
High Speed Ring Bus

(HSRB) Standard

AS4074.2

CANCELLED

Documents
Jan 17 2023
Document Sharing Hub

Linear Token Passing Multiplex Data Bus

SAE also publishes the Linear Token Passing Multiplex Data Bus Standard. This method 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 that 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 length up to 1000 meters can be accommodated.

RECEIVED
JAN 19 1993



Submitted for recognition as an American National Standard

HIGH SPEED RING BUS (HSRB) STANDARD

CONTENTS

Page No.

1. SCOPE	7
2. REFERENCED DOCUMENTS	7
3. GENERAL REQUIREMENTS	7
3.1 General Description	7
3.1.1 Ring station	7
3.1.2 Ring interface module	8
3.1.3 Ring control	8
3.1.4 Ring access	8
3.1.5 Data coding	11
3.1.6 Station addressing	11
3.1.7 Message acknowledgement	11
3.1.8 Message priority levels	11
3.1.9 Types of service	11
3.1.10 Adaptability	12
3.1.11 Media requirements	12
3.1.12 Error & fault detection & recovery	12
3.1.13 Loop back	12
3.1.14 Reconfiguration	12
3.1.15 Synchronization	14
3.1.16 Dual ring HSRB	14

SAE Technical Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

	<u>Page No.</u>
3.2 Operational Requirements	14
3.2.1 Serial transmission	14
3.2.2 Word length	14
3.2.3 Message length	14
3.2.4 Electrical isolation	14
3.2.5 Self test	14
3.3 Performance Requirements	14
3.3.1 Station delay	14
3.4 Semantics	14
3.4.1 Entities	14
3.4.2 Symbols	15
3.4.3 Protocol data units	16
3.4.3.1 Token frame	16
3.4.3.2 Message frame	18
3.4.3.3 Beacon frame	19
3.4.4 Fields	19
3.4.4.1 Token starting delimiter (TSD) field	19
3.4.4.2 Control (CON) field	20
3.4.4.2.1 Priority (PR) sub-field	20
3.4.4.2.2 Token Status 1 (TS1) sub-field	20
3.4.4.2.3 Short Message Count (SMC) sub-field	21
3.4.4.2.4 Token Status 2 (TS2) sub-field	21
3.4.4.2.5 Reservation (RES) sub-field ...	21
3.4.4.3 Token ending delimiter (TED) field	22
3.4.4.4 Interframe Adjustment (IFA) field	22
3.4.4.5 Message Frame Starting Delimiter (MFSD) field	22
3.4.4.6 Priority and Retry Status (PRS) field	22
3.4.4.6.1 Message Priority (PRM) sub-field	23
3.4.4.6.2 Retry Status Indicator (RSI) sub-field	23
3.4.4.7 Word count (WC) field	23
3.4.4.8 Sending Address (SA) field	24
3.4.4.9 Address Control (AC) field	24

Page No.

3.4.4.9.1	Logical-Physical (LP) sub-field	24
3.4.4.9.2	Address Word Count (AWC) sub-field	24
3.4.4.10	Global Address (GA) field	25
3.4.4.10.1	Global Address Physical (GAP) sub-field	25
3.4.4.10.2	Global Address Logical (GAL) sub-field	25
3.4.4.11	Destination Address (DA) field	26
3.4.4.11.1	Destination Address Physical (DAP) sub-field	26
3.4.4.11.2	Destination Address Logical (DAL) sub-field	26
3.4.4.12	Message Control Frame Check Sequence (MCFCS) field	27
3.4.4.13	Information (INFO) field	28
3.4.4.14	Information Frame Check Sequence (IFCS) field	29
3.4.4.15	Message Frame Ending Delimiter (MFED) field	29
3.4.4.16	Frame Status (FS) field	29
3.4.4.16.1	Message Control Error Detected 1 (MCED1) sub-field ..	30
3.4.4.16.2	Message Acknowledged 1 (ACK1) sub-field	30
3.4.4.16.3	Message Received 1 (RCVD1) sub-field	30
3.4.4.16.4	Information Error Detected 1 (IED1)	31
3.4.4.16.5	Message Control Error Detected 2 (MCED2) sub-field ..	31
3.4.4.16.6	Message Acknowledged 2 (ACK2) sub-field	31
3.4.4.16.7	Message Received 2 (RCVD2) sub-field	32
3.4.4.16.8	Information Error Detected 2 (IED2) sub-field	32
3.4.4.17	Beacon Frame Starting Delimiter (BFSD) field	32
3.4.4.18	Beacon Control (BCON) field	33
3.4.4.18.1	Beacon Type (BT) sub-field	33
3.4.4.18.2	Beacon Path Indicator (BPI) sub-field	33

	<u>Page No.</u>
3.4.4.19 Highest Known Address (HKA) field	34
3.4.4.20 Station Count (SC) field	34
3.4.4.21 Beacon Frame Check Sequence (BFCS) field ...	34
3.4.4.22 Beacon Frame Ending Delimiter (BFED) field	35
3.5 Protocols	35
3.5.1 Protocol state definitions	35
3.5.1.1 S1: Unconnected	35
3.5.1.2 S2: Reconfigured	37
3.5.1.3 S3: Inactive Ring	38
3.5.1.4 S4: Repeater Ring	38
3.5.1.5 S5: Active Ring	39
3.5.1.6 Unconnected state substate	39
3.5.1.6.1 S1.1: Unpowered	41
3.5.1.6.2 S1.2: Powered	41
3.5.1.6.3 S1.3: Quiescent	42
3.5.1.6.4 S1.4: Wait	42
3.5.1.6.5 S1.5: Synchronization	43
3.5.1.6.6 S1.6: Listen	43
3.5.1.7 Reconfiguration state substates	44
3.5.1.7.1 S2.1: Reconfiguration Initialization	44
3.5.1.7.2 S2.2: Vie	44
3.5.1.7.3 S2.3: Clock Master Configuration	47
3.5.1.7.4 S2.4: Clock Slave Configuration	47
3.5.1.8 Inactive Ring state substates	49
3.5.1.8.1 S3.1: Inactive	49
3.5.1.9 Repeater Ring state substates	49
3.5.1.9.1 S4.1: Repeater	50
3.5.1.10 Active Ring state substrates	50
3.5.1.10.1 S5.1: Await Token Starting Delimiter	50
3.5.1.10.2 S5.2: Check Token Priority ...	52
3.5.1.10.3 S5.3: Reserve Token Priority	54
3.5.1.10.4 S5.4: Repeat Message	55
3.5.1.10.5 S5.5: Token Claim	58

		Page No.
	3.5.1.10.6 S5.6: Originate Message	59
	3.5.1.10.7 S5.7: Issue Token	60
	3.5.1.10.8 S5.8: Strip Message	62
	3.5.1.10.9 S5.9: Check Beacon	64
	3.5.1.10.10 S5.10: Warm Start	65
3.5.2	Priority operation	66
3.5.3	Multiple short message frame option	67
	3.5.3.1 Long message	67
	3.5.3.2 Short message	67
	3.5.3.3 Short message count	68
3.5.4	Bus acquisition	68
3.5.5	Message frame transmission	68
3.5.6	Message frame stripping	68
3.5.7	Token issuance	69
3.5.8	Types of service	69
3.5.9	Message frame retry	69
3.5.10	Station operation	69
	3.5.10.1 Master station	69
	3.5.10.2 Clock slave station	70
	3.5.10.3 Message originating station	70
	3.5.10.4 Active repeater station	70
3.5.11	Message receipt	70
3.5.12	Error detection and recovery	71
	3.5.12.1 Information error	71
	3.5.12.2 Message control error	71
	3.5.12.3 Priority too high	71
	3.5.12.4 Token status errors	71
	3.5.12.5 Starting delimiter errors	71
	3.5.12.6 Token format errors	72
	3.5.12.7 Priority too low	72
	3.5.12.8 Reservation too high	72
	3.5.12.9 Reservation too low	72
	3.5.12.10 Short message count errors	72
	3.5.12.11 Time-outs	72
	3.5.12.11.1 Loop Timer	72
	3.5.12.11.2 Lost Token Starting Delimiter counter	73
	3.5.12.11.3 Lost Free Token Counter	73
	3.5.12.11.4 Uncontrolled Transmit Inhibit timer	73
	3.5.12.11.5 Beacon Loop Timer	73
	3.5.12.12 Warm Start	74

