare	Robert Lingle	Scott Mason	Reza Moattar
Ferdinando Lari	Marina Lipshteyn	Thomas Mathey	Merrick Moeller
Loren Larsen	Cathy Liu	Ziad Albert Matni	Fred Mohamadi
Donald C. Larson	Chang-Chi Liu	Hideyuki Matsuo	Dirk S. Mohl
Ryan Latchman	Fengkun Liu	Bob Matthys	Mart L. Molle
Tony Lau	William D. Livingston	Bret A. Matz	Ray Mompont
Tony Lauck	Martin Lobel	Bob Mayer	John Monson
Bruce LaVigne	Terry Lockyer	Joseph Mazor	Gabriel Montenegro
David J. Law	Hugh Logan	David S. McCallum	Cindy Montstream
Eric Lawrence	Larry Lomelino	Kent McCammon	Charles Moore
Michael Lawton	Leland Long	Philip L. McCarron	Paul B. Moore
John Laynor	Sherry J. Lorei	Frank McCarthy	Robert Moore
Yannick Le Goff	Jahan Lotfi	C. Phillip McClay	Andy Moorwood
My Le	James A. Lott	Brett McClellan	Matthew Mora
Quang Le	Dennis Lou	Kelly McClellan	Octavio Morales
Michael Lebar	Donald C. Loughry	Mike McConnell	Kazuyuki Mori
Greg LeCheminant	Bob Love	John McCool	Shohei Moriwaki
Changoo Lee	Rick Loveless	Michael S. McCormack	Robert L. Morrell
Chun-Tsung Lee	Raul Lozano	Gary McCoy	John Morris
Dong-Soo Lee	Ken Lu	Andy McDonald	Robert Mortonson
Eugene Lee	Fred A. Lucas	John McDonough	Simon Moseley
Fu-Ho Lee	James A. Lucas	Jerry McDowell	Jack Moses

Steven Moustakas	Raj Ojha	Y. Lisa Peng	Dan Rausch
Wayne A. Mueller	Mitsuji Okada	Petar Pepeljugoski	Peter Rautenberg
Robert Muir	Vladimir Oksman	Gerald Pepper	Eric Rawson
Shankar Mukherjee	Guy P. Oliveira	Drew D. Perkins	Robert Reed
Shimon Muller	Chris Oliver	Gerry Pesavento	Ivan Reede
Eric Multanen	Lloyd Oliver	William R. Peters	Dennis Rehm
Carrie Munson	David Olsen	Brian Peterson	Eugene Reilly
Ken Murakami	Bengt-Erik Olsson	David Peterson	Jim Reinstedler
Denis Murphy	Mike Oltmanns	John Petrilla	Maurice Reintjes
Thomas Murphy	Barry O'Mahony	Abhijit Phanse	Duane Remein
Brian Murray	Padraig OMathuna	Thomas L. Phinney	Andreas Rendel
Narayan Murthy	Keith Onodera	David Piede	Lawrence Rennie
Samba Murthy	Toshio Ooka	Roy Pierce	Victor Renteria
Angela Muscat	Philip Orlik	Robert Pieters	Tamir Reshef
Robert Musk	Aidan O'Rourke	Antti Pietilainen	Michael Ressler
Jim Muth	Akihiro Otaka	Velu C. Pillai	Pedro Reviriego
Yaron Nachman	Michael O'Toole	Rick Pimpinella	Bill Reysen
Gerard Nadeau	Tony O'Toole	Armin Pitzer	Behrooz Rezvani
Takeshi Nagahori	Michel Ouellette	Ed Pivonka	June-Koo (Kevin) Rhee
Ken Naganuma	George Oughton	Timothy R. Plunkett	Dave Richkas
Hari Naidu	George Oulundsén	David Poisner	Joseph Rickert
Wendell Nakamine	Pat Overs	Peter Pondillo	Sean Riley
Edward Nakamoto	Kazuyuki Ozawa	Petre Popescu	Poldi (Pavlick) Rimboim
Karl Nakamura	Paul Pace	Hayim Porat	John Ritger
Nersi Nazari	Robert R. Pace	Jeff Porter	Paul Rivett
W. P. Neblett	Charles Palanzo	Carl R. Posthuma	Ramez Rizk
Erwan Nedellec	Thomas Palkert	Bill Poston	Ramz Rizk
Jay Neer	Sesha Panguluri	David Potter	Anthony Rizzolo
Darcy Nelson	Donald Pannell	Kimberly Pottratz	Iain Robertson
James Nelson	Bill Panos	Scott R. Powell	Gary Robinson
Kristian Nelson	Gabriel D Papandrea	Gideon Prat	Steven Robinson
Trung Nguyen	Keshab K. Parhi	Bernd Prediger	Stuart Robinson
Thinh Nguyenphu	Jim Parker	Robert S. Printis	Timothy Rock
Henry T. Nicholas	Gavin Parnaby	Max Pritikin	Michael Rodensky
Gary Nicholl	Bidyut Parruck	John Proffitt	A. Rodriguez
Larry Nicholson	Elwood T. Parsons	Steve Pryor	Carlos Rodriguez
Paul Nikolich	Glenn W. Parsons	Haoli Qian	Josef Roese
David Nim	Vasu Parthasarathy	William Quackenbush	Shawn Rogers
Glenn Nishida	Joel Paslaski	Holger Quast	Derek Rohde
Shinji Nishimura	Jerry Pate	Tomas J. Quigley	Dan Romascanu
George Noh	Bhavesh Patel	Jim Quilici	Tume Römer
Kazuhiro Nojima	Dipak M. Patel	Patrick W. Quinn	Albrecht Rommel
Kevin Nolish	Piyush Patel	John Quirk	David Roos
Takumi Nomura	Pravin Patel	Rick Rabinovich	Robert Rosenthal
Michael Nootbaar	Sandeep Patel	Jerry K. Radcliffe	Floyd Ross
Ronald Nordin	Shashi Patel	Ted Rado	Tam Ross
Bob Norton	Vijay Pathak	Sreen Raghavan	Michael Rothenberg
Bob Noseworthy	Martin Patoka	Jurgen Rahn	Jessy Rouyer
Ahmad Nouri	Aidan Paul	Mohammad Rajabzadeh	Tony Rowell
Mark Nowell	Prasun K. Paul	Shlomo Rakib	Archana Roy
Ivan Oakley	Alex Pavlovsky	Naresh Raman	Larry Rubin
Satoshi Obara	John Payne	Brian Ramelson	Paul F. Russo
John Oberstar	Tony Peatfield	Brian J. Ramsey	Bill Ryan
J. Michael O'Connor	Anthony Peck	Adee Ran	Valerie Rybinski
David Ofelt	Neil Peers	Karen Randall	Hyunsurk (Eric) Ryu
Gourgen Oganessyan	Jan P. Peeters-Weem	William Randle	Khosrow Sadeghi
Stephen Oh	Arkadiy Peker	Randy K. Rannow	Jonathan Sadler
Steven O'Hara	Joseph Pelissier	Sailesh K. Rao	Naoto Saeki
Peter Ohlén	Jim Pelster	Jennifer G. Rasimas	Dalit Sagi

Ali Sajassi	Farhad Shafai	Bryan Sparrowhawk	Victor J. Tarassov
Ed Sakaguchi	Haim Shafir	Ben Speiser	Peter Tarrant
Dolors Sala	Amit Shah	Gary Spencer	Mike Tate
Peter Sallaway	Sunil Shah	Michael Spratt	Tsutomu Tatsuta
Joseph Salowey	Vadim Shain	Nurit Sprecher	Jim Tatum
Panagiotis Saltsidis	Abhijit Shanbhag	Matthew B. Squire	James M. Tavacoli
Michael M. Salzman	Megha Shanbhag	David Srodzinski	Sadry Tavana
Moni Samaan	Ron Shani	Joseph St. Amand	Ken Taylor
Sam Sambasivan	Sam Shen	David N. Stacy	Mark Taylor
Fred Sammartino	Ben Sheppard	Clayton Stanford	Tim Teckman
Henry Samueli	Paul Sherer	Patrick H. Stanley	Michael D. Johas Teener
Anthony Sanders	Robbie Shergill	Kevin Stanton	Antonio Teixeira
Gianluca Sanitá	Siddharth Sheth	Nick Stapleton	Vivek Telang
Mark Sankey	Masayuki Shigematsu	Graham Starkins	José Tellado
Concita Saracino	Cheng-Chung Shih	Peter Staub	Patricia Thaler
Arindam Sarkar	Hyungsoo Shin	Margit Stearns	R. Jonathan Thatcher
Bill Sarles	Jong-Yoon Shin	Henk Steenman	Sashisekaran Thiagarajan
F. Sarles	Ramin Shirani	David E. Stein	Walter Thirion
Akira Sasaki	Zion Shohet	Gary Stephens	Geoffrey O. Thompson
Stan Sassower	Larry Shorthill	Claus Stetter	Douglas Thomson
Ramesh Sastry	Avadhani Shridhar	Ronald Steudler	Lars E. Thon
Satish Sathe	Kapil Shrikhande	Donald S. Stewart	David Thorne
John Sauer	Martin Siegmund	Dean M. Stoddart	Ao Ting
Raj Savara	Som Sikdar	Daniel P. Stokesberry	Nathan Tobol
Olindo Savi	Nathan Silberman	Mario Stoltz	John Todd
T. Shannon Sawyer	Tim Simmons	Christopher Stook	Bruce Tolley
Sabit Say-Otun	Scott Simon	Olaf Storaasli	Carlos A. Tomaszewski
Edward Sayre	Jesse Simsarian	Steve Storozum	Peter Tomaszewski
J. David Schell	Bharat Singh	Rick Strohmayr	Paul Torgerson
Dieter W. Schickeltanz	Charan J. Singh	Stephen Strong	Luis Torres
Frederick Schindler	Paramjeet (P. J.) Singh	Richard Stuart	Rick Townsend
Ronald Schmidt	Semir Sirazi	Alan Sugg	Hidehiro Toyoda
Tom Schmitt	Ramesh Sivakolundu	Robert Sultan	Mario Träber
Peter Schoenmaker	Joseph Skorupa	Ron Sulyma	Nathan Tracy
Frederick Scholl	James P. Skoutas	Robert Summers	Mario Traeber
Thomas Schramm	Jeff Slavick	Ken F. Sumner	Hiep Tran
Thomas Schrans	Dinah Sloan	Tetsuyuki Suzuki	Matthew Traverso
Walter Schreuer	Tom Slykhouse	Hiroshi Suzuki	Francois Tremblay
Ted Schroeder	Andrew Smith	Ken-ichi Suzuki	Stephen J. Trowbridge
Scott Schube	David A. Smith	Muneyoshi Suzuki	Thomas E. Truman
Benjamin Schultz	Eric Smith	Naoki Suzuki	Shinji Tsuji
Klaus Schulz	Grant Smith	Daniel Svensson	Shiji Tsuju
David Schwartz	Michael Smith	Steve Swanson	Eddie Tsumura
Peter Schwartz	Robert Smith	Norman L. Swenson	Zbigniew Turlej
Harvey R. Scull	Robert W. Smith	Andre Szczepanek	Brad Turner
Anthony Seaman	Steve Smith	Daniel Sze	Edward Turner
Michael Seaman	Robert Snyder	Tad Szostak	Wendell Turner
Shawn Searles	Dror Sofer	Richard Taborek	Bulent Tusiray
Stephn Sedio	Ran Soffer	Dimitry Taich	Jacob Twersky
Ted Seely	Gregory Somer	Bharat Tailor	Bor-long Twu
Brian Seemann	Jaeyeon Song	Akio Tajima	Marcos Tzannes
Khorvash (Kory) Sefidvash	Jian Song	Eiichi Takahashi	Kiyoshi Uematsu
Rich Seifert	Massimo Sorbara	Hidenori Takahashi	Herbert Uhl
Katsutoshi Seki	David Sorensen	Noriyuki Takeda	Jayshree Ullal
Steve Selee	Michel Sorenson	Martin Takessian	Steven Ulrich
Lee Sendelbach	Walter Sotelo	Motoyuki Takizawa	Alexander Umnov
Shoichiro Seno	Stephen Soto	Keiji Tanaka	Gottfried Ungerboeck
Murat Serbay	Walt Soto	Wen-Tsung Tang	Sterling A. Vaden
Koichiro Seto	Fulvio Spagna	Sandray Tarana	Todd Vafiades

