



AEROSPACE STANDARD	AS4074™	REV. B
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	Superseding AS4074A	
Linear Token Passing Multiplex Data Bus		

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1. SCOPE:

This standard specifies the characteristics of the SAE Linear Token Passing Bus (LTPB) Interface Unit.

The LTPB provides a high reliability, high bandwidth, low latency serial interconnection network suitable for utilization in real time military and commercial applications. Multiple redundant data paths can be implemented to enhance reliability and survivability in those applications which require these attributes. The token passing and data exchange protocols are optimized to provide low latency and fast failure detection and correction. Physical configurations with bus lengths up to 1000 m can be accommodated.

This specification defines the following:

- a. General Description (3.1): An overview of the LTPB protocol.
- b. Physical Media Interface (3.2): This portion of the standard defines the physical interface to both optical and electrical bus media.
- c. Access Protocol Definition (3.3): This portion of the standard defines the symbols, frame formats, timing functions and traffic recording requirements of the Token Passing Interface Unit (TPIU).
- d. Network Protocol Definition (3.4): This portion of the standard defines the network control and station management functions.
- e. Test and Verification (Section 4): This paragraph defines the responsibilities and methods for test and verification of the LTPB.
- f. TPIU State Machine (Section 5): This section defines the TPIU States and state transition rules.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of all SAE Technical Reports shall apply.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR4288	Linear Token Passing Multiplex Data Bus User's Handbook
AS4290 DRAFT	Validation Test Plan for AS4074 linear Token Passing Multiplex Data Bus

2.1.2 Military Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

ISO/DIS 7498	International Systems Organization Open Systems
22 April 1982	Interconnection - Basic Reference Model, Draft International Standard
N1406	Working Draft for an Addendum to ISO 7498 Covering
March 1983	Connectionless Data Transmission

2.2 Acronyms and Abbreviations:

$A_{\max}$	Maximum end-to-end attenuation
$A_{\min}$	Minimum end-to-end attenuation
A_r	Attenuation of reflected signals
bps	Bits per second
BAT	Bus Activity Timer
BIT	Built-In-Test
BIU	Bus Interface Unit
BTO	BAT Timeout
BW	Spectral Bandwidth
CRC	Cyclic Redundancy Check
C/B	Center of Bit
CTLC	Claim Token Limit Counter
dB	Decibel
dBm	Decibel referenced to 1 milliwatt
D_{clad}	Fiber Optic cladding diameter
D_{cm}	Maximum total dispersion
D_{core}	Fiber Optic core diameter
D_{gp}	Group propagation delay difference
D_j	Jitter
DA	Destination Address field (may contain physical or logical address depending on frame type)
exp	Exponential value (raised to the power)
ED	End Delimiter
ELRX	Electrical Receiver
ELTX	Electrical Transmitter
ERA	Bus A Error
ERB	Bus B Error
E/T	End of Transmission
F	Frequency
FC	Frame Control
FORX	Fiber Optic Receiver
FOTX	Fiber Optic Transmitter
FT	Frame Type
FW	Filter Word
GCD	Global Clock Differential

2.2 (Continued):

HEX	Hexadecimal
INFO	Information Field
JIAWG	Joint Integrated Avionic Working Group
KHz	Kilohertz
LC	Load Configuration
LLC	Logical Link Control
LTPB	Linear Token Passing Bus
m	Bit position in FW field
M	Optical Margin
MAC	Media Access Control
Mbaud	Megabaud
Mbps	Megabits per Second
MER	Message Error
MFCS	Message Frame Check Sequence
MHz	Megahertz
MIU	Media Interface Unit
MPDU	Message Protocol Data Unit
MSA	Maximum Station Address in logical ring
N _{ct}	Number of words in Claim Token Frame
NA	Numerical Aperture
NSA	Next Station Address in logical ring
P	Preamble
P _r	Receiver Minimum Valid Preamble Length
P _t	Transmitter Preamble Length
Px	Priority
PDU	TPIU Protocol Data Unit
PSA	Physical Station Address
R _{ber}	Receiver Bit Error Rate
R _{cmr}	Receiver Common Mode Rejection Ratio
R _d	Data Rate (Mbps)
R _f	Receiver Maximum Fall Time (90% to 10%)
R _{idr}	Receiver Intertransmission Dynamic Range
R _{iz}	Receiver Input Impedance
R _{nv}	Receiver Noise Voltage Input
R _{or}	Receiver Operating Range
R _{ous}	Receiver Combined Over/Undershoot
R _p	Receiver Optical Power Input
R _{pwd}	Receiver Input Maximum Pulse Width Distortion
R _{pm}	Receiver Minimum Optical Power Input
R _{po}	Receiver Maximum Optical Power Input
R _r	Receiver Maximum Rise Time (10% to 90%)
R _s	Signaling Rate

2.2 (Continued):

R _{tm}	Start-of-Bit to Center-of-Bit
R _{to}	Start-of-Bit to Start-of-Bit
R _{vm}	Receiver Minimum Input Voltage
R _{vo}	Receiver Maximum Input Voltage
R _x	Receiver
RAT	Ring Admittance Timer
RC	Report Configuration
RQF	Receive Queue Full
RS	Report Status
RT	Report Time
RMT	Redundant Media Timeout
RMS	Redundant Media Skew Error
RMS	Root Mean Square
RPB	Receiver Primary Bus
RPE	Receiver Parity Error
RXE	Receiver Enable
RXM	Receive Message Available
S _d	Surge Voltage Duration
Sitg	System Minimum Intertransmission Gap
S _v	Surge Voltage
S ₀	Idle State
S ₁	Claim Token State
S ₂	Check Token Address State
S ₃	Send Message State
S ₄	Pass Token State
S ₅	Check Token Pass State
S ₆	Check Message Address State
S ₇	Receive Message State
SA	Source Address
SD	Start Delimiter
S/B	Start-of-Bit
S/T	Start-of-Transmission
SMC	Station Management Code
T _{ba}	Bus Activity Indication Time
T _d	Clock Maximum Uncompensated Drift Rate
T _{pwd}	Transmitter Maximum Pulse Width Distortion
T _{ds}	Data Streaming Timer
T _f	Transmitter Maximum Fall Time (90% to 10%)
T _{iz}	Transmitter Drive Impedance
T _m	Minimum Duration between Transitions
T _{ms}	Master and Most Distant Slave Station (Global Timer)
T _o	Nominal Bit Time
T _{ous}	Transmitter Combined Over/Undershoot
T _{pd}	Propagation Delay Time
T _{pl}	Transmitter Optical Leakage Power
T _{po}	Transmitter Optical Power
T _{pr}	Transmitter Residue Power
T _r	Transmitter Maximum Rise Time (10% to 90%)