	<u>Page No.</u>
3.5.13 Station insertion	74
3.5.14 Loss or acquisition of input	74
3.5.15 Reconfiguration (Beacon mode)	74
3.5.15.1 General RIU operation	75
3.5.15.1.1 Beacon field update rules	75
3.5.15.1.2 Station count	76
3.5.15.2 Master station determination	76
3.5.15.3 Master station operation	77
3.5.15.4 Station configuration	77
3.5.15.5 Configuration failure (special case)	77
4. QUALITY ASSURANCE	81
4.1 General	81
4.2 Verification Methods	81
4.3 Performance Verification	81
5. PREPARATION FOR DELIVERY	87
6. NOTES	87
7. LIST OF FIGURES	
Fig. 3.1-1 Single Ring	8
Fig. 3.1-2 Dual Ring	8
Fig. 3.1.1-1 Station Interface	9
Fig. 3.1.1-2 Additional Redundancy	10
Fig. 3.1.13-1 Station with Loop Back	13
Fig. 3.1.13-2 Loop Back Excluding a Fault	13
Fig. 3.4.1-1 Signaling and Code Bits	15
Fig. 3.4.3-1 Protocol Data Units	17
Fig. 3.5.1-1 Primary States	36
Fig. 3.5.1.6-1 Unconnected State Substates	40
Fig. 3.5.1.7-1 Reconfiguration State Substates	45
Fig. 3.5.1.10-1 Active Ring State Substates	51
8. LIST OF TABLES	
Table 3.4.2-1 Symbol Coding	15
Table 3.5.15-1 Both Rings Intact, Master Station	78
Table 3.5.15-2 Received Configure Beacon, Not Master	79
Table 3.5.15-3 Configure Timer Expired, Master	80
Table 4.1 Performance Verification, Matrix	82
9. APPENDIX 1	89
10. APPENDIX 2	102

1. SCOPE:

A fault tolerant, real time high speed data communication standard is defined based on a ring topology and the use of a Token passing access method with distributed control. The requirements for the HSRB standard have been driven predominantly, but not exclusively, by military applications. Particular attention has been given to the need for low message latency, deterministic message priority and comprehensive reconfiguration capabilities. This document contains a definition of the semantics and protocol including delimiters, tokens, message priority, addressing, error detection and recovery schemes; and is written to be independent of bit rate and media. Parameters related to particular media and bit rates are defined in the Appendix.

2. REFERENCED DOCUMENTS:

None

3. GENERAL REQUIREMENTS:

3.1 General Description: The HSRB system is a physical token passing ring network that connects a set of stations in a closed loop topology with a serial transmission medium. To insure that the applicability of the standard is not restricted to current implementation technologies, the semantics and protocol described are independent of the data transmission rate. Parameters relating to the particular media and bit rates are defined in slash sheets. Initial slash sheets specify 50 MBd and 100 MBd implementations. A single ring HSRB is shown in Fig. 3.1-1. This configuration provides no redundancy and should not be used in applications that require a high degree of reliability or fault tolerance. Fig. 3.1-2 shows a dual redundant ring HSRB, in which each station is connected by two rings that support message transmission in opposite directions. A HSRB can be configured with more than two rings if a further increase in reliability and fault tolerance is required. The dual ring configuration is the main subject of this standard.

3.1.1 Ring Station: A station consists of a Host, a Ring Interface Unit (RIU) and one or more Ring Interface Modules (RIM). The RIU interfaces with one or two rings through the RIM as shown in Fig. 3.1.1-1. The RIU performs the following functions:

- Interfaces with the Host
- Receives serial transmission from each Ring Interface Module
- Decodes symbols from a received Message frames
- Performs error checking on tokens, headers and data messages
- Repeats received messages to the next station on the ring
- Captures a Token when a transmission from the Host is queued
- Removes messages from the ring which it originated
- Transmits a Token at the completion of its transmissions

The station may contain more than one RIU to permit attachment of the Host to more than one HSRB, as shown in Fig. 3.1.1-2.

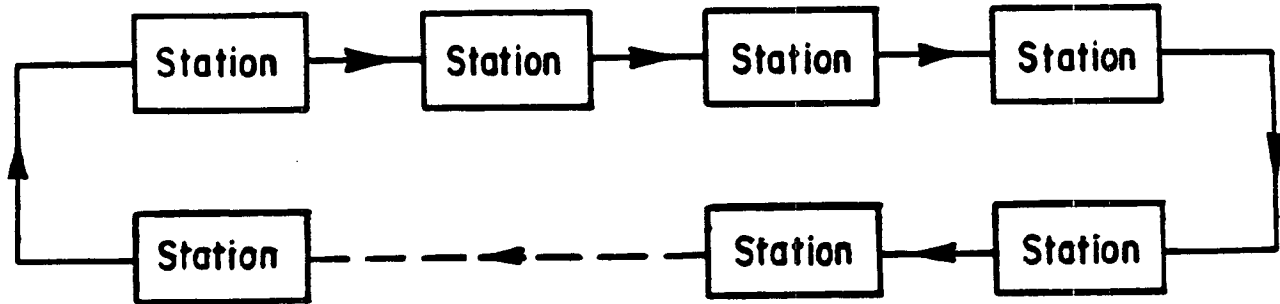


FIGURE 3.1-1 - Single Ring

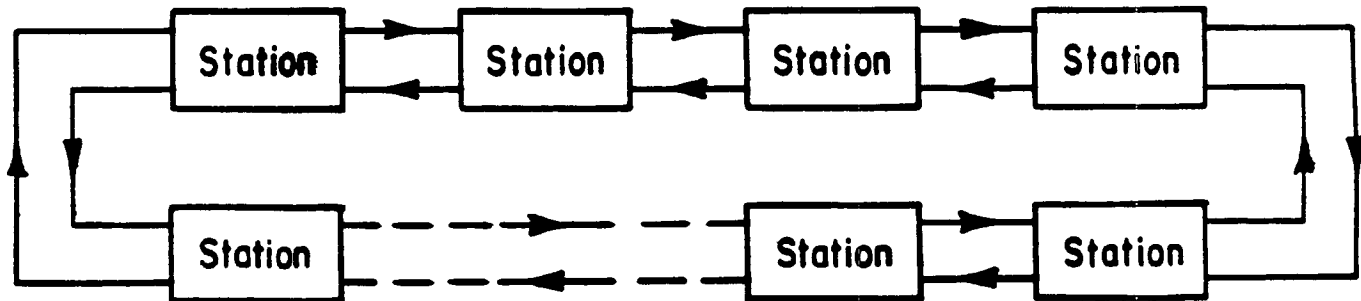


FIGURE 3.1-2 - Dual Ring

3.1.2 Ring Interface Module: The function of the RIM is either to connect the RIU to the HSRB or to permit the HSRB to bypass the RIU. If the RIU is operational, the RIM shall connect the previous ring station to the RIU and the RIU to the next ring station. When a station is removed, or is non-operational, a bypass mechanism is used to maintain the integrity of the ring by connecting the RIM output directly to its input. The two RIMs of a dual ring HSRB can be physically separated to reduce the risk of damage by a common cause.

3.1.3 Ring Control: The HSRB utilizes a Token passing protocol providing distributed control.

3.1.4 Ring Access: Ring access is achieved by means of a Token that passes from one station to the next to provide equitable access for any given priority of message. Data are transmitted in messages from one station to the next in a unidirectional manner, starting with the sending station, passing through the RIUs of the intermediate stations to the receiving-addressing station that copies the message for its Host. The message continues through the remaining stations until it reaches the sending station which removes it from the ring. The sending station must then transmit a Token following the end of the message. A station is permitted to transmit only one message before issuing a Token. Only a station that has claimed a valid Token is authorized to transmit a message for its Host. All other stations are constrained to repeat each message as received on the ring, with the exception of setting error-reporting and priority-reservation bits.

