

IEEE Standards for Local and Metropolitan Area Networks:

**Supplement to Carrier Sense Multiple Access with
Collision Detection (CSMA/CD) Access Method and
Physical Layer Specifications**

**Fiber Optic Active and Passive Star-Based Segments,
Type 10BASE-F (Sections 15–18)**

Sponsor

**Technical Committee on Computer Communications
of the
IEEE Computer Society**

Approved September 15, 1993

IEEE Standards Board

Abstract: This supplement to ISO/IEC 8802-3 : 1992 [ANSI/IEEE 802.3, 1993 Edition] defines conformance requirements for fiber optic active and passive star-based segments, Type 10BASE-F implementations for local and metropolitan area networks.

Keywords: carrier sense multiple access with collision detection; fiber optic star; Medium Attachment Unit (MAU); local area networks; metropolitan area networks

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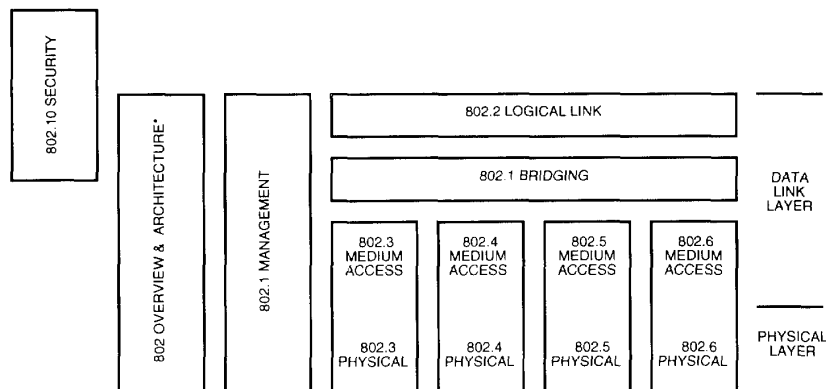
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Foreword

(This foreword is not a part of IEEE Std 802.3j-1993.)

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard numbers.)



* Formerly IEEE Std 802.1A.

This family of standards deals with the Physical and Data Link layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection Basic Reference Model (ISO 7498 : 1984). The access standards define several types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining these technologies are as follows:

- IEEE Std 802[†] : Overview and Architecture. This standard provides an overview to the family of IEEE 802 standards. This document forms part of the 802.1 scope of work.
- IEEE Std 802.1B: LAN/MAN Management. Defines an Open Systems Interconnection (OSI) management-compatible architecture, and service and protocol elements for use in a LAN/MAN environment for performing remote management.
- ISO/IEC 10038 [ANSI/IEEE Std 802.1D]: MAC Bridging. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.
- IEEE Std 802.1E: System Load Protocol. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.

[†] The 802 Architecture and Overview Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

- ISO 8802-2 [ANSI/IEEE Std 802.2]: Logical Link Control
- ISO/IEC 8802-3 [ANSI/IEEE Std 802.3]: CSMA/CD Access Method and Physical Layer Specifications
- ISO/IEC 8802-4 [ANSI/IEEE Std 802.4]: Token Bus Access Method and Physical Layer Specifications
- ISO/IEC 8802-5 [ANSI/IEEE Std 802.5]: Token Ring Access Method and Physical Layer Specifications
- IEEE Std 802.6: Metropolitan Area Network Access Method and Physical Layer Specifications
- IEEE Std 802.10: Interoperable Local Area Network (LAN) Security, *Currently Contains* Secure Data Exchange

In addition to the family of standards the following is a recommended practice for a common technology:

- IEEE Std 802.7: IEEE Recommended Practice for Broadband Local Area Networks

Conformance Test Methodology

A new standards series, identified by the number 1802, has been established to identify the conformance test methodology documents for the 802 family of standards. This makes the correspondence between the various 802 standards and their applicable conformance test requirements readily apparent. Thus the conformance test documents for 802.3 are numbered 1802.3, the conformance test documents for 802.5 will be 1802.5, and so on. Similarly, ISO will use 18802 to number conformance test standards for 8802 standards.

802.3j-1993

At the time this standard was approved, the complete IEEE 802.3 standard consisted of the following published documents:

- ISO/IEC 8802-3 : 1993 (ANSI/IEEE Std 802.3, 1993 Edition)
- IEEE Std 802.3k-1992, Layer Management for 10 Mb/s Baseband Repeaters (Section 19)
- IEEE Std 802.3l-1992, Type 10BASE-T Medium Attachment Unit (MAU) Protocol Implementation Conformance Statement (PICS) Proforma (Section 14.10)
- IEEE Std 802.3p-1993, Layer Management for 10 Mb/s Baseband Medium Attachment Units (MAUs) (Section 20)
- IEEE Std 802.3q-1993, Guidelines for the Development of Managed Objects (GDMO) (ISO 10164-4) Format for Layer-Managed Objects (Section 5)

Information on the current revision state of this standard and other IEEE 802 standards may be obtained from

Secretary, IEEE Standards Board
P.O. Box 1331
445 Hoes Lane
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IEEE 802 committee working documents are available from

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10201 N. 35th Avenue
Phoenix, AZ 85051, USA

Participants

When the IEEE 802.3 Working Group approved this standard, it had the following membership:

Patricia Thaler, Chair
Frederick Scholl, Type 10BASE-F Task Force Chair
Keith Amundsen, Past Chair
Michael E. Lee, Technical Editor

Karen Amavisca
Richard Anderson
Stephen J. Anderson
Ekkehard Antz
Mike Armstrong
Mogens Cash Balsby
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Mark Taylor
Geoffrey O. Thompson
Nathan Tobol
Nader Vijeh
Robert Watson
Alan Wetzel
Paul Woodruff

This standard is dedicated to the memory of Brian Hatfield in recognition of his significant contribution.

The following persons were on the balloting committee:

William B. Adams
Don Aelmore
Hasan S. Alkhatib
Kit Athul
William E. Ayen
Subhash Bhatia
Alan L. Bridges
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Mehmet U. Caglayan
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Contents

SECTION	PAGE
Revisions to ISO/IEC 8802-3 : 1993 [ANSI/IEEE Std 802.3, 1993 Edition]	15
4. Media Access Control	16
7. Physical Signaling (PLS) and Attachment Unit Interface (AUI) Specifications	16
8. Medium Attachment Unit and Baseband Medium Specifications, Type 10BASE5	16
9. Repeater Unit for 10 Mb/s Baseband Networks	17
10. Medium Attachment Unit and Baseband Medium Specifications, Type 10BASE2	24
13. System Considerations for Multisegment 10 Mb/s Baseband Networks	25
13.1 Overview	25
13.1.1 Repeater Usage	25
13.2 Definitions	25
13.3 Transmission System Model 1	26
13.4 Transmission System Model 2	30
13.4.1 Round-Trip Collision Delay	30
13.4.2 Interpacket Gap (IPG) Shrinkage	31
Annex A. Additional Reference Material	33
Appendix A. System Guidelines	34
A1. Baseband System Guidelines and Concepts	34
A1.5 Systems Consideration Calculations	34
A1.5.1 Overview	34
A1.5.2 Maximum Collision Fragment Size	34
A1.5.3 Interpacket Gap (IPG) Shrinkage	37
A1.5.4 Timing Parameters for Round-Trip Delay and Variability Calculations	38
A5. 10BASE-F	41
A5.1 System Jitter Budget	41
A5.2 10BASE-FP Fiber Optic Segment Loss Budget	41
Appendix C. Application Context, Selected Medium Specifications	43
C4. Type FOIRL and 10BASE-F Applications; Alternative Fiber Optic Medium Applications	43
C4.1 Alternative Fiber Types	43
C4.1.1 Theoretical Coupling Losses	43
C4.1.2 Maximum Launch Power	44
C4.2 Type 10BASE-FP Applications Using 50/125 μm Fiber	44
C4.2.1 Coupled Transmit Power	45
C4.2.2 Star Coupler Loss	45
C4.2.3 Collision Detection	45

SECTION	PAGE
15. Fiber Optic Medium and Common Elements of Medium Attachment Units and Star, Type 10BASE-F	47
15.1 Scope	47
15.1.1 Overview	47
15.1.2 Definitions	50
15.1.3 Applications Perspective: MAUs, Stars, and Fiber Optic Medium	52
15.2 MDI Optical Characteristics	53
15.2.1 Transmit Optical Parameters	53
15.2.2 Receive Optical Parameters	58
15.3 Characteristics of the Fiber Optic Medium	59
15.3.1 Optical Fiber and Cable	59
15.3.2 Optical Medium Connector Plug and Socket	60
15.3.3 Fiber Optic Medium Insertion Loss	61
15.3.4 Electrical Isolation	61
15.4 MAU Reliability	61
15.5 MAU-AUI Specification	62
15.5.1 MAU-AUI Electrical Characteristics	62
15.5.2 MAU-AUI Mechanical Connections	62
15.5.3 Power Consumption	62
15.5.4 MAU-AUI Messages	62
15.6 Environmental Specifications	63
15.6.1 Safety Requirements	63
15.6.2 Electromagnetic Environment	63
15.6.3 Other Environmental Requirements	63
15.7 MAU Labeling	63
15.7.1 10BASE-FP Star Labeling	64
15.8 Protocol Implementation Conformance Statement (PICS) Proforma for Section 15, Fiber Optic Medium and Common Elements of Medium Attachment Units and Star, Type 10BASE-F	65
15.8.1 Introduction	65
15.8.2 Abbreviations and Special Symbols	65
15.8.3 Instructions for Completing the PICS Proforma	66
15.8.4 Identification	68
15.8.5 Major Capabilities/Options	69
15.8.6 PICS Proforma for the Fiber Optic Medium	69
16. Fiber Optic Passive Star and Medium Attachment Unit, Type 10BASE-FP	72
16.1 Scope	72
16.1.1 Overview	72
16.2 PMA Interface Messages	73
16.2.1 PMA-to-MDI Interface Signal Encodings	73
16.2.2 PMA-to-MDI OTD Messages	73
16.2.3 MDI ORD-to-PMA Messages	74
16.3 10BASE-FP MAU Functional Specifications	74
16.3.1 Transmit Function Requirements	75
16.3.2 Receive Function Requirements	77
16.3.3 Loopback Function Requirements	77
16.3.4 Collision Presence Function Requirements	77
16.3.5 <i>signal_quality_error</i> Message (SQE) Test Function Requirements	79
16.3.6 Jabber Function Requirements	79
16.3.7 Link Fault Detection and Low Light Function Requirements	79

SECTION	PAGE
16.3.8	Interface Message Time References 80
16.3.9	MAU State Diagram 80
16.4	Timing Summary 89
16.5	10BASE-FP Star Functional Specifications 89
16.5.1	Star Functions.....89
16.5.2	Star Optical Characteristics 90
16.6	Protocol Implementation Conformance Statement (PICS) Proforma for Section 16, Fiber Optic Passive Star and Medium Attachment Unit, Type 10BASE-FP 91
16.6.1	Introduction.....91
16.6.2	Abbreviations and Special Symbols 91
16.6.3	Instructions for Completing the PICS Proforma.....92
16.6.4	Identification.....94
16.6.5	Major Capabilities/Options.....95
16.6.6	PICS Proforma for the Type 10BASE-FP MAU 95
16.6.7	PICS Proforma Tables for 10BASE-FP Stars 111
17.	Fiber Optic Medium Attachment Unit, Type 10BASE-FB..... 113
17.1	Scope..... 113
17.1.1	Overview..... 113
17.1.2	Relationship to AUI 113
17.2	PMA Interface Messages 113
17.2.1	PMA-to-MDI Interface Signal Encodings 114
17.2.2	PMA-to-MDI OTD Messages 114
17.2.3	MDI ORD-to-PMA Messages 115
17.2.4	Transitions Between Signals 116
17.2.5	Signaling Rate 116
17.3	MAU Functional Specifications 116
17.3.1	Transmit Function Requirements 116
17.3.2	Receive Function Requirements 116
17.3.3	Collision Function Requirements 117
17.3.4	Loopback Function Requirements 117
17.3.5	Fault-Handling Function Requirements 117
17.3.6	Jabber Function Requirements 118
17.3.7	Low Light Level Detection Function Requirements 118
17.3.8	Synchronous Qualification Function Requirements 118
17.3.9	Interface Message Time References 119
17.3.10	MAU State Diagrams..... 119
17.4	Timing Summary 124
17.5	Protocol Implementation Conformance Statement (PICS) Proforma for Section 17, Fiber Optic Medium Attachment Unit, Type 10BASE-FB..... 125
17.5.1	Introduction..... 125
17.5.2	Abbreviations and Special Symbols 125
17.5.3	Instructions for Completing the PICS Proforma..... 126
17.5.4	Identification..... 128
17.5.5	Major Capabilities/Options..... 129
17.5.6	PICS Proforma for the Type 10BASE-FB MAU 129