2.2 (Continued):

T _{sk}	Transmitter Redundant Media Skew Time
T _{sr}	Maximum Station Response Time
T _{tm}	Transmitter Minimum Signaling Duration
T _{to}	Transmitter Nominal Bit Time
T _{tp}	Token Passing Time Value
T _u	Time Master Update Rate (milliseconds)
T _{vo}	Transmitter Output Voltage Level
T _{vr}	Transmitter Peak Output Voltage
T _x	Transmitter
TBD	To Be Determined
TFCS	Token Frame Check Sequence
THT	Token Holding Timer
TIME	Global Clock Value (48 bits)
TPIU	Token Passing Interface Unit
TMA	Transmit Message Aborted
TMD	Time Master Disable
TME	Time Master Enable
TPE	Transmitter Parity Error
TPT	Token Passing Timer
TRT	Token Rotation Timer
TRTx	Token Rotation Timer (for priority level "x")
TS	This Station
TSM	Time Synchronization Message
TTA	Bus A Transmission Monitor Timeout
TTB	Bus B Transmission Monitor Timeout
TTO	TPT Timeout
TXE	Transmitter Enable
TXM	Transmit Message
W1	Optical Wavelength Lower
W2	Optical Wavelength Upper
WC	Word Count
WCE	Message Word Count Error

3. GENERAL REQUIREMENTS:

3.1 General Description:

The LTPB shall consist of a set of stations connected by a broadcast transmission medium - that is, each station which transmits shall be heard by all of the other stations. Stations shall accept a transmission based upon either physical or logical addressing mechanisms.

The functional block diagram for the LTPB is shown in Figure 3.1-1 along with its relationship to the ISO OSI Basic Reference Model. It shall consist of the following elements:

- a. **Physical Media:** The Physical Media shall be composed of 1 or 2 physical bus paths. Each bus path shall be characterized as a broadcast medium.

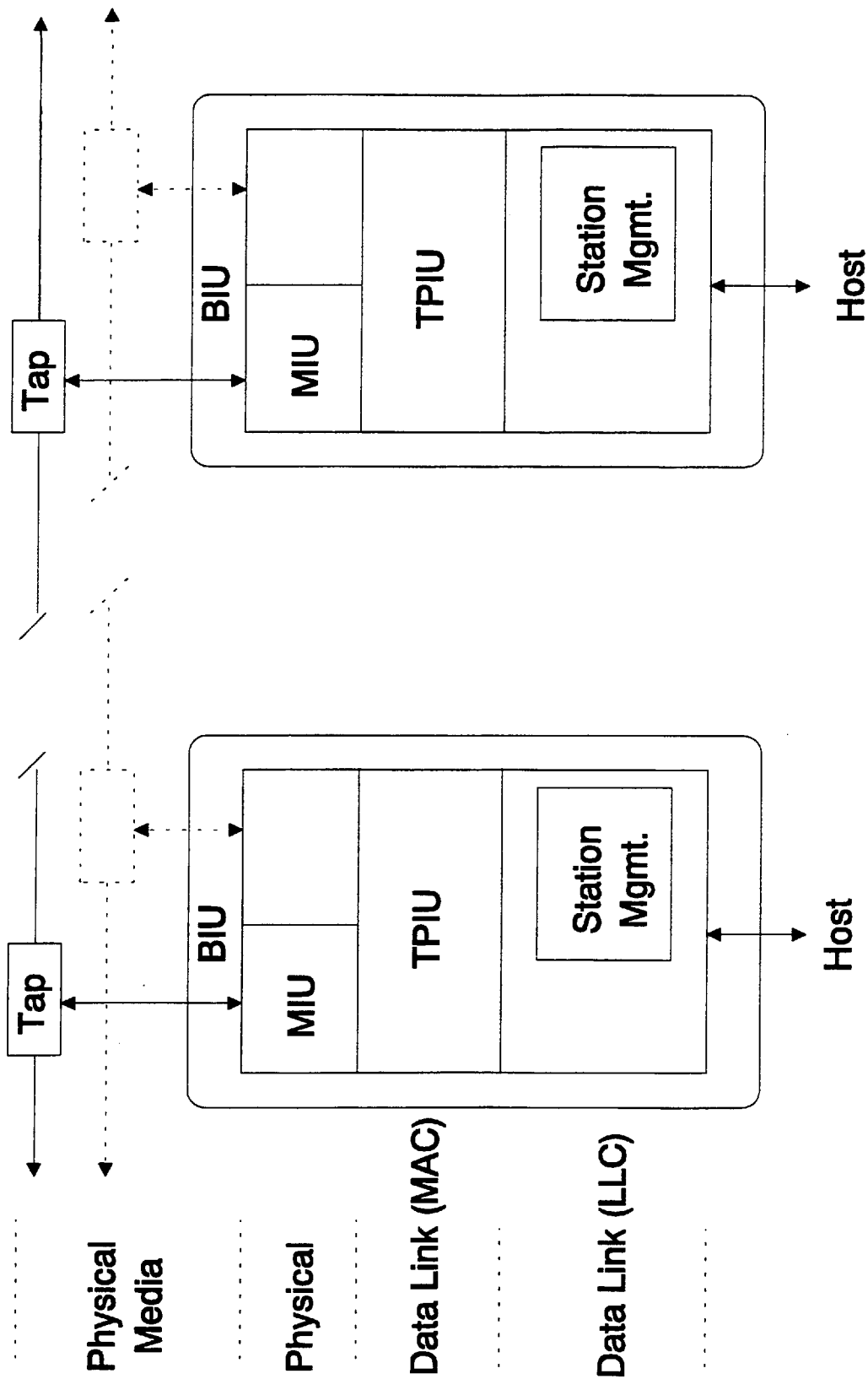


FIGURE 3.1-1 - Linear Token Passing Bus Block Diagram

3.1 (Continued):