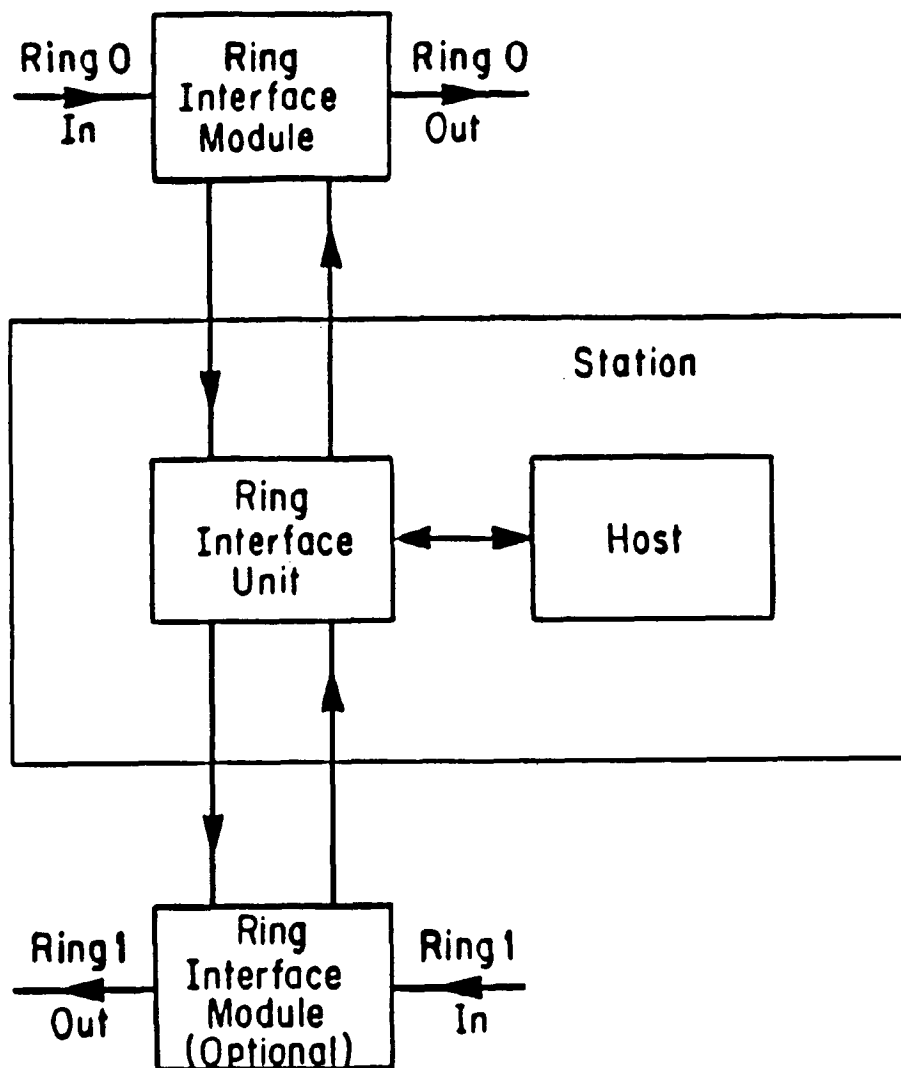


FIGURE 3.1.1-1 - Station Interface

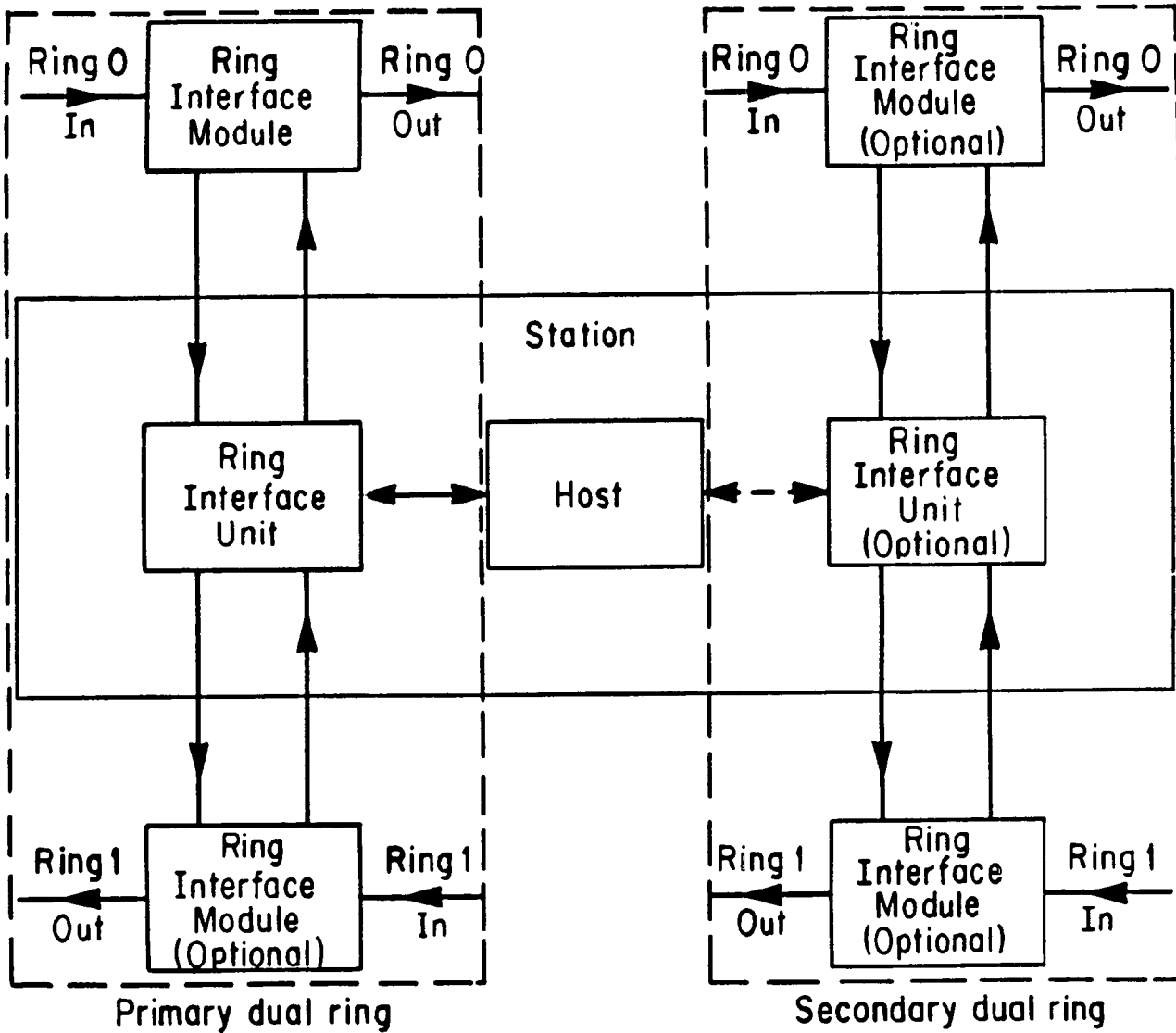


FIGURE 3.1.1-2 - Additional Redundancy

3.1.5 Data Coding: The HSRB utilizes a 16-bit word length with a variable message length of between 1 and 4096 words. Each word consists of four groups; each group consists of four data bits encoded into 5-bit symbols through 4B5B block encoding. The symbols are transmitted with a Non Return to Zero Invert (NRZI) format. A serial Non Return to Zero (NRZ) data stream is converted to the NRZI coding by using the following rules:

- The bit duration time for NRZI is the same as in NRZ.
- A NRZ logical '1' causes a transition in the NRZI signaling level.
- A NRZ logical '0' does not cause a transition in the NRZI signaling level.

The 5 bit symbols and NRZI coding provide a self-clocking serial code with no more than three signal-bit times between signal transitions on the media. This encoding allows the extraction of a clock signal from the data stream.

3.1.6 Station Addressing: The HSRB has provision for physically addressing 128 stations on each of four single or redundant rings which are connected by bridges, that is up to 512 stations in all. The semantics support 512 sub-addresses per station. The HSRB also supports logical addressing with up to 2^{64} addresses available. Logical addressing allows broadcasting (sending to all stations) and multicasting (sending to a logical group of stations) of messages to stations on the four connected rings.

3.1.7 Message Acknowledgement: Immediate acknowledgement of a message by the receiving RIU is implicit in the HSRB protocol. The protocol does not carry an overhead if immediate acknowledge is not required or possible, such as the case is in broadcast or multicast transmissions with a logical address.

3.1.8 Message Priority Levels: The HSRB supports eight priority levels for messages. Reservations are made in the Claimed Token so that the highest priority messages are serviced first. As an option, the system designer may allow multiple short messages to appear on the ring simultaneously. A short message, one in which a Token is issued by the sending station before the last Claimed Token is received, may result in the highest priority message not being serviced next. The HSRB protocol insures a minimum of delay in servicing the highest priority message by providing that no more than 16 consecutive short messages can be issued before priority levels are re-established.