SECTION	PAGE
18. Fiber Optic Medium Attachment Unit, Type 10BASE-FL.....	142
18.1 Scope.....	142
18.1.1 Overview.....	142
18.2 PMA Interface Messages.....	142
18.2.1 PMA to Fiber Optic Link Segment Messages.....	143
18.2.2 Fiber Optic Link Segment to PMA Messages.....	143
18.2.3 Interface Message Time References.....	143
18.3 MAU Functional Specifications.....	144
18.3.1 MAU Functions.....	144
18.3.2 MAU State Diagrams.....	146
18.4 Timing Summary.....	153
18.5 Protocol Implementation Conformance Statement (PICS) Proforma for Section 18, Fiber Optic Medium Attachment Unit, Type 10BASE-FL.....	154
18.5.1 Introduction.....	154
18.5.2 Abbreviations and Special Symbols.....	154
18.5.2.1 Status Symbols.....	154
18.5.2.2 Abbreviations.....	154
18.5.3 Instructions for Completing the PICS Proforma.....	155
18.5.3.1 General Structure of the PICS Proforma.....	155
18.5.3.2 Additional Information.....	155
18.5.3.3 Exception Information.....	155
18.5.3.4 Conditional Items.....	156
18.5.4 Identification.....	157
18.5.5 Major Capabilities/Options.....	158
18.5.6 PICS Proforma Tables for the Type 10BASE-FL MAU.....	158

FIGURES

Fig 13-4	Example of Maximum Transmission Path with Three Repeater Sets, Four Segments (One 1 km 10BASE-FB, One 1 km FOIRL Link Segment, One 400 m 10BASE-FL, and One 300 m 10BASE-FP).....	28
Fig 13-5	Example of Maximum Transmission Path with Four Repeater Sets, Five Segments (Two 500 m 10BASE-FB, One 500 m FOIRL, One 500 m 10BASE-FL, and One 300 m 10BASE-FP).....	29
Fig 13-6	Generalized Transmission Path Model.....	30
Fig A5	Round-Trip Delay Calculation Model.....	35
Fig A6	Variability Calculation Model.....	37
Fig 15-1	10BASE-F Relationship to the ISO Open Systems Interconnection (OSI) Reference Model and the IEEE 802.3 CSMA/CD LAN Model.....	48
	(a) 10BASE-FP Relationship to OSI and CSMA/CD LAN.....	48
	(b) 10BASE-FB Relationship to CSMA/CD LAN.....	49
	(c) 10BASE-FL Relationship to OSI and CSMA/CD LAN.....	49
Fig 15-2	Fiber Optic Link and Mixing Segments.....	51
	(a) Example Fiber Optic Link Segment, 10BASE-FB and 10BASE-FL.....	51
	(b) Example Fiber Optic Mixing Segment, 10BASE-FP.....	51
Fig 15-3	10BASE-FP MAU Transmit Waveform Template.....	56
Fig 15-4	10BASE-FB MAU Transmit Waveform Template.....	57
Fig 15-5	10BASE-FL MAU Transmit Waveform Template (Data Only).....	58
Fig 15-6	BFOC/2.5 Connector Plug.....	60
Fig 15-7	BFOC/2.5 Connector Socket.....	61
Fig 16-1	10BASE-FP MAU Preamble Encoding.....	76
Fig 16-2	Transmit and Receive Function State Diagram.....	84

FIGURES	PAGE
Fig 16-3	<i>signal_quality_error</i> Message Test Function State Diagram.....85
Fig 16-4	Link Fault State Diagram.....86
Fig 16-5	Jabber Function State Diagram.....87
Fig 16-6	Collision Detect State Diagram.....88
Fig 17-1	MDI Status Signaling Messages.....114
Fig 17-2	Synchronous Qualification State Machine.....121
Fig 17-3	Receive Jabber State Machine.....122
Fig 17-4	MAU Transmit, Receive, Loopback, and Collision Presence Functions State Diagram.....123
Fig 18-1	MAU Transmit, Receive, Loopback, and Collision Presence Functions State Diagram.....149
Fig 18-2	<i>signal_quality_error</i> Message Test Function State Diagram.....150
Fig 18-3	Jabber Function State Diagram.....151
Fig 18-4	Link Integrity Test Function State Diagram.....152

TABLES

Table 9-1	Start-of-Packet Propagation Delays 19
	NOTE: Table 9-1 in ISO/IEC 8802-3 : 1993 becomes Table 9-4.
Table 9-2	Start-of-Collision Jam Delays 20
Table 9-3	Cessation-of-Jam Delays.....21
Table 13-1	Delays for Network Media Segments.....27
Table 13-2	Segment Round-Trip Delay Values in Bit Times.....31
Table 13-3	Segment Variability Values in Bit Times.....32
Table A1	Timing Parameters for Round-Trip Delay and Variability Calculations.....40
Table C1	Alternative Fiber Types 43
Table C2	Worst-Case Loss Budget.....44
Table C3	Worst-Case Launch Power.....44
Table 15-1	MDI Optical Parameters 55
Table 15-2	Transmitted Optical Waveform Values for Fig 15-3 56
Table 15-3	Transmitted Optical Waveform Values for Fig 15-4 57
Table 15-4	Transmitted Optical Waveform Values for Fig 15-5 58
Table 16-1	Maximum Timing Parameters.....89
Table 17-1	MDI Fault Conditions and Their States 117
Table 17-2	Maximum Timing Parameters 124
Table 18-1	Maximum Timing Parameters 153

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**Fiber Optic Active and Passive Star-Based
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(These changes and additions are part of IEEE Std 802.3j-1993.)

The following changes to ISO/IEC 8802-3 : 1993 [ANSI/IEEE Std 802.3, 1993 Edition] include changes and additions to Sections 4, 7, 8, 9, 10, 13, the Annex, Appendix A, and Appendix C. Section 4.4.2.1 has been revised; a definition was modified in 7.1.1; a definition was modified in 8.1.2; 8.6.1 has been replaced with a new section, and Figs 8-10 through 8-14 have been deleted. Section 9 has been extensively revised. Section 10.7.1 has been replaced with a new section, and Figs 10-8 and 10-11 have been deleted. Section 13 has been replaced with a new section that includes modifications to one figure, the addition of Figs 13-4 through 13-6, and the addition of Tables 13-2 and 13-3. The Annex has been changed to Annex A and references have been added. A new subsection A1.5 and a new Section A5 have been added to Appendix A. Section C4 of Appendix C is new.

Editing instructions are shown in ***bold italic*** type.

4. Media Access Control

Change 4.4.2.1 to read as follows:

4.4.2.1 Parameterized Values. The following table identifies the parameter values that shall be used in the 10 Mb/s implementation of a CSMA/CD MAC procedure:

<u>Parameters</u>	<u>Values</u>
slotTime	512 bit times
interFrameGap	9.6 μ s
attemptLimit	16
backoffLimit	10
jamSize	32 bits
maxFrameSize	1518 octets
minFrameSize	512 bits (64 octets)
addressSize	48 bits

NOTE: The spacing between two successive noncolliding packets, from start of idle at the end of the first packet to start of preamble of the subsequent packet, can have a minimum value of 47 bit times, at the AUI receive line of the DTE. This InterFrameGap shrinkage is caused by variable network delays, added preamble bits, and clock skew.

WARNING: Any deviation from the above values specified for a 10 Mb/s system may affect proper operation of the LAN.

7. Physical Signaling (PLS) and Attachment Unit Interface (AUI) Specifications

Revise the definition of bit time in 7.1.1 to read as follows:

bit time (BT). The duration of one bit symbol (1/BR).

8. Medium Attachment Unit and Baseband Medium Specifications, Type 10BASE5

Revise 8.1.2 and 8.6.1 to read as follows:

8.1.2 Definitions

Medium Attachment Unit (MAU). In a local area network, a device used in a data station to couple the data terminal equipment or repeater to the transmission medium.

Replace all of 8.6.1 as follows:

8.6.1 Transmission System Model. The maximum configuration for the physical transmission system is as follows:

- (1) A trunk coaxial cable, terminated in its characteristic impedance at each end, constitutes a coaxial cable segment. A coaxial cable segment may contain a maximum of 500 m of coaxial cable and a maximum of 100 MAUs. The propagation velocity of the coaxial cable is assumed to be 0.77 c minimum ($c = 300\,000$

km/s). The maximum end-to-end propagation delay for a coaxial cable segment is 2165 ns.

- (2) Repeater sets are required for segment interconnection. Repeater sets occupy MAU positions on coaxial cable segments and count toward the maximum number of MAUs on a coaxial cable segment. Repeater sets may be located in any MAU position on a coaxial cable segment.
- (3) The repeater unit specified in Section 9 provides the means for connecting 10 Mb/s baseband segments into a CSMA/CD network. The proper operation of a CSMA/CD network requires network size to be limited to control round-trip propagation delay to meet the requirements of 4.2.3.2.3 and 4.4.2.1, and the number of repeaters between any two DTEs to be limited in order to limit the shrinkage of interpacket gap as it travels through the network. Configuration rules, which ensure that these limits are not exceeded, are given in Section 13.

Figure remains unaltered:

Fig 8-8
Coaxial Tap Connector Configuration Concepts

Figure remains unaltered:

Fig 8-9
Typical Coaxial Tap Connection Circuit

Delete all figures in the remainder of Section 8.

9. Repeater Unit for 10 Mb/s Baseband Networks

Change Section 9 subsections as shown below:

9.1 Overview. This section specifies a repeater for use with ISO/IEC 8802-3 10 Mb/s baseband networks. A repeater for any other ISO/IEC 8802-3 network type is beyond the scope of this section.

A repeater set connects segments of network medium together, thus allowing larger topologies and a larger MAU base than are allowed by rules governing individual segments.

Repeater sets are used to extend the network length and topology beyond what could be achieved by a single mixing segment. Mixing segments may be connected directly by a repeater set (Fig 9-1) or by several repeater units that are, in turn, connected by link segments. Repeater sets are also used as the hub in a star topology network in which DTEs attach directly to link segments (e.g., 10BASE-T, Section 14). Allowable topologies shall contain only one operative signal path between any two points on the network. The proper operation of a CSMA/CD network requires network size to be limited to control round-trip propagation delay to meet the requirements of 4.2.3.2.3 and 4.4.2.1, and the number of repeaters between any two DTEs to be limited in order to limit the shrinkage of interpacket gap as it travels through the network. The method for validating networks with respect to these requirements is specified in Section 13.

If the repeater set uses MAUs connected via AUIs to a repeater unit, these MAUs shall not perform the *signal_quality_error* Test function. A manufacturer may, optionally, integrate one or all MAUs into a single package with the repeater unit (internal MAUs). In all

cases, the MAU portion of the repeater set must be counted toward the maximum number of MAUs on each segment. A repeater set is not a station and does not count toward the overall limit of 1024 stations on a network.

A repeater set can receive and decode data from any segment under worst-case noise, timing, and signal amplitude conditions. It retransmits the data to all other segments attached to it with timing and amplitude restored. The retransmission of data occurs simultaneously with reception. If a collision occurs, the repeater set propagates the collision event throughout the network by transmitting a Jam signal.

9.2 Definitions

Add the following definition to 9.2:

mixing segment. A medium that may be connected to more than two Medium Dependent Interfaces.

9.3 References. See 1.3.

9.4 Compatibility Interface. The repeater shall attach to its network segments by any of the means specified below.

9.4.1 AUI Compatibility. The repeater unit shall be compatible at its AUI connector (if so equipped) as specified in Section 7 with the exception of the *signal_quality_error* message Test, 7.2.1.2.3, which shall not be implemented.

10BASE5 and 10BASE2 MAUs associated with the repeater unit shall be as specified in Section 8 for type 10BASE5 and Section 10 for type 10BASE2 with the following restrictions:

- (1) The MAU shall implement receive mode collision detect as defined in 8.3.1.5 or 10.4.1.5.
- (2) The MAU shall not implement the *signal_quality_error* Message Test function as defined in 8.2.1.1 and 10.3.1.1.
- (3) The MAU shall not activate its Jabber function when operated under the worst-case Jabber Lockup Protection condition as specified in 9.6.5.
- (4) The MAU shall operate only in the normal mode as defined in 8.1.3.4, not in the monitor mode.

All other MAUs associated with the repeater unit shall be as specified in their respective sections and shall not perform the *signal_quality_error* Message Test function.