- b. **Bus Interface Unit (BIU):** The BIU interfaces to the bus media and the Host. Each bus path shall be an independent entity requiring a Media Interface Unit (MIU). One TPIU shall serve all implemented MIUs. The remainder of the BIU shall perform station management, network management, and Host interface functions.

3.1.1 **Media Access:** Access to the media shall be controlled by the Token. The Token is continually passed around a logical ring (see Figure 3.1-2) superimposed on the linear bus. A station receiving the Token gains the right to make a transmission on the medium for a certain amount of time. This amount of time depends upon the following quantities:

- a. Value of the Token Holding Timer (THT), used for all messages of priority 0, as well as;
- b. The residual value of the Token Rotation Timers (TRTs), one for each priority from 1 to 3.

This amount of time shall always be less than or equal to a predetermined maximum value. When this amount of time has expired, or the station has sent all of its messages, then the station shall forward the Token to the next member of the logical ring.

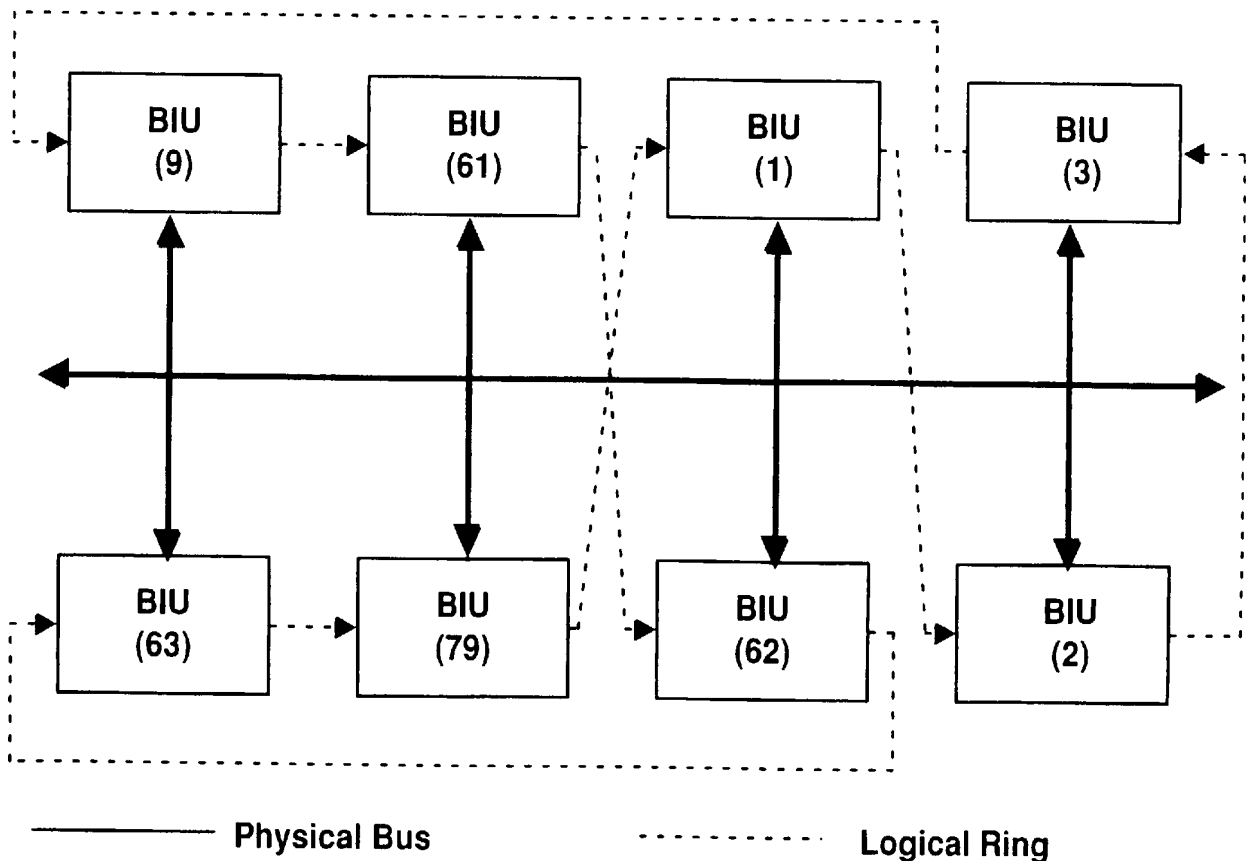


FIGURE 3.1-2 - Logical Ring Superimposed on a Linear Bus

- 3.1.2 Low Latency for High Priority Messages: Low latency for high priority messages shall be assured by the use of message priority TRTs. A station which has a message at the highest priority (Priority 0) shall always send that message when it receives the Token. Priority 0 messages continue to be sent until there are no Priority 0 messages or the THT expires. If that station has lower priority messages to send, it will send those messages as long as the TRT associated with that priority level has not expired. Otherwise, the station must forward the Token to its successor. In this way the token passing bus users shall defer to higher priority traffic when the traffic load becomes heavy.
- 3.1.3 Station Failures: Station failures shall be handled by the station immediately preceding the failed station in the logical ring sequence. The station passing the Token shall verify that there is Bus Activity. After two consecutive attempts at passing the Token the station shall automatically increment the destination address in the Token and try again. This incremental bridging shall continue until the station finds a successor or the destination address wraps around and matches the local station address, at which time the station shall cease its attempts to find a successor.
- 3.1.4 Logical Ring Admittance: Stations shall be allowed admittance to the logical ring on a periodic basis. Each station shall contain a Ring Admittance Timer (RAT). When this timer expires and there is a gap between the local station's address and that of its successor then the Token shall be passed to the sequential address following that of the local station. The normal Token passing rules shall then be applied. Therefore, if any of the stations in the gap desire admittance they shall be granted an opportunity during this time period.
- 3.1.5 Logical Ring Initialization: Initialization of the logical ring shall occur after the Token is lost or upon power up. Each station which powers up and completes its own internal diagnostic and startup procedures shall activate a Bus Activity Timer (BAT). If the station hears any bus activity it shall reset this timer. This indicates that some portion of the logical ring is active and the station shall defer to this activity. The station may receive a valid Token, addressed to it, because the RAT of a station numerically preceding it in the logical ring has expired. In this case, the station shall begin to hunt for a successor using the normal Token passing rules. If the BAT expires, the station shall attempt to gain control of the Token. It shall transmit a frame whose length is determined by the station address. After completing its transmission and waiting for a suitable period (based upon bus length) it shall listen. If the station hears any other transmission, it has lost the claiming process and shall wait for the Token. If the station hears nothing it shall assume that it has won the Token and begin to hunt for a successor. In this case the normal Token passing rules shall apply.

