MILITARY STANDARD

FIBER OPTICS MECHANIZATION OF AN AIRCRAFT INTERNAL TIME DIVISION COMMAND/RESPONSE MULTIPLEX DATA BUS

AMSC N/A FSC MCCR

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Fiber Optics Mechanization of an Aircraft Time Division Command/Response Multiplex Data Bus

DOD-STD-1773

1.This Military Standard is proposed for use by all Departments and Agencies of the Department of Defense

2.Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 5313), Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this standard or by letter.

FOREWORD

This Military Standard contains requirements for fiber optic mechanizations of an aircraft internal time division command/response multiplex data bus for use in systems integration of aircraft subsystems. The parent document for data bus protocol, bit assignment and related bus traffic management is MIL-STD-1553B. DOD-STD-1773 provides for the use of fiber optics as the transmission medium in a manner which is compatible with MIL-STD-1553B

This document is structured to follow the organization of MIL-STD-1553B as closely as possible with additions and omissions to MIL-STD-1553B only where necessary to allow fiber optics. To assist the reader in identifying changes which have been made, an asterisk (*) has been placed to the left of each paragraph, figure and table number which is not identical with MIL-STD-1553B. Paragraph numbers used in MIL-STD-1553B but omitted in DOD-STD-1773 include all subparagraph numbers of 4.5.1.5, 4.5.2.1 and 4 5 2.2

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APPENDIX FIGURES

1. SCOPE

* 1 1 Scope This standard defines requirements for digital, command/response time division multiplexing (data bus) techniques on aircraft. It encompasses the fiber optic data bus transmission line, the electro-optical transmission and reception units, and the associated interface electronics The concept of operation and information flow on the multiplex data bus and the optical, electrical and functional formats to be employed are also defined.

1.2 Application. When invoked in a specification or statement of work, these requirements shall apply to the multiplex data bus and associated equipment which is developed either alone or as a portion of an aircraft weapon system or subsystem development. The contractor is responsible for invoking all of the applicable requirements of this Military Standard on any and all subcontractors he may employ.

* 1.3 Purpose. The purpose of this standard is twofold· (a) it seeks to preserve the multiplex bus techniques which have been standardized in MIL-STD-1553B, and (b) it provides guidelines for the application of fiber optic transmission techniques to the MIL-STD-1553B interconnect. Use of this standard alone will not ensure total compatibility of transmission characteristics between different systems which employ a fiber optic interconnect; however, it will ensure general compatibility of the optical modulation technique. The optical power levels, optical wavelength and the means for distributing optical power in any specific implementation must be contained in a specification which references this standard.

2 REFERENCED DOCUMENTS

* 2.1 Issue of document. The following documents of the issue in effect on date of invitation for bid or request for proposal form a part of this standard to the extent specified herein.

SPECIFICATIONS

STANDARDS

MILITARY

MIL-STD-1553B	Aircraft Internal Time Division Command/Response Multiplex Data Bus

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3 DEFINITIONS

3.1 Bit. Contraction of binary digit: may be either zero or one In information theory a binary digit is equal to one binary decision or the designation of one of two possible values or states of anything used to store or convey information

3 2 Bit rate The number of bits transmitted per second

3.3 Pulse Code Modulation (PCM) The form of modulation in which the modulation signal is sampled, quantized and coded so that each element of information consists of different types or numbers of pulses and spaces.

3.4 Time Division Multiplexing (TDM). The transmission of information from several signal sources through one communication system with different signal samples staggered in time to form a composite pulse train

3.5 Half duplex. Operation of a data transfer system in either direction over a single line, but not in both directions on that line simultaneously.

3.6 Word In this document a word is a sequence of 16 bits plus sync and parity There are three types of words command, status and data

3 7 Message A single message is the transmission of a command word, status word and data words if they are specified For the case of a remote terminal to remote terminal (RT to RT) transmission, the message shall include the two command words, the two status words and data words

3.8 Subsystem. The device or functional unit receiving data transfer service from the data bus

* 3.9 Data bus Whenever a data bus or bus is referred to in this document, it shall imply all the hardware in the signal distribution network, including the harness assembly of fiber optic cables, access coupler(s), connectors, etc , required to provide a path between all terminals

3.10 Terminal. The electronic module necessary to interface the data bus with the subsystem and the subsystem with the data bus Terminals may exist as separate line replaceable units (LRUs) or be contained within the elements of the subsystem

3.11 Bus controller (BC). The terminal assigned the task of initiating information transfers on the data bus.

3.12 Bus monitor (BM). The terminal assigned the task of receiving bus traffic and extracting selected information to be used at a later time.

3.13 Remote Terminal (RT). All terminals not operating as the bus controller or as a bus monitor.

3.14 Asynchronous operation. For the purpose of this standard, asynchronous operation is the use of an independent clock source in each terminal for message transmission. Decoding is achieved in receiving terminals using clock information derived from the message.

3.15 Dynamic bus control. The operation of a data bus system in which designated terminals are offered control of the data bus.

3.16 Command/response. Operation of a data bus system such that remote terminals receive and transmit data only when commanded to do so by the bus controller.

3.17 Redundant data bus. The use of more than one data bus to provide more than one data path between the subsystems, i.e , dual redundant data bus, tri-redundant data bus, etc.

3.18 Broadcast Operation of a data bus system such that information transmitted by the bus controller or a remote terminal is addressed to more than one of the remote terminals connected to the data bus.

3.19 Mode code. A means by which the bus controller can communicate with the multiplex bus related hardware in order to assist in the management of information flow.

* 3.20 Access coupler. An access coupler is a device which distributes optical power among several ports. Star couplers and tee couplers are examples of access couplers.

* 3 21 Optical Signal Range (OSR). Optical Signal Range is the ratio of the maximum optical signal power to the minimum optical signal power expressed in dBs. As a system specification applied to an optical bus network, it describes the maximum range of signals that can be seen by any terminal over the operating conditions specified. Although OSR is expressed as a ratio, it is important that the maximum and minimum optical signal power levels be specified as well.

* 3.22 Mid-Bit Transition. The position in the sync waveform where the optical pulse goes from a high state to a completely off or low state

4. GENERAL REQUIREMENTS

4.1 Test and operating requirements. All requirements as specified herein shall be valid over the environmental conditions in which the multiplex data bus system shall be required to operate.

* 4.2 Data bus operation. The multiplex data bus system shall function asynchronously in a command/response mode, and transmission shall occur in a half duplex manner Sole control of information transmission on the bus shall reside with the bus controller, which shall initiate all transmissions. The

information flow on the data bus shall be comprised of messages which are, in turn, formed by three types of words (command, data and status) as defined in paragraph 4.3 3.5. A sample multiplex data bus system showing interconnection with a star configuration is illustrated on Figure 1. However, it is not the intent of this standard to dictate or recommend a specific configuration for distribution of optical power

4.3 Characteristics.

4 3 1 Data form. Digital data may be transmitted in any desired form, provided that the chosen form shall be compatible with the message and word formats defined in this standard. Any unused bit positions in a word shall be transmitted as logic zeros.

4 3 2 Bit priority. The most significant bit shall be transmitted first with the less significant bits following in descending order of value in the data word The number of bits required to define a quantity shall be consistent with the resolution or accuracy required. In the event that multiple precision quantities (information accuracy or resolution requiring more than 16 bits) are transmitted, the most significant bits shall be transmitted first, followed by the word(s) containing the lesser significant bits in numerical descending order Bit packing of multiple quantities in a single data word is permitted.

4 3 3 Transmission method.

4 3 3.1 Modulation The signal shall be transferred over the data bus in serial digital pulse code modulation form consistant with the resolution or accuracy required In the event that multiple precision quantities (information accuracy or resolution requiring more than 16 bits) are transmitted, the most significant bits shall be transmitted first, followed by the word(s) containing the lesser significant bits in numerical descending order Bit packing of multiple quantities in a single data word is permitted

* 4.3 3.2 Data code The data code shall be Manchester II bi-phase level. A logic one shall be transmitted as a coded signal I/O (i.e., an optical pulse followed by a low level or completely off condition). A logic zero shall be a coded signal 0/1 (i e., an optical pulse preceded by a low level or completely off condition). A transition occurs at the midpoint of each bit time (see Figure 2).

4.3.3.3 Transmission bit rate The transmission bit rate on the bus shall be 1.0 megabit per second with a combined accuracy and long-term stability of ±0 1 percent (i.e., ±1000 bits per second) The short-term stability (i.e., stability over 1 0 second interval) shall be at least 0 01 percent (i.e., ±100 bits per second).

4.3.3.4 Word size. The word size shall be 16 bits plus the sync waveform and the parity bit for a total of 20 bit times as shown on Figure 3.

4.3 3.5 Word formats. The word formats shall be as shown on Figure 3 for the command, data and status words

4.3.3.5.1 Command word. A command word shall be comprised of a sync waveform, remote terminal address field, transmit/receive (T/R) bit, subaddress/mode field, word count/mode code field and a parity (P) bit (see Figure 3).

* 4 3.3.5.1 1 Sync The command sync waveform shall be an invalid Manchester waveform as shown on Figure 4. The width of the sync waveform shall be three bit times, with an optical pulse for the first one and one-half bit times and then a low level or completely off condition for the following one and one-half bit times. If the next bit following the sync waveform is a logic zero, then the last half of the sync waveform will have an apparent width of two clock periods due to the Manchester encoding.

4.3.3.5 1.2 Remote terminal address. The next five bits following the sync shall be the RT address. Each RT shall be assigned a unique address. Decimal address 31 (11111) shall not be assigned as a unique address. In addition to its unique address, a RT shall be assigned decimal address 31 (11111) as the common address, if the broadcast option is used

4.3 3.5.1.3 Transmit/receive. The next bit following the remote terminal address shall be the T/R bit, which shall indicate the action required of the RT. A logic zero shall indicate the RT is to receive, and a logic one shall indicate the RT is to transmit.

4 3.3.5.1.4 Subaddress/mode. The next five bits following the T/R bit shall be utilized to indicate an RT subaddress or use of mode control, as is dictated by the individual terminal requirements. The subaddress/mode values of 00000 and 11111 are reserved for special purposes, as specified in 4 3.3 5 1 7, and shall not be utilized for any other function.

4 3.3 5 1.5 Data word count/mode code The next five bits following the subaddress/mode field shall be the quantity of data words to be either sent out or received by the RT or the optional mode code as specified in 4 3 3.5.1 7. A maximum of 32 data words may be transmitted or received in any one message block All 1s shall indicate a decimal count of 31 and all 0s shall indicate a decimal count of 32

4.3.3.5.1.6 Parity. The last bit in the word shall be used for parity over the preceding 16 bits Odd parity shall be utilized.