9.4.2 Mixing Segment Compatibility. The repeater set, which includes MAUs integrated with the repeater package (internal MAUs), may have any of the interfaces specified in the following subsections. The MAUs associated with the repeater that are connected in this manner shall be subject to the restrictions of MAUs as specified in 9.4.1.

9.4.2.1 Direct Coaxial Cable Attachment Compatibility. The repeater shall be compatible at its coaxial tap connector (if so equipped) as specified in 8.5.3 of the 10BASE5 standard.

9.4.2.2 “N” Connector Compatibility. The repeater shall be compatible at its Type N connector (if so equipped) as specified in 8.5.

9.4.2.3 BNC Compatibility. The repeater shall be compatible at its BNC connector (if so equipped) as specified in 10.6.

9.4.2.4 BFOC/2.5 (10BASE-FP) Compatibility. The repeater shall be compatible at its BFOC/2.5 10BASE-FP connector (if so equipped) as specified in 15.3.2 (also see 15.1).

9.4.3 Link Segment Compatibility. The compatibility interfaces for link segments including IRL segments are either vendor-dependent, as specified in 9.4.3.1, or are vendor-independent MDI, as defined in the remainder of this section. The MAUs associated with the repeater that are connected in this manner shall be subject to the restrictions of MAUs as specified in 9.4.1.

9.4.3.1 Vendor-Dependent IRL. The budget allowances for the topology supported by the IRL shall ensure that the total network round-trip delay requirement is met and the maximum collision frame size of 511 bits is not exceeded. (See 13.4.1).

9.4.3.2 Fiber Optic FOIRL Compatibility. The repeater shall be compatible at its FSMA connector (if so equipped) as specified in 9.9.

9.4.3.3 Twisted-Pair Jack Compatibility. The repeater set shall be compatible at its 8-pin modular jack (if so equipped), as specified in 14.5.

9.4.3.4 Fiber Optic 10BASE-FB and 10BASE-FL Compatibility. The repeater shall be compatible at its BFOC/2.5 (10BASE-FB and/or 10BASE-FL) connector (if so equipped) as specified in 15.3.2 (also see 15.1).

9.5 Basic Functions

9.5.1 Start-of-Packet Propagation Delays. The start-of-packet propagation delay for a repeater set is the time delay between the first edge transition of the packet on its repeated from (input) port to the first edge transition of the packet on its repeated to (output) port (or ports).

For a repeater unit with AUI connectors at input and output ports, this time shall be less than or equal to 8 bit times.

For a repeater set with internal MAUs on input and output ports, additional delays shall be allowed as enumerated in Table 9-1.

Table 9-1
Start-of-Packet Propagation Delays
(Repeater Unit Delay of 8 BT Plus)

MAU Type	Input (BT)	Output (BT)
10BASE5	6.5	3.5
10BASE2	6.5	3.5
FOIRL	3.5	3.5
10BASE-T	8	5
10BASE-FP	3	4
10BASE-FB	2	2
10BASE-FL	5	5

Existing Table 9-1 becomes Table 9-4.

9.5.5.2 Start-of-Packet Variability. The start-of-packet variability, defined as the total worst-case difference between start-of-packet propagation delays for successive packets separated by 96 bit times or less, shall be less than 4 bit times for a repeater unit. For a 10BASE-FB repeater set the total worst-case difference between start-of-packet propagation delays for successive packets separated by 96 bit times or less, shall be less than 2 bit times for a repeater set, all of which is allocated to the repeater unit.

9.5.6 Collision Handling

9.5.6.3 Collision-Jam Propagation Delays. The start-of-collision propagation delay for a repeater set is the time delay between the first edge transition of the *signal_quality_error* signal on any of its ports to the first edge transition of the Jam on its (output) port (or ports).

For a repeater unit with AUI connectors at input and output ports, this time shall be less than or equal to 6.5 bit times.

For a repeater set with internal MAUs on input and output ports, additional delays shall be allowed as enumerated in Table 9-2.

Table 9-2
Start-of-Collision Jam Delays

(Repeater Unit Delay of 6.5 BT Plus)

MAU Type	Input (BT)	Output (BT)
10BASE5	9*	3.5
10BASE2	9*	3.5
FOIRL	3.5	3.5
10BASE-T	9	5
10BASE-FP	11.5	1
10BASE-FB	3.5	2
10BASE-FL	3.5	5

* This does not include collision rise time on the coaxial media. For the worst-case round-trip delay calculation, collision rise time plus MAU propagation delay = 17 bit times.

The cessation-of-Jam propagation delay for a repeater unit is the time delay between the input signals at its ports reaching a state such that Jam should end at a port and the last transition of Jam at that port. The states of the input signals that should cause Jam to end are covered in detail in the repeater state diagrams.

For a repeater unit with AUI connectors at input and output ports, this time shall be less than or equal to 5 bit times when not extending fragments. When extending fragments, this delay may be longer as required by the fragment extension algorithm. See 9.6.4.

For a repeater set with internal MAUs on input and output ports, an additional allowance for cessation-of-Jam propagation shall be allowed as specified in Table 9-3.

For a repeater set with internal MAUs on its input ports, an additional delay allowance for DI and for *signal_quality_error* deassertion shall be made as specified in Table 9.3.

Table 9-3
Cessation-of-Jam Delays

(Repeater Unit Delay of 5 BT Plus)

MAU Type	Cessation-of-Collision Jam from DI (BT)		Cessation-of-Collision Jam from SQE (BT)	
	Input	Output	Input	Output
10BASE5	0.5	0.5	20	0.5
10BASE2	0.5	0.5	20	0.5
FOIRL	0.5	0.5	7	0.5
10BASE-T	2	2	9	2
10BASE-FP	3	3	36	3
10BASE-FB	5	2	5	2
10BASE-FL	2	2	7	2

9.6.3 Preamble Regeneration. The repeater unit shall output at least 56 bits of preamble followed by the SFD. When the repeater unit must send more than 56 bits, the maximum length preamble pattern it shall send is the number received plus 6. If the receive port is type 10BASE-FB, then the maximum length preamble pattern it shall send is the number received plus 2.

NOTE: Type 10BASE-FB ports always receive at least 56 bits of preamble due to the constraints on the transmitter and link.

9.7 Electrical Isolation. There are two electrical power distribution environments to be considered that require different electrical isolation properties.

Environment A — When a LAN or LAN segment, with all its associated interconnected equipment, is entirely contained within a single low-voltage power distribution system and within a single building.

Environment B — When a LAN crosses the boundary between separate power distribution systems or the boundaries of a single building.

The repeater unit shall comply with applicable local and national codes related to safety. See ECMA-97 [A9].

9.7.1 Environment A Requirements. Attachment of network segments via repeaters (sets) possessing internal MAUs requires electrical isolation of 500 V rms, 1 min withstand, between the segment and the protective ground of the repeater unit.

For repeater ports that connect to external MAUs via an AU Interface, the requirement for isolation is encompassed within the isolation requirements of the basic MAU/medium standard. (See 8.3.2.1, 9.9.3.1, 10.4.2.1, 14.3.1.1, and 15.3.4.) The repeater unit shall not require any electrical isolation between exposed AU Interfaces or between exposed AU Interfaces and chassis ground of the repeater unit. No isolation boundary need therefore exist at any AUI compatible interface (that is, “D” connector) provided by a repeater unit.

9.7.2 Environment B Requirements. The attachment of network segments, which cross environment A boundaries, requires electrical isolation of 1500 V rms, 1 min withstand, between each segment and all other attached segments and also the protective ground of the repeater unit.

If segments are of an electrically conductive medium, it is recommended that this isolation be provided by the use of external MAUs connected by AU Interfaces. If internal MAUs are used for attachment to conductive media segments, then the segments shall be installed such that it is not possible for an equipment user to touch the trunk cable screen or signal conductor. A repeater of this variety requires professional installation.

The requirements for interconnected electrically conducting LAN segments that are partially or fully external to a single building environment may require additional protection against lightning strike hazards. Such requirements are beyond the scope of this standard.

It is recommended that the above situation be handled by the use of a nonelectrically conducting LAN segment (see 9.9 or Section 15).

9.9 Medium Attachment Unit and Baseband Medium Specification for a Vendor-Independent FOIRL

9.9.1 Scope

9.9.1.1 Overview. A vendor-independent FOIRL provides a standard means for connecting a repeater via optical fiber to another repeater or to a DTE. It thus extends the network length and topology beyond that which could be achieved by interconnecting coaxial cable segments via repeater sets only, as defined in 8.6 or 10.7. A vendor-independent FOIRL is suited for interconnecting repeaters and their respective segments located in different buildings. FOMAUs that are used for the DTE end of the link segment are beyond the scope of this section. See Section 18.

NOTE: The FOMAU specified in 9.9 has been superseded by the specification to be found in Section 18. The new specification is fully compatible (except for media connector) with the specifications of 9.9 at the MDI. The new specification calls out more recent practice in connectors and state machines. It also provides improved performance for long link segments and reflects more recent industry input on flux parameters.

In particular, this section defines the following:

- (1) The functional, optical, electrical, and mechanical characteristics of a fiber optic MAU (FOMAU) suitable for interfacing to a repeater unit, either directly (FOMAU and repeater unit integrated into a single package) or via an AUI mechanical connection.
- (2) Various optical fiber sizes suitable for connecting only two FOMAUs.

A schematic of the vendor-independent FOIRL and its relationship to the repeater unit is shown in Fig 9-7. The vendor-independent FOIRL comprises an optical fiber cable link segment, a vendor-independent FOMAU at each end of the link segment and, if present, AUI cables.

The purpose of this specification is to enable interoperability of FOMAUs that originate from different manufacturers, thereby facilitating the development of simple and inexpensive inter-repeater links (IRLs). To satisfy this objective, the FOMAU has the following general characteristics:

- (a) Enables coupling the repeater unit PLS directly, or by way of the AUI mechanical connection, to the explicit baseband optical fiber cable link segment defined in this section of the standard.
- (b) Supports signaling at a data rate of 10 Mb/s.
- (c) Provides for driving up to 1000 m of an optical fiber cable link segment.
- (d) Operates indistinguishably from other types of repeater set MAUs, as defined in their respective 10 Mb/s baseband MAU sections when viewed from the AU Interface.

- (e) Supports 10 Mb/s baseband system configurations as defined in Section 13 of this standard.
- (f) Allows integration of the FOMAU into a single package with the repeater unit, thereby eliminating the need for an AUI mechanical connection.

Change the top and bottom text lines in Fig 9-7 to read as follows:

TO 10 Mb/s BASEBAND NET

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·
·

TO 10 Mb/s BASEBAND NET

9.9.1.2 Application Perspective: FOMAU and Medium Objectives. This section states the broad objectives underlying the vendor-independent FOIRL specification defined throughout this section of the standard. These are as follows:

- (1) Provide the physical means for connecting a repeater via fiber to another repeater or to a DTE.
- (2) Define a physical interface for the vendor-independent FOMAU component of the vendor-independent FOIRL that can be implemented independently among different manufacturers of hardware and achieve the intended level of compatibility when interconnected in a common IRL.
- (3) Provide a communication channel capable of high bandwidth and low bit error rate performance. The resultant BER of the FOIRL should be less than one part in 10^{10} .
- (4) Provide a means to prevent packet transmission through an FOIRL when transmission capability in one or both directions is disrupted.

Add the following text as a note at the end of the existing note that follows 9.9.4.1.8:

NOTE: The transmit optical power range specified above is the power coupled into the core of the optical fiber. Typical current fibers require 1 m to 5 m to remove optical power from the cladding. For links under 5 m in length, it may be necessary to use techniques such as attenuators or mode-stripping filters to attenuate optical power coupled into the cladding in order to meet the requirements of 9.9.4.2.1.

Add the following text as a note at the end of 9.9.5.1:

NOTE: For newer fiber installations, it is recommended that the requirements of 15.3 be used.

9.9.6.2 Timing Considerations. Table 9-4 summarizes...

Change Table 9-1 to Table 9-4.

9.9.7 Environmental Specifications

9.9.7.1 Safety Requirements

9.9.7.1.1 Electrical Safety. A major application for the vendor-independent FOIRL is interconnecting electrically conductive cable segments located within different buildings. The level of isolation provided by the optical fiber cable link segment shall be consistent with this application and provide adequate personnel and equipment safety from earth faults and lightning strike hazards.