- 3.1.6 System Monitor: System Monitoring shall be provided by monitoring of the passage of the Token throughout the logical ring and Station Management status messages. The Host shall be notified whenever a change has occurred or when commanded to do so. Station Management status messages shall be utilized by a station to report specific, non-fatal, failures such as a receiver failure, transmitter failure, etc.

3.2 Media Interface Unit (MIU):

The MIU shall provide connection between the TPIU and the bus medium. One MIU shall be required for each bus path. This section defines the following characteristics of the MIU:

- a. Symbol Set
- b. Transmitter, Receiver, and Media Characteristics
- c. Media Redundancy Requirements
- d. Transition Monitoring

This standard shall encompass both fiber optic and electrical transmission media, as well as redundant data paths, if necessary.

The general characteristics of the MIU shall be as defined in this section. Specific parameter values for each characteristic of the interface are summarized in tabular form as slash sheets referenced in Appendix A.

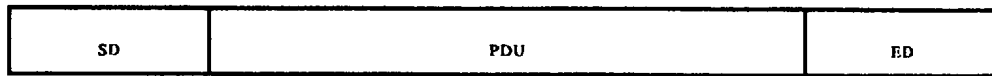
- 3.2.1 Symbol Set: The peer TPIU entities exchange Protocol Data Units via the MIU. The MIU provides the direct interface to the media through the following:

- a. Line States
- b. Control Symbols
- c. Data Symbols
- d. Violation Symbols

- 3.2.1.1 Line States: Two line states (mutually exclusive) are defined for the physical medium:

- a. Quiet/Idle: Indicates the state of the medium when no Bus Activity is present.
- b. Active: Indicates that a signal is being transmitted on the physical medium. This is defined by the presence of at least three signal transitions in a period of 4 bit times.

- 3.2.1.2 Control Symbols: Control symbols serve to synchronize the receiver to the signal and to delimit the boundaries of the TPIU Protocol Data Unit (PDU). The overall format of every frame which is transmitted on the media shall be as illustrated in Figure 3.2.1.2-1.



SD - START DELIMITER
PDU - TPIU PROTOCOL DATA UNIT
ED - END DELIMITER

FIGURE 3.2.1.2-1 - Overall Frame Structure

Three control symbols are defined (see slash sheets referenced in Appendix A for the specific format and length of these symbols):

- a. Preamble (P): The MIU shall append a preamble to the beginning of every transmission which is placed on the medium. Only one preamble shall be sent per transmission, which consists of zero, one, or more Message Frames followed by a Token Frame, or a Claim Token Frame of the structure shown in Figures 1.2-1 and 3.3.1-1. The receiving MIU shall use the preamble to stabilize its receiver to the amplitude and frequency of the incoming signal, but shall not pass any of it to the TPIU. Because part of the preamble may be lost in the media, both the transmitted length and the minimum length for the receiver to stabilize are specified. The transmitted preamble length shall be equal to PT data bits with a format as specified in the appropriate slash sheet referenced in Appendix A. The receiver shall work properly with any preamble which is at least PR consecutive bits immediately prior to the Start Delimiter (SD) conforming to the waveform limits of 3.2.2.1.3.4 and 3.2.2.2.3.1.
 - b. Start Delimiter (SD): The SD shall uniquely define the beginning of the TPIU PDU. It shall be appended to the front of the PDU by the sending MIU prior to transmission. The receiving MIU shall align itself to the PDU by detecting the SD. The SD shall be removed from the frame by the receiving MIU prior to passing the PDU to the TPIU.
 - c. End Delimiter (ED): The ED shall uniquely define the end of the TPIU PDU. It shall be appended to the end of the frame by the sending MIU after transmission of the PDU. The receiving MIU shall terminate the reception of the PDU by detecting the ED. The ED shall be removed from the frame by the receiving MIU prior to passing the PDU to the TPIU.
- 3.2.1.3 Data Symbols: Each Data Symbol shall convey 1 or more binary digits. The specific encoding method shall be as defined in the slash sheets referenced in Appendix A.

3.2.1.4 Invalid Symbols: An Invalid Symbol shall be defined as any activity detected on the physical medium which does not conform to any of the defined symbols.

