

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-89

LOCAL AREA NETWORKS

TOKEN RING TECHNIQUE

2nd Edition – March 1985

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BRIEF HISTORY

This Standard ECMA-89 is one of a series of Standards for Open Systems Interconnection.

Open Systems Interconnection Standards are intended to facilitate homogeneous interconnection of heterogeneous information processing systems.

This Standard is within the framework for the co-ordination of standards for Open Systems Interconnection which is defined by ISO 7498. It is based on the practical experience of ECMA member companies world-wide, and the results of their active participation in the current work of ISO, CCITT and IEEE, and the National Standards Bodies in Europe and the USA. It represents a pragmatic and widely based consensus.

This is one of a series of standards developed and published by ECMA in the field of Local Area Networks. These ECMA Standards refer to several LAN techniques :

- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
- Token Techniques (Bus, Ring).

Accepted as 2nd Edition of Standard ECMA-89 by the General Assembly of ECMA on Dec. 14, 1984.

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1. GENERAL

1.1 Scope

For the purpose of compatible interconnection of Data Processing equipment via a local area network using the token-passing ring access method, this ECMA Standard :

- Defines the frame format, including delimiters, addressing, and frame check sequence, and introduces timers, frame count, and priority stacks (see clause 3).
- Defines the medium access control protocol. The finite-state machine and state tables are supplemented with a prose description of the algorithms (see clause 4).
- Describes the services provided by the medium access control sublayer to the network management and LLC sublayer and the services provided by the Physical Layer to Network Management and the medium access control sublayer. These services are defined in terms of service primitives and associated parameters (see clause 5).
- Defines the Physical Layer functions of symbol encoding and decoding, symbol timing and latency buffering (see clause 6).
- Defines the 1- and 4- megabit per second, shielded twisted pair attachment of the DTE to the medium including the definition of the medium interface connector (see clause 7).

A particular emphasis of this Standard is to specify the homogeneous externally visible characteristics needed for interconnection compatibility, while avoiding unnecessary constraints upon and changes to internal design and implementation of the heterogeneous processing equipment to be interconnected.

1.2 References

- | | |
|----------|---|
| ISO-7498 | Data Processing - Open Systems Interconnection - Basic Reference Model. |
| ECMA-57 | Safety Requirements for Data Processing Equipment. |
| ECMA-71 | HDLC Selected Procedures. |
| ECMA-72 | Transport Protocol. |
| ECMA-80 | Local Area Networks - CSMA/CD Baseband - Coaxial Cable System. |
| ECMA-81 | Local Area Networks - CSMA/CD Baseband - Physical Layer. |
| ECMA-82 | Local Area Networks - CSMA/CD Baseband - Link Layer. |

- ECMA-90 Local Area Networks - Token Bus Technique.
- ECMA TR/14 Local Area Networks Layer 1 to 4 Architecture and Protocols.
- ECMA TR/19 Local Area Networks - Safety Requirements.
- IEC 364 Requirements for Electrical Installations.

1.3 Definitions

For the purpose this Standard, the following definitions apply.

1.3.1 Abort Sequence

A sequence which terminates the transmission of a frame prematurely.

1.3.2 Broadcast Transmission

A transmission addressed to all DTEs.

1.3.3 Differential Manchester Encoding

A signalling method used to encode clock and data bit information into bit symbols. Each bit symbol is split into two halves, where the second half is the inverse symbol of the first half. A ZERO bit is represented by a polarity change at the start of the bit time. A ONE bit is represented by no polarity change at the start of the bit time. Differential Manchester encoding is polarity-independent.

1.3.4 Fill

A bit sequence that may be either ZERO, ONE bits or any combination thereof.

1.3.5 Frame

A transmission unit which carries a Protocol Data Unit (PDU) on the ring.

1.3.6 Logical Link Control (LLC)

That part of the Data Link Layer which supports media-independent data link functions, and uses the services of the medium access control sublayer to provide services to the Network Layer.

1.3.7 Medium

The material on which the data may be represented. Twisted-pairs, coaxial cables and optical fibers are examples of media.

1.3.8 Medium Access Control (MAC)

The portion of the DTE which controls and mediates the access to the ring.

1.3.9 Medium Interface Connector (MIC)

The connector between the DTE and Trunk Coupling Unit (TCU) at which all transmitted and received signals are specified.

1.3.10 Monitor

The monitor is that function which recovers from various error situations. It is contained in each ring DTE, however only the monitor in one of the DTEs on a ring is the Active monitor at any point in time. The monitor function in all other DTEs on the ring is in standby mode.

1.3.11 Multiple Frame Transmission

A transmission where more than one frame is transmitted when a token is captured.

1.3.12 Network Management (NMT)

The conceptual control element of a DTE which interfaces with all of the layers of the DTE and is responsible for the setting and resetting of control parameters, obtaining reports of error conditions, and determining if the DTE should be connected to or disconnected from the medium.

1.3.13 Physical Layer (PHY)

The layer responsible for interfacing with the medium, detecting and generating signals on the medium, and converting and processing signals received from the medium and the medium access control layer.

1.3.14 Protocol-Data-Unit (PDU)

Information delivered as a unit between peer entities which contains control information and optionally data.

1.3.15 Repeat

The action of a DTE in receiving a bit stream (e.g. frame, token or fill) from the previous DTE and placing it on the medium to the next DTE. The DTE repeating the bit stream may copy it into a buffer or modify control bits as appropriate.

1.3.16 Repeater

A device used to extend the length, topology or interconnectivity of the transmission medium beyond that imposed by a single transmission segment.

1.3.17 Ring Latency

In a token ring medium access control system, the time (measured in bit times at the data transmission rate) required for a signal to propagate once around the ring. The ring latency time includes the signal propagation delay through the ring medium plus the sum of the propagation delays through each DTE connected to the token ring.

1.3.18 Service-Data-Unit (SDU)

Information delivered as a unit between adjacent entities which may also contain a PDU of the upper layer.

1.3.19 Token

The symbol of authority which is passed between DTEs using a token access method to indicate which DTE is currently in control of the medium.

1.3.20 Transmit

The action of a DTE generating a frame, token, abort sequence or fill and placing it on the medium to the next DTE. In use, this term contrasts with repeat.

1.3.21 Trunk Cable

The transmission cable which interconnects two trunk coupling units.

1.3.22 Trunk Coupling Unit (TCU)

A physical device which enables a DTE to connect to a trunk cable. The trunk coupling unit contains the means for inserting the DTE into the ring or, conversely, bypassing the DTE.

1.4 Notation

Hexadecimal values are denoted by (xxxx), where x = 0...9ABCDEF.

1.5 Conformance

Equipment claimed to conform with this Standard shall implement the provisions specified in clauses 3, 4, 6 and 7.

There is no conformance requirement for the layer services defined in clause 5.

2. GENERAL DESCRIPTION

This ECMA Standard specifies the formats and protocols used by the token-passing ring medium access control (MAC) sublayer, the Physical (PHY) Layer, and the means of attachment to the token-passing ring physical medium. The Local Area Network Model and its relationship to the Open System Interconnection (OSI) Reference Model of the International Organization for Standardization (ISO) is illustrated in Figure 1.

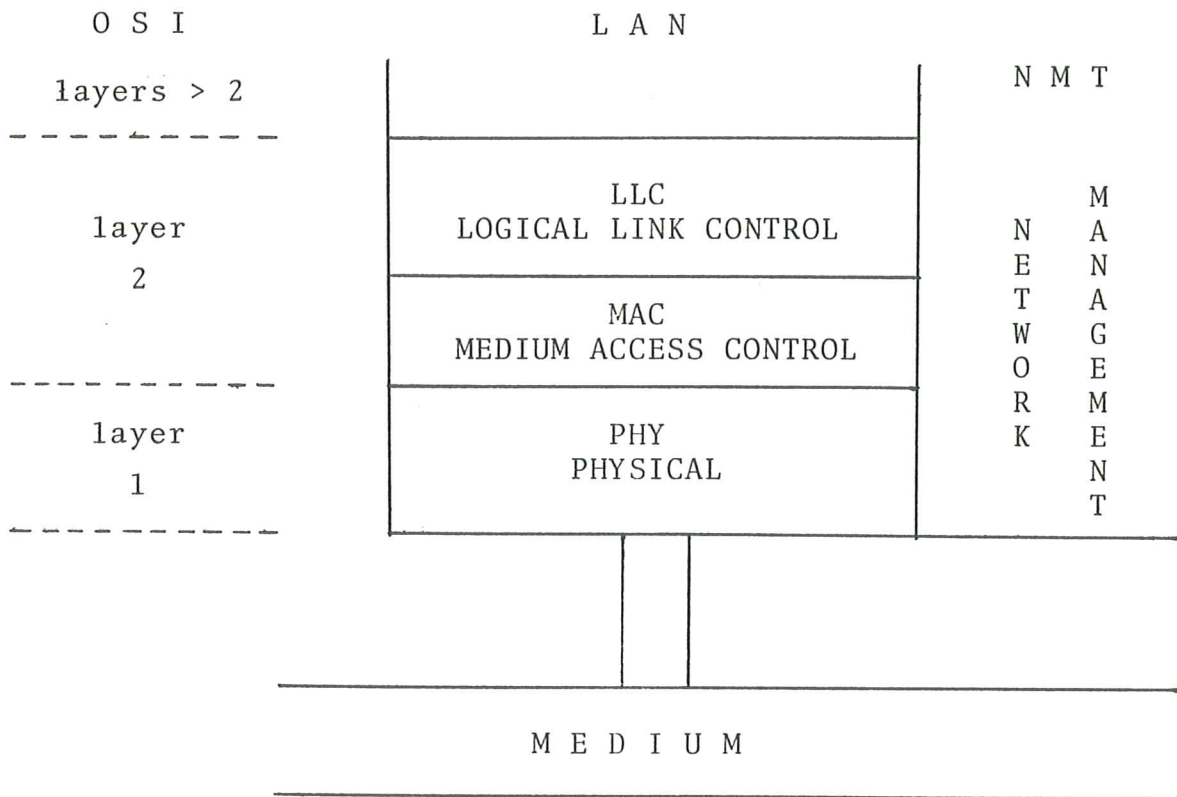
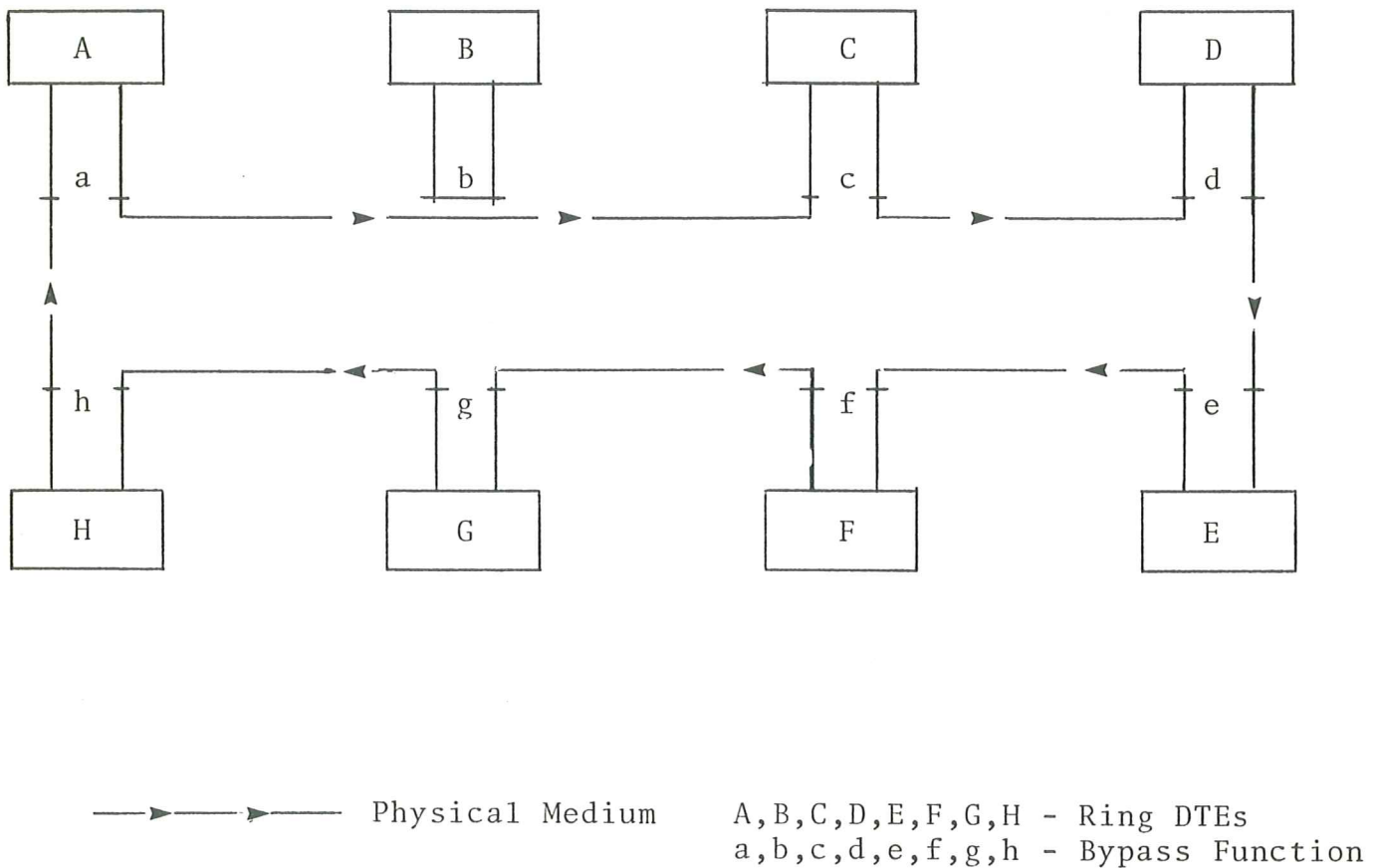


Figure 1 - Relation of OSI Reference Model to LAN Model

A token ring consists of a set of DTEs serially connected by a transmission medium (see Fig. 2). Information is transferred sequentially, bit-by-bit, from one active DTE to the next. Each DTE generally regenerates and repeats each bit and serves as the means for attaching one or more devices (terminals, work stations) to the ring for the purpose of communicating with other devices on the network. A given DTE (the one that has access to the medium) transfers information onto the ring, where the information circulates from one DTE to the next. The addressed destination DTE(s) "copies" the information as it passes. Finally, the DTE which transmitted the information effectively removes the information from the ring.

A DTE gains the right to transmit its information onto the medium when it detects a token passing on the medium. The token is a control signal comprising a unique signalling sequence that circulates on the medium following each information transfer. Any DTE, upon detection of an appropriate token, may capture the token by modifying it to a start of frame sequence and appending appropriate control and status fields, address fields, information field, frame check sequence and the end of frame sequence. At the completion of its information transfer and after appropriate checking for proper operation, the DTE initiates a new token, which provides other DTEs the opportunity to gain access to the ring.



All DTEs are active except B (b illustrated in bypass mode)

Figure 2 - Token Ring Configuration

A token holding timer controls the maximum period of time a DTE shall use (occupy) the medium before passing the token.

Multiple levels of priority are available for independent and dynamic assignment depending upon the relative class of service required for any given message, e.g., synchronous (real-time voice), asynchronous (interactive), immediate (network recovery). The allocation of priorities shall be by mutual agreement among users of the network.

Error detection and recovery mechanisms are provided to restore network operation in the event that transmission errors or medium transients (e.g., those resulting from DTE insertion or removal) cause the access method to deviate from normal operation. Detection and recovery for these cases utilizes a network monitoring function that is performed in a specific DTE with back-up capability in all other DTEs which are attached to the ring.

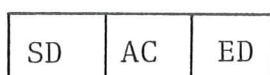
3. FORMATS AND FACILITIES

3.1 Formats

There are two basic formats used in token rings : tokens and frames. In the following discussion, the figures depict the formats of the fields in the sequence they are transmitted on the medium, with the left-most bit or symbol transmitted first.

Processes, which require comparison of fields or bits, perform that comparison upon those fields or bits as depicted, with the left-most bit or symbol compared first and for the purpose of comparison, considered most-significant.

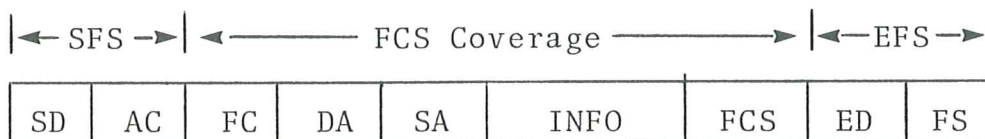
3.1.1 Token Format



SD = Starting Delimiter (1 octet)
 AC = Access Control (1 octet)
 ED = Ending Delimiter (1 octet)

The token shall be the means by which the right to transmit (as opposed to the normal process of repeating) is passed from one DTE to another.

3.1.2 Frame Format



SFS = Start of Frame Sequence
SD = Starting Delimiter (1 octet)
AC = Access Control (1 octet)
FC = Frame Control (1 octet)
DA = Destination Address (6 octets)
SA = Source Address (6 octets)
INFO = Information (0 or more octets) *
FCS = Frame Check Sequence (4 octets)
EFS = End of Frame Sequence
ED = Ending Delimiter (1 octet)
FS = Frame Status (1 octet)

* - See 3.2.5 for limitation of information field length

The frame format shall be used for transmitting both Medium Access Control (MAC) and Logical Link Control (LLC) messages to the destination DTE(s). It may or may not have an information field.

3.1.2.1 Abort Sequence



This sequence shall be used for the purpose of terminating the transmission of a frame prematurely. The abort sequence may occur anywhere in the bit stream, i.e., receiving DTEs shall be able to detect an abort sequence even if it does not occur on octet boundaries. The E and I bits of the ED shall be transmitted set to ZERO.

3.1.3 Fill

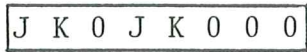
When a DTE is transmitting (as opposed to repeating), it shall transmit fill preceding or following frames, tokens or abort sequences to avoid what would otherwise be an inactive or indeterminate transmitter state.

Fill may be either ZEROs or ONES or any combination thereof and may be any number of bits in length, within the constraints of the Token Holding timer (THT).

3.2 Field Descriptions

The following is a detailed description of the individual fields in the tokens and frames.

3.2.1 Starting Delimiter (SD)

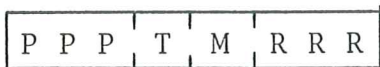


J = Non-data-J
 K = Non-data-K
 0 = ZERO

(For a discussion of non-data symbols, see 6.1.)

