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 Computer Society

Sponsored by the
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(Amendment to
IEEE Std 802.3™-2008)

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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 1GBASE-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

Contents

1. Introduction 2

1.4 Definitions 2
1.5 Abbreviations 2

14. Twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T including type 10BASE-Te 3

14.1 Scope 3
14.1.1 Overview 3
14.1.1.1 Medium Attachment Unit (MAU) 3
14.1.1.3 Twisted-pair media 3
14.3.1 MAU-to-MDI interface characteristics 4
14.3.1.2 Transmitter specifications 4
14.3.1.2.1 Differential output voltage 5
14.4 Characteristics of the simplex link segment 7
14.4.1 Overview 7
14.4.2 Transmission parameters 7
14.4.2.1 Insertion loss 7
14.5 MDI specification 7
14.5.2 Crossover function 7
14.8 MAU labeling 7
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 8
14.10.3 Identification of the protocol 8
14.10.4 PICS proforma for 10BASE-T 8
14.10.4.5 PICS proforma tables for MAU 8
14.10.4.5.12 Transmitter specification 8
14.10.4.7 PICS proforma tables for 10BASE-T link segment 9
14.10.4.7.1 10BASE-T link segment characteristics 9

22. Reconciliation Sublayer (RS) and Media Independent Interface (MII) 11

22.2 Functional specifications 11
22.2.1 Mapping of MII signals to PLS service primitives and Station Management 11
22.2.1.3 Mapping of PLS_CARRIER.indication 12
22.2.1.3.1 Semantics of the service primitive 12
22.2.1.3.2 When generated 12
22.2.2 MII signal functional specifications 12
22.2.2.2 RX_CLK (receive clock) 12
22.2.2.4 TXD (transmit data) 13
22.2.2.5 TX/ER (transmit coding error) 13
22.2.2.5a Transmit direction LPI transition 13
22.2.2.7 RXD (receive data) 14
22.2.2.8 RX_ER (receive error) 15
22.2.2.8a Receive direction LPI transition 15
22.6 Mechanical characteristics 15
22.6a LPI assertion and detection 15
22.6a.1 LPI messages 16
22.6a.2 Transmit LPI state diagram 16

22.6a.2.1 Conventions ... 17
22.6a.2.2 Variables and counters ... 17
22.6a.2.3 State diagram ... 17
22.6a.3 Considerations for transmit system behavior ... 18
22.6a.3.1 Considerations for receive system behavior ... 18
22.7 Protocol implementation conformance statement (PICS) proforma for Clause 22, Reconciliation Sublayer (RS) and Media Independent Interface (MII) ... 18
22.7.2 Identification ... 18
22.7.2.3 Major capabilities/options ... 18
22.7.3 PICS proforma tables for reconciliation sublayer and media independent interface ... 19
22.7.3.2 MII signal functional specifications ... 19
22.7.3.2a LPI functions ... 19

24. Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 100BASE-X ... 21

24.1 Overview ... 21
24.1.1 Scope ... 21
24.1.2 Objectives ... 21
24.1.3 Relationship of 100BASE-X to other standards ... 22
24.1.4 Summary of 100BASE-X sublayers ... 22
24.1.4.1 Physical Coding Sublayer (PCS) ... 22
24.1.4.2 Physical Medium Attachment (PMA) sublayer ... 22
24.1.4.4 Auto-Negotiation ... 23
24.1.6 Functional block diagram ... 23
24.2 Physical Coding Sublayer (PCS) ... 25
24.2.2 Functional requirements ... 25
24.2.2.1 Code-groups ... 25
24.2.2.1.1 Data code-groups ... 26
24.2.2.1.5a SLEEP code-groups (/P/) ... 26
24.2.3 State variables ... 26
24.2.3.1 Constants ... 26
24.2.3.2 Variables ... 26
24.2.3.4 Timers ... 27
24.2.4 State diagrams ... 28
24.2.4.2 Transmit ... 28
24.2.4.4 Receive ... 30
24.3 Physical Medium Attachment (PMA) sublayer ... 33
24.3.1 Service interface ... 33
24.3.1.8 PMA_LPILINKFAIL.request ... 33
24.3.1.8.1 Semantics of the service primitive ... 33
24.3.1.8.2 When generated ... 33
24.3.1.8.3 Effect of receipt ... 33
24.3.1.9 PMA_RXLPI.request ... 33
24.3.1.9.1 Semantics of the service primitive ... 33
24.3.1.9.2 When generated ... 33
24.3.1.9.3 Effect of receipt ... 33
24.3.2 Functional requirements ... 34
24.3.2.1 Far-End fault ... 34
24.3.2.3 EEE capability ... 34
24.3.3 State variables ... 34
24.3.3.2 Variables ... 34
24.3.4 Process specifications and state diagrams ... 35

24.3.4.4 Link Monitor ... 35
24.3.4.5 Far-End Fault Generation ... 36
24.4 Physical Medium Dependent (PMD) sublayer service interface ... 37
24.4.1 PMD service Interface ... 37
24.4.1.4 PMD_RXQUIET.request ... 37
24.4.1.4.1 Semantics of the service primitive ... 37
24.4.1.4.2 When generated ... 37
24.4.1.4.3 Effect of receipt ... 37
24.4.1.5 PMD_TXQUIET.request ... 37
24.4.1.5.1 Semantics of the service primitive ... 38
24.4.1.5.2 When generated ... 38
24.4.1.5.3 Effect of receipt ... 38
24.8 Protocol implementation conformance statement (PICS) proforma for Clause 24, Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 100BASE-X ... 38
24.8.2 Identification ... 38
24.8.2.3 Major capabilities/options ... 38
24.8.3 PICS proforma tables for the Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 100BASE-X ... 39
24.8.3.5 LPI functions ... 39

25. Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-TX ... 41

25.1 Overview ... 41
25.1.1 State diagram conventions ... 41
25.3 General exceptions ... 41
25.4 Specific requirements and exceptions ... 41
25.4.6 Change to 9.1.9, “Jitter” ... 41
25.4a EEE capability ... 41
25.4a.1 Change to TP-PMD 7.1.2 “Encoder” ... 42
25.4a.1.1 State variables ... 42
25.4a.1.1.1 Variables ... 42
25.4a.1.1.2 Messages ... 43
25.4a.1.2 State diagram ... 43
25.4a.2 Change to TP-PMD 7.2.2 “Decoder” ... 43
25.4a.2.1 State variables ... 43
25.4a.2.1.1 Variables ... 43
25.4a.2.1.2 Messages ... 44
25.4a.2.2 State diagram ... 45
25.4a.3 Changes to 10.1.1.1 “Signal_Detect assertion threshold” ... 45
25.4a.4 Changes to 10.1.1.2 “Signal_Detect de-assertion threshold” ... 45
25.4a.5 Change to 10.1.2 “Signal_Detect timing requirements on assertion” ... 45
25.4a.6 Change to 10.1.3 “Signal_Detect timing requirements on de-assertion” ... 45
25.4a.7 Changes to TP-PMD 10.2 “Transmitter” ... 46
25.4a.8 Replace TP-PMD Table 4 “Signal_Detect summary” with Table 25-3 ... 46
25.5 Protocol implementation conformance statement (PICS) proforma for Clause 25, Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-TX ... 47
25.5.3 Major capabilities/options ... 47
25.5.4 PICS proforma tables for the Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-TX ... 47
25.5.4.5 LPI functions ... 47

30. Management ... 49

30.2 Managed objects ... 49
30.2.5 Capabilities ... 50
30.3 Layer management for DTEs ... 50
30.3.1 MAC entity managed object class ... 50
30.3.1.1 MAC entity attributes ... 50
30.3.1.1.38 aTransmitLPIMicroseconds ... 50
30.3.1.1.39 aReceiveLPIMicroseconds ... 51
30.3.1.1.40 aTransmitLPITransitions ... 51
30.3.1.1.41 aReceiveLPITransitions ... 51
30.3.1.1.42 aLDFastRetrainCount ... 51
30.3.1.1.43 aLPFastRetrainCount ... 52
30.5 Layer management for medium attachment units (MAUs) ... 52
30.5.1 MAU managed object class ... 52
30.5.1.1 MAU attributes ... 52
30.5.1.1.20 aSNROpMarginChnlD ... 52
30.5.1.1.21 aEEESupportList ... 52
30.12 Layer Management for Link Layer Discovery Protocol (LLDP) ... 52
30.12.2 LLDP Local System Group managed object class ... 52
30.12.2.1 LLDP Local System Group attributes ... 52
30.12.2.1.14a LldpXdot3LocTxTwSys ... 52
30.12.2.1.15a LldpXdot3LocTxTwSysEcho ... 53
30.12.2.1.16a LldpXdot3LocRxTwSys ... 53
30.12.2.1.17a LldpXdot3LocRxTwSysEcho ... 53
30.12.2.1.18a LldpXdot3LocFbTwSys ... 53
30.12.2.1.19a LldpXdot3TxDllReady ... 53
30.12.2.1.20a LldpXdot3RxDllReady ... 54
30.12.2.1.21a LldpXdot3LocDllEnabled ... 54
30.12.3 LLDP Remote System Group managed object class ... 54
30.12.3.1 LLDP Remote System Group attributes ... 54
30.12.3.1.13a LldpXdot3RemMaxFrameSize ... 54
30.12.3.1.14a LldpXdot3RemTxTwSys ... 54
30.12.3.1.15a LldpXdot3RemTxTwSysEcho ... 55
30.12.3.1.16a LldpXdot3RemRxTwSys ... 55
30.12.3.1.17a LldpXdot3RemRxTwSysEcho ... 55
30.12.3.1.18a LldpXdot3RemFbTwSys ... 55

35. Reconciliation Sublayer (RS) and Gigabit Media Independent Interface (GMII) ... 57

35.1 Overview ... 57
35.1.1 Summary of major concepts ... 57
35.2 Functional specifications ... 57
35.2.1 Mapping of GMII signals to PLS service primitives and Station Management ... 57
35.2.2 GMII signal functional specifications ... 57
35.2.2.1 GTX_CLK (1000 Mb/s transmit clock) ... 57
35.2.2.2 RX_CLC (receive clock) ... 57
35.2.2.4 TXD (transmit data) ... 58
35.2.2.5 TX_ER (transmit coding error) ... 58
35.2.2.5a Transmit direction LPI transition ... 59
35.2.2.7 RXD (receive data) ... 59
35.2.2.8 RX_ER (receive error) ... 60
35.2.2.8a Receive direction LPI transition ... 60
35.3 Signal mapping ... 61