Magesh Valliappan	Chiung Hung Wang	Bruce Williams	Steven Yang
Nicholas Van Bavel	Greg Wang	Richard Williams	Yinglin (Frank) Yang
Schelto J. van Doorn	Peter Wang	Erica Williamson	Ronald Yara
David J. Van Goor	Yun-Che Wang	Robert S. Williamson	Masaki Yasukawa
Peter Van Laanen	Ken Ward	Roger Wilmarth	Lee Chung Yiu
Erik van Oosten	Tim Warland	Joris Wils	Doug Yoder
Paul Z. Vanderlaan	David Warren	Izumi Wilson	Tetsuya Yokomoto
Schelto vanDoorn	Jeff Warren	Mike Wincn	Nobushige Yokota
Dono Van-Mierop	Marc Warshaw	Mark Wingrove	Tae-Whan Yoo
Andre VanSchyndel	Ted Washburn	Darin Winterton	Bin Yeong Yoon
Albert Vareljian	Yuji Watanabe	Mike Witkowski	Chong Ho Yoon
Kumaran Veerayah	Bruce Watson	Kevin Witt	Jason Yorks
V. Kumar Venkatavaraton	Robert Watson	Andrew Witzner	Osamu Yoshihara
Ramakrishna Vepa	Dong Wei	John Wolcott	Takashi Yoshikawa
Gérard Vergnaud	Yuehua Wei	Jonghwa Won	George Young
Bill Verheggen	Jason Weil	King Won	Ken Young
Iain Verigin	Lyle Weiman	Shin-Hee Won	Leonard Young
Robert Verne	Nick Weiner	David Wong	Nariman Yousefi
Anoop Vetteth	Brian Weis	Don Wong	Ben Yu
Nader Vijeh	Alan Weissberger	Edward Wong	Hong Yu
Ron Vilozny	Andrew Weitzner	Leo Wong	Mark Yu
John Visser	Moti Weizman	Percy Wong	Nick Zades
Ionel Marius Vladan	Jim Welch	Bill Woodruff	Nelson Zagalsky
David Vogel	Fred Weniger	Paul Woodruff	Hank Zannini
Moshe Voloshin	Jason Wertz	Ted K. Woodward	Jamie Zartman
Brian Von Herzen	Willem Wery	Chien-Hsien Wu	Li Zeng
John von Voros	Alan Wetzell	Choa-Ping Wu	Jing-fan Zhang
Manoj Wadekar	David White	Robert Wu	Lizhi Zhong
William Wager	Hugh E. White	Stefan M. Wurster	Igor Zhovnirovsky
Martin Wagner	Lawrence White	Ariel Yagil	George Zimmerman
P. E. Wainwright	Martin White	Michael Yam	Pavel Zivny
Ikuo Wakayama	Tony Whitlow	Masaki Yamada	Bob Zona
Rick Walker	Bill Wiedemann	Hajime Yamashita	Mo R. Zonoun
Chang Jung Wang	Joseph A. Wiencko	Shuntaro Yamazaki	Glen Zorn
Chenxi Wang	Bert Wijnen	Howard Yang	

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

Thomas Alexander	Junghoon Jee	Stephen Palm
Jon Anderson	Michael D. Johas Teener	Glenn Parsons
Mark Anderson	Vincent Jones	Petar Pepeljugin
Peter Anslow	Shinkyu Kaku	Randy Perrie
Arthur Astrin	Piotr Karocki	John Petrilla
Kwok Shum Au	Stuart Kerry	Rick Pimpinella
Hugh Barrass	Lior Khermosh	Subburajan Ponnuswamy
Christian Beia	Yongbum Kim	Venkatesha Prasad
Jacob Ben Ary	Jonathan King	Jayaram Ramasastry
Michael Bennett	Paul Kolesar	R. K. Rannow
Brad Booth	Bruce Kraemer	Maximilian Riegel
Ralf-Peter Braun	Glen Kramer	Benjamin Rolfe
Nancy Bravin	Thomas Kurihara	Randall Safier
Matthew Brown	Lowell Lamb	Bartien Sayogo
William Bush	Mark Laubach	Stephen Schwarm
William Byrd	David J. Law	Rich Seifert
Steven B. Carlson	Matthew Lawson	Gil Shultz
Mandeep Chadha	David Lewis	Jeff Slavick
Keith Chow	Vincent Lipsio	Jeremy Smith
Charles Cook	Shen Loh	Kapil Sood
Glenn Davis	William Lumpkins	Matthew Squire
Piers J. G. Dawe	Greg Luri	Manikantan Srinivasan
Wael William Diab	Kent Lusted	Dorothy Stanley
Thomas Dineen	Michael Lynch	Thomas Starai
Daniel Dove	Elvis Maculuba	Walter Struppler
Michael Dudek	Valerie Maguire	Patrik Sundstrom
Sourav Dutta	Jeffery Maki	Joseph Tardo
David Dwelley	Wayne Manges	William Taylor
Richard Edgar	Roger Marks	Patricia Thaler
Howard Frazier	Arthur Marris	David Thompson
Yukihiro Fujimoto	William McBride	Geoffrey Thompson
Ilango Ganga	Edward McCall	Michael Thompson
Devon Gayle	C. Phillip McClay	Jerry Thrasher
Michael Grimwood	Brett McClellan	Stephen Trowbridge
Randall Groves	Michael McCormack	Edward Turner
Robert Grow	Michael McInnis	Dmitri Varsanofiev
Michael Gundlach	Jonathon McLendon	Prabodh Varshney
Chris Guy	Richard Mellitz	Srinivasa Vemuru
Marek Hajduczenia	Steven Methley	John Vergis
Hiroshi Hamano	Tremont Miao	Balasubramanian Vittal
Adam Healey	Charles Moorwood	Ionel Marius Vladan
David Hunter	Jose Morales	George Vlantis
C. Huntley	Joseph Moran	Ludwig Winkel
Noriyuki Ikeuchi	Shimon Muller	Forrest Wright
James Innis	Michael S. Newman	Oren Yuen
Paul Isaacs	Nick S. A. Nikjoo	Janusz Zalewski
Osamu Ishida	Satoshi Obara	Daidi Zhong
Akio Iso	Thomas Palkert	Zhen Zhou
Atsushi Ito		George Zimmerman

When the IEEE-SA Standards Board approved this standard on 30 August 2012, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert M. Grow, *Vice Chair*
Konstantinos Karachalios, *Secretary*

Satish Aggarwal
Masayuki Ariyoshi
Peter Balma
William Bartley
Ted Burse
Clint Chaplin
Wael Diab
Jean-Philippe Faure

Alexander Gelman
Paul Houzé
Jim Hughes
Young Kuyn Kim
Joseph L. Koepfinger*
David J. Law
Thomas Lee
Hung Ling

Oleg Logvinov
Ted Olsen
Gary Robinson
Jon Walter Rosdahl
Mike Seavey
Yatin Trivedi
Phil Winston
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Lisa Perry
IEEE Standards Program Manager, Document Development

Kathryn M. Bennett
IEEE Standards Program Manager, Technical Program Development

Introduction

This introduction is not part of IEEE Std 802.3-2012, IEEE Standard for Ethernet.

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 this standard. Each IEEE 802.3 project/amendment is identified with a suffix (e.g., IEEE Std 802.3ba™-2010). A historical listing of all projects that have added to or modified IEEE Std 802.3 follows as a part of this introductory material. The listing is in chronological order of project initiation and for each project describes: subject, clauses added (if any), approval dates, and committee officers.

The Media Access Control (MAC) protocol specified in IEEE Std 802.3 is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This MAC protocol was included in the experimental Ethernet developed at Xerox Palo Alto Research Center. While the experimental Ethernet had a 2.94 Mb/s data rate, IEEE Std 802.3-1985 specified operation at 10 Mb/s. Since 1985, new media options, new speeds of operation, and new capabilities have been added to IEEE Std 802.3.

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 802.3x specified full duplex operation and a flow control protocol, 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 802.3-2012 and are not maintained as separate documents.

IEEE Std 802.3-2012

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 90 and Annex 83A through Annex 86A. 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 89 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 802.3 will continue to evolve. New Ethernet capabilities are anticipated to be added within the next few years as amendments to this standard.

List of special symbols

For the benefit of users who have received this document by electronic means, what follows is a list of special symbols and operators. If any of these symbols or operators fail to print out correctly, the editors apologize and hope that this table will at least help to sort out the meaning of the resulting funny-shaped blobs and strokes.

Special symbols and operators

Printed character	Meaning	Font
*	Boolean AND	Symbol
+	Boolean OR, arithmetic addition	Symbol
^	Boolean XOR	Times New Roman
!	Boolean NOT	Symbol
×	Multiplication	Symbol
<	Less than	Symbol
≤	Less than or equal to	Symbol
>	Greater than	Symbol
≥	Greater than or equal to	Symbol
=	Equal to	Symbol
≈	Approximately equal to	Symbol
≠	Not equal to	Symbol
←	Assignment operator	Symbol
∈	Indicates membership	Symbol
∉	Indicates nonmembership	Symbol
±	Plus or minus (a tolerance)	Symbol
°	Degrees	Symbol
∑	Summation	Symbol
√	Square root	Symbol
—	Big dash (em dash)	Times New Roman
-	Little dash (en dash), subtraction	Times New Roman
	Vertical bar	Times New Roman
†	Dagger	Times New Roman
‡	Double dagger	Times New Roman
α	Lower case alpha	Symbol
β	Lower case beta	Symbol
γ	Lower case gamma	Symbol
δ	Lower case delta	Symbol
ε	Lower case epsilon	Symbol
λ	Lower case lambda	Symbol
μ	Lower case mu	Times New Roman
Π	Upper case pi	Symbol
Ω	Upper case omega	Symbol

This is a preview of "ISO/IEC/IEEE 8802-3:...". [Click here to purchase the full version from the ANSI store.](#)

IEEE Standard for Ethernet

SECTION ONE

This section includes Clause 1 through Clause 20, Annex A through Annex H, and Annex 4A.

