7.4 Electrical Characteristics. Terms BR and BR/2 have very specific meaning as used in this subsection. The term BR is used to mean the bit rate of the highest signaling rate supported by any one implementation of this interface, BR/2 is used to mean half the bit rate of the lowest signaling rate supported by any one implementation of this interface (see 7.3.2). An interface may support one or more signaling rates.

NOTE: The characteristics of the driver and receiver can be achieved with standard ECL logic with the addition of an appropriate coupling network; however, this implementation is not mandatory.

7.4.1 Driver Characteristics. The driver is a differential driver capable of driving the specified 78 Ω interface cable. Only the parameters necessary to ensure compatibility with the specified receiver and to assure personnel safety at the interface connector are specified in the following sections.

7.4.1.1 Differential Output Voltage, Loaded. Drivers shall meet all requirements of this section under *two* basic sets of test conditions (that is, each of two resistive values). For drivers located within a DTE, a combined inductive load of 27 μH ± 1% and either a 73 or 83 Ω ± 1% resistive load shall be used. For a driver located within a MAU, a combined inductive load of 50 μH ± 1% and either 73 or 83 Ω ± 1% resistive load shall be used.

The differential output voltage, V_{dm}, is alternately positive and negative in magnitude with respect to zero voltage. The value of V_{dm} into either of the two test loads identified above ($R = 73\ \Omega$ or $83\ \Omega \pm 1\%$) at the interface connector of the driving unit shall satisfy the conditions defined by values V_1, V_2, and V_3 shown in Fig 7-11 for signals in between BR and BR/2 meeting the frequency and duty cycle tolerances specified for the signal being driven. The procedure for measuring and applying the test condition is as follows:

(1) Measure the output voltage V_{dm} for the driver being tested at the waveform point after overshoot, before droop, under test load conditions of 7.4.1.1. This voltage is V_2.
(2) Calculate V_1 and V_3.
(3) V_1 shall be < 1315 mV, V_3 shall be > 450 mV.
(4) The waveform shall remain within shaded area limits.

The differential output voltage magnitude, V_{dm}, into either of the two test loads identified above, at the interface connector of the driving unit during the idle state shall be within 40 mV of 0 V. The current into either of the two test loads shall be limited to 4 mA.

When a driver, connected to the appropriate two test loads identified above, enters the idle state, it shall maintain a minimum differential output voltage of at least $0.7 \times V_2$ mV for at least 2 bit times after the last low to high transition. The driver differential output voltage shall then approach within 40 mV of 0 V within 80 bit times. In addition, the current into the appropriate test load shall be limited in magnitude to 4 mA within 80 bit times. Undershoot, if any, upon reaching 0 V shall be limited to –100 mV. See Fig 7-12.

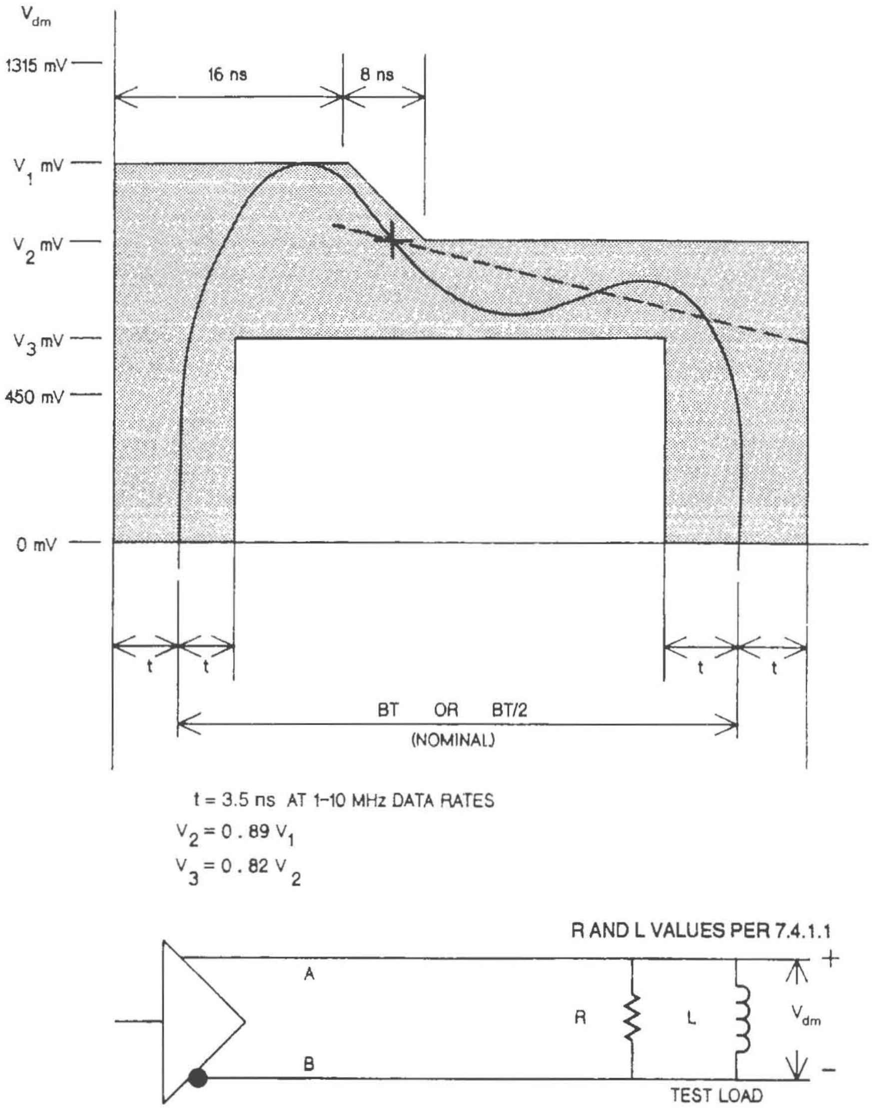
For drivers on either the CO or CI circuits, the first transition or the last positive going transition may occur asynchronously with respect to the timing of the following transitions or the preceding transition(s), respectively.

7.4.1.2 Requirements After Idle. When the driver becomes nonidle after a period of idle on the interface circuit, the differential output voltage at the interface connector shall meet the requirements of 7.4.1.1 beginning with the first bit transmitted. The first transition may occur asynchronously with respect to the timing of the following transitions.

7.4.1.3 AC Common-Mode Output Voltage. The magnitude of the ac component of the common-mode output voltage of the driver, measured between the midpoint of a test load consisting of a pair of matched 39 Ω ± 1% resistors and circuit VC, as shown in Fig 7-13, shall not exceed 40 mV peak.

7.4.1.4 Differential Output Voltage, Open Circuit. The differential output voltage into an open circuit, measured at the interface connector of the driving unit, shall not exceed 13 V peak.

7.4.1.5 DC Common-Mode Output Voltage. The magnitude of the dc component of the common-mode output voltage of the driver, measured between the midpoint of a test load consisting of a pair of matched 39 Ω ± 1% resistors and circuit VC, as shown in Fig 7-13, shall not exceed 5.5 V.



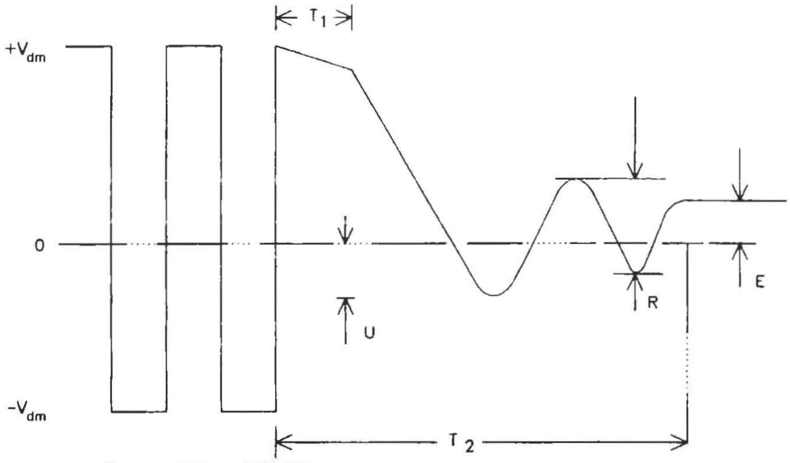
NOTE: The time t in this figure refers to the rise time envelope. Jitter and duty cycle are specified elsewhere.

Fig 7-11
Differential Output Voltage, Loaded

7.4.1.6 Fault Tolerance. Any single driver in the interface, when idle or driving any permissible signal, shall tolerate the application of each of the faults specified by the switch settings in Fig 7-14 indefinitely; and after the fault condition is removed, the operation of the driver, according to the specifications of 7.4.1.1 through 7.4.1.5, shall not be impaired.

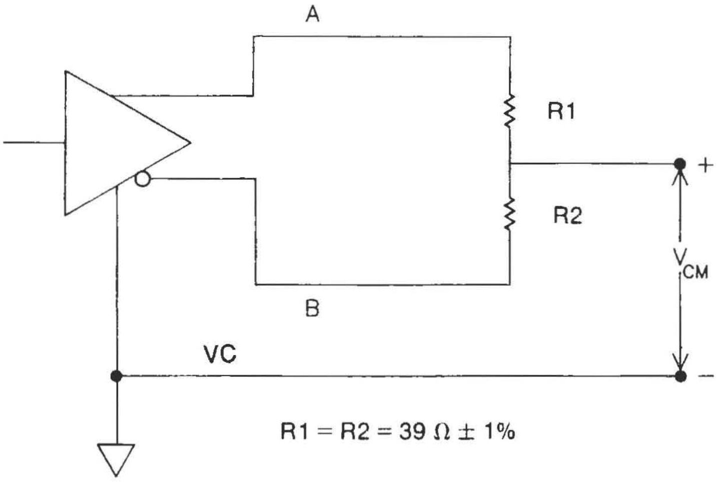
In addition, the magnitude of the output current from either output of the driver under any of the fault conditions specified shall not exceed 150 mA.

7.4.2 Receiver Characteristics. The receiver specified terminates the interface cable in its characteristic impedance. The receiver shall function normally over the specified dc and ac common-mode ranges.



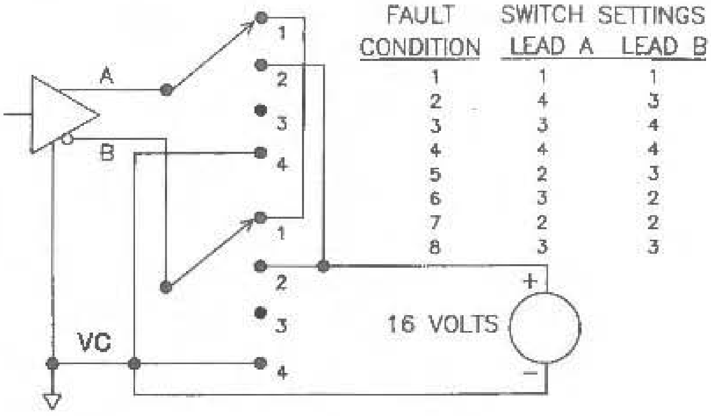
T_1 = 200 ns MINIMUM
T_2 = 80 BIT TIMES MAXIMUM
U = −100 mV MAXIMUM UNDERSHOOT
E = STEADY STATE OFFSET INTO SPECIFIED TEST LOAD
+/− 40 mV MAX
+/− 4 mA MAX
R = RINGING SHALL BE <200 mV PK−PK
AFTER T_1 AND BEFORE T_2

Fig 7-12
Generalized Driver Waveform



R1 = R2 = 39 Ω ± 1%

Fig 7-13
Common-Mode Output Voltage



FAULT CONDITION	SWITCH SETTINGS LEAD A	LEAD B
1	1	1
2	4	3
3	3	4
4	4	4
5	2	3
6	3	2
7	2	2
8	3	3

Fig 7-14
Driver Fault Conditions

7.4.2.1 Receiver Threshold Levels. When the receiving interface circuit at the interface connector of the receiving equipment is driven by a differential input signal at either BR or BR/2 meeting the frequency and duty cycle tolerances specified for the receiving circuit, when the A lead is 160 mV positive with respect to the B lead, the interface circuit is in the HI state, and when the A lead is 160 mV negative with respect to the B lead, the interface circuit is in the LO state. The receiver output shall assume the intended HI and LO states for the corresponding input conditions.

If the receiver has a squelch feature, the specified receive threshold levels apply only when the squelch is allowing the signal to pass through the receiver.

NOTE: The specified threshold levels do not take precedence over the duty cycle and jitter tolerance specified elsewhere. Both sets of specifications must be met.

7.4.2.2 AC Differential Input Impedance. The ac differential input impedance for AUI receivers located in MAUs shall have a real part of 77.83 Ω ± 6%, with the sign of the imaginary part positive, and the phase angle of the impedance in degrees less than or equal to 0.0338 times the real part of the impedance, when measured with a 10 MHz sine wave.

The ac differential input impedance for AUI receivers located in the DTE shall have a real part of 77.95 Ω ± 6%, with the sign of the imaginary part positive, and the phase angle of the impedance in degrees less than or equal to 0.0183 times the real part of the impedance, when measured with a 10 MHz sine wave.

A 78 Ω ± 6% resistor in parallel with an inductance of greater than 27 µH or 50 µH for receivers in the MAU and DTE respectively, satisfies this requirement.

7.4.2.3 AC Common-Mode Range. When the receiving interface circuit at the receiving equipment is driven by a differential input signal at either BR or BR/2 meeting the frequency and duty cycle tolerances specified for the circuit being driven, the receiver output shall assume the proper output state as specified in 7.4.2.1, in the presence of a peak common-mode ac sine wave voltage either of from 30 Hz to 40 kHz referenced to circuit VC in magnitude from 0 to 3 V, or in magnitude 0 to 100 mV for ac voltages of from 40 kHz to BR as shown in Fig 7-15.

NOTE: The receiver shall also be able to reject small ac common-mode signals in frequencies outside of this range.

7.4.2.4 Total Common-Mode Range. When the receiving interface circuit at the receiving equipment is driven by a differential input signal at either BR or BR/2 meeting the frequency and duty cycle tolerances specified for the circuit being driven, the receiver output shall assume the intended output state as specified in 7.4.2.1 in the presence of a total common-mode voltage, dc plus ac, referenced to circuit VC in magnitude from 0 to 5.5 V, as shown in the test setup of Fig 7-15. The ac component shall not exceed the requirements of 7.4.2.3.

