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Fiber Optics Mechanization of a Digital Time Division Command/Response Multiplex Data Bus

RATIONALE

AS-3 Committee has recommended that this document be stabilized.

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FOREWORD

This SAE Aerospace Standard (AS) contains requirements for fiber optic mechanization of a digital time division command/response multiplex data bus for use in systems integration. The parent document for data bus protocol, bit assignment and related bus traffic management is MIL-STD-1553B. AS1773 provides for the use of fiber optics as the transmission medium in a manner which is similar to MIL-STD-1553B with the added the option of increased performance by using an alternate data rate of 20 Mbps.

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.

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1. SCOPE

1.1 Scope:

This document defines requirements for digital, command/ response time division multiplexing (data bus) techniques for fiber optic implementation. The concept of operation and information flow on the multiplex data bus and the 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 a system or subsystem development. The contractor is responsible for invoking all of the applicable requirements of this aerospace standard on any and all subcontractors he may employ.

1.3 Purpose:

The purpose of this document is twofold:

- a. It seeks to preserve the multiplex bus techniques which have been standardized in MIL-STD-1553B.
- b. It provides guidelines for the application of fiber optic transmission techniques to the MIL-STD-1553B interconnect.

Use of this document with the Interoperability Requirements for AS1773 document (AIR4957) and the appropriate slash sheet is intended to provide interoperability between different suppliers of equipment.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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

AIR4508 MIL-STD-1773 User's Handbook
AIR4957 Interoperability Requirements for AS1773

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

MIL-STD-1553B	Aircraft Internal Time Division Command/Response Multiplex Data Bus
MIL-STD-1773	Fiber Optics Mechanization of a Digital Time Division Command/Response Multiplex Data Bus
MIL-S-1773	General Specification for MIL-STD-1773

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, 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 document, 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 COUPLER:

A coupler is an optical device which distributes optical power among two or more ports. Star couplers and tee couplers are examples of 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 is 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 maximum and minimum optical signal power levels be specified as well

3.22 MID-BIT TRANSITION:

The position in the optical waveform where the optical pulse goes from a high state to a completely off or low state or from a low state to a high state.

3.23 UNIPOLAR DATA:

Data signal transmission which includes only 2 possible states (i.e., 1 or 0). This type of transmission is typical of fiber optic signaling where optical power is typically modulated between the state of 1 (high light level) to off (low light level) in contrast to Bipolar data which includes two active states (i.e., positive or negative potential) and an inactive state (no potential). Bipolar transmission is typical of two wire bus networks such as 1553.

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 4.3.3.5. The multiplex data bus system architecture is illustrated in Figure 1.

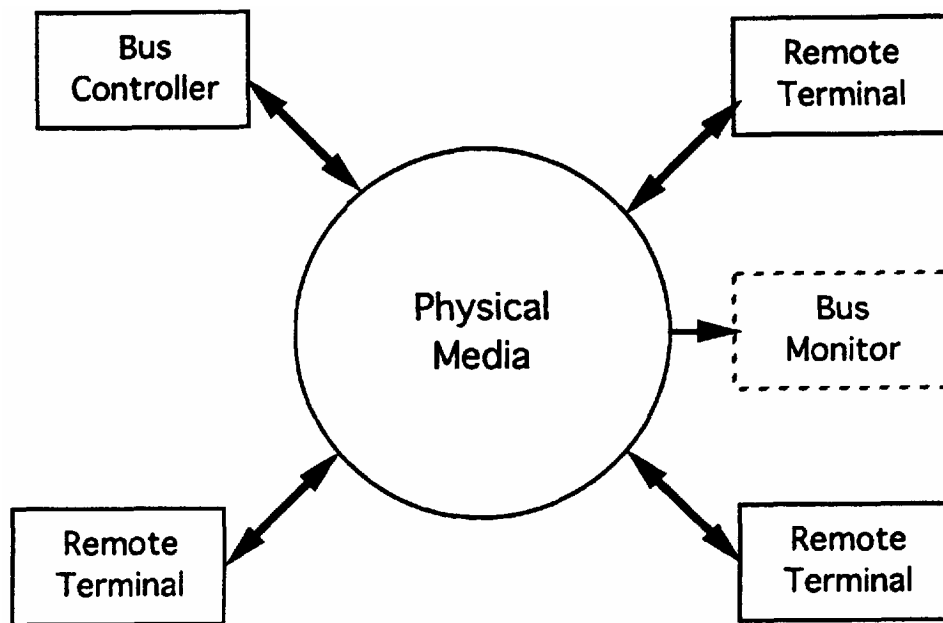


FIGURE 1 - Multiplex Data Bus Architecture

- 4.2.1 1 Mbps Operation: This is bus operation with all messages at 1 Mbps data rate. This is equivalent to MIL-STD-1553 and MIL-STD-1773 original release bus operation.
- 4.2.2 20 Mbps Operation: This is bus operation with all messages transmitted at 20 Mbps. The message format, with the exception listed in preamble 4.3.3.3.1, is identical to 1 Mbps operation.

