Description of State Diagram Variables

Input/Output Variables

DataIn (X)

Status of DataIn input at port X.
Values: II = *input_idle*; indicates no activity
–II; indicates activity
Note that DataIn (X) may be undefined during collision
but that it is a don't care in all instances when this is true.

CollIn (X)

Status of ControlIn input at port X.
Values: SQE = *signal_quality_error* ; indicates collision
–SQE ; indicates no collision

Out (X)

Type of output repeater is sourcing at port X.
Values: Idle ; Repeater is not transmitting
–Idle ; Repeater is transmitting Preamble Pattern or Data or Jam or TwoOnes.
Preamble Pattern ; Repeater is sourcing alternating 1's and 0's on port X.
Data ; Repeater is repeating data frame on port X.
Jam ; Repeater is sourcing Jam on port X.
TwoOnes ; Repeater is sourcing two consecutive Manchester encoded ones on port X.

DisableOut (X)

Override of Out (X)
Values: ON ; Disable repeater transmission regardless of value of Out (X).
–ON ; Repeater transmission depends on the value of Out (X).

Port Variables

TT (X)

Transmit Timer indicates number of bits transmitted on port X.
Values: Positive integers

Inter-Process Flags

AllDataSent

All received data frame bits have been sent.

Bit Transmitted

Indicates a bit has been transmitted by the repeater unit.

DataRdy

Indicates the repeater has detected the SFD and is ready to send the received data. The search for SFD shall not begin before 15 bits have been received. Note, transmit and receive clock differences shall also be accommodated.

Tw1

Wait Timer for the end of transmit recovery time (see 9.5.6.4). It is started by StartTw1. Tw1Done is satisfied when the end of transmit recovery time is completed.

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Tw2

Wait Timer for the end of carrier recovery time (see 9.5.6.5). It is started by StartTw2. Tw2Done is satisfied when the timer has expired.

Tw3

Wait Timer for length of continuous output (see 9.6.5). It is started by StartTw3. Tw3Done is satisfied when the timer has expired.

Tw4

Wait Timer for time to disable output for Jabber Lockup Protection (see 9.6.5). It is started by StartTw4. Tw4Done is satisfied when the timer has expired.

Port Functions

Port (*Test*)

A function that returns the designation of a port passing the test condition. For example, Port (CollIn=SQE) returns the designation: X for a port that has SQE true. If multiple ports meet the test condition, the Port function will be assigned one and only one of the acceptable values.

Port Designation

Ports are referred to by number. Port information is obtained by replacing the X in the desired function with the number of the port of interest. Ports are referred to in general as follows:

ALL — Indicates all repeater ports are to be considered. All ports shall meet test conditions in order for the test to pass.

ANY — Indicates all ports are to be considered. One or more ports shall meet the test conditions in order for the test to pass.

ONLY1 — Indicates all ports are to be considered. One, but not more than one, port shall meet the test condition in order for the test to pass.

X — Generic port designator. When X is used in a state diagram, its value is local to that diagram and not global to the set of state diagrams.

N — Is defined by the Port function on exiting the IDLE state of Fig 9-2. It indicates a port that caused the exit from the IDLE state.

M — Is defined by the Port function on exiting the TRANSMIT COLLISION state of Fig 9-2. It indicates the only port where CollIn=SQE.

ALLXN — Indicates all ports except N should be considered. All ports considered shall meet the test conditions in order for the test to pass.

ALLXM — Indicates all ports except M should be considered. All ports considered shall meet the test conditions in order for the test to pass.

ANYXN — Indicates any port other than N meeting the test conditions shall cause the test to pass.

ANYXM — Indicates any port other than M meeting the test conditions shall cause the test to pass.

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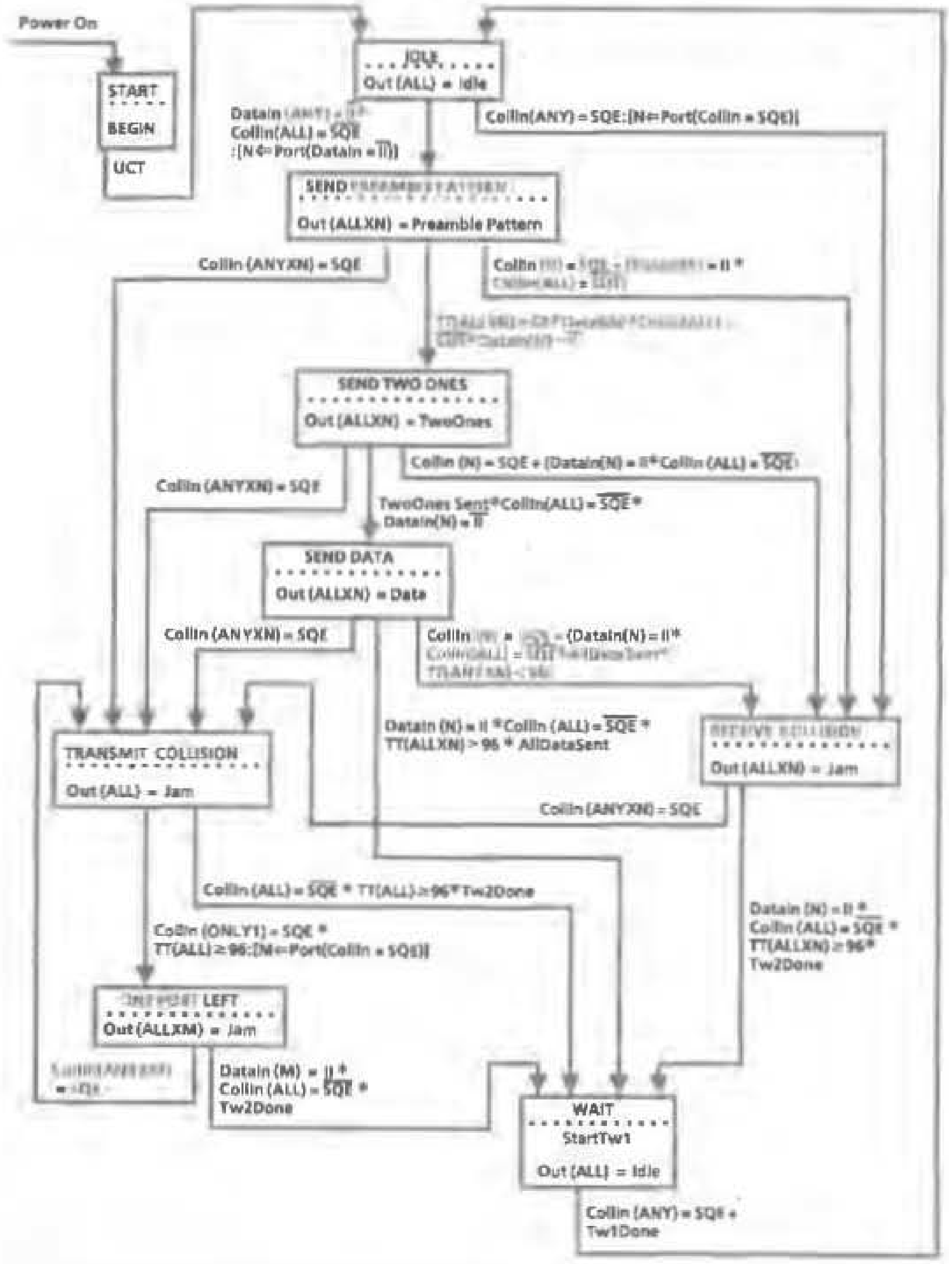

NOTE: Out (X) = Idle in all instances unless specified otherwise.

Fig 9-2
Repeater Unit State Diagram

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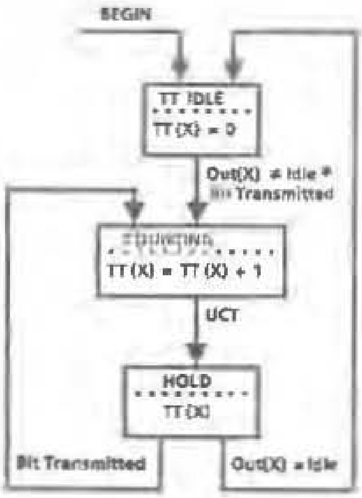

Fig 9-3
Transmit Timer State Diagram for Port X

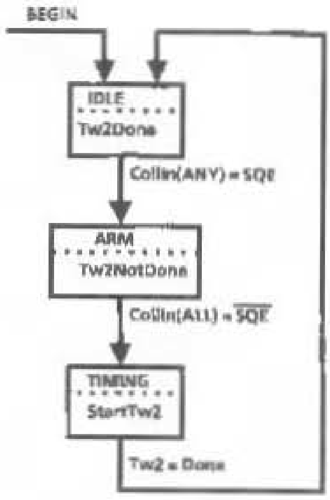

Fig 9-4
Tw2 State Diagram

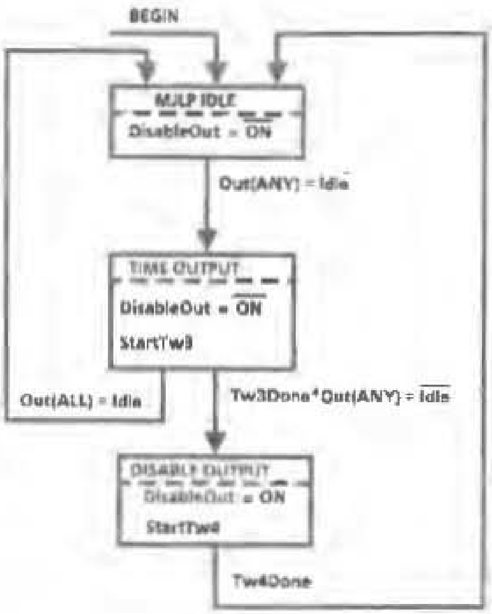

Fig 9-5
MAU Jabber Lockup Protection State Diagram

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9.6.2 Data and Collision Handling. The repeater unit shall implement the CARRIER_ON function for all its ports. Upon detection of carrier from one port, the repeater unit shall repeat all received signals in the Data Frame from that port to the other port (or ports).

The repeater unit data and collision-handling algorithm shall be as defined in Fig 9-2.

9.6.3 Preamble Regeneration. The repeater unit shall output at least 56 bits of preamble followed by the SFD. When the repeater unit must send more than 56 bits, the maximum length preamble pattern it shall send is the number received plus 6.

9.6.4 Fragment Extension. If the received bit sequence from CARRIER_ON to CARRIER_OFF is fewer than 96 bits in length, including preamble, the repeater unit shall extend the output bit sequence with Jam such that the total number of bits output from the repeater unit shall equal 96.