A frame or token shall be started with these eight symbols. If otherwise, it shall not be considered valid.

3.2.2 Access Control (AC)



PPP = Priority Bits
 T = Token Bit, M = Monitor Bit
 RRR = Reservation Bits

3.2.2.1 Priority Bits

The priority bits shall indicate the priority of a token and therefore which DTEs are allowed to use the token. In a multiple-priority system, DTEs use different priorities depending on the priority of the PDU to be transmitted.

The eight levels of priority increase from the lowest (000) to the highest (111) priority. For purposes of comparing priority values, the priority shall be transmitted most-significant bit first, e.g., 110 has higher priority than 011 (left-most bit transmitted first).

3.2.2.2 Token Bit

The token bit is set to ZERO in a token and to ONE in a frame. When a DTE with a PDU to transmit detects a token which has a priority equal to or less than the PDU to be transmitted it may change the token to a start of frame sequence and transmit the PDU.

3.2.2.3 Monitor Bit

The monitor bit is used to prevent a token the priority of which is greater than 0 or any frame from continuously circulating on the ring. If an active monitor detects a frame or a "high priority" token with the monitor bit set to ONE the frame or token is aborted.

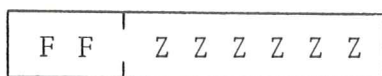
This bit shall be transmitted set to ZERO in all frames and tokens. The active monitor inspects and modifies this bit. All other DTEs shall repeat this bit as received.

3.2.2.4 Reservation Bits

The reservation bits allow DTEs with high priority PDUs to request (in frames or tokens as they are repeated) that the next token be issued at the requested priority. The precise protocol for setting these bits is described in 4.2.2.

The eight levels of reservation increase from 000 to 111. For purposes of comparing reservation values, the reservation shall be transmitted most-significant bit first, e.g., 110 has higher priority than 011 (left-most bit transmitted first).

3.2.3 Frame Control (FC)



FF = Frame Type Bits
ZZZZZZ = Control Bits

The Frame Control field defines the type of the frame and certain MAC and information frame functions.

3.2.3.1 Frame Type Bits

The Frame Type Bits shall indicate the type of the frame as follows :

- 00 = MAC frame (contains a MAC PDU)
- 01 = LLC frame (contains an LLC PDU)
- 1x = Undefined format (reserved for future use)

Medium Access Control Frames

If the Frame Type Bits indicate a MAC frame, all DTEs on the ring shall interpret and, based on the finite state of the DTE, act on the ZZZZZZ control bits. (For detail description of MAC frames see 3.3.)

Logical Link Control Frames

If the Frame Type Bits indicate an LLC frame, the ZZZZZZ bits are designated as rrrYYY. The rrr bits are reserved and shall be transmitted set to ZEROs in all transmitted frames and ignored upon reception. The YYY bits may be used to carry the priority (Pm) of the PDU from the source LLC entity to the target LLC entity or entities. Note that P (the priority in the AC field of a frame) is less than, or equal to, Pm when the frame is transmitted onto the ring.

The eight levels of YYY bits increase from 000 to 111 and are transmitted most-significant bit first, e.g. 110 has higher priority than 011 (left-most bit transmitted first).

Undefined Format

The value "lx" is reserved for frame types that may be defined in the future. However, although currently undefined, any future frame formats shall adhere to the following conditions :

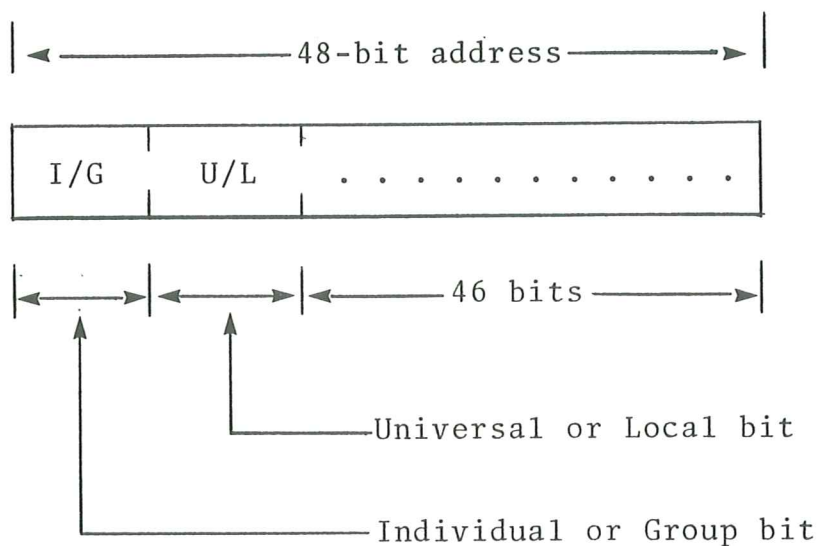
- i) The format shall be delimited by the 1-octet starting delimiter (SD) field and the 1-octet ending delimiter (ED) field, as defined in this Standard. Additional fields may follow the ending delimiter field.
- ii) The position of the Access Control (AC) and Frame Control (FC) fields shall be unchanged.
- iii) The starting delimiter and ending delimiter of the format shall be separated by an integral number of octets. This number shall be at least 2 (i.e., the AC and FC fields) and the maximum length is subject to the constraints of the Token Holding timer.
- iv) All symbols between the SD and ED shall be ZEROs and ONES.
- v) All DTEs on the ring check for data symbols and an integral number of octets between the SD and ED fields. The Error Detected Bit of formats which are repeated shall be set to ONE when a non-data symbol or a non-integral number of octets is detected between the SD and ED fields.
- vi) All bit errors that occur in the FC field which have a hamming distance of less than four must be detectable by DTEs using this format and shall not be accepted by any other DTE conforming to this Standard.

3.2.4 Destination and Source Address Fields

Each frame shall contain two address fields : the Destination Address and the Source Address, in that order. Both source and destination addresses are six octets in length.

3.2.4.1 Destination Address

The Destination Address identifies the DTE(s) for which the information field of the frame is intended. Included in the destination address is a first bit indicating whether the destination address is an individual or group address and a second bit indicating whether it is a universally or locally administered address.



Individual and Group Addresses

The first bit transmitted of the destination address distinguishes individual from group addresses :

- 0 = individual address
- 1 = group address

Individual addresses identify a particular DTE on the LAN and shall be distinct from all other individual DTE addresses on the same LAN (in the case of Local Administration), or from the individual addresses of other LAN DTEs on a global basis (in the case of Universal Administration).

NOTE 1

A group address is an address associated by convention with a group of logically related DTEs.

Broadcast Address

The group address consisting 48 ONES shall constitute a broadcast address, denoting the set of all DTEs on a given LAN.

Null Address

An address of 48 ZEROS shall be considered a null address. It will mean the frame is not addressed to any particular DTE.

Address Administration

The are two methods of administering the DTE addresses : locally or through a "universal" authority. The second bit of the destination address indicates whether the address has been assigned by a universal or local administrator :

- 0 = universally administered
- 1 = locally administered

Universal Administration

With this method, all individual addresses are distinct from the individual addresses of all other LAN DTEs on a global basis. The procedure for administration of these addresses is not specified in this Standard.

Local Administration

Individual DTE addresses are administered by a local (to the LAN) authority.

NOTE 2

Appendix A contains a suggested method for hierarchical structuring of locally administered addresses.

3.2.4.2 Source Address Field

The source Address shall identify the DTE originating the frame and shall have the same format and length as the destination address in a given frame. The individual/group bit shall be set to ZERO.

3.2.5 Information (INFO) Field

The information field contains zero, one or more octets that are intended for MAC, NMT, or LLC. Although there is no maximum length specified for the information field, the time required to transmit a frame may be no greater than the token holding period that has been established for the DTE.

The format of the information field is indicated in the frame type bits of the frame control field. The frame types defined are MAC frame and LLC frame.

3.2.5.1 MAC Frame Format

The following defines the format of the information field, when present, for MAC frames.

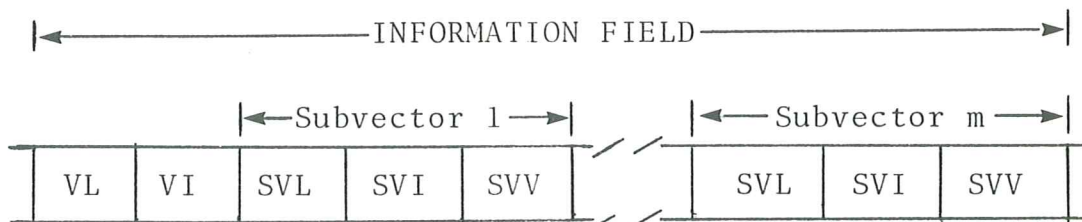


Figure 3 . MAX Frame Information Field Structure

VL (2 octets) = Vector Length
VI (2 octets) = Vector Identifier
SVL (1 octet) = Subvector Length
SVI (1 octet) = Subvector Identifier
SVV (n octets) = Subvector Value

Vector

The fundamental unit of MAC and NMT information. A vector contains its length, an identifier of its function, and zero or more subvectors. Only one vector is permitted per MAC frame.

VL (vector length)

A 16-bit binary number that gives the length, in octets, of the vector. The length includes the VL field and can have values such that $(0004) \leq VL \leq (FFFF)$ (subject to the constraints of the Token Holding Timer).

VI (vector identifier)

A two-octet identifier that identifies the vector.

SV (subvector)

Vectors require all data or modifiers to be contained within subvectors. One subvector is required to contain each piece of data or modifier that is being transported. A subvector is not position-dependent within a vector, but rather each subvector must be identified by its subvector identifier.

SVL (subvector length)

An 8-bit binary number that gives the length, in octets, of the subvector. The length includes the length of the SVL field. A subvector length of (FF) means that the subvector is longer than 254 octets and the actual length is included in the next two octets.

SVI (subvector identifier)

A one-octet identifier that identifies the subvector. The value (FF) indicates that an expanded identifier is being used and is contained in the next two octets.

The subvectors are of two types. The subvectors with values from (00) to (7F) are used so that certain specific, common (to many vectors) strings of MAC or NMT data can be formatted and labelled in a standard manner. This standardization is intended to facilitate sharing of data between MAC and NMT applications and make the data as application independent as possible.

The subvectors with values from (80) to (FE) are for specific definition within a particular vector by vector identifier. For example, the subvector (90) can have an entirely different definition in every different vector. The subvector (40) has only one definition across all vectors and applications.

Subvectors themselves may contain other subvectors and other types of vectors and optional fields which are unique only to the particular subvector to which they belong.

3.2.5.2 LLC Frame Format

The format of the information field for LLC frames is not specified in this Standard. However, in order to promote interworking among DTEs, all DTEs shall be capable of receiving frames the information field of which is up to, and including, 133 octets in length.

3.2.5.3 Order of Bit Transmission

Each octet of the information field shall be transmitted most-significant bit first.

3.2.6 Frame Check Sequence (FCS)

The FCS shall be a 32-bit sequence based on the following generator polynomial of degree 32.

$$G(X) = X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^8 + X^7 + X^5 + X^4 + X^2 + X + 1$$

The FCS shall be the ONE's complement of the sum (modulo 2) of the following :

- The remainder of X^k . ($X^{31} + X^{30} + X^{29} + \dots + X^2 + X + 1$) divided (modulo 2) by $G(X)$, where k is the number of bits in the Frame Control, Address, and Information fields and,
- The remainder after multiplication by X^{32} and then division (modulo 2) by $G(X)$ of the content (treated as a polynomial) of the FC, DA, SA, and INFO fields.

The FCS shall be transmitted commencing with the coefficient of the highest term.

As a typical implementation, at the transmitter, the initial remainder of the division is preset to all ONES and is then modified by division of the FC, DA, SA, and INFO fields by the generator polynomial, $G(X)$. The ONE's complement of this remainder is transmitted, most-significant bit first, as the frame check sequence.

At the receiver, the initial remainder is preset to all ONES and the serially incoming bits of FC, DA, SA, INFO and FCS, when divided by $G(X)$, results, in the absence of transmission errors, in a unique non-zero remainder value. The unique remainder value is the polynomial :

$$X^{31} + X^{30} + X^{26} + X^{25} + X^{24} + X^{18} + X^{15} + X^{14} + X^{12} + X^{11} + X^{10} + X^8 + X^6 + X^5 + X^4 + X^3 + X + 1.$$

3.2.7 Ending Delimiter (ED)



J = Non-data-J
 K = Non-data-K
 1 = ONE
 I = Intermediate Frame Bit
 E = Error Detected Bit

The transmitting DTE shall transmit the delimiter as shown. Receiving DTEs shall consider the ending delimiter valid if the first six symbols J K 1 J K 1 are received correctly.

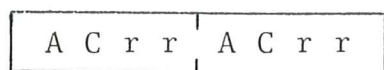
3.2.7.1 Intermediate Frame Bit (I Bit)

To indicate that this is an intermediate (or first) frame of a multiple-frame transmission the I-bit shall be transmitted set to ONE. An I bit set to ZERO indicates the last or only frame of the transmission.

3.2.7.2 Error Detected Bit (E Bit)

The error detected bit (E) shall be transmitted set to ZERO by the DTE that originates the token, abort sequence or frame. All DTEs on the ring check tokens and frames for errors (e.g., FCS error, non-data symbols - see 4.2.1). The E bit of tokens and frames which are repeated shall be set to ONE when a frame with error is detected ; otherwise the E bit is repeated as received.

3.2.8 Frame Status (FS)



A = Address Recognized Bits
 C = Frame Copied Bits
 r = Reserved Bits

Reserved Bits - These bits are reserved for future standardization. They shall be transmitted set to ZERO, however, their value shall be ignored by the receivers.

3.2.8.1 Address Recognized (A) Bits and Frame Copied (C) Bits

The A and C bits shall be transmitted set to ZERO by the DTE originating the frame. If another DTE recognizes the destination address as its own address or

relevant group address it shall set the A bits to ONE. If it copies the frame (into its receive buffer), it shall also set the C bits to ONE. This allows the originating DTE to differentiate among three conditions :

- DTE. non-existent/non-active on this ring,
- DTE. exists but frame not copied,
- Frame copied.

The A and C bits shall be set without regard to the value of the E bit and only if the frame is good as defined in 4.2.1, "Receive Actions". Only the values that are 00rr 00rr, 10rr 10rr and 11rr 11rr shall be considered valid. All other values are invalid and shall be ignored by the receiver.

NOTE 3

If a destination DTE detects that the A bits have already been set, and the DA is not a group address, it may imply that a duplicate address problem exists. The second condition (DTE existent but frame not copied) allows the originating DTE to log the instances when, for example, congestion has prevented a destination DTE from copying the frame.

3.3 Medium Access Control Frames

The following are descriptions of various MAC frames that are used in the management of the token ring. Values for the Frame Control (FC) bits are defined. Values, other than those defined below, will be ignored by the receiving DTE(s). All unassigned values are reserved for future specification.

The values for PDU priority (Pm), Destination Address (DA) and Information Field content (Vector Identifier - VI, Subvector Identifier - SVI and Subvector Value - SVV) associated with the particular MAC Supervisory Frame are also indicated. The general format for the information field of MAC frames is described in 3.2.5.

3.3.1 Claim Token MAC Frame (CL_TK)

When a DTE which is in standby state determines that there is no active monitor operating on the ring, it shall enter a "claiming token" state. While in this state the DTE shall send claim token frames and inspect the source address of the claim token MAC frames it receives. If the source address matches its own (MA) address and subvector 1 matches the Stored Upstream Neighbor's Address (SUA), it has claimed the token and shall enter active monitor mode and generate a new token (see also Figure 8).

The CL_TK values are as follows :

Pm : Zero
FC : 00 000011 (Claim Token)
DA : All DTEs, this ring
VI : (0003) (Claim Token)
SVI-1 : (02) (RUA - Received Upstream Neighbor's
Address)
SVV-1 : ---- (6-octet address)

3.3.2 Duplicate Address Test MAC Frame (DAT)

This frame is transmitted with DA = MA as part of the initialization process. If the frame returns with the A bits set to ONE, it indicates that there is another DTE on the ring with the same address. If such an event occurs, the DTE's network manager is notified and the DTE returns to bypass state. A DTE that copies a DAT frame will ignore it.

The DAT values are as follows :

Pm : Zero
FC : 00 000000
DA : MA (This DTE's address)
VI : (0007), (Duplicate Address Test)

3.3.3 Active Monitor Present MAC Frame (AMP)

This frame is transmitted by the active monitor. It shall be queued for transmission following the successful purging of the ring or following the expiration of the active monitor timer (TAM). Any DTE in standby state which receives this frame shall reset its standby monitor timer (TSM).

The AMP values are as follows :

Pm : Pr*
FC : 00 000101
DA : All DTEs, this ring
VI : (0005) (Active Monitor Present)
SVI-1 : (02) (RUA - Received Upstream Neighbor's
Address)
SVV-1 : ---- (6-octet address)

* - An AMP is transmitted at the ring service priority (Pr) which exists at the time a token is received after an AMP PDU is queued. The default value for Pm for this frame is seven ; see 5.3.2.1, "MA-INITIALIZE-PROTOCOL request" to change this value.

3.3.4 Standby Monitor Present MAC Frame (SMP)

This frame is transmitted by the standby monitor(s). After receipt of an AMP or SMP frame the A and C bits of which are set to ZERO, the queue PDU timer (TQP) is reset. When timer TQP expires, an SMP PDU shall be queued for transmission.

The queueing of a SMP PDU is delayed for a period of TQP to assure that the transmission of SMP frames do not use more than 1% of the bandwidth of the ring in any TQP period of time.

The SMP values are as follows :

Pm : Zero
FC : 00 000000
DA : All DTEs, this ring
VI : (0006) (Standby Monitor Present)
SVI-1 : (02) (RUA Received Upstream Neighbor's Address)
SVV-1 : ---- (6-octet address)

NOTE 4

DTEs which receive an AMP or SMP frame in which the A and C bits are set to ZERO will regard the frame as having originated from their upstream neighbor's DTE. Therefore, a DTE which copies such a frame shall record the source address contained in the frame as the Stored Upstream Neighbor's Address (SUA) for later transmission as a subvector in certain MAC frames as well as performing a comparison with certain MAC frames.

3.3.5 Beacon MAC Frame (BCN)

This frame shall be sent as a result of serious ring failure (e.g. broken cable, jabbering DTE etc.). It is useful in localizing the fault. The transmission of Beacon is covered in the Standby Monitor Finite-State Machine. (See Figure 7).