Contents

1. Introduction.....	1
1.1 Overview.....	1
1.1.1 Scope.....	1
1.1.2 Basic concepts.....	2
1.1.2.1 Half duplex operation	2
1.1.2.2 Full duplex operation	2
1.1.3 Architectural perspectives.....	2
1.1.3.1 Architectural rationale	3
1.1.3.2 Compatibility interfaces.....	3
1.1.4 Layer interfaces.....	6
1.1.5 Application areas	6
1.2 Notation	6
1.2.1 State diagram conventions	6
1.2.2 Service specification method and notation	7
1.2.2.1 Classification of service primitives.....	8
1.2.3 Physical Layer and media notation	8

1.2.4	Physical Layer message notation	9
1.2.5	Hexadecimal notation	9
1.2.6	Accuracy and resolution of numerical quantities	9
1.3	Normative references	9
1.4	Definitions	16
1.5	Abbreviations	44
2.	Media Access Control (MAC) service specification	49
2.1	Scope and field of application	49
2.2	Overview of the service	49
2.2.1	General description of services provided by the layer	49
2.2.2	Model used for the service specification	49
2.2.3	Overview of interactions	49
2.2.4	Basic services	50
2.3	Detailed service specification	50
2.3.1	MA_DATA.request	50
2.3.1.1	Function	50
2.3.1.2	Semantics of the service primitive	50
2.3.1.3	When generated	50
2.3.1.4	Effect of receipt	50
2.3.1.5	Additional comments	50
2.3.2	MA_DATA.indication	51
2.3.2.1	Function	51
2.3.2.2	Semantics of the service primitive	51
2.3.2.3	When generated	51
2.3.2.4	Effect of receipt	52
2.3.2.5	Additional comments	52
3.	Media Access Control (MAC) frame and packet specifications	53
3.1	Overview	53
3.1.1	Packet format	53
3.1.2	Service interface mappings	54
3.2	Elements of the MAC frame and packet	54
3.2.1	Preamble field	54
3.2.2	Start Frame Delimiter (SFD) field	54
3.2.3	Address fields	54
3.2.3.1	Address designation	55
3.2.4	Destination Address field	55
3.2.5	Source Address field	56
3.2.6	Length/Type field	56
3.2.7	MAC Client Data field	56
3.2.8	Pad field	57
3.2.9	Frame Check Sequence (FCS) field	57
3.2.10	Extension field	57
3.3	Order of bit transmission	58
3.4	Invalid MAC frame	58
4.	Media Access Control	59
4.1	Functional model of the MAC method	59
4.1.1	Overview	59
4.1.2	CSMA/CD operation	60

4.1.2.1	Normal operation	60
4.1.2.1.1	Transmission without contention	60
4.1.2.1.2	Reception without contention	61
4.1.2.2	Access interference and recovery	61
4.1.3	Relationships to the MAC client and Physical Layers	62
4.2	CSMA/CD Media Access Control (MAC) method: Precise specification	62
4.2.1	Introduction	62
4.2.2	Overview of the procedural model	62
4.2.2.1	Ground rules for the procedural model	63
4.2.2.2	Use of Pascal in the procedural model	63
4.2.2.3	Organization of the procedural model	64
4.2.2.4	Layer management extensions to procedural model	64
4.2.3	Packet transmission model	64
4.2.3.1	Transmit data encapsulation	65
4.2.3.2	Transmit media access management	70
4.2.3.2.1	Deference	70
4.2.3.2.2	Interpacket gap	70
4.2.3.2.3	Collision handling (half duplex mode only)	71
4.2.3.2.4	Collision detection and enforcement (half duplex mode only)	71
4.2.3.2.5	Collision backoff and retransmission (half duplex mode only)	71
4.2.3.2.6	Full duplex transmission	72
4.2.3.2.7	Packet bursting (half duplex mode only)	72
4.2.3.3	Minimum frame size	72
4.2.3.4	Carrier extension (half duplex mode only)	73
4.2.4	Frame reception model	73
4.2.4.1	Receive data decapsulation	73
4.2.4.1.1	Address recognition	73
4.2.4.1.2	Frame check sequence validation	74
4.2.4.1.3	Frame disassembly	74
4.2.4.2	Receive media access management	74
4.2.4.2.1	Framing	74
4.2.4.2.2	Collision filtering	74
4.2.5	Preamble generation	75
4.2.6	Start frame sequence	75
4.2.7	Global declarations	75
4.2.7.1	Common constants, types, and variables	75
4.2.7.2	Transmit state variables	77
4.2.7.3	Receive state variables	78
4.2.7.4	State variable initialization	78
4.2.8	Frame transmission	79
4.2.9	Frame reception	86
4.2.10	Common procedures	89
4.3	Interfaces to/from adjacent layers	90
4.3.1	Overview	90
4.3.2	MAC service	90
4.3.2.1	MAC client transmit interface state diagram	90
4.3.2.1.1	Variables	90
4.3.2.1.2	Functions	91
4.3.2.1.3	Messages	91
4.3.2.1.4	MAC client transmit interface state diagram	91
4.3.2.2	MAC client receive interface state diagram	92
4.3.2.2.1	Variables	92
4.3.2.2.2	Functions	92
4.3.2.2.3	Messages	92

4.3.2.2.4	MAC client receive interface state diagram	93
4.3.3	Services required from the Physical Layer	93
4.4	Specific implementations.....	95
4.4.1	Compatibility overview	95
4.4.2	MAC parameters.....	96
4.4.3	Configuration guidelines.....	97
5.	Layer Management	99
5.1	Introduction.....	99
5.1.1	Systems Management overview	99
5.1.2	Layer Management model	99
5.1.3	Packages.....	100
5.1.4	Conformance requirements	100
5.2	Management facilities.....	100
5.2.1	Introduction.....	100
5.2.2	DTE MAC Sublayer Management facilities	100
5.2.2.1	DTE MAC sublayer attributes	102
5.2.2.1.1	aMACID	102
5.2.2.1.2	aFramesTransmittedOK	102
5.2.2.1.3	aSingleCollisionFrames	102
5.2.2.1.4	aMultipleCollisionFrames	102
5.2.2.1.5	aFramesReceivedOK	103
5.2.2.1.6	aFrameCheckSequenceErrors	103
5.2.2.1.7	aAlignmentErrors.....	103
5.2.2.1.8	aOctetsTransmittedOK	103
5.2.2.1.9	aFramesWithDeferredXmissions	104
5.2.2.1.10	aLateCollisions	104
5.2.2.1.11	aFramesAbortedDueToXSColls	104
5.2.2.1.12	aFramesLostDueToIntMACXmitError	104
5.2.2.1.13	aCarrierSenseErrors	105
5.2.2.1.14	aOctetsReceivedOK.....	105
5.2.2.1.15	aFramesLostDueToIntMACRcvError	105
5.2.2.1.16	aPromiscuousStatus	105
5.2.2.1.17	aReadMulticastAddressList	106
5.2.2.1.18	aMulticastFramesXmittedOK	106
5.2.2.1.19	aBroadcastFramesXmittedOK	106
5.2.2.1.20	aFramesWithExcessiveDeferral.....	106
5.2.2.1.21	aMulticastFramesReceivedOK	107
5.2.2.1.22	aBroadcastFramesReceivedOK	107
5.2.2.1.23	aInRangeLengthErrors.....	107
5.2.2.1.24	aOutOfRangeLengthField.....	107
5.2.2.1.25	aFrameTooLongErrors.....	108
5.2.2.1.26	aMACEnableStatus.....	108
5.2.2.1.27	aTransmitEnableStatus	108
5.2.2.1.28	aMulticastReceiveStatus	108
5.2.2.1.29	aReadWriteMACAddress	109
5.2.2.1.30	aCollisionFrames	109
5.2.2.2	DTE MAC Sublayer actions	109
5.2.2.2.1	acInitializeMAC.....	109
5.2.2.2.2	acAddGroupAddress.....	109
5.2.2.2.3	acDeleteGroupAddress	110
5.2.2.2.4	acExecuteSelfTest.....	110
5.2.2.3	ResourceTypeID Managed Object Class	110

5.2.2.3.1	ResourceTypeID	110
5.2.3	DTE Physical Sublayer Management facilities	110
5.2.3.1	DTE Physical Sublayer attributes	110
5.2.3.1.1	aPHYID	110
5.2.3.1.2	aSQETestErrors	110
5.2.4	DTE Management procedural model.....	111
5.2.4.1	Common constants and types	111
5.2.4.2	Transmit variables and procedures	111
5.2.4.3	Receive variables and procedures.....	113
5.2.4.4	Common procedures	115
6.	Physical Signaling (PLS) service specifications.....	117
6.1	Scope and field of application	117
6.2	Overview of the service	117
6.2.1	General description of services provided by the layer.....	117
6.2.2	Model used for the service specification	117
6.2.3	Overview of interactions.....	117
6.2.4	Basic services and options	118
6.3	Detailed service specification	118
6.3.1	Peer-to-peer service primitives	118
6.3.1.1	PLS_DATA.request.....	118
6.3.1.1.1	Function	118
6.3.1.1.2	Semantics of the service primitive.....	118
6.3.1.1.3	When generated	118
6.3.1.1.4	Effect of receipt	118
6.3.1.2	PLS_DATA.indication	119
6.3.1.2.1	Function	119
6.3.1.2.2	Semantics of the service primitive.....	119
6.3.1.2.3	When generated	119
6.3.1.2.4	Effect of receipt	119
6.3.2	Sublayer-to-sublayer service primitives	119
6.3.2.1	PLS_CARRIER.indication	119
6.3.2.1.1	Function	119
6.3.2.1.2	Semantics of the service primitive.....	119
6.3.2.1.3	When generated	119
6.3.2.1.4	Effect of receipt	119
6.3.2.2	PLS_SIGNAL.indication.....	120
6.3.2.2.1	Function	120
6.3.2.2.2	Semantics of the service primitive.....	120
6.3.2.2.3	When generated	120
6.3.2.2.4	Effect of receipt	120
6.3.2.3	PLS_DATA_VALID.indication	120
6.3.2.3.1	Function	120
6.3.2.3.2	Semantics of the service primitive.....	120
6.3.2.3.3	When generated	120
6.3.2.3.4	Effect of receipt	120
7.	Physical Signaling (PLS) and Attachment Unit Interface (AUI) specifications	121
7.1	Scope.....	121
7.1.1	Definitions	121
7.1.2	Summary of major concepts	121
7.1.3	Application.....	122

7.1.4	Modes of operation	122
7.1.5	Allocation of function	122
7.2	Functional specification	122
7.2.1	PLS–PMA (DTE–MAU) Interface protocol	122
7.2.1.1	PLS to PMA messages	123
7.2.1.1.1	output message	123
7.2.1.1.2	output_idle message	124
7.2.1.1.3	normal message	124
7.2.1.1.4	isolate message (optional)	124
7.2.1.1.5	mau_request message (optional)	124
7.2.1.2	PMA to PLS interface	126
7.2.1.2.1	input message	126
7.2.1.2.2	input_idle message	128
7.2.1.2.3	signal_quality_error message	128
7.2.1.2.4	mau_available message	128
7.2.1.2.5	mau_not_available message (optional)	128
7.2.2	PLS interface to MAC and management entities	129
7.2.2.1	PLS–MAC interface	129
7.2.2.1.1	OUTPUT_UNIT	129
7.2.2.1.2	OUTPUT_STATUS	129
7.2.2.1.3	INPUT_UNIT	129
7.2.2.1.4	CARRIER_STATUS	129
7.2.2.1.5	SIGNAL_STATUS	130
7.2.2.1.6	DATA_VALID_STATUS	130
7.2.2.2	PLS–management entity interface	130
7.2.2.2.1	RESET_REQUEST	130
7.2.2.2.2	RESET_RESPONSE	131
7.2.2.2.3	MODE_CONTROL	131
7.2.2.2.4	SQE_TEST	131
7.2.3	Frame structure	131
7.2.3.1	Silence	132
7.2.3.2	Preamble	132
7.2.3.3	Start of Frame Delimiter (SFD)	132
7.2.3.4	Data	132
7.2.3.5	End of transmission delimiter	132
7.2.4	PLS functions	132
7.2.4.1	Reset and Identify function	133
7.2.4.2	Mode function	133
7.2.4.3	Output function	134
7.2.4.4	Input function	134
7.2.4.5	Error Sense function	134
7.2.4.6	Carrier Sense function	135
7.3	Signal characteristics	135
7.3.1	Signal encoding	135
7.3.1.1	Data encoding	135
7.3.1.2	Control encoding	139
7.3.2	Signaling rate	140
7.3.3	Signaling levels	140
7.4	Electrical characteristics	140
7.4.1	Driver characteristics	140
7.4.1.1	Differential output voltage, loaded	140
7.4.1.2	Requirements after idle	142
7.4.1.3	AC common-mode output voltage	142
7.4.1.4	Differential output voltage, open circuit	142