4.3 3.5.1.7 Optional mode control. For RTs exercising this option a subaddress/mode code of 00000 or 11111 shall imply that the contents of the data word count/mode code field are to be decoded as a five bit mode command. The mode code shall only be used to communicate with the multiplex bus related hardware, and to assist in the management of information flow, and not to extract data from or feed data to a functional subsystem. Codes 00000 through 01111 shall only be used for mode codes which do not require transfer of a data word. For these codes, the T/R bit shall be set to 1. Codes 10000 through 11111 shall only be used for mode codes which require transfer of a single data word. For these mode codes, the T/R bit shall indicate the

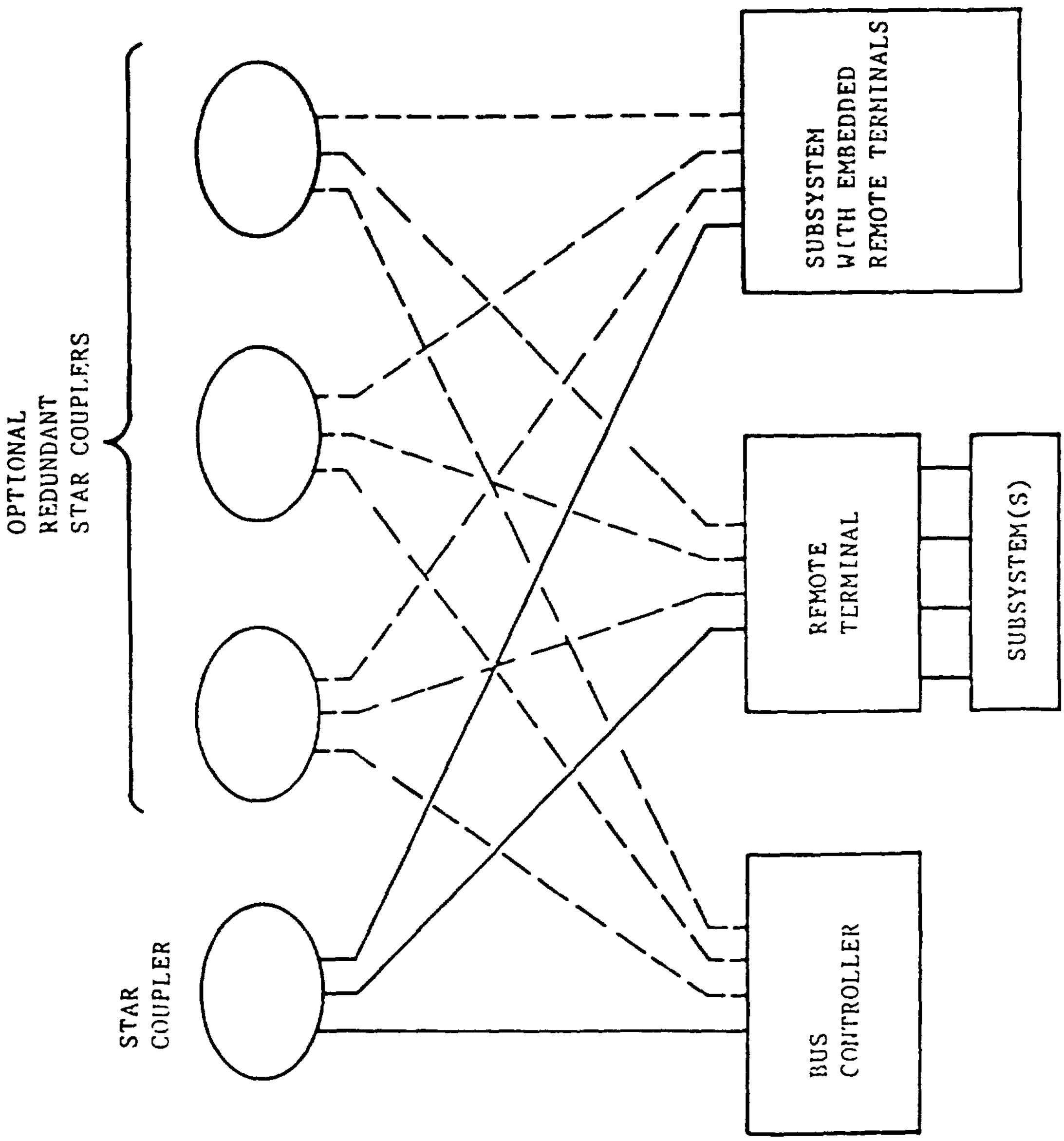


*FIGURE 1. Sample multiplex data bus architecture.

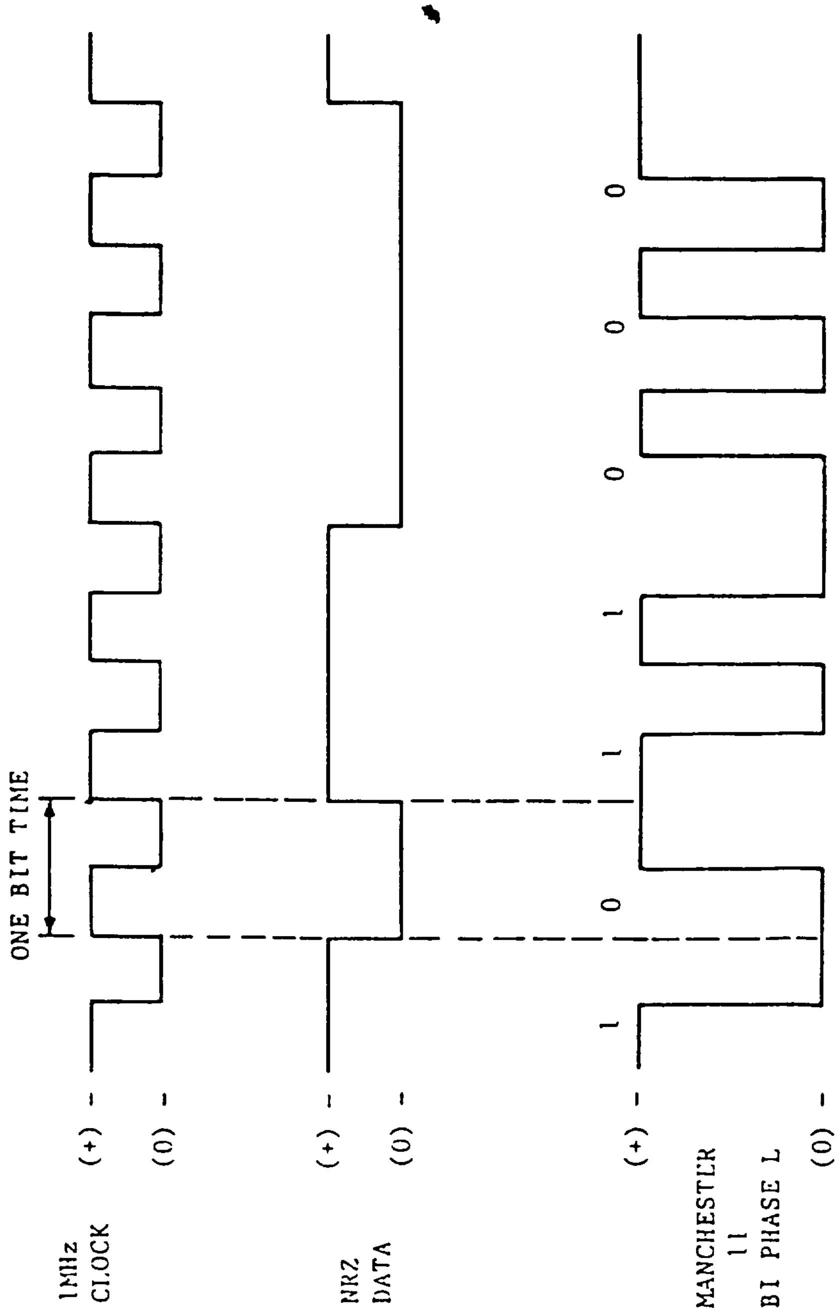


*FIGURE 2. Data encoding.

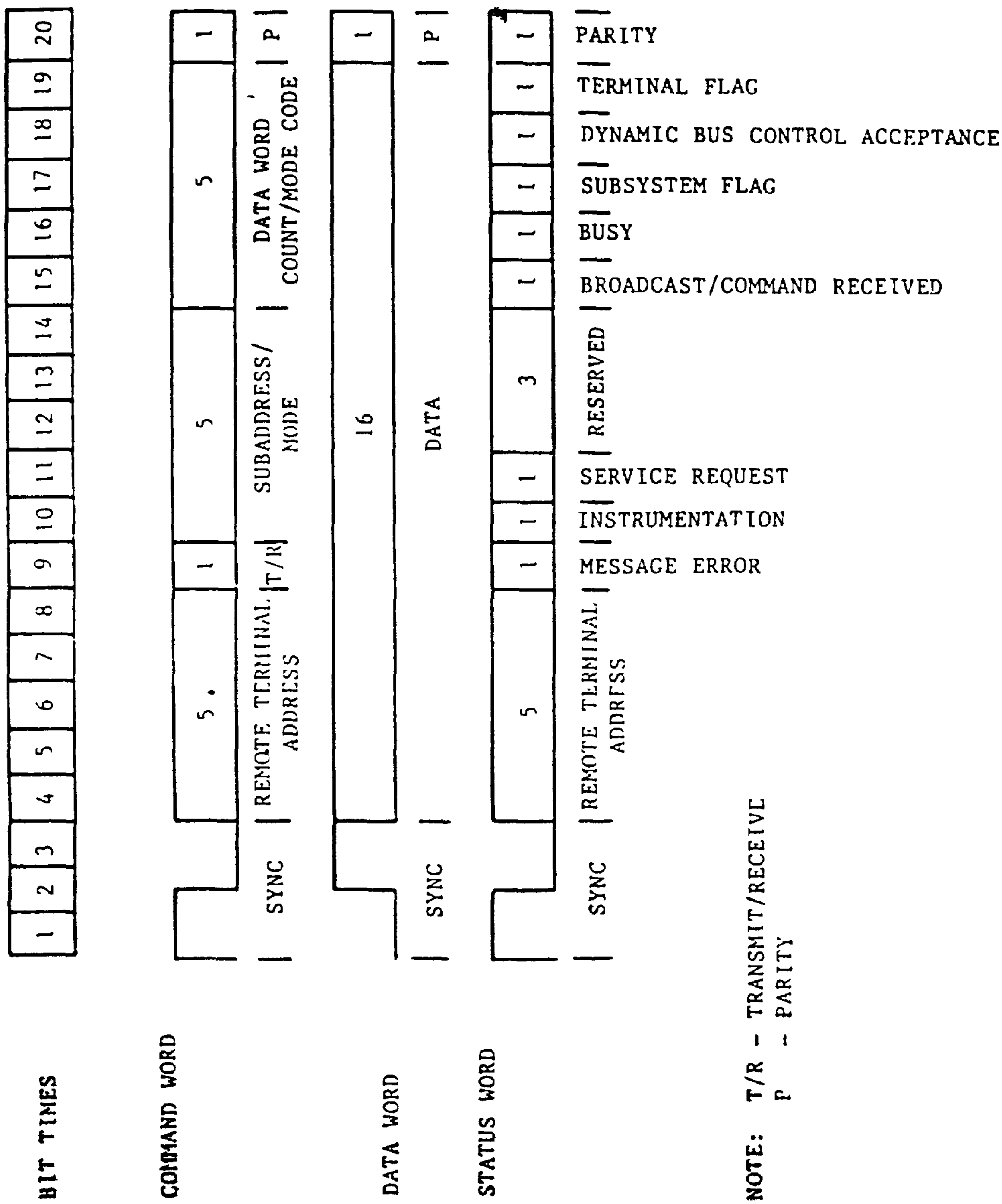


*FIGURE 3. Word formats.

direction of data word flow as specified in 4.3.3.5.1.3. No multiple data word transfer shall be implemented with any mode code. The mode codes are reserved for the specific functions as specified in Table I and shall not be used for any other purpose. If the designer chooses to implement any of these functions, the specific codes, T/R bit assignments and use of a data word, shall be used as indicated. The use of the broadcast command option shall only be applied to particular mode codes as specified in Table I.