The immediate upstream DTE is part of the failure domain about which the Beacon is reporting. Therefore, as noted above, the address of the upstream DTE which was previously recorded is included in the MAC information field.

The BCN values are as follows :

Pm : Zero
FC : 00 000010
DA : All DTEs, this ring
VI : (0002), (Beacon)
SVI-1 : (02) (RUA - Received Upstream Neighbor's Address)
SVV-1 : ---- (6-octet address)
SVV-2 : (01) (Beacon Type)
SVV-2
(0001) - Issued by DTE during reconfiguration (for future study)
(0002) - Continuous J symbols received
(0003) - Timer TNT expired during claiming token ; FR_CL_TK received
(0004) - Timer TNT expired during claiming token ; FR_CL_TK (SA<MA) received

3.3.6 Purge MAC Frame (PRG)

This frame is transmitted by the active monitor. It shall be transmitted following claiming the token or to perform reinitialization of the ring following the detection of an M bit set to ONE or the expiration of timer TVX.

The PRG values are as follows :

Pm	:	Zero	
FC	:	00 000100	
DA	:	All DTEs, this ring	
VI	:	(0004)	(Purge)
SVI-1	:	(02)	(RUA - Received Upstream Neighbor's Address)
SVV-1	:	----	(6-octet address)

3.4 Timers

The value of these timers shall be established by mutual agreement among the users of the LAN.

NOTE 5

The term Reset, when applied to timers, is to be understood to mean the timer is reset to its initial value and (re)started.

3.4.1 Timer, Return to Repeat (TRR)

Each DTE shall have a timer TRR to ensure that the DTE shall return to Repeat State. TRR shall have a value greater than the maximum ring latency. The maximum ring latency consists of the signal propagation delay around a maximum length ring plus the sum of all DTE latencies. The operation of TRR is described in the operational finite-state machine. The default time-out value of TRR shall be 2,5 ms.

3.4.2 Timer, Holding Token (THT)

Each DTE shall have a timer THT to control the maximum period of time the DTE may transmit frames after capturing a token. A DTE may initiate transmission of a frame if such transmission can be completed before timer THT expires. The operation of THT is described in the operational finite-state machine. The default time-out value of THT shall be 10 ms.

3.4.3 Timer, Queue PDU (TQP)

Each DTE shall have a timer TQP for the purpose of timing the enqueueing of a SMP PDU after reception of a AMP or SMP frame in which the A and C bits are set to ZERO. The default time-out value of TQP is 10 ms.

3.4.4 Timer, Valid Transmission (TVX)

Each DTE shall have a timer TVX which is used by the active monitor to detect the absence of valid transmission. The operation of TVX is described in the monitor finite-state machine. The time-out value of TVX shall be the sum of the time-out value of THT plus the time-out value of TRR.

3.4.5 Timer, No Token (TNT)

Each DTE shall have a timer TNT to recover from various token related error situations. TNT shall have a time-out value equal to TRR plus n times THT (where n is the maximum number of DTEs on the ring). The operation of TNT is described in the monitor finite-state machines. The default time-out value of TNT shall be 1 second.

3.4.6 Timer, Active Monitor (TAM)

Each DTE shall have a timer TAM which is used by the active monitor to stimulate the enqueueing of a AMP PDU for transmission. The default time-out value of timer TAM shall be 3 seconds.

3.4.7 Timer, Standby Monitor (TSM)

Each DTE shall have a timer TSM which is used by the standby monitor(s) to assure that there is an active monitor on the ring and to detect a continuous stream of tokens. The default time-out value of timer TSM shall be 7 seconds.

3.5 Flags

Flags are used to "remember" the occurrence of a particular event. They shall be set when the event occurs. The flags used are :

- I Flag : A flag which is set upon receiving an ED with the I bit set to ZERO.
- SFS Flag : A flag which is set upon receiving an SFS sequence.
- MA Flag : A flag which is set upon receiving an SA which is equal to the DTE's address.

3.6 Priority Registers and Stacks

Pr and Rr Registers : The value of the priority (P) and reservation (R) of the most recently received AC field are stored in registers as Pr and Rr.

Sr and Sx Stacks : If at the time of transmission of a token the value of Rr or Pm (the priority of a queued PDU) is greater than Pr, a token with a priority of the higher of Rr or Pm shall be transmitted. At the same time the DTE shall store the value of Pr in a stack as Sr and shall store the value of the priority of the token that was transmitted in a stack as Sx.

The use of the Pr and Rr registers and the Sr and Sx stacks in performing the priority function is described in detail in clause 4.

3.7 Latency Buffer

The Latency Buffer serves two purposes. The first is to ensure that there are at least 24 bits of latency in the ring. The second is to provide phase jitter compensation. The Latency Buffer is described in more detail in clause 6.

NOTE 6

The token management is structured so that only one Latency Buffer shall be active in a normally functioning ring and is provided by the active monitor in the ring.

4. TOKEN RING PROTOCOLS

This clause specifies the procedures that shall be used in the Medium Access Control (MAC) layer.

4.1 Overview

The following provides a descriptive overview of frame transmission and reception. The formal specifications of the operations are given in the Finite-State Machine (FSM) later in this clause.

4.1.1 Frame Transmission

Access to physical medium (the ring) is controlled by passing a token around the ring. The token gives the downstream (receiving) DTE (relative to the DTE passing the token) the opportunity to transmit a frame or a sequence of frames. Upon request for transmission of an LLC PDU or NMT PDU, MAC prefixes the PDU with the appropriate FC, DA, and SA fields and enqueues it to await the reception of a token that may be used for transmission.

Such a token has a priority less than or equal to the priority of the PDU(s) that is to be sent. Upon queuing the PDU for transmission and prior to receiving a usable token, if a frame or an unusable token is repeated on the ring the DTE requests a token of appropriate priority in the RRR bits of the repeated AC field. Upon receipt of a usable token, it is changed to a start of frame sequence by setting the token bit.

At this time, the DTE stops repeating the incoming signal and begins transmitting a frame. During transmission, the FCS for the frame is accumulated and appended to the end of the information field.

4.1.2 Token Transmission

After transmission of the frame(s) has been completed, the DTE checks to see if the DTE's address has returned in the SA fields, as indicated by the MA_FLAG. If it has not been seen, the DTE transmits until the MA_FLAG is set, at which time the DTE transmits a token.

4.1.3 Stripping

After transmission of the token the DTE will remain in transmit state until all of the frames that the DTE originated are removed from the ring. This is done to avoid unnecessary recovery action that would be caused if a frame were allowed to continuously circulate on the ring.

4.1.4 Frame Reception

DTEs, while repeating the incoming signal stream, check it for frames they should copy or act upon. If the frame type bits indicate a MAC frame, the control bits are interpreted by all DTEs on the ring. In addition, if the frame's DA field matches the DTE's individual address, relevant group address, or broadcast address the FC, DA, SA, INFO and FS fields are copied into a receive buffer and subsequently forwarded to the appropriate sublayer.

4.1.5 Priority Operation

The priority bits (PPP) and the reservation bits (RRR) contained in the Access Control field work together in an attempt to match the service priority of the ring to the highest priority PDU that is ready for transmission on the ring. As previously noted in 3.6, "Priority Registers and Stacks" these values are stored in registers as Pr and Rr. The current ring service priority is indicated by the priority bits in the Access Control field, which is circulated on the ring.

The priority mechanism operates in such a way that "fairness" (equal access to the ring) is maintained for all DTEs within a priority level. This is accomplished by having the same DTE that raised the service priority level of the ring (the "stacking" DTE) return the ring to the original service priority. As previously noted in 3.6., "Priority Registers and Stacks" the Sx and Sr stacks are used to perform this function.

The priority operation is explained as follows :

When a DTE has a priority (a value greater than ZERO) PDU (or PDUs) ready to transmit, it requests a priority token. This is done by changing the reservation bits (RRR) as the DTE repeats the Access Control field. If the priority level (Pm) of the PDU that is ready for transmission is greater than the RRR bits, the DTE increases the value of RRR field to the value Pm. If the value of the RRR bits is equal to or greater than Pm, the reservation bits (RRR) are repeated unchanged.

After a DTE has claimed the token it transmits PDUs which are at or above the present ring service priority level until it has completed transmission of those PDUs or until the transmission of another frame would not be completed before timer THT would expire (see 3.4.2, Timer, Holding Token (THT)). The priority of all of the PDUs that are transmitted should be at the present ring service priority value. The DTE will then generate a new token for transmission on the ring.

If the DTE does not have additional PDUs to transmit which have a priority (Pm) or does not have a reservation request (as contained in register Rr) neither of which is greater than the present ring service priority (as contained in register Pr), the token is transmitted with its priority at the present ring service priority and the reservation bits (RRR) at the greater of Rr or Pm and no further action taken.

However, if the DTE has a PDU ready for transmission or a reservation request (Rr), either of which is greater than the present ring service priority, the token is generated with its priority at the greater of Pm or Rr and its reservation bits (RRR) set to ZERO. Since the DTE has raised the service priority level of the ring it becomes a stacking DTE and, as such, stores the value of the old ring service priority as Sr and the new ring service priority as Sx. (These values will be used later to lower the service priority of the ring when there are no PDUs ready to transmit on the ring the Pm of which is equal to or greater than the stacked Sx).

NOTE 7

Since a DTE may have raised the service priority of the ring more than once before the service priority is returned to a lower priority, (e.g. from 1 to 3 and then 5 to 6) it may have multiple Sx and Sr values stored and hence the term "stacked". Also note that the terms stack and stacked are not to be confused with other usages of these same terms.

Having become a stacking DTE, the DTE claims every token which it receives which has a priority (PPP) equal to its Highest Stacked Transmitted Priority (Sx) in order to examine the RRR bits of the Access Control field for the purpose of raising, maintaining or lowering the service priority of the ring. The new token is transmitted with the value of its PPP bits equal to the value of the reservation bits (RRR) but no lower than the value of the Highest Stacked Received Priority Sr (which was the original ring priority service level).

If the value of the new ring service priority (PPP equal to Rr) is greater than Sr, the RRR bits are transmitted as set to ZERO and the old ring service priority contained in Sx is replaced with a new value Sx equal to Rr and the DTE continues its role as a stacking DTE.

However, if the R_r value is equal to or less than the value of the Highest Stacked Received Priority (S_r) the new token is transmitted at a priority value of the S_r , both S_x and S_r are removed ("popped") from the stack, and if no other values of S_x and S_r are stacked, the DTE discontinues its role as a stacking DTE.

NOTE 8

A stacking DTE that has claimed the token may transmit PDUs as well as examining RRR bits, as described above. Of course only those PDUs which have a priority equal to or greater than the ring service priority may be transmitted.

The frames that are transmitted to initialize the ring have a PPP field which is equal to zero. The receipt of a PPP field the value of which is less than a stacked S_x will cause any S_x or S_r values that may be stacked to be cleared in all DTEs on the ring.

The complete description of Priority Operating is contained in the Operational Finite-State Machine.

4.1.6 Beaconing and Neighbor Notification

When a hard failure is detected in a token ring local area network, its cause must be isolated to the proper failure domain so that recovery actions can take place. The failure domain consists of

- the DTE reporting the failure ("the beaconing DTE"),
- the DTE upstream of the beaconing DTE, and
- the ring medium between them.

For example, if a failure occurred within the domain shown in Figure 4 DTE G would report upon it by transmitting Beacon MAC frames.

A failure that causes bit disruption within the transmitter side of DTE F, in the medium between DTEs F and G, or within the receiver side of DTE G, will be detected and reported upon by DTE G using a Beacon MAC frame. This alerts all other DTEs on the ring that the token protocol has been suspended until such a time that the disruption terminates or is removed.

To do accurate problem determination, all elements of the failure domain must be known at the time that the failure is detected. This implies that at any given time, each DTE should know the identity of its upstream neighbor DTE. A process for obtaining this identity, known as Neighbor Notification, is described below.

- i) reset its timer TSM, based on seeing the AMP value in the Frame Control field,
- ii) if possible, copies the broadcast AMP MAC frame and stores the upstream DTE's identity in an "Upstream Neighbor's Address (UNA)" memory location,
- iii) sets the A bits (and C bits if the frame was copied) of the passing frame to ONE,
- iv) at a suitable transmit opportunity, broadcasts a similar Standby Monitor Present (SMP) MAC frame.

One-by-one, each DTE receives an SMP frame with the A and C bits set to ZERO, stores its upstream neighbor's address, and continues the process by broadcasting such a frame itself.

Since the AMP frame must pass each DTE on a regular basis (the Active Monitor Present MAC frame sent by the monitor), the continuous transmission of tokens onto a ring can be detected. In addition to the timer TAM in the active monitor, each standby DTE has a timer TSM that is reset each time an Active Monitor Present (AMP) MAC frame passes. If timer TSM expires, that standby monitor DTE begins transmitting Claim Token frames.

4.2 Specification

The operation of the ring is described in this clause.

In the case of a discrepancy between the FSM diagrams/tables and the supporting text the FSM diagrams/tables shall take precedence.

The MAC receives from the Physical Layer (PHY) a serial stream of symbols. Each symbol shall be one of the following.

0	- A ZERO	1	- A ONE
J	- Non Data Bit-J	K	- Non Data Bit-K

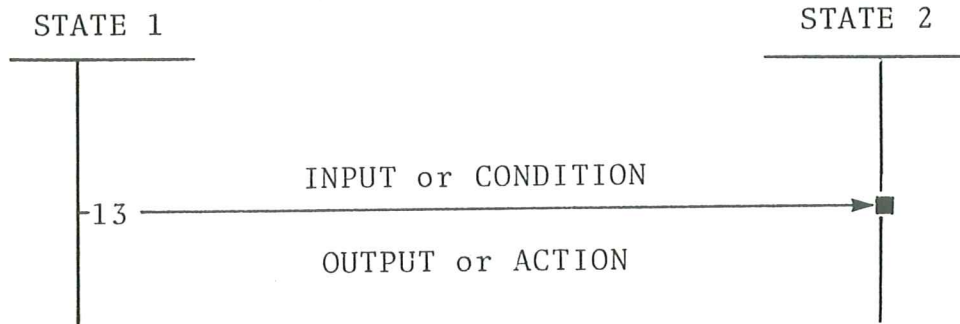
See 6.1, "Symbol Encoding" for a detailed description of these symbols.

From the received symbols MAC detects various types of input data, such as Tokens, MAC frames, and LLC information frames.

In turn, MAC stores values, sets flags and performs certain internal actions (as noted in the Receive Action Table) as well as generating tokens, frames or fill, or flipping bits and delivers them to the Physical Layer in the form of a serial stream of the 0, 1, J and K symbols.

For the purpose of accumulating the FCS and storing the contents of a frame, J and K symbols which are not part of the SD or ED shall be interpreted as ONE and ZERO respectively.

Finite-State Machine (FSM) Notation : The notation used in the FSM diagrams is as follows :



States are shown as vertical lines. Transitions are shown as horizontal lines with a number indicating the transition (e.g., 13) and the arrow indicating the direction of transition.

The inputs or conditions shown above the line are the requirements to make the transition. The output or action shown below the line occur simultaneously with making the transition. The transition begins when the input occurs or the condition specified is met and is complete when the output or action has occurred. If the state transition is in progress then no other FSM transition may be initiated.

If the exit conditions of a state are satisfied at the time the state is entered no action is taken in that state and the state is immediately exited.

Abbreviations (as used in FSM description)

- A = Address Recognized Bit
- AMP = Active Monitor Present
- BCN = Beacon
- C = Frame Copied Bit
- CL = Claim
- DA = Destination Address
- DAT = Duplicat Address Test
- E = Error Detected Bit
- ED = Ending Delimiter
- EFS = End of Frame Sequence
- FR = Frame
- FS = Frame Status (Field)
- I = Intermediate Frame Bit
- M = Monitor Bit
- MA = My (DTE's) Address
- MSI = MA_STATUS. Indication

NMT = Network Management
P = Priority (of the AC)
PDU = Protocol Data Unit
Pm = PDU Priority
Pr = Last Priority Value Received
PRG = Purge
R = Reservation (of the AC)
Rr = Last Reservation Value Received
RUA = Received Upstream Neighbor's Address
SUA = Stored Upstream Neighbor's Address
SA = Source Address
SFS = Start of Frame Sequence
SMP = Standby Monitor Present
Sr = Highest Stacked Received Priority
Sx = Highest Stacked Transmitted Priority
TAM = Timer, Active Monitor
THT = Timer, Holding Token
TK = Token
TNT = Timer, No Token
TQP = Timer, Queue PDU
TRR = Timer, Return to Repeat
TSM = Timer, Standby Monitor
TVX = Timer, Valid Transmission
TX = Transmit

TK(P=x, M=y, R=z) = Token with P=x, M=y and R=z
FR(P=x, M=y, R=z) = Frame with P=x, M=y and R=z

\neg = Boolean NOT
& = AND
V = OR
/ = the greater of

4.2.1 Receive Actions

Three varieties of frame identification are used in the state transitions and at the service interfaces described in this Standard : good frame, validly formed frame, and frame with error. The frame varieties are indicated by combinations of the following properties :

Properties of a Frame

- i) Is bounded by a valid SD and ED
- ii) Has the E (error) bit set to ZERO
- iii) Is an integral number of octets in length
- iv) Is composed only of ZEROs and ONES between the SD and ED
- v) Has the FF bits of the Frame Control Field set to 00 or 01
- vi) Has a valid FCS
- vii) Has a minimum of 18 octets between SD and ED.

The three frame varieties are defined below. This is not an inclusive list of all possible bit sequence formats ; for example, other format sequences known in this Standard are the token and the abort sequence. Note that the value of the I, E, A, & C bits are not part of these definitions.

Good Frame (FR_GOOD)

A bit sequence that satisfies the following condition, based on the properties of a frame listed above :

$$1 \ \& \ 3 \ \& \ 4 \ \& \ 5 \ \& \ 6 \ \& \ 7$$

Validly Formed Frame

A bit sequence that satisfies the following condition :

$$1 \ \& \ 3 \ \& \ 5 \ \& \ 7$$

Frame With Error (FR_WITH_ERROR)

A bit sequence that satisfies the following condition :

$$1 \ \& \ (\neg 3 \vee \neg 4 \vee (5 \ \& \ \neg 6) \vee (5 \ \& \ \neg 7))$$

The various internal actions that are taken as a result of an input received from the ring are summarized in the receive action table. They are explained as follows :

REF	RECEIVE	ACTION
R-A	Report Frame Condition	MSI
R-B	TK(P<Sx)	Clear Stacks
R-C	SA=MA	Set MA Flag
R-D	Token V Frame	Store (Pr, Rr)
R-E	I=0	Set I Flag
R-F	SFS	Set SFS Flag
R-G	FR_(SA=MA, RUA≠SUA)	Master Reset, MSI

Table 1 - Receive Action Table

(R-A) Report Frame Condition

The reporting actions for received frames are dependent upon the properties of a frame. Whenever one of the following report conditions is satisfied, MA_STATUS is indicated to NMT :

- 1 & 2 & 3 & 4 & 5 & 6 & 7
- 1 & $\neg 2$ & 3 & 4 & 5 & 6 & 7
- 1 & 2 & ($\neg 3 \vee \neg 4 \vee (5 \ \& \ \neg 6) \vee (5 \ \& \ \neg 7)$)

(R-B) Priority Level Error

If there is a Highest Stacked Transmitted Priority (Sx) stored and a token is received with a priority (P) less than the value of Sx, then an error has occurred. Therefore, the stacks shall be cleared.