7.4.1.5	DC common-mode output voltage.....	142
7.4.1.6	Fault tolerance.....	143
7.4.2	Receiver characteristics	143
7.4.2.1	Receiver threshold levels	143
7.4.2.2	AC differential input impedance.....	144
7.4.2.3	AC common-mode range.....	144
7.4.2.4	Total common-mode range.....	144
7.4.2.5	Idle input behavior	145
7.4.2.6	Fault tolerance.....	145
7.4.3	AUI cable characteristics	145
7.4.3.1	Conductor size	146
7.4.3.2	Pair-to-pair balanced crosstalk.....	146
7.4.3.3	Differential characteristic impedance	146
7.4.3.4	Transfer impedance.....	146
7.4.3.5	Attenuation.....	146
7.4.3.6	Timing jitter	146
7.4.3.7	Delay	146
7.5	Functional description of interchange circuits.....	147
7.5.1	General.....	147
7.5.2	Definition of interchange circuits	147
7.5.2.1	Circuit DO–Data Out	148
7.5.2.2	Circuit DI–Data In	148
7.5.2.3	Circuit CO–Control Out (optional).....	148
7.5.2.4	Circuit CI–Control In.....	148
7.5.2.5	Circuit VP–Voltage Plus.....	149
7.5.2.6	Circuit VC–Voltage Common	149
7.5.2.7	Circuit PG–Protective Ground.....	149
7.5.2.8	Circuit shield terminations.....	149
7.6	Mechanical characteristics	149
7.6.1	Definition of mechanical interface	149
7.6.2	Line interface connector	149
7.6.3	Contact assignments	150
8.	Medium Attachment Unit and baseband medium specifications, type 10BASE5	153
8.1	Scope.....	153
8.1.1	Overview.....	153
8.1.1.1	Medium Attachment Unit	153
8.1.1.2	Repeater unit	154
8.1.2	Definitions	154
8.1.3	Application perspective: MAU and MEDIUM objectives	154
8.1.3.1	Object.....	154
8.1.3.2	Compatibility considerations	154
8.1.3.3	Relationship to PLS and AU interface.....	155
8.1.3.4	Modes of operation	155
8.2	MAU functional specifications	155
8.2.1	MAU Physical Layer functions	155
8.2.1.1	Transmit function requirements.....	155
8.2.1.2	Receive function requirements	156
8.2.1.3	Collision Presence function requirements	157
8.2.1.4	Monitor function requirements (optional)	157
8.2.1.5	Jabber function requirements.....	158
8.2.2	MAU interface messages	158
8.2.2.1	DTE Physical Layer to MAU Physical Layer messages	158

8.2.2.2	MAU Physical Layer to DTE Physical Layer	159
8.2.2.2.1	input message.....	159
8.2.2.2.2	input_idle message.....	159
8.2.2.2.3	mau_available message.....	159
8.2.2.2.4	signal_quality_error message	159
8.2.3	MAU state diagrams	160
8.3	MAU–medium electrical characteristics	160
8.3.1	MAU-to-coaxial cable interface	160
8.3.1.1	Input impedance.....	160
8.3.1.2	Bias current	161
8.3.1.3	Coaxial cable signaling levels.....	161
8.3.1.4	Transmit output levels symmetry	167
8.3.1.5	Collision detect thresholds.....	167
8.3.2	MAU electrical characteristics.....	167
8.3.2.1	Electrical isolation	167
8.3.2.2	Power consumption.....	168
8.3.2.3	Reliability.....	168
8.3.3	MAU–DTE electrical characteristics.....	168
8.3.4	MAU–DTE mechanical connection.....	168
8.4	Characteristics of the coaxial cable	168
8.4.1	Coaxial cable electrical parameters	168
8.4.1.1	Characteristic impedance	168
8.4.1.2	Attenuation.....	168
8.4.1.3	Velocity of propagation	169
8.4.1.4	Edge jitter, untapped cable.....	169
8.4.1.5	Transfer impedance.....	169
8.4.1.6	Cable dc loop resistance	169
8.4.2	Coaxial cable properties.....	170
8.4.2.1	Mechanical requirements	170
8.4.2.1.1	General construction	170
8.4.2.1.2	Center conductor	170
8.4.2.1.3	Dielectric material.....	170
8.4.2.1.4	Shielding system	170
8.4.2.1.5	Overall jacket.....	170
8.4.2.2	Jacket marking	171
8.4.3	Total segment dc loop resistance	171
8.5	Coaxial trunk cable connectors	171
8.5.1	Inline coaxial extension connector	171
8.5.2	Coaxial cable terminator.....	172
8.5.2.1	Termination.....	172
8.5.2.2	Earthing.....	172
8.5.3	MAU-to-coaxial cable connection.....	172
8.5.3.1	Electrical requirements	172
8.5.3.2	Mechanical requirements	173
8.5.3.2.1	Connector housing	173
8.5.3.2.2	Contact reliability	173
8.5.3.2.3	Shield probe characteristics	174
8.6	System considerations.....	174
8.6.1	Transmission system model.....	174
8.6.2	Transmission system requirements	175
8.6.2.1	Cable sectioning.....	175
8.6.2.2	MAU placement.....	175
8.6.2.3	Trunk cable system grounding.....	175
8.6.3	Labeling	176

8.7	Environmental specifications.....	176
8.7.1	General safety requirements	176
8.7.2	Network safety requirements	176
8.7.2.1	Installations	176
8.7.2.2	Grounding	177
8.7.2.3	Safety	177
8.7.2.4	Breakdown path	177
8.7.2.5	Isolation boundary	177
8.7.2.6	Installation and maintenance guidelines	177
8.7.3	Electromagnetic environment	178
8.7.3.1	Susceptibility levels	178
8.7.3.2	Emission levels	178
8.7.4	Temperature and humidity	178
8.7.5	Regulatory requirements.....	178
8.8	Protocol implementation conformance statement (PICS) proforma for Clause 8, Medium Attachment Unit and baseband medium specifications, type 10BASE5.....	179
8.8.1	Overview.....	179
8.8.2	Abbreviations and special symbols.....	179
8.8.2.1	Status symbols	179
8.8.2.2	Abbreviations.....	179
8.8.3	Instructions for completing the PICS proforma.....	179
8.8.3.1	General structure of the PICS proforma	179
8.8.3.2	Additional information	180
8.8.3.3	Exception information	180
8.8.3.4	Conditional items	180
8.8.4	Identification	181
8.8.4.1	Implementation identification.....	181
8.8.4.2	Protocol summary	181
8.8.5	Global statement of conformance	181
8.8.6	PICS proforma tables for MAU.....	182
8.8.6.1	MAU compatibility.....	182
8.8.6.2	Transmit function	182
8.8.6.3	Receive function	183
8.8.6.4	Collision function	184
8.8.6.5	Monitor function	184
8.8.6.6	Jabber function	185
8.8.6.7	MAU to coaxial cable interface	186
8.8.6.8	MAU electrical characteristics	187
8.8.6.9	MAU-DTE requirements	187
8.8.6.10	MAU to coaxial cable connection	188
8.8.6.11	Safety requirements	188
8.8.7	PICS proforma tables for MAU AUI characteristics.....	189
8.8.7.1	Signal characteristics	189
8.8.7.2	DI and CI driver characteristics	189
8.8.7.3	DO receiver characteristics	190
8.8.7.4	CO receiver characteristics	191
8.8.7.5	Circuit termination.....	191
8.8.7.6	Mechanical characteristics	192
8.8.8	PICS proforma tables for 10BASE5 coaxial cable.....	193
8.8.8.1	10BASE5 coaxial cable characteristics	193
9.	Repeater unit for 10 Mb/s baseband networks.....	195
9.1	Overview.....	195

9.2	References.....	196
9.3	Definitions	196
9.4	Compatibility interface	196
9.4.1	AUI compatibility	196
9.4.2	Mixing segment compatibility	196
9.4.2.1	Direct coaxial cable attachment compatibility.....	196
9.4.2.2	“N” connector compatibility	196
9.4.2.3	BNC compatibility	196
9.4.2.4	BFOC/2.5 (10BASE-FP) compatibility	196
9.4.3	Link segment compatibility	197
9.4.3.1	Vendor-dependent IRL	197
9.4.3.2	Fiber optic FOIRL compatibility	197
9.4.3.3	Twisted-pair jack compatibility	197
9.4.3.4	Fiber optic 10BASE-FB and 10BASE-FL compatibility	197
9.5	Basic functions.....	197
9.5.1	Repeater set network properties.....	197
9.5.2	Signal amplification.....	197
9.5.3	Signal symmetry	197
9.5.4	Signal retiming.....	198
9.5.5	Data handling.....	198
9.5.5.1	Start-of-packet propagation delays	198
9.5.5.2	Start-of-packet variability	198
9.5.6	Collision handling.....	199
9.5.6.1	Collision presence.....	199
9.5.6.2	Jam generation	199
9.5.6.3	Collision-jam propagation delays	199
9.5.6.4	Transmit recovery time	200
9.5.6.5	Carrier recovery time	200
9.5.7	Electrical isolation	200
9.6	Detailed repeater functions and state diagrams	201
9.6.1	State diagram notation	201
9.6.2	Data and collision handling	204
9.6.3	Preamble regeneration	204
9.6.4	Fragment extension.....	204
9.6.5	MAU Jabber Lockup Protection	205
9.6.6	Auto-Partitioning/Reconnection (optional)	205
9.6.6.1	Overview.....	205
9.6.6.2	Detailed auto-partition/reconnection algorithm state diagram	205
9.7	Electrical isolation	208
9.7.1	Environment A requirements.....	208
9.7.2	Environment B requirements	208
9.8	Reliability.....	208
9.9	Medium attachment unit and baseband medium specification for a vendor-independent FOIRL	209
9.9.1	Scope.....	209
9.9.1.1	Overview.....	209
9.9.1.2	Application perspective: FOMAU and medium objectives.....	211
9.9.1.3	Compatibility considerations	211
9.9.1.4	Relationship to AUI.....	211
9.9.1.5	Mode of operation.....	211
9.9.2	FOMAU functional specifications.....	211
9.9.2.1	Transmit function requirements.....	212
9.9.2.2	Receive function requirements	213
9.9.2.3	Collision Presence function requirements	213

9.9.2.4	Jabber function requirements.....	214
9.9.2.5	Low Light Level Detection function requirements.....	214
9.9.2.6	Repeater Unit to FOMAU Physical Layer messages.....	215
9.9.2.7	FOMAU Physical Layer to repeater unit messages.....	215
9.9.2.7.1	input message.....	215
9.9.2.7.2	input_idle message.....	215
9.9.2.7.3	fomau_available message	215
9.9.2.7.4	signal_quality_error message	215
9.9.2.8	FOMAU state diagrams	216
9.9.3	FOMAU electrical characteristics	217
9.9.3.1	Electrical isolation	217
9.9.3.2	Power consumption.....	217
9.9.3.3	Reliability.....	218
9.9.3.4	FOMAU/Repeater unit electrical characteristics	218
9.9.3.5	FOMAU/Repeater unit mechanical connection.....	218
9.9.4	FOMAU/Optical medium interface	218
9.9.4.1	Transmit optical parameters.....	218
9.9.4.1.1	Wavelength	218
9.9.4.1.2	Spectral width	218
9.9.4.1.3	Optical modulation	218
9.9.4.1.4	Optical idle signal	218
9.9.4.1.5	Transmit optical logic polarity.....	218
9.9.4.1.6	Optical rise and fall times	220
9.9.4.1.7	Transmit optical pulse edge jitter.....	220
9.9.4.1.8	Peak coupled optical power	221
9.9.4.2	Receive optical parameters	221
9.9.4.2.1	Receive peak optical power range	221
9.9.4.2.2	Receive optical pulse edge jitter	221
9.9.4.2.3	Receive optical logic polarity	221
9.9.5	Characteristics of the optical fiber cable link segment	221
9.9.5.1	Optical fiber medium	222
9.9.5.2	Optical medium connector plug and socket.....	222
9.9.6	System requirements.....	222
9.9.6.1	Optical transmission system considerations	222
9.9.6.2	Timing considerations.....	223
9.9.7	Environmental specifications.....	224
9.9.7.1	Safety requirements	224
9.9.7.1.1	Electrical safety.....	224
9.9.7.1.2	Optical source safety.....	224
9.9.7.2	Electromagnetic environment	224
9.9.7.2.1	Susceptibility levels	224
9.9.7.2.2	Emission levels	224
9.9.7.3	Temperature and humidity	225
10.	Medium attachment unit and baseband medium specifications, type 10BASE2	227
10.1	Scope.....	227
10.1.1	Overview.....	227
10.1.1.1	Medium attachment unit (normally contained within the data terminal equipment [DTE]).....	228
10.1.1.2	Repeater unit	228
10.1.2	Definitions	228
10.1.3	Application perspective: MAU and medium objectives.....	228
10.1.3.1	Object.....	228