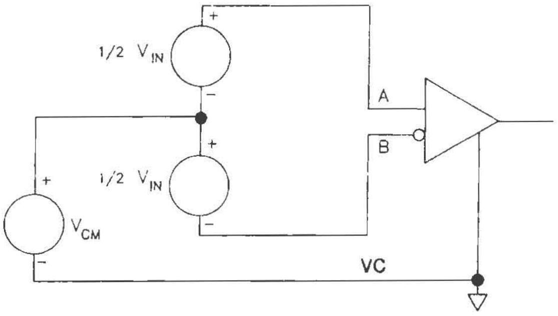


Fig 7-15
Common-Mode Input Test

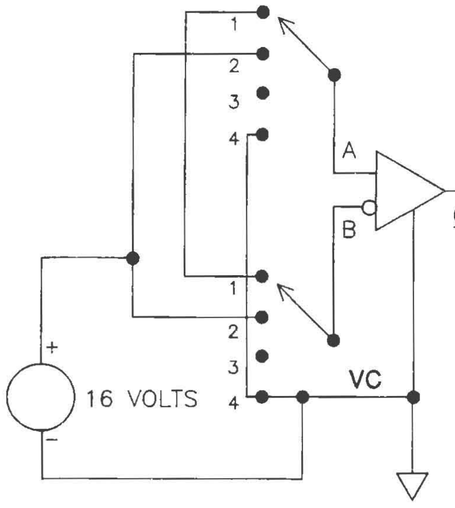
The receiver shall be so designed that the magnitude of the current from the common-mode voltage source used in the test shall not exceed 1 mA.

7.4.2.5 Idle Input Behavior. When the receiver becomes nonidle after a period of idle on the interface circuit, the characteristics of the signal at the output of the receiver shall stabilize within the startup delay allowed for the device incorporating the receiver so that it is not prevented from meeting the jitter specifications established for that device.

The receiving unit shall take precautions to ensure that a HI to idle transition is not falsely interpreted as an idle to nonidle transition, even in the presence of signal droop due to ac coupling in the interface driver or receiver circuits.

7.4.2.6 Fault Tolerance. Any single receiver in the interface shall tolerate the application of each of the faults specified by the switch settings in Fig 7-16 indefinitely, and after the fault condition is removed, the operation of the receiver according to the specifications of 7.4.2.1 through 7.4.2.6 shall not be impaired.

In addition, the magnitude of the current into either input of the receiver under any of the fault conditions specified shall not exceed 3 mA.



FAULT CONDITION	SWITCH SETTINGS LEAD A	LEAD B
1	1	1
2	4	3
3	3	4
4	4	4
5	2	3
6	3	2
7	2	2
8	3	3

Fig 7-16
Receiver Fault Conditions

7.4.3 AUI Cable Characteristics. The interface cable consists of individually shielded twisted pairs of wires with an overall shield covering these individual shielded wire pairs. These shields must provide sufficient shielding to meet the requirements of protection against rf interference and the following cable parameters. Individual shields for each signal pair are electrically isolated from the outer shield but not necessarily from each other.

The overall shield shall be returned to the MAU and DTE Units via the AUI connector shell as defined in 7.6.2 and 7.6.3. If a common drain wire is used for all the signal pair shields, then it shall be connected to pin 4. Individual drain wire returns for each signal pair may be used (see 7.6.3). It is recommended that individual drain wires be used on all control and data circuit shields to meet satisfactory crosstalk levels. If individual drain wires are used, they shall be interconnected within the AUI cable at each end and shall be connected at least to pin 4 at each end of the cable.

The presence of the Control Out signal pair is optional. If driver or receiver circuit components for CO are not provided, consideration should be given to properly terminating the CO signal pair within the DTE and MAU to preclude erroneous operation.

7.4.3.1 Conductor Size. The dc power pair in the interconnecting cable, voltage common and voltage minus, shall be composed of a twisted pair of sufficient gauge stranded wires to result in a nominal dc resistance not to exceed 1.75 Ω per conductor.

Conductor size for the signal pairs shall be determined according to the ac related parameters in 7.4.3.2–7.4.3.6.

7.4.3.2 Pair-to-Pair Balanced Crosstalk. The balanced crosstalk from one pair of wires to any other pair in the same cable sheath (when each pair is driven per 7.4.1.1–7.4.1.5) shall have a minimum value of 40 dB of attenuation measured over the range of BR/2 to BR.

7.4.3.3 Differential Characteristic Impedance. The differential characteristic impedance for all signal pairs shall be equal within 3 Ω and shall be 78 ± 5 Ω measured at a frequency of BR.

7.4.3.4 Transfer Impedance

(1) The common-mode transfer impedance shall not exceed the values shown in Fig 7-17 over the indicated frequency range.

(2) The differential mode transfer impedance for all pairs shall be at least 20 dB below the common-mode transfer impedance.

7.4.3.5 Attenuation. Total cable attenuation levels between driver and receiver (at separate stations) for each signal pair shall not exceed 3 dB over the frequency range of BR/2 to BR (Hz) for sinewave measurements.

7.4.3.6 Timing Jitter. Cable meeting this specification shall exhibit edge jitter of no more than 1.5 ns at the receiving end when the longest legal length of the cable as specified in 7.4.3.1 through 7.4.3.7 is terminated in a 78 Ω ± 1% resistor at the receiving end and is driven with pseudorandom Manchester encoded binary data from a data generator which exhibits no more than 0.5 ns of edge jitter on half bit cells of exactly 1/2 BT and whose output meets the specifications of 7.4.1.1 through 7.4.1.5. This test shall be conducted in a noise-free environment. The above specified component is not to introduce more than 1 ns of edge jitter into the system.

NOTE: Special attention will have to be applied to the cable characteristics and length at 20 Mb/s.

7.4.3.7 Delay. Total signal delay between driver and receiver (at separate stations) for each signal pair shall not exceed 257 ns.

7.5 Functional Description of Interchange Circuits

7.5.1 General. The AUI consists of either three or four differential signal circuits, power, and ground. Two of the circuits carry encoded data and two carry encoded control information. Circuits DO (Data Out) and CO (Control Out) are sourced by the DTE, and circuits DI (Data In) and CI (Control In) are sourced by

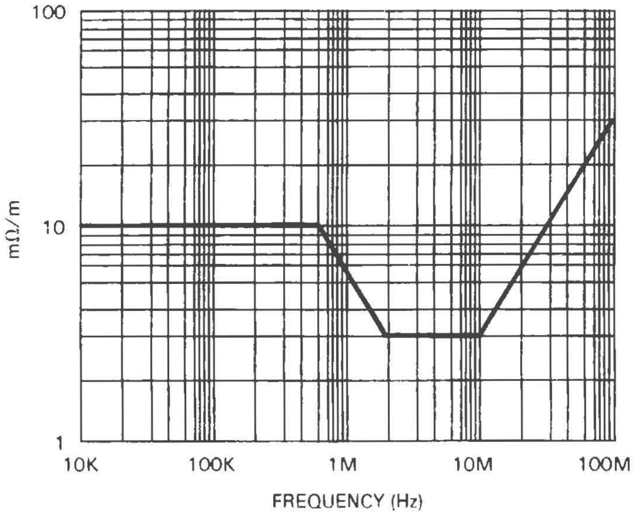


Fig 7-17
Common-Mode Transfer Impedance

the MAU. The interface also provides for power transfer from the DTE to the MAU. The CO circuit is optional.

7.5.2 Definition of Interchange Circuits. The following circuits are defined by this specification:

Circuit	Name	Signal Direction to MAU	Signal Direction from MAU	Remarks
DO	Data Out	X		Encoded Data
DI	Data In		X	Encoded Data
CO	Control Out	X		Encoded Control
CI	Control In		X	Encoded Control
VP	Voltage Plus	X		12 Volts
VC	Voltage Common	X		Return for VP
PG	Protective Ground	X		Shield

7.5.2.1 Circuit DO–Data Out. The Data Out (DO) circuit is sourced by the DTE. It is a differential pair consisting of DO-A (Data Out circuit A) and DO-B (Data Out circuit B).

The signal transferred over this circuit is Manchester encoded. An *output* message containing a one bit is encoded as CD1. An *output_idle* message is encoded as an IDL.

The following symmetry requirements shall be met when the DTE transfers pseudo-random Manchester encoded binary data over a DO circuit loaded by the test load specified in 7.4.1.1.

Bit cells generated internal to the DTE are required to be 1 BT within the permitted tolerance on data rate specified in 7.3.2. Half bit cells in each data bit are the be exactly 1/2 BT (that is, the reference point for edge jitter measurements) within the permitted tolerance on the data rate specified in 7.3.2. Each transition on the DO circuit is permitted to exhibit edge jitter not to exceed 0.5 ns in each direction. This means that any transition may occur up to 0.5 ns earlier or later than this transition would have occurred had no edge jitter occurred on this signal.

7.5.2.2 Circuit DI–Data In. The Data In (DI) circuit is sourced by the MAU. It is a differential pair consisting of DI-A (Data In circuit A) and DI-B (Data In circuit B).

The signal transferred over this circuit is Manchester encoded. An *input* message containing a zero bit is encoded as CD0. An *input* message containing a one bit is encoded as CD1. An *input_idle* message is encoded as an IDL.

A DTE meeting this specification shall be able to receive, on the DI circuit without a detectable FCS error, normal preamble data arranged in legal length packets as sent by another station to the DTE. The test generator for the data on the DI circuit shall meet the requirements for drivers in MAUs specified in 7.4.1.1 through 7.4.1.5 and shall drive the DI circuit through a zero length AUI cable. Random amounts of edge jitter from 0 to 12 ns on either side of each transition shall be added by the test generator to transitions in bits in the preamble, and random amounts of edge jitter of from 0 to 18 ns on either side of each transition shall be added to the transitions in all bits in the frame. Preamble length from the test generator shall be 47 bits of preamble, followed by the 8 bit SFD.

NOTE: A significant portion of the system jitter may be nonrandom in nature and consists of a steady-state shift of the midbit transitions in either direction from their nominal placement. A 16.5 ns edge jitter is expected on the transmitted signal at the receiving DTE, worst case. The difference between 16.5 ns and 18 ns jitter represents receiver design margin.

7.5.2.3 Circuit CO–Control Out (Optional). The Control Out (CO) circuit is sourced by the DTE. It is a differential pair consisting of CO-A (Control Out circuit A) and CO-B (Control Out circuit B).

The signal transferred over this circuit is encoded as described in 7.3.1.2. A *mau_request* message is encoded as CS1. A *normal* message is encoded as IDL. An *isolate* message is encoded as CS0.

7.5.2.4 Circuit CI–Control In. The Control In (CI) circuit is sourced by the MAU. It is a differential pair consisting of CI-A (Control In circuit A) and CI-B (Control In circuit B).

The signal transferred over this circuit is encoded as described in 7.3.1.2. A *mau_available* message is encoded as IDL. A *mau_not_available* message is encoded as CS1. A *signal_quality_error* message is encoded as a CS0.

7.5.2.5 Circuit VP–Voltage Plus. The Voltage Plus (VP) circuit is an optional circuit that may be sourced from the DTE. If this circuit is sourced from the DTE it shall be capable of operating at one fixed level between + 12 V dc – 6% and + 15 V dc + 5% with respect to circuit VC for all currents from 0 to 500 mA. The source shall provide protection for this circuit against an overload condition. The method of overload protection is not specified; however, under no conditions of operation, either normal or overload, shall the source apply a voltage to circuit VP of less than 0 or greater than + 15.75 V dc as specified above. MAU designers are cautioned that protection means employed by power sources may cause the voltage at signal VP to drop below the minimum operational voltage specified without going completely to zero volts when loads drawing in excess of the current supplied are applied between VP and VC. Adequate provisions shall be made to ensure that such a condition does not cause the MAU to disrupt the medium.

If the DTE does not support circuit VP, it shall have no connection to this circuit.

7.5.2.6 Circuit VC–Voltage Common. Circuit VC is the ground return to the power source for circuit VP, capable of sinking 2.0 A. Also, all common-mode terminators for AUI circuits shall be made to circuit VC.

7.5.2.7 Circuit PG–Protective Ground. Circuit PG shall be connected to chassis ground through a maximum dc resistance of 20 mΩ at the DTE end.

7.5.2.8 Circuit Shield Terminations. Individual pin terminations shall meet the following requirements:

(1) Pins 1, 4, 8, 11, 14 connected to logic ground in the DTE
(2) Pins 1, 4, 8, 11, 14 capacitively coupled to VC in MAU
(3) Impedance to ground < 5 Ω at the lowest operational BR/2 in the MAU and at the highest BR in the DTE

7.6 Mechanical Characteristics

7.6.1 Definition of Mechanical Interface. All connectors used shall be as specified in 7.6.2. The DTE shall have a female connector and the MAU shall have a male connector. The MAU may be plugged directly into the DTE or may be connected by one or more cable segments whose total length is less than or equal to 50 m. All cable segments shall have a male connector on one end and a female connector on the other end. All female connectors shall have the slide latch, and all male connectors shall have the locking posts (as defined in Figs 7-18, 7-19, and 7-20) as the retention system.

7.6.2 Line Interface Connector. A 15-pole connector having the mechanical mateability dimensions as specified in IEC 807-2 [7] with gold-plated contacts shall be used for the line interface connector. The shells of these connectors shall be tin plated to ensure the integrity of the cable shield to chassis current path. The resistance of the cable shield to equipment chassis shall not exceed 5 mΩ, after a minimum of 500 cycles of mating and unmaking.