(R-C) My Address Received

If the source address that is received is equal to the DTE's individual address the MA flag shall be set. Note that the MA flag shall be set without regard to whether the frame is good, validly formed or a frame with error.

(R-D) Access Control Field Received

Upon the receipt of an access control field (AC) in a token or a frame the value of the priority bits shall be stored as Pr and the reservation bits shall be stored as Rr and the previously stored Pr and Rr shall be discarded.

(R-E) I Bit Equal Zero Received

If an end of frame sequence with the I bit set to ZERO is received the I_FLAG shall be set.

(R-F) Start of Frame Sequence Received

If a start of frame sequence is received the SFS_FLAG shall be set.

(R-G) SA = MA and Received and Stored Upstream Neighbor's Address Not Equal

If a MAC frame is received in which the source address equals the DTE's address and it contains an Upstream Neighbor's address (RUA) (i.e., BCN, CL_TK, AMP, SMP or PRG frame) not equal to the Stored Upstream Neighbor's Address (SUA), transition shall be made to Bypass state (Standby Monitor State 0) and MA STATUS_indicated (i.e. Master Reset).

4.2.2 Operational Finite-State Machine

The operational finite-state machine is explained as follows :

4.2.2.1 Resume (Operational FSM Activity)

When the DTE is in monitor states of Bypass, Inserted, Transmit Claim Token, Transmit Beacon, Transmit Fill, or Transmit Purge (e.g. not in Initialize, Standby, or Active states) activity of the operational FSM is suspended. Upon reentry into Initialize, Standby or Active Monitor states, activity of the operational FSM shall be resumed in Repeat state.

4.2.2.2 State 0 : Repeat (Repeat State)

In Repeat State, the bits which are received are, in general, repeated on the line to the next DTE. Certain

bits and fields in the repeated bit stream may be modified and certain actions taken without changing state. Transition shall be made to State 1 : TX DATA_FR (Transmit Data Frame(s)) when there are one or more Protocol Data Units (PDUs) queued for transmission and the conditions for transmission are satisfied. Transition shall be made to State 4 : TX ZEROS & MOD STACKS (Transmit Zeros and Modify Stacks) for the purpose of modifying the priority stacks.

(01) Usable Token Received

If a PDU is queued for transmission and a token is received whose priority (P) is equal to or less than the PDU priority (Pm) the DTE shall change the token to a start of frame sequence (by changing the Token Bit from ZERO to ONE), and transmit M and R set to ZERO initiate the transmission of the enqueued PDU, reset the Token Holding Timer and the MA flag and make a transition to State 1.

(02) Bit Flipping Loop

A number of actions may be taken without changing state. These actions are shown in Figure 6 and are explained as follows :

(02A) Request Usable Token

If there is a PDU queued for transmission with priority Pm, the reservation (R) shall be set to Pm on frames in which the reservation is less than Pm, and on tokens in which the priority is greater than Pm and the reservation is less than Pm and the priority is not equal to the highest stacked transmitted priority.

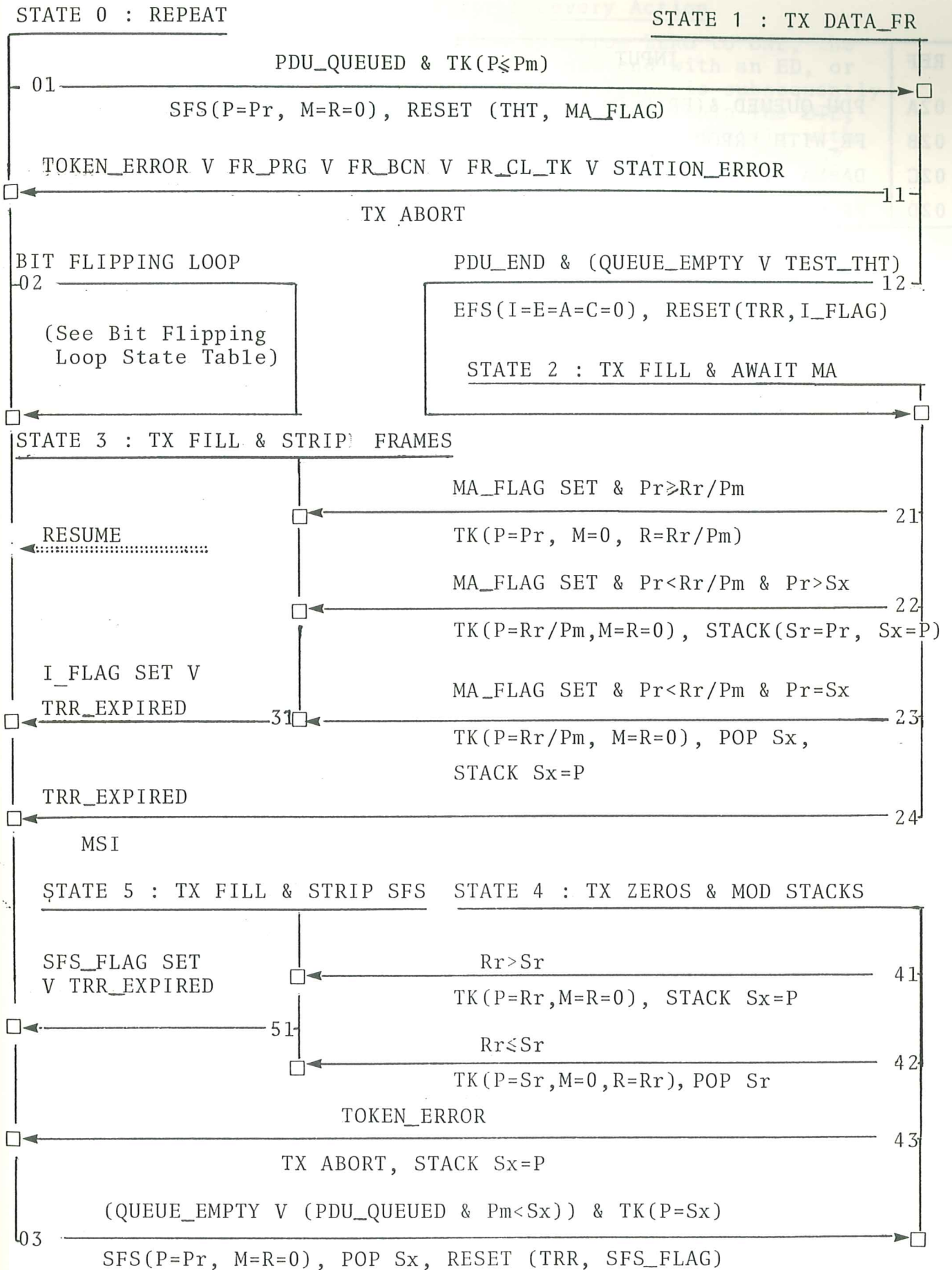


Figure 5. Operational Finite-State Machine Diagram

REF	INPUT	OUTPUT
02A	PDU_QUEUED & (FR(R<Pm) V TK(P>Pm>R, P≠Sx)	SET R=Pm
02B	FR_WITH_ERROR	SET E=1
02C	DA=MA (ADDRESS RECOGNIZED)	SET A=1
02D	FR_COPIED	SET C=1

Figure 6 - Bit Flipping Loop State Table

(02B) Frame With Error

The E (error) bit shall be transmitted set to ONE if a frame with error is detected. (See Reference R-B 4.2.1, "Receive Actions")

(02C) Own Address Detected

If the DTE detected its own address or relevant group address in the destination address field, the A bits in the FS field shall be transmitted set to ONE.

(02D) Frame Copied

If the DTE copies the frame from the ring, the C bits in the FS field shall be transmitted set to ONE.

(03) Re-stack Operation

If there are no frames enqueued with priority (Pm) equal to or greater than the highest stacked transmitted priority (Sx) and a token is received with priority (P) equal to the highest stacked transmitted priority (Sx), the following actions are taken. The token shall be changed to a start of frame sequence by changing the T bit from ZERO to ONE, the Sx popped from the stack, timer TRR and the SFS flag reset and a transition made to State 4. If there is no Sx value stacked, the test P=Sx shall be considered being false.

4.2.2.3 State 1 : TX DATA_FR (Transmit Data Frame(s))

While in this state, the DTE transmits one or more frames. The first and all subsequent PDUs that are transmitted shall have a Pm equal to or greater than the priority of the token that was used. All frames transmitted will have P equal to Pr and M set to ZERO and R equal to zero. On the receive side, as noted in Table 1, the DTE shall monitor the receive data for the value of the priority and reservation bits, its DTE address, which has been transmitted in the source address field, and the ending delimiter.

(11) Abort State 1 - Error Recovery Action

If after changing the token bit from ZERO to ONE, the DTE detects that the token did not end with an ED, or if a Beacon, Purge or Claim Token frame is subsequently received, or if an error has occurred within the DTE, the transmission shall be terminated immediately with an Abort Sequence, the PDU dequeued, LLC notified of the action and transition made to State 0.

(12) End of Frame Transmission

If the transmission of the PDU is completed (PDU_END) and there are no more PDUs to transmit at this priority or a higher priority (QUEUE_EMPTY) or if transmission of an additional frame could not be completed before THT expires (TEST_THT), an End of Frame Sequence (EFS) shall be transmitted with I, E, A and C bits set to ZERO, timer TRR and the I flag shall be reset and transition made to State 2.

4.2.2.4 State 2 : TX FILL & AWAIT MA (Transmit Fill and Await My Address)

If a source address equal to the DTE's address has not been received (i.e., MA_FLAG reset) the DTE shall transmit fill until MA_FLAG is set or TRR expires. If upon entering State 2 MA_FLAG is already set, transition shall be made directly to State 3 via transitions 21, 22 or 23.

(21) Token Transmission, Same Priority

If both the stored value Rr and a queued PDU priority (Pm) are less than or equal to the stored value Pr, a token shall be transmitted with the P equal to Pr, M set to ZERO and R equal to the greater of Rr or Pm and transition made to State 3.

(22) Token Transmission, Higher Priority and Pr > Sx (Push Ring Priority)

If the Rr or an enqueued PDU priority (Pm) is greater than the Pr, and the highest stacked transmitted priority (Sx) is less than the last priority value received (Pr), a token shall be transmitted with the P equal to the greater of Rr or Pm, and M set to ZERO and R equal to zero. Pr shall be stacked as Sr and P shall be stacked as Sx and a transition made to State 3. If there is no Sx value stacked, the test Pr > Sx shall be considered true.

(23) Token Transmission, Higher Priority and Pr = Sx (Pop Ring Priority)

If the Rr or an enqueued PDU priority (Pm) is greater than the Pr, and the highest stacked transmitted prio-

rity (Sx) is equal to the last priority value received (Pr), a token shall be transmitted with the P equal to the greater of Rr or Pm and M set to ZERO and R equal to zero. Sx shall be popped from the stack and a new value P shall be stacked as Sx and transition made to State 3. If there is no Sx value stacked, the test Pr=Sx shall be considered false.

(24) TRR Expires

If, while waiting for the MA flag to be set timer TRR expires, transition shall be made directly to Repeat state (State 0) and MA_STATUS indicated to NMT.

4.2.2.5 State 3 : TX FILL & STRIP FRAMES (Transmit Fill and Strip Frames)

If an EFS with I=0 has not been received (i.e., I_FLAG reset) the DTE shall transmit fill until the I_FLAG is set or TRR expires. If upon entering State 3 the I_FLAG is already set or TRR has already expired, transition shall be made directly to State 0.

(31) Strip Complete

In this state, fill shall be transmitted until an EFS with I equal set to ZERO is received or TRR expires whereupon transition shall be made to State 0.

4.2.2.6 State 4 : TX ZEROS & MOD STACK (Transmit Zeros and Modify Stack)

A continuous string of ZEROs shall be transmitted immediately following the SFS until the internal logic of the DTE can perform the necessary functions to transmit a token.

Transmission of ZEROs may or may not terminate on an octet boundary. Note that this state shall cause consecutive SDs to exist on the ring without an intervening ED and that the SD of the transmitted token may not occur on an octet boundary relative to the transmitted ZEROs.

(41) Reservation Request (Rr) > Highest Stacked Received Priority (Sr)

If Rr is greater than the highest stacked received priority Sr, a token with its priority (P) set to Rr and its M set to ZERO and R equal to zero shall be transmitted, P shall be stacked as Sx and a transition shall be made to State 5.

(42) Reservation Request (Rr) < Highest Stacked Received Priority (Sr)

If Rr is equal to or less than the Sr, a token with P equal to Sr, M set to ZERO and an R equal to Rr shall be transmitted, Sr popped from the stack and transition shall be made to State 5.

(43) Token Recognition Error

If after changing a token to a SFS, the DTE detects that the token did not end properly (with MRRR, JK1JK1), the transmission shall be terminated immediately with an Abort Sequence, Pr stacked as Sx and transition shall be made to State 0.

4.2.2.7 State 5 : TX FILL & STRIP SFS (Transmit Fill and Strip SFS)

In this state, fill shall be transmitted until the transmitted SFS is received or TRR expires.

(51) Strip Complete

Upon receipt of the SFS or TRR expiring transition shall be made to State 0.

4.2.3 Standby Monitor Finite-State Machine

Upon coming on line or after the DTE has been reset, (re)-initialization is performed to assure that no other DTE on the ring has the same address as this DTE and that its (re)entry into the ring is known to its immediate downstream neighbor.

Upon completion of initialization, transition is made to Standby state where the ring is monitored to assure that there is a properly operating active monitor on the ring. It does so by observing the tokens and AMP frames as they are repeated on the ring. If tokens and AMP frames are not periodically detected the standby monitor shall time-out and initiate claiming token.

The standby monitor utilizes timers TNT and TSM in its operation. When in Transmit Claim Token and Transmit Beacon States (States 3 and 5) the DTE shall utilize its own oscillator for transmission timing.

The standby monitor function is explained as follows :

4.2.3.1 Master Reset

If the DTE is reset, MA_STATUS will be indicated and transition will be made from the current state of the monitor to Standby Monitor Bypass state (State 0). The latency buffer, if in use, will be deleted and all timers will be reset.

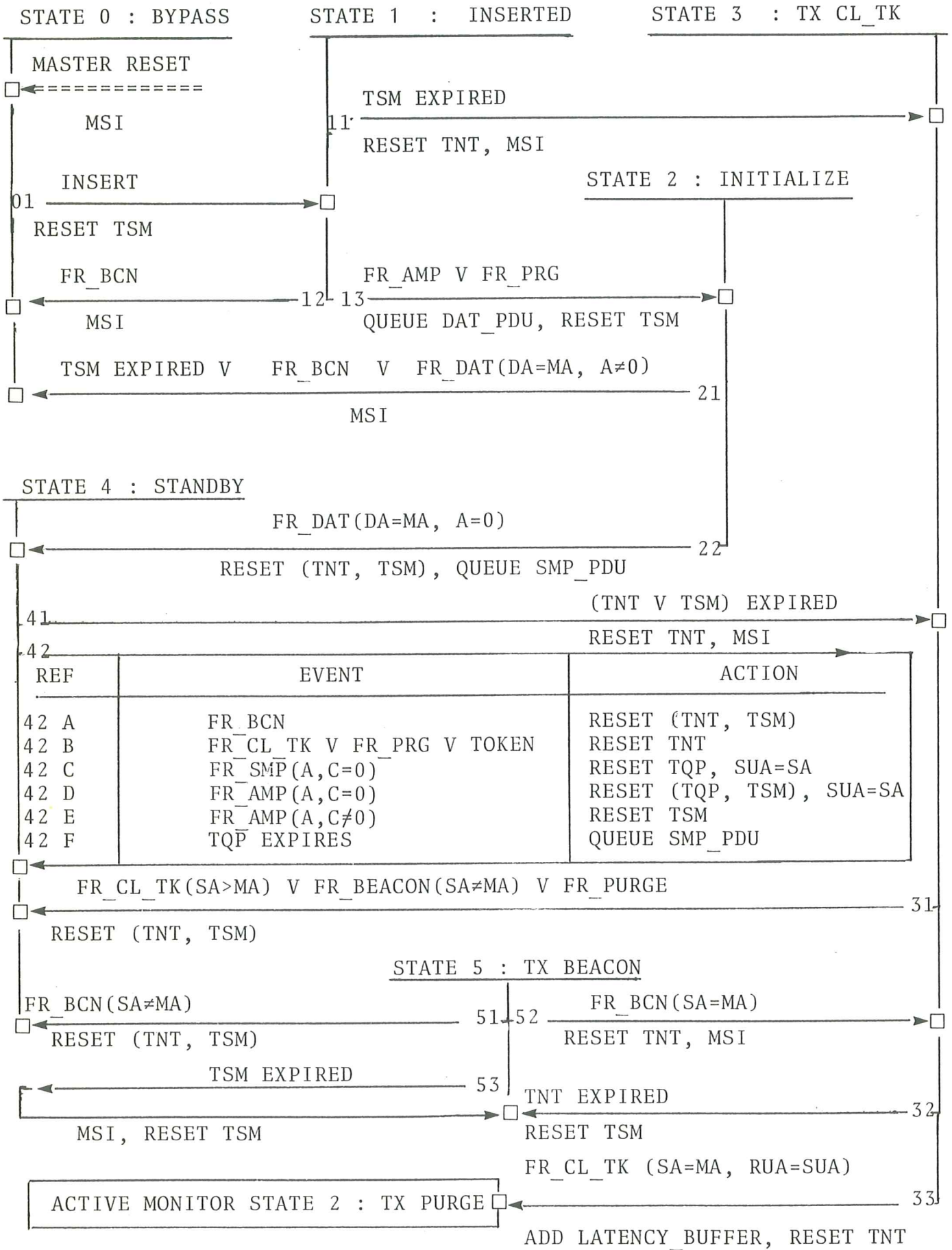


Figure 7. Standby Monitor Finite-State Machine Diagram

4.2.3.2 State 0 : BYPASS

In this state the DTE is not inserted in the ring.