10.1.3.2	Compatibility considerations	229
10.1.3.3	Relationship to PLS and AUI	229
10.1.3.4	Mode of operation.....	229
10.2	References.....	229
10.3	MAU functional specifications	229
10.3.1	MAU Physical Layer functional requirements	230
10.3.1.1	Transmit function requirements.....	230
10.3.1.2	Receive function requirements	231
10.3.1.3	Collision Presence function requirements	231
10.3.1.4	Jabber functional requirements	232
10.3.2	MAU interface messages	232
10.3.2.1	DTE to MAU messages	232
10.3.2.2	MAU to DTE messages	232
10.3.2.2.1	input message.....	234
10.3.2.2.2	input_idle message.....	234
10.3.2.2.3	mau_available message.....	234
10.3.2.2.4	signal_quality_error (SQE) message	234
10.3.3	MAU state diagrams	234
10.4	MAU–medium electrical characteristics	235
10.4.1	MAU-to-coaxial cable interface	235
10.4.1.1	Input impedance.....	235
10.4.1.2	Bias current	235
10.4.1.3	Coaxial cable signaling levels.....	235
10.4.1.4	Transmit output levels symmetry	237
10.4.1.5	Collision detect thresholds.....	237
10.4.2	MAU electrical characteristics.....	237
10.4.2.1	Electrical isolation	237
10.4.2.2	Power consumption.....	237
10.4.2.3	Reliability.....	238
10.4.3	MAU–DTE electrical characteristics.....	238
10.5	Characteristics of coaxial cable system	238
10.5.1	Coaxial cable electrical parameters	238
10.5.1.1	Characteristic impedance	238
10.5.1.2	Attenuation.....	238
10.5.1.3	Velocity of propagation	238
10.5.1.4	Edge jitter; entire segment without DTEs attached	238
10.5.1.5	Transfer impedance.....	239
10.5.1.6	Cable dc loop resistance	239
10.5.2	Coaxial cable physical parameters.....	239
10.5.2.1	Mechanical requirements	239
10.5.2.1.1	General construction	240
10.5.2.1.2	Center conductor.....	240
10.5.2.1.3	Dielectric material.....	240
10.5.2.1.4	Shielding system	240
10.5.2.1.5	Overall jacket.....	240
10.5.2.2	Jacket marking	240
10.5.3	Total segment dc loop resistance	240
10.6	Coaxial trunk cable connectors	241
10.6.1	In-line coaxial extension connector	241
10.6.2	Coaxial cable terminator.....	242
10.6.3	MAU-to-coaxial cable connection.....	242
10.7	System considerations.....	242
10.7.1	Transmission system model.....	242
10.7.2	Transmission system requirements	244

10.7.2.1	Cable sectioning.....	244
10.7.2.2	MAU placement.....	244
10.7.2.3	Trunk cable system earthing	244
10.7.2.4	Static discharge path	244
10.7.2.4.1	Installation environment	244
10.8	Environmental specifications.....	245
10.8.1	Safety requirements	245
10.8.1.1	Installations	245
10.8.1.2	Earthing.....	245
10.8.2	Electromagnetic environment	245
10.8.2.1	Susceptibility levels	245
10.8.2.2	Emission levels	245
10.8.3	Regulatory requirements.....	245
11.	Broadband medium attachment unit and broadband medium specifications, type 10BROAD36	247
11.1	Scope.....	247
11.1.1	Overview.....	247
11.1.2	Definitions	249
11.1.3	MAU and medium objectives	249
11.1.4	Compatibility considerations	250
11.1.5	Relationship to PLS and AUI	250
11.1.6	Mode of operation.....	250
11.2	MAU functional specifications	250
11.2.1	MAU functional requirements	250
11.2.1.1	Transmit function requirements.....	250
11.2.1.2	Receive function requirements	251
11.2.1.3	Collision Detection function requirements	251
11.2.1.3.1	Collision enforcement transmitter requirements.....	252
11.2.1.3.2	Collision enforcement detection requirements	252
11.2.1.4	Jabber function requirements.....	252
11.2.2	DTE PLS to MAU and MAU to DTE PLS messages	253
11.2.2.1	DTE Physical Layer to MAU Physical Layer messages	253
11.2.2.2	MAU Physical Layer to DTE Physical Layer messages	253
11.2.2.2.1	input message.....	253
11.2.2.2.2	input_idle message.....	253
11.2.2.2.3	mau_available message.....	253
11.2.2.3	signal_quality_error message	253
11.2.3	MAU state diagrams	254
11.2.3.1	MAU state diagram messages.....	254
11.2.3.2	MAU state diagram signal names	254
11.3	MAU characteristics	257
11.3.1	MAU-to-coaxial cable interface	257
11.3.1.1	Receive interface.....	257
11.3.1.1.1	Receive input impedance	257
11.3.1.1.2	Receiver squelch requirements	257
11.3.1.1.3	Receive level requirements.....	258
11.3.1.1.4	Receiver selectivity and linearity requirements.....	258
11.3.1.1.5	Receive input mechanical requirements	258
11.3.1.2	Transmit interface	258
11.3.1.2.1	Transmit output impedance	258
11.3.1.2.2	Transmitted RF packet format	258
11.3.1.2.3	Transmit spectrum and group delay characteristics.....	259
11.3.1.2.4	Transmit out-of-band spectrum	261

11.3.1.2.5	Transmit level requirements	261
11.3.1.2.6	Nontransmitting signal leakage requirement	261
11.3.1.2.7	Transmit spurious output requirement	261
11.3.1.2.8	Collision enforcement signal leakage requirement.....	262
11.3.1.2.9	Transmit output mechanical requirements.....	262
11.3.2	MAU frequency allocations.....	262
11.3.2.1	Single-cable systems frequency allocations	262
11.3.2.2	Dual-cable systems frequency allocations	263
11.3.3	AUI electrical characteristics.....	263
11.3.3.1	Electrical isolation requirements	263
11.3.3.2	Current consumption.....	263
11.3.3.3	Driver and receiver requirements	264
11.3.3.4	AUI mechanical connection.....	264
11.3.4	MAU transfer characteristics	264
11.3.4.1	AUI to coaxial cable framing characteristics.....	264
11.3.4.1.1	Scrambler and differential encoding requirements.....	265
11.3.4.2	Coaxial cable to AUI framing characteristics.....	266
11.3.4.3	Circuit DO to circuit DI framing characteristics	267
11.3.4.4	AUI to coaxial cable delay characteristics.....	267
11.3.4.4.1	Circuit DO to RF data signal delay.....	267
11.3.4.4.2	Circuit DO to CE RF output delay.....	267
11.3.4.4.3	Transmit postamble to SQE test signal delay	267
11.3.4.4.4	SQE test signal length.....	267
11.3.4.5	Coaxial cable to AUI delay characteristics.....	267
11.3.4.5.1	Received RF to circuit DI delay	268
11.3.4.5.2	Received RF to CE RF output and circuit CI delay.....	268
11.3.4.5.3	Collision enforcement to circuit CI delay.....	268
11.3.4.5.4	Receive data to SQE test delay	268
11.3.4.6	Delay from circuit DO to circuit DI.....	269
11.3.4.7	Interpacket gap requirement	270
11.3.4.8	Bit error ratio	270
11.3.5	Reliability.....	270
11.4	System considerations.....	271
11.4.1	Delay budget and network diameter	271
11.4.2	MAU operation with packets shorter than 512 bits	271
11.5	Characteristics of the coaxial cable system	272
11.5.1	Electrical requirements	272
11.5.2	Mechanical requirements	272
11.5.3	Delay requirements	272
11.6	Frequency translator requirements for the single-cable version	273
11.6.1	Electrical requirements	273
11.6.2	Mechanical requirements	273
11.7	Environmental specifications.....	273
11.7.1	Safety requirements	273
11.7.2	Electromagnetic environment	274
11.7.2.1	Susceptibility levels	274
11.7.2.2	Emission levels	274
11.7.3	Temperature and humidity.....	274
12.	Physical signaling, medium attachment, and baseband medium specifications, type 1BASE5	275
12.1	Introduction.....	275
12.1.1	Overview.....	275

12.1.2	Scope.....	275
12.1.3	Definitions	275
12.1.4	General characteristics	275
12.1.5	Compatibility	276
12.1.6	Objectives of type 1BASE5 specification	276
12.2	Architecture	276
12.2.1	Major concepts.....	276
12.2.2	Application perspective	277
12.2.3	Packet structure.....	277
12.2.3.1	Silence.....	278
12.2.3.2	Preamble	278
12.2.3.3	Start-of-frame delimiter	279
12.2.3.4	Data.....	279
12.2.3.5	End-of-transmission delimiter	279
12.3	DTE physical signaling (PLS) specification.....	280
12.3.1	Overview.....	280
12.3.1.1	Summary of major concepts	280
12.3.1.2	Application perspective	280
12.3.2	Functional specification	281
12.3.2.1	PLS-PMA interface.....	281
12.3.2.1.1	output message.....	281
12.3.2.1.2	output_idle message.....	281
12.3.2.1.3	input message.....	281
12.3.2.1.4	input_idle message.....	281
12.3.2.2	PLS-MAC interface	282
12.3.2.2.1	OUTPUT_UNIT	282
12.3.2.2.2	OUTPUT_STATUS.....	282
12.3.2.2.3	INPUT_UNIT	282
12.3.2.2.4	CARRIER_STATUS	282
12.3.2.2.5	SIGNAL_STATUS.....	282
12.3.2.3	PLS functions.....	283
12.3.2.3.1	State diagram variables	283
12.3.2.3.2	Output function	283
12.3.2.3.3	Input function.....	284
12.3.2.3.4	Error Sense function	284
12.3.2.3.5	Carrier Sense function	285
12.3.2.4	Signal encoding.....	285
12.3.2.4.1	Data transmission rate.....	285
12.3.2.4.2	Data symbol encoding	285
12.3.2.4.3	Collision presence encoding	285
12.3.2.4.4	Idle line encoding.....	286
12.4	Hub specification	287
12.4.1	Overview.....	287
12.4.1.1	Summary of major concepts	288
12.4.1.2	Application perspective	288
12.4.2	Hub structure.....	288
12.4.2.1	Upward side	288
12.4.2.2	Downward side	288
12.4.3	Hub PLS functional specification	289
12.4.3.1	Hub PLS to PMA interface	289
12.4.3.2	Hub PLS functions.....	289
12.4.3.2.1	State diagram variables	289
12.4.3.2.2	Upward Signal Transfer function	290
12.4.3.2.3	Jabber function.....	290