4.2.3 Combined Data Rates Operation: This is bus operation which allows one bus controller to control 1 Mbps and 20 Mbps RTs on the same physical media.

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 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.

4.3.3.2 Data Code Modulation Format: The data code shall be Manchester II bi-phase level. A logic one shall be transmitted as a coded signal 1/0 (i.e., an optical high level pulse followed by a low level). A logic zero shall be coded 0/1 (i.e., an optical high level pulse preceded by a low level). 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 Mbps or 20 Mbps with a combined accuracy and long-term stability of $\pm 0.1\%$. The short-term stability (i.e., stability over 1.0 second interval) shall be at least 0.01% (i.e., ± 100 bits per second for 1 Mbps operation, ± 2000 bits per second for 20 Mbps operation).

4.3.3.3.1 Preamble: For any 20 Mbps message transmission a 16 bit preamble consisting of all Manchester 1's shall immediately and contiguously precede the Command Word and Status Word. For 1 Mbps operation no preamble is allowed.

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.

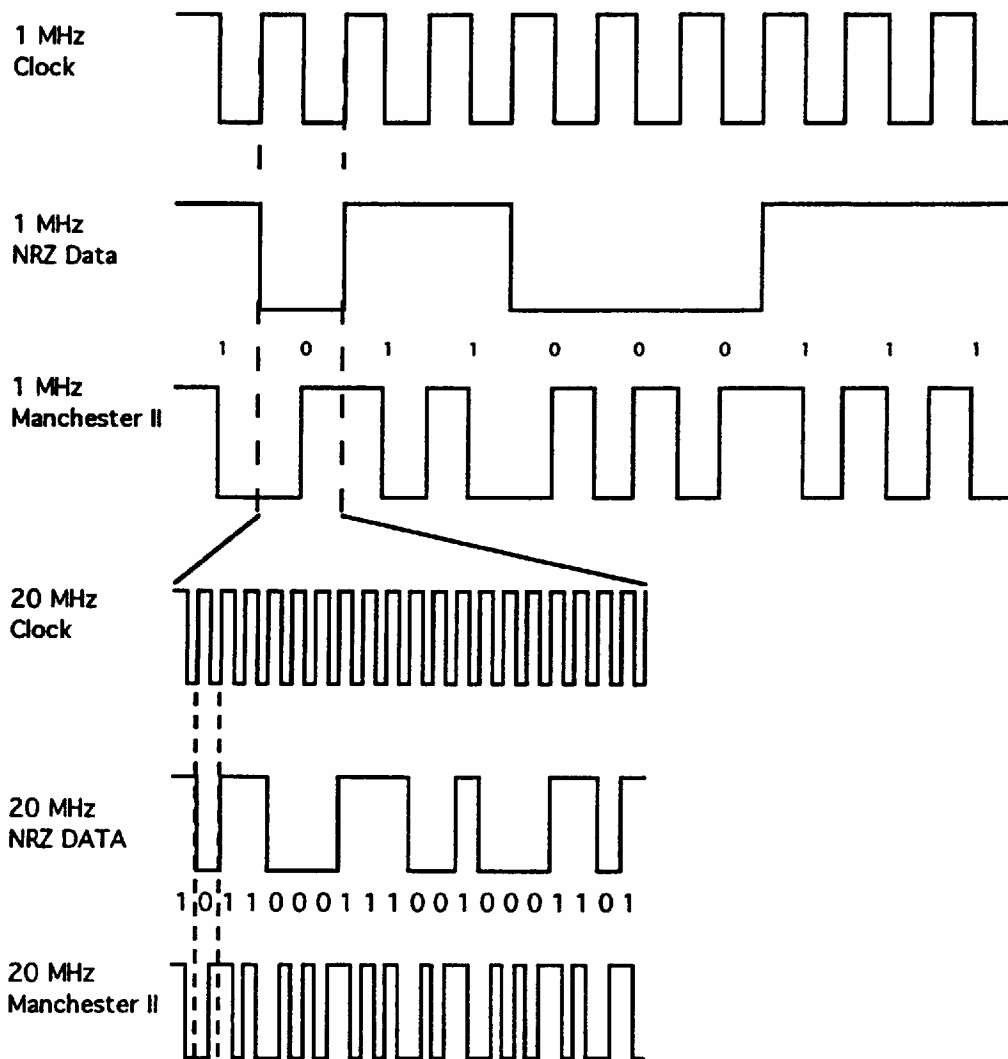


FIGURE 2 - Date Encoding

- 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, sub-address/mode field, word count/mode code field and a parity (P) bit (see Figure 3).