35.3a LPI Assertion and Detection 61
35.3a.1 LPI messages 62
35.3a.2 Transmit LPI state diagram 62
35.3a.2.1 Conventions 62
35.3a.2.2 Variables and counters 63
35.3a.2.3 State diagram 63
35.3a.3 Considerations for transmit system behavior 63
35.3a.3.1 Considerations for receive system behavior 64
35.5 Protocol implementation conformance statement (PICS) proforma for Clause 35, Reconciliation Sublayer (RS) and Gigabit Media Independent Interface (GMII) 64
35.5.2 Identification 64
35.5.2.3 Major capabilities/options 64
35.5.3 PICS proforma tables for reconciliation sublayer and Gigabit Media independent interface 64
35.5.3.3 Data stream structure 64
35.5.3.3a LPI functions 64

36. Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 1000BASE-X 65

36.2 Physical Coding Sublayer (PCS) 65
36.2.4 8B/10B transmission code 65
36.2.4.7 Ordered_sets 65
36.2.4.12 IDLE (/I/) 65
36.2.4.12a Low Power Idle (LPI) 65
36.2.5 Detailed functions and state diagrams 65
36.2.5.1 State variables 65
36.2.5.1.2 Constants 65
36.2.5.1.3 Variables 66
36.2.5.1.5 Counters 67
36.2.5.1.6 Messages 67
36.2.5.1.7 Timers 67
36.2.5.2.1 Transmit 68
36.2.5.2.2 Receive 71
36.2.5.2.6 Synchronization 74
36.2.5.2.8 LPI state diagram 76
36.2.5.2.9 LPI status and management 77
36.7 Protocol implementation conformance statement (PICS) proforma for Clause 36, Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 1000BASE-X 77
36.7.3 Major capabilities/options 77
36.7.4 PICS proforma tables for the PCS and PMA sublayer, type 1000BASE-X 78
36.7.4.9 LPI functions 78

40. Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 1000BASE-T 79

40.1 Overview 79
40.1.3 Operation of 1000BASE-T 79
40.1.3.1 Physical Coding Sublayer (PCS) 81
40.1.3.2 Physical Medium Attachment (PMA) sublayer 81
40.1.4 Signaling 81
40.2 1000BASE-T Service Primitives and Interfaces 81
40.2.2 PMA Service Interface 81

40.2.10 PMA_RESET.indication ... 82
40.2.11 PMA_LPIMODE.indication ... 82
40.2.11.1 Semantics of the primitive ... 82
40.2.11.2 When generated ... 83
40.2.11.3 Effect of receipt ... 83
40.2.12 PMA_LPIREQ.request ... 83
40.2.12.1 Semantics of the primitive ... 83
40.2.12.2 When generated ... 83
40.2.12.3 Effect of receipt ... 83
40.2.13 PMA_REMLPIREQ.request ... 83
40.2.13.1 Semantics of the primitive ... 83
40.2.13.2 When generated ... 84
40.2.13.3 Effect of receipt ... 84
40.2.14 PMA_UPDATE.indication ... 84
40.2.14.1 Semantics of the primitive ... 84
40.2.14.2 When generated ... 84
40.2.14.3 Effect of receipt ... 84
40.2.15 PMA_REMUPDATE.request ... 84
40.2.15.1 Semantics of the primitive ... 84
40.2.15.2 When generated ... 85
40.2.15.3 Effect of receipt ... 85
40.3 Physical Coding Sublayer (PCS) ... 85
40.3.1 PCS functions ... 87
40.3.1.3 PCS Transmit function ... 87
40.3.1.3.4 Generation of bits Sdn[8:0] ... 87
40.3.1.4 PCS Receive function ... 88
40.3.1.6 PCS Local LPI Request function ... 88
40.3.3 State variables ... 88
40.3.3.1 Variables ... 88
40.3.4 State diagrams ... 89
40.4 Physical Medium Attachment (PMA) sublayer ... 91
40.4.2 PMA functions ... 91
40.4.2.4 PHY Control function ... 92
40.4.5 State variables ... 93
40.4.5.1 State diagram variables ... 93
40.4.5.2 Timers ... 94
40.4.6 State diagrams ... 95
40.4.6.1 PHY Control state diagram ... 95
40.4.6.2 Link Monitor state diagram ... 97
40.5 Management interface ... 98
40.5.1 Support for Auto-Negotiation ... 98
40.5.1.1 1000BASE-T use of registers during Auto-Negotiation ... 99
40.5.1.2 1000BASE-T Auto-Negotiation page use ... 100
40.6 PMA electrical specifications ... 100
40.6.1 PMA-to-MDI interface tests ... 100
40.6.1.2 Transmitter electrical specifications ... 100
40.6.1.2.5 Transmitter timing jitter ... 100
40.6.1.2.6 Transmit clock frequency ... 100
40.6.1.2.7 Transmitter operation following a transition from the QUIET to the WAKE state ... 100
40.6.1.3.5 Signal_detect ... 101
40.12 Protocol implementation conformance statement (PICS) proforma for Clause 40, Physical coding sublayer (PCS), physical medium attachment (PMA) sublayer and baseband medium, type 1000BASE-T ... 101

40.12.2 Major capabilities/options 101
40.12.4 Physical Coding Sublayer (PCS) 101
40.12.4.1 PCS receive functions 102
40.12.5 Physical Medium Attachment (PMA) 102
40.12.6 Management interface 103
40.12.6.1 1000BASE-T Specific Auto-Negotiation Requirements 103
40.12.7 PMA Electrical Specifications 103