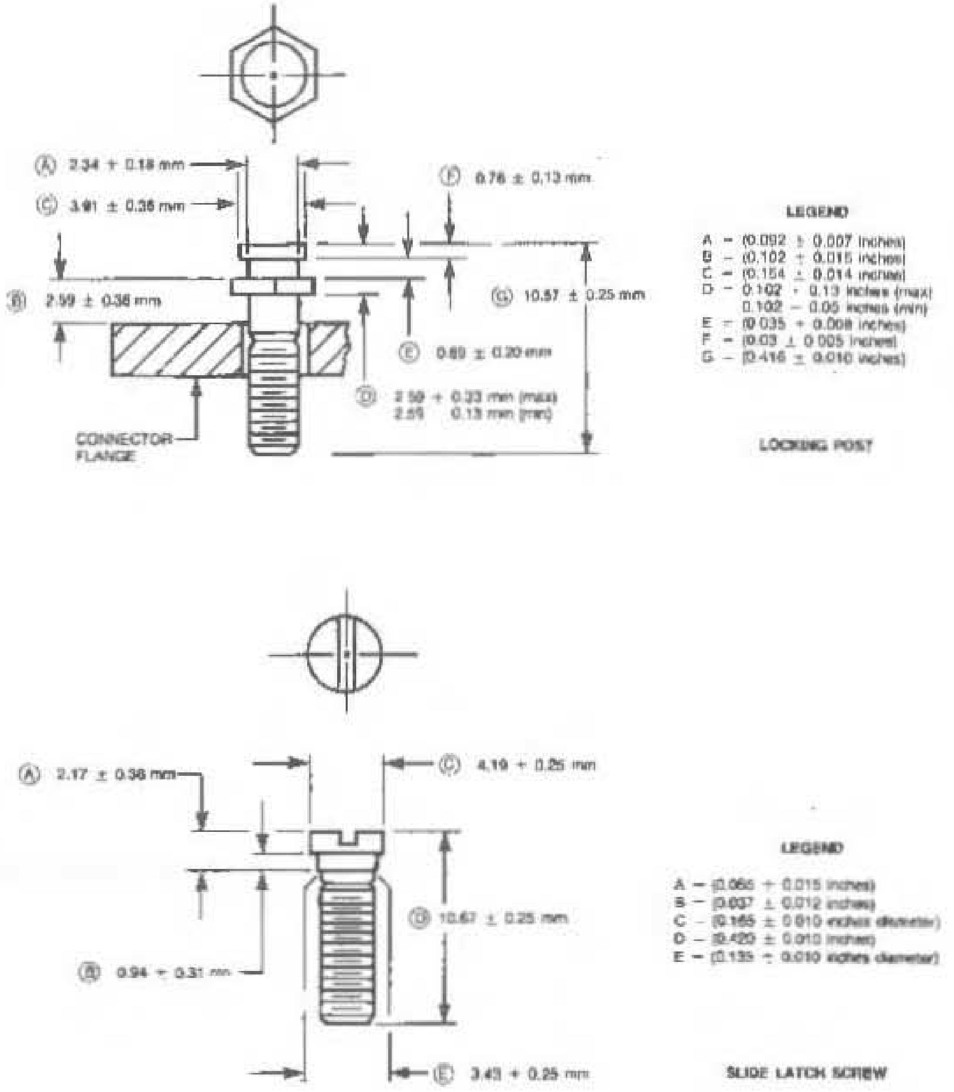


Fig 7-18
Connector Locking Posts

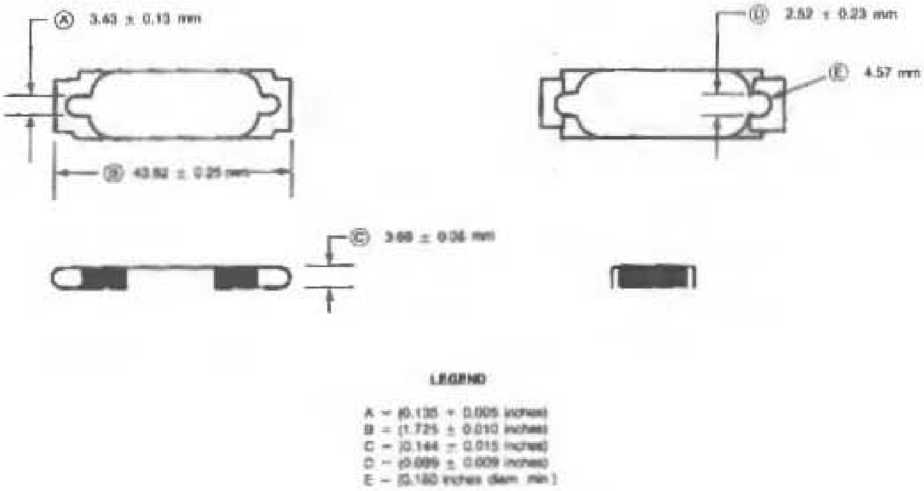


Fig 7-19
Connector Slide Latch

(material 24 gauge maximum)

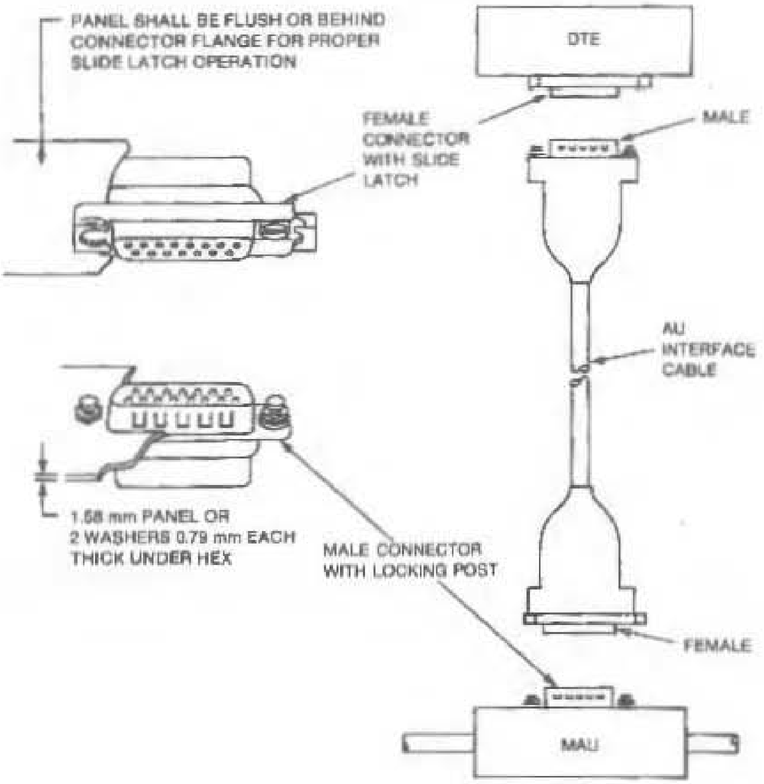


Fig 7-20
Connector Hardware and AUI Cable Configuration

In order to ensure intermateability of connectors obtained from different manufacturers, the connector with female contacts shall conform to IEC 807-2 [7] and have gold-plated contacts and tin-plated shells. All additions to provide for female shell to male shell conductivity shall be on the shell of the connector with male contacts. There should be multiple contact points around the sides of this shell to provide for shield continuity.

NOTE: Use of similar metallic surfaces on connector conductors and similar metallic surfaces on the connector shells minimizes galvanic action and reduced performance.

The connector is not specified to prevent operator contact with the shield, and precautions shall be taken at installation time to ensure that the installer is warned that the shield is not to be brought into contact with any hazardous voltage while being handled by operating personnel.

See reference [A13].

7.6.3 Contact Assignments. The following table shows the assignment of circuits to connector contacts:

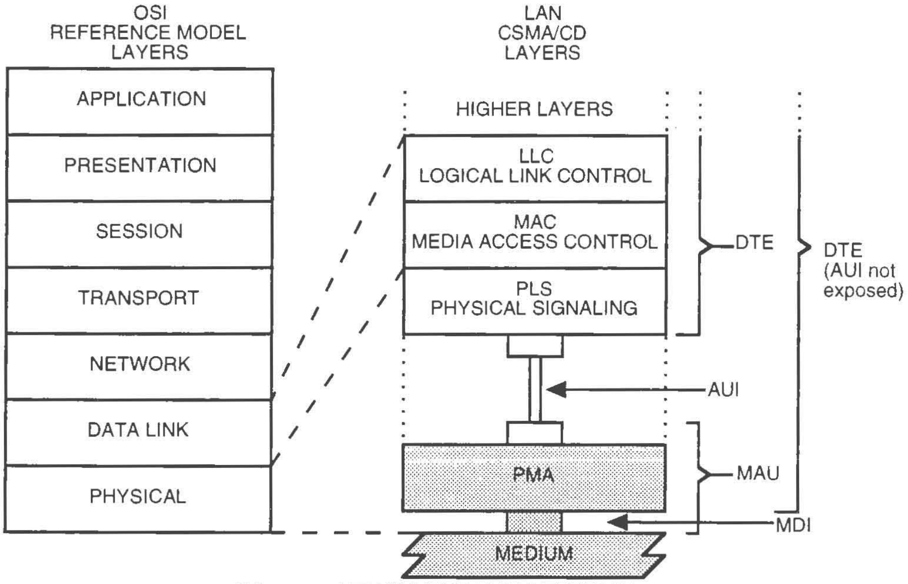
Contact	Circuit	Use
3	DO-A	Data Out circuit A
10	DO-B	Data Out circuit B
11	DO-S	Data Out circuit Shield
5	DI-A	Data In circuit A
12	DI-B	Data In circuit B
4	DI-S	Data In circuit Shield
7	CO-A	Control Out circuit A
15	CO-B	Control Out circuit B
8	CO-S	Control Out circuit Shield
2	CI-A	Control in circuit A
9	CI-B	Control In circuit B
1	CI-S	Control In circuit Shield
6	VC	Voltage Common
13	VP	Voltage Plus
14	VS	Voltage Shield
Shell	PG	Protection Ground (Conductive Shell)

NOTES: (1) Voltage Plus and Voltage Common use a single twisted pair in the AUI cable.
(2) As indicated in 7.4.2.1, the A lead of a circuit is positive relative to the B lead for a HI signal and negative for a LO signal.

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

8.1 Scope

8.1.1 Overview. This standard defines the functional, electrical, and mechanical characteristics of the MAU and one specific medium for use with local networks. The relationship of this specification to the entire ISO [IEEE] Local Network specification is shown in Fig 8-1. The purpose of the MAU is to provide a simple, inexpensive, and flexible means of attaching devices to the local network medium.



AUI = ATTACHMENT UNIT INTERFACE
MAU = MEDIUM ATTACHMENT UNIT
MDI = MEDIUM DEPENDENT INTERFACE
PMA = PHYSICAL MEDIUM ATTACHMENT

Fig 8-1
Physical Layer Partitioning, Relationship to the ISO Open Systems Interconnection (OSI) Reference Model

8.1.1.1 Medium Attachment Unit. The MAU has the following general characteristics:

(1) Enables coupling the PLS by way of the AUI to the explicit baseband coaxial transmission system defined in this section of the standard.
(2) Supports message traffic at a data rate of 10 Mb/s (alternative data rates may be considered in future additions to the standard).
(3) Provides for driving up to 500 m (1640 ft) of coaxial trunk cable without the use of a repeater.
(4) Permits the DTE to test the MAU and the medium itself.
(5) Supports system configurations using the CSMA/CD access mechanism defined with baseband signaling.
(6) Supports a bus topology interconnection means.

8.1.1.2 Repeater Unit. The repeater unit is used to extend the physical system topology, has the same general characteristics as defined in 8.1.1.1, and provides for coupling together two or more 500 m (1640 ft) coaxial trunk cable segments. Multiple repeater units are permitted within a single system to provide a maximum trunk cable connection path of 2.5 km (8200 ft) between any two MAUs.

8.1.2 Definitions

baseband coaxial system. A system whereby information is directly encoded and impressed on the coaxial transmission medium. At any point on the medium, only one information signal at a time can be present without disruption (see collision).

BR. The rate of data throughput (bit rate) on the medium in bits per second.

BR/2. One half of the BR in Hertz.

branch cable. The AUI cable interconnecting the DTE and MAU system components.

carrier sense. In a local area network, an ongoing activity of a data station to detect whether another station is transmitting.

NOTE: A collision presence signal is provided by the PLS to the PMA sublayer to indicate that one or more stations are currently transmitting on the trunk coaxial cable.

coaxial cable. A two-conductor (center conductor, shield system), concentric, constant impedance transmission line used as the trunk medium in the baseband system.

coaxial cable interface. The electrical and mechanical interface to the shared coaxial cable medium either contained within or connected to the MAU. Also known as MDI (Medium Dependent Interface).

coaxial cable segment. A length of coaxial cable made up from one or more coaxial cable sections and coaxial connectors, and terminated at each end in its characteristic impedance.

collision. An unwanted condition that results from concurrent transmissions on the physical medium.

collision presence. A signal provided by the PLS to the PMA sublayer (within the data link layer) to indicate that multiple stations are contending for access to the transmission medium.

compatibility interfaces. The MDI coaxial cable interface and the AUI branch cable interface, the two points at which hardware compatibility is defined to allow connection of independently designed and manufactured components to the baseband transmission system.

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

Medium Dependent Interface (MDI). The mechanical and electrical interface between the trunk cable medium and the MAU.

Physical Medium Attachment (PMA). The portion of the MAU that contains the functional circuitry.

Physical Signaling (PLS). That portion of the Physical Layer, contained within the DTE that provides the logical and functional coupling between MAU and Data Link Layers.

repeater. A device used to extend the length, topology, or interconnectivity of the physical medium beyond that imposed by a single segment, up to the maximum allowable end-to-end trunk transmission line length. Repeaters perform the basic actions of restoring signal amplitude, waveform, and timing applied to normal data and collision signals.

trunk cable. The trunk coaxial cable system.

8.1.3 Application Perspective: MAU and MEDIUM Objectives. This section states the broad objectives and assumptions underlying the specifications defined throughout this section of the standard.

8.1.3.1 Object

(1) Provide the physical means for communication between local network data link entities.

NOTE: This standard covers a portion of the physical layer as defined in the OSI Reference Model and, in addition, the physical medium itself, which is beyond the scope of the OSI Reference Model.

(2) Define a physical interface that can be implemented independently among different manufacturers of hardware and achieve the intended level of compatibility when interconnected in a common local network.

(3) Provide a communication channel capable of high bandwidth and low bit error rate performance. The resultant mean bit error rate, at the physical layer service interface should be less than one part in 10^8 (on the order of one part in 10^9 at the link level).

(4) Provide for ease of installation and service.

(5) Provide for high network availability (ability of a station to gain access to the medium and enable the data link connection in a timely fashion).

(6) Enable relatively low-cost implementations.

8.1.3.2 Compatibility Considerations. All implementations of this baseband coaxial system shall be compatible at the MDI.

This standard provides one explicit trunk cable medium specification for the interconnection of all MAU devices. The medium itself, the functional capability of the MAU, and the AUI are defined to provide the highest possible level of compatibility among devices designed by different manufacturers. Designers are free to implement circuitry within the MAU in an application-dependent manner provided the MD Interface and AUI specifications are satisfied.

Subsystems based on this specification may be implemented in several different ways provided compatibility at the medium is maintained. It is possible, for example, to design an integrated station where the MAU is contained within a physical DTE system component, thereby eliminating the AUI cable. The device designer (and system user) shall then consider such factors as topological flexibility, system availability, and configurability.

8.1.3.3 Relationship to PLS and AU Interface. This section defines the primary physical layer for the local area network, a layer comprised of both the physical medium and the rudimentary circuitry necessary to couple a station's message path directly to/from the medium. The complete logical physical layer of the local area network may reside physically in two distinct locations, the MAU and the DTE. Therefore, a close relationship exists between this section and Section 7. This section specifies all of the physical medium parameters, all of the PMA logical functions residing in the physical MAU, and references the AUI associated with and defined throughout Section 7.

NOTE: The design of a physical MAU component requires the use of both this section and Section 7 for the PLS and AUI specifications.