3.1.9 Types of Service: For physical addressing, an acknowledged datagram service with priorities is provided with Host selectable single retry in the event of a detected data error or non receipt of the message. For logical addressing, an unacknowledged datagram service is provided with Host selectable single retry in the event of a detected error. All other classes of service can be provided by the Host.

- 3.1.10 Adaptability: The HSRB protocol has no requirement for physical pre-ordering of the stations on the rings. Insertion of additional stations or removal of current stations is easily accomplished. Growth to higher data rates and longer station separation is well supported by the HSRB since the ring efficiency is almost independent of these parameters. Increases in the media signaling rates are accompanied by an almost pro rata increase in throughput.
- 3.1.11 Media Requirements: The media requirements for the rings of the HSRB consist of a set of unidirectional point-to-point links. This standard does not specify the media, the data signaling rate, or the station separation. The semantics and protocol of the HSRB are designed to be independent of the data signaling rate, which is limited only by the technologies employed.
- 3.1.12 Error & Fault Detection & Recovery: The HSRB provides error detection and recovery mechanisms to maintain or restore ring operation in the event of errors. Fault detection and recovery schemes allow station and media faults to be tolerated while maintaining ring operation. Redundant rings are provided on the dual HSRB so that a backup ring is available to overcome single media faults. Faults on both segments of media between adjacent stations can be tolerated without loss of station or system availability. A smaller ring, containing a subset of the stations, can be configured in the event of other multiple media faults.
- 3.1.13 Loop Back: The RIU has the ability to perform a loop back function. In the example shown in Fig. 3.1.13-1, this function breaks the physical rings by receiving from 'Ring 0 In' and retransmitting on 'Ring 1 Out' instead of 'Ring 0 Out'. The capability is provided for isolating faults on Ring 0 and Ring 1 by having two stations perform the loop back function and forming a new ring that excludes the fault, as shown in Fig. 3.1.13-2.
- 3.1.14 Reconfiguration: Reconfiguration is the process by which the operation of the HSRB is initialized using Beacon frames following the application of power, the presence of failures or the detection of certain errors using Beacons. The Beacon frame is a control entity with a uniquely defined starting delimiter. The reconfiguration process accomplishes the following:
- determines the ring configuration that shall include the maximum number of participating stations consistent, where possible, with the maintenance of static redundancy
 - establishes the master station

The master station inserts a Token buffer to provide Token storage in systems consisting of a small number of stations. The master station transmits the initial Token after the ring is configured. All stations must be capable of performing the master function.

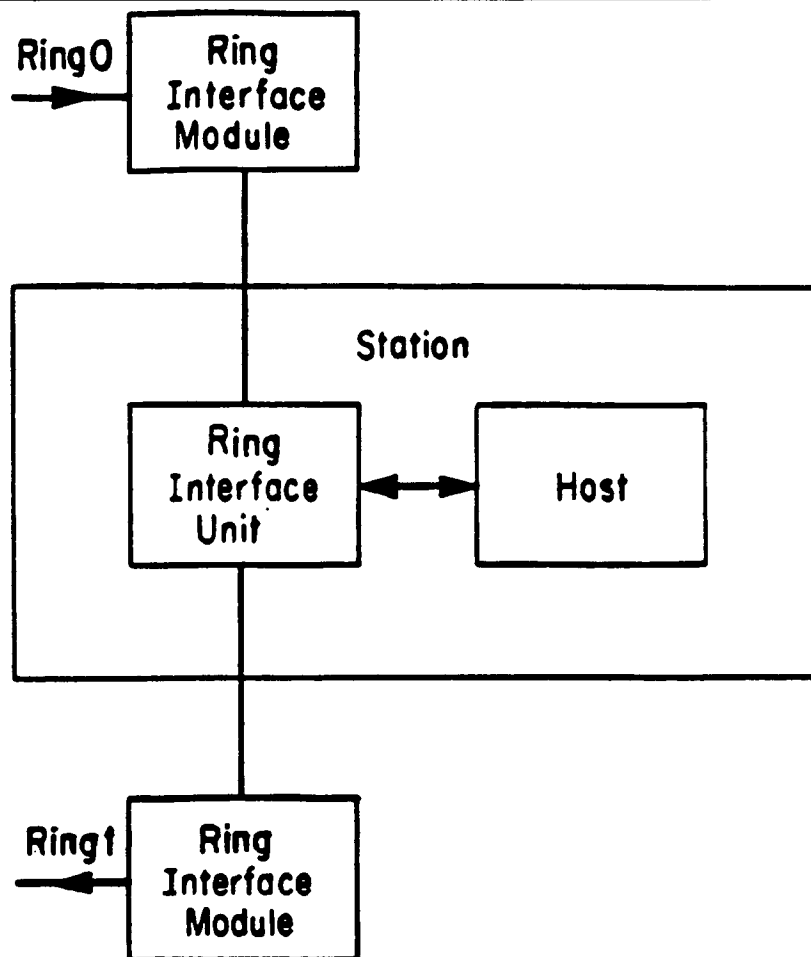


FIGURE 3.1.13-1 - Station With Loop Back

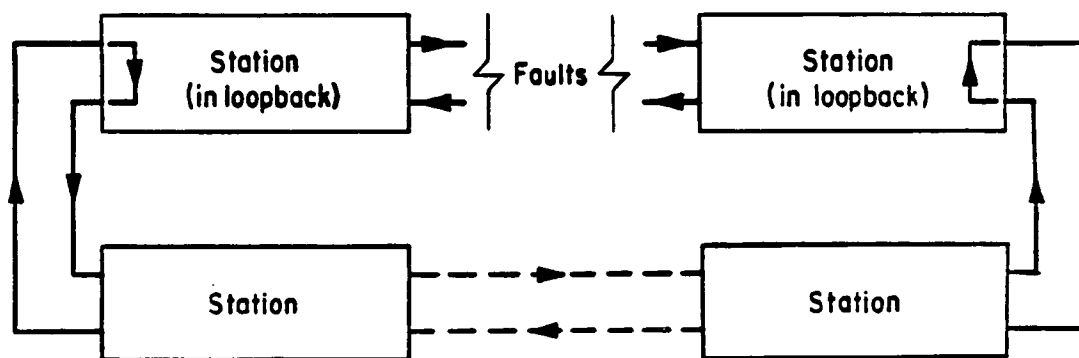


FIGURE 3.1.13-2 - Loop Back Excluding A Fault

3.1.15 Synchronization: Each link on the ring is clocked using an independent clock in each transmitter. The receiver clock in each station is locked to transitions in its incoming waveform. An elastic buffer is placed between the receiver and the transmitter in each station to accommodate differences in receiver and transmitter clock frequencies.

3.1.16 Dual Ring HSRB: A dual ring HSRB, in a failure-free mode, consists of two complete rings. During reconfiguration the Master station selects one of the rings to be the Active ring. This is the ring over which all messages are transmitted. The other ring is the Inactive ring. A station initiating or repeating a message transmits the message on both the Active and Inactive ring. All messages on the inactive ring other than Beacon frames are ignored.

A dual ring HSRB in a loopback mode shall form a ring consisting of two segments. The Active ring segment shall operate in the same manner as an Active ring in a failure-free HSRB. The Repeater ring segment is the counter rotating position. The RIMs which form the Repeater segment shall repeat any messages received, but shall not copy them.

3.2 Operational Requirements:

3.2.1 Serial Transmission: The HSRB is a serial data transfer system. All information (data, clock, addresses, etc.) shall be placed on a single transmission medium.

3.2.2 Word Length: The HSRB shall incorporate a word length of 16 information data bits.

3.2.3 Message Length: The HSRB shall allow for a message of any length from 1 data word to 4096 data words.

3.2.4 Electrical Isolation: Except for electrical wire shields, there shall not be a direct connection (that is one capable of carrying direct current) in the signal path between any physical stations on the HSRB.

3.2.5 Self Test: A station shall guarantee its health, on a non-interrupting basis, before joining a ring. Having joined a ring, the station shall perform according to the protocols defined in 3.5.

3.3 Performance Requirements:

3.3.1 Station Delay: The delay of a slave station, not including transmitter and receiver delay, shall not exceed 6 bit times at the signalling bit rate as measured between a ring input and a corresponding ring output when its elastic buffer is in the initialized state. A station acting as the master station shall insert an additional delay of 40 bit times at the signaling bit rate.