3.2.2 Transmitter, Receiver, and Media Characteristics: Two types of bus media interfaces may be defined as follows:

- a. Fiber Optic Bus Media Interface Characteristics
- b. Electrical Bus Media Interface Characteristics

3.2.2.1 Fiber Optic Bus Media Interface Characteristics: The fiber optic bus media interface characteristics shall be specified in four groups as follows:

- a. Common Characteristics
- b. Transmitter Characteristics
- c. Receiver Characteristics
- d. Transmission Media Characteristics

The general requirements for these characteristics are defined in 3.2.2.1.1 through 3.2.2.1.4. Specific numerical values for all quantities shall be as given in slash sheets referenced in Appendix A.

3.2.2.1.1 Fiber Optic Media Common Characteristics: The characteristics common to the transmitter, receiver, and medium, and independent of the specific implementation shall be as given in this paragraph. They shall include:

- a. MIU Input/Output Ports
- b. Data Rate
- c. Signaling Rate
- d. System Minimum Intertransmission Gap
- f. Wavelength and Spectral Bandwidth

3.2.2.1.1.1 Fiber Optic Media Station Input/Output Ports: Each MIU shall have a receiver input port and transmitter output port. Other signals, such as control or power, if required, shall be provided as specified in the slash sheet. A short circuit on any electrical signal shall not result in damage to the BIU.

3.2.2.1.1.2 Fiber Optic Media Data Rate: The data rate for continuous transmission shall be R_d Mbps. The nominal bit time shall be T_o nanoseconds ($T_o = 1000/R_d$)

3.2.2.1.1.3 Fiber Optic Media Signaling Rate: The signaling rate for continuous transmission on the fiber optic medium shall be R_s Mbaud. The minimum duration between transitions shall be T_m nanoseconds ($T_m = 1000/R_s$).

- 3.2.2.1.1.4 Fiber Optic Media System Minimum Intertransmission Gap: Under control of the TPIU, an optical transmitter shall remain in the off state between successive transmissions such that a system minimum intertransmission gap is guaranteed at the receiver. The optical receiver shall operate as specified in Section 3.2.2.1.3 with an intertransmission gap of S_{itg} nanoseconds under the worst case condition where the full intertransmission dynamic range R_{idr} exists between the end bit of the previous message and the start bit of the next message.
- 3.2.2.1.1.5 Fiber Optic Media Wavelength and Spectral Bandwidth: The nominal wavelength of the emitted optical radiation shall be in the range $W1$ to $W2$ nanometers. The spectral bandwidth shall be less than BW nanometers as measured between the 3 dB power points. Therefore, the extreme (3 dB) power points must both lie within $W1 - BW/2$ and $W2 + BW/2$.
- 3.2.2.1.2 Fiber Optic Transmitter (FOTX) Characteristics: This section defines the general characteristics which are applicable to the FOTX of the MIU. These characteristics shall be measured at the output port of the MIU.
- 3.2.2.1.2.1 FOTX Output Power: The optical output power shall be T_{po} dBm in the spectral range $W1 - BW/2$ to $W2 + BW/2$. This parameter shall be measured for a continuous transmission at R_s Mbaud and shall constitute the peak optical power.
- 3.2.2.1.2.2 FOTX Maximum Residual Power: During any signaling event time slot corresponding to the off time of the optical source, the peak optical power shall reach a value of less than T_{pr} dBm peak in the spectral range $W1 - BW/2$ to $W2 + BW/2$.
- 3.2.2.1.2.3 FOTX Maximum Leakage Power: When any transmitting station completes its transmission, or is commanded not to transmit, its leakage power shall be less than T_{pl} dBm peak in the spectral range $W1 - BW/2$ to $W2 + BW/2$. This requirement shall also be satisfied during power up and power down conditions.
- 3.2.2.1.2.4 FOTX Output Waveform: The transmitter shall produce a waveform within the limits shown in Figure 3.2.2.1.2.4-1 after application of the appropriate parameter values from the slash sheets referenced in Appendix A. There shall be no reversal of the signal during the 10% to 90% and 90% to 10% transition periods. Mid- and End-Bit mid-amplitude crossings shall deviate less than T_{pwd} from the ideal crossing point as measured from the previous crossing point. The rise times and fall times shall be less than T_r and T_f nanoseconds, respectively, as measured between the 10% and 90% points. Waveform distortion due to the cumulative effects of undershoot, overshoot, and ringing shall be less than T_{ous} .