9.6.5 MAU Jabber Lockup Protection. MAU Jabber Lockup Protection must operate as shown in the MAU Jabber Lockup Protection state diagram. The repeater unit shall interrupt its output if it has transmitted continuously for longer than 5 ms or 50 000 bit times – 20% + 50%. The repeater unit shall then, after 96 to 116 bit times (9.6 to 11.6 μs), re-enable transmissions.

9.6.6 Auto-Partitioning/Reconnection (Optional)

9.6.6.1 Overview. In large multisegment networks it may be desirable that the repeater unit protect the network from some fault conditions that would halt all network communication. A potentially likely cause of this condition could be due to a cable break, a faulty connector, or a faulty or missing termination.

In order to isolate a faulty segment's collision activity from propagating through the network, the repeater unit may optionally implement an auto-partition algorithm and, on detection of the malfunction being cleared, an auto-reconnection algorithm.

9.6.6.2 Detailed Auto-Partition/Reconnection Algorithm State Diagram. Repeater sets with 10BASE-T MAUs shall implement an auto-partition/reconnection algorithm on those parts. The repeater unit may optionally implement an auto-partition/reconnection algorithm that protects the rest of the network from an open-circuited segment. If the repeater unit provides this function, it shall conform to the state diagram of Fig 9-6.

The algorithm defined in Fig 9-6 shall isolate a segment from the network when one of the following two conditions has occurred on the segment:

(1) When a consecutive collision count has been reached; or
(2) When a single collision duration has exceeded a specific amount of time.

When a segment is partitioned, DataIn (X) and CollIn (X) from that segment are forced to II (input idle) and –SQE (no collision), respectively, so that activity on the port will not affect the repeater unit. Output from the repeater to the segment is not blocked.

The segment will be reinstated when the repeater has detected activity on the segment for more than the number of bits specified for Tw5 without incurring a collision.

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Description of State Diagram Variables and Constants

Port Constants

CCLimit

The number of consecutive collisions that must occur before a segment is partitioned. The value shall be greater than 30.

Input/Output Variables

DIPresent(X)

Data in from the MAU on port X. (This input is gated by the partition state machine to produce DataIn (X) to the main state machine.)
Values: II = *input_idle* ; no activity
–II = Input not idle ; activity

CIPresent(X)

Control input from the MAU on port X. (This input is gated by the partition state machine to produce CollIn (X) to the main state machine.)
Values: SQE = *signal_quality_error* ; indicates collision
–SQE ; indicates no collision

Port Variables

CC(X)

Consecutive port collision count on a particular port X. Partitioning occurs on a terminal count of CCLimit being reached.
Values: Positive integers up to a terminal count of CCLimit.

Inter-Process Flags

Tw5

Wait Timer for length of packet without collision. Its value shall be between 450 and 560 bit times. It is started by StartTw5. Tw5Done is satisfied when the timer has expired.

Tw6

Wait Timer for excessive length of collision. Its value shall be between 1000 and 30 000 bit times. It is started by StartTw6. Tw6Done is satisfied when the timer has expired.

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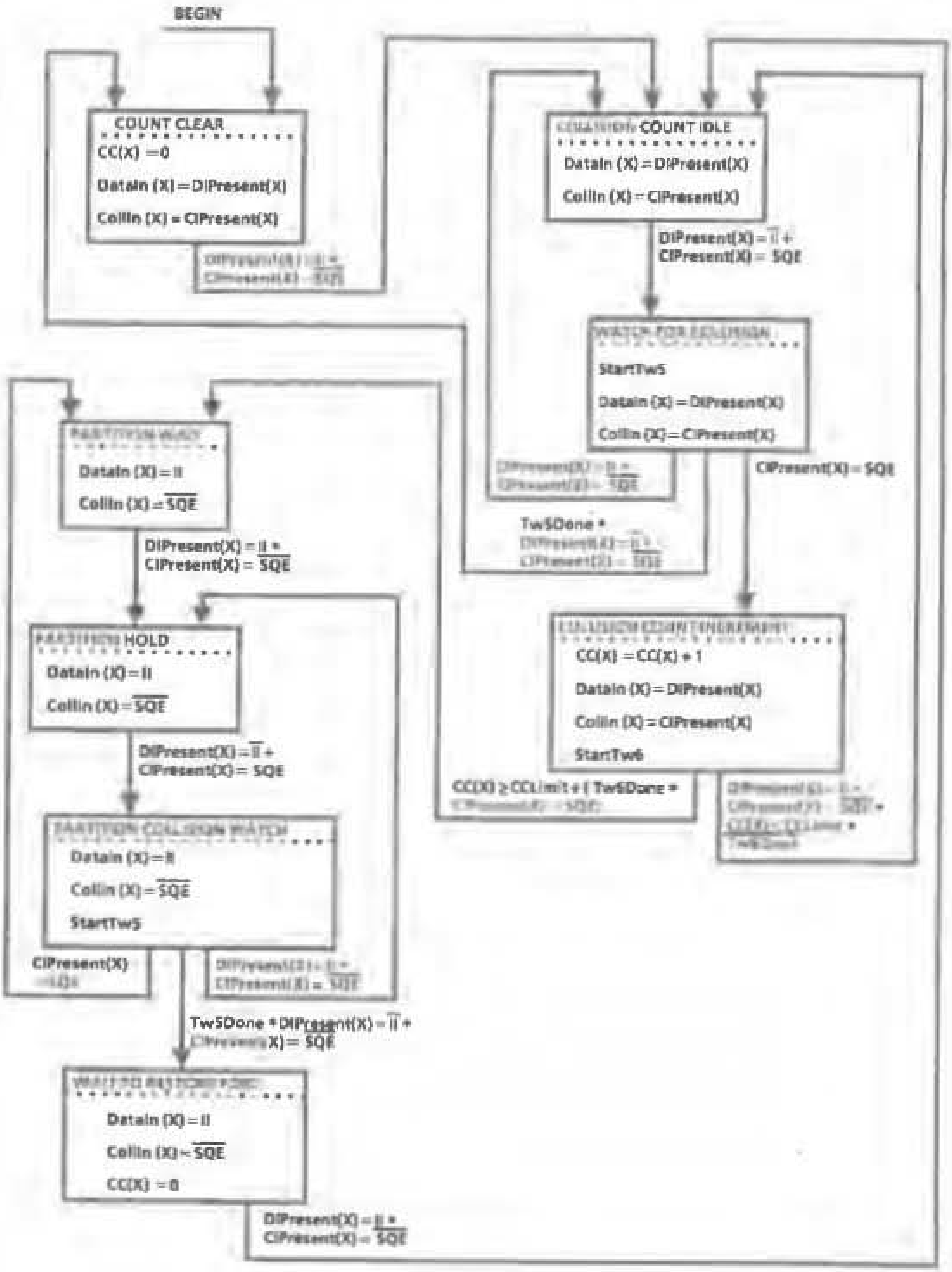

Fig 9-6
Partitioning State Diagram for Port X

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

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

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

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

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

For repeater ports that connect to external MAUs via an AU Interface, the requirement for isolation is encompassed within the isolation requirements of the basic MAU standard. (See 8.3.2.1, 10.4.2.1, and 14.3.11.) The repeater unit shall not require any electrical isolation between exposed AU Interfaces or between exposed AU Interfaces and chassis ground of the repeater unit. No isolation boundary need therefore exist at any AUI compatible interface (that is "D" connector) provided by a repeater unit.

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

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

The requirements for interconnected coaxial cable/electrically conducting LAN segments that are partially or fully external to a single building environment may require additional protection against lightning strike hazards. Such requirements are beyond the scope of this standard. It is recommended that the above situation be handled by the use of a nonelectrically conducting IRL (for example, fiber optic).

It is assumed that any nonelectrically conducting segments will provide sufficient isolation within that media to satisfy the isolation requirements of environment B.

9.8 Reliability. A 2-port repeater set shall be designed to provide a mean time between failure (MTBF) of at least 50 000 hours of continuous operation without causing a communication failure among stations attached to the network medium. Repeater sets with more than two ports shall add no more than 3.46×10^{-6} failures per hour for each additional port.

The repeater set electronics shall be designed to minimize the probability of component failures within the repeater electronics that prevent communication among the other MAUs on the individual coaxial cable segments. Connectors and other passive components comprising the means of connecting the repeater to the coaxial cable shall be designed to minimize the probability of total network failure.

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

9.9.1 Scope

9.9.1.1 Overview. A vendor-independent FOIRL provides a standard means for connecting only two repeater units. It thus extends the network length and topology beyond that which could be achieved by interconnecting coaxial segments via repeater sets only, as defined in 8.6 or 10.7. A vendor-independent FOIRL is particularly suited for interconnecting coaxial segments located in different buildings. The FOMAU described in this document is not intended for use in connecting DTEs.

In particular, this section defines the following:

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

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

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

(a) Enables coupling the repeater unit PLS directly, or by way of the AUI mechanical connection, to the explicit baseband optical fiber cable link segment defined in this section of the standard.
(b) Supports signaling at a data rate of 10 Mb/s.
(c) Provides for driving up to 1000 m of an optical fiber cable link segment.
(d) Operates indistinguishably from a repeater set MAU, as defined in Section 8, 10, or 14 when viewed from the AU Interface.
(e) Supports 10BASE2, 10BASE5, and 10BASE-T system configurations as defined in Sections 8, 10, and 13 of this standard.
(f) Allows integration of the FOMAU into a single package with the repeater unit, thereby eliminating the need for an AUI mechanical connection.

The implementation may incorporate additional features, for example those that allow compatibility with vendor-dependent FOMAUs, as in 9.4.3.1. The means to support these features are beyond the scope of this subsection.

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

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

9.9.1.3 Compatibility Considerations. All implementations of the vendor-independent FOMAU shall be compatible at the FOMDI and at the AUI (when physically and mechanically implemented).

This standard provides an optical fiber cable link segment specification for the interconnection of only two FOMAU devices. The medium itself, the functional capability of the FOMAU, 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 FOMAU in an application-dependent manner provided the FOMDI and AUI are satisfied. (The provision of the physical and mechanical implementation of the AUI is optional.)

9.9.1.4 Relationship to AUI. A close relationship exists between this section and Section 7. This section specifies all of the physical medium parameters, all of the FOPMA logical functions residing in the FOMAU, and references the AUI defined in Section 7 with the exception of the *signal_quality_error* message Test of 7.2.1.2.3(3), which shall not be implemented, that is, shall not be enabled when connected to a repeater unit.

NOTE: The specification of a FOMAU component requires the use of both this section and Section 7 for the AUI specifications.