8.1.3.4 Modes of Operation. The MAU is capable of operating in either a "Normal" mode or an optional "Monitor" mode.

(1) *Normal Mode.* The MAU functions as a direct connection between the baseband medium and the DTE. Data output from the DTE is output to the coaxial trunk medium and all data on the coaxial trunk medium is input to the DTE. This mode is the "normal" mode of operation for the intended message traffic between stations.

(2) *Monitor Mode.* The MAU Transmit Function is disabled to prevent data from being output on the trunk coaxial medium while the receive function and collision presence function remain active for purposes of monitoring medium message traffic. This mode also serves as a limited test mode at the same time it isolates the MAU transmitter from the medium. Under most local (that is, intrastation) fault conditions the monitor mode enables continued use of the network while the local station is being serviced.

8.2 MAU Functional Specifications. The MAU component provides the means by which signals on the four physically separate AUI signal circuits to/from the DTE and their associated interlayer messages are coupled to the single coaxial cable baseband signal line. To achieve this basic objective, the MAU component contains the following functional capabilities to handle message flow between the DTE and the baseband medium:

(1) *Transmit Function.* The ability to transmit serial data bit streams on the baseband medium from the local DTE entity and to one or more remote DTE entities on the same network.
(2) *Receive Function.* The ability to receive serial data bit streams over the baseband medium.
(3) *Collision Presence Function.* The ability to detect the presence of two or more stations' concurrent transmissions.
(4) *Monitor Function* (Optional). The ability to inhibit the normal transmit data stream to the medium at the same time the normal receive function and collision presence function remain operational.
(5) *Jabber Function.* The ability to automatically interrupt the transmit function and inhibit an abnormally long output data stream.

8.2.1 MAU Physical Layer Functions

8.2.1.1 Transmit Function Requirements. At the start of a frame transmission on the coaxial cable, no more than 2 bits (2 full bit cells) of information may be received from the DO circuit and not transmitted onto the coaxial medium. In addition, it is permissible for the first bit sent to contain encoded phase violations or invalid data; however, all successive bits of the frame shall be reproduced with no more than the specified amount of jitter. The second bit cell transmitted onto the coaxial cable shall be carried from the DO signal line and transmitted onto the coaxial trunk cable medium with the correct timing and signal levels. The steady-state propagation delay between the DO circuit receiver input and the coaxial cable output shall not exceed one-half bit cell. There shall be no logical signal inversions between the branch cable DO circuit and the coaxial trunk cable (for example, a "high" logic level input to the MAU shall result in the less negative current flow value on the trunk coaxial medium). A positive signal on the A signal lead of the DO circuit shall result in a more positive voltage level on the trunk coaxial medium. It is assumed that the AUI shall provide adequate protection against noise. It is recommended that the designer provide an implementation in which a minimum threshold signal is required to establish a transmit bit stream.

The Transmit Function shall output a signal on the trunk coaxial medium whose levels and waveform comply with 8.3.1.3.

In addition, when the DO circuit has gone idle after a frame is output, the MAU shall then activate the collision presence function as close to the trunk coaxial cable as possible without introducing an extraneous signal on the trunk coaxial medium. The MAU shall initiate the collision presence state within 0.6 μs to 1.6 μs after the start of the output idle signal and shall maintain an active collision presence state for a time equivalent to 10 ± 5 bit cells.

8.2.1.2 Receive Function Requirements. The signal from the coaxial trunk cable shall be directly coupled to the receiver and subsequently ac coupled before reaching the receive circuit connected to the DTE. The receive function shall output a signal onto the DI circuit of the AUI cable that complies with the AUI specification for drivers in MAUs.

At the start of a frame reception from the coaxial cable, no more than 5 bits (five full bit cells) of information may be received from the coaxial cable and not transmitted onto the receive (DI) circuit. In addition, it is permissible for the first bit sent over the receive circuit to contain encoded phase violations or invalid data; however, all successive bits of the frame shall reproduce the incoming signal with no more than the above specified amount of jitter. This implies that the second bit cell sent onto the DI circuit presents valid data to the branch cable. The steady-state propagation delay between the coaxial cable and the receive (DI) circuit output shall not exceed one-half bit cell. There are no logical signal inversions between the coaxial (trunk) cable and the MAU (branch) cable receive circuit. The circuit bandwidth of the receiver function shall be limited to 50 MHz.

A MAU meeting this specification shall exhibit edge jitter into the DI pair when terminated in the appropriate test load specified in 7.4.3.6, of no more than 8.0 ns in either direction when it is installed on the distant end of all lengths between 2.5 m and 500 m of the cable specified in 8.4.1.1 through 8.4.2.1.5 terminated at both ends with terminators meeting the impedance requirements of 8.5.2.1 and driven at one end with pseudo-random Manchester encoded binary data from a data generator that exhibits no more than 1.0 ns of edge jitter in either direction on half-bit cells of exactly 1/2 BT and whose output meets the specifications of 8.3.1.3 except that the risetime of the signal must be 30 ns + 0, − 2 ns. This test shall be conducted in a noise-free environment. The combination of coaxial cable and MAU receiver introduce no more than 6 ns of edge jitter into the system.

The local transmit and receive functions shall operate simultaneously while connected to the medium operating in the half duplex operating mode.

8.2.1.3 Collision Presence Function Requirements. The signal presented to the CI circuit in the absence of a collision shall be the IDL signal except when the MAU is required to signal the CS1 signal.

The signal presented to the CI circuit during the presence of a collision shall be the CS0 signals encoded as specified in 7.3.1.2. This signal shall be presented to the CI circuit no more than 9 bit times after the signal (for example, dc average) on the coaxial cable at the MAU equals or exceeds that produced by two (or more) MAU outputs transmitting concurrently under the condition that the MAU detecting collision presence is transmitting. Under no conditions shall the collision presence function generate an output when only one MAU is transmitting. A MAU, while not transmitting, may detect the presence of two other MAUs transmitting and shall detect the presence of more than two other MAUs transmitting. Table 8-1 summarizes the allowable conditions under which collisions shall be detected.

The collision presence function may, in some implementations, be able to sense an abnormal (for example, open) medium. The use of MAUs in repeaters requires added considerations; see 8.3.1.5.

Table 8-1
Generation of Collision Presence Signal

MAU	Numbers of Transmitters		
	<2	=2	>2
Transmitting	N	Y	Y
Not transmitting	N	May	Y

Y = will generate SQE message
N = will not generate SQE message
May = may generate SQE message

8.2.1.4 Monitor Function Requirements (Optional). Upon receipt of the *isolate* message the MAU shall, within 20 ms (implementations: solid-state preferred, relay switched permitted), disable the transmit function in such a way as to prevent both the transmission of signals on the trunk coaxial medium and any abnormal loading by the disabled transmitter on the trunk coaxial medium itself. The monitor function is intended to prevent a malfunctioning active component (for example, transmit driver) from bringing down the network. The *isolate* message shall not interact with the receive or collision presence functions, thus permitting the normal operational mode wherein all data appearing on the trunk coaxial medium are carried to the DTE on the DI signal circuit.

NOTE: Verification for successful execution of the *isolate* message requires use of the trunk coaxial medium itself. This level of guaranteed performance requires use of system layers above the physical layer and implies some interruption of normal trunk coaxial medium message traffic.

8.2.1.5 Jabber Function Requirements. The MAU shall contain a self-interrupt capability to inhibit transmit data from reaching the medium. Hardware within the MAU (with no external message other than the detection of output data, bits, or leakage, by way of the transmit function) shall provide a nominal window of at least 20 ms to at most 150 ms during which time a normal data link frame may be transmitted. If the frame length exceeds this duration, the jabber function shall inhibit further output data from reaching the medium.

When the transmit function has been positively disabled, the MAU shall then activate the collision presence function as close to the trunk coaxial medium as possible without introducing an extraneous signal on the trunk coaxial medium. A MAU without the monitor function and powered by the DTE may reset the jabber and collision presence functions on power reset once the error condition has been cleared. Alternatively, a self-powered MAU may reset these functions after a period of 0.5 s ± 50% if the monitor function has not been implemented. If the monitor function has been implemented then it shall be used to reset the collision presence and jabber functions.

8.2.2 MAU Interface Messages

8.2.2.1 DTE Physical Layer to MAU Physical Layer Messages. The following messages can be sent by the DTE physical layer entities to the MAU physical layer entities:

Message	Circuit	Signal	Meaning
output	DO	CD1, CD0	Output information
output_idle	DO	IDL	No data to be output
normal	CO	IDL	Assume the nonintrusive state on the trunk coaxial medium
	(Optional Circuit)		
isolate	CO	CS0(BR)	Positively disable the trunk coaxial medium transmitter

8.2.2.2 MAU Physical Layer to DTE Physical Layer. The following messages can be sent by the MAU physical layer entities to the DTE physical layer entities:

Message	Circuit	Signal	Meaning
input	DI	CD1, CD0	Input information
input_idle	DI	IDL	No information to be input
mau_available	CI	IDL	MAU is available for output
signal_quality_error	CI	CS0	Error detected by MAU

8.2.2.2.1 *input* Message. The MAU physical layer sends an *input* message to the DTE physical layer when the MAU has a bit of data to send to the DTE. The physical realization of the input message is a CD0 or CD1 sent by the MAU to the DTE on the data in circuit. The MAU sends CD0 if the *input* bit is a zero or CD1 if the *input* bit is a one. No retiming of the CD1 or CD0 signals takes place within the MAU.

8.2.2.2.2 *input_idle* Message. The MAU physical layer sends an *input_idle* message to the DTE physical layer when the MAU does not have data to send to the DTE. The physical realization of the *input_idle* message is the IDL signal sent by the MAU to the DTE on the data in circuit.

8.2.2.2.3 *mau_available* Message. The MAU physical layer sends the *mau_available* message to the DTE physical layer when the MAU is available for output. The *mau_available* message is always sent by a MAU that is always prepared to output data unless the *signal_quality_error* message shall be sent instead. Such a MAU does not require *mau_request* to prepare itself for data output. The physical realization of the *mau_available* message is an IDL signal sent by the MAU to the DTE on the control in circuit.

8.2.2.2.4 *signal_quality_error* Message. The *signal_quality_error* message shall be implemented in the following fashion:

(1) The *signal_quality_error* message shall not be sent by the MAU if no MAU or only one MAU is transmitting on the trunk coaxial medium in the normal mode.

(2) If two or more remote MAUs are transmitting on the trunk coaxial medium, but the MAU connected to the local node is not transmitting, then the local MAU shall send the *signal_quality_error* message in every instance when it is possible for it to ascertain that more than one MAU is transmitting on the trunk coaxial medium. The MAU shall make the best determination possible. It is acceptable for the MAU to fail to send the *signal_quality_error* message when it is unable to conclusively determine that more than one MAU is transmitting.

(3) When the local MAU is transmitting on the trunk coaxial medium, all occurrences of one or more additional MAUs transmitting shall cause the *signal_quality_error* message to be sent by the local MAU to its DTE.
(4) When the MAU has completed each output frame it shall perform an SQE test sequence, as defined in Figs 8-2 and 8-3.
(5) When the MAU has inhibited the transmit function it shall send the *signal_quality_error* message in accordance with the jabber function requirements of 8.2.1.5.

The *signal_quality_error* message shall be asserted less than 9 bit cells after the occurrence of the multiple-transmission condition is present at the MDI and shall no longer be asserted within 20 bit cells after the indication of multiple transmissions ceases to be present at the MDI. It is to be noted that an extended delay in the removal of the *signal_quality_error* message may affect adversely the access method performance.

The physical realization of the *signal_quality_error* message is the CS0 signal sent by the MAU to the DTE on the control in circuit.

Note that the MAU is required to assert the *signal_quality_error* message at the appropriate times whenever the MAU is powered and not just when the DTE is providing output data.

8.2.3 MAU State Diagrams. The state diagrams Figs 8-2, 8-3, and 8-4 depict the full set of allowed MAU state functions relative to the control circuits of the DTE-MAU interface for MAUs without conditioning requirements. Messages used in these state diagrams are explained below:

(1) *positive_disable.* Activates the positive means provided in the MAU transmitter to prevent interference with the trunk coaxial medium.
(2) *enable_driver.* Activates the path employed during normal operation to cause the MAU transmitter to impress data onto the trunk coaxial medium.
(3) *disable_driver.* Deactivates the path employed during normal operation to cause the MAU transmitter to impress data onto the trunk coaxial medium.
(4) *no_collision.* Signifies that the condition of multiple transmitters simultaneously active on the trunk coaxial medium does not exist.
(5) *collision.* Signifies that the condition of multiple transmitters simultaneously active on the trunk coaxial medium does exist.
(6) *not_positive_disable.* Deactivates the positive means provided in the MAU transmitter to prevent interference with the trunk coaxial medium.

8.3 MAU–Medium Electrical Characteristics

8.3.1 MAU-to-Coaxial Cable Interface. The following sections describe the interface between the MAU and the coaxial cable. Negative current is defined as current into the MAU (out of the center conductor of the cable).

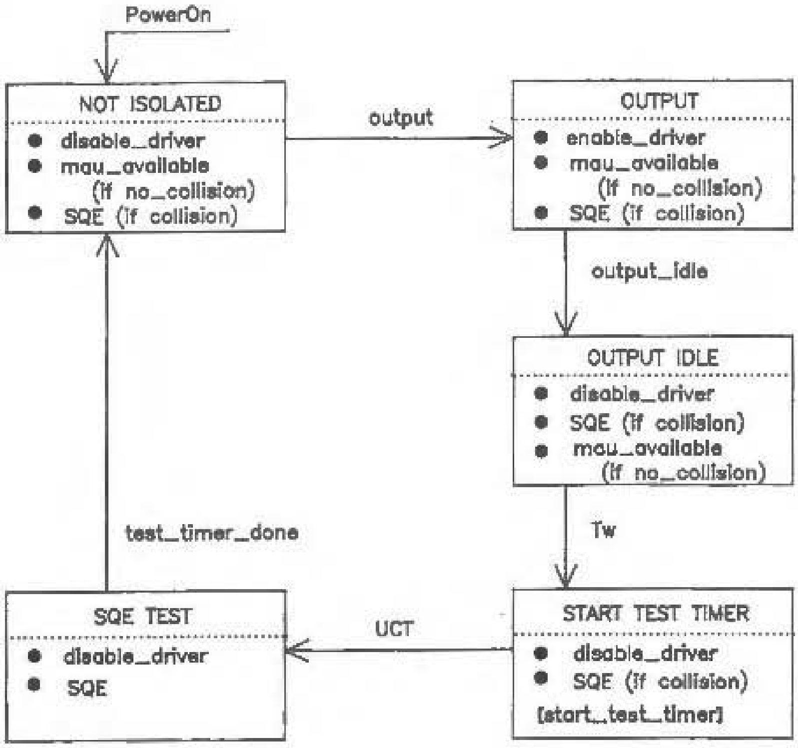
8.3.1.1 Input Impedance. The shunt capacitance presented to the coaxial cable by the MAU circuitry (not including the means of attachment to the coaxial cable) is recommended to be no greater than 2 pF. The resistance to the coaxial cable shall be greater than 100 kΩ.