10. Medium Attachment Unit and Baseband Medium Specifications, Type 10BASE2

Change 10.7.1 to read as follows:

10.7.1 Transmission System Model. The maximum configuration for the physical transmission system is as follows:

- (1) A trunk coaxial cable, terminated in its characteristic impedance at each end, constitutes a coaxial cable segment. A coaxial cable segment may contain a maximum of 185 m (600 ft) of coaxial cable and a maximum of 30 MAUs. The propagation velocity of the coaxial cable is assumed to be 0.65 c minimum ($c = 3 \times 10^8$ m/s). The maximum end-to-end propagation delay for a coaxial cable segment is 950 ns.
- (2) The maximum transmission path permitted between any two MAUs is limited by the number of repeater sets that can be connected in series.

NOTE: Care should be taken to ensure that the safety requirements are met when extending the trunk cable by the use of repeaters (see 10.7.2.5).

- (3) The repeater unit specified in Section 9 provides the means for connecting 10 Mb/s baseband segments into a CSMA/CD network. The proper operation of a CSMA/CD network requires network size to be limited to control round-trip propagation delay to meet the requirements of 4.2.3.2.3 and 4.4.2.1, and the number of repeaters between any two DTEs to be limited in order to limit the shrinkage of the interpacket gap as it travels through the network. Configuration rules, which ensure that these limits are not exceeded, are given in Section 13.

Delete this figure:

**Fig 10-8
Maximum Transmission Path**

Figure remains unaltered:

**Fig 10-8 (old 10-9)
The Minimum System Configuration**

Figure remains unaltered:

**Fig 10-9 (old 10-10)
The Minimum System Configuration Requiring a
Repeater Set**

Delete this figure:

**Fig 10-11
An Example of a Large Hybrid System**

13. System Considerations for Multisegment 10 Mb/s Baseband Networks

Change and amend Section 13 as shown below:

13.1 Overview. This section provides information on building 10 Mb/s multisegment baseband networks within a single collision domain. The proper operation of a CSMA/CD network requires network size to be limited to control round-trip propagation delay to meet the requirements of 4.2.3.2.3 and 4.4.2.1, and the number of repeaters between any two DTEs to be limited in order to limit the shrinkage of the interpacket gap as it travels through the network.

This section provides two network models. Transmission System Model 1 is a set of configurations that have been validated under conservative rules and have been qualified as meeting the two requirements set forth above. Transmission System Model 2 is a set of calculation aids that allow a configuration to be qualified against the two requirements. This set of calculation aids allows those configuring a network to test a proposed configuration against a simple set of criteria that allows it to be qualified. The Model 2 Transmission System Model validates an additional broad set of topologies that are fully functional and do not fit within the simpler but more restrictive rules of Model 1.

The physical size of a CSMA/CD network is limited by the characteristics of individual network components. These characteristics include the following:

- (1) Media lengths and their associated propagation time delay
- (2) Delay of repeater units (start-up and steady-state)
- (3) Delay of MAUs (start-up and steady-state)
- (4) Interpacket gap shrinkage due to repeater units
- (5) Delays within the DTE associated with the CSMA/CD access method
- (6) Collision detect and deassertion times associated with MAUs

Table 13-1 summarizes the delays for the various network media segments. In addition, Section 14 summarizes the delays for the 10BASE-T MAU (Table 14.2); Section 8, the delays for the 10BASE5 MAU; Section 10, the delays for the 10BASE2 MAU; Section 9, the delays of the Fiber Optic Inter Repeater Link (FOIRL) and the repeater (Table 9-1, 9-2, and 9-3); Section 16, the delays for the 10BASE-FP MAU (Table 16-1, also see 15.1); Section 17, the delays for the 10BASE-FB MAU (Table 17-1, also see 15.1), and Section 18, the delays for the 10BASE-FL MAU (Table 18-1, also see 15.1).

For a more detailed description of the calculation methods used to arrive at Transmission System Model 2, see Appendix A1.5.

13.1.1 Repeater Usage. Repeaters are the means used to connect segments of network medium together, thus allowing larger topologies and a larger MAU base than are allowed by the rules governing individual segments. Different media/segment types can only be connected to each other using repeaters.

13.2 Definitions. This section defines the terminology used in this section.

Collision Domain. A single CSMA/CD network. If two or more MACs are within the same collision domain and both transmit at the same time, a collision will occur. MACs separated by a repeater are within the same collision domain. MACs separated by a bridge are within different collision domains.

Link Segment. The point-to-point full duplex medium connection between two and only two Medium Dependent Interfaces.

Mixing Segment. A medium that may be connected to more than two Medium Dependent Interfaces.

Path. The sequence of segments and repeaters providing the connectivity between two DTEs. In CSMA/CD networks, there is one and only one path between any two DTEs.

Path Delay Value (PDV). The sum of the SDVs for all the segments along a given path.

Path Variability Value (PVV). The sum of the SVVs for all the segments along a given path.

Segment. The medium connection, including connectors, between Medium Dependent Interfaces in a CSMA/CD LAN.

Segment Delay Value (SDV). A number associated with a given segment that represents the delay on that segment (including a repeater and end stations, if present). The SDV calculation methodology and value table is specified in 13.4.1.2.

Segment Variability Value (SVV). A number associated with a given segment that represents the delay variability on that segment (including a repeater). The SVVs for different segment types are specified in Table 13-3.

13.3 Transmission System Model 1. The following network topology constraints apply to networks using Transmission System Model 1. If no segment length constraints are given for a segment type, the maximum segment length, as defined in the relevant MAU section, applies.

- (1) Repeater sets are required for all segment interconnection.
- (2) MAUs that are part of repeater sets count toward the maximum number of MAUs on a segment.
- (3) The transmission path permitted between any two DTEs may consist of up to five segments, four repeater sets (including optional AUIs), two MAUs, and two AUIs.
- (4) AUI cables for 10BASE-FP and 10BASE-FL shall not exceed 25 m. (Since two MAUs per segment are required, 25 m per MAU results in a total AUI cable length of 50 m per segment).
- (5) When a transmission path consists of four repeater sets and five segments, up to three of the segments may be mixing and the remainder must be link segments (Figs 13-1, 13-2, and 13-5). When five segments are present, each fiber optic link segment (FOIRL, 10BASE-FB, or 10BASE-FL) shall not exceed 500 m, and each 10BASE-FP segment shall not exceed 300 m.
- (6) When a transmission path consists of three repeater sets and four segments (Figs 13-3 and 13-4), the following restrictions apply:
 - (a) The maximum allowable length of any inter-repeater fiber segment shall not exceed 1000 m for FOIRL, 10BASE-FB, and 10BASE-FL segments and shall not exceed 700 m for 10BASE-FP segments.
 - (b) The maximum allowable length of any repeater to DTE fiber segment shall not exceed 400 m for 10BASE-FL segments and shall not exceed 300 m for 10BASE-FP segments and 400 m for segments terminated in a 10BASE-FL MAU.
 - (c) There is no restriction on the number of mixing segments in this case.

Table 13-1
Delays for Network Media Segments

Media Type	Maximum Number of MAUs per Segment	Maximum Segment Length (m)	Maximum Medium Delay per Segment (ns)
Mixing Segment			
10BASE5	100	500	2165
10BASE2	30	185	950
10BASE-FP	33*	1000**	5000
Link Segment			
FOIRL	2	1000	5000
10BASE-T	2	100†	1000
10BASE-FB	2	2000	10000
10BASE-FL	2	2000	10000
AUI‡ 1 DTE/1 MAU		50	257

* Actual number depends on the passive-star characteristics; see 16.5.2.1.

** In addition, a MAU to passive-star link will not exceed 500 m.

† Actual maximum segment length depends on cable characteristics; see 14.1.1.3.

‡ AUI is not a segment.

Revise the remainder of Section 13 as follows:

- (1) *Existing Fig 13-1 goes here with the following changes:*
 - (a) *Change the title from “Maximum Transmission Path with Three Coaxial Cable Segments” to “Maximum Transmission Path with Three Coaxial Cable Segments and Two Link Segments.”*
 - (b) *Change labeling of both end segments from “10BASE-T Link Seg 100 m” to*

10BASE-T	10BASE-T
Link Seg	Link Seg
100 m	100 m
or FOIRL/	or FOIRL/
10BASE-FL	10BASE-FL
Link Seg	Link Seg
500 m	500 m

- (2) *Existing Fig 13-2 goes here with no changes.*
- (3) *Existing Fig 13-3 goes here with no changes.*

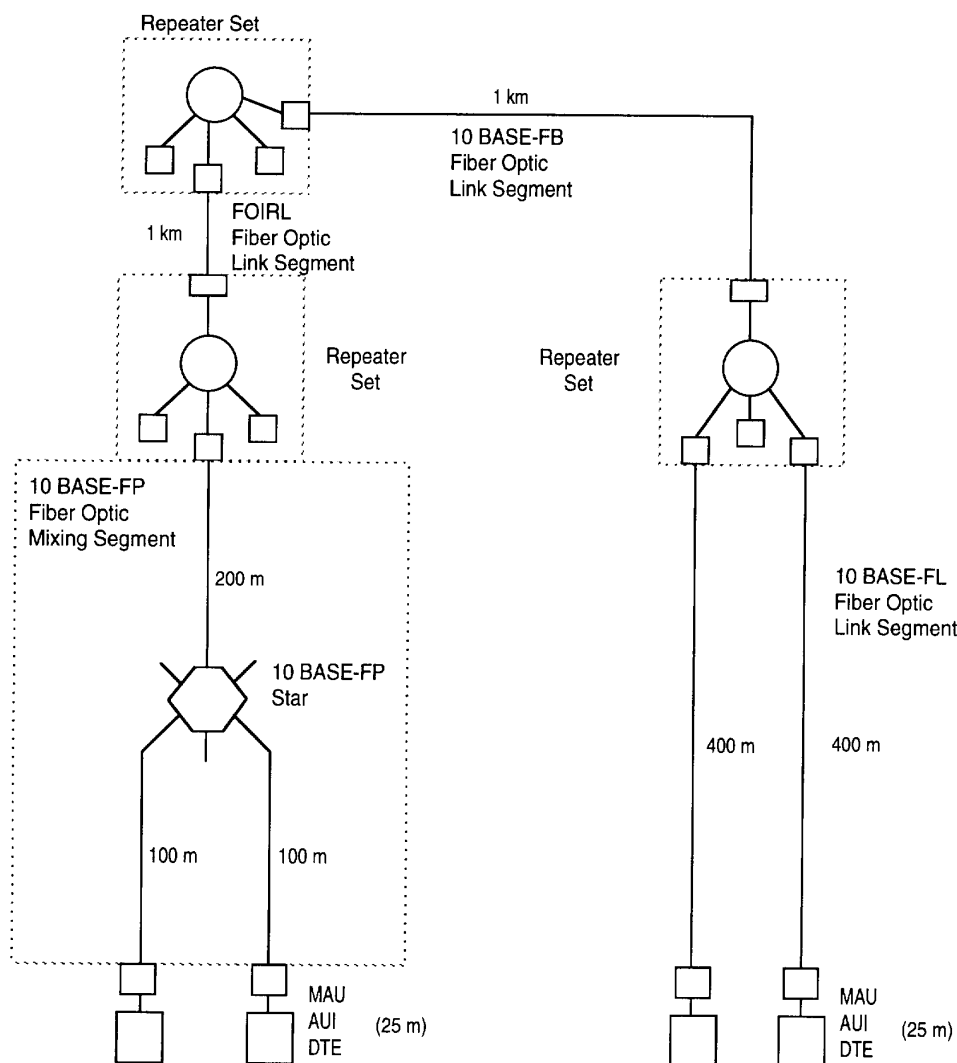


Fig 13-4
Example of Maximum Transmission Path with Three Repeater Sets, Four Segments
(One 1 km 10BASE-FB, One 1 km FOIRL Link Segment, One 400 m 10BASE-FL,
and One 300 m 10BASE-FP)