9.9.1.5 Mode of Operation. The FOMAU functions as a direct connection between the optical fiber cable link segment and the repeater unit. During collision-free operation, data from the repeater unit is

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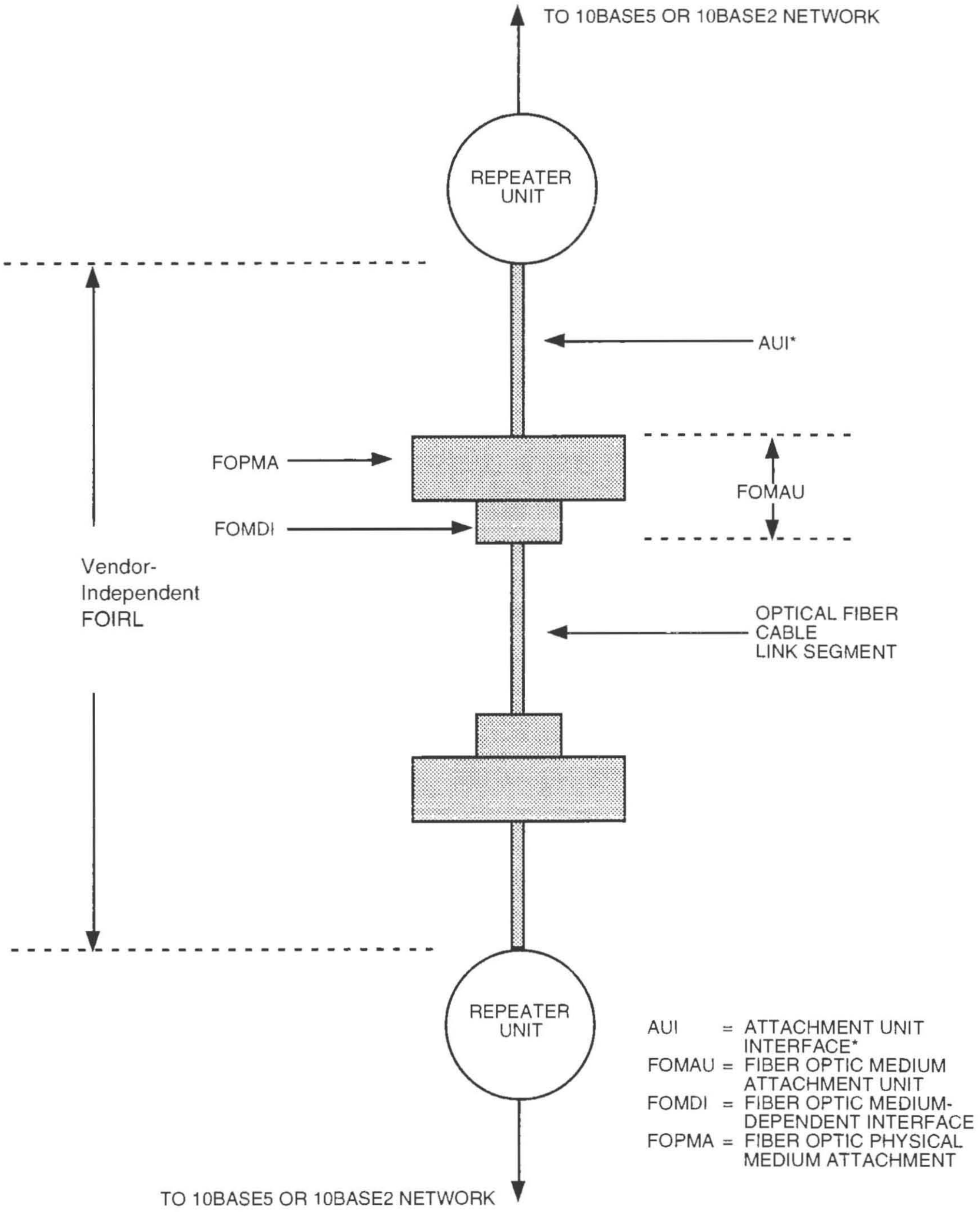

* See 9.9.1.3 for implementation requirements.

Fig 9-7
Schematic of the Vendor-Independent FOIRL and Its Relationship to the Repeater Unit

transmitted into the FOMAU's transmit optical fiber, and all data in the FOMAU's receive optical fiber is transmitted to the repeater unit.

9.9.2 FOMAU Functional Specifications. The FOMAU component provides the means by which signals on the three AUI signal circuits are coupled:

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(1) From the repeater unit into the FOMAU's transmit optical fiber, and
(2) From the FOMAU's receive optical fiber to the repeater unit.

To achieve this basic objective, the FOMAU component contains the following functional capabilities to handle message flow between the repeater unit and the optical fiber cable link segment:

(a)	*Transmit Function*	: The ability to receive serial bit streams from the attached repeater unit and transmit them into the FOMAU's optical fiber.
(b)	*Receive Function*	: The ability to receive serial data bit streams from the FOMAU's receive optical fiber and transmit them to the attached repeater unit.
(c)	*Collision Presence Function*	: The ability to detect, and report to the attached repeater unit, an FOIRL collision.
(d)	*Jabber Function*	: The ability to automatically interrupt the Transmit Function and inhibit an abnormally long output data stream.
(e)	*Low Light Level Detection Function*	: The ability to automatically interrupt the Receive Function and inhibit the reception of signals from the FOMAU's receive optical fiber which could result in abnormally high BERs.

9.9.2.1 Transmit Function Requirements. At the start of a packet transmission into the FOMAU's transmit optical fiber, no more than two bits (two full bit cells) of information may be received from the DO circuit and not transmitted into the FOMAU's transmit optical fiber. In addition, it is permissible for the first bit sent to contain encoded phase violations or invalid data. All successive bits of the packet shall be transmitted into the FOMAU's transmit optical fiber and shall exhibit the following:

(1) No more edge jitter than that given by the sum of the worst-case edge jitter components specified in 7.4.3.6, 7.5.2.1, and 9.9.4.1.7, and
(2) The levels and waveforms specified in 9.9.4.1.

The FOMAU DO circuit shall comply with the AUI specification for receivers given in 7.4.2. The FOMAU's DI circuit driver shall comply with the AUI specification for drivers given in 7.4.1.

The steady-state propagation delay between the DO circuit receiver input and the FOMAU's transmit optical fiber input shall not exceed one-half a bit cell. It is recommended that the designer provide an implementation in which a minimum threshold level is required on the DO circuit to establish a transmit bit stream.

The higher optical power level transmitted into the FOMAU's transmit optical fiber shall be defined as the low (LO) logic state on the optical fiber link segment. There shall be no logical signal inversions between the DO circuit and the FOMAU's transmit optical fiber, as specified in 9.9.4.1.5.

The difference in the start-up delay (bit loss plus invalid bits plus steady-state propagation delay), as distinct from the absolute start-up delays, between any two packets that are separated by 9.6 µs or less shall not exceed 2 bit cells.

The FOMAU shall loop back a packet received from the DO circuit into the DI circuit. At the start of a packet transmission, no more than five bits of information may be received from the DO circuit and not transmitted into the DI circuit. It is permissible for the first bit sent to contain encoded phase violations or invalid data. All successive bits of the packet shall be transmitted into the DI circuit and shall exhibit no more edge jitter than that specified for signals transmitted into the DI circuit by the Receive Function, as specified in 9.9.2.2. The steady-state propagation delay between the DO circuit receiver input and the DI circuit driver output for such signals shall not exceed one bit cell. There shall be no logical signal inversions between the DO circuit and the DI circuit during collision-free transmission.

When the DO circuit has gone idle after a packet has been transmitted into the FOMAU's transmit optical fiber, the FOMAU shall not activate the Collision Presence Function so as not to send the *signal_quality_error* message Test of 7.2.1.2.3(3) to the repeater unit.

During the idle state of the DO circuit, the Transmit Function shall output into the transmit optical fiber an optical idle signal as specified in 9.9.4.1.4. The transmitted optical signals shall exhibit the optical power levels specified in 9.9.4.1.8. At the end of a packet transmission, the first optical idle signal pulse

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transition to the higher optical power level must occur no sooner than 400 ns and no later than 2100 ns after the packet's last transition to the lower optical power level. This first optical pulse must meet the timing requirements of 9.9.4.1.4.

The FOMAU shall not introduce extraneous optical signals into the transmit optical fiber under normal operating conditions, including powering-up or powering-down of the FOMAU.

9.9.2.2 Receive Function Requirements. At the start of a packet reception from the FOMAU's receive optical fiber, no more than two bits (two full bit cells) of information may be received from the FOMAU's receive optical fiber and not transmitted into the DI circuit. It is permissible for the first bit transmitted into the DI circuit to contain encoded phase violations or invalid data. All successive bits of the packet shall be transmitted into the DI circuit and shall exhibit the following:

(1) The levels and waveforms specified in 7.4.1, and
(2) No more edge jitter than that given by the sum of the worst-case edge jitter components specified in 7.4.3.6, 7.5.2.1, 9.9.4.1.7, 9.9.4.2.2, and 9.9.5.1.

The steady-state propagation delay between the output of the FOMAU's receive optical fiber and the output of the DI circuit driver shall not exceed one-half a bit cell. There shall be no logical signal inversions between the FOMAU's receive optical fiber and the DI circuit during collision-free operation, as specified in 9.9.4.2.3.

The difference in the start-up delay (bit loss plus invalid bits plus steady-state propagation delay), as distinct from the absolute start-up delays, between any two packets that are separated by 9.6 μs or less shall not exceed 2 bit cells.

The FOMAU shall not introduce extraneous signals into the DI circuit under normal operating conditions, including powering-up or powering-down of the FOMAU.

9.9.2.3 Collision Presence Function Requirements. The signal presented to the CI circuit in the absence of an SQE signal shall be the IDL signal.

The signal presented to the CI circuit during the presence of a collision shall be the CS0 signal, a periodic pulse waveform of frequency 10 MHz +25 % −15% with pulse transitions that are no less than 35 ns and no greater than 70 ns apart at the zero crossing points. This signal shall be presented to the CI circuit no more than 3.5 bit times after the simultaneous appearance of signals at both the input of the FOMAU's transmit optical fiber and the output of the FOMAU's receive optical fiber. This signal shall be deasserted no earlier than 4.5 bit times and no later than 7 bit times after the above defined collision condition ceases to exist.

During a collision, if a packet is received at the DO circuit before a packet is received at the FOMAU's receive optical fiber, then only the packet received at the DO circuit shall be transmitted into the DI circuit, as specified in 9.9.2.1. Conversely, if during a collision a packet is received at the FOMAU's receive optical fiber before a packet is received at the DO circuit, then only the packet received at the FOMAU's receive optical fiber shall be transmitted into the DI circuit, as specified in 9.9.2.2. In the event of both packets being received at their respective ports within 3.5 bit times of each other, then either one, but only one, of the packets shall be selected to be transmitted into the DI circuit.

The Collision Function shall not introduce extraneous signals into the CI circuit under normal operating conditions, including powering-up or powering-down of the FOMAU.