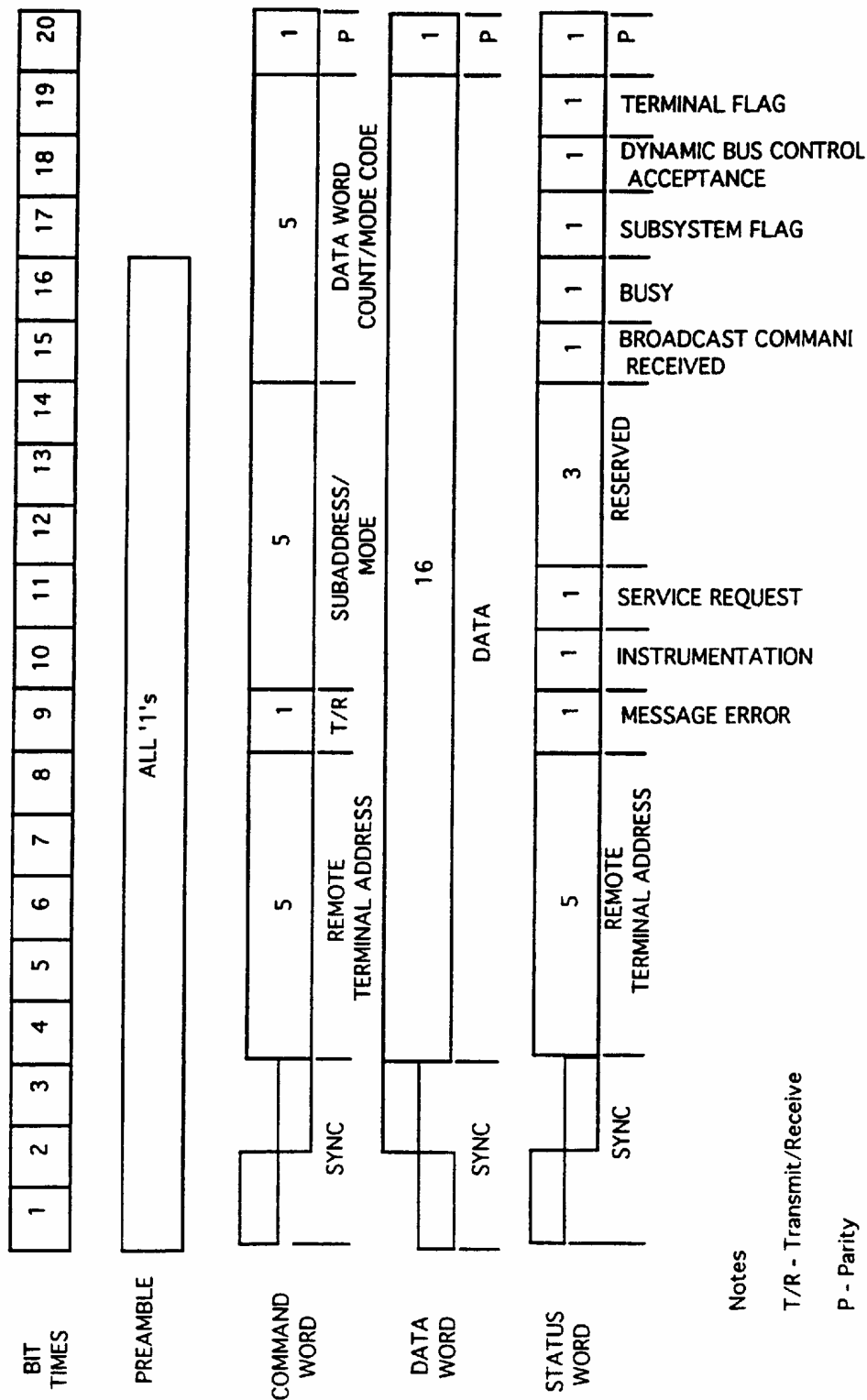


FIGURE 3 - Word Formats