45. Management Data Input/Output (MDIO) Interface 105

45.2 MDIO Interface Registers 105
45.2.1 PMA/PMD registers 105
45.2.1.76 10GBASE-KR PMD control register (Register 1.150) 105
45.2.1.76a 10GBASE-T fast retrain status and control register (Register 1.147) 105
45.2.1.76a.1 LP fast retrain count (1.147.15:11) 105
45.2.1.76a.2 LD fast retrain count (1.147.10:6) 106
45.2.1.76a.3 Fast retrain ability (1.147.4) 106
45.2.1.76a.4 Fast retrain negotiated (1.147.3) 106
45.2.1.76a.5 Fast retrain signal type (1.147.2:1) 106
45.2.1.76a.6 Fast retrain enable (1.147.0) 106
45.2.3 PCS registers 106
45.2.3.1 PCS control 1 register (Register 3.0) 107
45.2.3.1.3a Clock stop enable (3.0.10) 107
45.2.3.2 PCS status 1 register (Register 3.1) 107
45.2.3.2a Transmit LPI received (3.1.11) 108
45.2.3.2b Receive LPI received (3.1.10) 108
45.2.3.2c Transmit LPI indication (3.1.9) 108
45.2.3.2d Receive LPI indication (3.1.8) 108
45.2.3.2.2a Clock stop capable (3.1.6) 108
45.2.3.8 PCS package identifier (Registers 3.14 and 3.15) 108
45.2.3.8a EEE capability (Register 3.20) 108
45.2.3.8a.1 10GBASE-KR EEE supported (3.20.6) 109
45.2.3.8a.2 10GBASE-KX4 EEE supported (3.20.5) 109
45.2.3.8a.3 1000BASE-KX EEE supported (3.20.4) 109
45.2.3.8a.4 10GBASE-T EEE supported (3.20.3) 109
45.2.3.8a.5 1000BASE-T EEE supported (3.20.2) 109
45.2.3.8a.6 100BASE-TX EEE supported (3.20.1) 109
45.2.3.8b EEE wake error counter (Register 3.22) 110
45.2.4 PHY XS registers 110
45.2.4.1 PHY XS control 1 register (Register 4.0) 110
45.2.4.1.3 Low power (4.0.11) 110
45.2.4.1.3a Clock stop enable (4.0.10) 111
45.2.4.1.3b XAUI stop enable (4.0.9) 111
45.2.4.2 PHY XS status 1 register (Register 4.1) 111
45.2.4.2a Transmit LPI received (4.1.11) 111
45.2.4.2b Receive LPI received (4.1.10) 112
45.2.4.2c Transmit LPI indication (4.1.9) 112
45.2.4.2d Receive LPI indication (4.1.8) 112
45.2.4.2.2a Clock stop capable (4.1.6) 112
45.2.4.7 PHY XS package identifier (Registers 4.14 and 4.15) 112
45.2.4.7a EEE capability (Register 4.20) 112
45.2.4.7a.2 PHY XS EEE supported (4.20.4) 113
45.2.4.7a.3 XAUI stop capable (4.20.0) 113
45.2.4.7b EEE wake error counter (Register 4.22) 113

45.2.5 DTE XS registers ... 113
45.2.5.1 DTE XS control 1 register (Register 5.0) ... 113
45.2.5.1.3 Low power (50.1.11) ... 114
45.2.5.1.3a Clock stop enable (5.0.10) ... 114
45.2.5.1.3b XAUI stop enable (5.0.9) ... 114
45.2.5.2 DTE XS status 1 register (Register 5.1) ... 114
45.2.5.2a Transmit LPI received (5.1.11) ... 114
45.2.5.2b Receive LPI received (5.1.10) ... 115
45.2.5.2c Transmit LPI indication (5.1.9) ... 115
45.2.5.2d Receive LPI indication (5.1.8) ... 115
45.2.5.2.2a Clock stop capable (5.1.6) ... 115
45.2.5.7 DTE XS package identifier (Registers 5.14 and 5.15) ... 115
45.2.5.7a EEE capability (Register 5.20) ... 115
45.2.5.7a.1 PHY XS EEE supported (5.20.4) ... 116
45.2.5.7a.2 XAUI stop capable (5.20.0) ... 116
45.2.5.7b EEE wake error counter (Register 5.22) ... 116
45.2.7 Auto-Negotiation registers ... 116
45.2.7.10 10GBASE-T AN control register (Register 7.32) ... 116
45.2.7.10.5 LD PMA training reset request (7.32.2) ... 117
45.2.7.10.5a Fast retrain ability ... 117
45.2.7.11 10GBASE-T AN status register (Register 7.33) ... 117
45.2.7.11.7 Link partner PMA training reset request (7.33.9) ... 117
45.2.7.11.8 Fast retrain ability ... 117
45.2.7.12 Backplane Ethernet statue (Register 7.48) ... 117
45.2.7.13 EEE advertisement (Register 7.60) ... 117
45.2.7.13.1 10GBASE-KR EEE supported (7.60.6) ... 118
45.2.7.13.2 10GBASE-KX4 EEE supported (7.60.5) ... 118
45.2.7.13.3 1000BASE-KX EEE supported (7.60.4) ... 118
45.2.7.13.4 10GBASE-T EEE supported (7.60.3) ... 119
45.2.7.13.5 1000BASE-T EEE supported (7.60.2) ... 119
45.2.7.13.6 100BASE-TX EEE supported (7.60.1) ... 119
45.2.7.14 EEE link partner ability (Register 7.61) ... 119
45.5 Protocol implementation conformance statement (PICS) proforma for Clause 45, MDIO interface ... 120
45.5.3.6 PCS options ... 120
45.5.3.7 PCS management functions ... 120
45.5.3.8 Auto-Negotiation options ... 121
45.5.3.9 Auto-Negotiation management functions ... 121