(01)

Upon activation of the insertion logic (see 5.3.2.3), timer TSM is reset and transition made to State 1.

4.2.3.3 State 1 : INSERTED

In this state the DTE synchronizes its receive clock with the receive signal and then, having achieved synchronization, repeats the received symbols on the line and awaits the receipt of an Active Monitor Present (AMP) or Purge (PRG) MAC frame.

(11)

If an AMP or PRG is not received before timer TSM expires, it is assumed that there is no active monitor in the ring, timer TNT is reset, MA_STATUS is indicated and transition is made to the Claiming Token state (State 3).

(12)

If a FR_BCN is received the DTE shall return to Bypass state (State 0) and the MA_STATUS shall be indicated.

(13)

However, if AMP or PRG has been received a Duplicate Address Test (DAT) PDU is enqueued for transmission awaiting the receipt of a useable token, timer TSM is reset and transition made to Initialize State (State 2).

4.2.3.4 State 2 : INITIALIZE

This state exists to detect the existence of a duplicate DTE address on the ring. This enhances the validity of later checks within the FSMs for SA=MA, etc. This is particularly useful in environments in which the DTE address assignments are not rigidly controlled. While in this state the DTE transmits the queued DAT_PDU when a useable token is received and repeats the received symbols on the line until one of the following events occur.

(21)

If the DAT MAC frame that was transmitted by the DTE is not received before timer TSM has expired or if a Beacon MAC frame is received or if a DAT MAC frame which the DTE originated (DA=MA) is received with the

Address Recognized bits not set to ZERO (A≠0) MA_STATUS is indicated to the NMT and the DTE returned to a Bypass state (State 0.) (Note : NMT may determine if the DTE should retry insertion into the ring.)

(22)

However, if the DAT MAC frame is returned indicating that there is not another DTE on the ring with the same address (A=0), an SMP protocol data unit (PDU) is enqueued for transmission awaiting the receipt of a useable token, timers TNT and TSM are reset, and transition is made to Standby state (State 4).

4.2.3.5 State 3 : TX_CLAIM TOKEN (Transmit Claim Token)

In this state, Claim Token MAC frames are continuously transmitted. If the SUA value is unknown a null (all ZEROs) address will be used.

(31)

If a Claim Token MAC frame is received in which the source address is greater than the DTE's address, or a beacon frame in which the source address does not equal the DTE's address, or a purge frame is received, transition is made to Standby state (State 4) after resetting timers TNT and TSM.

(32)

However, if timer TNT expires, timer TSM is reset and transition is made to beaconing state (State 5).

(33)

Or, if the DTE receives a FR_CL_TK with a source address equal to the DTE's address and Received Upstream Neighbor's Address (RUA) equal to the Stored Upstream Neighbor's Address (SUA), the bid for active monitor has been won. The latency buffer shall be inserted in the ring, timer TNT reset, and transition made to ACTIVE MONITOR Purge state (State 2).

4.2.3.6 State 4 : STANDBY

In this state the monitor is in standby mode, monitoring the ring to ascertain that there is a properly operating active monitor on the ring. It does so by observing the tokens and AMP frames as they are repeated on the ring. If tokens and AMP frames are not periodically detected the standby monitor will time-out and initiate claiming token.

(41)

If timers TNT or TSM expire, timer TNT is reset and transition made to claiming token state (State 3).

(42A)

If a Beacon frame is received, timers TNT and TSM are reset without changing state.

(42B)

If a Claim Token frame, a Purge frame, or a token is received, timer TNT is reset without changing state.

(42C)

If an FR_SMP the A and C bits of which are set to ZERO is received, the SA of the SMP frame shall be stored as the SUA and timer TQP be reset.

(42D)

If an FR_AMP the A and C bits of which are set to ZERO is received, the SA of the AMP frame shall be stored as the SUA and timers TQP and TSM reset.

(42E)

If an FR_AMP the A and C bits of which are not set to ZERO is received timer TSM shall be reset.

(42F)

If timer TQP expires a SMP PDU shall be enqueued for transmission.

4.2.3.7 State 5 : TX BCN (Transmit Beacon)

This state is entered when a serious ring failure has occurred. MAC Supervisory Beacon Frames will continue to be transmitted until Beacon MAC frames are received at which time :

(51)

If SA does not equal MA, timers TNT and TSM shall be reset and transition made to Standby state (State 4).

(52)

However, if SA does equal MA then transition shall be made to Claiming Token state (State 3) after resetting timer TNT and indicating MA_STATUS.

(53)

If while transmitting FR_BCN timer TSM expires, MA_STATUS will be indicated to NMT of the event and timer TSM reset.

4.2.4 Active Monitor Finite-State Machine

The function of the active monitor is to recover from various error situations such as absence of validly-formed frames or tokens on the ring, a persistently circulating priority token, or a persistently circulating frame. In normal operation there is only one active monitor in a ring at any point in time. Timers TVX, TNT, TAM and TRR are used by the active monitor.

The active monitor shall utilize its own oscillator to provide timing for all symbols repeated or transmitted on the ring. The active monitor also supplies the latency buffer for the ring.

The operation of the active monitor is as follows.

4.2.4.1 State 0 : ACTIVE

The active monitor is in this state when the ring is operating normally.

(01A)

The M bit is set to ONE on a token the M bit of which is set to ZERO and the priority of which is greater than zero or a frame the M bit of which is set to ZERO, and timer TVX reset.

(01B)

Receipt of a token the M bit of which is set to ZERO and its priority is zero will cause timer TVX to be reset.

(01C)

If timer TAM expires an Active Monitor Present PDU is enqueued for transmission awaiting the receipt of a useable token and timer TAM reset without changing state.

(01D)

If an FR_SMP the A and C bits of which are set to ZERO is received, the SA of the SMP frame shall be stored as the SUA.

(02)

If a frame or a token which is being repeated has its M bit set to ONE, the frame or token is aborted, timer TNT is reset, and transition made to Transmit Purge state (State 2).

(03)

If timer TVX expires, timer TNT is reset, and transition made to Transmit Purge state (State 2).

(04)

If the monitor DTE receives an Active Monitor Present frame with a source address that does not equal the DTE's address, a Purge frame, a Claim Token frame, or a Beacon frame, the latency buffer shall be deleted, timers TNT and TSM reset, MA STATUS indicated to NMT and transition made to STANDBY MONITOR Standby state (State 4).

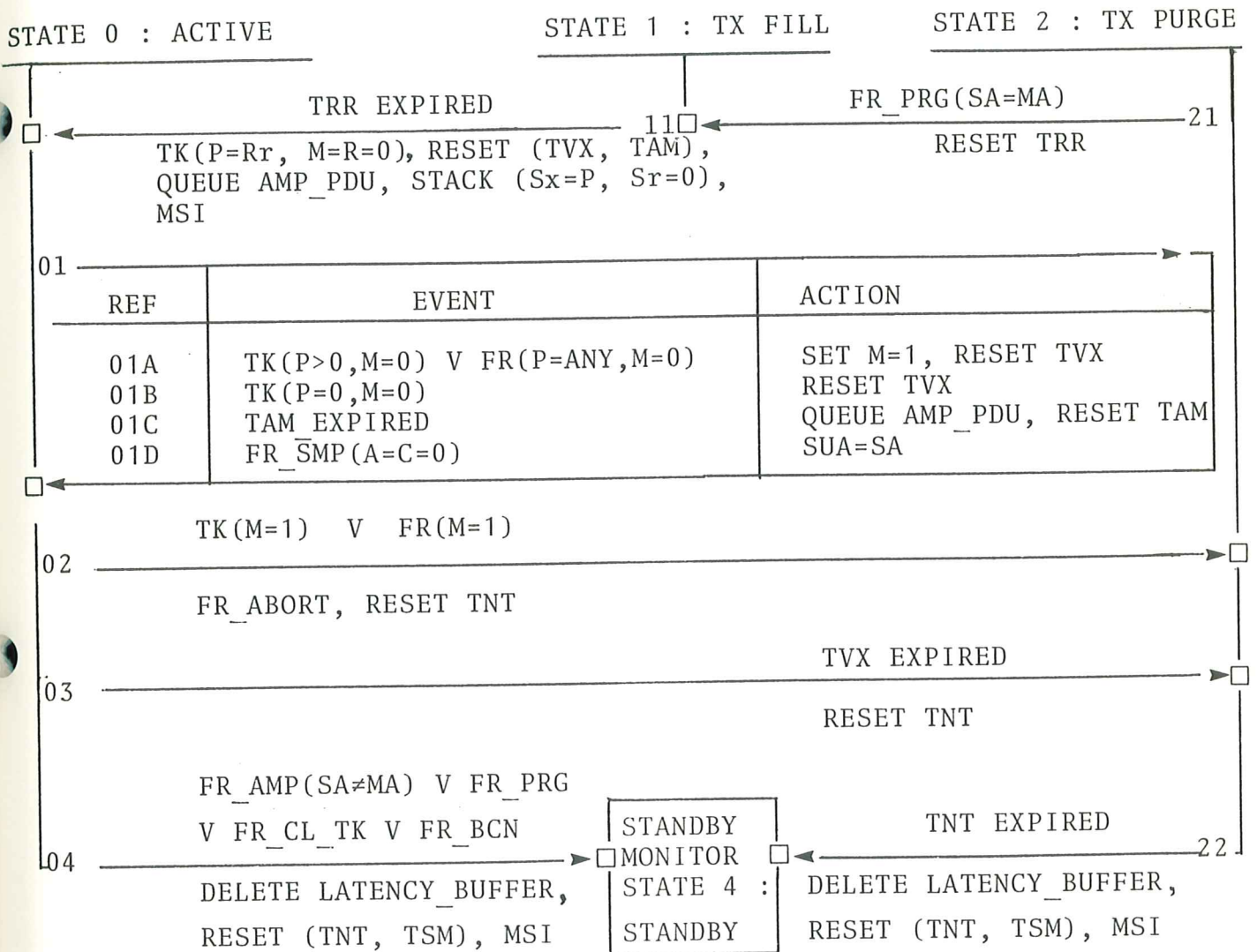


Figure 8. Active Monitor Finite-State Machine Diagram

4.2.4.2 State 1 : TX FILL (Transmit Fill)

This state exists to assure that all Purge frames have been stripped from the ring before transmitting a new token.

(11)

When timer TRR expires a token is transmitted with P equal to Rr and M and R equal to zero. P is stacked as Sx and a zero is stacked as Sr, timers TVX and TAM are reset, MA STATUS indicated to NMT and transition made to State 0.

4.2.4.3 State 2 : TX PURGE (Transmit Purge)

In this state Purge MAC frames are continuously transmitted to purge the ring before transmitting a new token.

(21)

If the DTE receives a FR_PRG whose source address equals the DTE's address and with a subvector equal to UNA, timer TRR is reset and transition is made to Transmit Fill state (State 1).

(22)

If timer TNT expires while waiting for receipt of the DTE's source address, the latency buffer shall be deleted, timers TNT and TSM reset, MA STATUS indicated to NMT and transition made to STANDBY MÖNITOR Standby state (State 4).

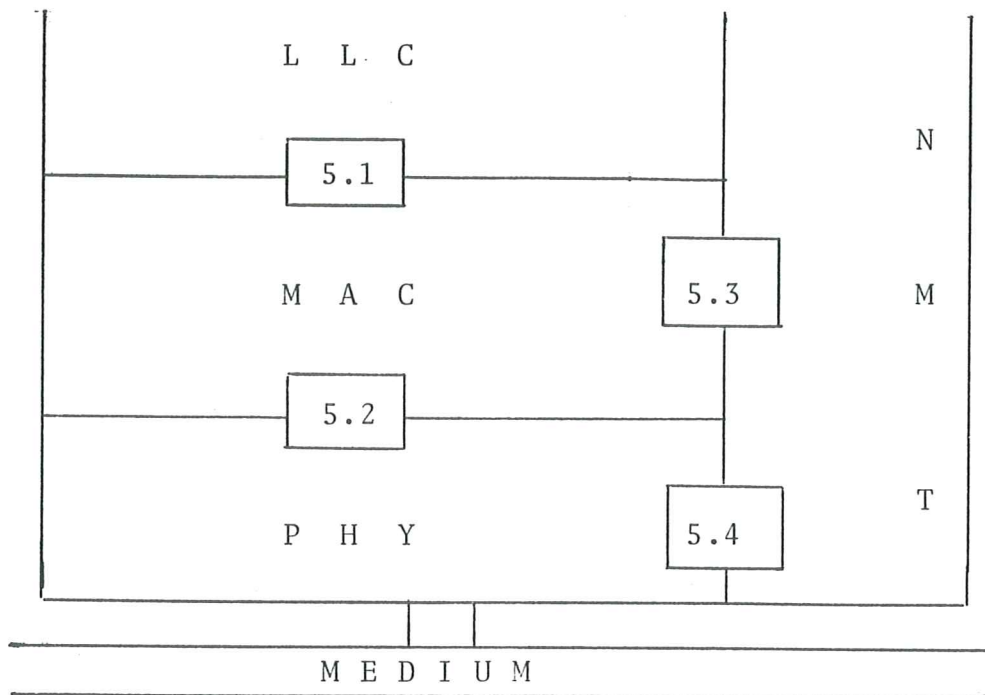
5. SERVICE SPECIFICATIONS

This clause specifies the services provided :

- by the Medium Access Control (MAC) sublayer to the Logical Link Control (LLC) sublayer,
- by the Physical Layer to the MAC sublayer,
- by the MAC sublayer to Network Management (NMT),
- by the Physical Layer to NMT.

The services are described in an abstract way and do not imply any particular implementation, or any exposed interface.

The diagram below serves as a guide to the subsections (5.1 to 5.4) that define the services provided.



5.1 MAC to LLC Service

This clause specifies the services required of the Medium Access Control (MAC) sublayer by the Logical Link Control (LLC) to allow the local LLC sublayer entity to exchange LLC data units with peer LLC sublayer entities.

5.1.1 Interactions

The following primitives are defined for the LLC sublayer to request service from the MAC sublayer :

MA_DATA.request
MA_DATA.indication
MA_DATA.confirmation

All primitives described in this clause are mandatory.

5.1.2 Detailed Service Specifications

All primitives are specified in an exemplary form only. Each service shall name the particular primitive and the required information that is passed between the LLC sublayer and MAC sublayer.

5.1.2.1 MA_DATA.request

This primitive defines the transfer of a MAC service data unit from a local LLC sublayer entity to a single peer LLC entity, or multiple peer LLC entities in the case of group addresses.

Semantics of the Service Primitive :

```
MA_DATA.request (
    frame_control,
    destination_address,
    m_sdu,
    requested_service_class
)
```

The `frame_control` parameter specifies the value for the frame's FC (frame control) octet. The `destination_address` parameter may specify either an individual or a group MAC entity address. It shall contain sufficient information to create the DA field that is appended to the frame by the local MAC sublayer entity as well as any lower level address information. The `m_sdu` parameter specifies the MAC service data unit to be transmitted by the MAC sublayer entity. There is sufficient information associated with `m_sdu` for the MAC sublayer entity to determine the length of the data unit. The `requested_service_class` parameter specifies the priority (Pm) desired for the data unit transfer.

When Generated

This primitive shall be generated by the LLC sublayer entity whenever data must be transferred to a peer LLC entity or entities. This can be in response to a request from higher layers of protocol or from data generated internally to the LLC sublayer, such as required by LLC Type 2 service as defined by IEEE 802.2.

Effect of Receipt

The receipt of this primitive shall cause the MAC entity to append all MAC specific fields, including DA, SA, and any fields that are unique to the particular medium access method, and pass the properly formed frame to the lower layers of protocol for transfer to the peer MAC sublayer entity or entities.

Additional Comments : Requested_service_class is one of eight levels.

5.1.2.2 MA_DATA.indication

This primitive defines the transfer of data from the MAC sublayer entity to the LLC sublayer entity or entities in the case of group addresses.

Semantics of the Service Primitive :

```
MA_DATA.indication (
    frame_control,
    destination_address,
    source_address,
    m_sdu,
    reception_status
)
```

The frame_control parameter is the FC (frame control) octet received. The destination_address parameter may be either an individual or a group address as specified by the DA field of the incoming frame. The source_address parameter must be an individual address as specified by the SA field of the incoming frame. The m_sdu parameter shall specify the MAC service data unit as received by the local MAC entity. The reception_status parameter indicates the success or failure of the incoming frame. It consists of the following elements

1. frame_status : FR_GOOD, FR_WITH_ERROR

If a FR_WITH_ERROR is reported, the reason for the error shall also be reported. The reason shall be one of the following :

- a. invalid_FCS - calculated FCS does not match the received FCS
- b. code_violation - J or K symbol received between the SD and ED
- c. frame_truncated - the received frame, although free from errors, exceeded the internal buffer space.
- d. short_frame - the received frame was shorter than the minimum.

2. E_value : zero, one, invalid

3. A & C_value : zero_zero, one_zero, one_one, invalid.

When Generated

The MA_DATA.indication primitive shall be generated by the MAC sublayer entity to the LLC sublayer entity or entities to indicate the arrival of an LLC frame at the local MAC sublayer entity. Such frames shall be reported only if they are validly formed and their destination address designates the local MAC entity, or the source address designates the local MAC entity if the DTE was so initialized (see 5.3.2.1)

Effect of Receipt

The effect of receipt of this primitive by the LLC sublayer is dependent upon the validity and content of the frame.

Additional Comments

If the local MAC sublayer entity is designated by the destination address parameter of an MA_DATA.request primitive, the indication primitive shall also be invoked by the MAC entity to the local LLC entity. This full duplex characteristic of the MAC

sublayer may be due to unique function capabilities within the MAC sublayer or full duplex characteristics of the lower layers, e.g., all frames transmitted to the broadcast address shall invoke MA_DATA.indication primitives at all DTEs in the network including the DTE that generated the request.

5.1.2.3 MA_DATA.confirmation

The primitive has local significance and shall provide an appropriate response to the LLC sublayer MA_DATA.request primitive signifying the success or failure of the request.

Semantics of the Service Primitive :

```
MA_DATA.confirmation (
    transmission_status,
    provided_service_class
)
```

The transmission_status parameter shall be used to pass status information back to the local requesting LLC sublayer entity. It shall be used to indicate the success or failure of the previous associated MA_DATA.request. The provided_service_class parameter specifies the service class that was provided for the data unit transfer.