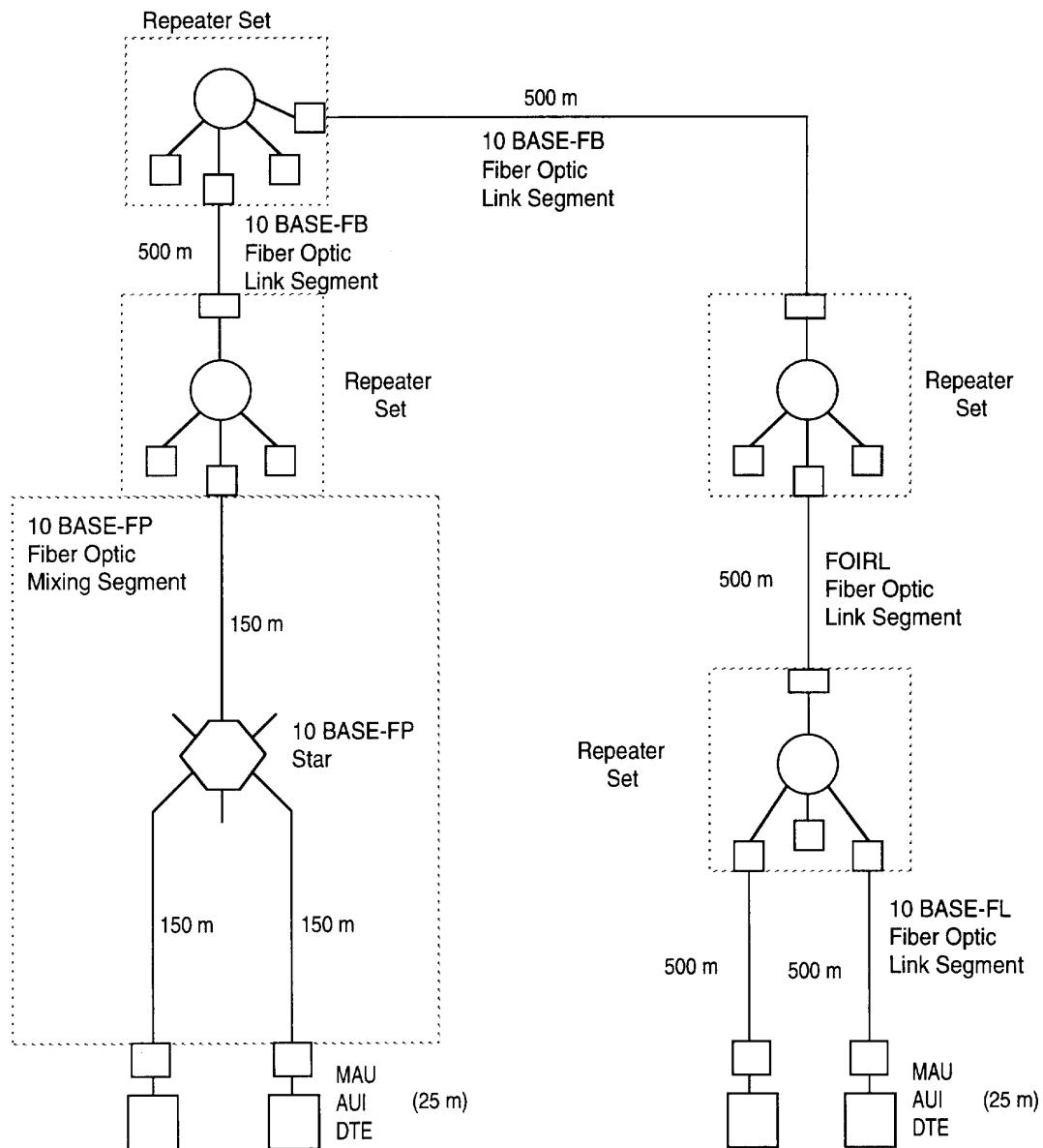


Fig 13-5
Example of Maximum Transmission Path with Four Repeater Sets, Five Segments
 (Two 500 m 10BASE-FB, One 500 m FOIRL, One 500 m 10BASE-FL,
 and One 300 m 10BASE-FP)

13.4 Transmission System Model 2. The physical size and number of topological elements in a 10 Mb/s baseband network is limited by two factors, round-trip collision delay and interpacket gap shrinkage. A network configuration must be validated against each of these separately. A model of the network is required for each of the calculations. The model consists of a series of segments consisting of a left-end segment, mid-segments, and a right-end segment. The model of the network used in the calculations consists of the worst-case path through the network for that particular calculation. The calculations are sufficiently straightforward that they can be done manually. They are also easy to implement in a spreadsheet. In general, the worst-case path for the two calculations is not the same for any single network. The requirements for each calculation and its respective model are detailed in the following subsections and in Fig 13-6.

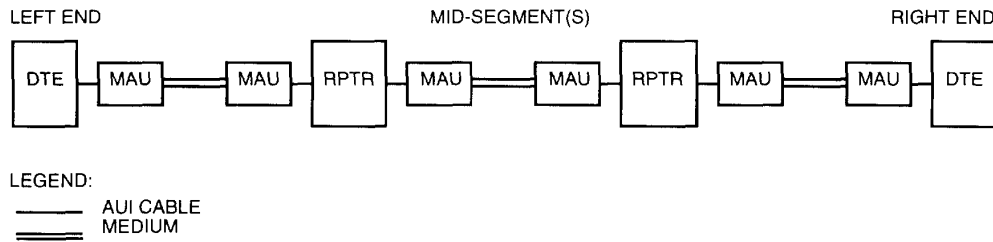


Fig 13-6
Generalized Transmission Path Model

13.4.1 Round-Trip Collision Delay. For a network to be valid, it must be possible for any two DTEs on that network to contend for the network at the same time. Each station attempting to transmit must be notified of the contention by the returned “collision” signal within the “collision window” [see 4.1.2.2 and 5.2.2.1.2(1)]. Additionally, the maximum length fragment created must contain less than 511 bits after the Start Frame Delimiter (SFD). This requirement limits the physical diameter (maximum distance between DTEs) of a network. The maximum round-trip delay must be qualified between all pairs of DTEs in the network. In practice this means that the qualification must be done between those that, by inspection of the topology, are candidates for the longest delay.

The following network modeling methodology is provided to assist that calculation.

13.4.1.1 Worst-Case Path Delay Value (PDV) Selection. The worst-case path through a network to be validated shall be identified. The worst case consists of the path between the two DTEs at opposite ends of the network that have the longest round-trip time (see Fig 13-6).

13.4.1.2 Worst-Case PDV Calculation. Once a set of paths is chosen for calculation, each shall be checked for validity against the following formulas. (If a candidate for worst-case path has end segments of different types, calculations for the path must be performed twice, considering first one end segment as the left end, and then the other, and the maximum value obtained used as the PDV.)

- (1) Determine the Segment Delay Value (SDV) from Table 13-2 for each of the segments in the path.

$$\text{SDV} = \text{Base} + [\text{Length} * (\text{Round-Trip Delay/meter})]$$

(For mixing segments, length is the length between the repeater and the farthest end of the segment for end segments, or the length between two repeaters for mid-segments.)

or

SDV = Max

(Max is equal to the value above for the maximum media segment length. It is provided for ease of calculation with segments that are at their maximum length or as a default value when the length is not known).

NOTE: The SDV figure in the table includes allowance for an AUI at each end of the segment (except for 10BASE-FB) and up to 2 m of drop cable. In 10BASE5 segments, AUI cables are normally longer than 2 m. Care should be exercised to assure that provision is made for the delay associated with their actual length.

- (2) From Table 13-2, determine the SDV for the sum of all AUI cables in excess of 2 m (except the AUI associated with the left end DTE, which does not contribute to the PDV).
- (3) Sum all SDVs from item (1) and item (2) plus a margin of up to 5 bits to form the PDV. The margin may be from 0 to 5 bits; 5 bits is recommended. If the PDV is less than or equal to 575, the path is qualified in terms of worst-case delay.

Table 13-2
Segment Round-Trip Delay Values in Bit Times

(PDV Not to Exceed 572)

Segment Type	Max Length	Left End		Mid-segment		Right End		RT Delay/ meter
		Base	Max	Base	Max	Base	Max	
10BASE5 Coax	500	11.75	55.05	46.5	89.8	169.5	212.8	0.0866
10BASE2 Coax	185	11.75	30.731	46.5	65.48	169.5	188.48	0.1026
FOIRL	1000	7.75	107.75	29	129	152	252	0.1
10BASE-T	100*	15.25	26.55	42	53.3	165	176.3	0.113
10BASE-FP	1000	11.25	111.25	61	161	183.5	284	0.1
10BASE-FB	2000	N/A **	N/A **	24	224	N/A **	N/A **	0.1
10BASE-FL	2000	12.25	212.25	33.5	233.5	156.5	356.5	0.1
Excess length AUI	48	0	4.88	0	4.88	0	4.88	0.1026

* Actual maximum segment length depends on cable characteristics; see 14.1.1.3.

** N/A: Not Applicable, 10BASE-FB does not support end connections.

13.4.2 Interpacket Gap (IPG) Shrinkage. The worst-case variabilities of transmission elements in the network plus some of the signal reconstruction facilities required in the 10 Mb/s baseband repeater specification combine in such a way that the gap between two packets travelling across the network may be reduced below the interFrameGap specified in 4.4.2.1. This parameter limits the equipment (i.e., number of repeaters) between any two DTEs. Again this limit applies to all combinations of DTEs on any network but the worst case is apparent from an inspection of a map or schematic representation of the topology in question.

13.4.2.1 Worst-Case Path Variability Value (PVV) Selection. A worst-case path through a network to be validated shall be identified.

It should be noted that the receive end segment is not counted in this scenario. This means that in an asymmetrical network where the end segments are of different types, the end segment with the worst variability shall be designated as the "Transmitting End" for this evaluation.

13.4.2.2 Worst-Case Path Variability Value (PVV) Calculation. Once a set of paths is chosen for calculation each shall be checked for qualification by the following method:

- (1) Determine the Segment Variability Value (SVV) from Table 13-3 for each of the segments in the Path, excluding the end segment with the lower SVV.
- (2) Sum all of the SVVs from item 1 to form the PVV. If the PVV is less than or equal to 49, the path is qualified in terms of worst-case variability.

Table 13-3
Segment Variability Values in Bit Times

(PVV Not to Exceed 49)

Segment Type	Transmitting End	Mid-segment
Coax	16	11
Link except 10BASE-FB	10.5	8
10BASE-FB	N/A *	2
10BASE-FP	11	8

* N/A: Not Applicable, 10BASE-FB does not support end connections.

Annex A. Additional Reference Material

Add the following references to the existing Annex, and retitle it “Annex A.”

[A20] ANSI/EIA 455-34 (1985), Fiber Optics—Interconnection Device Insertion Loss Test.

[A21] ANSI/EIA/TIA 455-59 (1989), Measurement of Fiber Point Defects Using an Optical Time Domain Reflectometer (OTDR).

[A22] ANSI/EIA/TIA 526-14 (1990), Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.

[A23] ANSI/EIA/TIA 455-180 (1990), Measurement of the Optical Transfer Coefficients of a Passive Branching Device (Coupler).

[A24] IEC Publication 86B (Secretariat) 127, Optical Fiber Connectors.

[A25] ISO 9646-1...¹, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 1: General concepts.

[A26] ISO 9646-2..., Information technology—Open Systems Interconnection— Conformance testing methodology and framework—Part 2: Abstract test suite.

¹Presently at state of draft amendment.

Appendix A. System Guidelines

A1. Baseband System Guidelines and Concepts

Add the following to Appendix A, Section A1:

A1.5 Systems Consideration Calculations

A1.5.1 Overview. Section A1.3 contains a calculation of maximum fragment size for a network of 10BASE5 and IRL segments. That calculation was based on the maximum delay for a transmission to reach the far end of the network and for a collision to propagate back. Since that calculation was written, many new media and MAU types have been added to this standard. Also, the calculation of A1.3 did not address the interpacket gap shrinkage, which can limit the network size. It is not practical to perform a separate calculation for each possible combination of segment types.

Some new segment types also support much longer media (up to 2 km). Introduction of longer media also required a more flexible calculation method that allowed trading segment length for repeaters. The method in this section was developed to meet these needs.

Actual numbers used to calculate delay and variability are tabulated (Table A1) at the end of this section.

A1.5.2 Maximum Collision Fragment Size. The round-trip delay must be calculated to determine that collision will be received within the collision window of transmitting DTEs and that collision fragments will be less than the minimum frame size. The following scenario is used for the calculations (see Fig A5):

- (1) DTE1 transmits.
- (2) DTE1's transmission propagates to DTE2.
- (3) DTE2 begins transmitting at the last possible time, colliding and transmitting 96 bits.
- (4) DTE2's transmission propagates to DTE1.
- (5) DTE1 detects collision, jams, and stops transmitting.

The following conditions must be met for proper network operation:

- (1) DTE1 must detect collision before having transmitted the 512th bit (including preamble and SFD bits).
- (2) DTE1 must stop transmitting before having transmitted a minimum length frame, 576 bits (512 bits after SFD).
- (3) The overlap between DTE1's transmission and DTE2's transmission must be less than 575 bits (511 bits after the SFD transmitted by DTE1).

For all existing segment types, the last condition is the limiting factor; if it is met then the other two conditions are also met.