46. Reconciliation Sublayer (RS) and 10 Gigabit Media Independent Interface (XGMII) ... 123

46.1 Overview ... 123
46.1.1 Summary of major concepts ... 123
46.1.7 Mapping of XGMII signals to PLS service primitives ... 123
46.1.7.3 Mapping of PLS_CARRIER.indication ... 123
46.3 XGMII functional specifications ... 124
46.3.1 Transmit ... 124
46.3.1.1 TX_CLK (10 Gb/s transmit clock) ... 124
46.3.1.2 TXC<3:0> (transmit control) ... 124
46.3.1.5 Transmit direction LPI transition ... 124
46.3.2 Receive ... 125
46.3.2.1 RX_CLK (receive clock) ... 125
46.3.2.2 RXC<3:0> (receive control) ... 125
46.3.2.4 Receive direction LPI transition ... 125

46.3.4 Link fault signaling ... 126
46.3.4.2 Variables and counters ... 127
46.3.4.3 State diagram ... 128
46.3a LPI Assertion and Detection ... 128
46.3a.1 LPI messages ... 129
46.3a.2 Transmit LPI state diagram ... 129
46.3a.2.1 Variables and counters ... 129
46.3a.2.2 State diagram ... 130
46.3a.3 Considerations for transmit system behavior ... 130
46.3a.3.1 Considerations for receive system behavior ... 131
46.5 Protocol implementation conformance statement (PICS) proforma for Clause 46, Reconciliation Sublayer (RS) and 10 Gigabit Media Independent Interface (XGMII) ... 131
46.5.2 Identification ... 131
46.5.2.3 Major capabilities/options ... 131
46.5.3 PICS proforma Tables for Reconciliation Sublayer and 10 Gigabit Media Independent Interface ... 131
46.5.3.3 Data stream structure ... 131
46.5.3.3a LPI functions ... 132
46.5.3.3b Link Interruption ... 132

47. XGMII Extender Sublayer (XGXS) and 10 Gigabit Attachment Unit Interface (XAUI) ... 133

47.1 Overview ... 133
47.1.4 Allocation of functions ... 133
47.1.5 Global signal detect function ... 133
47.1.6 Global transmit disable function ... 133
47.3 XAUI Electrical characteristics ... 134
47.3.3 Driver characteristics ... 134
47.3.3.2 Amplitude and swing ... 134
47.3.4 Receiver characteristics ... 134
47.3.4.7 EEE receiver timing ... 134
47.6 Protocol implementation conformance statement (PICS) proforma for Clause 47, XGMII Extender (XGMII) and 10 Gigabit Attachment Unit Interface (XAUI) ... 135
47.6.3 Major capabilities/options ... 135
47.6.4 PICS Proforma tables for XGXS and XAUI ... 135
47.6.4.4 LPI functions ... 135

48. Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 10GBASE-X ... 137

48.1 Overview ... 137
48.1.5 Allocation of functions ... 137
48.2 Physical Coding Sublayer (PCS) ... 137
48.2.3 Use of code-groups ... 137
48.2.4 Ordered_sets and special code-groups. ... 138
48.2.4.2 Idle (||I||) and Low Power Idle (||LPIDLE||) ... 139
48.2.4.2.3 Skip ||R|| ... 140
48.2.6 Detailed functions and state diagrams ... 140
48.2.6.1 State variables ... 140
48.2.6.1.2 Constants ... 140
48.2.6.1.3 Variables ... 141
48.2.6.1.5 Counters ... 141
48.2.6.1.5a Timers ... 141
48.2.6.1.6 Message ... 142

48.2.6.2 State diagrams ... 142
48.2.6.2.2 Synchronization ... 145
48.2.6.2.3 Deskew ... 145
48.2.6.2.4 Receive ... 146
48.2.6.2.5 LPI state diagrams ... 146
48.2.6.2.6 LPI status and management ... 148
48.7 Protocol implementation conformance statement (PICS) proforma for Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 10GBASE-X ... 149
48.7.3 Major capabilities/options ... 149
48.7.4 PICS proforma tables for the PCS and PMA sublayer, type 10GBASE-X ... 149
48.7.4.5 LPI functions ... 149

49. Physical Coding Sublayer (PCS) for 64B/66B, type 10GBASE-R ... 151

49.1 Overview ... 151
49.1.5 Inter-sublayer interfaces ... 151
49.1.6 Functional block diagram ... 151
49.2 Physical Coding Sublayer (PCS) ... 152
49.2.4 64B/66B transmission code ... 152
49.2.4.4 Control codes ... 152
49.2.4.5 Ordered sets ... 152
49.2.4.7 Idle /I/ and Low Power Idle /LI/ ... 153
49.2.6 Scrambler ... 153
49.2.9 Block synchronization ... 154
49.2.13.2.2 Variables ... 156
49.2.13.2.3 Functions ... 157
49.2.13.2.4 Counters ... 159
49.2.13.2.5 Timers ... 159
49.2.13.3 State diagrams ... 160
49.2.13.3.1 LPI state diagrams ... 161
49.2.14.1 Status ... 164
49.3 Protocol implementation conformance statement (PICS) proforma for Clause 49, Physical Coding Sublayer (PCS) type 10GBASE-R ... 165
49.3.3 Major Capabilities/Options ... 165
49.3.6 Management ... 165
49.3.6.5 Auto-Negotiation for Backplane Ethernet functions ... 165
49.3.6.6 LPI functions ... 166