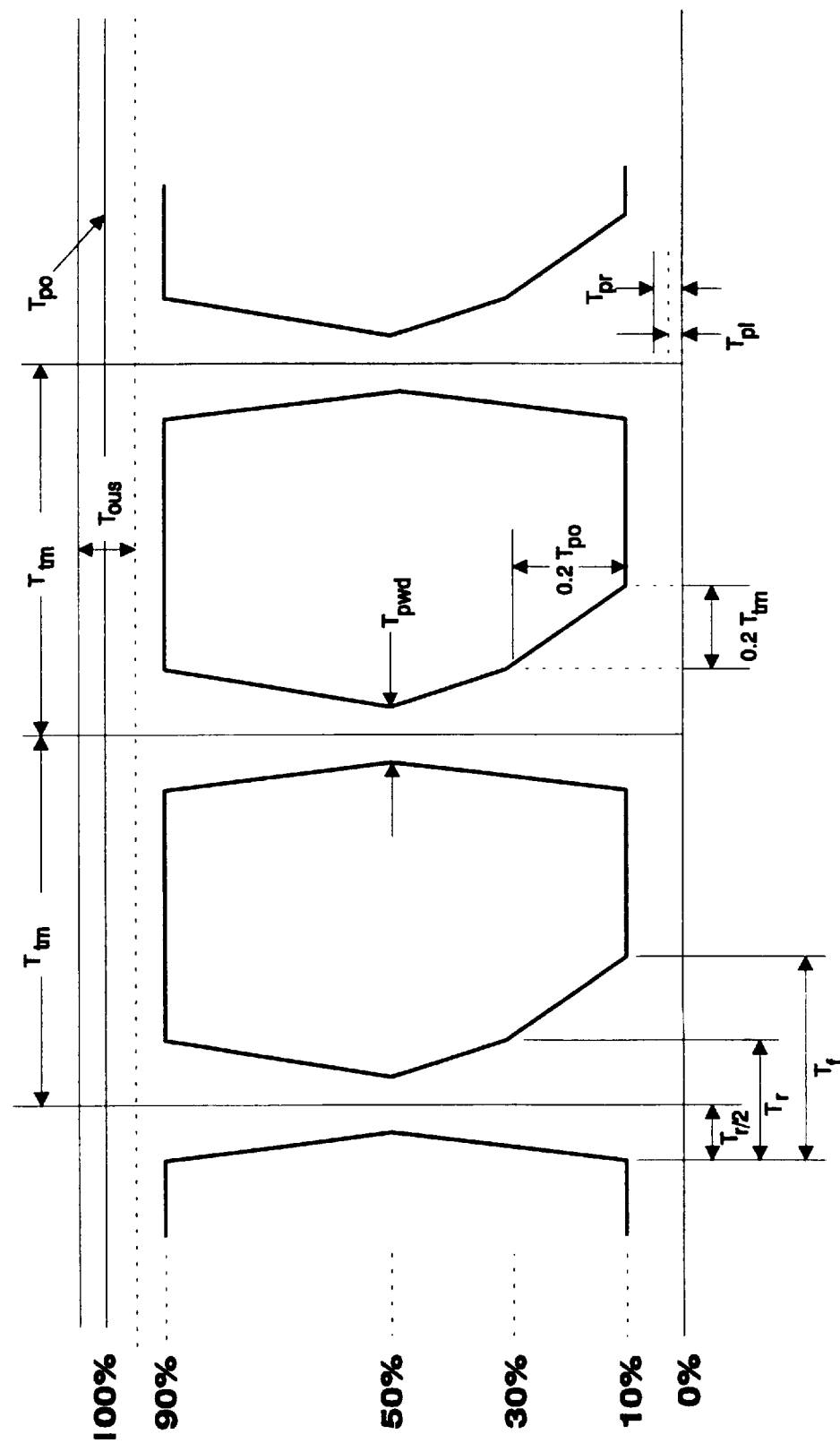


FIGURE 3.2.2.1.2.4-1 - Fiber Optic Transmitter Output Waveform

- 3.2.2.1.2.5 FOTX Data Streaming Timeout: The transmitted signal shall be monitored. If the transmission does not cease within T_{ds} after its start, the transmitter shall shut down and indicate a fault condition to the TPIU. No further transmission from that faulty MIU shall occur until a positive clear signal has been received from the TPIU.
- 3.2.2.1.3 Fiber Optic Receiver (FORX) Characteristics: This section specifies the general characteristics of the FORX of the MIU. These characteristics shall be measured at the input port to the MIU.
- 3.2.2.1.3.1 FORX Sensitivity: The optical receiver shall operate at no greater than the maximum bit error rate R_{ber} with a received optical power of R_{pm} dBm. The received power shall be the minimum steady state peak power level, during the optical signal high state, required for the receiver to correctly signal an output logic level high state.
- 3.2.2.1.3.2 FORX Operating Range and Margin: The optical receiver shall operate as specified in 3.2.2.1.3.3 with any input signal ranging from R_{pm} dBm to $R_{pm} + R_{or}$ dBm. R_{or} shall be the Operating Range, in dB, of the receiver. The Operating Range shall not be confused with the Receiver Intertransmission Dynamic Range, R_{idr} , or interpreted as the optical margin between the transmitter and receiver. The optical margin (M) shall be defined as the difference between the mean Transmitter Peak Optical Power (Signal High) and the Receiver Minimum Optical Power Input (see Equation 1):

$$M = T_{po} - R_{pm} \text{ dB} \quad (\text{Eq.1})$$

Optical margin shall be utilized for determining the required loss characteristics of the bus transmission system. Refer to Figure 3.2.2.1.3.2-1 for clarification.

In no case shall the receiver be impaired, or otherwise damaged, by an optical input up to R_{po} dBm, a condition which may occur during Token Claim.

- 3.2.2.1.3.3 FORX Bit Error Rate: The overall bit error rate shall be less than R_{ber} . This error rate shall be sustained for the worst case waveforms and over the entire operating range of the receiver which includes signal variations up to the intertransmission dynamic range.
- 3.2.2.1.3.4 FORX Input Waveform: The receiver shall correctly process the optical input waveform shown in Figure 3.2.2.1.3.4-1 after application of the appropriate parameter values as specified in the slash sheets referenced in Appendix A.