9.9.2.4 Jabber Function Requirements. The FOMAU shall have the capability, as defined in Fig 9-9, to interrupt a transmission from the repeater unit that exceeds a time duration determined by the FOMAU. This time duration shall not be less than 20 ms nor more than 150 ms. If the packet being transmitted is still being transmitted after the specified time duration, the FOMAU shall activate the Jabber Function by the following:

(1) First inhibiting the transmission of bits from its DO circuit into its transmit optical fiber,
(2) Then transmitting into its transmit optical fiber the optical idle signal specified in 9.9.4.1.4, and
(3) Presenting the CS0 signal to the CI circuit.

Once the error condition has been cleared, the FOMAU shall reset the Jabber Function and present the IDL signal to the CI circuit:

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(a) On power reset, and
(b) Optionally, automatically after a continuous period of 0.5 s ± 50% of inactivity on the DO circuit.

The FOMAU shall not activate its Jabber Function when operated under the worst-case Jabber Lockup Protection condition specified in 9.6.5.

When both the Jabber Function and the Low Light Level Detection Function (see 9.9.2.5) have been activated, the Jabber Function shall override the Low Light Level Detection Function.

9.9.2.5 Low Light Level Detection Function Requirements. The FOMAU shall have a low light level detection capability, as defined in Fig 9-10, whereby it shall interrupt the reception of both the optical idle signal and packets from the FOMAU's receive optical fiber when reliable reception can no longer be assured. This error condition shall not be activated if the peak optical power level at the output of the FOMAU's receive optical fiber exceeds –27 dBm. It shall be activated before the peak optical power level at the output of the FOMAU's receive optical fiber has fallen to a level that is lower than the peak optical power level that corresponds to a BER = 10^{-10} for the FOMAU under consideration. Once this error condition has been activated, the FOMAU shall, no earlier than 30 bit times and no later than 200 bit times

(1) Disable its Receive Function so that the transmission of bits from its receive optical fiber to the DI circuit is inhibited.
(2) Assure that only the optical idle signal is transmitted into its transmit optical fiber, irrespective of the state of the DO circuit.
(3) Disable its Transmit Function during the period of time that the FOMAU recognizes the presence of a packet on the DO circuit such that the transmission of the packet from the DO circuit into the DI circuit is inhibited.

Once this error condition has been cleared, the FOMAU shall return automatically to its normal mode of operation within 40 bit times once the DO circuit is in the idle state.

When both the Jabber Function (see 9.9.2.4) and the Low Light Level Detection Function have been activated, the Jabber Function shall override the Low Light Level Detection Function.

NOTE: It is recommended that, for diagnostic purposes, the status of the Low Light Level Detection Function be indicated on the exterior of the FOMAU package.

9.9.2.6 Repeater Unit to FOMAU Physical Layer Messages. The following messages can be received by the FOMAU physical layer entities from the repeater unit:

Message	Circuit	Signal	Meaning
output	DO	CD1, CD0	Output information
output_idle	DO	IDL	No data to be output

9.9.2.7 FOMAU Physical Layer to Repeater Unit Messages. The following messages can be sent by the FOMAU physical layer entities to the repeater unit:

Message	Circuit	Signal	Meaning
input	DI	CD1, CD0	Input information
input_idle	DI	IDL	No information to be input
fomau_available	CI	IDL	FOMAU is available for output
signal_quality_error	CI	CS0	Collision or error detected by FOMAU

9.9.2.7.1 *input* Message. The FOMAU physical layer sends an *input* message to the repeater unit when the FOMAU has a bit of data to send to the repeater unit. The physical realization of the *input* message is a CD0 or CD1 sent by the FOMAU to the repeater unit on the DI circuit. The FOMAU sends CD0 if

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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 FOMAU.

9.9.2.7.2 *input_idle* Message. The FOMAU physical layer sends an *input_idle* message to the repeater unit when the FOMAU does not have data to send to the repeater unit. The physical realization of the *input_idle* message is the IDL signal sent by the FOMAU to the repeater unit on the DI circuit.

9.9.2.7.3 *fomau_available* Message. The FOMAU physical layer sends the *fomau_available* message to the repeater unit when the FOMAU is available for output, and when the FOMAU has activated the Low Light Level Detection Function in accordance with the Low Light Level Detection Function requirements of 9.9.2.5 and Fig 9-10. The *fomau_available* message shall be sent by a FOMAU that is prepared to output data. The physical realization of the *fomau_available* message is an IDL signal sent by the FOMAU to the repeater unit on the CI circuit.

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

(1) When the FOMAU has completed the transmission of a packet into its transmit optical fiber, it shall not send any *signal_quality_error* message Test sequence.
(2) The simultaneous appearance of packets at both the input of a FOMAU's transmit optical fiber and the output of its receive optical fiber shall cause the *signal_quality_error* message to be sent by the FOMAU to the repeater unit.
(3) When the FOMAU has activated the Jabber Function, it shall send the *signal_quality_error* message in accordance with the Jabber Function requirements of 9.9.2.4 and Fig 9-9.

The physical realization of the *signal_quality_error* message is the CS0 signal sent by the FOMAU to the repeater unit on the CI circuit.

The FOMAU is required to assert the *signal_quality_error* message at the appropriate times whenever the FOMAU is powered and not just when the repeater unit is providing output data.

9.9.2.8 FOMAU State Diagrams. The state diagrams, Figs 9-8, 9-9, and 9-10, depict the full set of allowed FOMAU state functions relative to the control circuits of the repeater unit/FOMAU interface for FOMAUs. Messages used in these state diagrams are explained as follows:

NOTE: Figures 9-8, 9-9, and 9-10 must all be considered together.

(1) *enable_opt_driver* : Activates the path employed during normal operation to cause the FOMAU transmitter to impress the packet data received from the DO circuit into the FOMAU's transmit optical fiber.

(2) *disable_opt_driver* : Deactivates the path employed during normal operation to cause the FOMAU transmitter to impress the packet data received from the DO circuit into the FOMAU's transmit optical fiber.

(3) *enable_opt_idle_driver* : Causes the FOMAU transmitter to impress the optical idle signal into the FOMAU's transmit optical fiber.

(4) *disable_opt_idle_driver* : Causes the FOMAU to stop transmitting the optical idle signal into the FOMAU's transmit optical fiber.

(5) *enable_loop_back* : Activates the path employed during normal operation to cause the FOMAU Transmit Function to impress the packet data received from the DO circuit into the DI circuit.

(6) *disable_loop_back* : Deactivates the path employed during normal operation to cause the FOMAU Transmit Function to impress the packet data received from the DO circuit into the DI circuit.

(7) *enable_opt_receiver* : Activates the path employed during normal operation to cause the FOMAU to impress the packet data received from the FOMAU's receive optical fiber into the DI circuit.

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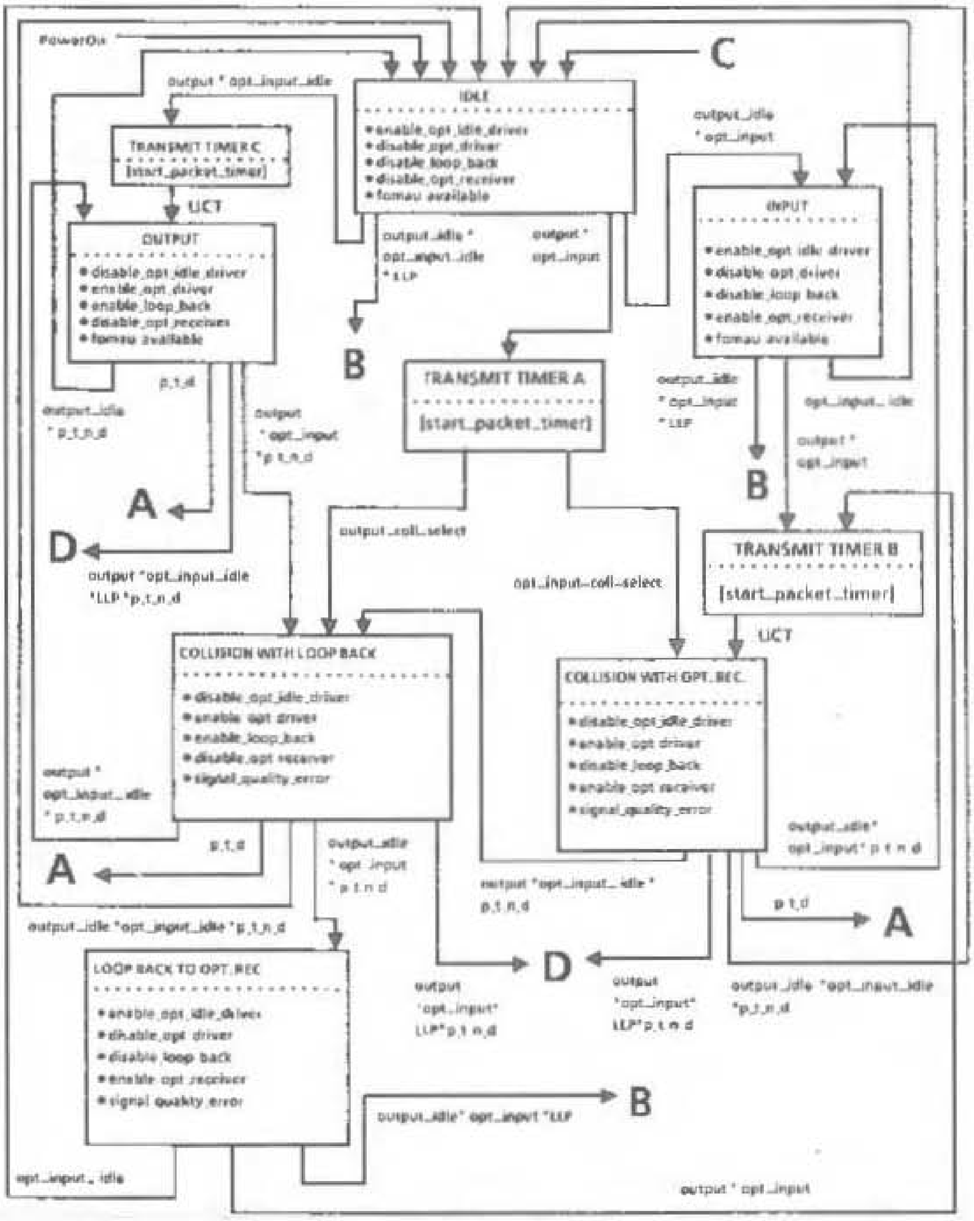