51. Physical Medium Attachment (PMA) sublayer, type Serial ... 167

51.2 PMA Service Interface ... 167
51.2.3 PMA_SIGNAL.indication ... 167
51.2.4 PMA_RXMODE.request ... 167
51.2.4.1 Semantics of the service primitive ... 167
51.2.4.2 When generated ... 167
51.2.4.3 Effect of receipt ... 167
51.2.5 PMA_TXMODE.request ... 167
51.2.5.1 Semantics of the service primitive ... 167
51.2.5.2 When generated ... 167
51.2.5.3 Effect of receipt ... 168
51.2.6 PMA_ENERGY.indication ... 168
51.2.6.1 Semantics of the service primitive ... 168
51.2.6.2 When generated ... 168

51.2.6.3 Effect of receipt ... 168
51.4 Sixteen-Bit Interface (XSBI) ... 168
51.4.2 Optional Signals ... 170
51.10 Protocol implementation conformance statement (PICS) proforma for Clause 51, Physical Medium Attachment (PMA) sublayer, type Serial ... 170
51.10.3 Major capabilities/options ... 170

55. Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10GBASE-T ... 171

55.1 Overview ... 171
55.1.1 Objectives ... 171
55.1.3 Operation of 10GBASE-T ... 171
55.1.3.2 Physical Medium Attachment (PMA) sublayer ... 173
55.1.3.3 EEE capability ... 173
55.1.4 Signaling ... 174
55.2 10GBASE-T service primitives and interfaces ... 174
55.2.2 PMA service interface ... 174
55.2.2.3 PMA_UNITDATA.request ... 175
55.2.2.3.1 Semantics of the primitive ... 175
55.2.2.8 PMA REMRX_STATUS.request ... 176
55.2.2.9 PMA_ALERTDETECT.indication ... 176
55.2.2.9.1 Semantics of the primitive ... 176
55.2.2.9.2 When generated ... 176
55.2.2.9.3 Effect of receipt ... 176
55.2.2.10 PCS_RX_LPI_STATUS.request ... 176
55.2.2.10.1 Semantics of the primitive ... 177
55.2.2.10.2 When generated ... 177
55.2.2.10.3 Effect of receipt ... 177
55.2.2.11 PMA_PCSDATAMODE.indication ... 177
55.2.2.11.1 Semantics of the primitive ... 177
55.2.2.11.2 When generated ... 177
55.2.2.11.3 Effect of receipt ... 177
55.2.2.12 PMA_FR_ACTIVE.indication ... 177
55.2.2.12.1 Semantics of the primitive ... 177
55.2.2.12.2 When generated ... 177
55.2.2.12.3 Effect of receipt ... 177
55.3 Physical Coding Sublayer (PCS) ... 178
55.3.2 PCS Functions ... 178
55.3.2.2 PCS Transmit function ... 178
55.3.2.2.1 Use of blocks ... 179
55.3.2.2.9 Idle (/I/) ... 180
55.3.2.2.9a LPI (/LI/) ... 181
55.3.2.2.20 65B-LDPC framer ... 181
55.3.2.2.21 EEE capability ... 181
55.3.2.3 PCS Receive function ... 182
55.3.4 PMA training side-stream scrambler polynomials ... 183
55.3.4a LPI signaling ... 183
55.3.4a.1 LPI Synchronization ... 183
55.3.4a.2 Quiet period signaling ... 185
55.3.4a.3 Refresh period signaling ... 185
55.3.5 Detailed functions and state diagrams ... 186
55.3.5.2 State diagram parameters ... 186
55.3.5.2.1 Constants ... 186

55.3.5.2.2 Variables 186
55.3.5.2.3 Timers 188
55.3.5.2.4 Functions 188
55.3.5.2.5 Counters 189
55.3.5.4 State diagrams 190
55.3.6 PCS management 197
55.3.6.1 Status 197
55.4 Physical Medium Attachment (PMA) sublayer 197
55.4.1 PMA functional specifications 197
55.4.2 PMA functions 198
55.4.2.2 PMA Transmit function 198
55.4.2.2.1 Alert signal 199
55.4.2.2.2 Link failure signal 200
55.4.2.4 PMA Receive function 200
55.4.2.5 PHY Control function 201
55.4.2.5.14 Startup sequence 201
55.4.2.5.15 Fast retrain function 201
55.4.2.6 Link Monitor function 202
55.4.2.6a Refresh Monitor function 202
55.4.4 Automatic MDI/MDI-X configuration 202
55.4.5 State variables 202
55.4.5.1 State diagram variables 202
55.4.5.2 Timers 204
55.4.5.4 Counters 204
55.4.6 State diagrams 205
55.4.6.1 PHY Control state diagram 205
55.4.6.2 Transition counter state diagrams 206
55.4.6.3 Link Monitor state diagram 207
55.4.6.4 EEE Refresh monitor state diagram 208
55.4.6.5 Fast retrain state diagram 209
55.5 PMA electrical specifications 209
55.5.3 Transmitter electrical specifications 209
55.5.3.5 Transmit clock frequency 209
55.6 Management interfaces 209
55.6.1 Support for Auto-Negotiation 209
55.6.1.2 10GBASE-T Auto-Negotiation page use 210
55.10 PHY labeling 210
55.12 Protocol implementation conformance statement (PICS) proforma for Clause 55, Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10GBASE-T 211
55.12.2 Major capabilities/options 211
55.12.3 Physical Coding Sublayer (PCS) 211
55.12.4 Physical Medium Attachment (PMA) 213
55.12.5 Management interface 213
55.12.6 PMA Electrical Specifications 214