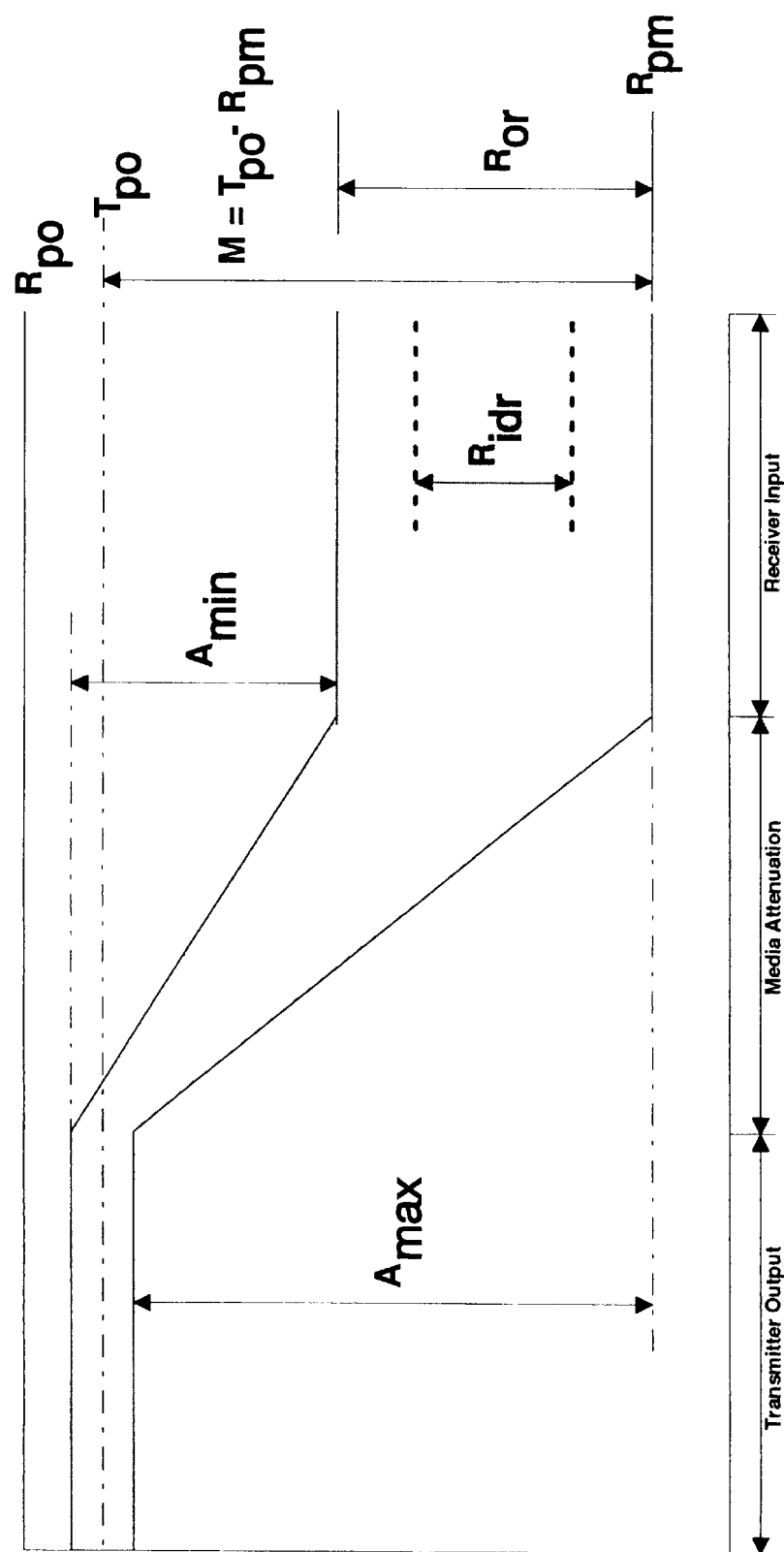


FIGURE 3.2.2.1.3.2-1 - Transmitter/Receiver Optical Power Levels

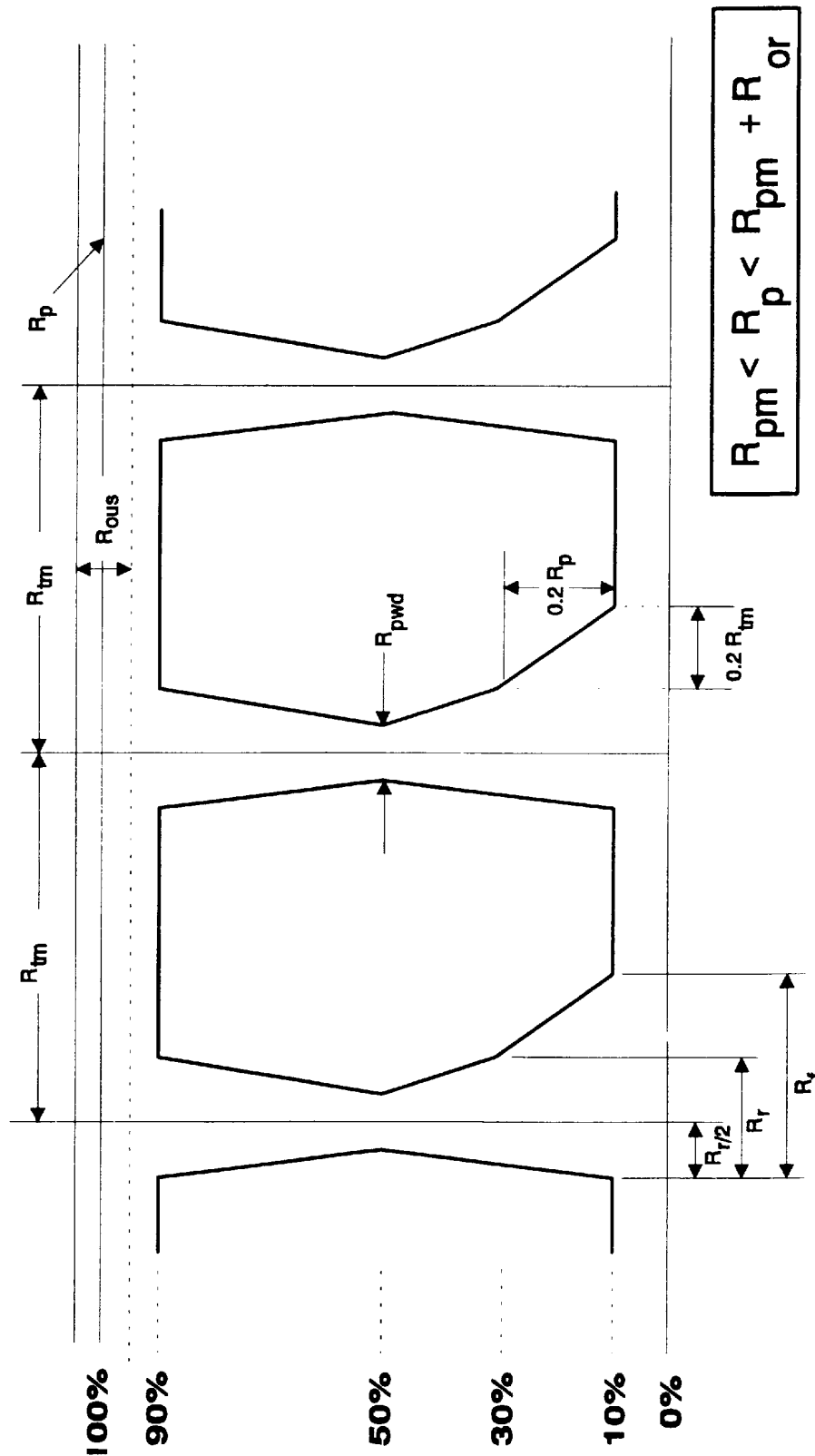


FIGURE 3.2.2.1.3.4-1 – Fiber Optic Receiver Input Waveform

- 3.2.2.1.4 Fiber Optic Media Characteristics: A minimum set of fiber optic transmission medium characteristics shall be specified in order to insure interoperability between stations in the same system:
- Physical Characteristics
 - Numerical Aperture
 - Chromatic and Modal Dispersion
 - Attenuation
- 3.2.2.1.4.1 Fiber Optic Media Physical Characteristics: The optical fiber utilized shall have a core diameter of D_{core} micrometers and a cladding diameter of D_{clad} micrometers.
- 3.2.2.1.4.2 Fiber Optic Media Numerical Aperture: The minimum numerical aperture of the fiber, measured in accordance with the applicable standard, shall be at least NA.
- 3.2.2.1.4.3 Fiber Optic Media Chromatic and Modal Dispersion: The total dispersion (chromatic and multimode) due to the fiber optic transmission medium components between any transmitter and receiver shall not exceed D_{cm} (nanoseconds). D_{cm} shall be interpreted as the 10% to 90% rise time of the received optical pulse when the medium is excited by an optical step waveform meeting the characteristics in 3.2.2.1.2.4.
- 3.2.2.1.4.4 Fiber Optic Media Attenuation: The optical transmission system (including all connectors, fiber optic cable, and access couplers, and other transmission components) shall have a minimum end-to-end attenuation of A_{min} dB and a maximum attenuation of A_{max} dB, as measured between any two ports to the transmission system.
- 3.2.2.2 Electrical Bus Media Interface Definition: The Electrical Bus Media Interface shall be specified in four groups as follows:
- Common Characteristics
 - Transmitter Characteristics
 - Receiver Characteristics
 - Transmission Characteristics
- The electrical characteristics are specified generically with specific numerical requirements being defined in slash sheets referenced in Appendix A.
- 3.2.2.2.1 Electrical Bus Media Interface Characteristics: The characteristics common to the transmitter, receiver, and medium, and independent of the specific implementation shall be given in this paragraph. They shall include:
- Station Input/Output Ports
 - Data Rate
 - Signaling Rate
 - System Minimum Intertransmission Gap
 - Surge Voltage

- 3.2.2.2.1.1 Electrical Media Station Input/Output Ports: Each MIU shall have a receiver input port and transmitter output port. Other signals, such as control or power, if required, shall be provided as specified in the slash sheet. A short circuit on any electrical signal shall not result in damage to the BIU.