3.4 Semantics:

3.4.1 Entities: The set of entities within the semantics shall consist of data bits, symbols, code bits and signaling bits. The relationship between them is as shown in Fig. 3.4.1-1.

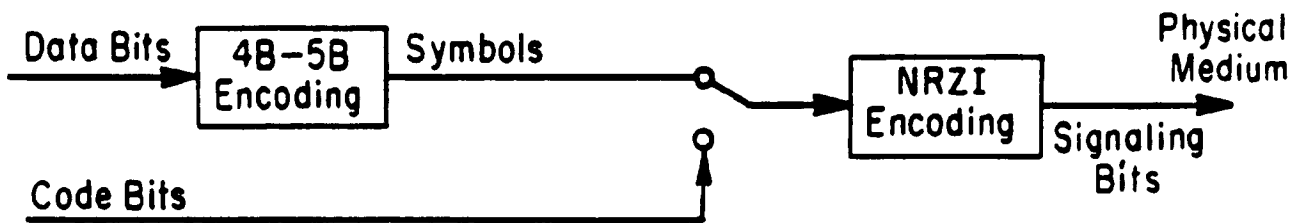


FIGURE 3.4.1-1 - Signaling And Code Bits

3.4.1 (Continued):

Signaling bits shall be defined as NRZI bits. Signaling bits shall be generated from 5-bit symbols or from code bits. Fields consisting of code bits shall include bits preassigned to logic 1 to ensure that the number of bit times between transitions is a maximum of three.

3.4.2 Symbols: A symbol shall be defined as an encoded group of four data bits and shall be the basic unit for data transfer. The symbol set shall be as defined in Table 3.4.2-1.

TABLE 3.4.2-1 - Symbol Coding

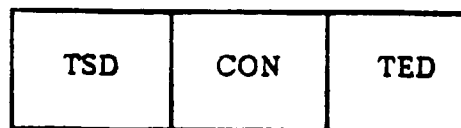
<u>Symbol</u>	<u>Code Group</u>	<u>Assignment</u>
0	11110	Data Symbol '0000' Binary
1	01001	Data Symbol '0001' Binary
2	10100	Data Symbol '0010' Binary
3	10101	Data Symbol '0011' Binary
4	01010	Data Symbol '0100' Binary
5	01011	Data Symbol '0101' Binary
6	01110	Data Symbol '0110' Binary
7	01111	Data Symbol '0111' Binary
8	10010	Data Symbol '1000' Binary
9	10011	Data Symbol '1001' Binary
A	10110	Data Symbol '1010' Binary. Also used with a preceding 'J' symbol as the message frame starting delimiter.
B	10111	Data Symbol '1011' Binary
C	11010	Data Symbol '1100' Binary
D	11011	Data Symbol '1101' Binary
E	11100	Data Symbol '1110' Binary
F	11101	Data Symbol '1111' Binary
I	11111	IDLE: No information currently being transmitted
J	11000	Used for Token, Message Frame and Beacon Frame Starting Delimiters
K	10001	Used for Token and Beacon Frame Starting Delimiters
Q	00000	QUIET: No signal being transmitted
T	01101	TERMINATE: Ending Delimiter for Token, Message Frame and Beacon Frame
S	11001	Never transmitted as a symbol but may occur in a Token or Frame status

TABLE 3.4.2-1 - Symbol Coding
(Continued)

<u>Symbol</u>	<u>Code Group</u>	<u>Assignment</u>
V	00001	INVALID: These symbols shall not be used as they violate consecutive code-bit zeros, duty cycle or prevent unique starting delimiter patterns
V	00010	
V	00100	
V	01000	
V	10000	
V	00011	
V	00101	
V	00110	
V	00111	
V	01100	

3.4.3 Protocol Data Units: Three Protocol Data Units (PDUS) shall be used: Token frames, Message frames and Beacon frames (Fig. 3.4.3-1). The order of transmission on the medium shall be as shown in the corresponding diagram with the left-most field first.

3.4.3.1 Token Frame: The Token frame shall be the means by which the right to transmit (as opposed to the process of repeating) is transferred from one station to another. A free Token frame (also referred to as a free Token) may be converted to a Claimed Token sub-frame (also referred to as a Claimed Token) by a station having a message to transmit, according to the protocol defined in 3.5. Conversion of a free Token frame to a Claimed Token sub-frame is achieved by modification of the Control Field and deletion of the TED. The Claimed Token sub-frame becomes part of the Message frame. The free Token frame shall consist of the Token Starting Delimiter field, the Control field and the Ending Delimiter field.

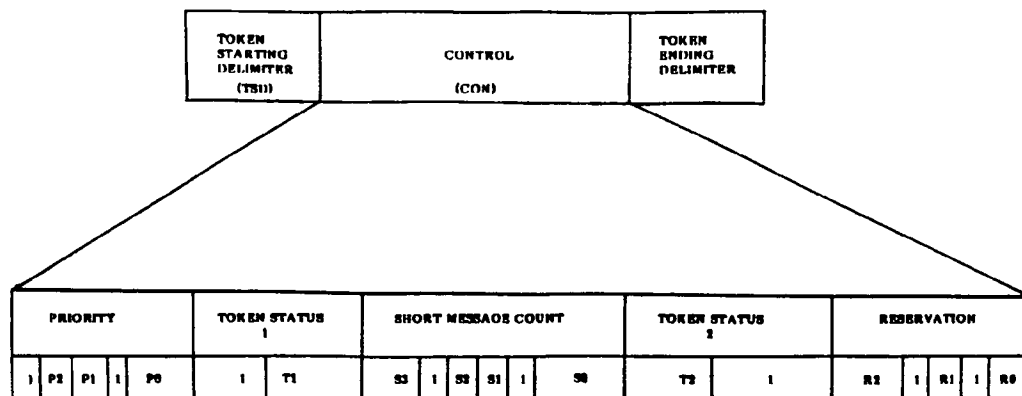


TSD Token Starting Delimiter: 10 code bits (2 symbols)

CON Control: 20 code bits

TED Token Ending Delimiter: 5 code bits (1 symbol)

Note: TED is removed by the transmitting station in a Claimed Token



Token Frame

TSD	CON	INTER FRAME ADJUSTMENT	MESSAGE FRAME STARTING DELIMITER	PRIORITY AND RETRY STATUS	WORD COUNT	SENDING ADDRESS	ADDRESS CONTROL	GLOBAL ADDRESS	DESTINATION ADDRESS	MESSAGE CONTROL FRAME CHECK SEQUENCE	INFORMATION	INFORMATION FRAME CHECK SEQUENCE	MESSAGE FRAME ENDING DELIMITER	FRAME STATUS	INTER FRAME ADJUSTMENT
-----	-----	------------------------	----------------------------------	---------------------------	------------	-----------------	-----------------	----------------	---------------------	--------------------------------------	-------------	----------------------------------	--------------------------------	--------------	------------------------

MESSAGE CONTROL ERROR DETECTED 1		MESSAGE ACKNOWLEDGE 1		MESSAGE RECEIVED 1		MESSAGE ERROR DETECTED 1		MESSAGE CONTROL ERROR DETECTED 2		MESSAGE ACKNOWLEDGE 2		MESSAGE RECEIVED 2		MESSAGE ERROR DETECTED 2	
ABE	1	ACK 1		RCVD 1	1	DEB	1	ABE		ACK 2	1	RCVD 2	1	DEB 2	1

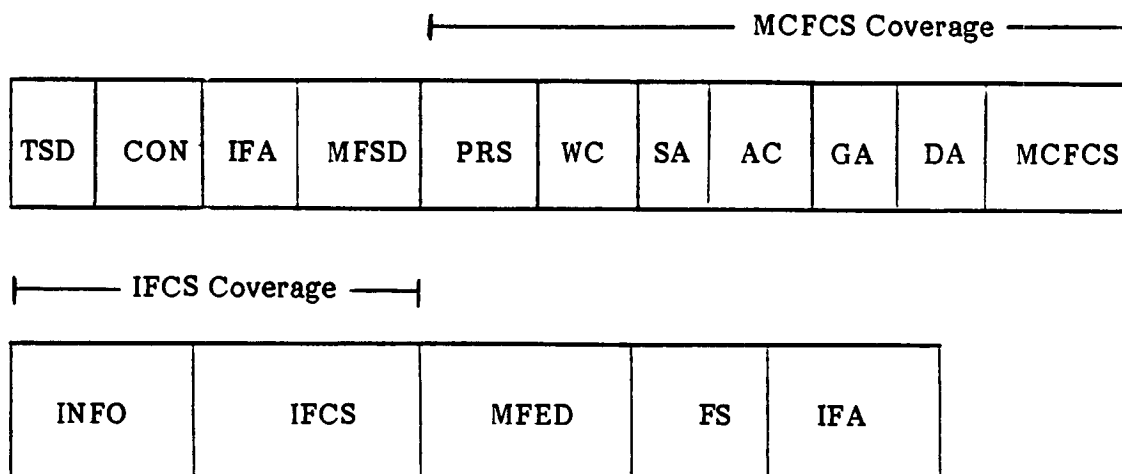
Message Frame

BEACON FRAME STARTING DELIMITER	BEACON CONTROL	HIGHEST KNOWN ADDRESS	STATION COUNT	BEACON FRAME CHECK SEQUENCE	BEACON FRAME ENDING DELIMITER
---------------------------------	----------------	-----------------------	---------------	-----------------------------	-------------------------------