The maximum time between the first bit and the last bit of the overlapping transmissions of the two DTEs colliding across a path will be called the Path Delay Value (PDV). Many factors contribute to this delay. Simplification of the delay calculation, as compared to the method used in A1.3, can be achieved by using a set of base numbers, Segment Delay Values (SDV), for each segment type that combines the factors that contribute to the round-trip delay associated with that segment. The PDV is the sum of SDVs of the segments that comprise the path.

For each segment type, one of three base SDVs is used depending on the position of the segment: left-end, mid-, or right-end. The left-end segment is connected to the DTE that

transmits first (DTE1). The right-end segment is connected to the colliding DTE (DTE2). All segments between these are mid-segments.

For this calculation, the left-end base SDV contains all delays from DTE1 through the MAU and its AUI connected to the repeater unit. Each mid-base SDV includes the delays from the repeater unit on the left through the MAU and its AUI connected to the right repeater unit. The right-end base SDV includes the delays from the repeater unit immediately to its left through DTE2. (See Fig A5.)

Only the bit loss of DTE1's MAU on the left-end segment contributes to fragment size. The steady-state delay of that MAU and the AUI cable delay do not contribute. For the remainder of the network, start-up delay (the sum of steady-state delay and bit loss) contribute. Therefore, the left-end base SDV uses MAU transmit bit loss and 1 AUI delay. In all other cases, start-up delay and 2 AUI delays are used.

Propagation delays for media are not included in the base SDVs. These are added in separately to allow for various segment lengths (see 13.4.1). The base SDVs for the mid- and right-end segments (except 10BASE-FB) include two 2 m AUI cables and the delay of each one is experienced twice, once in the forward path and once in the reverse path. Therefore, a delay of 0.5 BT per segment is added and corresponds to the round-trip delay through two 2 m AUI cables. The base numbers for the left segment include one 2 m AUI cable, 0.25 BT.

For each segment type, both the delay to transmission of the 96th bit after collision rise and delay to transmission of the last bit due to collision fall are calculated. The base SDV is the larger of these two.

The maximum allowed sum of SDVs plus media propagation delays is 575 BT.

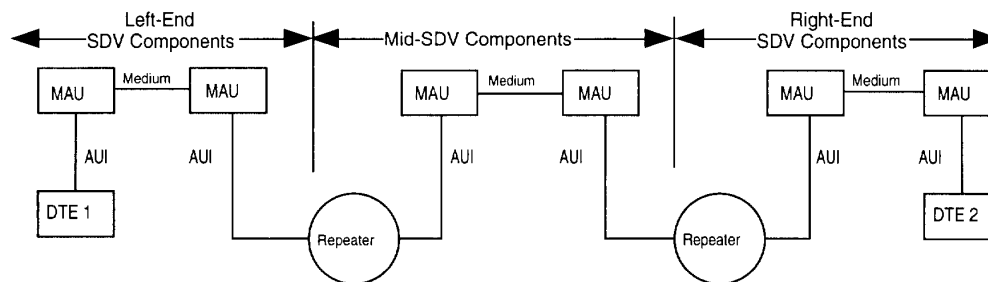


Fig A5
Round-Trip Delay Calculation Model

A1.5.2.1 Left-End Base SDV. The Left-End Segment collision delay is the sum of the following:

Forward delay:

- AUI
- MAU transmit bit-loss delay
- Media rise time
- MAU receive start-up delay

Reverse delay:

- MAU transmit fall delay after collision
- MAU receive fall delay after collision

A1.5.2.2 Mid-Base SDV. The Mid-Segment collision rise delay is the sum of the following:

Forward delay:

- AUI * 2
- Repeater start-of-packet propagation delay
- MAU transmit start-up delay
- Media rise time
- MAU receive start-up delay

Reverse delay:

- MAU transmit start-up delay
- MAU collision detect delay
- Repeater start-of-collision propagation delay

The Mid Segment collision fall delay is the sum of the following:

Forward delay:

- AUI * 2
- Repeater start-of-packet propagation delay
- MAU transmit start-up delay
- Media rise time
- MAU receive start-up delay

Reverse delay:

- MAU transmit fall delay
- MAU collision fall delay
- Repeater cessation-of-jam propagation delay

A1.5.2.3 Right-End Base SDV. The Right-End Segment collision rise delay is the sum of the following:

Forward delay:

- AUI * 2
- Repeater start-of-packet propagation delay
- MAU transmit start-up delay
- Media rise time
- MAU receive start-up delay
- DTE receive-to-transmit-not-deferred delay

Reverse delay:

- MAU transmit start-up delay
- MAU collision detect delay
- Repeater start-of-collision propagation delay
- Repeater minimum transmit length

The Right End Segment collision fall delay is the sum of the following:

Forward delay:

- AUI * 2
- Repeater start-of-packet propagation delay
- MAU transmit start-up delay
- Media rise time
- MAU receive start-up delay

DTE receive-to-transmit-not-deferred delay
DTE minimum transmit length

Reverse delay:

MAU transmit fall delay
MAU collision fall delay
Repeater cessation-of-jam propagation delay

A1.5.3 Interpacket Gap (IPG) Shrinkage. IPG shrinkage occurs because two successive packets may experience differing bit loss on the same path. When the packet passes through a repeater, the lost preamble bits are regenerated. If the first packet experiences greater bit loss than the second, the IPG between them will shrink.

IPG shrinkage is also calculated using a lumped number for each segment, the Segment Variability Value (SVV). For each segment type, one of two SVVs is used depending on the position of the segment: transmitting end or mid. The transmitting end segment is connected to the transmitting DTE or DTEs. The mid-segments are all the remaining segments except the one connected to the receiving DTE.

The transmitting end segment and the mid-segment SVVs each include the variability from the transmitting MAU through the repeater unit. Since, IPG shrinkage only occurs when a repeater restores the lost bits, the final segment does not contribute any variability (see Fig A6).

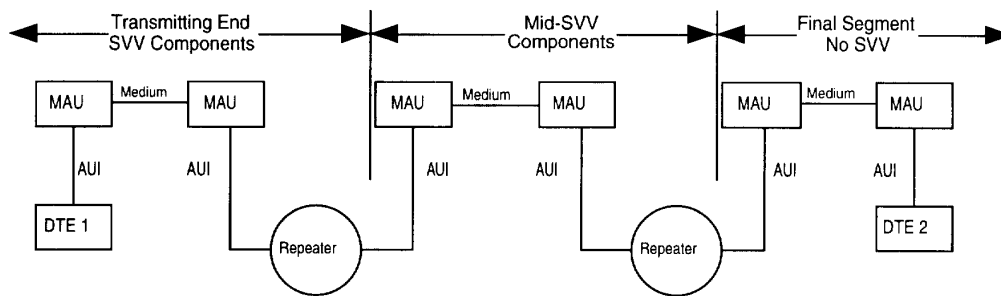


Fig A6
Variability Calculation Model

A1.5.3.1 Transmitting End Segment Variability Value. The transmitting end segment variability value is the sum of the following:

MAU transmit start-up-delay variability
MAU transmit start-up-delay variability correction
MAU receive start-up-delay variability
MAU receive start-up-delay variability correction
Repeater start-of-packet propagation delay variability
Clock skew (2.5 BT)

NOTE: The variability correction values account for the possibility that on mixing segments the two successive packets can be originated by two different MAUs.

A1.5.3.2 Mid-Segment Variability Value. The mid-segment variability value is the sum of the following:

- MAU transmit start-up-delay variability
- MAU receive start-up-delay variability
- Repeater start-of-packet propagation delay variability

A1.5.4 Timing Parameters for Round-Trip Delay and Variability Calculations. Table A1 contains the timing parameters used in the calculation of SDVs and SVVs. The values in the table for MAU Collision Rise and MAU Collision Fall are those specific to the worst-case scenario. The parameters are defined in the following subsections.

A1.5.4.1 MAU Parameters

Transmit Bit Loss. Number of bits received on the DO circuit and not transmitted to the MDI.

Transmit Start-up Delay. Delay from the first bit received on the DO circuit to the first bit transmitted to the MDI. This is the sum of transmit bit loss and steady-state delay.

Receive Start-up Delay. Delay from the first bit received on the MDI to the first bit transmitted to the DI circuit. This is the sum of receive bit loss and steady-state delay.

Collision Detect Delay. Delay from the arrival of collision at the MDI to transmission of *signal_quality_error* to the CI circuit. For 10BASE2 and 10BASE5, this includes the DC rise time on the media, given that the MAU has been transmitting for at least 20 BT when the collision arrives. For 10BASE-FP, this includes the delay until the second CRV occurs on the media (16.3.4.3).

Transmit Fall Delay. Delay from the last bit received on the DO circuit to the last bit transmitted to the MDI. This is the same as the steady-state delay.

Collision Fall Delay. Delay from arrival of end of collision at the MDI to end of transmission of *signal_quality_error* to the CI circuit. For 10BASE2 and 10BASE5, it includes the DC fall time of the media. For 10BASE-FP it includes the delay of 33 BT to pass with no more than one *ORD_crv*.

Transmit Start-up Delay Variability. Packet-to-packet variations in transmit start-up delay.

Transmit Start-up Delay Variability Correction. Additional variability, when the transmitting end segment is a mixing segment, due to two MAUs transmitting with different start-up delays. For 10BASE5 and 10BASE2, start-up delay variability plus transmit start-up delay variability correction equal transmit start-up delay since these MAUs may transmit with as little as 0 BT delay. For 10BASE-FP MAUs, implementation considerations imposed by the requirements of 16.3.1.1 require the MAU to have at least 2 BT start-up delay. Therefore, the transmit start-up delay variability correction equals the transmit start-up delay minus 2 BT.

Receive Start-up Delay Variability. Packet-to-packet variability in receive start-up delay.

Transmit Fall Delay After Collision. Delay from the last bit received on the DO circuit to the last bit transmitted to the MDI after the MAU has detected a collision. For all MAUs except 10BASE-FB, this is the same as transmit fall delay.

Receive Fall Delay After Collision. Delay from the last bit received on the MDI to the last bit transmitted to DI. For all MAUs except 10BASE-FB and 10BASE-FP, this is the same as receive steady-state delay.

A1.5.4.2 Repeater Parameters

Start-of-Packet Propagation Delay. Delay from first bit received on DI to first bit transmitted on DO.

Start-of-Collision Propagation Delay. Delay from start of *signal_quality_error* on CI to first bit transmitted on DO.

Cessation-of-Jam Propagation Delay. Delay from end of *signal_quality_error* on CI to last bit transmitted on DO.

Minimum Transmit Length. Minimum delay from first bit transmitted on DO to last bit transmitted on DO.

Start-of-Packet Propagation Delay Variability. Packet-to-packet variation in start-of-packet propagation delay.

A1.5.4.3 Media Parameters

Media Rise Time. Start-of-packet DC rise time on 10BASE2 and 10BASE5 segments.

A1.5.4.4 DTE Parameters

Receive-to-Transmit-Not-Deferred Delay. Delay from first bit on DI to first bit on DO when the DTE does not detect carrier in time to defer.

Minimum Transmit Length. Minimum delay from first bit transmitted on DO to last bit transmitted on DO.

Table A1
Timing Parameters for Round-Trip Delay and Variability Calculations

Parameter	10BASE5	10BASE2	FOIRL	10BASE-T	10BASE-FP	10BASE-FB	10BASE-FL
AUI (2 m)	0.25	0.25	0.25	0.25	0.25	0.00	0.25
MAU							
Transmit Bit Loss	3.00	3.00	3.00	3.00	2.00	0.00	3.00
Transmit Start-up Delay	3.50	3.50	3.50	5.00	5.50	2.00	5.00
Receive Start-up Delay	6.50	6.50	3.50	8.00	2.50	2.00	5.00
Collision Detect Delay	17.00	17.00	3.50	9.00	9.50	3.50	3.50
Transmit Fall Delay	0.50	0.50	0.50	2.00	3.50	2.00	2.00
Collision Fall Delay	20.00	20.00	7.00	9.00	36.00	5.00	7.00
Transmit Start-up Delay Variability	2.00	2.00	2.00	2.00	3.00	0.00	2.00
Transmit Start-up Delay Variability Correction	1.50	1.50	0.00	0.00	0.50	0.00	0.00
Receive Start-up Delay Variability	5.00	5.00	2.00	2.00	1.00	0.00	2.00
Receive Start-up Delay Variability Correction	1.00	1.00	0.00	0.00	0.00	0.00	0.00
Transmit Fall Delay After Collision	0.50	0.50	0.50	2.00	3.50	5.00	2.00
Receive Fall Delay After Collision	0.50	0.50	0.50	2.00	3.00	5.00	2.00
REPEATER							
Start-of-Packet Propagation Delay	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Start-of-Collision Propagation Delay	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Cessation-of-Jam Propagation Delay	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Minimum Transmit Length	96.00	96.00	96.00	96.00	96.00	96.00	96.00
Start-of-Packet Propagation Delay Variability	4.00	4.00	4.00	4.00	4.00	2.00	4.00
MEDIA RISE TIME	1.00	1.00	0.00	0.00	0.00	0.00	0.00
DTE							
Receive-to-Transmit-not-Deferred Delay	27.00	27.00	27.00	27.00	27.00	N/A *	27.00
Minimum Transmit Length	96.00	96.00	96.00	96.00	96.00	N/A *	96.00

* N/A: Not Applicable; 10BASE-FB does not support end (DTE) connections.