Fig 9-8
FOMAU Transmit, Receive, and Collision Functions State Diagram

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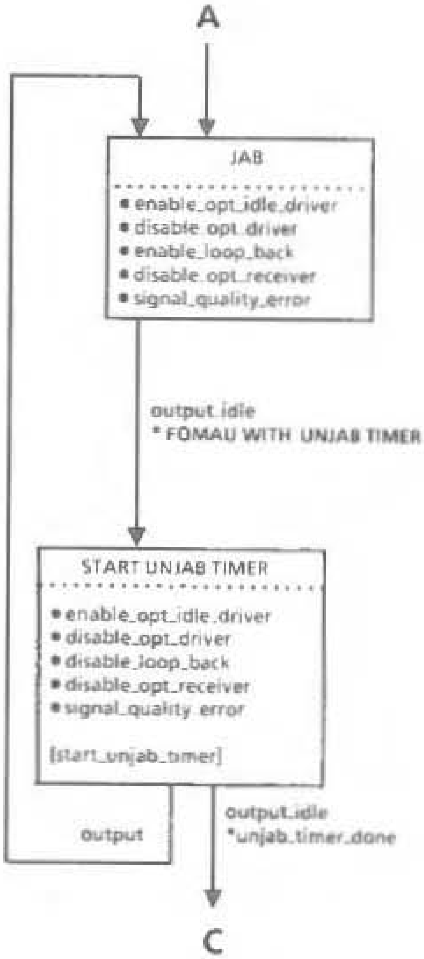

Fig 9-9
FOMAU Jabber Function
State Diagram

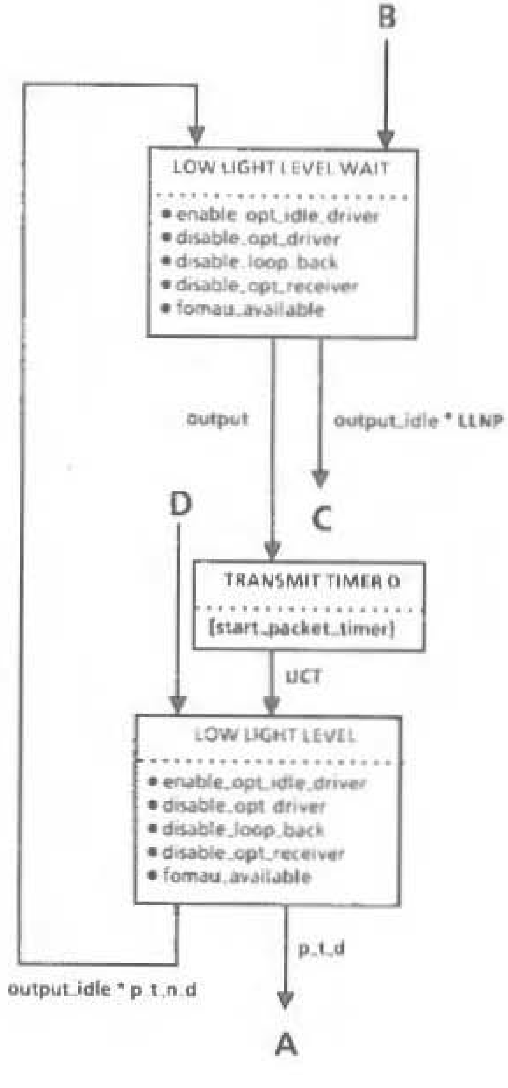

Fig 9-10
Low Light Level Detection
Function State Diagram

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(8) *disable_opt_receiver* : Deactivates the path employed during normal operation to cause the FOMAU to impress the packet data received from the FOMAU's receive optical fiber into the DI circuit.

(9) [*start_packet_timer*] : Starts a timing function which is used to monitor the amount of time the FOMAU is transmitting a packet into the transmit optical fiber. The timing function is maintained as long as *output* is true and is stopped on the transition to *output_idle true*. The term *packet_timer_done* is satisfied when the timing function has run to expiration (see 9.9.2.4).

(10) [*start_unjab_timer*] : Starts a timing function that is used to monitor the amount of time that the Jabber error condition has been clear. The timing function is maintained as long as *output_idle* is true and is stopped on the transition to *output true*. The term *unjab_timer_done* is satisfied when the timing function has run to expiration (see 9.9.2.4).

(11) *opt_input* : Signifies that a packet is present at the FOMAU's receive optical fiber.

(12) *opt_input_idle* : Signifies that a packet is no longer present at the FOMAU's receive optical fiber.

(13) *opt_input_coll_select* : Signifies that, during a collision, a packet has been received at the DO circuit within 3.5 bit times of a packet being received at the FOMAU's receive optical fiber, and that only the packet received at the FOMAU's receive optical fiber is to be tranamitted into the DI circuit.

(14) *output_coll_select* : Signifies that, during a collision, a packet has been received at the DO circuit within 3.5 bit times of the packet being received at the FOMAU's receive optical fiber, and that only the packet received at the DO circuit is to be transmitted into the DI circuit.

The following abbreviations have been used in Figs 9-8, 9-9, and 9-10:

(1) LLP = Low Light Level Condition Present
(2) LLNP = Low Light Level Condition Not Present
(3) p_t_d = *packet_timer_done*
(4) p_t_n_d = *packet_timer_not_done*
(5) * = logical AND operator

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Exhibit 1026-00157

9.9.3 FOMAU Electrical Characteristics

9.9.3.1 Electrical Isolation. Electrical isolation shall be provided between FOMAUs attached to the FOIRL by the optical fiber cable link segment. There shall be no conducting path between the optical medium connector plug and any conducting element within the optical fiber cable link segment. This isolation shall withstand at least one of the following electrical strength tests:

(1) 1500 V rms at 50–60 Hz for 60 s, applied as specified in 5.3.2 of IEC Publication 950 [8].
(2) 2250 V dc for 60 s, applied as specified in 5.3.2 of IEC Publication 950 [8].
(3) A sequence of ten 2400 V impulses of alternating polarity, applied at intervals of not less than 1 s. The shape of the impulses shall be 1.2/50 μs (1.2 μs virtual front time, 50 μs virtual time of half value), as defined IEC Publication 60 [11].

There shall be no isolation breakdown, as defined in 5.3.2 of IEC Publication 950 [8], during the test. The resistance after the test shall be at least 2 MΩ, measured at 500 V dc.

NOTE: Although isolation is provided by the optical fiber cable link segment, it is recommended that the normal noise immunity provided by common-mode isolation on the AUI be retained.

9.9.3.2 Power Consumption. The current drawn by the FOMAU shall not exceed 0.5 A when powered by the AUI source. The FOMAU shall be capable of operating from all possible voltage sources as supplied by the repeater unit (7.5.2.5 and 7.5.2.6) through the resistance of all permissible AUI cables. The surge current drawn by the FOMAU on power-up shall not exceed 5 A peak for a period of 10 ms. In addition, the FOMAU shall be capable of powering-up from 0.5 A current limited sources.

It is permissible as an option to provide a separate power source for the FOMAU. If a separate power source is implemented, provision will be made to assure that power shall under no circumstances be sourced on pin 13 (Circuit VP) of the AUI.

The FOMAU shall be labeled externally to identify the maximum value of power supply current required by the device when the AUI mechanical connection is implemented.

The FOMAU shall not introduce into the FOMAU's transmit optical fiber or onto the DI or CI circuits of the AUI any extraneous signal on routine power-up or power-down under normal operating conditions.

The FOMAU shall be fully functional no later than 0.5 s after power is applied to it.

9.9.3.3 Reliability. The FOMAU shall be designed to provide a MTBF of at least 200 000 hours of operation without causing a communication failure amongst DTEs attached to the network. The FOMAU electronics shall be designed to minimize the probability of component failures within the FOMAU that prevent communication amongst other MAUs on the 10BASE5 and 10BASE2 segments. Connectors and other passive means of connection shall be designed to minimize the probability of total network failure.

9.9.3.4 FOMAU/Repeater Unit Electrical Characteristics. The electrical characteristics of the driver and receiver components connected to the AUI cable shall be identical to those specified in Section 7.

9.9.3.5 FOMAU/Repeater Unit Mechanical Connection. The FOMAU, if it implements the AUI mechanical connection, shall be provided with a 15-pin male connector, as specified in the AUI specification of Section 7.

9.9.4 FOMAU/Optical Medium Interface

9.9.4.1 Transmit Optical Parameters

9.9.4.1.1 Wavelength. The center wavelength of the optical source emission shall be between 790 and 860 nm. See Appendix D.

9.9.4.1.2 Spectral Width. The spectral width of the optical source shall be less than 75 nm full width half maximum (FWHM).

9.9.4.1.3 Optical Modulation. The optical modulation during packet transmission shall be on-off keying of the optical source power. The minimum extinction ratio shall be 13 dB.

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9.9.4.1.4 Optical Idle Signal. During the idle state of the DO circuit, the Transmit Function shall input into the FOMAU's transmit optical fiber an optical idle signal. This signal shall consist of a periodic pulse waveform of frequency 1 MHz +25% –15% with a duty cycle ratio between 45/55 and 55/45.

9.9.4.1.5 Transmit Optical Logic Polarity. The higher optical power level transmitted into the FOMAU's transmit optical fiber shall correspond to the low (LO) logic state (see 7.4.2.1) of the AUI DO circuit.

9.9.4.1.6 Optical Rise and Fall Times. The optical rise and fall times of the FOMAU shall be no more than 10 ns from the 10% to the 90% levels. There shall be no more than 3 ns difference between the rise and fall times.

9.9.4.1.7 Transmit Optical Pulse Edge Jitter. The additional edge jitter introduced by the FOMAU from the input of the DO circuit receiver to the output of the electro-optic source shall be no more than 2 ns. The jitter measured at the input of the DO circuit receiver shall be measured at the zero crossing points, as determined from the previous 16 or more transitions in any valid bit stream. The jitter measured at the output of the electro-optic source shall be measured at the power level median of the optical waveform's upper and lower power levels, as determined from the previous 16 or more transitions in any valid optical bit stream.

9.9.4.1.8 Peak Coupled Optical Power. At the beginning of the FOMAU's lifetime, the peak optical power coupled into the FOMAU's transmit optical fiber, when terminated with an optical connector as specified in 9.9.5.2, shall be –12 dBm ± 2 dB, when measured with a graded index optical fiber of nominal dimension of 62.5 μm core diameter and 0.275 nominal numerical aperture. The actual optical power, which will be coupled into other fiber sizes listed in 9.9.5.1, may differ from the above value. The peak optical power shall be measured in the steady state, and the measurement shall be independent of optical pulse ringing effects. Peak optical overshoot shall not exceed 10%.

NOTE: The above value does not include an aging margin. The source is allocated an aging margin of 3 dB over its operating lifetime. The variation in the peak-coupled optical power due to tolerances allowed by IEC Publication 793-2 [14][11] for type A1b (62.5/125 μm) fiber is ±1 dB. Hence, the minimum power level at the start of life will be –15 dBm.

9.9.4.2 Receive Optical Parameters

9.9.4.2.1 Receive Peak Optical Power Range. The BER shall be $< 10^{-10}$ for peak optical powers at the output of the FOMAU's receive optical fiber between –27 dBm and –9 dBm.