4.3.3.5.1.7 1 Dynamic bus control The controller shall issue a transmit command to an RT capable of performing the bus control function. This RT shall respond with a status word as specified in 4.3.3.5.3. Control of the data bus passes from the offering bus controller to the accepting RT upon completion of the transmission of the status word by the RT. If the RT rejects control of the data bus, the offering bus controller retains control of the data bus

4.3.3.5.1 7.2 Synchronize (without data word). This command shall cause the RT to synchronize (e.g., to reset the internal timer, to start a sequence, etc.). The RT shall transmit the status word as specified in 4.3.3.5.3.

4.3.3.5 1.7.3 Transmit status word. This command shall cause the RT to transmit the status word associated with the last valid command word preceding this command. This mode command shall not alter the state of the status word.

4.3.3.5.1.7.4 Initiate self test. This command shall be used to initiate self test within the RT. The RT shall transmit the status word as specified in 4.3.3.5.3.

4.3.3.5.1 7.5 Transmitter shutdown. This command (to only be used with dual redundant bus systems) shall cause the RT to disable the transmitter associated with the redundant bus. The RT shall not comply with a command to shut down a transmitter on the bus from which this command is received. In all cases, the RT shall respond with a status word as specified in 4.3.3.5 3 after this command

4.3.3.5.1.7 6 Override transmitter shutdown. This command (to only be used with dual redundant bus systems) shall cause the RT to enable a transmitter which was previously disabled. The RT shall not comply with a command to enable a transmitter on the bus from which this command is received. In all cases, the RT shall respond with a status word as specified in 4. 3.3.5.3 after this command.

4.3.3.5.1 7.7 Inhibit terminal flag (T/F) bit. This command shall cause the RT to set the T/F bit in the status word specified in 4.3.3.5.3 to logic zero until otherwise commanded. The RT shall transmit the status word as specified in 4.3.3.5.3.

4.3.3.5.1.7.8 Override inhibit T/F bit. This command shall cause the RT to override the inhibit T/F bit specified in 4.3.3.5.1.7.7. The RT shall transmit the status word as specified in 4.3.3.5.3.

TABLE I. Assigned mode codes.

T/R Bit	Mode Code	Function	Associated Data Word	Broadcast Command Allowed
1	00000	Dynamic Bus Control	No	No
1	00001	Synchronize	No	Yes
1	00010	Transmit Status Word	No	No
1	00011	Initiate Self Test	No	Yes
1	00100	Transmitter Shutdown	No	Yes
1	00101	Override Transmitter Shutdown	No	Yes
1	00110	Inhibit Terminal Flag Bit	No	Yes
1	00111	Override Inhibit Terminal Flag Bit	No	Yes
1	01000	Reset Remote Terminal	No	Yes
1	01001	Reserved	No	TBD
1	01111	Reserved	No	TBD
1	10000	Transmit Vector Word	Yes	No
1	10001	Synchronize	Yes	Yes
1	10010	Transmit Last Command	Yes	No
1	10011	Transmit BIT Word	Yes	No
1	10100	Selected Transmitter Shutdown	Yes	Yes

NOTE. To be determined (TBD)

TABLE I. Assigned mode codes.

T/R Bit	Mode Code	Function	Associated Data Word	Broadcast Command Allowed
0	00000	Reserved	yes	TBD
0	10000	Reserved	YES	TBD
0	10001	Synchronize	Yes	Yes
0	10010	Reserved	Yes	TBD
0	10011	Reserved	Yes	TBD
0	10100	Selected Transmitter Shutdown	Yes	Yes
0	10101	Override Selected Transmitter Shutdown	Yes	Yes
1 or 0	10110	Reserved	Yes	TBD
1 or 0	11111	Reserved	Yes	TBD

NOTE: To be determined (TBD)

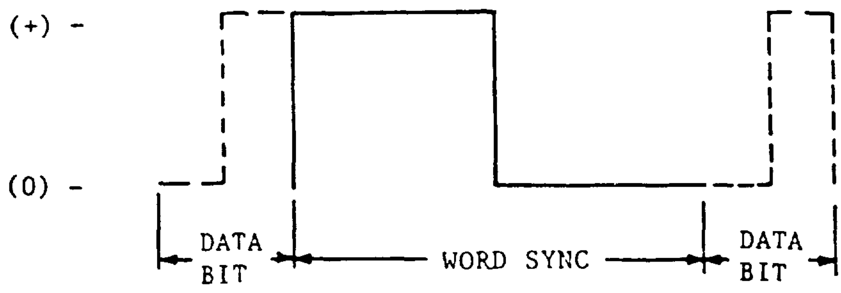


*FIGURE 4. Command and status sync.

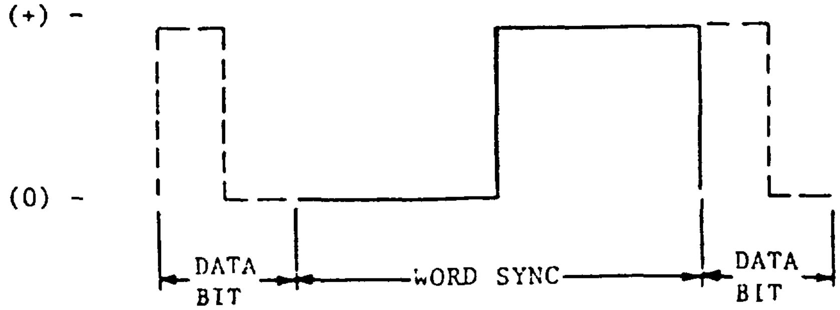


*FIGURE 5. Data sync.

4 3.3.5.1.7.9 Reset remote terminal. This command shall be used to reset the RT to a power up initialized state. The RT shall first transmit its status word and then reset.

4.3.3.5.1.7.10 Reserved mode codes (01001 to 01111). These mode codes are reserved for future use and shall not be used.

4.3.3.5.1.7.11 Transmit vector word. This command shall cause the RT to transmit a status word as specified in 4.3.3.5.3 and a data word containing service request information.

4.3 3.5.1.7.12 Synchronize (with data word). The RT shall receive a command word followed by a data word as specified in 4.3.3.5.2. The data word shall contain synchronization information for the RT. After receiving the command and data word, the RT shall transmit the status word as specified in 4.3.3.5.3.

4 3.3.5.1.7.13 Transmit last command word. This command shall cause the RT to transmit its status word as specified in 4.3.3 5.3 followed by a single data word which contains bits 4-19 of the last command word, excluding a transmit last command word mode code received by the RT. This mode command shall not alter the state of the RT's status word

4 3 3 5 1.7.14 Transmit Built-In-Test (BIT) word. This command shall cause the RT to transmit its status word as specified in 4.3.3.5.3 followed by a single data word containing the RT BIT data This function is intended to supplement the available bits in the status word when the RT hardware is sufficiently complex to warrant its use The data word, containing the RT BIT data, shall not be altered by the reception of a transmit last command or a transmit status word mode code. This function shall not be used to convey BIT data from the associated subsystem(s).

4.3.3.5.1.7.15 Selected transmitter shutdown This command shall cause the RT to disable the transmitter associated with a specified redundant data bus The command is designed for use with systems employing more than two redundant buses. The transmitter that is to be disabled shall be identified in the data word following the command word in the format as specified in 4.3.3.5.2. The RT shall not comply with a command to shut down a transmitter on the bus from which this command is received. In all cases, the RT shall respond with a status word as specified in 4.3.3.5.3.

4 3.3.5.1.7.16 Override selected transmitter shutdown. This command shall cause the RT to enable a transmitter which was previously disabled. The command is designed for use with systems employing more than two redundant buses. The transmitter that is to be enabled shall be identified in the data word following the command word in the format as specified in 4.3.3.5.2. The RT shall not comply with a command to enable a transmitter on the bus from which this command is received. In all cases, the RT shall respond with a status word as specified in 4.3.3.5 3.

4.3.3.5.1.7.17 Reserved mode codes (10110 to 11111). These mode codes are reserved for future use and shall not be used.

4.3.3.5.2 Data word. A data word shall be comprised of a sync waveform, data bits and a parity bit (see Figure 3)

* 4.3.3 5 2.1 Sync The data sync waveform shall be an invalid Manchester waveform as shown on Figure 5. The width shall be three bit times, with the waveform being a low level or completely off condition for the first one and one-half bit times, and then an optical pulse for the following one and one-half bit times Note that if the bits preceding and following the sync are logic ones, then the apparent width of the sync waveform will be increased to four bit times.

4.3.3.5.2.2 Data. The sixteen bits following the sync shall be utilized for data transmission as specified in 4.3 2.

4.3.3.5.2 3 Parity The last bit shall be utilized for parity as specified in 4.3.3 5.1.6.

4 3.3.5.3 Status word. A status word shall be comprised of a sync waveform, RT address, message error bit, instrumentation bit, service request bit, three reserved bits, broadcast command received bit, busy bit, subsystem flag bit, dynamic bus control acceptance bit, terminal flag bit and a parity bit For optional broadcast operation, transmission of the status word shall be suppressed as specified in 4.3 3.6.7.