Beacon Frame

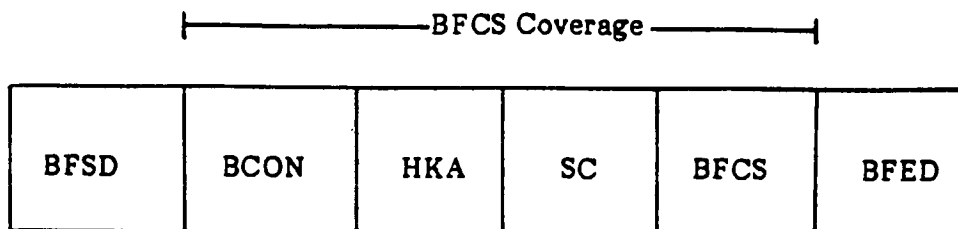
FIGURE 3.4.3-1 - Protocol Data Units

- 3.4.3.2 **Message Frame:** The Message frame shall be used to transmit data. The Message frame shall consist of the Token frame claimed by the station with its TED field removed followed by the Preamble field, the Message Frame Starting Delimiter field, the Priority and Retry Status field, the Word Count field, the Sending Address field, the Address Control field, the Global Address field, the Destination Address field, the Message Control Frame Check Sequence field, the Information field, the Information Frame Check Sequence field, the Message Frame Ending Delimiter field, the Frame Status field, and the Adjustment field.



TSD	Token Starting Delimiter: 10 code bits (2 symbols)	Claimed Token sub-frame
CON	Control: 20 code bits	
IFA	Interframe Adjustment	
MFSD	Message Frame Starting Delimiter: 2 symbols	
PRS	Priority and Retry Status: 1 symbol	
WC	Word Count: 3 symbols	
SA	Sending Address: 2 symbols	
AC	Address Control: 1 symbol	
GA	Global Address: 1 symbol	
DA	Destination Address: 4, 8, 12 or 16 symbols	
MCFCS	Message Control FCS: 4 symbols	
INFO	Information: 4-16384 symbols in multiples of 4 symbols	
IFCS	Information FCS: 4 symbols	
MFED	Message Frame Ending Delimiter: 1 symbol	
FS	Frame Status: 15 code bits	
IFA	Interframe Adjustment: 6 IDLE symbols (transmitted)	

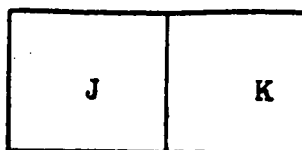
- 3.4.3.3 Beacon Frame: The Beacon frame shall be used to transmit control information during system start up and reconfiguration. The Beacon frame shall consist of the Beacon Frame Starting Delimiter field, the Beacon Control field, the Highest Known Address field, the Station Count field, the Beacon Frame Check Sequence field and the Beacon Frame Ending Delimiter field.



BFSD Beacon Frame Starting Delimiter: 2 symbols
BCON Beacon Control: 1 symbol
HKA Highest Known Address: 2 symbols
SC Station Count: 2 symbols
BFCS Beacon Frame Check Sequence: 4 symbols
BFED Beacon Frame Ending Delimiter: 1 symbol

- 3.4.4 Fields: The fields contained within the PDUs shall be in accordance with the corresponding definitions in 3.4.4.1 - 3.4.4.23. The order of transmission on the medium shall be as shown in the corresponding diagram with the left-most symbol and the left-most code bit first.

- 3.4.4.1 Token Starting Delimiter (TSD) Field: The TSD field shall indicate the starting boundary of a Token. The TSD shall consist of a J symbol followed by a K symbol.



J: J symbol
K: K symbol

This sequence shall be recognized as the TSD regardless of any sequence of bits preceding it.

3.4.4.2 Control (CON) Field: The CON field shall consist of the Priority (PR) sub-field, the Token Status (TS1) sub-field, the Short Message Count (SMC) sub-field, the Token Status 2 (TS2) sub-field, and the Reservation (RES) sub-field.

PR	TS1	SMC	TS2	RES
----	-----	-----	-----	-----

PR Priority: 5 code bits
TS1 Token Status 1: 2 code bits
SMC Short Message Count: 6 code bits
TS2 Token Status 2: 2 code bits
RES Reservation: 5 code bits

3.4.4.2.1 Priority (PR) Sub-Field: The PR sub-field shall indicate the priority level of a Token. The PR sub-field shall consist of code bits as follows:

1	P ₂	P ₁	1	P ₀
---	----------------	----------------	---	----------------

P₂ Priority bit 2 (most significant)
P₁ Priority bit 1
P₀ Priority bit 0 (least significant)

The PR value 0 shall indicate the highest priority and the PR value 7 shall indicate the lowest priority.

3.4.4.2.2 Token Status 1 (TS1) Sub-Field: The TS1 sub-field shall indicate the status of the Token. The TS1 sub-field shall consist of code bits as follows:

1	T ₁
---	----------------

T₁ = 0 shall indicate Claimed Token
T₁ = 1 shall indicate free Token

- 3.4.4.2.3 Short Message Count (SMC) Sub-Field: The SMC sub-field shall indicate the number of consecutive short messages, excluding the Message frame following the Claimed Token sub-frame, that have been transmitted. The SMC sub-field shall consist of code bits as follows:

S ₃	1	S ₂	S ₁	1	S ₀
----------------	---	----------------	----------------	---	----------------

S₃ SMC bit 3 (most significant)
S₂ SMC bit 2
S₁ SMC bit 1
S₀ SMC bit 0 (least significant)

The SMC value 0 shall indicate the lowest count and the SMC value 15 shall indicate the highest count.

- 3.4.4.2.4 Token Status 2 (TS2) Sub-Field: The TS2 sub-field shall indicate the Status of the Token. The TS2 sub-field shall consist of code bits as follows:

T ₂	1
----------------	---

T₂ = 0 shall indicate Claimed Token
T₂ = 1 shall indicate free Token

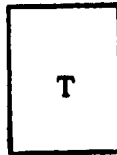
- 3.4.4.2.5 Reservation (RES) Sub-Field: The RES sub-field shall indicate the highest reservation made by a station with a pending Message Frame. The RES sub-field shall consist of code bits as follows:

R ₂	1	R ₁	1	R ₀
----------------	---	----------------	---	----------------

R₂ Reservation bit 2 (most significant)
R₁ Reservation bit 1
R₀ Reservation bit 0 (least significant)

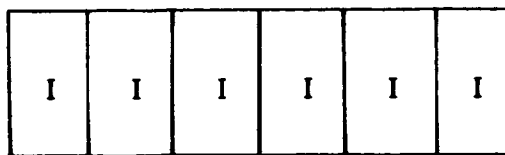
The RES value 0 shall indicate the highest priority and the RES value 7 shall indicate the lowest priority.

- 3.4.4.3 Token Ending Delimiter (TED) Field: The TED field shall indicate the ending boundary of a Token. The TED shall consist of a T symbol



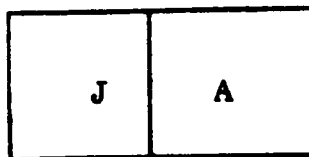
T: Terminate Symbol

- 3.4.4.4 Interframe Adjustment Field (IFA): The IFA field as transmitted shall consist of six IDLE symbols. The IFA field may be adjusted in length by any station to allow elastic buffer initialization.