9.9.4.2.2 Receive Optical Pulse Edge Jitter. The additional edge jitter introduced by the FOMAU from the input of the opto-electric detector to the output of the DI circuit driver shall be no more than 4 ns. The jitter measured at the input of the opto-electric receiver shall be measured at the power level median of the optical waveform's upper and lower power levels as determined from the previous 16 or more transitions in any valid optical bit stream. The jitter measured at the output of the DI circuit driver shall be measured at the zero crossing points as determined from the previous 16 or more transitions in any valid bit stream. This requirement shall apply when the optical receive peak power level is in the range –27 to –9 dBm.

9.9.4.2.3 Receive Optical Logic Polarity. The low (LO) logic state (see 7.4.2.1) on the DI circuit shall correspond to the presence of the higher optical power level at the output of the FOMAU's receive optical fiber.

9.9.5 Characteristics of the Optical Fiber Cable Link Segment. The optical fiber cable link segment is a length of optical fiber cable (IEC Publications 794-1 [15] and 794-2 [16]) containing two optical fibers, as specified in 9.9.5.1, and comprising one or more optical fiber cable sections and their means of

[11]This FOIRL specification is to be read with the understanding that the following changes to IEC Publications 793-2 [14] have been requested:
(1) Correction of the numerical aperture tolerance in Table III to ±0.015.
(2) Addition of another bandwidth category, of > 150 MHz referred to 1 km, for the type A1b fiber in Table III.

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interconnection. Each optical fiber is terminated at each end in the optical connector plug specified in 9.9.5.2. The two optical fibers correspond to the FOMAU's transmit and receive optical fibers.

9.9.5.1 Optical Fiber Medium. The FOMAU can operate with a variety of optical fiber sizes, e.g., 50/125 μm, 62.5/125 μm, 85/125 μm, 100/140 μm.

Interoperability of FOMAUs that originate from different manufacturers, using any of these fiber sizes, is assured provided that the received peak optical power is between –27 dBm and –9 dBm and the optical fiber cable link segment bandwidth is greater than or equal to 150 MHz.

In order to satisfy the above attenuation and bandwidth criteria for all allowable FOIRL lengths, and assuming up to 4 dB of connection losses within the optical fiber cable link segment, it is recommended that the cabled optical fiber have an attenuation ≤ 4 dB/km and a bandwidth of ≥ 150 MHz referred to 1 km at a wavelength of 850 nm.

The total incremental optical pulse edge jitter introduced by the optical fiber cable link segment shall be less than 1 ns when driven by an optical transmitter as specified in 9.9.4.1. The pulse delay introduced by the optical fiber cable shall not exceed 50 bit times for a 1 km length.

In the specific case of 62.5/125 μm fiber, to ensure interoperability of FOMAUs that originate from different manufacturers:

(1) The two cabled optical fibers contained in the optical fiber cable link segment shall satisfy the optical fiber parameters specified in IEC Publication 793-2 [14] type A1b (62.5/125 μm),[12] and
(2) The optical fiber cable link segment shall have an attenuation less than or equal to 8 dB and a bandwidth greater than or equal to 150 MHz.

9.9.5.2 Optical Medium Connector Plug and Socket. The two optical fibers contained in the optical fiber cable link segment shall be terminated at each end in an optical connector plug as specified in IEC Publications 874-1 [18] and 874-2 [19].

The corresponding mating connector socket shall conform with the specifications given in IEC Publications 874-1 and 874-2. This document specifies the mechanical mating face dimensions to ensure mechanical intermateability without physical damage, of all F-SMA connectors covered by the document. In addition, the optical insertion loss when interconnecting two optical connector plugs shall not exceed 2.5 dB (measured using a socket adaptor conforming to the mechanical specifications given in IEC Publications 874-1 and 874-2 and also using two identical fibers, as specified in 9.9.5.1, assuming uniform mode distribution launch conditions).

9.9.6 System Requirements

9.9.6.1 Optical Transmission System Considerations. 9.9.4.2.1 specifies that the BER shall be $<10^{-10}$ for peak optical powers at the output of the FOMAU's receive optical fiber between -27 dBm and -9 dBm. The value of -9 dBm corresponds to the maximum allowable peak optical power that can be coupled into the worst-case optical fiber specified in 9.9.5.1 at the beginning of the FOMAU's lifetime (see 9.9.4.1.8), and assumes zero optical loss between the optical source output and the optical detector input.

The value of -27 dBm is calculated by subtracting the FOIRL flux budget from the minimum allowable peak optical power that can be coupled into the FOMAU's transmit optical fiber at the beginning of the FOMAU's lifetime (see 9.9.4.1.8). The flux budget is the maximum loss allowed within the FOIRL to guarantee a BER $< 10^{-10}$ assuming worst-case link components. A portion of the flux budget has been allocated as a design margin to allow for degradation and tolerance effects in the optical source. This is noted in the table below as the optical source lifetime degradation. The remaining flux budget of 9 dB assumes a system margin allowance for the optical fiber cable link segment over its lifetime, and may be allocated to the optical fiber cable link segment loss at the discretion of the network planner/installer. The following summarizes the allocated optical flux budgets for the example graded index optical fiber of worst-case dimensions 62.5 μm – 3 μm (i.e., 59.5 μm) core diameter and 0.275 – 0.015 (i.e., 0.260) numerical aperture:

[12]This FOIRL specification is to be read with the understanding that the following changes to IEC Publication 793-2 [14] have been requested:
(1) Correction of the numerical aperture tolerance in Table III to ± 0.015.
(2) Addition of another bandwidth category, of > 150 MHz to 1 km, for the type A1b fiber in Table III.

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Start of life minimum peak coupled optical power (9.9.4.1.8)	: –15 dBm
Optical source lifetime degradation	: 3 dB
Maximum optical fiber cable link segment loss including system margin allowance	: 9 dB
Resultant required receive peak optical power	: –27 dBm

9.9.6.2 Timing Considerations. Table 9-1 summarizes the maximum allowable timing budget contributions to the system timing budget for the FOIRL. The last bit in to last bit out delay shall equal the Steady-State Propagation Delay.

Table 9-1
Maximum Allowable Timing Budget Contributions to the FOIRL System Timing Budget

Symbol	Function	Bit Loss (bit times)	Invalid Bits (bit times)	Steady-State Propagation Delay (bit times)	Start-Up Delay (bit times)
I1	OPTICAL DATA IN ASSERT→INPUT	2.0	1.0	0.5	3.5
I2	OUTPUT→OPTICAL DATA OUT ASSERT	2.0	1.0	0.5	3.5
LOOP BACK	DO CIRCUIT ASSERT →DI CIRCUIT ASSERT	5.0	1.0	1.0	7.0
I3	OPTICAL COLLISION →SQE ASSERT	—	—	—	3.5
I4	COLLISION DEASSERT →SQE DEASSERT	—	—	—	7.0*
A1	AUI Propagation	—	—	2.57	2.57
F1	Optical Fiber Propagation per Kilometer	—	—	50	50

*Minimum Start-up Delay for I4 is 4.5 bit times.

9.9.7 Environmental Specifications

9.9.7.1 Safety Requirements

9.9.7.1.1 Electrical Safety. A major application for the vendor-independent FOIRL is for interconnecting 10BASE5 and/or 10BASE2 coaxial cable segments located within different buildings. The level of isolation provided by the optical fiber cable link segment shall be consistent with this application and provide adequate personnel and equipment safety from earth faults and lightning strike hazards.

9.9.7.1.2 Optical Source Safety. The recommendations of IEC 825 Publication [17], if applicable, shall be adhered to in determining the optical source safety and user warning requirements.

9.9.7.2 Electromagnetic Environment

9.9.7.2.1 Susceptibility Levels. Sources of interference from the environment include electromagnetic fields, electrostatic discharge, and transient voltages between earth connections. Several sources of interference contribute to voltage between the optical fiber cable link segment (either a metallic strength member in the cable, a metallic optical connector plug, or the outermost conducting element of the FOMAU for the case of no metallic strength member) and the earth connection of a DTE.

For information on limits and methods of measurements of radio interference characteristics of information technology equipment, see 1.3 in CISPR Publication 22 [1].

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

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

NOTE: These are the levels typically found 1 km from radio broadcast stations.

(2) Interference source voltage of 15.8 V peak sine wave of frequency 10 MHz in series with a 50 Ω source resistance applied between the optical fiber cable link segment (either a metallic strength member in the cable, a metallic optical connector plug, or the outermost conducting element of the FOMAU for the case of no metallic strength member) and the earth connection of a DTE.

NOTE: The optical fiber link segment is capable of withstanding higher levels of electromagnetic interference. The above specifications are the minimum requirements for the environment in which the FOMAU is required to operate.

9.9.7.2.2 Emission Levels. The FOMAU and optical fiber cable link segment shall comply with CISPR Publication 22 [1].

9.9.7.3 Temperature and Humidity. The FOMAU 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 beyond the scope of this standard. Manufacturers should indicate in the literature associated with the FOMAU (and on the FOMAU if possible) the operating environment specifications to facilitate selection, installation, and maintenance of these components. It is further recommended that such specifications be stated in standard terms, as specified in IEC Publications 68 [12], IEC 793-1 [13], IEC 794-1 [15], and IEC 874-1 [18].

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

10.1 Scope

10.1.1 Overview. This standard defines the functional, electrical, and mechanical characteristics of the Medium Attachment Unit (MAU) and one specific medium for use with local area networks. The relationship of this specification to the entire CSMA/CD Local Area Network Specification is shown in Fig 10-1.