4.3 3.5 3.1 Sync The status sync waveform shall be as specified in 4.3.3.5.1 1

4.3 3.5 3 2 RT address The next five bits following the sync shall contain the address of the RT which is transmitting the status word as defined in 4.3.3.5.1.2

4.3.3.5.3.3 Message error bit The status word bit at bit time nine (see Figure 3) shall be utilized to indicate that one or more of the data words associated with the preceding receive command word from the bus controller has failed to pass the RT's validity tests as specified in 4 4 1.1. This bit shall also be set under the conditions specified in 4.4.1.2, 4 4.3 4 and 4.4.3.6. A logic one shall indicate the presence of a message error and a logic zero shall show its absence All RTs shall implement the message error bit.

4.3.3.5.3.4 Instrumentation bit. The status word at bit time ten (see Figure 3) shall be reserved for the instrumentation bit and shall always be a logic zero. This bit is intended to be used in conjunction with a logic one in bit time ten of the command word to distinguish between a command word and a status word. The use of the instrumentation bit is optional.

4.3.3.5 3.5 Service request bit. The status word bit at bit time eleven (see Figure 3) shall be reserved for the service request bit. The use of this bit is optional. This bit, when used, shall indicate the need for the bus controller to take specific predefined actions relative to either the RT or associated subsystem. Multiple subsystems, interfaced to a single RT, which individually require a service request signal, shall logically OR their individual signals into the single status word bit. In the event this logical OR is performed, then the designer must make provisions in a separate data word to identify the specific requesting subsystem. The service request bit is intended to be used only to trigger data transfer operations which take place on an exception rather than periodic basis. A logic one shall indicate the presence of a service request, and a logic zero its absence. If this function is not implemented, the bit shall be set to zero.

4.3.3.5.3.6 Reserved status bits. The status word bits at bit times twelve through fourteen are reserved for future use and shall not be used. These bits shall be set to a logic zero.

4 3.3.5.3.7 Broadcast command received bit. The status word at bit time fifteen shall be set to a logic one to indicate that the preceding valid command word was a broadcast command and a logic zero shall show it was not a broadcast command. If the broadcast command option is not used, this bit shall be set to a logic zero.

4.3 3.5.3.8 Busy bit. The status word bit at bit time sixteen (see Figure 3) shall be reserved for the busy bit. The use of this bit is optional This bit, when used, shall indicate that the RT or subsystem is unable to move data to or from the subsystem in compliance with the bus controller's command A logic one shall indicate the presence of a busy condition, and a logic zero its absence. In the event the busy bit is set in response to a transmit command, then the RT shall transmit its status word only If this function is not implemented, the bit shall be set to logic zero.

4.3.3 5.3 9 Subsystem flag bit. The status word bit at bit time seventeen (see Figure 3) shall be reserved for the subsystem flag bit. The use of this bit is optional This bit, when used, shall flag a subsystem fault condition, and alert the bus controller to potentially invalid data Multiple subsystems, interfaced to a single RT, which individually require a subsystem flag bit signal, shall logically OR their individual signals into the single status word bit. In the event this logical OR is performed, then the designer must make provisions in a separate data word to identify the specific reporting subsystem. A logic one shall indicate the presence of the flag, and a logic zero its absence If not used, this bit shall be set to logic zero.

4.3 3 5.3 10 Dynamic bus control acceptance bit. The status word bit at bit time eighteen (see Figure 3) shall be reserved for the acceptance of dynamic bus control. This bit shall be used if the RT implements the optional dynamic bus control function. This bit, when used, shall indicate acceptance or rejection of a dynamic bus control offer as specified in 4.3.3.5.1.7.1. A logic one shall indicate acceptance of control, and a logic zero shall indicate rejection of control. If this function is not used, this bit shall be set to logic zero.

4.3.3.5.3.11 Terminal flag bit. The status word bit at bit time nineteen (see Figure 3) shall be reserved for the terminal flag function. The use of this bit is optional This bit, when used, shall flag a RT fault condition. A logic one shall indicate the presence of the flag, and a logic zero, its absence. If not used, this bit shall be set to logic zero

4 3.3.5 3.12 Parity bit The least significant bit in the status word shall be utilized for parity as specified in 4 3 3.5 1.6

4 3.3.5.4 Status word reset. The status word bit, with the exception of the address, shall be set to logic zero after a valid command word is received by the RT with the exception as specified in 4 3.3.5.1.7. If the conditions which caused bits in the status word to be set (e.g., terminal flag) continue after the bits are reset to logic zero, then the affected status word bit shall be again set, and then transmitted on the bus as required.

4 3.3.6 Message formats. The messages transmitted on the data bus shall be in accordance with the formats on Figure 6 and Figure 7. The maximum and minimum response times shall be as stated in 4 3 3.7 and 4.3 3 8 No message formats, other than those defined herein, shall be used on the bus

4.3 3.6.1 Bus controller to remote terminal transfers. The bus controller shall issue a receive command followed by the specified number of data words The RT shall, after message validation, transmit a status word back to the controller. The command and data words shall be transmitted to a contiguous fashion with no interword gaps

4 3.3 6 2 Remote terminal to bus controller transfers. The bus controller shall issue a transmit command to the RT. The RT shall, after command word validation, transmit a status word back to the bus controller, followed by the specified number of data words. The status and data words shall be transmitted in a contiguous fashion with no interword gaps

4.3.3 6.3 Remote terminal to remote terminal transfers The bus controller shall issue a receive command to RT A followed continuously by a transmit command to RT B. RT B shall, after command validation, transmit a status word followed by the specified number of data words The status and data words shall be transmitted in a contiguous fashion with no gap At the conclusion of the data transmission by RT B, RT A shall transmit a status word within the specified time period.

4 3.3.6.4 Mode command without data word The bus controller shall issue a transmit command to the RT using a mode code specified in Table I. The RT shall, after command word validation, transmit a status word

4 3.3.6.5 Mode command with data word (transmit). The bus controller shall issue a transmit command to the RT using a mode code specified in Table I. The RT shall, after command word validation, transmit a status word followed by one data word. The status word and data word shall be transmitted in a contiguous fashion with no gap

4 3 3.6.6 Mode command with data word (receive). The bus controller shall issue a receive command to the RT using a mode code specified in Table I, followed by one data word. The command word and data word shall be transmitted in a contiguous fashion with no gap. The RT shall, after command and data word validation, transmit a status word back to the controller.

4.3.3 6.7 Optional broadcast command. See 10 5 for additional information on the use of the broadcast command

4.3.3.6.7.1 Bus controller to remote terminal(s) transfer (broadcast). The bus controller shall issue a receive command word with 11111 in the RT address field followed by the specified number of data words. The command word and data words shall be transmitted in a contiguous fashion with no gap. The RT(s) with the broadcast option shall, after message validation, set the broadcast command received bit in the status word as specified in 4.3.3.5.3.7 and shall not transmit the status word.

4.3.3.6.7.2 Remote terminal to remote terminal(s) transfers (broadcast) The bus controller shall issue a receive command word with 11111 in the RT address field followed by a transmit command to RT A using the RT's address RT A shall, after command word validation, transmit a status word followed by the specified number of data words. The status and data words shall be transmitted in a contiguous fashion with no gap. The RT(s) with the broadcast option, excluding RT A, shall after message validation, set the broadcast received bit in the status word as specified in 4.3 3 5.3 7 and shall not transmit the status word.

4.3.3.6 7.3 Mode command without data word (broadcast). The bus controller shall issue a transmit command word with 11111 in the RT address field, and a mode code specified in Table I. The RT(s) with the broadcast option shall, after command word validation, set the broadcast received bit in the status word as specified in 4 3.3.5.3.7 and shall not transmit the status word.

4.3.3.6 7.4 Mode command with data word (broadcast) The bus controller shall issue a receive command word with 11111 in the RT address field and a mode code specified in Table I, followed by one data word. The command word and data word shall be transmitted in a contiguous fashion with no gap. The RT(s) with the broadcast option shall, after message validation, set the broadcast received bit in the status word as specified in 4.3.3.5 3.7 and shall not transmit the status word.

* 4.3.3.7 Intermessage gap. The bus controller shall provide a minimum gap time of 4.0 microseconds (us) between messages as shown on Figure 6 and Figure 7. This time period, shown as T on Figure 8, is measured at point A of the bus controller as shown on Figure 9 or Figure 10. The time is measured from the mid-bit transition of the last bit of the preceding message to mid-sync transition of the next command word sync.