I: I symbol

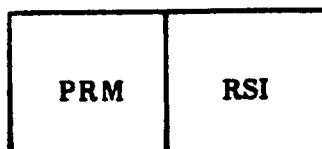
- 3.4.4.5 Message Frame Starting Delimiter (MFSD) Field: The MFSD field shall indicate the starting boundary of a Message Frame. The MFSD shall consist of the J symbol followed by the A symbol.



J: J Symbol

A: A Symbol

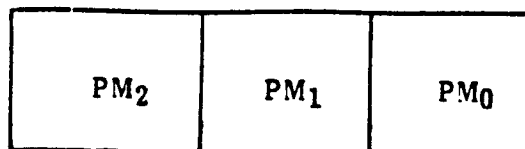
- 3.4.4.6 Priority and Retry Status (PRS) Field: The PRS field shall consist of the Message Priority (PRM) sub-field and the Retry Status Indicator (RSI) sub-field.



PRM Message Priority: 3 data bits

RSI Retry Status Indicator: 1 data bit

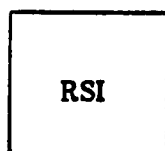
- 3.4.4.6.1 Message Priority (PRM) Sub-Field: The PRM sub-field shall indicate the priority level of the message. The PRM sub-field shall consist of data bits as follows:



PM₂ Priority bit 2 (most significant)
PM₁ Priority bit 1
PM₀ Priority bit 0 (least significant)

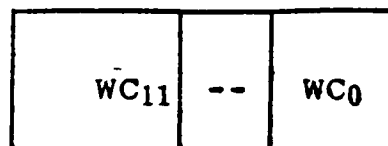
The PRM value 0 shall indicate the highest priority, and the PRM value 7 shall indicate the lowest priority.

- 3.4.4.6.2 Retry Status Indicator (RSI) Sub-Field: The RSI sub-field shall indicate the Message Frame retry status. The RSI sub-field shall consist of data bits as follows:



RSI = 0 shall indicate that the Message Frame is not a retry
RSI = 1 shall indicate that the Message Frame is a retry

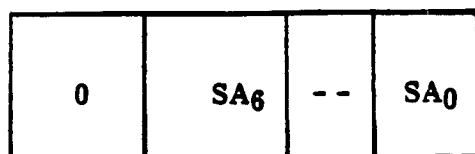
- 3.4.4.7 Word Count (WC) Field: The WC field shall indicate the number of words in the Information Field (INFO) of a Message frame. The number of words indicated by the WC field shall be not less than 1 and no more than 4096. The WC field shall consist of data bits as follows:



WC₁₁ Word Count bit 11 (most significant)
WC₀ Word Count bit 0 (least significant)

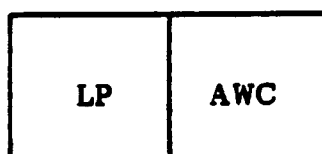
WC = 1 shall indicate 1 word
WC = 4095 shall indicate 4095 words
WC = 0 shall indicate 4096 words

- 3.4.4.8 Sending Address (SA) Field: The SA field shall identify the station originating the Message frame. The SA field shall consist of data bits as follows:

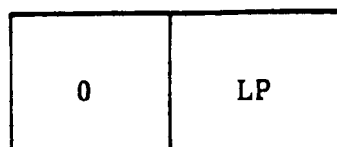


SA₆ Sending Address bit 6 (most significant)
SA₀ Sending Address bit 0 (least significant)

- 3.4.4.9 Address Control (AC) Field: The AC field shall consist of the Logical-Physical (LP) sub-field and the Address Word Count (AWC) sub-field.

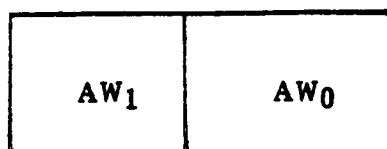


- 3.4.4.9.1 Logical-Physical (LP) Sub-Field: The LP sub-field shall indicate the mode of addressing. The LP sub-field shall consist of data bits as follows:



LP = 0 shall indicate Physical Address Mode
LP = 1 shall indicate Logical Address Mode

- 3.4.4.9.2 Address Word Count (AWC) Sub-Field: The AWC sub-field shall indicate the number of logical address words transmitted. The AWC sub-field shall consist of data bits as follows:



3.4.4.9.2 (Continued):

AW₁ Address Word Count bit 1 (most significant bit)
 AW₀ Address Word Count bit 0 (least significant bit)

AWC = 0 shall indicate 2¹⁶ logical address space
 AWC = 1 shall indicate 2³² logical address space
 AWC = 2 shall indicate 2⁴⁸ logical address space
 AWC = 3 shall indicate 2⁶⁴ logical address space

In Physical Address Mode, the value AWC = 0 shall be transmitted.

3.4.4.10 Global Address (GA) Field: The GA field shall indicate the ring or rings for which the Message Frame is intended. In the Physical Address Mode the GA field shall consist of the Global Address Physical (GAP) sub-field and in the Logical Address Mode the GA field shall consist of the Global Address Logical (GAL) sub-field.

3.4.4.10.1 Global Address Physical (GAP) Sub-Field: The GAP sub-field shall identify the ring number for which the Message Frame is intended. The GAP sub-field shall consist of data bits as follows:

BA	0	GP ₁	GP ₀
----	---	-----------------	-----------------

BA Bridge Access bit
 GP₁ Global Address Physical bit 1 (most significant)
 GP₀ Global Address Physical bit 0 (least significant)

BA = 0, GP = 0 shall indicate transmission on ring of originating station
 BA = 1, GP = n shall indicate transmission on destination ring n
 BA = 0, GP ≠ 0 is invalid and shall not be transmitted

3.4.4.10.2 Global Address Logical (GAL) Sub-Field: The GAL sub-field shall identify the ring or rings for which the Message Frame is intended. The GAL sub-field shall consist of data bits as follows:

GL ₃	GL ₂	GL ₁	GL ₀
-----------------	-----------------	-----------------	-----------------

3.4.4.10.2 (Continued):

GL_3 Global Address Logical bit 3
 GL_2 Global Address Logical bit 2
 GL_1 Global Address Logical bit 1
 GL_0 Global Address Logical bit 0

$GL_n = 1$ shall indicate that the Message Frame is intended for ring n
 $GL_n = 0$ shall indicate that the Message Frame is not intended for ring n

3.4.4.11 Destination Address (DA) Field: The DA field shall identify the ring station or stations for which the Message Frame is intended. In the Physical Address Mode, the DA field shall consist of the Destination Address Physical (DAP) sub-field and in the Logical Address Mode the DA field shall consist of the Destination Address Logical (DAL) sub-field.

3.4.4.11.1 Destination Address Physical (DAP) Sub-Field: The DAP sub-field shall identify the ring station for which the Message Frame is intended. The DAP sub-field shall consist of data bits as follows:

DP ₁₅	--	DP ₉	--	DP ₈	--	DP ₀
------------------	----	-----------------	----	-----------------	----	-----------------

DP_{15} Physical Address bit 6 (most significant)
 DP_9 Physical Address bit 0 (least significant)

DP_8 Sub-Address bit 8 (most significant)
 DP_0 Sub-Address bit 0 (least significant)

3.4.4.11.2 Destination Address Logical (DAL) Sub-Field: The DAL sub-field shall indicate the ring station or stations for which the Message Frame is intended. The DAL sub-field shall consist of data bits as follows:

DL _{AWC15}	--	DL _{AWC0}	DL _{(AWC-1)15}	--	DL _{(AWC-1)0}
---------------------	----	--------------------	-------------------------	----	------------------------

DL ₀₁₅	--	DL ₀₀
-------------------	----	------------------

3.4.4.11.2 (Continued):

$DL_{AWC_{15}}$	Destination Address Logical (most significant word, most significant bit)
DL_{AWC_0}	Destination Address Logical (most significant word, least significant bit)
$DL(AWC-1)_{15}$	Destination Address Logical (second most significant word, most significant bit)
$DL(AWC-1)_0$	Destination Address Logical (second most significant word, least significant bit)
$DL_{0_{15}}$	Destination Address Logical (least significant word, most significant bit)
DL_{0_0}	Destination Address Logical (least significant word, least significant bit)

A station that is capable of receiving a logical address of no more than M words shall recognize addresses of M words or less but shall not recognize a logical address of more than M words. If a logical address of less than M words is received, the words received shall be treated as the least significant bits of the address.

The logical address zero is reserved and shall be used for broadcast.