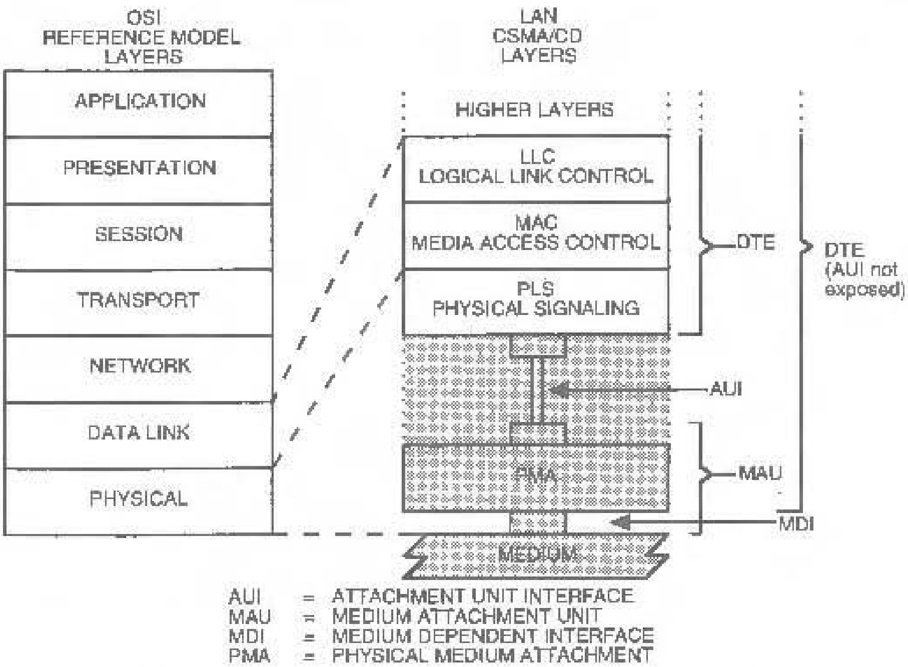

Fig 10-1
Physical Layer Partitioning, Relationship to the ISO Open Systems Interconnection (OSI) Reference Model

The purpose of the MAU is to provide a simple, inexpensive, and flexible means of attaching devices to the local area network medium. This standard defines a means of incorporating the MAU function within the DTE and bringing the trunk coaxial cable directly to the DTE. Interconnection of DTE units is easily achieved by the use of industry standard coaxial cables and BNC connectors.

This MAU and medium specification is aimed primarily at applications where there are a relatively small number of devices located in a work area. Installation and reconfiguration simplicity is achieved by the type of cable and connectors used. An inexpensive implementation is achieved by eliminating the MAU and Attachment Unit Interface (AUI) as separate components and using widely available interconnection components.

10.1.1.1 Medium Attachment Unit (normally contained within the data terminal equipment [DTE]). The MAU has the following general characteristics:

(1) Enables coupling the PLS to the explicit baseband coaxial transmission system defined in this section of the standard.
(2) Supports message traffic at a data rate of 10 megabits per second (Mb/s).
(3) Provides for driving up to 185 m (600 ft) coaxial trunk cable segment without a repeater.
(4) Permits the DTE to test the MAU and the medium itself.

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(5) Supports system configurations using the CSMA/CD access mechanism defined in the ISO [IEEE] Local Area Network Specification.
(6) Supports a bus topology interconnection means.
(7) Supports low-cost capability by incorporating the MAU function within the physical bounds of the DTE, thereby eliminating the need for a separate AU connector and cable but containing the remaining AU interface functionality.

10.1.1.2 Repeater Unit. The Repeater Unit is used to extend the physical system topology and provides for coupling two or more coaxial trunk cable segments. Multiple Repeater Units are permitted within a single system to provide the maximum trunk cable connection path specified in 10.7. The repeater is not a DTE and therefore has slightly different attachment requirements.

10.1.2 Definitions. This section defines the specialized terminology applicable to MAUs and Repeater Units.

Attachment Unit Interface (AUI). In a local area network, the interface between the Medium Attachment Unit (MAU) and the data terminal equipment within a data station.

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.

carrier sense. In a local area network, an ongoing activity of a data station to detect whether or not 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 section. A single length of coaxial cable terminated at each end with a BNC male connector. Cable sections are joined to other cable sections via BNC plug/receptacle barrel or Type T adapters.

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

collision. An unwanted condition that results from concurrent transmission 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.

Medium Attachment Unit (MAU). In a local area network, a device used in a data station to couple the data terminal equipment (DTE) 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 Sublayer (PLS). The 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.

NOTE: For additional definitions, see 8.1.2.

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10.1.3 Application Perspective: MAU and Medium Objectives. This section states the broad objectives and assumptions underlying the specifications defined throughout Section 10 of the standard.

10.1.3.1 Object

(1) Provide the physical means for communication between local network Data Link entities.

NOTE: This specification 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 achieves 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 10^7 (on the order of one part in 10^8 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 low-cost implementations.

NOTE: The figures and numerous textual references throughout the section refer to terminology associated with the AUI (that is, DO, DI, CI). Since the normal embodiment of the Type 10BASE2 configuration does not require an AUI, actual existence of the DO, DI, CI circuit may not be required. Use of this terminology, however, is retained throughout Section 10 for purposes of clarity and consistency.

10.1.3.2 Compatibility Considerations. All implementations of this baseband coaxial system shall be compatible at the Medium Dependent Interface (MDI).

This standard provides one explicit trunk cable medium specification for the interconnection of all MAU devices. The medium itself, and the functional capability of the MAU, 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 MDI specifications are satisfied.

10.1.3.3 Relationship to PLS and AUI. 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 resides within the DTE. Therefore, a close relationship exists between this section and Section 7. This section specifies the physical medium parameters, the PMA logical functions residing in the MAU, and references the signal circuits associated with the AUI as defined in Section 7.

The design of a MAU component requires the use of both this section and parts of the PLS and AUI specifications contained in Section 7.

10.1.3.4 Mode of Operation. The MAU functions as a direct connection between the baseband medium and the DTE. Data from the DTE is output to the coaxial trunk medium and all data on the coaxial trunk medium is input to the DTE.

10.2 References. References to such local or national standards that may be useful resource material for the reader are identified and located in the Annex at the end of this book.

10.3 MAU Functional Specifications. The MAU component provides the means by which signals on the three 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 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.

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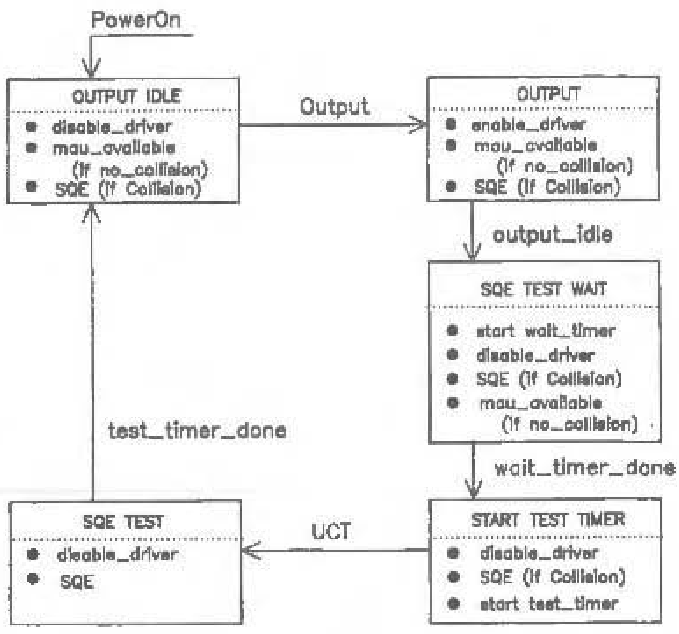
(4) Jabber Function. The ability to automatically interrupt the Transmit Function and inhibit an abnormally long output data stream.

10.3.1 MAU Physical Layer Functional Requirements

10.3.1.1 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 invalid data or timing; however, all successive bits of the frame shall be reproduced with no more than the specified amount of jitter. The 4th bit cell 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 1/2 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 10.4.1.3.

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 Output Idle signal (Wait_Timer_Done in Fig 10-2) and shall maintain an active Collision Presence state for a time equivalent to 10 ± 5 bit cells.



(UCT = unconditional transition)
(Wait_Timer_Done is specified in 10.3.1.1)

Fig 10-2
MAU Interface Function

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10.3.1.2 Receive Function Requirements. The signal from the coaxial trunk cable shall be ac coupled before reaching the receive DI circuit. The Receive Function shall output a signal onto the DI circuit that complies with the specification for drivers in MAUs (7.5).

At the start of a frame reception from the coaxial cable, no more than 5 bits (5 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 invalid data or timing; however, all successive bits of the frame shall reproduce the incoming signal with no more than the amount of jitter specified below. This implies that the 7th bit cell presents valid data to the PLS. The steady-state propagation delay between the coaxial cable and the receive DI circuit output shall not exceed 1/2 bit cell. There are no logical signal inversions between the coaxial (trunk) cable and the MAU receive circuit.

A MAU meeting this specification shall exhibit edge jitter into the DI pair when terminated in the appropriate test load specified in 7.4.1.1, of no more than 7.0 ns in either direction when it is installed on the distant end of all lengths up to 185 m (600 ft) of the cable specified in 10.5.1.1 through 10.5.2.1.5 terminated at both ends with terminators meeting the impedance requirements of 10.6.2.1 and 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 10.4.1.3 except that the rise time of the signal shall be 30 ns + 0, – 2 ns. 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.

10.3.1.3 Collision Presence Function Requirements. The signal presented to the CI circuit in the absence of a collision shall be the IDL 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 (that is, 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 10-1 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 additional considerations; see 10.4.1.5

Table 10-1
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

10.3.1.4 Jabber Functional Requirements. The MAU shall contain the capability as defined in Fig 10-3 to interrupt a transmission from a DO circuit that exceeds a time duration determined by the MAU. This time duration shall not be less than 20 ms nor more than 150 ms. If the frame being transmitted continues longer than the specified time duration, the MAU shall inhibit transmission and assume its not-transmitting state on the coaxial cable.

When the Transmit Function has been positively disabled, the MAU shall then activate the Collision Presence Function without introducing an extraneous signal on the trunk coaxial medium. A MAU may reset the Jabber and Collision Presence Functions on power reset once the error condition has been cleared. Alternately, a MAU may reset these functions automatically after a period of 0.5 s ± 50%.