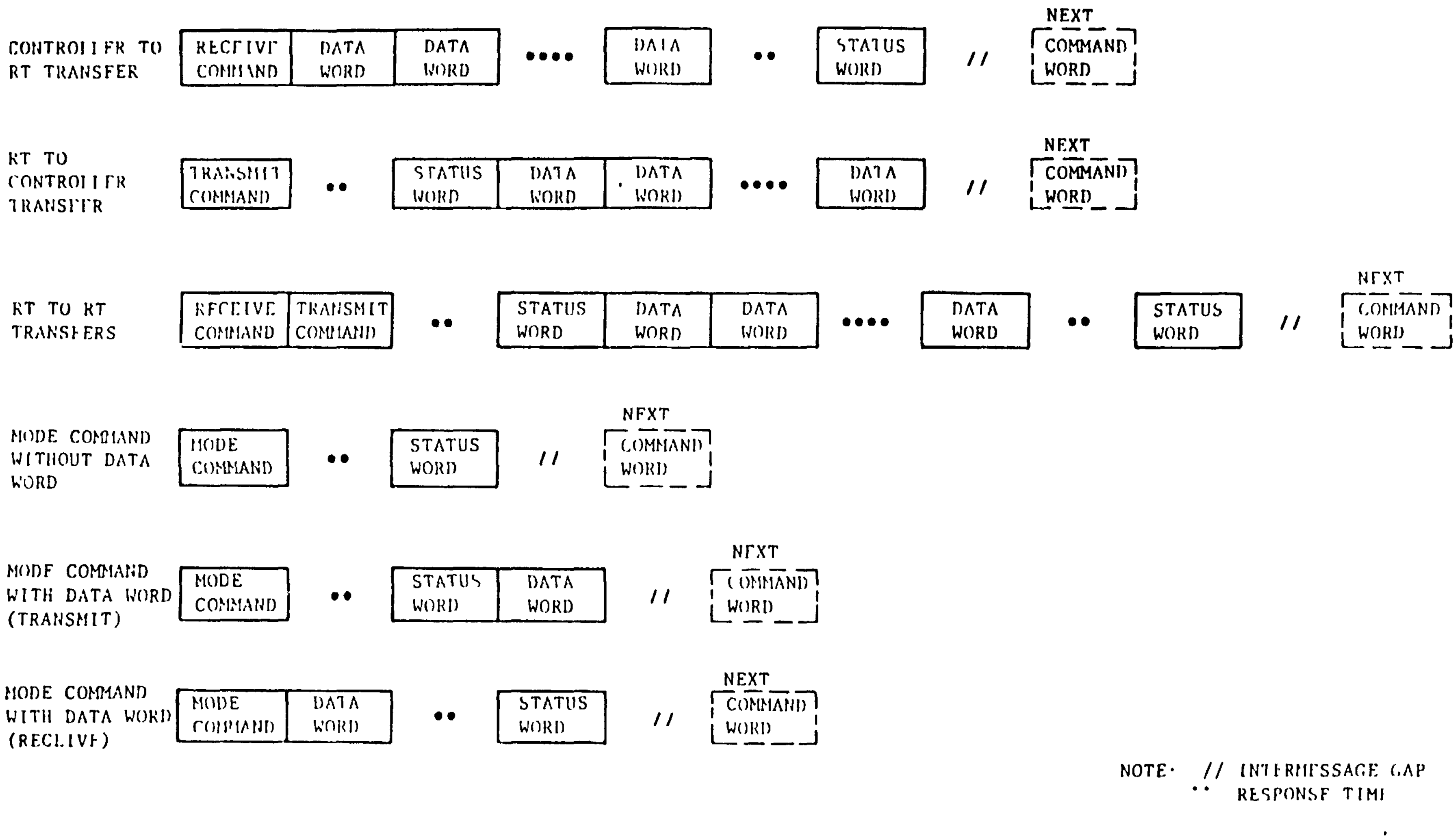
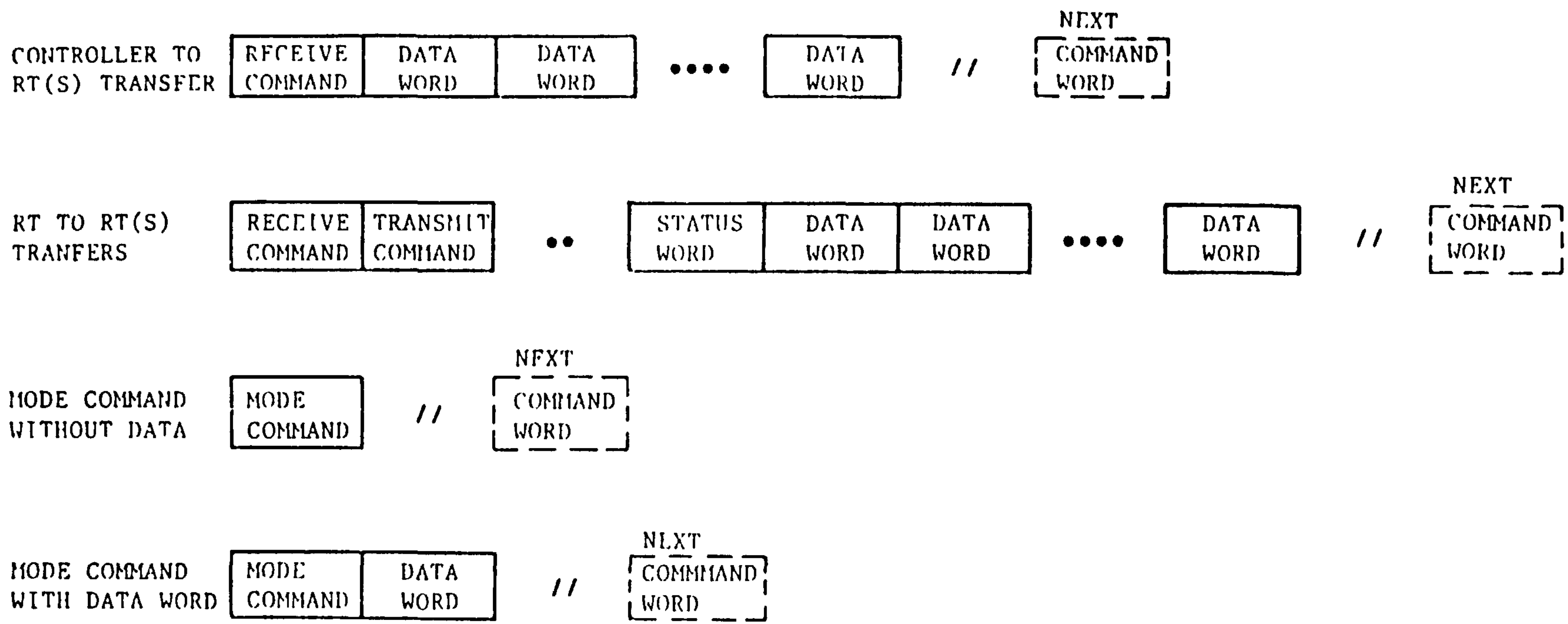


FIGURE 6. Information transfer formats.



NOTE: // INTERMESSAGE GAP
•• RESPONSE TIME

FIGURE 7. Broadcast information transfer formats.

* 4 3.3 8 Response time. The RT shall respond, in accordance with 4.3.3.6, to a valid command word within the time period of 4.0 to 12 0 us This time period, shown as T on Figure 8, is measured at point A of the RT as shown on Figure 9 or Figure 10 The time is measured from the mid-bit transition of the last word as specified in 4.3.3 6 and as shown on Figure 6 and Figure 7 to the mid-sync transition of the status word sync.

* 4.3.3.9 Minimum no-response time-out. The minimum time that a terminal shall wait before considering that a response as specified in 4.3.3 8 has not occurred shall be 14.0 us. The time is measured from the mid-bit transition of the last bit of the last word to the mid-sync transition of the expected status word sync at point A of the terminal as shown on Figure 9 or Figure 10

4.4 Terminal operation.

4.4.1 Common operation. Terminals shall have common operating capabilities as specified in the following paragraphs.

4.4.1.1 Word validation. The terminal shall insure that each word conforms to the following minimum criteria:

a. The word begins with a valid sync field.

b. The bits are in a valid Manchester II code.

c. The information field has 16 bits plus parity.

d. The word parity is odd.

When a word fails to conform to the preceding criteria, the word shall be considered invalid.

4.4.1.2 Transmission continuity. The terminal shall verify that the message is contiguous as defined in 4 3.3.6. Improperly timed data syncs shall be considered a message error.

4.4.1.3 Terminal fail-safe. The terminal shall contain a hardware implemented time-out to preclude a signal transmission of greater than 800.0 us. This hardware shall not preclude a correct transmission in response to a command Reset of this time-out function shall be performed by the reception of a valid command on the bus on which the time-out has occurred.

4 4.2 Bus controller operation. A terminal operating as a bus controller shall be responsible for sending data bus commands, participating in data transfers, receiving status responses, and monitoring system status as defined in this standard. The bus controller function may be embodied as either a stand-alone terminal, whose sole function is to control the data bus(s), or contained within a subsystem Only one terminal shall be in active control of a data bus at any one time.

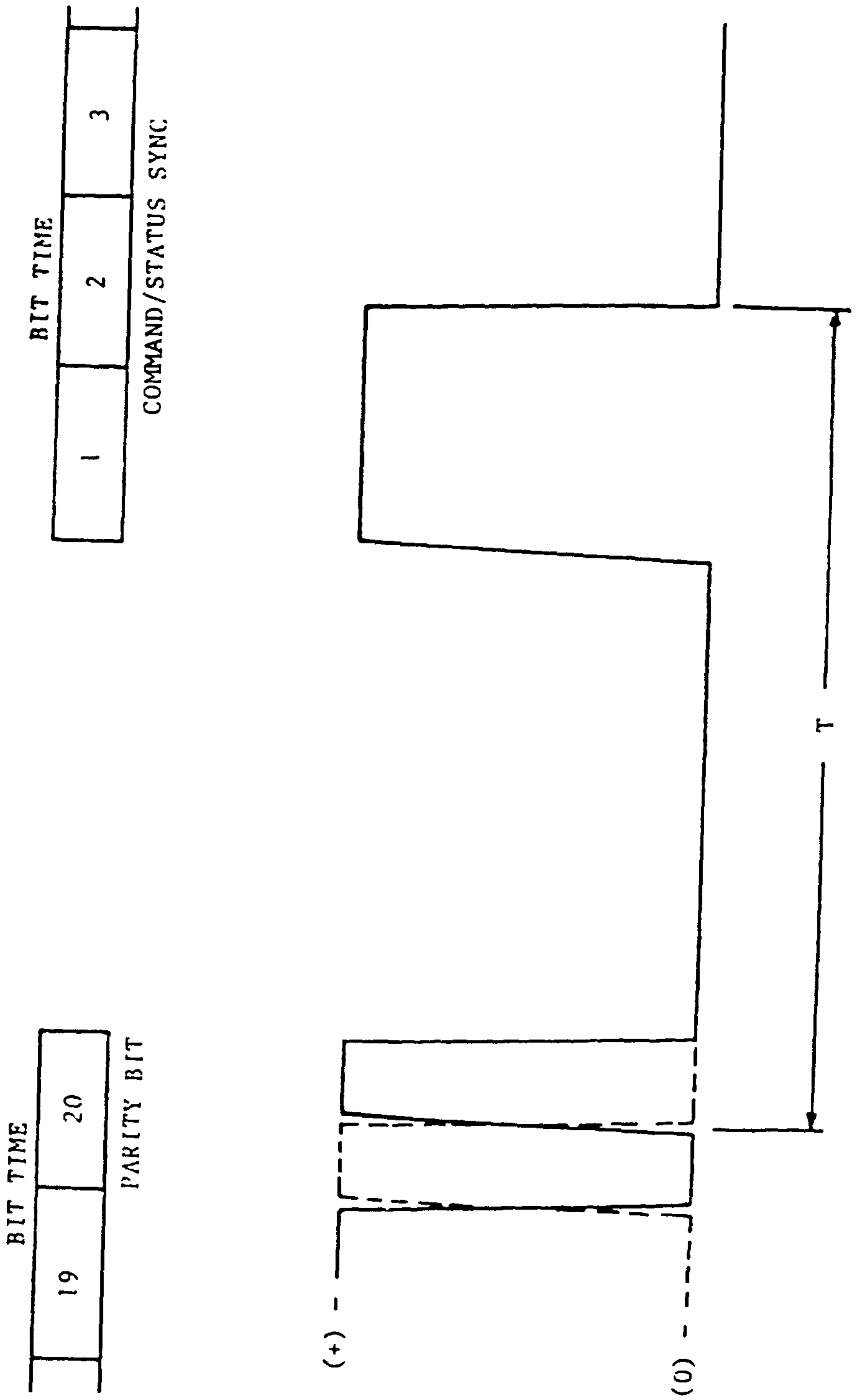


*FIGURE 8. Intermessage gap and response time.