Add the following to Appendix A. This is a new Section A5.

A5. 10BASE-F

A5.1 System Jitter Budget. The jitter budgets for 10BASE-FP, 10BASE-FB, and 10BASE-FL are apportioned as follows:

Encoder	10BASE-FP	10BASE-FB	10BASE-FL
Encoder	0.5	0.5	0.5
AUI Cable including SNR (DO Pair)	1.5	N/A	1.5
MAU DO Receiver (10BASE-FP only)	2.0	N/A	N/A
10BASE-FP Total at Retiming	4.0	N/A	N/A
Subtotal (10BASE-FP Retimes)	0.0	0.5	2.0
Transmitter*	2.0	4.0	4.5
Subtotal (at the MDI)	2.0	4.5	6.5
Fiber Optic Medium	0.0	0.0	0.0
10BASE-FP Passive Star	0.0	N/A	N/A
Fiber Optic Medium (10BASE-FP return)	0.0	N/A	N/A
Receiver**	1.0	2.0	8.5
10BASE-FP Total at Retiming	3.0	N/A	N/A
Subtotal (10BASE-FP Retimes)	0.0	6.5	15.0
Unallocated	8.5	10.0	0.0
MAU DI Transmitter (10BASE-FP only)	6.5	N/A	N/A
AUI Cable incl-SNR (DI Pair)	<u>1.5</u>	<u>N/A</u>	<u>1.5</u>
Total	16.5	16.5	16.5

*Includes jitter plus duty cycle distortion.

** 10BASE-FL figure includes MAU DI Transmitter jitter allocation.

A5.2 10BASE-FP Fiber Optic Segment Loss Budget. The 10BASE-FP MDI optical parameters specified in 15.2.1 and 15.2.2 have been selected to guarantee operation using a properly specified system of up to 500 m radius segment. This Appendix illustrates how the loss budget may be allocated to star, optical fiber, and patch panel connectors, including examples at 100 m and 500 m radius.

The allowed system attenuation values are determined by the average transmit and receive power ranges specified in Table 15-1. The average optical power launched into a 62.5 μm fiber must be greater than -15 dBm and less than -11 dBm. (This includes any launch power variation and source degradation.) Receiver operation is specified for average received power greater than -41 dBm and less than -27 dBm. Thus the maximum attenuation allowed for optical plant, including star, is 26 dB, and the minimum allowed attenuation is 16 dB.

This attenuation can be allocated between the star, fiber optic cable, and patch panel connectors in any manner as long as the maximum and minimum losses are within the

limits stated below. Note that the 10BASE-FP Star insertion loss includes the loss of one optical connector pair as specified in 16.5.2.1.

Item	Min (dB)	Max (dB)
Star	16	20
Fiber and Connectors	0	6
Totals	16	26

Example 1:

For a 500 m radius segment (1 km MDI to MDI) of 3.75 dB/km (measured at 850 nm) optical fiber and a connector system with a maximum loss of 2 dB, the worst-case optical fiber and connector loss would be 5.75 dB. This would fall within the 6 dB limit, and result in a worst-case margin of 0.25 dB.

Example 2:

A horizontal structured building wiring system (e.g., as detailed in ANSI/EIA/TIA 568 [A19]) of 100 m from the wiring closet to the desk top (100 m radius segment, 200 m MDI to MDI) of 3.75 dB/km optical fiber would have a loss of 0.75 dB. With four connector pairs in the path from MDI to MDI (wall plate, patch panel, patch panel, wall plate [see Fig 15-2]) and one connector pair at the 10BASE-FP Star (the other star connector pair is already included in the star loss [see 16.5.2.1]), and using a worst-case loss of 1 dB for each connector pair, the worst-case optical fiber and connector loss would be 5.75 dB. This would fall within the 6 dB limit, and would result in a worst-case margin of 0.25 dB.

In addition to these loss budgets, the overall system return loss must be greater than 27 dB. The return loss is the ratio of the desired signal to all undesired, multiple reflected signals, observed at a 10BASE-FP MAU MDI. Use of connectors with less return loss than specified in 15.3.2.2 as well as use of more than two patch panels on each side of the star is permitted, as long as the overall system return loss requirement is met.

The 8.0 dB differential flux budget (16.3.4.2) can be allocated as follows:

Contribution	(dB)
Variation at Star Input due to combined effects	4.8
1/2 star connector	0.5
Star including 1/2 connector	2.5
Wavelength in ORD leg	0.2
Total	8.0

Each of these contributions to the differential budget is a measurable quantity. For example, the variation in the optical power at the star input due to combined effects of launch power, LED lifetime degradation, connectors, distance from 10BASE-FP MAU to Star, and wavelength of transmitter can be measured at the star input port. Also, star differential loss measurement is described in 16.5.2.2.

Appendix C. Application Context, Selected Medium Specifications*Replace Section C4 of Appendix C as follows:***C4. Type FOIRL and 10BASE-F Applications;
Alternative Fiber Optic Medium Applications**

C4.1 Alternative Fiber Types. Table C1 provides a listing of other fiber types that may be used in an FOIRL or a 10BASE-F Cable Link Segment. These fiber types have not been studied, and details for their use are not provided for in the main body of the standard. Therefore, using these fiber types may reduce the maximum achievable distance.

Table C1
Alternative Fiber Types

Nominal Core diameter (mm) IEC 793-2 [14]	Nominal cladding diameter (mm) IEC 793-2 [14]	Nominal Numerical aperture IEC 793-2 [14]
50	125	0.2
50	125	0.21
50	125	0.22
85	125	0.26
100	140	0.29

C4.1.1 Theoretical Coupling Losses. The body of the standard references a single fiber type to facilitate interoperability and conformance testing; however, other fiber types may also be used. The use of an alternate fiber type with a particular implementation may have the following consequences. At the transmit MDI, more or less light may be launched into the fiber, depending on whether the optics are optimized for a core size and a numerical aperture (NA) that are smaller or larger than that of the alternate fiber size. At the receive MDI, the sensitivity may be increased or decreased depending on the optimization of the collecting optics. Table C2 summarizes the potential effects of the use of alternate fiber sizes and provides the loss budget remaining for cable plant attenuation. All adjustments are relative to an implementation using the minimum diameter and NA 62.5 μm core fiber as specified in IEC Publication 793-2 [14], Type A1b, Category ≤ 3.5 dB/km. This cable plant has a loss budget of 9 dB for FOIRL segments and 12.5 dB for 10BASE-FL and 10BASE-FB link segments.

The worst-case loss budget in Table C2 is calculated on the assumption that the transmitter and receiver core diameter and NA are 62.5 μm and 0.275, respectively. Launching into a smaller core diameter or NA will incur a loss. Launching into a larger core diameter or NA will not result in a gain.

Similarly, receiving from a larger core diameter or NA incurs a loss, but receiving from smaller core diameter or NA provides no gain.

The values for transmit powers assume a worst-case condition that no additional power is launched into an increased core diameter and NA link fiber when referred to the 62.5 μm core fiber. This assumption is valid for underfilled launch conditions such as may occur from a MAU containing a pigtailed or laser emitter.

Table C2
Worst-Case Loss Budget

Fiber Type	Transmit Loss (dB)	Receive Loss (dB)	Loss Budget Remaining (dB)	
			FOIRL	10BASE-FB/L
50 $\mu\text{m}/\text{NA}=0.20$	5.7	0	3.3	6.8
50 $\mu\text{m}/\text{NA}=0.21$	5.2	0	3.8	7.3
50 $\mu\text{m}/\text{NA}=0.22$	4.8	0	4.2	7.7
85 $\mu\text{m}/\text{NA}=0.26$	1.6	2.6	4.8	8.3
100 $\mu\text{m}/\text{NA}=0.29$	0.5	4.5	4.0	7.5

C4.1.2 Maximum Launch Power. When large core diameter and NA launch conditions are used in conjunction with a launch fiber of larger core diameter and NA than the 62.5 μm reference, significantly greater launch power can occur. For example, this is typically the case with wide area surface emitter LED devices that are directly aligned with a fiber in a device mount header.

Table C3 summarizes the maximum launch power into fibers with larger core diameters than 62.5 μm and the corresponding excess power that can result with a receiver utilizing all the optical power from the fiber.

Table C3
Worst-Case Launch Power

Fiber Type	Maximum Transmit Power (dBm)	Maximum Excess Power (dBm)
85 $\mu\text{m}/\text{NA}=0.26$	−6.1	2.9
100 $\mu\text{m}/\text{NA}=0.29$	−3.8	5.2

In this case, sufficient attenuation should be installed in the link segment to ensure that for FOIRL segments the peak received optical power does not exceed −9 dBm, and for 10BASE-F segments the average received optical power does not exceed the appropriate optical Receive Average Power (Max) in Table 15-1.

C4.2 Type 10BASE-FP Applications Using 50/125 μm Fiber. It is recognized that, in some cases, designers are constrained to use fiber sizes other than 62.5/125 μm in LAN designs. Such LAN designs are beyond the scope of this standard but can operate properly if optical power and loss budgets are adjusted to compensate for the different fiber characteristics. The following guidance is provided for system implementors who are constrained to design LANs with the 50/125 μm fiber described in C4.1.

WARNING: Interoperability of nonconforming implementations cannot be ensured. It is the responsibility of the designer(s) of nonconforming implementation(s) to assure LAN operation. The following is only advisory information for implementations outside the scope of this standard.

C4.2.1 Coupled Transmit Power. As shown in C4.1, reduction of coupled power introduces the greatest difference between LANs using 62.5/125 μm and those using 50/125 μm fiber. Typically, for an emitter technology that produces a uniform, overfilled launch condition, this difference will be 3.5 dB. Implementors of 50/125 μm systems may choose to deal with this by trying one of the following alternatives:

- (1) Selecting an emitter technology with coupled power that is less susceptible to variation with fiber size, or
- (2) Increasing receiver sensitivity and dynamic range, or
- (3) Reducing the star coupler loss to compensate for the reduction in coupled transmit power. This may be accomplished by reducing the number of ports on the star coupler, or
- (4) Reducing the connector losses in the system, either by reducing the number of in-line connectors or reducing the loss per connector.

C4.2.2 Star Coupler Loss. Also in accordance with C4.1, the transmission loss of 50/125 μm star couplers may be as much as 1 dB greater than their 62.5/125 μm counterparts. Implementors of 50/125 μm systems may choose to deal with this by trying one of the following alternatives:

- (1) Procurement—specification of coupler loss characteristics to be the same as those shown for 62.5/125 μm star couplers, per 16.5, or
- (2) Compensation—all items shown in C4.2.1 (1) to (4) may be used to compensate for an increase in coupler loss.

For example, a passive-star coupler (with connectors) with 33 ports typically has the following losses:

Contributor	Loss (dB)
Splitting:	–15
Connector (1):	–1
Excess:	0 to –4
Total:	–16 to –20

If, in a LAN that used 50/125 μm fiber, the maximum allowable number of ports per passive-star coupler was reduced to 17, the appropriate losses would be as follows:

Contributor	Loss (dB)
Splitting:	–12
Connector (1):	–1
Excess:	0 to –3
Total:	–13 to –16

The 3.5 dB lost to the MDI OTD would then be recovered allowing this “reduced nodes” LAN to still operate at the proposed maximum of 500 m MAU to the star.

It should be noted that the MAU parameters remain unchanged.