The total capacitive load due to MAU circuitry and the mechanical connector as specified in 8.5.3.2 shall be no greater than 4 pF.

These conditions shall be met in the power-off and power-on, not transmitting states (over the frequencies BR/2 to BR).

The magnitude of the reflection from a MAU shall not be more than that produced by a 4 pF capacitance when measured by both a 25 ns rise time and 25 ns fall time waveform. This shall be met in both the power on and power off, not transmitting states.

8.3.1.2 Bias Current. The MAU shall draw (from the cable) between + 2 μA and – 25 μA in the power-off and the power-on, not transmitting states.



NOTE: UCT = unconditional transition
Tw = wait time, see 8.2.1.1

Fig 8-2
Interface Function: Simple MAU Without Isolate Capability

8.3.1.3 Coaxial Cable Signaling Levels. The signal on the coaxial cable due to a single MAU as measured at the MAU transmitter output is composed of an ac component and an offset component. Expressed in terms of current immediately adjacent to the MAU connection (just prior to splitting the current flow in each direction) the signal has an offset component (direct current including the effects of timing distortion) of from –37 mA minimum to –45 mA maximum and an ac component from +28 mA up to the offset value.

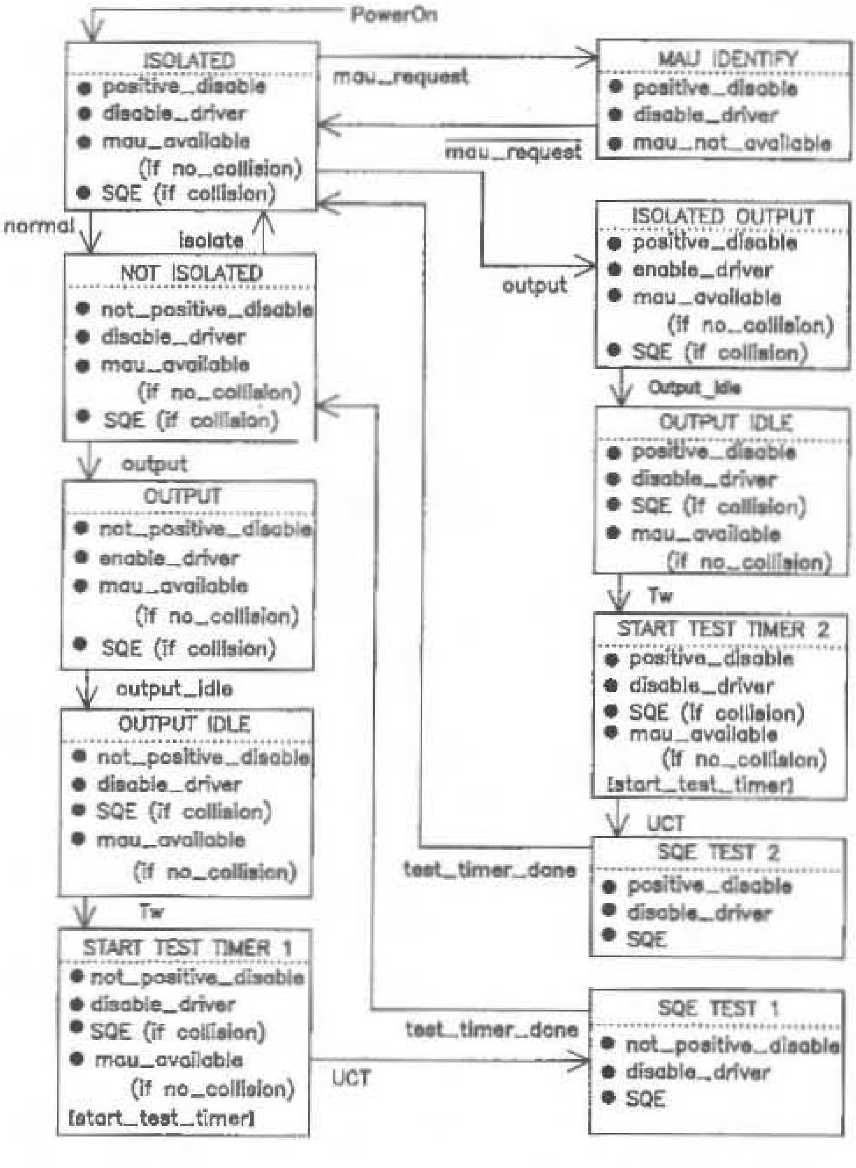
The current drive limit shall be met even in the presence of one other MAU transmitter. A MAU shall be capable of maintaining at least 2.2 V of average dc level on the coaxial cable in the presence of two or more other MAUs transmitting concurrently. The MAU shall, in addition, sink no more than ±250 µA when the voltage on the center conductor of the cable drops to –10 V when the MAU is transmitting.

The MAU shall sink no more than –25 µA when the voltage on the center conductor of the cable drops to –7 V when the MAU is transmitting.

The actual current measured at a given point on the cable is a function of the transmitted current and the cable loss to the point of measurement. Negative current is defined as current out of the center conductor of the cable (into the MAU). The 10–90% rise/fall times shall be 25 ± 5 ns at 10 Mb/s. The rise and fall times shall match within 2 ns. Figures 8-5 and 8-6 shows typical waveforms present on the cable. Harmonic content generated from the BR fundamental periodic input shall meet the following requirements:

2nd and 3rd Harmonics:	at least 20 dB below fundamental
4th and 5th Harmonics:	at least 30 dB below fundamental
6th and 7th Harmonics:	at least 40 dB below fundamental
All Higher Harmonics:	at least 50 dB below fundamental

NOTE: Even harmonics are typically much lower.



NOTE: UCT = unconditional transition
Tw = wait time, see 8.2.1.1

Fig 8-3
Interface Function: Simple MAU with Isolate Capability

The above specifications concerning harmonics cannot be satisfied by a square-wave with a single-pole filter, nor can they be satisfied by an output waveform generator employing linear ramps without additional waveshaping. The signals as generated from the encoder within PLS shall appear on the coaxial cable without any inversions (see Fig 8-6).

8.3.1.4 Transmit Output Levels Symmetry. Signals received from the AUI DO circuit shall be transmitted onto the coaxial cable with the characteristics specified in 8.3.1.3. Since the coaxial cable proceeds in two directions from the MAU, the current into the MAU is nominally twice the current measured on the coaxial cable.

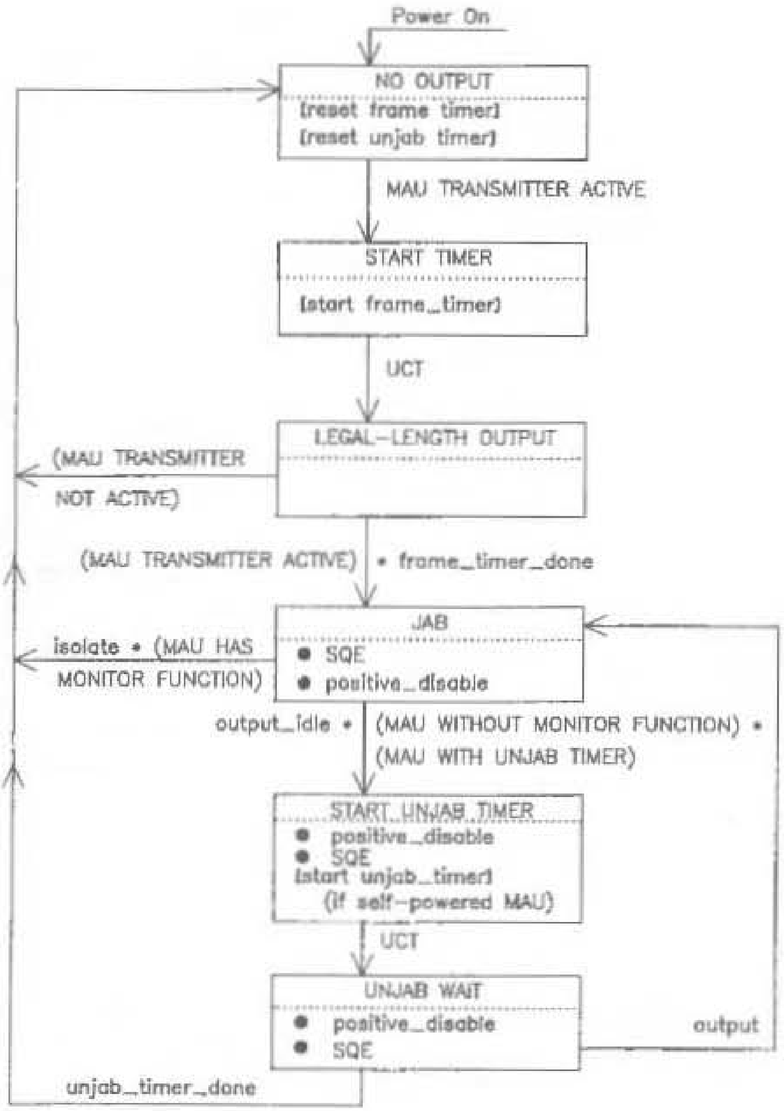


Fig 8-4
Jabber Function

The output signal of a MAU meeting this specification shall exhibit edge jitter of no more than 2.5 ns into a 25 Ω ± 1% resistor substituted for the connection to the coaxial cable when the DO circuit into the MAU is driven through a zero length AUI cable with pseudorandom Manchester encoded binary data from a data generator that exhibits no more than 0.5 ns of edge jitter on half bit cells of exactly 1/2 BT whose output meets the specifications of 7.4.1.1 through 7.4.1.5. The above specified component is not to introduce more than 2 ns of edge jitter into the system.

The MAU shall not transmit a negative going edge after cessation of the CD output data stream on DO or before the first edge of the next frame on the DO circuit.

8.3.1.5 Receive Collision Detect Threshold. It is recommended that the MAU implement the collision detect function with a –1.492 V to –1.629 V threshold range corresponding to the recommended tolerances for coax drive currents specified in 8.3.1.3. The threshold voltage is measured on the coax at the MAU connector.

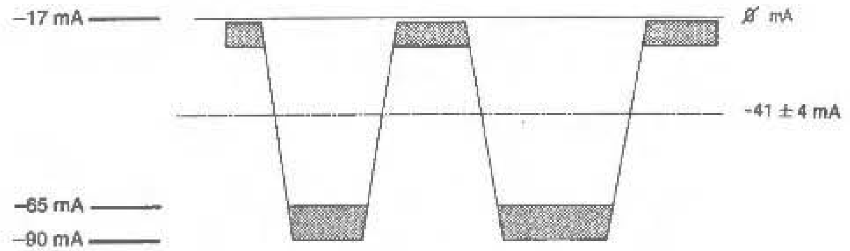
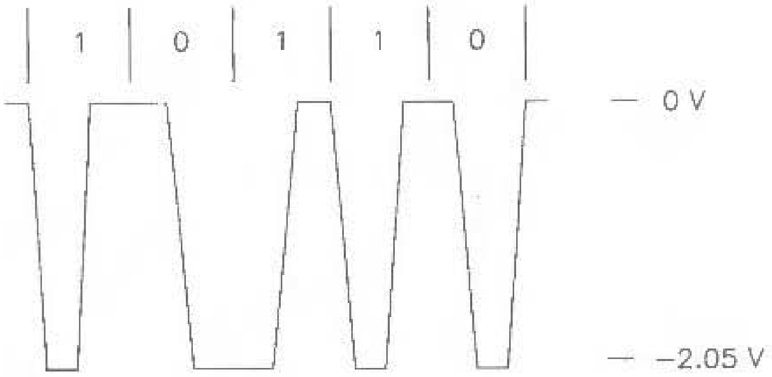


Fig 8-5
Recommended Driver Current Signal Levels



NOTES: (1) Voltages given are nominal, for a single transmitter
(2) Rise and fall time is 25 ns nominal at 10 Mb/s rate
(3) Voltages are measured on terminated coaxial cable adjacent to transmitting MAU
(4) Manchester coding

Fig 8-6
Typical Coaxial Trunk Cable Signal Waveform

Collision detection threshold voltages tighter than those recommended above may be used to improve collision detection performance in the presence of noise on the coax, poor system component tolerances, and coaxial transmit levels outside of the recommended range.

A MAU that implements the recommended receive threshold shall be considered to have implemented receive mode collision detect. Receive mode collision detect indicates that a nontransmitting MAU has the capability to detect collisions when two or more MAUs are transmitting simultaneously. Repeater units require both MAUs directly connected to it to implement receive mode collision detection.[9]

8.3.2 MAU Electrical Characteristics

8.3.2.1 Electrical Isolation. The MAU must provide isolation between the AUI cable and the coaxial trunk cable. The isolation impedance measured between each conductor (including shield) of the AUI cable and either the center conductor or shield of the coaxial cable shall be greater than 250 kΩ at 60 Hz and not greater than 15 Ω between 3 MHz and 30 MHz. The breakdown of the isolation means provided shall be at least 250 V ac, rms. See references [A7], [A8], and [A9].

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[9] Repeatered networks may require all MAU components to use the recommended coaxial drive connect levels. This matter is under consideration.

8.3.2.2 Power Consumption. The current drawn by the MAU shall not exceed 0.5 A as powered by the AUI source. The MAU shall be capable of operating from all possible voltage sources as supplied by the DTE through the resistance of all permissible AUI cables. The MAU shall not disrupt the trunk coaxial medium should the DTE power source fall below the minimum operational level under abnormal MAU load conditions.

The MAU shall be labeled externally to identify the maximum value of current required by the device at any specified input voltage.

8.3.2.3 Reliability. The MAU shall be designed to provide an MTBF of at least 1 million hours of continuous operation without causing communication failure among other stations attached to the local network medium. Component failures within the MAU electronics should not prevent communication among other MAUs on the coaxial cable. Connectors and other passive components comprising the means of connecting the MAU to the coaxial cable shall be designed to minimize the probability of total network failure.

It should be noted that a fault condition that causes a MAU to draw in excess of 2 mA may cause communication failure among other stations.

8.3.3 MAU–DTE Electrical Characteristics. The electrical characteristics for the driver and receiver components connected to the branch cable within the MAU shall be identical to those as specified in Section 7 of this standard.

8.3.4 MAU–DTE Mechanical Connection. The MAU shall be provided with a 15-pin male connector as specified in detail in the AUI specification, Section 7.

8.4 Characteristics of the Coaxial Cable. The trunk cable is of constant impedance, coaxial construction. It is terminated at each end by a terminator (see 8.5.2), and provides the transmission path for MAU device connection. Coaxial cable connectors are used to make the connection from the cable to the terminators, and between cable sections (if needed). The cable has various electrical and mechanical requirements that shall be met to ensure proper operation.