69. Introduction to Ethernet operation over electrical backplanes 215

69.1 Overview 215
69.1.1 Scope 215
69.1.2 Objectives 215
69.2 Summary of Backplane Ethernet Sublayers 215
69.2.3 Physical Layer signaling systems 215
69.2.6 Low-Power Idle 216

70. Physical Medium Dependent Sublayer and Baseband Medium, Type 1000BASE-KX 217

70.1 Overview 217
70.2 Physical Medium Dependent (PMD) service interface 217
70.2.1 PMD_RXQUIET.request 217
70.2.1.1 Semantics of the service primitive 217
70.2.1.2 When generated 218
70.2.1.3 Effect of receipt 218
70.2.2 PMD_TXQUIET.request 218
70.2.2.1 Semantics of the service primitive 218
70.2.2.2 When generated 218
70.2.2.3 Effect of receipt 218
70.6 PMD functional specifications 218
70.6.4 PMD signal detect function 218
70.6.5 PMD transmit disable function 219
70.6.10 PMD LPI function 219
70.7 1000BASE-KX electrical characteristics 219
70.7.1 Transmitter characteristics 219
70.7.1.5 Output amplitude 220
70.10 Protocol implementation conformance statement (PICS) proforma for Clause 70, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-KX 221
70.10.3 Major capabilities/options 221
70.10.4 PICS proforma tables for Clause 70, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-KX 221
70.10.4.1 PMD functional specifications 221
70.10.4.3 Transmitter electrical characteristics 222

71. Physical Medium Dependent Sublayer and Baseband Medium, Type 10GBASE-KX4 223

71.1 Overview 223
71.2 Physical Medium Dependent (PMD) service interface 223
71.2.1 PMD_RXQUIET.request 223
71.2.1.1 Semantics of the service primitive 223
71.2.1.2 When generated 224
71.2.1.3 Effect of receipt 224
71.2.2 PMD_TXQUIET.request 224
71.2.2.1 Semantics of the service primitive 224
71.2.2.2 When generated 224
71.2.2.3 Effect of receipt 224
71.6 PMD functional specifications 224
71.6.4 Global PMD signal detect function 224
71.6.6 Global PMD transmit disable function 225
71.6.12 PMD LPI function 225
71.7 Electrical characteristics for 10GBASE-KX4 225
71.7.1 Transmitter characteristics 225
71.7.1.4 Output amplitude 226
71.7.2 Receiver characteristics 226
71.10 Protocol implementation conformance statement (PICS) proforma for Clause 71, Physical Medium Dependent (PMD) sublayer and baseband medium, type 10GBASE-KX4 227
71.10.3 Major capabilities/options 227
71.10.4 PICS proforma tables for Clause 71, Physical Medium Dependent (PMD) sublayer and baseband medium, type 10GBASE-KX4 228

71.10.4.2 PMD functional specifications ... 228
71.10.4.4 Transmitter electrical characteristics ... 228

72. Physical Medium Dependent Sublayer and Baseband Medium, Type 10GBASE-KR ... 229

72.1 Overview ... 229
72.2 Physical Medium Dependent (PMD) service interface ... 229
72.2.1 PMD_RX_MODE.request ... 229
72.2.1.1 Semantics of the service primitive ... 230
72.2.1.2 When generated ... 230
72.2.1.3 Effect of receipt ... 230
72.2.2 PMD_TX_MODE.request ... 230
72.2.2.1 Semantics of the service primitive ... 230
72.2.2.2 When generated ... 230
72.2.2.3 Effect of receipt ... 230
72.6 PMD functional specifications ... 230
72.6.2 PMD transmit function ... 230
72.6.4 PMD signal detect function ... 231
72.6.5 PMD transmit disable function ... 231
72.6.10 PMD control function ... 231
72.6.10.1 Overview ... 231
72.6.11. PMD LPI function ... 232
72.7 10GBASE-KR electrical characteristics ... 232
72.7.1 Transmitter characteristics ... 232
72.7.1.4 Output Amplitude ... 233
72.10 Protocol implementation conformance statement (PICS) proforma for Clause 72, Physical Medium Dependent (PMD) sublayer and baseband medium, type 10GBASE-KR ... 233
72.10.3 Major capabilities/options ... 233
72.10.4 PICS proforma tables for Clause 72, Physical Medium Dependent (PMD) sublayer and baseband medium, type 10GBASE-KR ... 233
72.10.4.2 PMD functional specifications ... 233
72.10.4.5 Transmitter electrical characteristics ... 234