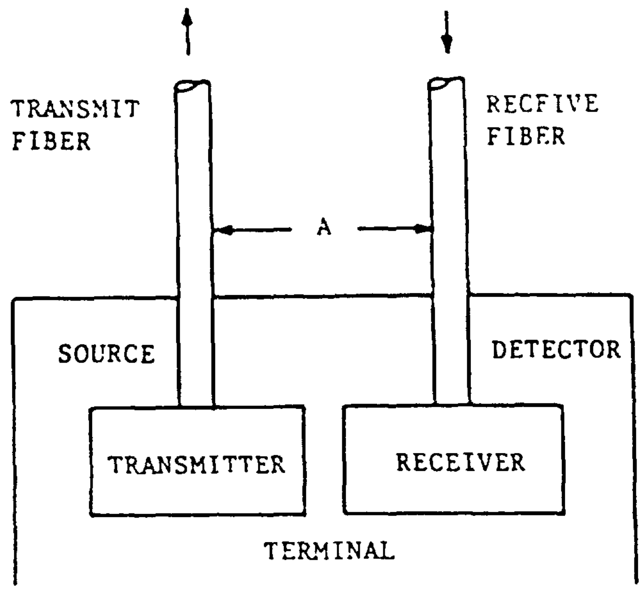


*FIGURE 9. Data bus interface using separate transmit and receive fibers.

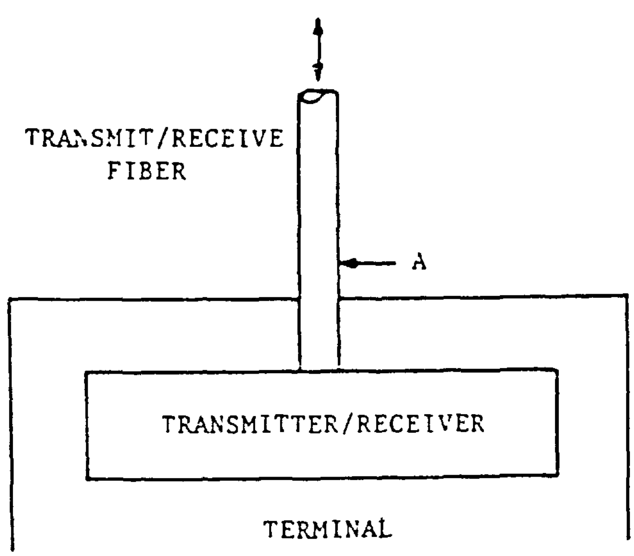


*FIGURE 10. Data bus interface using a single transmit and receive fiber.

4.4.3 Remote terminal.

4.4.3.1 Operation. A remote terminal (RT) shall operate in response to valid commands received from the bus controller. The RT shall accept a command word as valid when the command word meets the criteria of 4.4.1.1, and the command word contains a terminal address which matches the RT address or an address of 11111, if the RT has the broadcast option. No combination of RT address bits, T/R bit, subaddress/mode bits and data word count/mode code bits of a command word shall result in invalid transmission by the RT. Subsequent valid commands shall be properly responded to by the RT.

4.4.3.2 Superseding valid commands. The RT shall be capable of receiving a command word on the data bus after the minimum intermessage gap time as specified in 4.3.3.7 has been exceeded, when the RT is not in the time period T as specified in 4 3.3 8 prior to the transmission of a status word, and when it is not transmitting on that data bus. A second valid command word sent to an RT shall take precedence over the previous command. The RT shall respond to the second valid command as specified in 4 3.3 8.

4.4.3.3 Invalid commands. A remote terminal shall not respond to a command word, which fails to meet the criteria specified in 4.4.3.1.

4.4.3.4 Illegal command. An illegal command is a valid command as specified in 4.4.3 1, where the bits in the subaddress/mode field, data word count/mode code field and the T/R bit indicate a mode command, subaddress or word count that has not been implemented in the RT. It is the responsibility of the bus controller to assure that no illegal commands are sent out. The RT designer has the option of monitoring for illegal commands. If an RT that is designed with this option detects an illegal command and the proper number of contiguous valid data words as specified by the illegal command word, it shall respond with a status word only, setting the message error bit, and not use the information received.

4.4.3.5 Valid data reception. The remote terminal shall respond with a status word when a valid command word and the proper number of contiguous valid data words are received, or a single valid word associated with a mode code is received. Each data word shall meet the criteria specified in 4.4.1.1

4.4.3.6 Invalid data reception. Any data word(s) associated with a valid receive command that does not meet the criteria specified in 4.4.1.1 and 4.4.1.2 or an error in the data word count shall cause the remote terminal to set the message error bit in the status word to a logic one and suppress the transmission of the status word. If a message error has occurred, then the entire message shall be considered invalid.

4.4.4 Bus monitor operation. A terminal operating as a bus monitor shall receive bus traffic and extract selected information. While operating as a bus monitor, the terminal shall not respond to any message except one containing its own unique address if one is assigned All information obtained while acting as a bus monitor shall be strictly used for off-line applications (e.g , flight test recording, maintenance recording or mission analysis) or to provide the back-up bus controller sufficient information to take over as the bus controller.

4.5 Hardware characteristics.

4.5.1 Data bus characteristics.

* 4.5.1.1 Cable. The mechanical and optical characteristics of the fiber optic cable shall be in accordance with the system specification The bus network cable fibers shall be compatible with the I/O fiber(s) of the bus terminal, in accordance with the system specification(s).

* 4.5.1.2 Cable termination The fiber optic cable termination characteristics (connection losses, environmental characteristics, etc.) shall be in accordance with the system specification(s).

* 4.5.1.3 Connectors. The fiber optic connectors shall be in accordance with the system specification(s).

* 4.5.1.4 Bus configuration. The selection of bus configuration and access technique shall be as specified by the system designer but shall be compatible with the terminal input/output characteristics in accordance with the system specification(s).

* 4.5.1 5 Optical signal requirements The data bus shall be designed such that the optical signal received at every terminal receiver port from any terminal on the data bus shall be greater than the minimum level and within the optical signal range (OSR) specified in the system specification(s).

* 4.5.2 Terminal output characteristics

* 4 5.2 1 Output optical power. Output optical power shall be in accordance with the system specification(s)

* 4.5.2.2 Output waveform The output optical waveform shall be in accordance with the system specification(s).

* 4.5.2.3 Output noise. The output noise shall be in accordance with the system specification(s).

* 4.5.2.4 Output spectral characteristics. The output spectral characteristics shall be in accordance with the system specification(s)

* 4.5.3 Terminal input characteristics. The terminal shall have the specified input characteristics at the optical bus interface at point A shown on Figure 9 or Figure 10.

* 4.5 3.1 Input waveform compatibility The terminal shall be capable of receiving and operating with the incoming signals in accordance with the system specification(s).

* 4.5.3.2 Minimum input signal. The terminal shall achieve an error rate not greater than that specified in 4.5.3.3 when operated with the minimum input optical signal level and the environmental conditions in accordance with the system specification(s).

* 4 5.3 3 Error rate. The terminal shall exhibit a maximum word error rate of one part in 10^7 on all words received by the terminal after validation checks as specified in 4.4. A word error shall include any fault which causes the message error bit to be set in the terminal's status word or one which causes a terminal to not respond to a valid command. The terminal shall achieve this error rate when receiving two successive messages which differ in optical power by the maximum OSR in accordance with the system specification(s) for messages separated in time by the intermessage gap as specified in 4.3 3.7 (i.e , 4.0 us), irrespective of order. The error test shall be run continuously until, for a particular number of failures, the number of words received by the terminal, including both command and data words, exceeds the required number for acceptance of the terminal or is less than the required number for rejection of the terminal in accordance with Table II. All data words used in the test shall contain random bit patterns. These bit patterns shall be unique for each data word in a message and shall change randomly from message to message.

4.6 Redundant data bus requirements If redundant data buses are used, the requirements specified in Table II shall apply.

*TABLE II Criteria for acceptance or rejection of a terminal for the error rate test.

TOTAL WORDS RECEIVED BY THE TERMINAL (in multiples of 10^7)

No. of Errors	Reject (Equal or Less)	Accept (Equal or More)
0	N/A	4.40
1	N/A	5.21
2	N/A	6.02
3	N/A	6.83
4	N/A	7.64
5	N/A	8.45
6	0.45	9.27
7	1.26	10.08
8	2.07	10.89
9	2.88	11.70
10	3.69	12.51
11	4.50	13.32
12	5.31	14.13
13	6.12	14.94
14	6.93	15.75

*TABLE II. Criteria for acceptance or rejection of a terminal for the error rate test

TOTAL WORDS RECEIVED BY THE TERMINAL
(in multiples of 10^7)

No. of Errors	Reject (Equal or Less)	Accept (Equal or More)
15	7.74	16.56
16	8.55	17.37
17	9.37	18.19
18	10.18	19.00
19	10.99	19.81
20	11.80	20.62
21	12.61	21.43
22	13.42	22.24
23	14.23	23.05
24	15.04	23.86
25	15.85	24.67
26	16.66	25.48
27	17.47	26.29
28	18.29	27.11
29	19.10	27.92
30	19.90	28.73
31	20.72	29.54
32	21.53	30 35
33	22.34	31.16
34	23.15	31.97
35	23.96	32.78
36	24.77	33.00
37	25.58	33.00
38	26.39	33 00
39	27.21	33.00
40	28.02	33.00
41	33.00	N/A

* 4.6.1 Electrical/optical isolation. Electrical and/or optical isolation between multiple-redundant data buses shall be as specified in the system specification(s).

4.6 2 Single event failures. All data buses shall be routed to minimize the possibility that a single event failure to a data bus shall cause the loss of more than that particular data bus.

4.6.3 Dual standby redundant data bus. If a dual redundant data bus is used, then it shall be a dual standby redundant data bus as specified in the following paragraphs

4.6.3.1 Data bus activity Only one data bus can be active at any given time except as specified in 4 6.3.2.

4.6.3.2 Reset data bus transmitter. If while operating on a command, a terminal receives another valid command, from the other data bus, it shall reset and respond to the new command on the data bus on which the new command is received. The terminal shall respond to the new command as specified in 4.3.3.8.

5. DETAILED REQUIREMENTS

* 5.1 Specific implementations. Specific fiber optic bus implementation, based on this standard, involving specifications of parameters such as optical transmitter output power, optical receiver minimum signal level (sensitivity), optical interfaces and optical cable configuration, shall be in accordance with system specifications which reference this standard, as required by the invitation for bid or request for proposal.

6 NOTES

6.1 Intended use. Multiplex data buses conforming to the requirements of this standard are intended for use in general military fiber optic applications.