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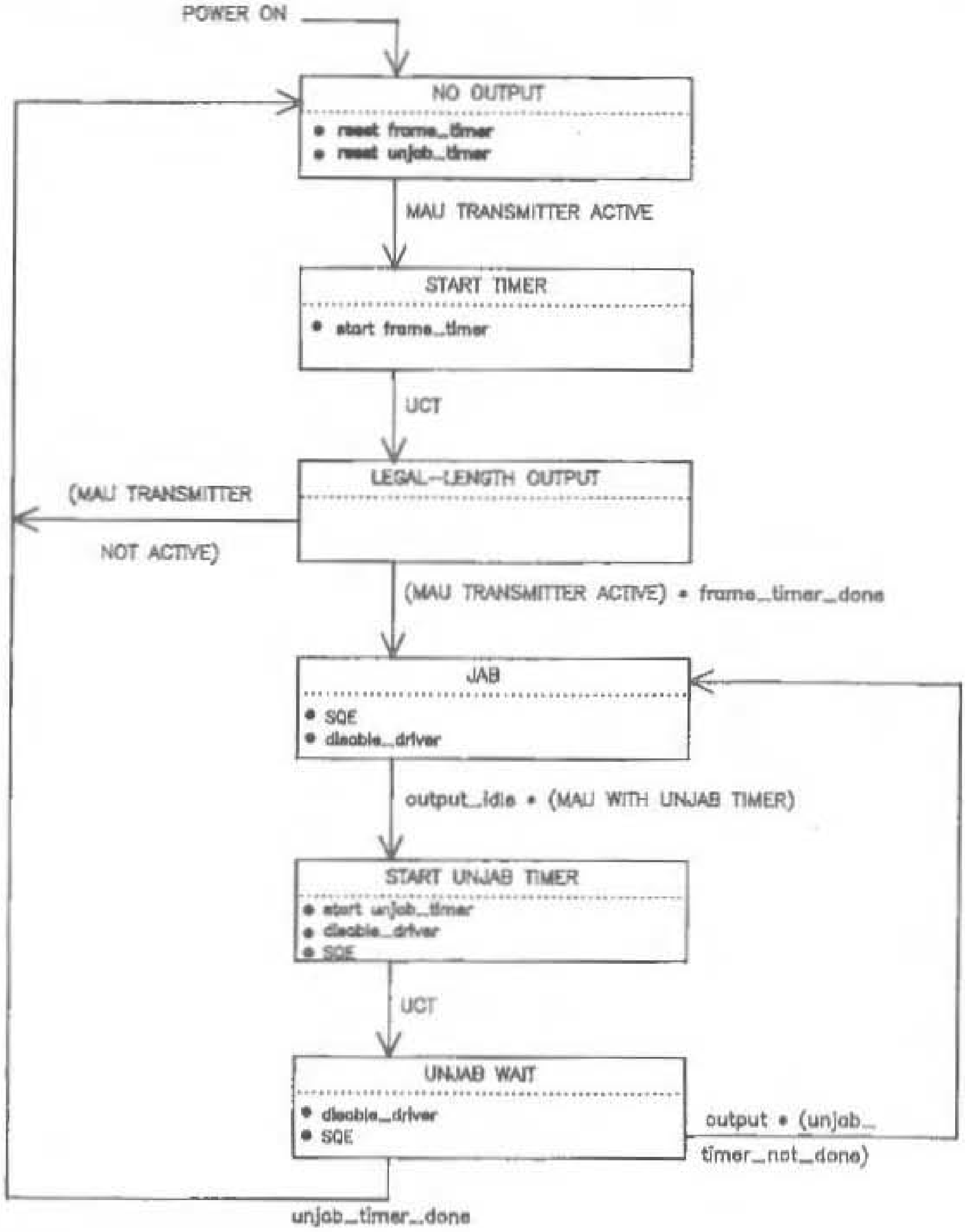

(Figure 10-3 outputs override those in Fig 10-2.
Optional states: START UNJAB TIMER, UNJAB WAIT.)

Fig 10-3
Jabber Function State Diagram

10.3.2 MAU Interface Messages

10.3.2.1 DTE to MAU Messages. The following messages can be sent by the DTE Physical Layer (PLS Sublayer) Entities to the MAU Entities:

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Message	Circuit	Signal	Meaning
output	DO	CD1, CD0	Output information
output_IDL	DO	IDL	No data to be output

10.3.2.2 MAU to DTE Messages. 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
SQE	CI	CS0	Error detected by MAU

*It is assumed that no retiming of these clocked data signals takes place within the MAU.

10.3.2.2.1 *input* Message. The MAU 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.

10.3.2.2.2 *input_idle* Message. The MAU 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.

10.3.2.2.3 *mau_available* Message. The MAU 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 SQE message should 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.

10.3.2.2.4 *signal_quality_error* (SQE) Message. The SQE message shall be implemented in the following fashion:

(1) The SQE message shall not be sent by the MAU if no or only one MAU is transmitting on the trunk coaxial medium.
(2) If more than two remote MAUs are transmitting on the trunk coaxial medium, but the MAU connected to the local DTE is not transmitting, then the local MAU shall send the SQE message. In every instance when more than one MAU is transmitting on the coaxial medium, the MAU shall make the best determination possible. It is acceptable for the MAU to fail to send the SQE 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 SQE 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. Note that MAUs associated with repeaters shall not generate the SQE test sequence.
(5) When the MAU has inhibited the Transmit Function, it shall send the SQE message in accordance with the Jabber Function requirements of 10.3.1.4 and Fig 10-3.

The SQE message shall be asserted less than 9 bit cells after the occurrence of the multiple-transmission condition is present at the Medium Dependent Interface (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

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that an extended delay in the removal of the SQE message may adversely affect the access method performance.

The physical realization of the SQE message is the CS0 signal sent by the MAU to the DTE physical layers on the Control In circuit.

NOTE: The MAU is required to assert the SQE at the appropriate times whenever the MAU is powered and not just when the DTE physical layer is providing data output.

10.3.3 MAU State Diagrams. The state diagrams, Figs 10-2 and 10-3, 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:

enable_driver. Activates the path employed during normal operation to cause the MAU transmitter to impress data onto the trunk coaxial medium.

disable_driver. Deactivates the path employed during normal operation to cause the MAU transmitter to impress data onto the trunk coaxial medium.

no_collision. Signifies that the condition of multiple transmitters simultaneously active on the trunk coaxial medium does not exist.

collision. Signifies that the condition of multiple transmitters simultaneously active on the trunk coaxial medium does exist.

frame_timer. Measures the time the MAU transmits on the trunk coaxial cable.

test_timer. Measures the length of the SQE Test.

unjab_timer. Measures the amount of time the MAU has been in Jab mode.

wait_timer. Measures the time between output idle and the start of the SQE Test.

10.4 MAU–Medium Electrical Characteristics

10.4.1 MAU-to-Coaxial Cable Interface. The following subsections 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).

10.4.1.1 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 not greater than 6 pF. The magnitude of the reflection from a MAU plus the cable connection specified in 10.6.3 shall not be more than that produced by an 8 pF capacitance when measured by both a 25 ns rise time and 25 ns fall time waveform. The resistance presented to the coaxial cable shall be greater than 100 kΩ.

These conditions shall be met in both the power-off and power-on, not-transmitting states.

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

10.4.1.3 Coaxial Cable Signaling Levels. The signal on the coaxial cable due to a single MAU as measured at the MAU's 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 (average dc current including the effects of timing distortion) of from – 37 mA min to – 45 mA max 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. The MAU shall be capable of generating at least 2.2 V of average dc level on the coaxial cable in the presence of two or

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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 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 must match within 2 ns. Figure 10-4 shows typical waveforms present on the cable. Harmonic content generated from the 10 MHz fundamental periodic input shall meet the following requirements:

Second and Third Harmonics: At least 20 dB below fundamental
Fourth and Fifth Harmonics: At least 30 dB below fundamental
Sixth and Seventh Harmonics: At least 40 dB below fundamental
All Higher Harmonics: At least 50 dB below fundamental

NOTE: Even harmonics are typically much lower.

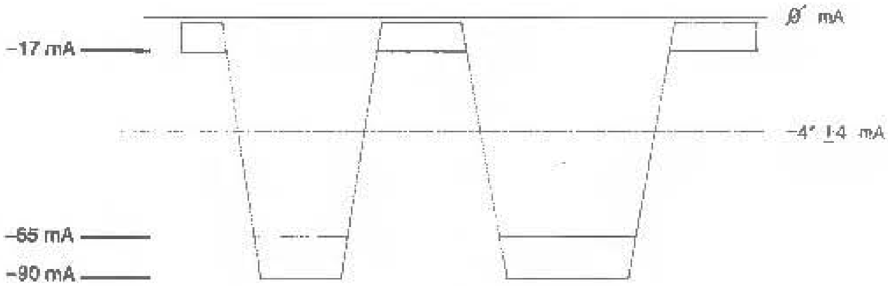
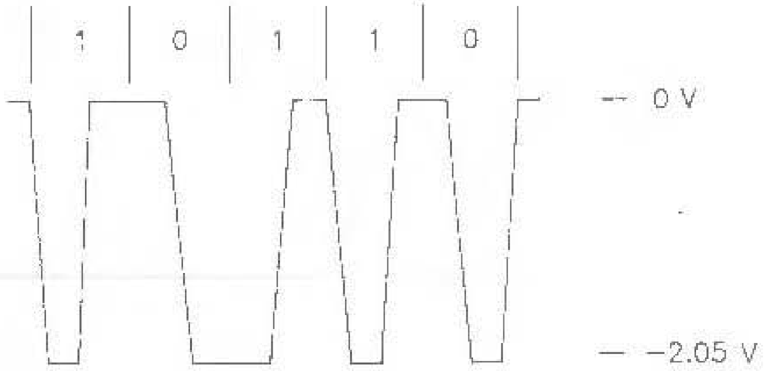


Fig 10-4
Driver Current Signal Levels

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 10-5).



NOTE: (1) Voltages given are nominal, for a single transmitter.
(2) Rise 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 10-5
Coaxial Trunk Cable Signal Waveform

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10.4.1.4 Transmit Output Levels Symmetry. Signals received from the DO circuit must be transmitted onto the coaxial cable with the characteristics specified in 10.4.1.3. 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.

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 with pseudo-random 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 shall not 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 or before the first valid edge of the next frame.

10.4.1.5 Collision Detect Thresholds. For receive mode collision detection the MAU shall have its collision detection threshold set in the range –1404 mV and –1581 mV. These limits take account of up to 8% collision detect filter impulse response. If a specific filter implementation has a higher value of impulse response, the lower threshold limit of –1404 mV is required to be replaced by 1300 mV × [1 + impulse response].

Receive mode collision detection indicates that a nontransmitting MAU has the capability to detect collisions when two or more MAUs are transmitting simultaneously.

MAUs included with repeater sets are required to implement receive mode collision detection.

When receive mode collision detection is not implemented, the upper limit of –1581 mV may be relaxed to –1782 mV.

NOTE: The above threshold limits are measured at the coaxial cable center conductor with respect to the shield at the MAU connector. The MAU designer must take into account circuit offsets, low-frequency noise (for example, 50 Hz, 60 Hz), and 5 MHz ripple at the filter output in determining the actual internal threshold value and its tolerance.

10.4.2 MAU Electrical Characteristics

10.4.2.1 Electrical Isolation. The MAU must provide isolation between the DTE Physical Layer circuits and the coaxial trunk cable. The isolation impedance measured between any conductor in the DTE Physical Layer circuitry and either the center conductor or shield of the coaxial cable shall be greater than 250 kΩ at 50 Hz, 60 Hz. In addition, the isolation impedance between the DTE ground and the coaxial cable shield shall be less than 15 Ω between 3 MHz and 30 MHz. The isolation means provided shall withstand 500 V ac, rms for one minute.

10.4.2.2 Power Consumption. The current drawn by the MAU shall not exceed 0.5 A if powered by the AUI source. The MAU shall be capable of operating from all permissible 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. This requirement only applies to MAUs that are external to DTEs.

10.4.2.3 Reliability. The MAU shall be designed to provide an MTBF of at least 100 000 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 impede the 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 from the coaxial cable may cause communication failure among other stations.

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