When Generated

This primitive shall be generated by the MAC entity in response to an MA_DATA.request primitive from the local LLC sublayer entity.

Effect of Receipt

The effect of receipt of this primitive by the LLC sublayer is unspecified.

Additional Comments

It is assumed that sufficient information is available to the LLC sublayer to associate the response with the appropriate request.

5.2 PHY to MAC Service

The services provided by the PHY Layer allow the local MAC sublayer entity to exchange MAC data units with peer MAC sublayer entities.

NOTE 9

All PHY data units have the duration of one symbol period.

5.2.1 Interactions

The following primitives are defined for the MAC sublayer to request service from the PHY layer :

PH_DATA.request
PH_DATA.indication
PH_DATA.confirmation

All primitives described in this section are mandatory.

5.2.2 Detailed Service Specifications

All primitives are specified in an exemplary form only. Each service shall name the particular primitive and the required information that shall be passed between the MAC sublayer and PHY Layer.

5.2.2.1 PH_DATA.request

This primitive defines the transfer of data from a local MAC sublayer entity to the DTE's PHY Layer.

Semantics of the Service Primitive :

```
PH_DATA.request (
                symbol
                )
```

The symbol specified shall be one of the following :

0 = ZERO, 1 = ONE, J = non-data-J, K = non-data K

When Generated

The MAC sublayer shall send the PHY layer a PH_DATA.request every time the MAC sublayer has a symbol to output. Once the MAC sublayer has sent a PH_DATA.request to the PHY layer, it may not send another PH_DATA.request until it has received a PH_DATA.confirmation from the PHY layer.

Effect of Receipt

Upon receipt of this primitive the PHY entity shall encode and transmit the symbol. When the PHY entity is ready to accept another PH_DATA.request, it shall return to the MAC sublayer a PH_DATA.confirmation.

Additional Comments

None

5.2.2.2 PH_DATA.indication

This primitive defines the transfer of data from the PHY Layer to the MAC sublayer entity.

Semantics of the Service Primitive :

```
PH_DATA.indication (
                    symbol
                    )
```

The symbol specified shall be one of the following :

0 = ZERO, 1 = ONE, J = non-data J, K = non-data K

When Generated

The PHY Layer shall send the MAC sublayer a PH_DATA.indication every time the PHY Layer decodes a symbol. This indication is sent once every symbol period.

Effect of Receipt

Upon receipt of this primitive the MAC sublayer accepts a symbol from the PHY Layer.

Additional Comments

None.

5.2.2.3 PH_DATA.confirmation

This primitive has local significance and shall provide an appropriate response to the MAC sublayer PH_DATA.request primitive signifying the acceptance of a symbol specified by the PH_DATA.request and willingness to accept another symbol.

Semantics of the Service Primitive :

```
PH_DATA.confirmation (
                    transmission_status
                    )
```

The transmission_status parameter shall be used to signify the transmission completion status.

When Generated

The PHY layer shall send the MAC sublayer PH_DATA.confirmation in response to every PH_DATA.request received by the PHY layer. The purpose of the PH_DATA.confirmation is to synchronize the MAC sublayer data output with the data rate of the PHY layer medium.

Effect of Receipt

The receipt of this primitive enables the MAC sublayer to send another PH_DATA.request to the PHY layer.

Additional Comments

The PHY layer provides a "synchronous" service, i.e., upon completion of a PH_DATA.confirmation, it expects an immediate PH_DATA.request.

5.3 MAC to NMT Service

This clause specifies the services provided at the boundary between the network management and the MAC sublayer. This interface is used by NMT to monitor and control the operations of the MAC sublayer.

5.3.1 Interactions

The following primitives are defined for the NMT to request service from the MAC sublayer :

```
MA_INITIALIZE_PROTOCOL.request
MA_INITIALIZE_PROTOCOL.confirmation
MA_CONTROL.request
MA_STATUS.indication
MA_NMT_DATA.request
MA_NMT_DATA.indication
MA_NMT_DATA.confirmation
```

All primitives described in this clause are mandatory.

5.3.2 Detailed Service Specifications

All primitives are specified in exemplary form only. Each service shall name the particular primitive and the required information that will be passed between the MAC sublayer and NMT.

5.3.2.1 MA_INITIALIZE_PROTOCOL.request

This primitive has local significance and is used by NMT to reset the MAC sublayer and optionally to change operational parameters of the MAC sublayer.

Semantics of the Service Primitive :

```
MA_INITIALIZE_PROTOCOL.request
(
    individual_MAC_address,
    group_MAC_addresses,
    all_DTEs_this_ring_address,
    THT_value,
    TRR_value,
    TVX_value,
    TNT_value,
    TQP_value,
    TSM_value,
    TAM_value,
    priority_of_AMP_data_unit,
    indicate_for_frame_with_SA=MA,
    indicate_for_rcv_only_good_frames
)
```

- The individual MAC address is the octet string the MAC sublayer will use as its individual address.
- The group MAC addresses is the octet string the MAC sublayer will use as its group addresses.
- The all DTEs this ring address parameter is the octet string the MAC sublayer will use as the destination address in frames sent to all DTEs, this ring. This value will also be used to determine whether to copy a frame sent by another DTE with a destination address of all DTEs, this ring. The default value is all ones.
- The THT value is the value the MAC sublayer will use for this Timer, Holding Token (THT).
- The TRR value is the value the MAC sublayer will use for the time-out value of its Timer, Return to Repeat (TRR).
- The TVX value is the value the MAC sublayer will use for the time-out value of its Timer, Valid Transmission (TVX).
- The TNT value is the value the MAC sublayer will use for the time-out value of its Timer, No Token (TNT).
- The TQP value is the value the MAC sublayer will use for the time-out value of its Timer, Queue PDU (TQP).
- The TSM value is the value the MAC sublayer will use for the time-out value of its Timer, Standby Monitor (TSM).
- The TAM value is the value the MAC sublayer will use for the time-out value of its Timer, Active Monitor (TAM).
- The priority of AMP data unit parameter is the value the MAC sublayer will use for the requested service class when sending the AMP data unit (see 3.3.3)
- The indicate for frame with SA=MA parameter is the value the MAC sublayer will use to initialize the DTE to generate MA DATA.indication and MA NMT DATA.indication primitives for frames that the DTE itself transmitted (i.e., SA=MA).
- The indicate for rcv only good frames parameter is the value the MAC sublayer will use to decide whether to generate MA DATA.indication and MA NMT DATA.indication primitives on only frames that are good (see 4.2.1) or alternatively on all frames that are validly formed. In both cases data is terminated when a bit synchronization error is recognized.

NOTE 10

All parameters of this primitive are optional. If a parameter is omitted, the MAC sublayer will use the most recently provided value for this parameter or if no value has been previously provided, the default value for the parameter will be used. The default value for the individual MAC_address parameter is not defined here.

When Generated

This primitive shall be generated by NMT whenever NMT requires the MAC sublayer to reset and reconfigure.

Effect on Receipt

Receipt of this primitive shall cause the MAC sublayer to reset its protocol and establish the values of its addresses, timers, and other initialization parameters. Upon completion of this primitive, the MAC sublayer shall generate a MA_INITIALIZE_PROTOCOL.confirmation.

Additional Comments

The timer values specified by NMT to the MAC sublayer by this primitive, may effect the maximum length frame that LLC may request the MAC sublayer to transmit. It is the responsibility of NMT to inform the appropriate-higher layers responsible for segmenting, blocking and/or concatenating messages of the MAC sublayer maximum frame size.

5.3.2.2 MA_INITIALIZE_PROTOCOL.confirmation

This primitive is used by the MAC sublayer to inform NMT that the MA_INITIALIZE_PROTOCOL.request primitive is complete.

Semantics of the Service Primitive :

```
MA_INITIALIZE_PROTOCOL.confirmation (
                                     status
                                     )
```

The status parameter indicates the success or failure of the MA_INITIALIZE_PROTOCOL.request.

When Generated

This primitive shall be generated by MAC upon completion of a MA_INITIALIZE_PROTOCOL.request.

Effect On Receipt

Unspecified.

Additional Comments

None.

5.3.2.3 MA_CONTROL.request

This primitive has local significance and is used by NMT to control the operation of the MAC sublayer.

Semantics of the Service Primitive :

```
MA_CONTROL.request (
                    control_action
                    )
```

The control_action parameter shall be one of the following :

MASTER RESET - see 4.2.3.

insert - see 4.2.3.

When Generated

This primitive shall be generated by NMT whenever NMT requires the MAC sublayer to take specific actions.

Effect on Receipt

Receipt of this primitive shall cause the MAC sublayer to take the action specified by the control_action parameter.

Additional Comments

None

5.3.2.4 MA_STATUS.indication

This primitive is used by the MAC sublayer to inform NMT of errors and significant status changes. The specific errors and status changes reported are defined in the following section.

Semantics of the Service Primitive :

```
MA_STATUS.indication (
                    status_report
                    )
```

The status_report parameter shall be one of the following :

FRAME_CONDITION - see Receive Actions reference R-A

CLAIM_TOKEN - see Standby Monitor FSM transitions
11, 41, 52

ENTER_ACTIVE_MONITOR - see Active Monitor FSM transition 11

ENTER_STANDBY_MONITOR - see Active Monitor FSM transitions 04, 22

DUPLICATE_ADD_DETECTED - see Standby Monitor FSM transition 21 and Receive Actions Reference R-G

When Generated

This primitive shall be generated by the MAC sublayer by the operation of the Operational, Standby Monitor, or Active Monitor FSMs.

Effect on Receipt

Unspecified.

Additional Comments

None.

5.3.2.5 MA_NMT_DATA.request

This primitive defines the transfer of data from a local NMT entity to the local MAC entity.

Semantics of the Service Primitive

```
MA_NMT_DATA.request (
    frame_control,
    destination_address,
    m_sdu,
    requested_service_class
)
```

The `frame_control` parameter specifies the value for the frame's FC (frame control) octet. The `destination_address` parameter may specify either an individual or a group MAC entity address. It shall contain sufficient information to create the DA field that is appended to the frame by the local MAC sublayer entity as well as any lower level address information. The `m_sdu` parameter specifies the MAC service data unit to be transmitted by the MAC sublayer entity. There is sufficient information associated with `m_sdu` for the MAC sublayer entity to determine the length of the data unit. The `requested_service_class` parameter specifies the priority (Pm) desired for the data unit transfer.

When Generated

This primitive shall be generated by the NMT entity whenever data must be transferred to one or more peer NMT entities.

Effect of Receipt

The receipt of this primitive shall cause the MAC entity to append all MAC specific fields, including DA, SA, and any fields that are unique to the particular medium access method, and pass the properly formed frame to the lower layers of protocol for transfer to the peer NMT entity or entities.

Additional Comments

Requested_service_class is one of eight levels.

5.3.2.6 MA_NMT_DATA.indication

This primitive defines the transfer of data from the MAC sublayer entity to the NMT entity.

Semantics of the Service Primitive :

```
MA_NMT_DATA.indication (  
    frame_control,  
    destination_address,  
    source_address,  
    m_sdu,  
    reception_status  
)
```

The frame_control parameter is the FC (Frame control) octet received. The destination_address parameter may be either an individual or a group address as specified by the DA field of the incoming frame. The source_address parameter must be an individual address as specified by the SA field of the incoming frame. The m_sdu parameter shall specify the MAC service data unit as received by the local MAC entity. The reception_status parameter indicates the success or failure of the incoming frame. It consists of the following elements :

1. frame_status : FR_GOOD, FR_WITH_ERROR

If a FR_WITH_ERROR is reported, the reason for the error shall also be reported. The reason shall be one of the following :

- a. invalid_FCS - calculated FCS does not match the received FCS
- b. code_violation - J or K symbol received between the SD and ED
- c. frame_truncated - the received frame, although free from errors, exceeded the internal buffer space
- d. short_frame - the received frame was shorter than the minimum.

2. E_value : zero, one, invalid.

3. A & C_value : zero_zero, one_zero, one_one, invalid.

When Generated

The MA_NMT_DATA.indication primitive shall be generated by the MAC sublayer entity to the NMT entity or entities to indicate the arrival of a MAC frame at the

local MAC sublayer entity. Such frames shall be reported only if they are validly formed and their destination address designates the local MAC entity, or the source address designates the local MAC entity if the DTE was so initialized (see 5.3.2.1)

Effect of Receipt

The effect of receipt of this primitive by NMT is dependent upon the validity and content of the frame.

Additional Comments

If the local MAC sublayer entity is designated by the destination_address parameter of an MA_NMT_DATA.request primitive, the indication primitive shall also be invoked by the MAC entity to the local NMT entity. This full duplex characteristic of the MAC sublayer may be due to unique function capabilities within the MAC sublayer or full duplex characteristics of the lower layers (e.g. all frames transmitted to the broadcast address shall invoke MA_NMT_DATA.indication primitives at all DTEs in the network including the DTE that generated the request).

5.3.2.7 MA_NMT_DATA.confirmation

This primitive has local significance and shall provide an appropriate response to the NMT's MA_NMT_DATA.request primitive signifying the success or failure of the request.

Semantics of the Service Primitive :

```
MA_NMT_DATA.confirmation (
                                transmission_status,
                                provided_service_class
                                )
```

The transmission_status parameter shall be used to pass status information back to the local requesting NMT entity. It shall be used to indicate the success or failure of the previous associated MA_DATA.request. The provided_service_class parameter specifies the service class that was provided for the data unit transfer.

When Generated

This primitive shall be generated by MAC in response to MA_NMT_DATA.request from the local NMT entity.

Effect of Receipt

The effect of receipt of this primitive by the NMT is unspecified.

Additional Comments

It is assumed that sufficient information is available to the NMT entity to associate the response with the appropriate request.

5.4 PHY to NMT Service

The services provided by the PHY Layer to NMT allow the local NMT to control the operation of the PHY layer.

5.4.1 Interactions

The following primitives are defined for the NMT to request services from the PHY layer.

PH_CONTROL.request
PH_STATUS.indication

All primitives described in this clause are mandatory.

5.4.2 Detailed Service Specifications

This primitive is specified in exemplary form only. The service shall name the primitive and specify the information that will be passed between PHY and NMT.

5.4.2.1 PH_CONTROL.request

This primitive shall be generated by NMT to request the PHY layer to insert or remove itself to/from the ring.

Semantics of the Service Primitives :

```
PH_CONTROL.request (
                    control_action
                    )
```

The control_action parameter shall be one of the following :

INSERT - signal insertion into ring
REMOVE - signal removal from ring.

When Generated

This primitive shall be generated by NMT when NMT requires insertion or removal of the DTE from the ring.

Effect Upon Receipt

The Physical layer shall take appropriate action to cause insertion or removal from the ring. (see 7.4 for specific actions for shielded twisted pair medium).

Additional Comments

None.

5.4.2.2 PH_STATUS.indication

This primitive is used by the PHY layer to inform NMT of errors and significant status changes. The specific errors and status changes reported are defined in the following section.

Semantics of the Service Primitives :

```
PH_STATUS.indication (
                        status_report
                      )
```

The status_report parameter shall be one of the following :

BURST_CORRECTION_START - the PHY layer has begun generating 0 or 1 symbols and passing them to the MAC sublayer (on the PH_DATA.indication), to correct detected silence on the medium.

BURST_CORRECTION_END - the PHY layer has stopped generating symbols ; transitions have again been detected on the medium.

LATENCY_BUFFER_OVERFLOW - the PHY layer has attempted to expand the latency buffer beyond 30 bits (see 6.5).

LATENCY_BUFFER_UNDERFLOW - the PHY layer has attempted to contract the latency buffer beyond 24 bits.

When Generated

This primitive shall be generated by the PHY layer by its operation, as defined in 6.

Effect Upon Receipt

Unspecified.

Additional Comments

None.

6. PHYSICAL LAYER

The following clauses define Physical Layer specifications. These include data symbol encoding and decoding, symbol timing and reliability.

Throughout these clauses the word "repeater" is used to mean the repeater part of a DTE or a separate unit.

6.1 Symbol Encoding

The Physical Layer encodes and transmits the four symbols presented to it at its MAC interface by the MAC Sublayer.

The symbols exchanged between the MAC and PHY layers are shown below. (Specific implementations are not constrained in the method of making this information available).

0 = ZERO, 1 = ONE, J = Non-Data-J, K = Non-Data-K

The symbols are transmitted to the medium in the form of Differential Manchester type coding which is characterized by the transmission of two line signal elements per symbol.

In the case of the two data symbols, ONE and ZERO, a signal element of one polarity is transmitted for one half the duration of the symbol to be transmitted, followed by the contiguous transmission of a signal element of the opposite polarity for the remainder of the symbol duration. This provides two distinct advantages :

- The resulting signal has no dc component and can readily be inductively or capacitively coupled, and
- the forced "mid-bit" transition conveys inherent timing information on the channel.

In the case of Differential Manchester coding, the sequence of line signal element polarities is completely dependent on the polarity of the trailing signal element of the previously transmitted data or non-data symbol (bit).

If the symbol to be transmitted is a ZERO, the polarity of the leading signal element of the sequence is opposite to that of the trailing element of the previous symbol and, consequently, a transition occurs at the bit (symbol) boundary as well as mid-bit. If the symbol to be transmitted is a ONE, the algorithm is reversed and the polarity of the leading signal element is the same as that of the trailing signal element of the previous bit. Here there is no transition at the bit (symbol) boundary.

The Non-Data symbols, J and K, depart from the above rule in that a signal element of the same polarity is transmitted for both signal elements of the symbol and there is therefore no mid-bit transition. A J symbol has the same polarity as the preceding symbol whereas a K symbol is the opposite polarity to the preceding symbol. The transmission of only one non-data symbol introduces a dc component on the ring. To avoid an accumulating dc component, non-data symbols are normally transmitted as a pair of J and K symbols (by its nature a K symbol is opposite to the polarity of the preceding symbol).