12.4.3.2.4	Downward Signal Transfer function.....	291
12.4.3.2.5	Retiming (jitter removal)	293
12.4.3.2.6	Header hub wrap-around	293
12.4.3.2.7	Collision presence startup.....	293
12.4.3.3	Reliability.....	294
12.5	Physical medium attachment (PMA) specification	294
12.5.1	Overview.....	294
12.5.2	PLS–PMA interface.....	294
12.5.3	Signal characteristics	295
12.5.3.1	Transmitter characteristics	295
12.5.3.1.1	Differential output voltage.....	295
12.5.3.1.2	Output timing jitter	298
12.5.3.1.3	Transmitter impedance balance	298
12.5.3.1.4	Common-mode output voltage	299
12.5.3.1.5	Common-mode tolerance.....	299
12.5.3.1.6	Transmitter fault tolerance.....	300
12.5.3.2	Receiver characteristics	300
12.5.3.2.1	Differential input voltage.....	300
12.5.3.2.2	Input timing jitter	300
12.5.3.2.3	Idle input behavior	300
12.5.3.2.4	Differential input impedance	301
12.5.3.2.5	Common-mode rejection	301
12.5.3.2.6	Noise immunity.....	302
12.5.3.2.7	Receiver fault tolerance	302
12.6	Medium Dependent Interface (MDI) specification	302
12.6.1	Line interface connector	302
12.6.2	Connector contact assignments.....	303
12.6.3	Labeling	303
12.7	Cable medium characteristics	304
12.7.1	Overview.....	304
12.7.2	Transmission parameters	304
12.7.2.1	Attenuation.....	304
12.7.2.2	Differential characteristic impedance	304
12.7.2.3	Medium timing jitter	304
12.7.2.4	Dispersion	305
12.7.3	Coupling parameters	305
12.7.3.1	Pair-to-pair crosstalk.....	305
12.7.3.2	Multiple-disturber crosstalk.....	305
12.7.3.3	Balance.....	306
12.7.4	Noise environment.....	306
12.7.4.1	Impulse noise	306
12.7.4.2	Crosstalk	307
12.8	Special link specification	307
12.8.1	Overview.....	307
12.8.2	Transmission characteristics	307
12.8.3	Permitted configurations.....	307
12.9	Timing.....	307
12.9.1	Overview.....	307
12.9.2	DTE timing	308
12.9.3	Medium timing	308
12.9.4	Special link timing	308
12.9.5	Hub timing	308
12.10	Safety	309
12.10.1	Isolation	309

12.10.2	Telephony voltages	310
13.	System considerations for multisegment 10 Mb/s baseband networks	311
13.1	Overview	311
13.1.1	Repeater usage	312
13.2	Definitions	312
13.3	Transmission System Model 1	312
13.4	Transmission System Model 2	319
13.4.1	Round-trip collision delay	319
13.4.1.1	Worst-case path delay value (PDV) selection	319
13.4.1.2	Worst-case PDV calculation	319
13.4.2	Interpacket gap (IPG) shrinkage	320
13.4.2.1	Worst-case path variability value (PVV) selection.....	321
13.4.2.2	Worst-case path variability value (PVV) calculation	321
13.5	Full duplex topology limitations	321
14.	Twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T including type 10BASE-Te	323
14.1	Scope.....	323
14.1.1	Overview.....	323
14.1.1.1	Medium Attachment Unit (MAU)	323
14.1.1.2	Repeater unit	324
14.1.1.3	Twisted-pair media	324
14.1.2	Definitions	324
14.1.3	Application perspective	325
14.1.3.1	Objectives	325
14.1.3.2	Compatibility considerations	326
14.1.3.3	Modes of operation	326
14.1.4	Relationship to PLS and AUI	326
14.2	MAU functional specifications	326
14.2.1	MAU functions	327
14.2.1.1	Transmit function requirements.....	328
14.2.1.2	Receive function requirements	328
14.2.1.3	Loopback function requirements (half duplex mode only)	329
14.2.1.4	Collision Presence function requirements (half duplex mode only).....	329
14.2.1.5	signal_quality_error Message (SQE) Test function requirements.....	329
14.2.1.6	Jabber function requirements.....	329
14.2.1.7	Link Integrity Test function requirements	330
14.2.1.8	Auto-Negotiation	331
14.2.2	PMA interface messages.....	331
14.2.2.1	PLS to PMA messages.....	331
14.2.2.1.1	PMA to PLS messages.....	331
14.2.2.2	PMA to twisted-pair link segment messages.....	332
14.2.2.3	Twisted-pair link segment to PMA messages.....	332
14.2.2.4	Interface message time references	332
14.2.3	MAU state diagrams	332
14.2.3.1	State diagram variables	332
14.2.3.2	State diagram timers	338
14.3	MAU electrical specifications	338
14.3.1	MAU-to-MDI interface characteristics.....	338
14.3.1.1	Isolation requirement	338
14.3.1.2	Transmitter specifications.....	339

14.3.1.2.1	Differential output voltage	340
14.3.1.2.2	Transmitter differential output impedance	343
14.3.1.2.3	Output timing jitter	344
14.3.1.2.4	Transmitter impedance balance	344
14.3.1.2.5	Common-mode output voltage	344
14.3.1.2.6	Transmitter common-mode rejection.....	345
14.3.1.2.7	Transmitter fault tolerance.....	345
14.3.1.3	Receiver specifications	346
14.3.1.3.1	Receiver differential input signals	346
14.3.1.3.2	Receiver differential noise immunity	346
14.3.1.3.3	Idle input behavior	347
14.3.1.3.4	Receiver differential input impedance.....	347
14.3.1.3.5	Common-mode rejection	347
14.3.1.3.6	Receiver fault tolerance	347
14.3.2	MAU-to-AUI specification.....	347
14.3.2.1	MAU-AUI electrical characteristics	347
14.3.2.2	MAU-AUI mechanical connection	348
14.3.2.3	Power consumption.....	348
14.4	Characteristics of the simplex link segment	349
14.4.1	Overview.....	349
14.4.2	Transmission parameters	349
14.4.2.1	Insertion loss	349
14.4.2.2	Differential characteristic impedance	349
14.4.2.3	Medium timing jitter.....	349
14.4.2.4	Delay	350
14.4.3	Coupling parameters	350
14.4.3.1	Differential near-end crosstalk (NEXT) loss	350
14.4.3.1.1	Twenty-five-pair cable and twenty-five-pair binder groups.....	350
14.4.3.1.2	Four-pair cable.....	350
14.4.3.1.3	Other cables	350
14.4.3.2	Multiple-disturber NEXT (MDNEXT) loss	350
14.4.4	Noise environment.....	351
14.4.4.1	Impulse noise	351
14.4.4.2	Crosstalk noise.....	351
14.5	MDI specification	351
14.5.1	MDI connectors	351
14.5.2	Crossover function.....	352
14.6	System considerations.....	353
14.7	Environmental specifications.....	354
14.7.1	General safety	354
14.7.2	Network safety	354
14.7.2.1	Installation	354
14.7.2.2	Grounding	354
14.7.2.3	Installation and maintenance guidelines	354
14.7.2.4	Telephony voltages	354
14.7.3	Environment.....	355
14.7.3.1	Electromagnetic emission	355
14.7.3.2	Temperature and humidity	355
14.8	MAU labeling	355
14.9	Timing summary.....	356
14.10	Protocol implementation conformance statement (PICS) proforma for Clause 14, Twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T and type 10BASE-Te	357
14.10.1	Introduction.....	357

14.10.1.1	Scope.....	357
14.10.1.2	Reference	357
14.10.1.3	Definitions	357
14.10.1.4	Conformance.....	357
14.10.2	Identification of implementation	358
14.10.2.1	Supplier information	358
14.10.2.2	Implementation information	358
14.10.3	Identification of the protocol	358
14.10.4	PICS proforma for 10BASE-T	359
14.10.4.1	Abbreviations.....	359
14.10.4.2	PICS Completion instructions and implementation statement	359
14.10.4.3	Additional information	359
14.10.4.4	References.....	359
14.10.4.5	PICS proforma tables for MAU.....	360
14.10.4.5.1	MAU functions	360
14.10.4.5.2	Transmit function.....	361
14.10.4.5.3	Receive function	361
14.10.4.5.4	Loopback function	362
14.10.4.5.5	Collision Detect function	362
14.10.4.5.6	signal_quality_error Message Test function.....	363
14.10.4.5.7	Jabber function.....	363
14.10.4.5.8	Link Integrity Test function.....	364
14.10.4.5.9	MAU state diagram requirements.....	365
14.10.4.5.10	AUI requirements	365
14.10.4.5.11	Isolation requirements.....	365
14.10.4.5.12	Transmitter specification	366
14.10.4.5.13	Receiver specification.....	367
14.10.4.5.14	MDI requirements.....	368
14.10.4.5.15	Safety requirements	368
14.10.4.6	PICS proforma tables for MAU AUI characteristics.....	369
14.10.4.6.1	Signal characteristics	369
14.10.4.6.2	DI and CI driver characteristics	369
14.10.4.6.3	DO receiver characteristics.....	370
14.10.4.6.4	Power consumption.....	370
14.10.4.6.5	Circuit termination.....	371
14.10.4.6.6	Mechanical characteristics.....	371
14.10.4.7	PICS proforma tables for 10BASE-T link segment.....	372
14.10.4.7.1	10BASE-T link segment characteristics	372
14.10.4.8	PICS proforma tables for Auto-Negotiation able MAUs	373
15.	Fiber optic medium and common elements of medium attachment units and star, type 10BASE-F.....	375
15.1	Scope.....	375
15.1.1	Overview.....	375
15.1.1.1	Fiber optic medium attachment units (MAUs).....	375
15.1.1.2	Fiber optic passive star	375
15.1.1.3	Repeater unit	376
15.1.2	Definitions	377
15.1.3	Applications perspective: MAUs, stars, and fiber optic medium	377
15.1.3.1	Objectives	377
15.1.3.2	Compatibility considerations	377
15.1.3.3	Relationship to PLS and AUI	378
15.1.3.4	Guidelines for implementation of systems	379

15.1.3.5	Modes of operation	379
15.2	MDI optical characteristics	380
15.2.1	Transmit optical parameters.....	380
15.2.1.1	Center wavelength	380
15.2.1.2	Spectral width	380
15.2.1.3	Optical modulation extinction ratio	380
15.2.1.4	Optical Idle Signal amplitude	380
15.2.1.5	Optical transmit pulse logic polarity.....	380
15.2.1.6	Optical transmit pulse rise and fall times.....	380
15.2.1.7	Optical transmit pulse overshoot and undershoot.....	380
15.2.1.8	Optical transmit pulse edge jitter	380
15.2.1.9	Optical transmit pulse duty cycle distortion	382
15.2.1.10	Optical transmit average power range	382
15.2.1.11	Optical transmit signal templates.....	382
15.2.1.11.1	10BASE-FP optical transmit signal template	383
15.2.1.11.2	10BASE-FB optical transmit signal template.....	384
15.2.1.11.3	10BASE-FL Optical transmit signal template	386
15.2.2	Receive optical parameters	387
15.2.2.1	Optical receive average power range.....	387
15.2.2.2	Optical receive pulse edge jitter.....	387
15.2.2.3	Optical receive pulse logic polarity	388
15.2.2.4	Optical receive pulse rise and fall times	388
15.3	Characteristics of the fiber optic medium.....	388
15.3.1	Optical fiber and cable	388
15.3.1.1	Attenuation.....	388
15.3.1.2	Modal bandwidth	388
15.3.1.3	Propagation delay	388
15.3.2	Optical medium connector plug and socket.....	389
15.3.2.1	Optical connector insertion loss.....	389
15.3.2.2	Optical connector return loss	389
15.3.3	Fiber optic medium insertion loss.....	390
15.3.3.1	10BASE-FP segment insertion loss	390
15.3.3.2	10BASE-FB and 10BASE-FL segment insertion loss	390
15.3.4	Electrical isolation	390
15.4	MAU reliability.....	390
15.5	MAU–AUI specification.....	390
15.5.1	MAU–AUI electrical characteristics	390
15.5.2	MAU–AUI mechanical connections.....	391
15.5.3	Power consumption.....	391
15.5.4	MAU–AUI messages	391
15.5.4.1	PLS to PMA messages.....	391
15.5.4.2	PMA to PLS messages.....	391
15.5.4.2.1	signal_quality_error message	391
15.6	Environmental specifications.....	392
15.6.1	Safety requirements	392
15.6.2	Electromagnetic environment	392
15.6.3	Other environmental requirements	393
15.7	MAU labeling	393
15.7.1	10BASE-FP star labeling.....	393
15.8	Protocol implementation conformance statement (PICS) proforma for Clause 15, Fiber optic medium and common elements of medium attachment units and star, type 10BASE-F.....	394
15.8.1	Introduction.....	394
15.8.2	Abbreviations and special symbols.....	394