C4.2.3 Collision Detection. Reliable collision detection requires that designers of systems using nonconforming fiber optic cable ensure that the optical power levels of all possible colliding signals on the LAN differ at the mixing element (passive-star coupler) by no more than that specified in 16.3.4.2. This requires that

$$10 * \text{abs}(\log((P_{Ti} - L_{Ti} - U_{Ti})/(P_{Tj} - L_{Tj} - U_{Tj}))) \leq \text{that specified in 16.3.4.2}$$

for all i not equal j , and where

P_{Tn} = coupled optical transmit power, MAU n

L_{Tn} = optical cable and connector and transmit fiber loss, from MAU n to star input
port m

U_{Tm} = input port uniformity, port m

15. Fiber Optic Medium and Common Elements of Medium Attachment Units and Star, Type 10BASE-F

15.1 Scope

15.1.1 Overview. Sections 15, 16, 17, and 18 define the functional, electrical, optical, and mechanical characteristics of the Type 10BASE-FP (Passive) MAU, the Type 10BASE-FB Backbone (Synchronous Active) MAU, the Type 10BASE-FL Link (Asynchronous Active) MAU, the Type 10BASE-FP (Passive) Star, and one common medium for use with those MAUs and the star. The purpose of the MAUs is to provide a means of attaching DTEs (10BASE-FP and 10BASE-FL only) or repeaters to the local network medium. The purpose of the 10BASE-FP Star is to provide the means of interconnecting 10BASE-FP MAUs into a star topology segment. 802.3 repeaters are used to interconnect the star segment to other 10 Mb/s baseband segments. Information on selecting segment types for various applications is provided in 15.1.3.4.

The 10BASE-F specification builds upon Sections 1 through 7 and Section 9 of this standard. The relationship of this standard to the entire ISO/IEC 8802-3 : 1993 CSMA/CD standard is shown in Figs 15-1(a), 15-1(b), and 15-1(c) for 10BASE-FP, 10BASE-FB, and 10BASE-FL, respectively.

10BASE-F is specifically intended to be interoperable and compliant with the requirements for attachment to DTEs and repeaters via the 10 Mb/s Attachment Unit Interface (AUI). The use of 10BASE-F in networks with other ISO/IEC 8802-3, 10 Mb/s baseband segments is governed by the system considerations detailed in Section 13.

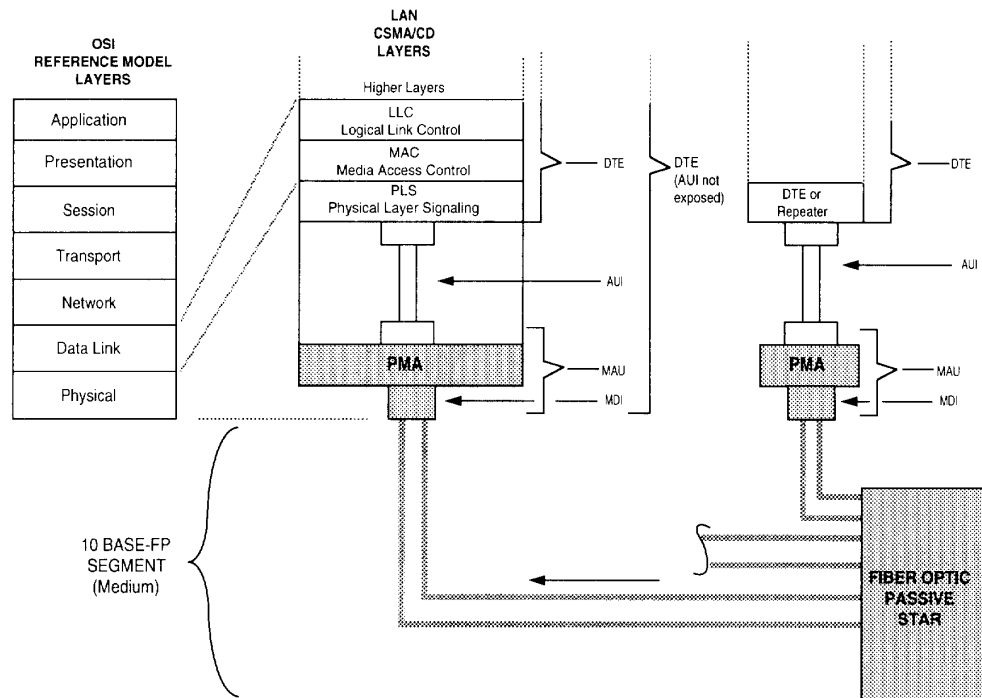
15.1.1.1 Fiber Optic Medium Attachment Units (MAUs). The MAUs specified in this section, Section 16 (10BASE-FP), Section 17 (10BASE-FB), and Section 18 (10BASE-FL) have the following general characteristics:

- (1) They provide a means of coupling the PLS through the AUI to the fiber optic segment by way of the MDI.
- (2) They support message traffic at a data rate of 10 Mb/s.
- (3) They provide for driving up to 0.5 km of fiber optic cable between a 10BASE-FP MAU and a 10BASE-FP Star (resulting in up to 1 km between 10BASE-FP MAUs). Provide for driving up to 2 km of fiber optic cable between two repeaters that have embedded 10BASE-FB MAUs. Provide for driving up to 2 km of fiber optic cable between two 10BASE-FL MAUs. Provide backward compatibility for communicating between FOIRL MAUs and 10BASE-FL MAUs over up to 1 km of fiber optic cable.
- (4) They permit the DTE to test the MAU and the availability of the medium.
- (5) They support system configurations using the CSMA/CD access mechanism defined in ISO/IEC 8802-3 : 1993.
- (6) They provide uninterrupted carrier sense during collisions.
- (7) They support a star cabling topology.
- (8) They allow incorporation of the MAU within the physical bounds of a DTE or repeater. (See Section 17 for 10BASE-FB restrictions.)

15.1.1.2 Fiber Optic Passive Star. The 10BASE-FP Star is a passive optical device that receives optical signals from, and distributes them to, connected devices. The 10BASE-FP Star is not a repeater.

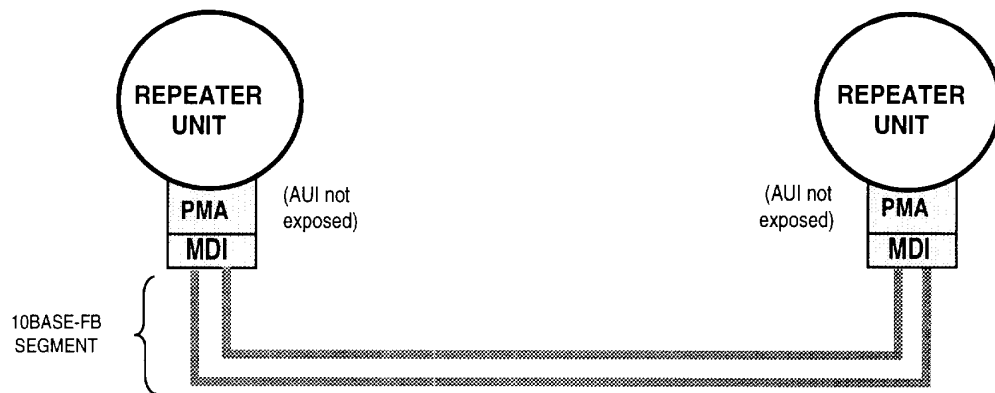
15.1.1.3 Repeater Unit. The repeater unit has the characteristics defined in Section 9. Repeater units are used as a hub in a star topology network in which DTEs attach directly to link segments. Repeater units are also used to extend the physical system topology of mixing segments by connecting 10BASE-FP or coaxial cable segments to other segments. Repeater units are used to connect 10BASE-F segments of any type to other 10BASE-F segments, and to any other 10 Mb/s baseband media types. 10BASE-FB segments connect only 10BASE-FB ports on repeaters.

NOTE: While 9.6.6 autopartitioning is not required as a mandatory feature on 10BASE-FB ports, it should be recognized that it could be of benefit where there is a high probability of misconnections of incompatible ports, e.g., patch panels shared between 10BASE-FB and other fiber optic communication technologies.

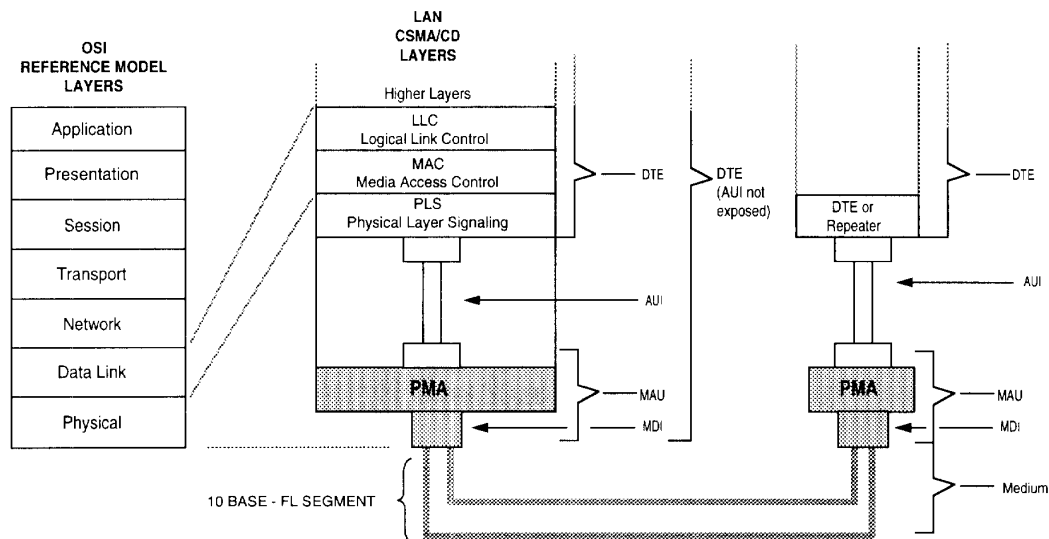


(a) 10BASE-FP Relationship to OSI and CSMA/CD LAN

Fig 15-1
10BASE-F Relationship to the ISO Open Systems Interconnection (OSI)
Reference Model and the IEEE 802.3 CSMA/CD LAN Model



(b) 10BASE-FB Relationship to CSMA/CD LAN



(c) 10BASE-FL Relationship to OSI and CSMA/CD LAN

Fig 15-1 (Continued)
10BASE-F Relationship to the ISO Open Systems Interconnection (OSI)
Reference Model and the IEEE 802.3 CSMA/CD LAN Model

15.1.2 Definitions. This section defines the specialized terminology applicable to MAUs, stars, and fiber optic segments within the context of Sections 15, 16, 17, and 18. The definitions of Sections 7 and 9 apply but are not reproduced here.

10BASE-FP Star. (See 16.5.) A passive device that is used to couple fiber pairs together to form a 10BASE-FP segment. Optical signals received at any input port of the 10BASE-FP Star are distributed to all of its output ports (including the output port of the optical interface from which it was received). A 10BASE-FP Star is typically comprised of a passive-star coupler, fiber optic connectors, and a suitable mechanical housing.

10BASE-FP Segment. A fiber optic mixing segment (see definition of **mixing segment**, 13.2) including one 10BASE-FP Star and all of the attached fiber pairs. [See Fig 15-1(a) and Fig 15-2.]

10BASE-FB Port. (See 17.3 and Section 9.) A port on a repeater that contains an internal 10BASE-FB MAU that can connect to a similar port on another repeater. [See Fig 15-1(b).]

10BASE-FB Segment. A fiber optic link segment (see definition of **link segment**, 13.2) providing a point-to-point connection between two 10BASE-FB ports on repeaters. [See Fig 15-1(b) and Fig 15-2.]

10BASE-FL Segment. A fiber optic link segment (see definition of **link segment**, 13.2) providing a point-to-point connection between two 10BASE-FL MAUs. [See Fig 15-1(c) and Fig 15-2.]

Center Wavelength. The average of the two optical wavelengths at which the spectral radiant intensity is 50% of its maximum value.

Code Rule Violation (CRV). An analog waveform that is not the result of the valid Manchester-encoded output of a single optical transmitter. The collision of two or more 10BASE-FP optical transmissions will cause multiple CRVs. The preamble encoding of a single 10BASE-FP optical transmission (16.3.1.1) contains a single CRV.

Collision. A condition that results from concurrent transmissions from multiple signal sources.

Extinction Ratio. The ratio of the low optical power level to the high optical power level on an optical segment.

Fiber Optic Cable. A cable containing one or more of the optical fibers specified in 15.3.1.

Fiber Optic Inter-Repeater Link (FOIRL). A Fiber Optic Inter-Repeater Link segment and its two attached MAUs.

FOIRL Segment. A fiber optic link segment (see definition of **link segment**, 13.2) providing a point-to-point connection between two FOIRL MAUs or between one FOIRL MAU and one 10BASE-FL MAU. (See 15.1.3.2.)

Fiber Pair. Optical fibers as specified in 15.3.1, interconnected to provide two continuous light paths terminated at each end in an optical connector. Any intermediate optical connections must have insertion and return loss characteristics that meet or exceed 15.3.2.1 and 15.3.2.2, respectively.