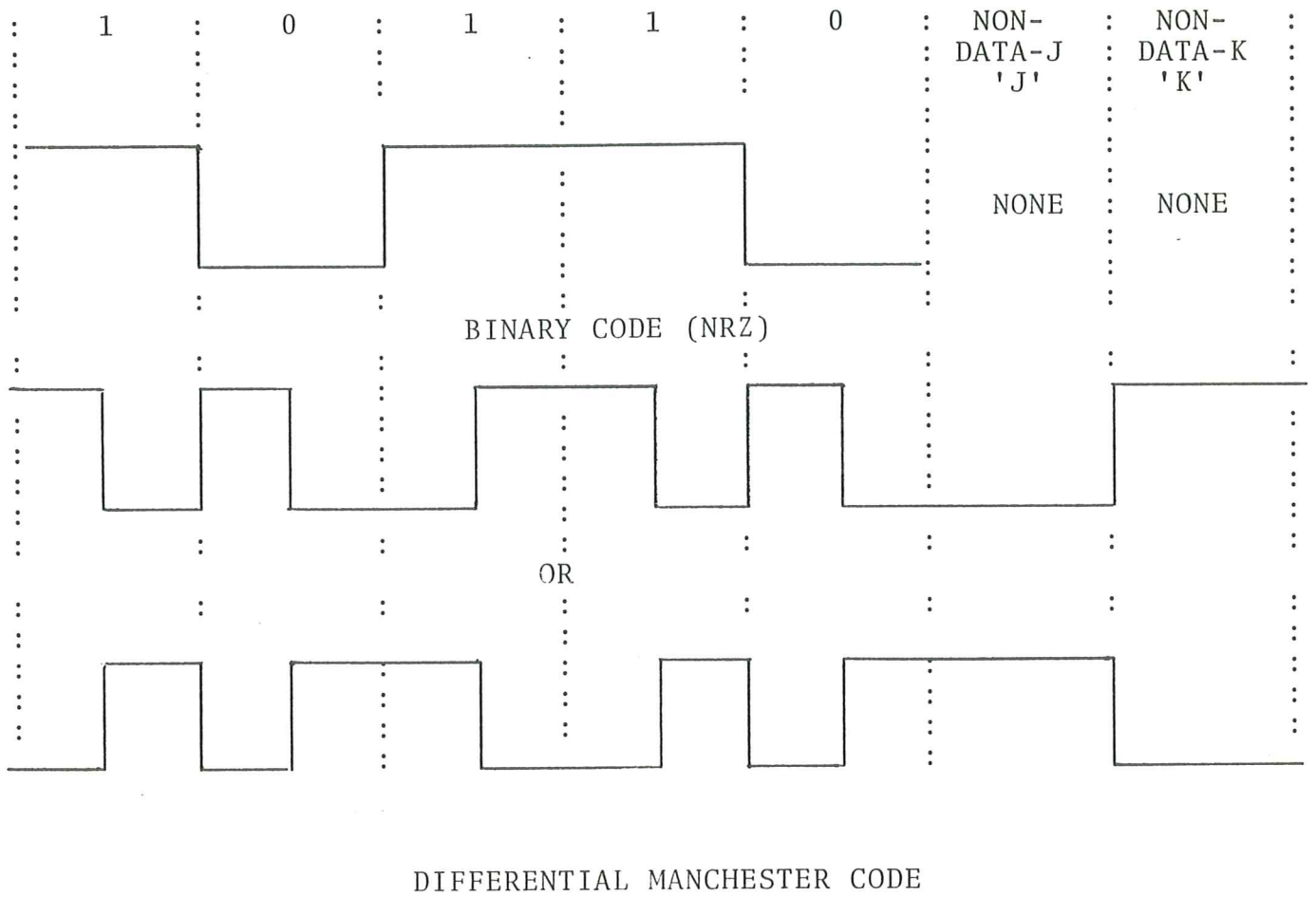


Figure 9 . Example of Symbol Encoding

6.2 Symbol Decoding

Received symbols shall be decoded using an algorithm which is the inverse of the one described for symbol encoding and the decoded symbols shall be presented at the MAC interface.

If the Physical Layer receives more than four signal elements of the same polarity in succession it shall introduce a change of polarity (i.e., a transition) at the end of the fourth signal element in the received bit stream and continue to introduce a transition each signal element time until a transition is received from the ring. The resulting bit stream is then decoded and the symbols presented to the MAC interface.

In a similar manner, during periods of loss of clock synchronization or under-run/ over-run of the latency buffer, the Physical Layer shall generate a transition each signal element time, decode the new bit stream and present the resulting symbols to the MAC interface.

6.3 Data Signalling Rates

The data signalling rates shall be 1 or 4 Mbits/s with a tolerance of $\pm 0,01\%$.

6.4 Symbol Timing

The Physical Layer shall recover the symbol timing information inherent in the transitions between levels of the received signal. It shall minimize the phase jitter in this recovered timing signal to provide suitable timing at the data signalling rate for internal use and for the transmission of symbols on the ring. The rate at which symbols are transmitted is adjusted continuously in order to remain in phase with the receive signal.

In normal operation there is one DTE on the ring that is the active monitor. All other DTEs on the ring are frequency and phase locked to this DTE. They extract timing from the received data by means of a phase locked loop. The phase locked loop design shall be based on the following criteria :

- i) It shall limit the dynamic alignment jitter at any DTE in the ring to a 3-sigma value of 10 degrees.
- ii) Whenever a DTE is inserted into the ring or loses phase lock with the upstream DTE, it shall, upon receipt of a signal which is within specification from the upstream DTE (re)acquire phase lock within 1,5 ms.
- iii) It shall accommodate at least a combined total of 250 DTEs and repeaters on the ring.
- iv) It shall operate with a receive signal as specified in clause 7.

- v) It shall operate with a jitter power spectral density of $2,5 \times 10^{-25} \text{ s}^2/\text{Hz}$ which may have been added by the medium interface cable and medium, to the output of the upstream DTE.

NOTE 11

Items i), ii), and iii) above require the design of the phase lock loop to meet the simultaneous requirements of large loop bandwidth to meet the 1,5 ms clock acquisition, and high damping to meet the 250 DTE capability. The loop transfer function must be designed to have a gain overshoot which is less than 0,2 dB above 0,0 dB.

6.5 The Latency Buffer

The latency buffer is provided by the active monitor. It serves two distinct functions.

Assured Minimum Latency

In order for the token to continuously circulate around the ring when all DTEs are in repeat mode the ring must have a latency (i.e., time, expressed in number of bits transmitted, for a signal element to proceed around the entire ring) of, at least, the number of bits in the token sequence, i.e., 24. Since the latency of the ring varies from one system to another and no a priori knowledge is available, a delay of at least 24 bits shall be provided by the active monitor.

Phase Jitter Compensation

The source timing or master oscillator of the ring shall be supplied by the active monitor DTE. All other DTEs in the ring track the frequency and phase of the incoming signal they receive. Although the mean data signalling rate around the ring is controlled by the active monitor DTE, segments of the ring can, instantaneously, operate at speeds slightly higher or lower than the frequency of the master oscillator. The cumulative effect of these variations in speed are sufficient to cause effective variations of up to ± 3 bits in the latency of a ring that has been configured with a maximum number of DTEs (i.e., 250).

However, unless the latency of the ring remains constant bits will be either dropped (not retransmitted) as the latency of the ring decreases or additional bits added as the latency increases. In order to maintain a constant ring latency, an elastic buffer with a length of 6 bits (12 signal elements) is added to the fixed 24-bit buffer. The resulting 30-bit buffer is initialized to 27 bits. If the received signal at the active monitor DTE is slightly faster than the master oscillator, the buffer will expand, as required, to 28, 29 or 30 bits to avoid dropping bits. If the received signal is slow, the buffer will contract to 26, 25 or 24 bits to avoid adding bits to the repeated bit stream.

7. DTE ATTACHMENT SPECIFICATIONS - SHIELDED TWISTED PAIR

7.1 Scope

This clause specifies the functional, electrical and mechanical characteristics of balanced, baseband, shielded twisted pair attachment to the trunk cable of a token ring.

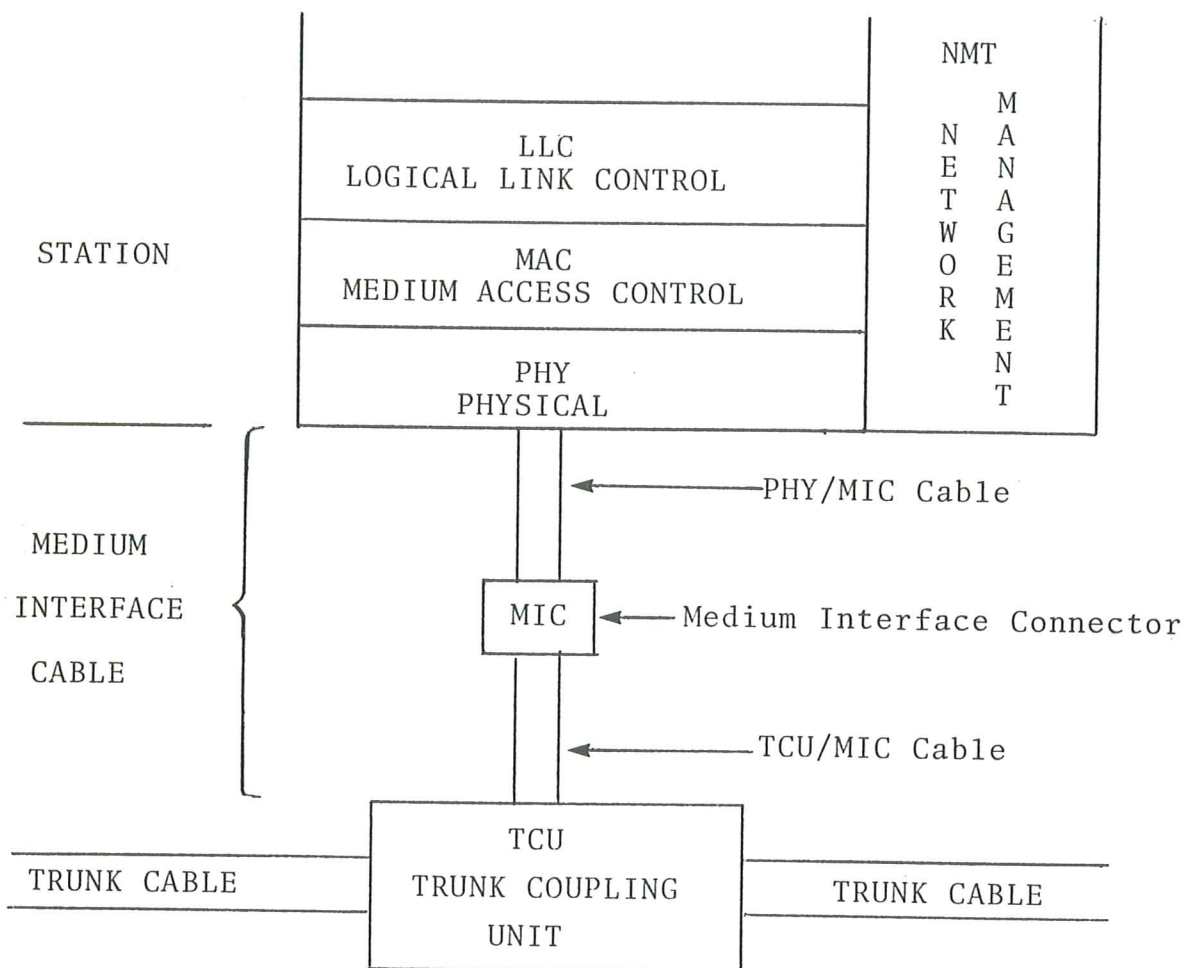


Figure 10 - Partitioning of The Physical Layer and Medium

7.2 Overview

The function of the Trunk Cable medium is to transport data signals between successive DTEs of a baseband ring local area network. This communication medium consists of a set of TCUs interconnected sequentially by Trunk Cable links. Each TCU is connected to a TCU/MIC cable to which a DTE may be connected. The relationship between these embodiments and the LAN model are shown in Figure 10.

Repeaters may be used, where required, to extend the length of a trunk link beyond limits imposed by normal signal degradation due to link impairments. These repeaters serve to restore the amplitude, shape and timing of signals passing through them. The repeater's regenerative functions have the same characteristics as a repeating DTE on the ring and must be included in the count of the number of DTEs supported by the ring.

The Medium Interface Cable shown in Figure 10 may be as shown or may include multiple sections of cable joined by connectors identical to the MIC. By definition, the MIC is the connector at which all transmitted and received signal specifications shall be met. It may be attached to the DTE directly or on a "pig tail".

7.3 Coupling of the DTE to the Trunk Cable Medium

The connection of the DTE to the trunk cable medium shall be via a shielded cable containing two balanced $150 \text{ Ohm} \pm 15 \text{ Ohm}$ twisted pairs. The DTE transmitter shall deliver the specified signal at the MIC, and the DTE receiver shall have sufficient sensitivity and distortion margin to operate properly with the appearance of the specified signal levels and distortion at this interface point. The shield of the cables shall be connected to the shield terminal of the MIC.

An exemplary implementation of the connection, in bypass mode, of the DTE to the ring is shown in Figure 11.

7.4 Ring Access Control

DTE insertion into the ring is controlled by the DTE. The mechanism for effecting the insertion or bypass of the DTE resides in the TCU. The DTE exercises control of the mechanism via the media interface cable using a phantom circuit technique. The phantom circuit impresses a DC voltage on the medium interface cable. This DC voltage is transparent to the passage of DTE transmitted symbols, hence the name "phantom". The voltage impressed is used within the TCU to effect the transfer of a switching action to cause the serial insertion of the DTE in the ring. Cessation of the phantom drive causes a switching action which will bypass the DTE and cause the DTE to be put in a looped ("wrapped") state. This loop may be used by the DTE for off line self testing functions.

The phantom drive circuit is designed such that the DTE may detect open-wire and certain short-circuit faults in either the receive pair or transmit pair of signal wires. This is done by detecting DC current imbalance in two separate phantom circuits. In order to do this the transformers (or their equivalent) in the TCU and the DTE must provide two coils which are DC isolated but AC signal coupled to each other. Circuits attached between the transmit pair and the receive pair of conductors shall be designed such that a line-to-line DC current balance is maintained within each pair.

7.4.1 Current and Voltage Limits

The point of measurement of the voltage and current limits is at the MIC (Medium Interface Connector).

Insertion shall be effected with a voltage of 4,1 V to 7,0 V on MIC pin B and O with return on pin G and R respectively within the current range of 0,65 mA to 2,0 mA.

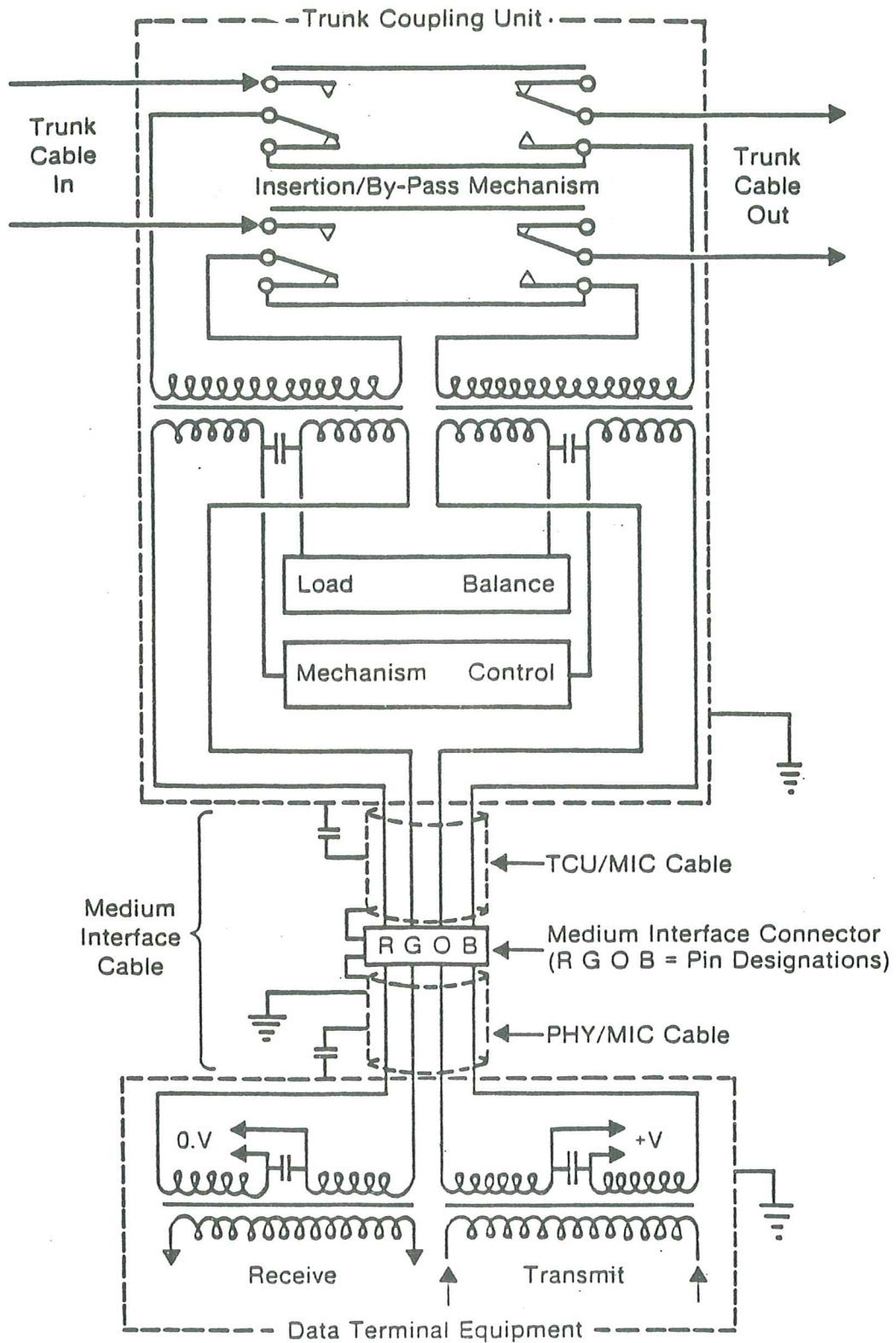


Figure 11 - Example of DTE Connection to the Medium

Bypass shall be effected when a voltage of less than 1 V is present on MIC pin B and O with respect to pins R and G.

A load with a DC resistance within 5% of the insertion/bypass mechanism resistance shall be presented by the TCU on pins G and O.

The operating voltage supplied by the DTE on MIC pins B and O shall be within 1% of each other over the operating current range of 0,65 mA to 2,0 mA.

The MIC, as described later, will automatically short circuit pin R to pin O and pin G to B when it is withdrawn. Therefore, the DTE shall provide means to assure the short circuit current will not exceed 20 mA.

7.4.2 Insertion/Bypass Timing

The insertion/bypass mechanism shall break the existing circuit before establishing the new circuit. The maximum time that the ring trunk circuit is open shall not exceed 5 ms.

