



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

**Part 3: Carrier Sense Multiple Access with  
Collision Detection (CSMA/CD) Access Method  
and Physical Layer Specifications**

**Amendment 5: Media Access Control Parameters,  
Physical Layers, and Management Parameters for  
Energy-Efficient Ethernet**

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**IEEE Computer Society**

Sponsored by the  
LAN/MAN Standards Committee

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27 October 2010

**IEEE Std 802.3az™-2010**  
(Amendment to  
IEEE Std 802.3™-2008)

802.3az™



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Energy-Efficient Ethernet**

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

Approved 30 September 2010  
**IEEE SA-Standards Board**

**Abstract:** This amendment to IEEE Std 802.3–2008 specifies changes to several existing physical layers to enable energy-efficient operation of Ethernet. Changes to 10BASE-T include a reduction in transmit voltage requirements. Changes to 100BASE-TX, 1000BASE-T, 10GBASE-T, 1000BASE-KX, 10GBASE-KX4 and 10GBASE-KR include the definition of a Low Power Idle (LPI) mode and mechanisms to communicate and manage the entry and exit into and out of LPI and the operation of this mode. New Link Layer Discovery Protocol (LLDP) TLVs are defined for negotiating system level energy-efficiency parameters.

**Keywords:** 10BASE-T, 100BASE-TX, 1000BASE-KX, 1000BASE-T, 10GBASE-KR, 10GBASE-KX4, 10GBASE-T, Backplane Ethernet, Energy-Efficient Ethernet (EEE), IEEE 802.3az, LLDP, Low Power Idle Mode (LPI), TLV

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## Introduction

This introduction is not part of IEEE Std 802.3az-2010, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient 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 the standard. Each IEEE 802.3 project/amendment is identified with a suffix (e.g., IEEE 802.3az-2010).

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*); and IEEE Std 802.3ah™ specified access network Ethernet (also called *Ethernet in the First Mile*). These major additions are all now included in, and are superseded by, IEEE Std 802.3-2008 and are not maintained as separate documents.

At the time of publication of IEEE Std 802.3az-2010, IEEE Std 802.3 consists of the following documents:

### IEEE Std 802.3-2008

Section One—Includes Clause 1 through Clause 20, 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 74 and Annex 57A through Annex 74A. Clause 56 through Clause 67 and associated annexes specify subscriber access and other Physical Layers and sublayers for operation from 512 kb/s to 1000 Mb/s, and defines services and protocol elements that enable the exchange of IEEE 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.

#### IEEE Std 802.3av™-2009

This amendment includes changes to IEEE Std 802.3-2008 and adds Clause 75 through Clause 77 and Annex 75A through Annex 76A. This amendment adds new Physical Layers for 10 Gb/s operation on point-to-multipoint passive optical networks.

#### IEEE Std 802.3bc™-2009

This amendment includes changes to IEEE Std 802.3-2008 and adds Clause 79. This amendment moves the Ethernet Organizationally Specific Type, Length, Value (TLV) information elements that were specified in IEEE Std 802.1AB™ to IEEE Std 802.3.

#### IEEE Std 802.3at™-2009

This amendment includes changes to IEEE Std 802.3-2008. This amendment augments the capabilities of IEEE Std 802.3-2008 with higher power levels and improved power management information.

#### IEEE Std 802.3™-2008/Cor 1–2009

This corrigendum corrects the PAUSE reaction timing delay value for the 10GBASE-T PHY type.

#### IEEE Std 802.3ba™-2010

This amendment includes changes to IEEE Std 802.3-2008 and adds Clause 80 through Clause 88 and Annex 83A through Annex 83C, Annex 85A, and Annex 86A. This amendment adds MAC parameters, Physical Layers, and management parameters for the transfer of IEEE 802.3 format frames at 40 Gb/s and 100 Gb/s.

#### IEEE Std 802.3az-2010

This amendment includes changes to IEEE Std 802.3-2008 and adds Clause 78. This amendment adds changes required to enable energy-efficient operation of several existing Physical Layers.

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.

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### 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



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# IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements

## Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

### Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet

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(This amendment is based on IEEE Std 802.3™-2008.)

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

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

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

## 1. Introduction

### 1.4 Definitions

*Insert the following new definitions into the definitions list, in alphanumeric order, as follows:*

**10BASE-Te:** IEEE 802.3 Physical Layer specification for an energy-efficient version of 10BASE-T for a 10 Mb/s CSMA/CD local area network over two pairs of Category 5 or better-balanced cabling. (See IEEE Std 802.3, Clause 14.)

**Low Power Idle (LPI) mode:** An optional mode intended to save power that may be enabled during periods of low link utilization in which either side of a link may disable portions of device or system functionality.

### 1.5 Abbreviations

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

EEE     Energy-Efficient Ethernet

LPI     Low Power Idle