15.8.2.1	Status symbols	394
15.8.2.2	Abbreviations.....	394
15.8.3	Instructions for completing the pics proforma.....	394
15.8.3.1	General structure of the PICS proforma	394
15.8.3.2	Additional information	395
15.8.3.3	Exception information	395
15.8.3.4	Conditional items	396
15.8.4	Identification	396
15.8.4.1	Implementation identification.....	396
15.8.4.2	Protocol summary	396
15.8.5	Major capabilities/options.....	397
15.8.6	PICS Proforma for the fiber optic medium.....	397
15.8.6.1	Characteristics of the fiber optic medium.....	397
15.8.6.2	Optical medium connector plug and socket.....	398
15.8.6.3	Fiber optic medium insertion loss.....	398
15.8.6.4	Electrical isolation requirements	398
16.	Fiber optic passive star and medium attachment unit, type 10BASE-FP	399
16.1	Scope.....	399
16.1.1	Overview.....	399
16.1.1.1	10BASE-FP medium attachment unit.....	399
16.1.1.2	10BASE-FP Star	399
16.1.1.3	Repeater unit	399
16.2	PMA interface messages.....	400
16.2.1	PMA-to-MDI interface signal encodings	400
16.2.2	PMA-to-MDI OTD messages	400
16.2.2.1	OTD_output	400
16.2.2.2	OTD_idle	400
16.2.2.3	OTD_manach_violation.....	401
16.2.3	MDI ORD-to-PMA messages.....	401
16.2.3.1	ORD_input.....	401
16.2.3.2	ORD_idle	402
16.2.3.3	ORD_crv.....	402
16.3	10BASE-FP MAU functional specifications	402
16.3.1	Transmit function requirements	402
16.3.1.1	Preamble encoding.....	403
16.3.1.1.1	Synchronization pattern	403
16.3.1.1.2	Packet header code rule violation	403
16.3.1.1.3	Unique word	403
16.3.1.2	Data transmit.....	403
16.3.1.3	Collision encoding (unique word jam)	404
16.3.2	Receive function requirements	404
16.3.2.1	Preamble reconstruction and alignment.....	404
16.3.2.2	Data receive	404
16.3.2.3	Signal presence during collision	404
16.3.3	Loopback function requirements	404
16.3.4	Collision presence function requirements.....	405
16.3.4.1	CI Circuit signaling.....	405
16.3.4.2	Collision detection	405
16.3.4.3	End of collision.....	406
16.3.5	signal_quality_error Message (SQE) Test function requirements.....	406
16.3.6	Jabber function requirements.....	406
16.3.7	Link fault detection and low light function requirements.....	407

16.3.8	Interface message time references	408
16.3.9	MAU state diagram.....	408
16.3.9.1	MAU state diagram variables	408
16.3.9.2	MAU state diagram timers.....	410
16.3.9.3	MAU state diagram counters	411
16.4	Timing summary.....	416
16.5	10BASE-FP Star functional specifications.....	416
16.5.1	Star functions	416
16.5.1.1	Number of ports	416
16.5.1.2	Optical power division.....	416
16.5.1.3	Configuration	417
16.5.1.4	Reliability.....	417
16.5.2	Star optical characteristics	417
16.5.2.1	Star insertion loss.....	417
16.5.2.2	Star single output port uniformity.....	417
16.5.2.3	Star directivity.....	417
16.6	Protocol implementation conformance statement (PICS) proforma for Clause 16, Fiber optic passive star and medium attachment unit, type 10BASE-FP	418
16.6.1	Introduction.....	418
16.6.2	Abbreviations and special symbols.....	418
16.6.2.1	Status symbols	418
16.6.2.2	Abbreviations.....	418
16.6.3	Instructions for completing the PICS proforma.....	418
16.6.3.1	General structure of the PICS proforma	418
16.6.3.2	Additional information	419
16.6.3.3	Exception information	419
16.6.3.4	Conditional items	420
16.6.4	Identification.....	420
16.6.4.1	Implementation identification.....	420
16.6.4.2	Protocol summary	420
16.6.5	Major capabilities/options.....	421
16.6.6	PICS proforma for the type 10BASE-FP MAU	421
16.6.6.1	Compatibility considerations	421
16.6.6.2	Optical transmit parameters.....	422
16.6.6.3	Optical receive parameters.....	423
16.6.6.4	Optical medium connector plug and socket.....	423
16.6.6.5	MAU functions	423
16.6.6.6	PMA interface messages.....	423
16.6.6.7	PMA to MDI OTD messages.....	424
16.6.6.8	MDI ORD to PMA messages	424
16.6.6.9	Transmit functions	424
16.6.6.10	Collision Encoding (Unique Word Jam) function	425
16.6.6.11	Receive functions.....	425
16.6.6.12	Preamble reconstruction and alignment function	426
16.6.6.13	Data receive function	426
16.6.6.14	Signal presence during collision.....	426
16.6.6.15	Loopback function	427
16.6.6.16	Collision presence function	427
16.6.6.17	signal_quality_error Message (SQE) test function.....	428
16.6.6.18	Jabber function.....	428
16.6.6.19	Link Fault Detect function.....	428
16.6.6.20	MAU state diagram requirements	429
16.6.6.21	MAU-to-AUI signal characteristics.....	429
16.6.6.22	MAU-to-AUI DI and CI driver characteristics	429

16.6.6.23	AUI-to-MAU DO receiver characteristics.....	430
16.6.6.24	MAU-to-AUI circuit termination.....	430
16.6.6.25	MAU-to-AUI mechanical connections.....	431
16.6.6.26	MAU reliability.....	431
16.6.6.27	Power consumption.....	432
16.6.6.28	PLS-PMA requirements.....	432
16.6.6.29	signal_quality_error message (SQE).....	432
16.6.6.30	Environmental requirements.....	433
16.6.6.31	MAU labeling.....	433
16.6.7	PICS proforma tables for 10BASE-FP stars.....	433
16.6.7.1	Star basic functions.....	433
16.6.7.2	Star optical characteristics.....	434
16.6.7.3	Star environmental requirements.....	434
16.6.7.4	10BASE-FP star labeling.....	434
17.	Fiber optic medium attachment unit, type 10BASE-FB.....	435
17.1	Scope.....	435
17.1.1	Overview.....	435
17.1.1.1	Medium attachment unit.....	435
17.1.1.2	Relationship to repeater.....	435
17.1.1.3	Remote diagnostic messages.....	435
17.1.2	Relationship to AUI.....	435
17.2	PMA interface messages.....	436
17.2.1	PMA-to-MDI interface signal encodings.....	436
17.2.2	PMA-to-MDI OTD messages.....	436
17.2.2.1	OTD_output.....	437
17.2.2.2	OTD_sync_idle.....	437
17.2.2.3	OTD_remote_fault.....	437
17.2.3	MDI ORD-to-PMA messages.....	437
17.2.3.1	Status decoding.....	437
17.2.3.2	ORD_input.....	437
17.2.3.3	ORD_sync_idle.....	437
17.2.3.4	ORD_remote_fault.....	438
17.2.3.5	ORD_invalid_data.....	438
17.2.4	Transitions between signals.....	438
17.2.5	Signaling rate.....	438
17.3	MAU functional specifications.....	438
17.3.1	Transmit function requirements.....	438
17.3.1.1	Data transmit.....	439
17.3.1.2	Synchronous idle.....	439
17.3.1.3	Fault signaling.....	439
17.3.2	Receive function requirements.....	439
17.3.2.1	Data receive.....	439
17.3.2.2	Remote status message handling.....	439
17.3.3	Collision function requirements.....	439
17.3.3.1	Collision detection.....	439
17.3.3.2	End of collision.....	440
17.3.4	Loopback function requirements.....	440
17.3.5	Fault-handling function requirements.....	440
17.3.6	Jabber function requirements.....	440
17.3.7	Low light level detection function requirements.....	441
17.3.8	Synchronous qualification function requirements.....	441
17.3.9	Interface message time references.....	442

17.3.10	MAU state diagrams	442
17.3.10.1	MAU state diagram variables	442
17.3.10.2	MAU state diagram timers	443
17.4	Timing summary	446
17.5	Protocol implementation conformance statement (PICS) proforma for Clause 17, Fiber optical medium attachment unit, type 10BASE-FB	447
17.5.1	Introduction	447
17.5.2	Abbreviations and special symbols	447
17.5.2.1	Status symbols	447
17.5.2.1.1	Abbreviations	447
17.5.3	Instructions for completing the PICS proforma	447
17.5.3.1	General structure of the PICS proforma	447
17.5.3.2	Additional information	448
17.5.3.3	Exception information	448
17.5.3.4	Conditional items	449
17.5.4	Identification	449
17.5.4.1	Implementation identification	449
17.5.4.2	Protocol summary	449
17.5.5	PICS proforma for the type 10BASE-FB MAU	449
17.5.6	PICS proforma for the type 10BASE-FB MAU	450
17.5.6.1	Compatibility considerations	450
17.5.6.2	Optical transmit parameters	450
17.5.6.3	Optical receive parameters	451
17.5.6.4	Optical medium connector plug and socket	451
17.5.6.5	MAU functions	452
17.5.6.6	PMA-to-MDI OTD messages and signaling	452
17.5.6.7	MDI ORD-to-PMA messages and signaling	453
17.5.6.8	Transitions between signals	453
17.5.6.9	Signaling rate	453
17.5.6.10	Transmit functions	454
17.5.6.11	Receive functions	454
17.5.6.12	Data receive function	455
17.5.6.13	Remote status message handling	455
17.5.6.14	Collision function requirements	455
17.5.6.15	End of collision	456
17.5.6.16	Loopback function	456
17.5.6.17	Fault-handling function	456
17.5.6.18	Jabber-handling function	457
17.5.6.19	Low light detection	457
17.5.6.20	Synchronous qualification	458
17.5.6.21	MAU state diagram requirements	458
17.5.6.22	MAU reliability	458
17.5.6.23	PLS–PMA requirements	459
17.5.6.24	signal_quality_error message (SQE)	459
17.5.6.25	Environmental requirements	459
17.5.6.26	MAU labeling	459
18.	Fiber optic medium attachment unit, type 10BASE-FL	461
18.1	Scope	461
18.1.1	Overview	461
18.1.1.1	10BASE-FL medium attachment unit (MAU)	461
18.1.1.2	Repeater unit	461
18.2	PMA interface messages	461

18.2.1	PMA to fiber optic link segment messages	462
18.2.1.1	OTD_output	462
18.2.1.2	OTD_idle	462
18.2.2	Fiber optic link segment to PMA messages.....	462
18.2.2.1	ORD_input.....	462
18.2.2.2	ORD_idle	462
18.2.3	Interface message time references	463
18.3	MAU functional specifications	463
18.3.1	MAU functions	463
18.3.1.1	Transmit function requirements	464
18.3.1.2	Receive function requirements	465
18.3.1.3	Loopback function requirements (half duplex mode only)	465
18.3.1.4	Collision Presence function requirements (half duplex mode only).....	465
18.3.1.5	signal_quality_error Message (SQE) Test function requirements.....	466
18.3.1.6	Jabber function requirements.....	466
18.3.1.7	Link Integrity Test function requirements	466
18.3.1.8	Auto-Negotiation	467
18.3.2	MAU state diagrams	467
18.3.2.1	MAU state diagram variables	467
18.3.2.2	MAU state diagram timers.....	469
18.4	Timing summary	474
18.5	Protocol implementation conformance statement (PICS) proforma for Clause 18, Fiber optical medium attachment unit, type 10BASE-FL	475
18.5.1	Introduction.....	475
18.5.2	Abbreviations and special symbols.....	475
18.5.2.1	Status symbols	475
18.5.2.2	Abbreviations.....	475
18.5.3	Instructions for completing the PICS proforma.....	476
18.5.3.1	General structure of the PICS proforma	476
18.5.3.2	Additional information	476
18.5.3.3	Exception information	476
18.5.3.4	Conditional items	477
18.5.4	Identification	477
18.5.4.1	Implementation identification.....	477
18.5.4.2	Protocol summary	477
18.5.5	Major capabilities/options.....	478
18.5.6	PICS proforma tables for the type 10BASE-FL MAU.....	478
18.5.6.1	Compatibility considerations	478
18.5.6.2	Optical transmit parameter	479
18.5.6.3	Optical receive parameters	480
18.5.6.4	Optical medium connector plug and socket.....	480
18.5.6.5	MAU functions	481
18.5.6.6	PMA interface messages.....	481
18.5.6.7	PMA-to-MDI OTD messages.....	481
18.5.6.8	MDI ORD-to-PMA messages.....	481
18.5.6.9	Transmit function	482
18.5.6.10	Receive function	482
18.5.6.11	Loopback function	483
18.5.6.12	Collision Presence function	483
18.5.6.13	signal_quality_error Message (SQE) Test function.....	483
18.5.6.14	Jabber function.....	484
18.5.6.15	Link Integrity Test function.....	484
18.5.6.16	MAU state diagram requirements.....	486
18.5.6.17	MAU-to-AUI signal characteristics.....	486