7.5 Signal Characteristics

7.5.1 Transmitted Signals

Data Signalling Rates

The data signalling rates are 1 or 4 Mbit/s. The permitted tolerance for each signalling rate is $\pm 0,01\%$.

Signal Jitter

Maximum cumulative deviation of a transmitted signal element transition from the ideal transition (i.e. timing distortion and "jitter") measured at the MIC shall have a 3-sigma value of 10 degrees.

Signal Level

The magnitude of the transmitted signal, measured at the MIC, with a 150-Ohm resistive termination, shall be 3,0 V to 4,5 V, peak-to-peak. The amplitude of the positive and the negative transmitted levels shall be balanced within 5%.

Rise/Fall Times

During transitions of the transmitted signals between alternating binary states, the differential voltage measured across a 150 Ohm \pm 15 Ohm test load at the MIC shall be such that the voltage changes between the 10% and 90% points of the output signal within a time interval which shall be no greater than 25 ns for a 4 Mbit/s data rate (100 ns for a 1 Mbit/s data rate). In addition, the harmonic content of the transmitted signal generated by a pattern of all ZEROs or all ONES shall meet the following requirement:

- 2nd and 3rd harmonics: each at least 10 dB below fundamental.
- 4th and 5th harmonics: each at least 15 dB below fundamental.
- 6th and 7th harmonics: each at least 20 dB below fundamental.
- all higher harmonics: each at least 25 dB below fundamental.

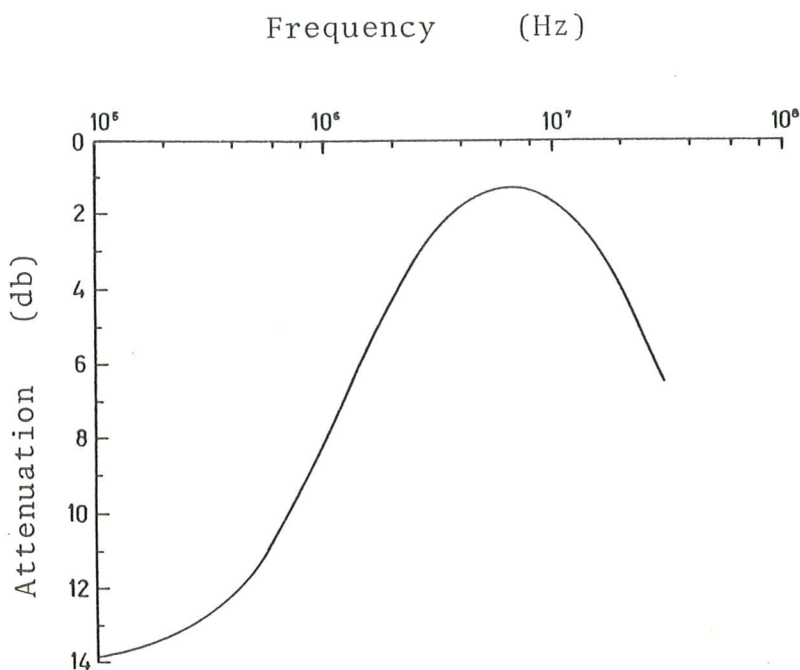


Figure 12 - Receive Filter Characteristics for
4 Mbit/s Operational 150-Ohm Impedance

7.5.2 Received Signals

The transmission medium may distort the transmitted signal. The distortion is bounded by the distortion produced by the cable which has a square root of the frequency attenuation characteristic.

NOTE 12

This characteristic is well known and can be found in many reference text books. Specifically, the form of the characteristic is in Reference Data For Radio Engineers, page 574, 4th edition published by ITT.

In addition, flat (non-distorting) attenuation may be caused by the medium, especially TCUs and connectors. The total attenuation may vary from 0 dB to 29 dB

at 4 MHz (at 1 MHz for 1 MBit/s data rate) including flat attenuation not exceeding 15 dB, and cable attenuation not exceeding 26 dB at 4 MHz (at 1 MHz for 1 MBit/s data rate). The total allowable attenuation may be less than 29 dB based on the actual noise level at the MIC and the required error rate of the LAN. The error rate required of a LAN shall be established by mutual agreement among the users of the LAN but in no case shall it be less than 10^{-8} .

In order to specify meaningful measurements at the MIC a measurement is outlined which, while not part of the specification, allows confirmation of system level conformance. All received signals and noise will be specified at the output of an equalizing filter. The filter is a 2-pole, 1-zero device. For 4-megabit ring operation the filter shall have poles at 2,7 MHz and 16 MHz and zero at 540 kHz each with a tolerance of $\pm 5\%$. (For 1-megabit operation, the frequency points are all divided by 4.). A plot of the characteristics of the filter are shown in Figure 12.

Signal Level

The receive signal at the output of the terminated filter shall have at least a magnitude of 25 mV during the central third of the half bit time. Figure 13 is the characteristic "eye" pattern of the received signal when viewed on an oscilloscope triggered by a non-critical phase lock loop with a band width equal to or less than 0,01 times the data rate. A compliant signal shall have an opening such that a rectangular area of 50 mV high (2 x 25 mV) and a width of 33 % of the half bit time will fit, symmetrically, within the eye as shown in Figure 13.

Error Rate

The DTE shall provide an output with an error rate not exceeding 10^{-9} when the S/N (signal to noise ratio) at the output of the specified filter is at least 22 dB. S/N, measured in dB, is defined as $20 \log (1/2 \text{ minimum eye height during the central third of the half bit time divided by RMS noise})$.

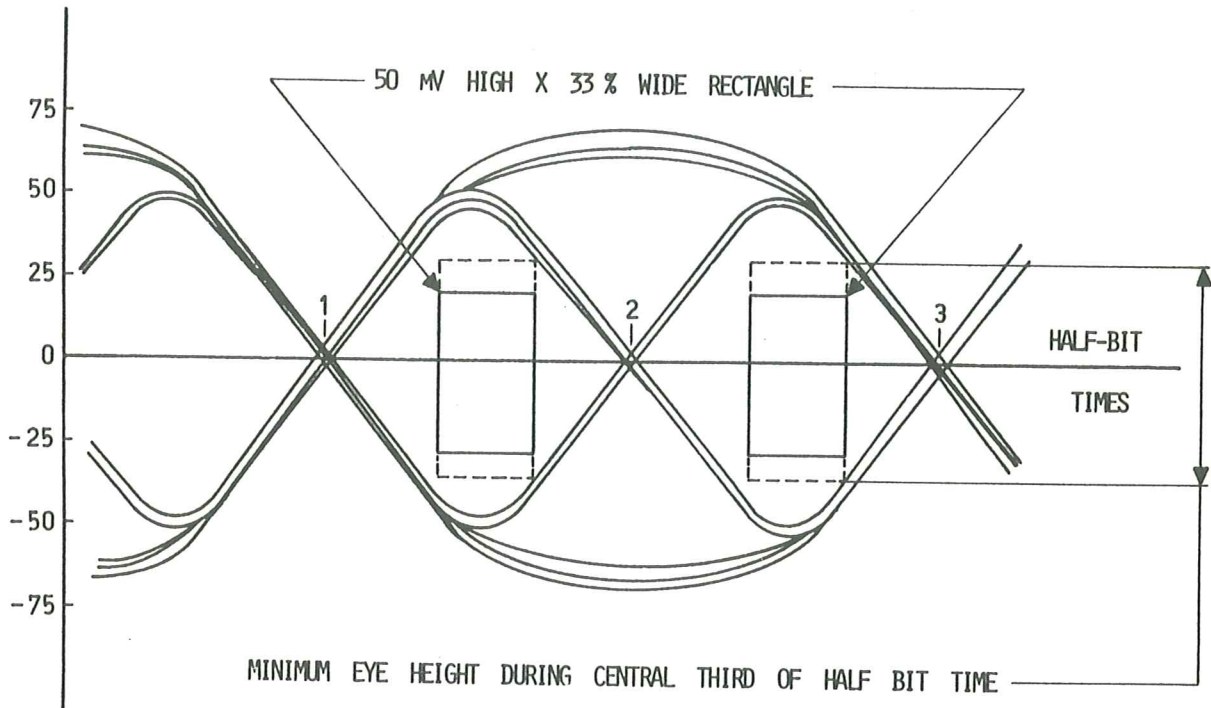
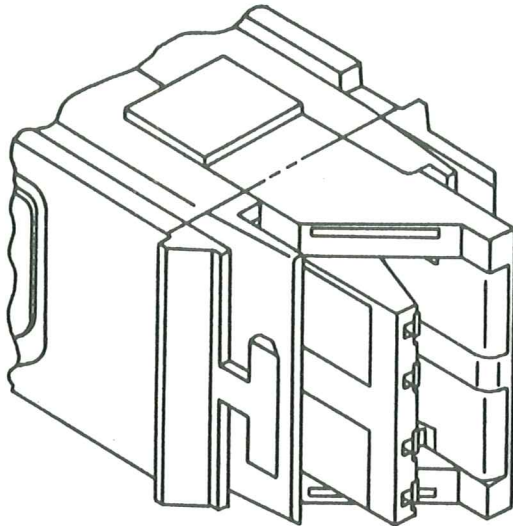


Fig. 13 - Receive Signal Eye Pattern

7.6 Reliability

The MAC Physical Layers, and connecting cable up to and including the MIC of each DTE shall be designed to minimize the probability of causing communication failure among other DTEs attached to the local network. The mean time to the occurrence of such a failure shall be at least one million hours of operation without requiring manual intervention to restore the network to operational status.

7.7 Medium Interface Connector



Shown above is an isometric view of the Medium Interface Connector (MIC) as it would be oriented when it is wall mounted. It has four signal contacts with a ground contact and is hermetic in design so that two identical units will mate when oriented 180 degrees with respect to each other.

Electrical Characteristics

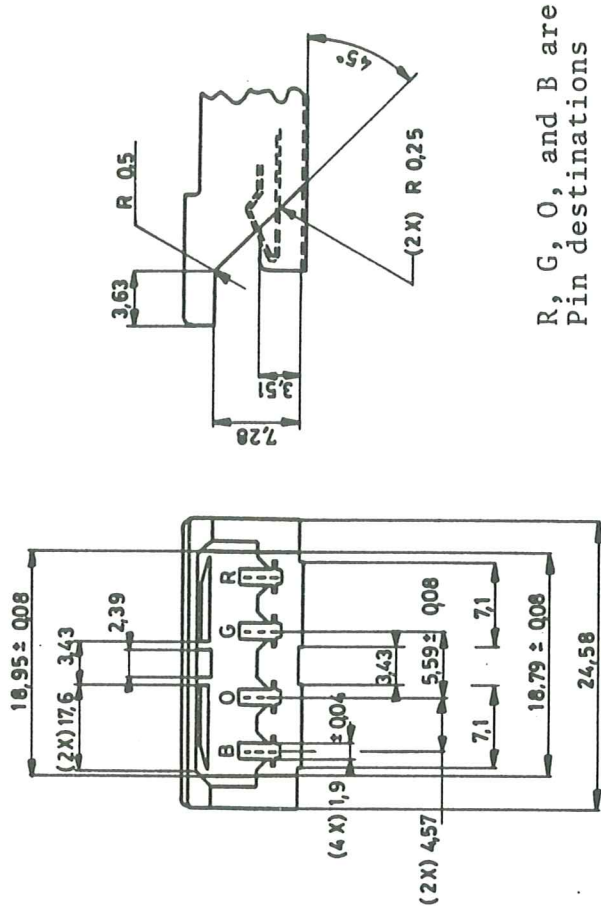
Crosstalk rejection	> 62 dB at 100 kHz to 4 MHz
Connector Insertion Loss in a 150-Ohm impedance line	<0,1 dB at 100 kHz to 4 MHz
DC Contact resistance	
pins	20 mOhm average, 100 mOhm maximum
shield	25 mOhm average, 100 mOhm maximum
self shorting path	40 mOhm average, 100 mOhm maximum
* connection according to IEC 130-14	
Carry Current	≥ 0,1 A
Voltage proof contact-contact	≥ 750 V dc

Mechanical Characteristics

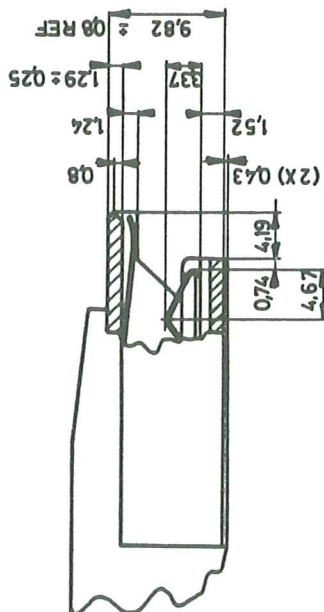
Contact force	0,5 N to 1,0 N
Insertions	> 1000
Life span	> 15 years
Surface treatment (compatible with the following) :	
Point of pin contact	- Plating with 3 um of hard gold
Point of shield contact-	Plating with 5 um of tin

7.7.1 Medium Interface Connector - Contractor Detail

The following shows the details of the signal and ground contractors. When the connector is disconnected pin R shall be shorted to pin O and pin G shorted to pin B for automatic looping capability. Only those dimensions that are essential to mating are shown.



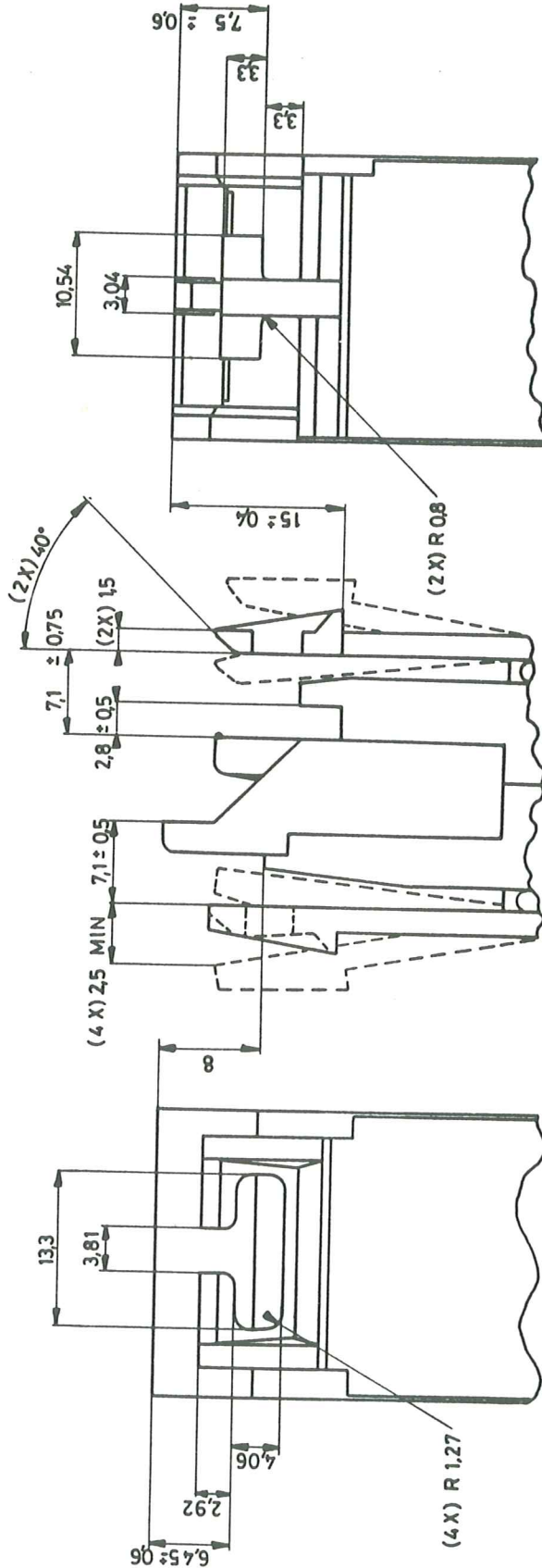
R, G, O, and B are
Pin destinations



Tolerance ± 0,13
unless otherwise specified

7.7.2 Medium Interface Connector - Locking Mechanism Detail

The following shows the locking mechanism of the connector. Only those dimensions that are essential to mating are shown.



Tolerance ± 0,13
unless otherwise specified

APPENDIX A

HIERARCHICAL STRUCTURING FOR LOCALLY-ADMINISTERED ADDRESSES

This appendix is not part of this Standard ECMA-89, and is included for information only.

A.1 General Structure

The following structure provides for a token-ring LAN divided into multiple rings, with one or more MAC-level relay DTEs interconnecting the rings. Structuring MAC addresses in a hierarchical fashion can facilitate the operation of these relay DTEs.

A ring is defined as the collection of all DTEs of a LAN which have the same ring number and which can exchange frames without any intermediary MAC-level relay entity. DTEs on a ring can communicate with DTEs with different ring numbers only through a MAC-level relay or some other intermediary.

A hierarchical address permits a MAC-level relay DTE to recognize frames which require forwarding to other rings by applying a straightforward algorithm to the frames to be forwarded.

The source and destination address partitioning recommended for this purpose is the locally administered hierarchical form.

I/G	1	14-bit ring number	32-bit DTE subaddress
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In addition to the definitions of Broadcast Address and Null Address, the following addressing conventions are recommended :

This ring : The ring number field is set to all ZEROs or to the ring number of this ring, if known

All DTEs, this ring : The ring number field is set to all ZEROs or to the ring number of this ring, if known ; the DTE subaddress field is set to all ONES.

All rings : The ring number field is set to all ONES.

A. 2 Group Addressing Modes

Two formats for group addressing are defined within the structure of hierarchical addressing (as described above), using the first bit of the DTE subaddress field :

0 = bit-significant mode, 1 = conventional group mode

Bit-significant mode

Specifies that each bit in the DTE subaddress field represents a single group address 31 bit-significant addresses may be defined.

DTEs that are to copy frames destined for many different functions may implement a bit-significant mask, to facilitate the copying of frames with bit-significant destination addresses. Such a mask could have a bit set to 1 for each bit-significant address for which the DTE wishes to copy frames.

For example :

Function 'K' has bit-significant address B'0010000'.
Function 'P' has bit-significant address B'0000010'.

Ring DTE 'Y' has bit-significant mask B'0010010',
implying that DTE Y can copy frames destined for both functions K and P.

Conventional Group Mode

Specifies that the remaining bits in the DTE subaddress field represent a single group address. This allows about 2^{31} group addresses in conventional group mode.

The two options are illustrated below.

- (1) Locally administered hierarchical form, bit-significant mode

1	1	14-bit ring number	0	up to 31 bit-significant addresses
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- (2) Locally administered hierarchical form, conventional group mode

1	1	14-bit ring number	1	31-bit conventional group address
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