73. Auto-Negotiation for Backplane Ethernet ... 235

73.11 Protocol implementation conformance statement (PICS) proforma for Clause 73, Auto-Negotiation for Backplane Ethernet ... 235
73.11.4 PICS proforma tables for Auto-Negotiation for Backplane Ethernet ... 235
73.11.4.9 Auto-Negotiation annexes ... 235

74. Forward Error Correction (FEC) sublayer for BASE-R PHYs ... 237

74.4 Inter-sublayer interfaces ... 237
74.4.1 Functional Block Diagram for 10GBASE-R PHYs ... 237
74.5 FEC service interface ... 238
74.5.1 10GBASE-R Service primitives ... 238
74.5.1.3 FEC_SIGNAL.indication ... 238
74.5.1.4 FEC_ENERGY.indication (optional) ... 238
74.5.1.4.1 Effect of receipt ... 238
74.5.1.5 FEC_LPI_ACTIVE.request (optional) ... 238
74.5.1.5.1 When generated ... 238
74.5.1.5.2 Effect of receipt ... 239
74.5.1.6 FEC_RX_MODE.request (optional) ... 239

74.5.1.6.1 When generated 239
74.5.1.6.2 Effect of receipt 239
74.5.1.7 FEC_TX_MODE.request (optional) 239
74.5.1.7.1 When generated 239
74.5.1.7.2 Effect of receipt 239
74.7 FEC principle of operation 239
74.7.4 Functions within FEC sublayer 239
74.7.4.7 FEC block synchronization 239
74.7.4.8 FEC rapid block synchronization for EEE (optional) 239
74.8 FEC MDIO function mapping 240
74.8.4 FEC Error monitoring capability 240
74.10 Detailed functions and state diagrams 240
74.10.2 State variables 240
74.10.2.3 Functions 240
74.11 Protocol implementation conformance statement (PICS) proforma for Clause 74, Forward Error Correction (FEC) sublayer for BASE-R PHYs 241
74.11.3 Major capabilities/options 241
74.11.6 FEC Error Monitoring 241

78. Energy-Efficient Ethernet (EEE) 243

78.1 Overview 243
78.1.1 LPI Signaling 243
78.1.1.1 Interlayer service interfaces 244
78.1.1.2 Responsibilities of LPI Client 244
78.1.2 LPI Client service interface 244
78.1.2.1 LP_IDLE.request 244
78.1.2.1.1 Function 244
78.1.2.1.2 Semantics of the service primitive 245
78.1.2.1.3 When generated 245
78.1.2.1.4 Effect of receipt 245
78.1.2.2 LP_IDLE.indication 245
78.1.2.2.1 Function 245
78.1.2.2.2 Semantics of the service primitive 245
78.1.2.2.3 When generated 245
78.1.2.2.4 Effect of receipt 245
78.1.3 Reconciliation sublayer operation 246
78.1.3.1 RS LPI assert function 246
78.1.3.2 LPI detect function 247
78.1.3.3 PHY LPI operation 247
78.1.3.3.1 PHY LPI transmit operation 247
78.1.3.3.2 PHY LPI receive operation 248
78.1.4 EEE Supported PHY types 248
78.2 LPI mode timing parameters description 248
78.3 Capabilities Negotiation 249
78.4 Data Link Layer Capabilities 250
78.4.1 Data Link Layer capabilities timing requirements 251
78.4.2 Control state diagrams 251
78.4.2.1 Conventions 251
78.4.2.2 Constants 251
78.4.2.3 Variables 251
78.4.2.4 Functions 253
78.4.2.5 State diagrams 254
78.4.3 State change procedure across a link 256

78.4.3.1 Transmitting link partner's state change procedure across a link 257
78.4.3.2 Receiving link partner's state change procedure across a link 257
78.5 Communication link access latency 258
78.5.1 10 Gb/s PHY extension using XGXS 259
78.6 Protocol implementation conformance statement (PICS) proforma for EEE Data Link Layer Capabilities 259
78.6.1 Introduction 259
78.6.2 Identification 260
78.6.2.1 Implementation identification 260
78.6.2.2 Protocol summary 260
78.6.3 Major capabilities/options 260
78.6.4 DLL requirements 261

79. IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and values (TLV) information elements 263

79.3 IEEE 802.3 Organizationally Specific TLVs 263
79.3.5 EEE TLV 263
79.3.5.1 Transmit Tw 264
79.3.5.2 Receive Tw 264
79.3.5.3 Fallback Tw 264
79.3.5.4 Echo Transmit and Receive Tw 264
79.3.5.5 EEE TLV usage rules 264
79.4 IEEE 802.3 Organizationally Specific TLV selection management 264
79.4.2 IEEE 802.3 Organizationally Specific TLV/LLDP Local and Remote System group managed object class cross references 264
79.5 Protocol implementation conformance statement (PICS) proforma for IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and values (TLV) information elements 266
79.5.3 Major capabilities/options 266
79.5a EEE TLV 266

Annex 28C (normative) Next page Message Code field definitions 267

28C.12 Message code 10—EEE technology message code 267

Annex 28D (normative) Description of extensions to Clause 28 and associated annexes 268

28D.7 Extensions required for Energy-Efficient Ethernet (Clause 78) 268

Annex 73A (normative) Next page Message Code field definitions 269

73A.4 Message code 10—EEE technology message code 269

Annex 74A (informative) FEC block coding examples 271

74A.4 Output of the PN-2112 sequence generator 271

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

(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.[1]

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (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.

[1]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