18.5.6.18	MAU-to-AUI DI and CI driver characteristics	487
18.5.6.19	AUI-to-MAU DO receiver characteristics	487
18.5.6.20	AUI circuit termination	488
18.5.6.21	MAU-to-AUI mechanical connections	488
18.5.6.22	MAU reliability	489
18.5.6.23	Power consumption	489
18.5.6.24	PLS–PMA requirements	489
18.5.6.25	signal_quality_error message (SQE)	489
18.5.6.26	Environmental requirements	490
18.5.6.27	MAU labeling	490
19.	Layer Management for 10 Mb/s baseband repeaters	491
19.1	Introduction	491
19.1.1	Scope	491
19.1.2	Relationship to objects in IEEE Std 802.1F-1993	491
19.1.3	Definitions	491
19.1.4	Symbols and abbreviations	491
19.1.5	Management model	492
19.2	Managed objects	493
19.2.1	Introduction	493
19.2.2	Overview of managed objects	493
19.2.2.1	Text description of managed objects	493
19.2.2.2	Port functions to support management	493
19.2.2.3	Containment	495
19.2.2.4	Naming	496
19.2.2.5	Packages and capabilities	496
19.2.3	Repeater managed object class	498
19.2.3.1	Repeater attributes	498
19.2.3.1.1	aRepeaterID	498
19.2.3.1.2	aRepeaterGroupCapacity	498
19.2.3.1.3	aGroupMap	498
19.2.3.1.4	aRepeaterHealthState	498
19.2.3.1.5	aRepeaterHealthText	499
19.2.3.1.6	aRepeaterHealthData	499
19.2.3.1.7	aTransmitCollisions	499
19.2.3.2	Repeater actions	499
19.2.3.2.1	acResetRepeater	499
19.2.3.2.2	acExecuteNonDisruptiveSelfTest	500
19.2.3.3	Repeater notifications	500
19.2.3.3.1	nRepeaterHealth	500
19.2.3.3.2	nRepeaterReset	501
19.2.3.3.3	nGroupMapChange	501
19.2.4	ResourceTypeID Managed Object Class	501
19.2.5	Group managed object class	501
19.2.5.1	Group attributes	501
19.2.5.1.1	aGroupID	501
19.2.5.1.2	aGroupPortCapacity	502
19.2.5.1.3	aPortMap	502
19.2.5.2	Group Notifications	502
19.2.5.2.1	nPortMapChange	502
19.2.6	Port managed object class	502
19.2.6.1	Port Attributes	502
19.2.6.1.1	aPortID	502

19.2.6.1.2	aPortAdminState	503
19.2.6.1.3	aAutoPartitionState	503
19.2.6.1.4	aReadableFrames	503
19.2.6.1.5	aReadableOctets	503
19.2.6.1.6	aFrameCheckSequenceErrors	504
19.2.6.1.7	aAlignmentErrors	504
19.2.6.1.8	aFramesTooLong	504
19.2.6.1.9	aShortEvents	504
19.2.6.1.10	aRunts	505
19.2.6.1.11	aCollisions	505
19.2.6.1.12	aLateEvents	505
19.2.6.1.13	aVeryLongEvents	506
19.2.6.1.14	aDataRateMismatches	506
19.2.6.1.15	aAutoPartitions	506
19.2.6.1.16	aLastSourceAddress	506
19.2.6.1.17	aSourceAddressChanges	507
19.2.6.2	Port Actions	507
19.2.6.2.1	acPortAdminControl	507
20.	Layer Management for 10 Mb/s baseband medium attachment units	509
20.1	Introduction	509
20.1.1	Scope	509
20.1.2	Management model	509
20.2	Managed objects	509
20.2.1	Text description of managed objects	509
20.2.1.1	Naming	509
20.2.1.2	Containment	510
20.2.1.3	Packages	510
20.2.2	MAU Managed object class	511
20.2.2.1	MAU attributes	511
20.2.2.1.1	aMAUID	511
20.2.2.1.2	aMAUType	511
20.2.2.1.3	aMediaAvailable	512
20.2.2.1.4	aLoseMediaCounter	512
20.2.2.1.5	aJabber	512
20.2.2.1.6	aMAUAdminState	513
20.2.2.1.7	aBbMAUXmitRcvSplitType	513
20.2.2.1.8	aBroadbandFrequencies	513
20.2.2.2	MAU actions	514
20.2.2.2.1	acResetMAU	514
20.2.2.2.2	acMAUAdminControl	514
20.2.2.3	MAU notifications	514
20.2.2.3.1	nJabber	514
Annex A	(informative) Bibliography	515
Annex B	(informative) System guidelines	519
B.1	Baseband system guidelines and concepts, 10 Mb/s	519
B.1.1	Overall system objectives	519
B.1.2	Analog system components and parameter values	519
B.1.3	Minimum frame length determination	521
B.1.4	System jitter budgets	522

B.1.4.1	Nominal jitter values.....	522
B.1.4.2	Decoder evaluation	523
B.1.5	Systems consideration calculations	524
B.1.5.1	Overview.....	524
B.1.5.2	Maximum collision fragment size	524
B.1.5.2.1	Left-end base SDV.....	525
B.1.5.2.2	Mid-base SDV	526
B.1.5.2.3	Right-end base SDV	526
B.1.5.3	Interpacket Gap (IPG) shrinkage	527
B.1.5.3.1	Transmitting end segment variability value.....	527
B.1.5.3.2	Mid-segment variability value.....	528
B.1.5.4	Timing parameters for round-trip delay and variability calculations	528
B.1.5.4.1	MAU parameters.....	528
B.1.5.4.2	Repeater parameters.....	529
B.1.5.4.3	Media parameters.....	529
B.1.5.4.4	DTE parameters	529
B.2	System parameters and budgets for 1BASE5	531
B.2.1	Delay budget	531
B.2.2	Minimum frame length determination	532
B.2.3	Jitter budget.....	533
B.3	Example crosstalk computation for multiple disturbers, balanced-pair cable	534
B.4	10BASE-T guidelines	536
B.4.1	System jitter budget	536
B.4.2	Filter characteristics	536
B.4.3	Notes for conformance testing	536
B.4.3.1	Notes for 14.3.1.2.1 on differential output voltage.....	536
B.4.3.2	Note for 14.3.1.2.2 on transmitter differential output impedance	537
B.4.3.3	Note for 14.3.1.2.3 on output timing jitter.....	537
B.4.3.4	General note on common-mode tests.....	538
B.4.3.5	Note for 14.3.1.3.4 on receiver differential input impedance.....	538
B.4.3.6	Note for 14.3.1.3.3 on receiver idle input behavior.....	538
B.4.3.7	Note for 14.3.1.3.5 on receiver common-mode rejection	538
B.5	10BASE-F.....	539
B.5.1	System jitter budget	539
B.5.2	10BASE-FP fiber optic segment loss budget	539
Annex C (informative) State diagram, MAC sublayer		542
Annex D (informative) Application context, selected medium specifications		543
D.1	Introduction.....	543
D.2	Type 10BASE5 applications	543
D.3	Type 10BASE2 applications	543
D.4	Type FOIRL and 10BASE-F applications; alternative fiber optic medium applications	544
D.4.1	Alternative fiber types	544
D.4.1.1	Theoretical coupling losses.....	544
D.4.1.2	Maximum launch power	545
D.4.2	Type 10BASE-FP applications using 50/125 μm fiber	546
D.4.2.1	Coupled transmit power.....	546
D.4.2.2	Star coupler loss.....	546
D.4.2.3	Collision detection	547
D.5	10BASE-T use of cabling systems with a nominal differential characteristic impedance of 120 Ω	547

D.6	10BASE-T use of cabling systems with a nominal differential characteristic impedance of 150 Ω	548
	Annex E (informative) Receiver wavelength design considerations (FOIRL).....	550
	Annex F (normative) Additional attributes required for systems	551
F.1	Introduction	551
F.1.1	Scope.....	551
F.2	Objects/Attributes/Actions/Notifications.....	551
F.2.1	TimeSinceSystemReset attribute	551
F.2.2	RepeaterResetTimeStamp attribute	552
F.2.3	ResetSystemAction action	552
	Annex G (normative) Additional material required for conformance testing	553
G.1	Introduction	553
G.1.1	Material in support of the aDataRateMismatches attribute	553
	Annex H (normative) GDMO specifications for CSMA/CD managed objects	554
	Annex 4A (informative) Simplified full duplex media access control.....	555
4A.1	Functional model of the MAC method	555
4A.1.1	Overview.....	555
4A.1.2	Full duplex operation	556
4A.1.2.1	Transmission.....	556
4A.1.2.2	Reception	556
4A.1.3	Relationships to the MAC client and Physical Layers	557
4A.2	Media access control (MAC) method: precise specification	557
4A.2.1	Introduction.....	557
4A.2.2	Overview of the procedural model	557
4A.2.2.1	Ground rules for the procedural model.....	557
4A.2.2.2	Use of Pascal in the procedural model.....	558
4A.2.2.3	Organization of the procedural model	558
4A.2.2.4	Layer management extensions to procedural model.....	563
4A.2.3	Packet transmission model.....	563
4A.2.3.1	Transmit data encapsulation	563
4A.2.3.2	Transmit media access management.....	563
4A.2.3.2.1	Deference	563
4A.2.3.2.2	Interpacket gap.....	564
4A.2.3.2.3	Transmission.....	564
4A.2.3.2.4	Minimum frame size.....	564
4A.2.4	Frame reception model	564
4A.2.4.1	Receive data decapsulation	564
4A.2.4.1.1	Address recognition	564
4A.2.4.1.2	Frame check sequence validation	565
4A.2.4.1.3	Frame disassembly.....	565
4A.2.4.2	Receive media access management	565
4A.2.5	Preamble generation	565
4A.2.6	Start frame sequence.....	565
4A.2.7	Global declarations	566
4A.2.7.1	Common constants, types, and variables	566
4A.2.7.2	Transmit state variables	567

4A.2.7.3	Receive state variables	567
4A.2.7.4	State variable initialization	567
4A.2.8	Frame transmission	568
4A.2.9	Frame reception	571
4A.2.10	Common procedures	574
4A.3	Interfaces to/from adjacent layers	574
4A.3.1	Overview	574
4A.3.2	MAC service	574
4A.3.2.1	MAC client transmit interface state diagram	574
4A.3.2.1.1	Variables	574
4A.3.2.1.2	Functions	575
4A.3.2.1.3	Messages	575
4A.3.2.1.4	MAC client transmit interface state diagram	575
4A.3.2.2	MAC client receive interface state diagram	575
4A.3.2.2.1	Variables	576
4A.3.2.2.2	Functions	576
4A.3.2.2.3	Messages	576
4A.3.2.2.4	MAC client receive interface state diagram	576
4A.3.3	Services required from the Physical Layer	578
4A.4	Specific implementations	579
4A.4.1	Compatibility overview	579
4A.4.2	MAC parameters	579