8.4.1 Coaxial Cable Electrical Parameters

8.4.1.1 Characteristic Impedance. The average characteristic cable impedance shall be 50 ± 2 Ω, measured according to IEC Publications 96-1 [2] and 96-1A [3]. Periodic variations in impedance along a single piece of cable may be up to ± 3 Ω sinusoidal centered around the average value, with a period of less than 2 m.

NOTE: If the requirements of 8.4.2.1.1 (2), 8.4.2.1.2, 8.4.2.1.3, 8.4.2.1.4 (2) are met, then it is expected that the characteristic impedance periodicity requirement shall be considered met.

8.4.1.2 Attenuation. The attenuation of a 500 m (1640 ft) cable segment shall not exceed 8.5 dB (17 dB/km) measured with a 10 MHz sine wave, nor 6.0 dB (12 dB/km) measured with a 5 MHz sine wave.

8.4.1.3 Velocity of Propagation. The minimum required velocity of propagation is 0.77 c.

8.4.1.4 Edge Jitter, Untapped Cable. Untapped coaxial cable meeting this specification shall exhibit edge jitter of no more the 8.0 ns in either direction at the receiving end when 500 m of the cable is terminated at both ends with terminators meeting the impedance requirements of 8.5.2.1 and is driven at one end with pseudorandom Manchester encoded binary data from a data generator that exhibits no more than 1.0 ns of edge jitter in either direction on half bit cells of exactly 1/2 BT and whose output meets the specifications of 8.3.1.3 except that the rise time of the signal must be 30 ns + 0, – 2 ns, and no offset component in the output current is required. This test shall be conducted in a noise-free environment. The above specified component is not to introduce more than 7 ns of edge jitter into the system.

8.4.1.5 Transfer Impedance. The coaxial cable medium shall provide sufficient shielding capability to minimize its susceptibility to external noise and also to minimize the generation of interference by the medium and related signals. While the cable construction is not mandated, it is necessary to indicate a measure of performance expected from the cable component. A cable's EMC performance is determined, to a large extent, by the transfer impedance value of the cable. See reference [A12].

The transfer impedance of the cable shall not exceed the values shown in Fig 8-7 as a function of frequency.

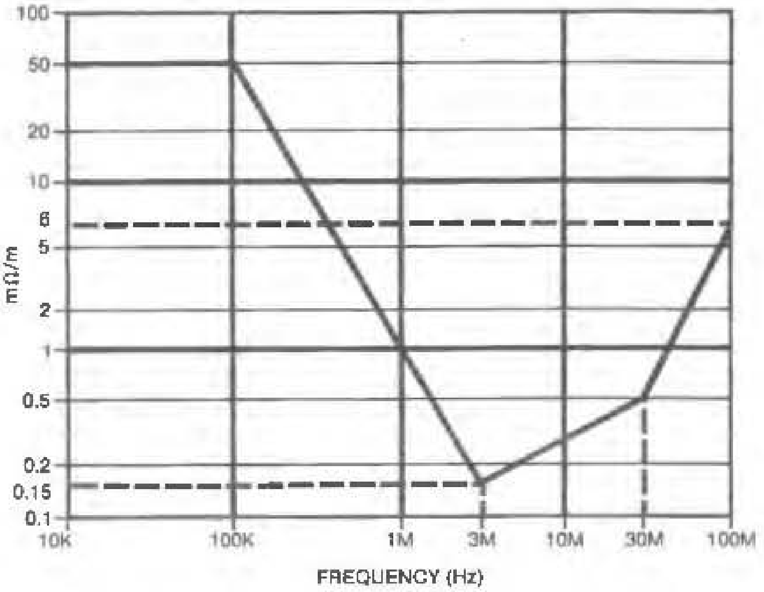


Fig 8-7
Maximum Coaxial Cable Transfer Impedance

8.4.1.6 Cable DC Loop Resistance. The sum of the center conductor resistance plus the shield resistance, measured at 20 °C, shall not exceed 10 mΩ/m.

8.4.2 Coaxial Cable Properties

8.4.2.1 Mechanical Requirements. The cable used should be suitable for routing in various environments, including but not limited to, dropped ceilings, raised floors, cable troughs, and throughout open floor space. The jacket shall provide insulation between the cable sheath and any building structural metal. Also, the cable shall be capable of accepting coaxial cable connectors, described in 8.5. The cable shall conform to the following requirements.

8.4.2.1.1 General Construction

(1) The coaxial cable shall consist of a center conductor, dielectric, shield system, and overall insulating jacket.

(2) The concentricity (for example, positional relationship between center conductor to shield system and outer jacket) of the coaxial cable elements shall be greater than 92% as measured in accordance with the following general configuration:

$$\frac{(\text{jacket radius}) - (\text{center offset})}{\text{jacket radius}} \times 100 \geq 92\%$$

It is assumed that the offset and radius values are worst case at any point within the measured system.

(3) The coaxial cable jacket, shield system, and dielectric material shall be pierceable either by means of the connector type specified in 8.5.3.2 or by an external core tool. Overall cable system pierceability (the ability of a tap probe to pierce the jacket, shields, and dielectric cable system without

substantial dielectric deformation and without causing a short circuit between center conductor and shield system) is a vital parameter affecting tap connection reliability.

Pierceability of the cable system can be measured in terms of the probe's load versus displacement signature. A pierceable cable exists where the displacement is ≥ 1.52 mm (0.06 in) between rupture (piercing) of the shield system and contact with the center conductor.

(4) The coaxial cable shall be sufficiently flexible to support a bend radius of 254 mm (10 in).

8.4.2.1.2 Center Conductor. The center conductor shall be 2.17 mm ± 0.013 mm (0.0855 ± 0.0005 in) diameter solid copper.

8.4.2.1.3 Dielectric Material. The dielectric may be of any type provided the conditions of 8.4.1.2, 8.4.1.3, and 8.4.2.1.1(3) are met.

8.4.2.1.4 Shielding System

(1) The shielding system may contain both braid and foil elements sufficient to meet the transfer impedance of 8.4.1.5 and the EMC specifications of 8.7.2.
(2) The inside diameter of the innermost shield shall be 6.15 mm (0.242 in) minimum.
(3) The outside diameter of the outermost shield shall be 8.28 mm ± 0.178 mm (0.326 ± 0.007 in).
(4) The outermost shield shall be greater than 90% coverage. The use of tinned copper braid is advised to meet the contact resistance requirements.

8.4.2.1.5 Overall Jacket

(1) Any one of several jacket materials shall be used provided the specifications of 8.4.1 and 8.4.2 are met.
(2) Either of two jacket dimensions may be used for the two broad classes of materials, provided the specification of 8.4.2.1.1 are met:
    (a) Polyvinyl Chloride (for example, PVC) or equivalent having an OD of 10.287 mm ± 0.178 mm (0.405 nominal ± 0.007 in).
    (b) Fluoropolymer (for example, FEP, E-CTFE) or equivalent having an OD of 9.525 mm ± 0.254 mm (0.375 nominal ± 0.010 in).

The cable shall meet applicable flammability and smoke criteria and local and national codes for the installed environment. See 8.7.4. Different types of cable sections (for example, polyvinyl chloride and fluoropolymer dielectric) may be interconnected, while meeting the sectioning requirements of 8.6. See references [A6] and [A14].

8.4.2.2 Jacket Marking. The cable jacket shall be marked with annular rings in a color contrasting with the background color of the jacket. The rings shall be spaced at 2.5 m ± 5 cm regularly along the entire length of the cable. It is permissible for the 2.5 m spacing to be interrupted at discontinuities between cable sections joined by connectors. (See 8.6.2.2 for MAU placement rules that mandate cable markings.) It is recommended that the base color of the cable jacket itself be a bright color (for example, yellow) other than that normally used for power mains.

8.4.3 Total Segment DC Loop Resistance. The sum of the center conductor, connectors, and shield resistance shall not exceed 5 Ω total per segment.

Each in-line connector pair or MAU shall be no more than 10 mΩ. Use of these components reduces the overall allowable segment length accordingly. Values given above are at 20 °C. For temperature variations, cable length shall be adjusted accordingly such that the 5 Ω total is not exceeded.

If a trunk coaxial cable segment consists of several cable sections, then all connectors and internal resistance of the shield and center conductor shall be included in the loop resistance measurement.

8.5 Coaxial Trunk Cable Connectors. The trunk coaxial medium requires termination and may be extended or partitioned into sections. Devices to be attached to the medium as MAUs require a means of connection to the medium. Two basic connector types provide the necessary connection means:

(1) Standard Type N connectors (IEC Publication 169-16 [4])
(2) A coaxial "tap" connector

All Type N connectors shall be of the 50 Ω constant impedance type. Since the frequencies present in the transmitted data are well below UHF range (being band-limited to approximately 20 MHz), high-quality versions of the connectors are not required (but are recommended).

All of the coaxial tap connectors shall follow the requirements as defined in 8.5.3.

8.5.1 Inline Coaxial Extension Connector. All coaxial cables shall be terminated with the Type N plug connectors. A means shall be provided to ensure that the connector shell (which connects to the cable sheath) does not make contact with any building metal or other unintended conductor. An insulating sleeve or boot slipped over the connector at installation time is suitable.

Inline coaxial extensions between two sections of coaxial cable shall be made with a pair of Type N receptacle connectors joined together to form one "barrel." An insulating sleeve or boot shall also be provided with each barrel assembly.

8.5.2 Coaxial Cable Terminator

8.5.2.1 Termination. Coaxial cable terminators are used to provide a termination impedance for the cable equal in value to its characteristic impedance, thereby minimizing reflection from the ends of the cables. Terminators shall be packaged within an inline female receptacle connector. The termination impedance shall be 50 Ω ± 1% measured from 0 – 20 MHz, with the magnitude of the phase angle of the impedance not to exceed 5°. The terminator power rating shall be 1 W or greater.

8.5.2.2 Earthing. Either the coaxial cable terminator or inline extension connector provides a convenient location for meeting the earth grounding requirement of 8.6.2.3. It is recommended that a ground lug with current rating of at least 1500 ampacity be provided on one of the two terminators or on one extension connector used within a cable segment.

NOTES: (1) A single ground return lug on an inline connector located in the center of the cable transmission system may be used to satisfy this requirement.
(2) Alternatively, terminators might be supplied in pairs, one with and one without the ground lug connection point.

8.5.3 MAU-to-Coaxial Cable Connection. A means shall be provided to allow for attaching a MAU to the coaxial cable. The connection shall not disturb the transmission line characteristics of the cable significantly; it shall present a predictably low shunt capacitance, and therefore a negligibly short stub length. This is facilitated by the MAU being located as close to its cable connection as possible; the MAU and connector are normally considered to be one assembly. Long (greater than 30 mm) connections between the coaxial cable and the input of the MAU jeopardize this objective.

Overall system performance is dependent largely on the MAU-to-coaxial cable connection being of low shunt capacitance.

If the design of the connection is such that the coaxial cable is to be severed to install the MAU, the coaxial cable segment shall still meet the sectioning requirements of 8.6.2.1. Coaxial connectors used on a severed cable shall be type N, as specified in 8.5.1.

The type N connectors selected should be of high quality (that is, low contact resistance) to minimize the impact on system performance.

If the design of the connection is such that the piercing tap connector is to be used without severing the cable, then the tap connector and cable assembly shall conform to the mechanical and electrical requirements as defined throughout 8.5.3.1 and 8.5.3.2.

8.5.3.1 Electrical Requirements. Requirements for the coaxial tap connector are as follows:

(1) Capacitance: 2 pF nominal connector loading measured at 10 MHz.

NOTE: Total capacitance of tap and active circuitry connected directly shall be no greater than 4 pF. Specific implementations may allocate capacitance between tap and circuitry as deemed appropriate.

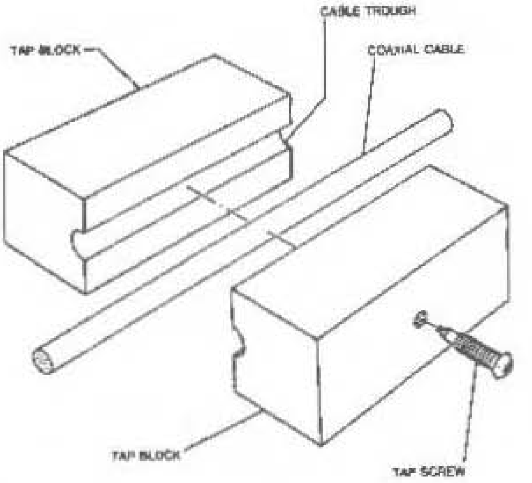
(2) Contact resistance (applies to center conductor and shield contacts): 50 mΩ maximum for both shield and center conductor over useful connector lifetime.

(3) Contact material: surface material on signal probe or shield sufficient to meet contact resistance requirements in environment and over time.
(4) Voltage rating: 600 V dc or ac rms maximum.
(5) Insulation: dc leakage resistance of tap housing shall be higher than 1 GΩ between braid and external conductors in the normal operating environment.
(6) Probe current rating: 0.1 A per contact (probe and shield)
(7) Shield current rating: 1 A surge for 1 s

8.5.3.2 Mechanical Requirements

8.5.3.2.1 Connector Housing. Shielding characteristics: > 40 dB at 50 MHz.

8.5.3.2.2 Contact Reliability. Overall performance of the LAN system depends to a large extent on the reliability of the coaxial cable medium and the connection to that medium. Tap connection systems should consider the relevant electrical and mechanical parameters at the point of electrical connection between tap probe and cable center conductor to ensure that a reliable electrical contact is made and retained throughout the useful life of these components. It is recommended that some means be provided to ensure relatively constant contact loading over time, with creep, in temperature, and typical environment. Typical coaxial tap connector configurations are shown in Figs 8-8 and 8-9. See references [A1], [A15], and [A16].