6.2 Subject term (key word) listing.

Access coupler
Bit
Bit rate
Bus controller
Bus monitor
Cable
Connectors
Data bus
Detector
Error rate
Fiber optics
Mode code
Modulation
Optical signal power
Optical signal terminal
Parity
Remote terminal
Source
Terminal
Time division multiplexing
Word

Custodians:
Navy-AS
Air Force-11
Army-AV

Preparing Activity:
Navy-AS
Project Number MCCR-0025

APPENDIX

*10. GENERAL. The following paragraphs in this appendix are presented in order to discuss certain aspects of the standard in a general sense. They are intended to provide a user of the standard with more insight into the aspects discussed.

10.1 Redundancy. It is intended that this standard be used to support rather than to supplant the system design process. However, it has been found, through application experience in various aircraft, that the use of a dual standby redundancy technique is very desirable for use in integrating mission avionics. For this reason, this redundancy scheme is defined in 4 6 of this standard. Nonetheless, the system designer should utilize this standard as the needs of a particular application dictate. The use of redundancy, the degree to which it is implemented, and the form which it takes must be determined on an individual application basis. Figures 11 and 12 illustrate some possible approaches to dual redundancy. These illustrations are not intended to be inclusive, but rather representative It should be noted that analogous approaches exist for the triple and quad redundant cases.

10.2 Bus controller. The bus controller is a key part of the data bus system. The functions of the bus controller, in addition to the issuance of commands, must include the constant monitoring of data bus and the traffic on the bus It is envisioned that most of the routine minute details of bus monitoring (e g., parity checking, terminal non-response time-out, etc) will be embodied in hardware, while the algorithms for bus control and decision making will reside in software It is also envisioned that, in general, the bus controller will be the general purpose airborne computer with a special input/output (I/O) to interface with the data bus It is of extreme importance in bus controller design that the bus controller be readily able to accommodate terminals of differing protocols and status word bits used Equipment designed to MIL-STD-1553A will be in use for a considerable period of time, thus, bus controllers must be capable of adjusting to their differing needs. It is also important to remember that the bus controller will be the focal point for modification and growth within the multiplex system and thus the software must be written in such a manner as to permit modification with relative ease.

*10 3 Multiplex selection criteria. The selection of candidate signals for multiplexing is a function of the particular application involved, and criteria will in general vary from system to system Obviously, those signals which have bandwidths of 400 Hz or less are prime candidates for inclusion on the bus It is also obvious that video, audio, and high speed parallel digital signals should be excluded The area of questionable application is usually between 400 Hz and 3kHz bandwidth The transfer of these signals on the data bus will depend heavily upon the loading of the bus in a particular application. The decision must be based on projected future bus needs as well as the current loading. Another class of signals which in general are not suitable for multiplexing are those which can be typified by a low rate (over a mission) but possessing a high priority or urgency. Examples of such signals might be a nuclear event detector output or a missile launch alarm

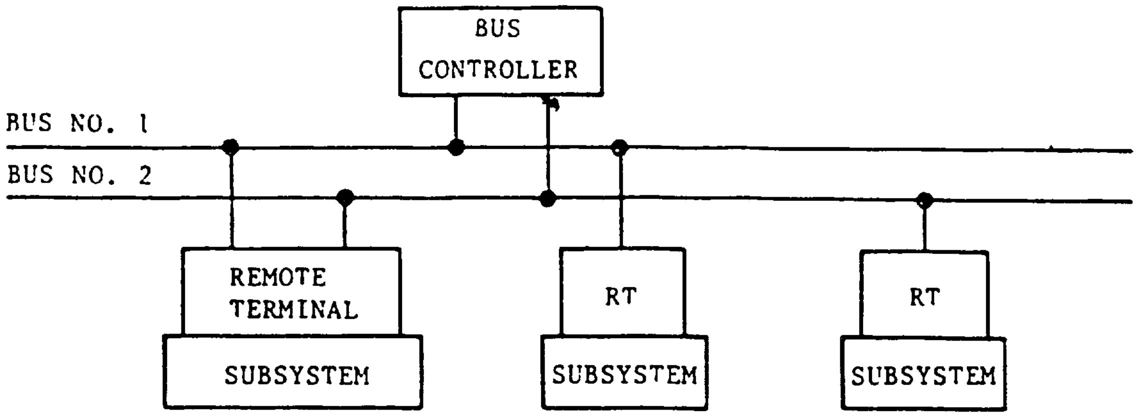
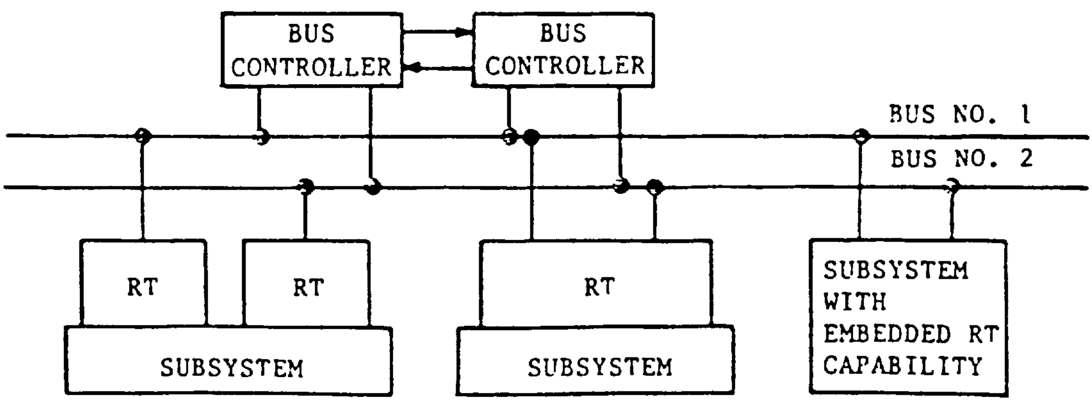


FIGURE 11. Illustration of possible redundancy.



RT - REMOTE TERMINAL

FIGURE 12. Illustration of possible redundancy.

from a warning receiver. Such signals are usually better left hardwired, but they may be accommodated by the multiplex system if a direct connection to the bus controller's interrupt hardware is used to trigger a software action in response to the signal.

10.4 High reliability requirements The use of simple parity for error detection within the multiplex bus system was dictated by a compromise between the need for reliable data transmission, system overhead and remote terminal simplicity. Theoretical and emperical evidence indicates that an undetected bit error rate of 10^{-12} can be expected from a practical multiplex system built to MIL-STD-1553B It is expected that a MIL-STD-1553B bus implemented in Fiber Optics (DOD-STD-1773) will achieve a comparable undetected error rate If a particular signal requires a bit error rate which is better than that provided by the parity checking, then it is incumbent upon the system designer to provide the reliability within the constraints of the standard or to not include this signal within the multiplex bus system A possible approach in this case would be to have the signal source and sink extra data words to transfer the information Another approach would be to partition the message, transmit a portion at a time, and then verify (by interrogation) the proper transfer of each segment.

*10.5 Use of broadcast option. The use of a broadcast message as defined in 4.3 3.6 7 of this standard represents a significant departure from the basic philosophy of this standard in that it is a message format which does not provide positive closed-loop control of bus traffic. The system designer is strongly encouraged to solve any design problems through the use of the three basic message formats without resorting to use of the broadcast If system designers do choose to use the broadcast command, they should carefully consider the potential effects of a missed broadcast message, and the subsequent implications for fault or error recovery design in the remote terminals and bus controllers, which corresponds to paragraph number 10 5 of MIL-STD-1553B

*20 OPTICAL BUS NETWORK CONSIDERATIONS

*20 1 Comparison with wire bus networks. An optical data bus network is more analogous to a constant current electrical network than to a constant voltage network, such as the wire bus network described in MIL-STD-1553B Thus, the effective distribution of optical power from a bus terminal to N other terminals on the bus calls for the consideration of bus network configurations considerably different from the tee-tap daisy chain method of MIL-STD-1553B Worst-case optical losses for line replaceable unit (LRU) connectors, in-line bulkhead connectors, access couplers, cable, etc., must be combined with available optical power and receiver unit sensitivity to derive optical power budget and optical signal range (OSR) figures for any proposed bus configuration. The power budget must also be computed taking into account applications factors such as temperature, altitude, humidity, statistical component variations, age and radiation effects over the ranges detailed in the applicable system and item specifications. Reliability, installation, maintainability and related life cycle cost factors must also be considered, especially with regard to use of active (repeater) access coupling devices.

*20.2 Typical fiber optic data bus configurations. Fiber optic data bus configuration is determined by selection of the coupling elements which provide the terminals with access to the bus. Tee couplers will allow a single transmission line to be tapped at selected locations. Depending upon the mode of operation of the tee couplers, either a one dimension, bidirectional data bus or a looped, unidirectional data bus can be constructed. Of the basic fiber optic data bus configurations, the bi-directional tee-coupled configuration is closest in form to the MIL-STD-1553B wire bus. Use of a star coupler required that each terminal be provided with a transmission path to and from the coupler. The path can consist of either one or two fiber optic transmission lines depending upon the type of star coupler chosen. Figure 13 illustrates some of the fundamental fiber optic data bus configurations.

*20.3 Optical signal power reduction in access couplers. Access couplers exhibit three optical power reduction mechanisms. The first is power division. Unlike data bus systems which utilize a wire interconnection, a fiber optic system divides signal power among all terminals having access to the bus. This division of power is accomplished by one or more access couplers. Thus, for a N port transmissive star coupler in which input power P_{in} is evenly distributed, the power available from any port due to this mechanism will equal P_{in}/N. This division loss, L_D, can be expressed as:

$$L_D = 10 \log N \text{ dB}$$

The second reduction mechanism results from the inefficiency of the coupler itself and is called excess loss, L_E. Excess loss can be described by:

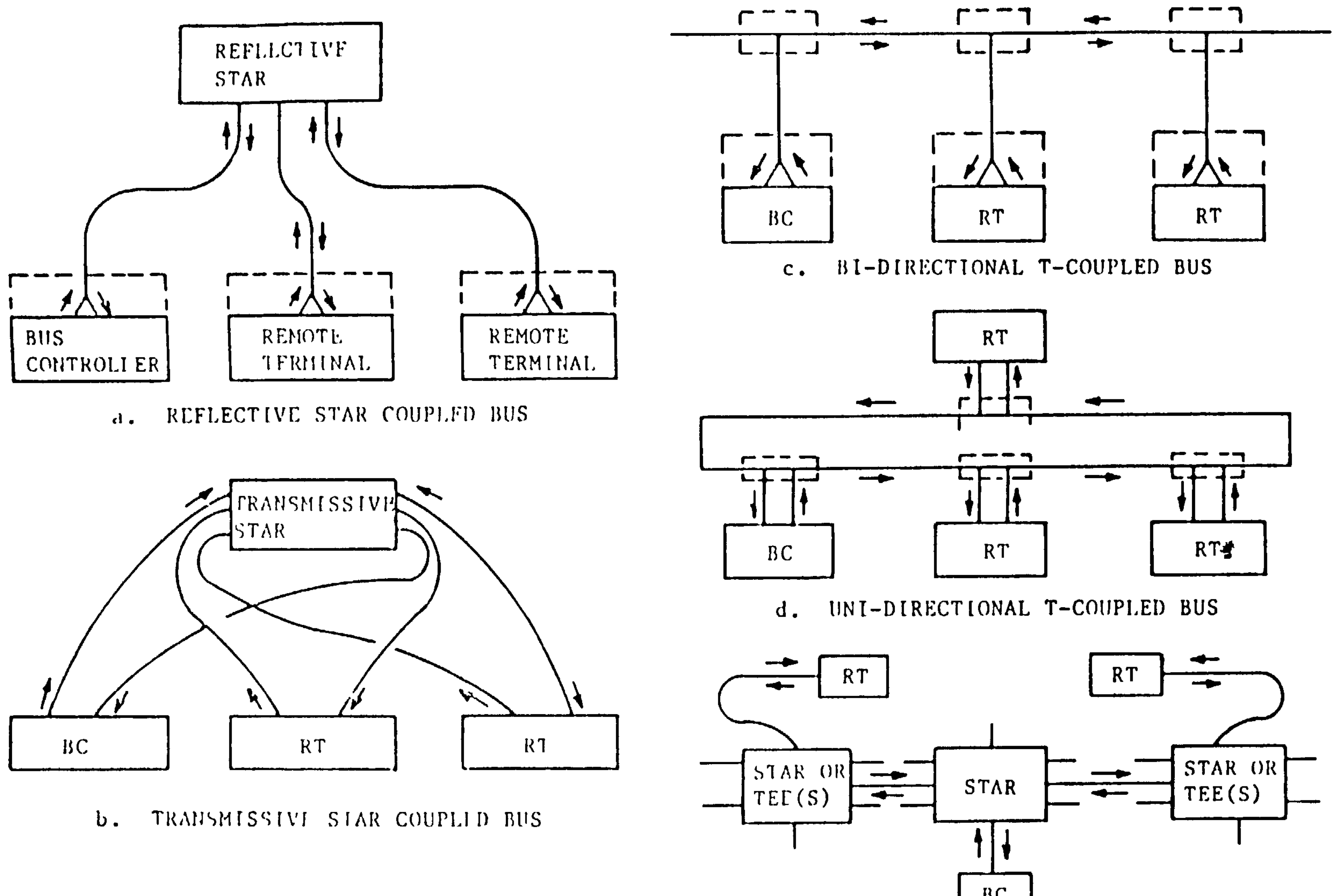
$$L_E = 10 \log \left[1 - \frac{\sum_{i=1}^{N} P_{out_i}}{P_{in}} \right] \text{ dB}$$

where P_{in} is the optical power into the coupler and P_{out_i} is the optical power out of the ith output port. These losses are attributable primarily to optomechanical factors, such as packing fraction, numerical aperture mismatch, scattering and assembly tolerance losses.

Finally, power is reduced by interface losses, L_I, at the cable-to-coupler and coupler-to-cable interfaces. These losses may be due to either connectors or splices, depending on the system assembly technique adopted, but each interface will have a characteristic loss, L_I.

30. GENERAL REQUIREMENTS

30.1 Option selection. This section of the appendix shall select those options required to further define portions of the standard to enhance tri-service interoperability. References in parenthesis are to paragraphs in standard which are affected.



e. BI-DIRECTIONAL HYBRID COUPLED BUS

NOTE: STAR AND TEE ACCESS COUPLERS MAY BE PASSIVE OR ACTIVE AND MAY RESIDE WITHIN OR EXTERNAL TO THE LRUs.

*FIGURE 13. Typical fiber optic data bus system configurations.

30.2 Application. Section 30 of this appendix shall apply to all dual redundant applications for the Army, Navy, and Air Force. All Air Force aircraft internal avionics applications shall be dual standby redundant, except where safety critical or flight critical requirements dictate a higher level of redundancy..

30 3 Unique address (4.3.3.5.1.2). All remote terminals shall be capable of being assigned any unique address from decimal address 0 (00000) through decimal address 30 (11110). The address shall be established through an external connector which is part of the system wiring and connects to the remote terminal. Changing the unique address of a remote terminal shall not require the physical modification or manipulation of any part of the remote terminal. The remote terminal shall, as a minimum, determine and validate its address during power-up conditions. No single point failure shall cause a terminal to validate a false address. The remote terminal shall not respond to any messages if it has determined its unique address is not valid.

30.4 Mode codes (4.3.3.5.1.7).

30.4 1 Subaddress/mode (4.3.3.5.1.4). An RT shall have the capability to respond to mode codes with both subaddress/mode of 00000 and 11111. Bus controllers shall have the capability to issue mode commands with both subaddress/mode of 00000 and 11111. The subaddress/mode of 00000 and 11111 shall not convey different information.

30.4.2 Required mode codes (4.3.3.5.1.7).

30.4.2.1 Remote terminal required mode codes. An RT shall implement the following mode codes as a minimum:

Mode Code	Function
00010	Transmit status word
00100	Transmitter shutdown
00101	Override transmitter shutdown
01000	Reset remote terminal

30.4.2.2 Bus controller required mode codes. The bus controller shall have the capability to implement all of the mode codes as defined in 4.3.3.5.1.7. For Air Force applications, the dynamic bus control mode command shall never be issued by the bus controller.

30.4.3 Reset remote terminal (4.3.3.5.1.7.9). An RT receiving the reset remote terminal mode code shall respond with a status word as specified in 4.3.3 5.1.7.9 and then reset. While the RT is being reset, the RT shall respond to a valid command with any of the following· No response on either data bus, status word transmitted with the busy bit set, or normal response. If any data is transmitted from the RT while it is being reset, the information content of the data shall be valid An RT receiving this mode code shall complete the reset function within 5.0 milliseconds following transmission of the status word specified in 4.3.3.5.1.7.9. The time shall be measured from the mid-bit zero crossing of the parity bit of the status word to the mid-sync zero crossing of the command word at point A on Figures 9 and 10.

30.4.4 Initiate RT self-test (4 3.3.5.1.7.4). If the initiate self-test mode command is implemented in the RT, then the RT receiving the initiate self-test mode code shall respond with a status word as specified in 4.3.3.5.1.7.4 and then initiate the RT self-test function. Subsequent valid commands may terminate the self-test function. While the RT self-test is in progress, the RT shall respond to a valid command with any of the following: No response on either data bus, status word transmitted with the busy bit set, or normal response If any data is transmitted from the RT while it is in self-test, the information content of the data shall be valid An RT receiving this mode code shall complete the self-test function and have the results of the self-test available within 100.0 milliseconds following transmission of the status word specified in 4.3.3.5.1.7.4. The time shall be measured from the mid-bit zero crossing of the parity bit of the status word to the mid-sync zero crossing of the command word at point A on Figures 9 and 10

30.5 Status word bits (4.3.3 5.3).

30.5.1 Information content. The status word transmitted by an RT shall contain valid information at all times, e.g., following RT power-up, during initialization and during normal operation.

30 5.2 Status bit requirements (4.3.3.5 3). An RT shall implement the status bits as follows:

Message error bit (4.3.3 5 3) - Required

Instrumentation bit (4.3 3.5.3 4) - Always logic zero

Service request bit (4 3.3 5 3 5) - Optional

Reserved status bits (4.3 3.5.3 6) - Always logic zero.

Broadcast command received bit (4.3 3 5 3 7) - If the RT implements the broadcast option, then this bit shall be required.

Busy bit (4.3.3.5.3 8) - As required by 30 5 3

Subsystem flag bit (4.3.3.5.3 9) - If an associated subsystem as the capability for self-test, then this bit shall be required.

Dynamic bus control acceptance bit (4.3.3.5.1.10) - If the RT implements the dynamic bus control function, then this bit shall be required.

Terminal flag bit (4.3.3.5.3.11) - If an RT has the capability for self-test, then this bit shall be required

30.5.3 Busy bit (4.3.3.5 3.8). The existence of busy conditions is discouraged. However, any busy condition, in the RT or the subsystem interface that would affect communication over the bus shall be conveyed via the busy bit. Busy conditions, and thus the setting of the busy bit, shall occur only as a result of particular commands/messages sent to an RT. Thus for a non-failed RT, the bus controller can, with prior knowledge of the remote terminal characteristics, determine when the remote terminal can become busy and when it will not be busy. However, the RT may also set the busy bit (in addition to setting the terminal flag bit or subsystem flag bit) as a result of failure/fault conditions within the RT/subsystem.

30.6 Broadcast (4.3.3.6.7) All hardware implementations shall include both command/response and broadcast capability If the broadcast option is implemented the RT shall be capable of distinguishing between a broadcast and a non-broadcast message to the same subaddress for non-mode command messages. The RT address of 11111 is reserved for broadcast and shall not be used for any other purpose.

30.7 Data wraparound (4.3.3.5.1.4). Remote terminals shall provide a receive subaddress to which one to N data words of any bit pattern can be received Remote terminals shall provide a transmit subaddress from which a minimum of N data words can be transmitted. N is equal to the maximum word count from the set of all messages defined for the RT. A valid receive message to the data wraparound receive address followed by a valid transmit command to the data wraparound transmit subaddress, with the same word count and without any intervening valid commands to the RT, shall cause the RT to respond with each data word having the same bit pattern corresponding to the received data word.

30.8 Message formats (4.3 3.6). Remote terminals shall, as a minimum, implement the following non-broadcast message formats as defined in 4.3.3 6 RT to BC transfers, BC to RT transfers, RT to RT transfers (receive and transmit), and mode code command without data word transfers. For non-broadcast messages, the RT shall not distinguish between data received during a BC to RT transfer or data received during a RT to RT transfer (receive) to the same address. The RT shall not distinguish between data to be transmitted during an RT to BC transfer or data to be transmitted during an RT to RT transfer (transmit) from the same subaddress. Bus controllers shall have the capability to issue all message formats defined in 4.3.3.6.

30.9 RT to RT validation (4.3.3.9). For RT to RT transfers, in addition to the validation criteria specified in 4 4.3.6, if a valid receive command is received by the RT and the first data word is received after 57.0 plus or minus 3.0 microseconds, the RT shall consider the message invalid and respond as specified in 4.3.3 6 The time shall be measured from the mid-bit zero crossing of the parity bit of the receive command to the mid-sync zero crossing of the expected data word at point A as shown on Figures 9 and 10. It is recommended that the receiving RT of an RT to RT transfer verify the proper occurrence of the transmit command word and status word as specified in 4.3.3.6.3.

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