- 3.2.2.2.1.2 Electrical Media Data Rate: The data rate for continuous transmission on the electrical media shall be R_d Mbps. The bit symbol period shall be T_o nanoseconds ($T_o=1/R_d$).
- 3.2.2.2.1.3 Electrical Media Signaling Rate: The signaling rate for continuous transmission on the electrical medium shall be R_s Mbaud. The minimum duration between transitions shall be T_m nanoseconds ($T_m = 1000/R_s$).
- 3.2.2.2.1.4 Electrical Media System Minimum Intertransmission Gap: Under control of the TPIU, the electrical transmitter shall remain in the off state between successive transmissions such that a system minimum intertransmission gap is guaranteed at the receiver. The electrical receiver shall operate correctly with an intertransmission gap of S_{itg} nanoseconds under the worst case condition where the full intertransmission dynamic range R_{idr} exists between the end of the previous message and the start of the next message.
- 3.2.2.2.1.5 Electrical Media Surge Voltage: The transmitter and receiver shall survive a surge voltage level of S_v volts for a duration of S_d milliseconds without damage. Normal operation shall return within S_d milliseconds after the surge voltage condition has terminated.
- 3.2.2.2.2 Electrical Transmitter (ELTX) Characteristics: This section defines the general characteristics which are applicable to the ELTX of the MIU. These characteristics shall be measured at the output port of the MIU. They are as follows:
- Output Voltage level
 - Peak Residual Output Voltage Level
 - Output Waveform
 - Data Streaming Timeout
- 3.2.2.2.2.1 ELTX Output Voltage Level: The transmitter shall generate a peak to peak output voltage level of $2 \cdot T_{vo}$ as measured from line-to-line at the MIU port for a continuous wave signal in the frequency range of W1 to W2 MHz. The transmitter shall maintain an output impedance level of T_{iz} ohms in the powered or unpowered state over the frequency range of W1 to W2 MHz.
- 3.2.2.2.2.2 ELTX Peak Residual Output Voltage Level: The peak output voltage level of the transmitter in the off state shall be less than $|2 \cdot T_{vr}|$ volts as measured from line-to-line at the MIU port. This level shall be maintained during power-up, power-down, master clear, and all other situations where the transmitter is in the off condition. This voltage level shall also be achieved within $5.5 \cdot T_o$ after the last mid-bit transition of the last symbol of a frame.