3.4.4.12 Message Control Frame Check Sequence (MCFCFS) Field: The MCFCFS field shall cover the PRS field, the WC field, the SA field, the AC field, the GA field, the DA field and the MCFCFS field in accordance with the following generator polynomial:

$$G(X) = X^{16} + X^{12} + X^5 + 1$$

The initial remainder shall be preset to FFFF_H. The 1's complement of the remainder of the division of the fields covered by the generator polynomial G(X) shall be transmitted as the MCFCFS.

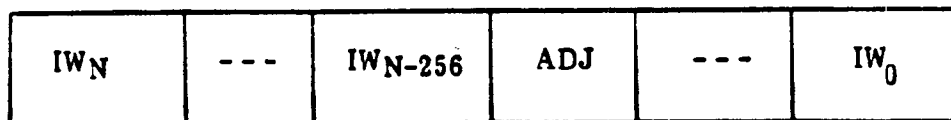
The MCFCFS field shall consist of data bits as follows:



MCFCFS₁₅ Message Control Frame Check Sequence bit 15 (most significant bit)

MCFCFS₀ Message Control Frame Check Sequence bit 0 (least significant bit)

- 3.4.4.13 Information (INFO) Field: The INFO field shall contain the data to be transmitted in the Message frame. The INFO field shall consist of Information Word (IW) sub-fields and Adjustment (ADJ) sub-fields.



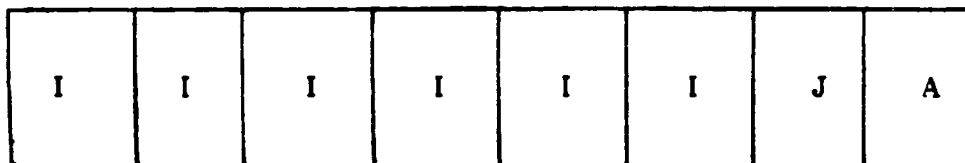
IW_N Information Word N
 IW_{N-256} 256th Transmitted Information Word
 IW₀ Information Word 0
 N Number of Information Words Transmitted

- 3.4.4.13.1 Information Word (IW) Sub-Field: The IW sub-field shall contain 16 Information Bits. The IW sub-field shall consist of data bits as follows:



IB₁₅ Information Bit 15 (most significant)
 IB₀ Information Bit 0 (least significant)

- 3.4.4.13.2 Adjustment (ADJ) Sub-Field: The ADJ sub-field shall be transmitted within the Information (INFO) field at intervals of 256 Information Word (IW) sub-fields. The ADJ sub-field may be adjusted in length by any station to allow elastic buffer initialization. The ADJ sub-field as transmitted shall consist of six I symbols followed by the J symbol followed by the A symbol.



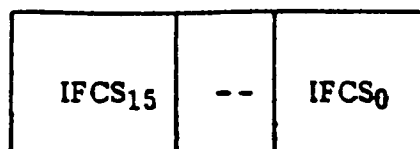
I: I symbol
 J: J symbol
 A: A symbol

- 3.4.4.14 Information Frame Check Sequence (IFCS) Field: The IFCS field shall cover the INFO field (excluding the adjustment sub-fields) and the IFCS field in accordance with the following generator polynomial:

$$G(X) = x^{16} + x^{12} + x^5 + 1$$

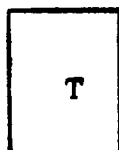
The initial remainder shall be preset to FFFF_H. The 1's complement of the remainder of the division of the fields covered by the generator polynomial $G(X)$ shall be transmitted as the IFCS.

The IFCS field shall consist of data bits as follows:



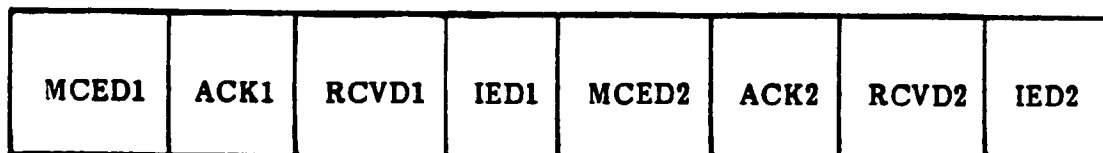
IFCS₁₅ Information Frame Check Sequence bit 15 (most significant bit)
 IFCS₀ Information Frame Check Sequence bit 0 (least significant bit)

- 3.4.4.15 Message Frame Ending Delimiter (MFED) Field: The MFED field shall indicate the ending boundary of the INFO field. The MFED shall consist of a T symbol



T: Terminate symbol

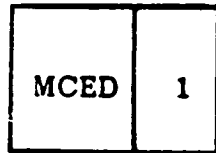
- 3.4.4.16 Frame Status (FS) Field: The FS field shall consist of the Message Control Error Detected 1 (MCED1) sub-field, the Message Acknowledged 1 (ACK1) sub-field, the Message Received 1 (RCVD1) sub-field, the Information Error Detected 1 (IED1) sub-field, the Message Control Error Detected 2 (MCED2) sub-field, the Message Acknowledged 2 (ACK2) sub-field, the Message Received 2 (RCVD2) sub-field and the Information Error Detected 2 (IED2) sub-field.



3.4.4.16 (Continued):

MCED1 Message Control Error Detected 1 : 2 code bits
ACK1 Message Acknowledged 1 : 1 code bit
RCVD1 Message Received 1 : 2 code bits
IED1 Information Error Detected 1 : 2 code bits
MCED2 Message Control Error Detected 2 : 1 code bit
ACK2 Message Acknowledged 2 : 2 code bits
RCVD2 Message Received 2 : 2 code bits
IED2 Information Error Detected 2 : 3 code bits

- 3.4.4.16.1 Message Control Error Detected 1 (MCED1) Sub-Field: The MCED1 sub-field shall indicate any disparity between the received and calculated values of the MCFCS. The MCED1 sub-field shall consist of code bits as follows:



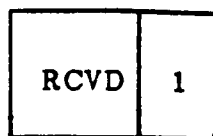
MCED = 0 shall indicate no error detected
MCED = 1 shall indicate error detected

- 3.4.4.16.2 Message Acknowledged 1 (ACK1) Sub-Field: The ACK1 sub-field shall indicate that a message has been received without error and made available to the Host. The ACK1 sub-field shall consist of code bits as follows:



ACK = 0 shall indicate negative acknowledgement
ACK = 1 shall indicate acknowledgement

- 3.4.4.16.3 Message Received 1 (RCVD1) Sub-Field: The RCVD1 sub-field shall indicate that a station has received a message containing its address. The RCVD1 sub-field shall consist of code bits as follows:



3.4.4.16.3 (Continued):

RCVD = 0 shall indicate not received
RCVD = 1 shall indicate received

3.4.4.16.4 Information Error Detected 1 (IED1): The IED1 sub-field shall indicate any disparity between the received and calculated values of the IFCS. The IED1 sub-field shall consist of code bits as follows:

IED	1
-----	---

IED = 0 shall indicate no error detected
IED = 1 shall indicate error detected

3.4.4.16.5 Message Control Error Detected 2 (MCED2) Sub-Field: The MCED2 sub-field shall indicate any disparity between the received and calculated values of the MCFCFS. The MCED2 sub-field shall consist of code bits as follows:

MCED

MCED = 0 shall indicate no error detected
MCED = 1 shall indicate error detected

3.4.4.16.6 Message Acknowledged 2 (ACK2) Sub-Field: The ACK2 sub-field shall indicate that a message has been received without error and made available to the Host. The ACK2 sub-field shall consist of code bits as follows:

ACK	1
-----	---

ACK = 0 shall indicate negative acknowledgement
ACK = 1 shall indicate acknowledgement

- 3.4.4.16.7 Message Received 2 (RCVD2) Sub-Field: The RCVD2 sub-field shall indicate that a station has received a message containing its address. The RCVD2 sub-field shall consist of code bits as follows:

RCVD	1
------	---

RCVD = 0 shall indicate not received
RCVD = 1 shall indicate received

- 3.4.4.16.8 Information Error Detected 2 (IED2) Sub-Field: The IED2 sub-field shall indicate any disparity between the received and calculated values of the IFCS. The IED2 sub-field shall consist of code bits as follows:

IED	1	1
-----	---	---

IED = 0 shall indicate no error detected
IED = 1 shall indicate error detected

- 3.4.4.17 Beacon Frame Starting Delimiter (BFSD) Field: The BFSD field shall indicate the starting boundary of a Beacon frame. The BFSD shall consist of the K symbol followed by the J symbol:

K	J
---	---

K: K symbol
J: J symbol