NOTE: Tutorial only and not part of specification

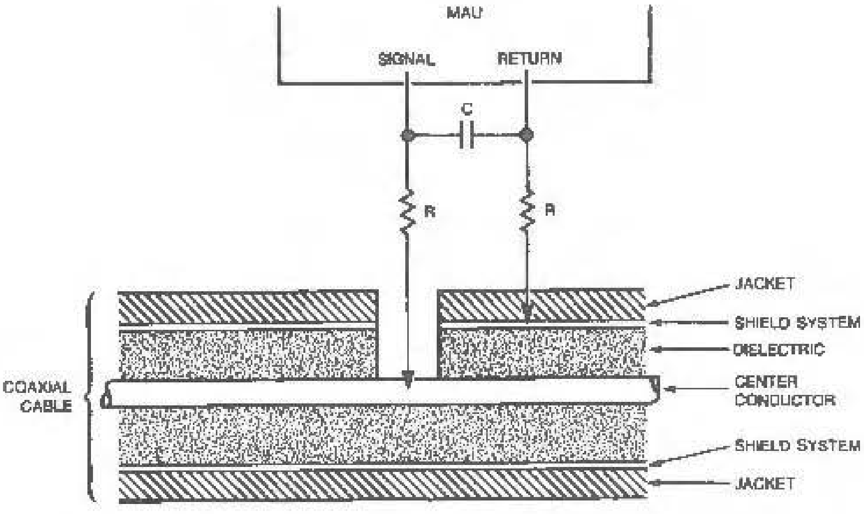
Fig 8-8
Coaxial Tap Connector Configuration Concepts

8.5.3.2.3 Shield Probe Characteristics. The shield probe shall penetrate the cable jacket and outer layer(s) of the shield system to make effective capture of the outer braid (pick 2 or more typical strands).

8.6 System Considerations

8.6.1 Transmission System Model. Certain physical limits have been placed on the physical transmission system. These revolve around maximum cable lengths (or maximum propagation times), as these affect critical time values for the CSMA/CD access method. These maxima, in terms of propagation times, were derived from the physical configuration model described here. The maximum configuration is as follows:

(1) A trunk coaxial cable, terminated in its characteristic impedance at each end, constitutes a coaxial segment. A coaxial segment may contain a maximum of 500 m of coaxial cable and a maximum of



C — CAPACITIVE LOADING, SEE 8.5.3.1

R = CONTACT RESISTANCE, SEE 8.5.3.1

Fig 8-9
Typical Coaxial Tap Connection Circuit

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 segment is 2165 ns.

(2) A point-to-point link constitutes a link segment. A link segment may contain a maximum end-to-end propagation delay of 2570 ns.

(3) Repeater sets are required for segment interconnection. Repeater sets occupy MAU positions on coaxial segments and count toward the maximum number of MAUs on a coaxial segment. Repeater sets may be located in any MAU position on a coaxial segment but shall only be located at the ends of a link segment.

(4) The maximum length, between driver and receivers, of an AUI cable is 50 m. The propagation velocity of the AUI cable is assumed to be 0.65 c minimum. The maximum allowable end-to-end delay for the AUI cable is 257 ns.

(5) The maximum transmission path permitted between any two stations is five segments, four repeater sets (including optional AUIs), two MAUs, and two AUIs. Of the five segments a maximum of three may be coaxial segments; the remainder are link segments.

NOTE: If only two link segments are used in the entire network and they are adjacent, the repeater set joining them is not required (see Fig 8-14). End-to-end jitter, propagation delay, and attenuation requirements shall still be met.

The maximum transmission path consists of 5 segments, 4 repeater sets (with AUIs), 2 MAUs, and 2 AUIs (see Fig 8-10). The total number of segments equals the number of link segments plus the number of coaxial segments. If there are two link segments on the transmission path, there may be a maximum of three coaxial segments on that path. If there are no link segments on a transmission path, there may be a maximum of three coaxial segments on that path given current repeater technology.

Figures 8-11, 8-12, 8-13, and 8-14 show transmission systems of various sizes to illustrate the boundary conditions on topologies generated according to the specifications in this section.

8.6.2 Transmission System Requirements

8.6.2.1 Cable Sectioning. The 500 m (1640 ft) maximum length coaxial cable segment need not be made from a single, homogeneous length of cable. The boundary between two cable sections (joined by coaxial connectors: two male plugs and a barrel) represents a signal reflection point due to the impedance discontinuity caused by the batch-to-batch impedance tolerance of the cable. Since the worst-case variation from 50 Ω is 2 Ω, a possible worst-case reflection of 4% may result from the joining of two cable sections.

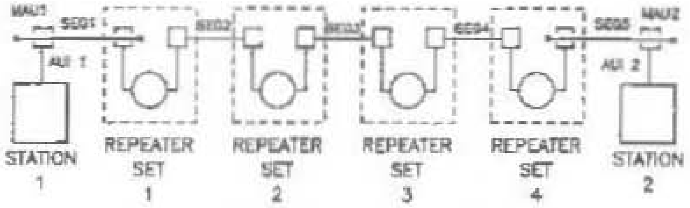


Fig 8-10
Maximum Transmission Path

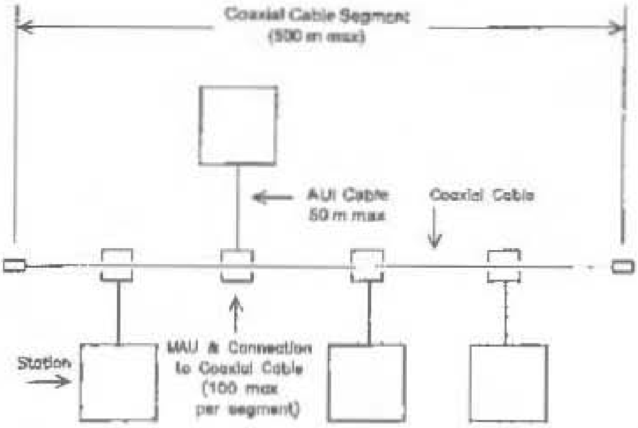


Fig 8-11
Minimal System Configuration

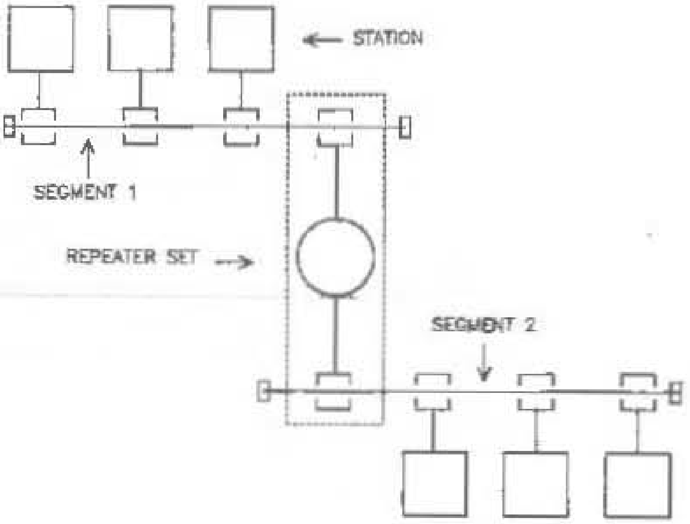


Fig 8-12
Minimal System Configuration Requiring a Repeater Set

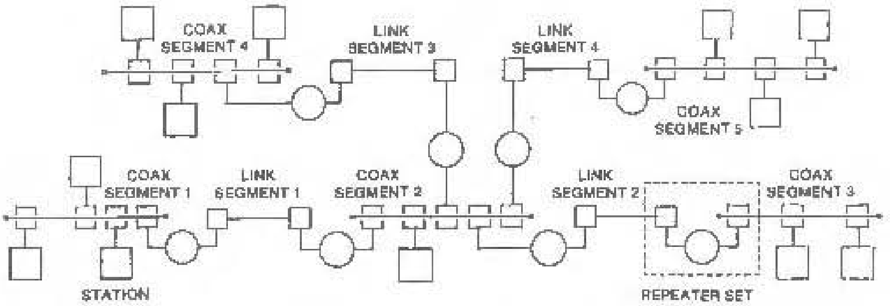


Fig 8-13
An Example of a Large System with Maximum Transmission Paths

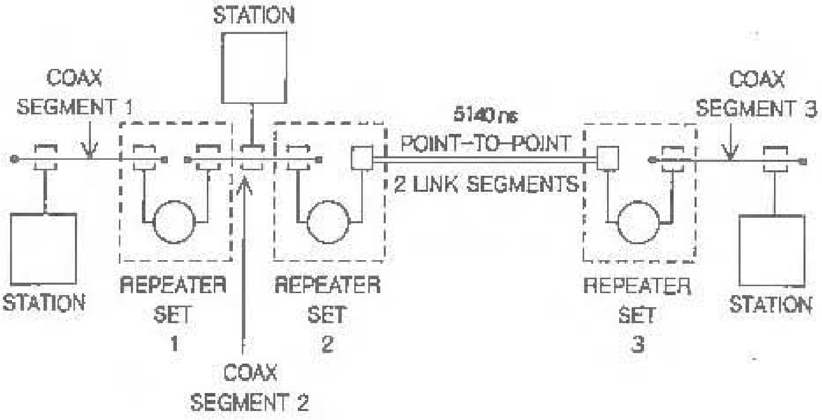


Fig 8-14
An Example of a Large Point-to-Point Link System (5140 ns)

The configuration of long cable segments (up to 500 m) from smaller sections must be made with care. The following *recommendations* apply, and are *given in order of preference*:

(1) If possible, the total segment should be made from one homogeneous (no breaks) cable. This is feasible for short segments, and results in minimal reflections from cable impedance discontinuities.

(2) If cable segments are built up from smaller sections, it is recommended that all sections come from the same manufacturer and lot. This is equivalent to using a single cable, since the cable discontinuities are due to extruder limitations, and not extruder-to-extruder tolerances. There are no restrictions in cable sectioning if this method is used. However, if a cable section in such a system is later replaced, it shall be replaced either with another cable from the same manufacturer and lot, or with one of the standard lengths described below.

(3) If uncontrolled cable sections must be used in building up a longer segment, the lengths should be chosen so that reflections, when they occur, do not have a high probability of adding in phase. This can be accomplished by using lengths that are odd integral multiples of a half wavelength in the cable at 5 MHz; this corresponds to using lengths of 23.4 m, 70.2 m, and 117 m (± 0.5 m) for all sections. These are considered to be the standard lengths for all cable sections. Using these lengths exclusively, any mix or match of cable sections may be used to build up a 500 m segment without incurring excessive reflections.

NOTE: If cable segments are to be added to existing installations, then care shall be taken (explicit physical or TDR measurements) to ensure that no more than a 500 m cable segment results.

(4) As a last resort, an arbitrary configuration of cable sections may be employed, if it has been confirmed by analysis or measurement that the worst-case signal reflection due to the impedance discontinuities at any point on the cable does not exceed 7% of the incident wave when driven by a MAU meeting these specifications.

8.6.2.2 MAU Placement. MAU components and their associated connections to the cable cause signal reflections due to their noninfinite bridging impedance. While this impedance shall be implemented as specified in Section 7, placement of MAUs along the coaxial cable must also be controlled to ensure that reflections from the MAU do not add in phase to a significant degree.

Coaxial cables marked as specified in 8.4.2.2 have marks at regular 2.5 m spacing; a MAU shall only be placed at a mark on the cable. This guarantees both a minimum spacing between MAUs of 2.5 m, and controlling the relative spacing of MAUs to ensure nonalignment on fractional wavelength boundaries.

The total number of MAUs on a cable segment shall not exceed 100.

8.6.2.3 Trunk Cable System Grounding. The *shield conductor* of each coaxial cable segment *shall make electrical contact with an effective earth reference* (see Annex) *at one point and shall not make electrical contact with earth elsewhere* on such objects as building structural metal, ducting, plumbing fixture, or other unintended conductor. Insulators may be used to cover any coaxial connectors used to join cable sections and terminators, to ensure that this requirement is met. A sleeve or boot attached at installation time is acceptable.

This specification is intended for use within (intraplant) buildings. Applications requiring interplant connections by way of external (outdoors) means may require special consideration beyond the scope of the standard.

The sheath conductor of the AUI cable shall be connected to the earth reference or chassis of the DTE.

8.6.3 Labeling. It is recommended that each MAU (and supporting documentation) be labeled in a manner visible to the user with at least these parameters:

(1) Data rate capability in Mb/s
(2) Power level in terms of maximum current drain
(3) Safety warning (for example, shock hazard)

8.7 Environmental Specifications

8.7.1 General Safety Requirements. All stations meeting this standard shall conform to one of the following IEC Publications: 380 [5], 435 [6], or 950 [8].

NOTE: For ISO/IEC 8802-3:1993, conformance shall be to IEC 950 [8].

8.7.2 Network Safety Requirements. This section sets forth a number of recommendations and guidelines related to safety concerns, the list is neither complete nor does it address all possible safety issues. The designer is urged to consult the relevant local, national, and international safety regulations to ensure compliance with the appropriate standards. References [A5] and [A9] provide additional guidance.

Local area network trunk cable systems as described in this standard are subject to at least four direct electrical safety hazards during their use. These hazards are

(1) Direct contact between local network components and power or lighting circuits.
(2) Static charge buildup on local network cables and components.
(3) High-energy transients coupled onto the local network cabling system.
(4) Potential differences between safety grounds to which various network components are connected.

These electrical safety hazards, to which all similar cabling systems are subject, should be alleviated properly for a local network to perform properly. In addition to provisions for properly handling these faults in an operational system, special measures must be taken to ensure that the intended safety features are not negated during installation of a new network or during modification of an existing network.

Proper implementation of the following provisions will greatly decrease the likelihood of shock hazards to persons installing and operating the local area network.

8.7.2.1 Installations. Sound installation practice, as defined by applicable local codes and regulations, shall be followed in every instance in which such practice is applicable.

8.7.2.2 Grounding. The shield of the trunk coaxial cable shall be effectively grounded at only one point along the length of the cable. Effectively grounded means permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity to prevent the building up of voltages that may result in undue hazard to connected equipment or to persons.

8.7.2.3 Safety. All portions of the trunk cabling system that are at the same potential as the trunk cable shall be insulated by adequate means to prevent their contact by either persons or by unintended conductors or grounds. The insulation employed shall provide the same or greater dielectric resistance to current flow as the insulation required between the outermost shield of the trunk cable and the above-mentioned unintended conductors. The use of insulating boots is permitted, provided that such boots (or sleeves) are mechanically and electrically equivalent to the trunk cable outer insulation characteristics and are not removed easily (that is, they shall prevent inadvertent removal by a system operator).

The MAU shall be so designed that the provisions of 8.7.2.3 and 8.7.2.4 are not defeated if the connector affixing the AUI cable to the MAU is removed.

Portions of the trunk cabling system that may become live during the dissipation of a high-energy transient by the cabling system shall also be insulated as described in 8.7.2.3.

8.7.2.4 Breakdown Path. MAUs meeting this standard should provide a controlled breakdown path that will shunt high-energy transients to an effective ground either through a separate safety ground connection or through the overall shield of the branch cable. The breakdown voltage of this controlled breakdown path must meet the isolation requirements for the MAU specified in 8.3.2.1.

8.7.2.5 Isolation Boundary. The isolation boundary between the branch cable and trunk cable specified in 8.3.2.1 shall be maintained to properly meet the safety requirements of this standard.

WARNING: It is assumed that the DTE equipment is properly earthed and not left floating or serviced by "doubly insulated ac power distribution system." The use of floating or insulated DTEs is beyond the scope of this standard.

8.7.2.6 Installation and Maintenance Guidelines

(1) When exposing the shield of the trunk coaxial cable for any reason, care shall be exercised to ensure that the shield does not make electrical contact with any unintended conductors or grounds. Personnel performing the operation should not do so if dissipation of a high energy transient by the cabling system is likely during the time the shield is to be exposed. Personnel should not contact both the shield and any grounded conductor at any time.

(2) Before breaking the trunk coaxial cable for any reason, a strap with ampacity equal to that of the shield of the coaxial cable shall be affixed to the cable shield in such a manner as to join the two pieces and to maintain continuity when the shield of the trunk cable is severed. This strap shall not be removed until after normal shield continuity has been restored.

(3) At no time should the shield of any portion of the coaxial trunk cable to which an MAU or MAUs are attached be permitted to float without an effective ground connection. If a section of floating cable is to be added to an existing cable system, the installer shall take care not to complete the circuit between the shield of the floating cable section and the grounded cable section through body contact.

(4) The installation instructions for network components shall contain language which familiarizes the installer with the cautions mentioned in the above paragraphs.

(5) Network components shall contain prominent warning labels that refer installers and service personnel to the safety notes in the installation instructions.

8.7.3 Electromagnetic Environment

8.7.3.1 Susceptibility Levels. Sources of interference from the environment include electromagnetic fields, electrostatic discharge, transient voltages between earth connections, and similar interference. Multiple sources of interference may contribute to voltage buildup between the coaxial cable and the earth connection of a DTE.

The physical channel hardware shall meet its specifications when operating in either of the following conditions:

(1) Ambient plane wave field of 2 V/m from 10 kHz through 30 MHz, 5 V/m from 30 MHz through 1 GHz.

NOTE: Levels typically 1 km from broadcast stations.

(2) Interference voltage of 1 V/ns peak slope, between coaxial cable shield and DTE earth connection; for example, 15.8 V peak for a 10 MHz sine wave with a 50 Ω source resistance.

MAUs meeting this standard should provide adequate rf ground return to satisfy the referenced EMC specifications.

8.7.3.2 Emission Levels. The physical MAU and trunk cable system shall comply with applicable local and national codes such as FCC Docket 20780-1980 [A11] in the USA. Equipment shall comply with local and national requirements for limitation of electromagnetic interference. Where no local or national requirements exist, equipment shall comply with CISPR Publication 22 [1].

8.7.4 Temperature and Humidity. The MAU and associated connector/cable systems are expected to operate over a reasonable range of environmental conditions related to temperature, humidity, and physical handling such as shock and vibration. Specific requirements and values for these parameters are considered to be beyond the scope of this standard. Manufacturers are requested to indicate in the literature associated with the MAU (and on the MAU if possible) the operating environment specifications to facilitate selection, installation, and maintenance of these components. See reference [A10] for specification terminology.

8.7.5 Regulatory Requirements. The design of MAU and medium components should take into consideration applicable local or national requirements. See references [A5], [A6], [A7], [A8], [A9], and [A11] and Appendix A for helpful resource material.[10]

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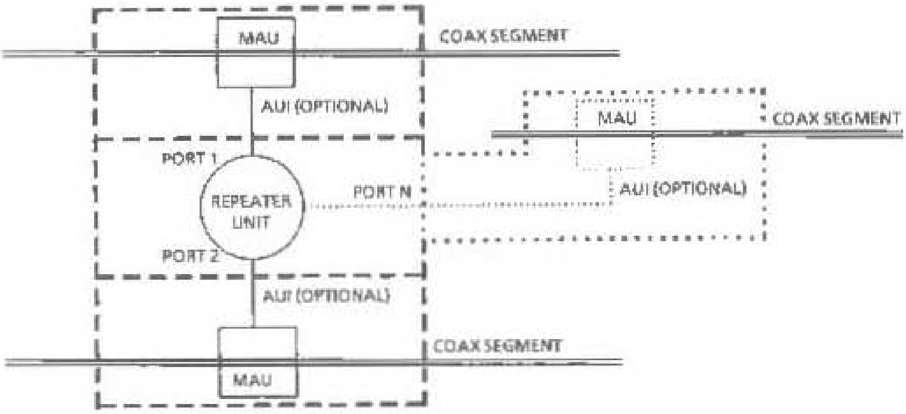
[10] Appendix A provides useful system guidelines on delays and bit budgets.

9. Repeater Unit for 10 Mb/s Baseband Networks

9.1 Overview. This section specifies a repeater for use with type 10BASE5, 10BASE2, and 10BASE-T networks and fiber optic inter-repeater links (FOIRLs). A repeater for any other ISO 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 (that is, for 10BASE5, 500 m and 100 stations; for 10BASE2, 185 m and 30 stations; for 10BASE-T, nominal 100 m link segment).

Repeater sets are used to extend the network length and topology beyond what could be achieved by a single coaxial segment, as defined in 8.6 or 10.7. Segments may be connected directly by a repeater set (Fig 9-1) or by pairs of repeater units which are, in turn, connected by inter-repeater links (IRLs). Allowable topologies shall contain only one operative signal path between any two points on the network. A maximum of four repeater sets may be in the signal path between any two stations on the network (this assumes two link segments).



NOTE: The AUI is not necessarily exposed when the MAU is, optionally, part of the physical repeater.

Fig 9-1
Repeater Set, Coax-to-Coax Configuration

If the repeater set uses MAUs connected via AUIs to a repeater unit, the external MAUs shall be basic MAUs with the exception of 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, as specified in 8.6 and 10.7. 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

data frame. Consists of the Destination Address, Source Address, Length Field, LLC Data, Pad, and Frame Check Sequence.

Fiber Optic Medium Attachment Unit (FOMAU). The portion of the physical layer between the FOMDI and AUI (or repeater unit physical layer signaling [PLS] when the AUI is not implemented) which contains the electronics that transmit, receive, and manage the encoded signals impressed on, and recovered from, the optical fiber cable link segment.

Fiber Optic Medium-Dependent Interface (FOMDI). The mechanical and optical interface between the optical fiber cable link segment and the FOMAU.

Fiber Optic Physical Medium Attachment (FOPMA). The portion of the FOMAU that contains the functional circuitry.

FOIRL BER. Mean bit error rate of the FOIRL.

FOIRL Collision. Simultaneous transmission and reception of data in a FOMAU.

FOIRL Compatibility Interfaces. The FOMDI and the AUI (optional); the two points at which hardware compatibility is defined to allow connection of independently designed and manufactured components to the baseband optical fiber cable link segment.

FOMAU's Transmit Optical Fiber. The optical fiber into which the local FOMAU transmits signals.

FOMAU's Receive Optical Fiber. The optical fiber from which the local FOMAU receives signals.

IRL (Inter-Repeater Link). A mechanism for interconnecting two and only two repeater units.

link segment. The point-to-point full duplex medium connection between two and only two Medium-Dependent Interfaces (MDIs).

optical fiber. A filament-shaped optical waveguide made of dielectric materials.

Optical Fiber Cable Interface. See FOMDI.

Optical Fiber Cable Link Segment. A length of optical fiber cable that contains two optical fibers, as specified in 9.9.5.1, and is comprised of one or more optical fiber cable sections and their means of interconnection, with each optical fiber terminated at each end in the optical connector plug specified in 9.9.5.2.

Optical Idle Signal. The signal transmitted by the FOMAU into its transmit optical fiber during the idle state of the DO circuit.

Packet. Consists of a data frame as defined previously, preceded by the Preamble and the Start Frame Delimiter.

port. A segment or IRL interface of a repeater unit.

repeater unit. The portion of a repeater set that is inboard of its PMA/PLS interfaces.

repeater set. A repeater unit plus its associated MAUs and, if present, AU Interfaces (AUIs).

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.

The MAUs associated with the repeater shall be as specified in Section 8 for type 10BASE5 or 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.

MAUs associated with the repeater unit shall be as specified in Section 14 for type 10BASE-T with the restriction that the MAU shall not perform the *signal_quality_error* message Test function as defined in 14.2.1.5.

9.4.2 Direct Coaxial Cable 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.

9.4.2.1 Direct 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. 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.

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

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

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 8.6.1 and 10.7.1.)

9.4.3.2 Vendor-Independent FOIRL. A vendor-independent FOIRL provides a standard means of connecting two repeater units. It comprises a fiber optic medium link segment, a FOMAU at each end of the link segment, and if present, AU Interfaces. A vendor-independent FOIRL is suitable for interconnecting coaxial segments, especially segments located in different buildings.

The vendor-independent FOMAU should be compatible at its FOMDI, as specified in 9.9. If a FOMAU contains an AU Interface, it shall be electrically and mechanically compatible at its AUI connector 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.

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. The MAUs associated with the repeater set that are connected in this manner shall be subject to the restrictions of MAUs, as specified in 9.4.1.

9.5 Basic Functions

9.5.1 Repeater Set Network Properties. The repeater set shall be transparent to all network acquisition activity and to all DTEs. The repeater set shall not alter the basic fairness criterion for all DTEs to access the network or weigh it toward any DTE or group of DTEs regardless of network location. A repeater set shall not attempt to be a packet store and forward device.

Repeaters are not addressable. An addressable station on the network that controls a repeater is outside the scope of this standard.

9.5.2 Signal Amplification. The repeater set (including its associated or integral MAUs) shall ensure that the amplitude characteristics of the signals at the MDI outputs of the repeater set are within the tolerance of the specification for the appropriate MAU type. Therefore, any loss of signal-to-noise ratio due to cable loss and noise pickup is regained at the output of the repeater set as long as the incoming data is within the system specification.

9.5.3 Signal Symmetry. The repeater set shall ensure that the symmetry characteristics of the signals at the MDI outputs of a repeater set are within the tolerance of the specification for the appropriate MAU type. Therefore, any loss of symmetry due to MAUs and media distortion is regained at the output of the repeater set.

9.5.4 Signal Retiming. The repeater unit shall ensure that the encoded data output from the repeater unit is within the jitter tolerance of a transmitting DTE as specified in 7.3. Therefore jitter cannot accumulate over multiple segments.

9.5.5 Data Handling. The repeater unit, when presented a packet at any of its ports, shall pass the data frame of said packet intact and without modification, subtraction, or addition to all other ports connected with the repeater unit. The only exceptions to this rule are when contention exists among any of the ports or when the receive port is partitioned as defined in 9.6.6. Between unpartitioned ports, the rules for collision handling (9.5.6) take precedence.

9.5.5.1 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 FOMAUs, 10BASE2, or 10BASE5 MAUs on both input and output ports, an additional 6.5 bit times delay for an input port MAU and 3.5 bit times delay for an output port MAU shall be allowed. This added delay does not include any dc rise time for the coaxial cable.

For a repeater set with internal 10BASE-T MAUs on input and output ports, an additional 8 BT delay for an input port MAU and 5 BT delay for an output port MAU shall be allowed.

9.5.6 Collision Handling

9.5.6.1 Collision Presence. The repeater set shall implement the Collision Presence Function using receive-mode collision detection as specified for the media with which it is connected.

9.5.6.2 Jam Generation. If a collision is detected on any of the ports to which the repeater set is transmitting, the repeater set shall transmit a Jam to all of the ports to which it is connected. The Jam shall be transmitted in accordance with the Repeater Unit State Diagram in Fig 9-2 and shall be as specified in 4.2.3.2.4 with the further constraint that the first 62 bits transmitted to any port shall be a pattern of alternate 1's and 0's starting with the first bit transmitted as a 1.

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 FORMAUs, 10BASE2, or 10BASE5 MAUs on both input and output ports, an additional allowance of 9 bit times delay for an input port MAU and 3.5 bit times delay for an output port MAU shall be made. This added delay does not include any dc rise time for the coaxial cable.

For a repeater set with internal 10BASE-T MAUs on input and output ports, an additional 9 BT delay for an input port MAU and 5 BT delay for an output port MAU shall be allowed.

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 FOMAUs, 10 BASE2, and 10BASE5 MAUs on its input ports, an additional allowance of 0.5 bit time delay for DI and 20 bit times for *signal_quality_error* deassertion shall be made. For a repeater set with internal FOMAUs, 10BASE2, and 10BASE5 MAUs on its output ports, an additional allowance of 0.5 bit time delay shall be made. This added delay does not include any dc fall time for the coaxial cable.

For a repeater set with internal 10BASE-T MAUs on its input ports, an additional 2 BT delay for DI and 9 BT for *signal_quality_error* deassertion shall be allowed. For a repeater set with internal MAUs on its output ports, an additional 2 BT delay shall be allowed.

9.5.6.4 Transmit Recovery Time. It is essential that the repeater unit not monitor a port for input for a short time after the repeater stops transmitting to that port. This recovery time prevents the repeater from receiving its own transmission as a new receive activity. The minimum recovery time allowable for a repeater is implementation-dependent, but must be greater than the sum of the delays in the transmit and receive paths for the port. In all cases the recovery time must be less than 10 bit times from the last transition on the transmitting AU Interface.

9.5.6.5 Carrier Recovery Time. During a collision, the *input_idle* signal is unreliable for short periods of time (bits) because of the possibility of signal cancellation on the collision segment. In order to prevent premature detection of the true end of the collision, the repeater unit must wait for data to become sensed from a port for a short time after *signal_quality_error* has gone inactive from that port. This recovery time prevents the repeater from prematurely ending a Jam on an active network. The minimum carrier recovery time allowable for a repeater is implementation-dependent, but shall be greater than the CARRIER ON time after *signal_quality_error* is deasserted. In all cases, the carrier recovery time shall be less than 4 bit times from the last transition on the AU Interface.

9.5.7 Electrical Isolation. Network segments that have different isolation and grounding requirements shall have those requirements provided by the port-to-port isolation of the repeater set.

9.6 Detailed Repeater Functions and State Diagrams. A precise algorithmic definition is given in this section, providing a complete procedural model for the operation of a repeater, in the form of state diagrams. Note that whenever there is any apparent ambiguity concerning the definition of repeater operation, the state diagrams should be consulted for the definitive statement.

The model presented in this section is intended as a primary specification of the functions to be provided by any repeater unit. It is important to distinguish, however, between the model and a real implementation. The model is optimized for simplicity and clarity of presentation, while any realistic implementation should place heavier emphasis on such constraints as efficiency and suitability to a particular implementation technology.

It is the functional behavior of any repeater unit implementation that shall match the standard, not the internal structure. The internal details of the procedural model are useful only to the extent that they help specify the external behavior clearly and precisely. For example, the model uses a separate Transmit Timer state machine for each port. However, in an actual implementation, the hardware may be shared.

9.6.1 State Diagram Notation. The notation used in the state diagrams (Figs 9-2 through 9-5) follows the conventions in 1.2.1.