

GE
Intelligent Platforms



MIL-STD-1553

Reference Guide



imagination at work



An Interpretation of

MIL-STD-1553B

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An Interpretation of MIL-STD-1553B

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TABLE OF CONTENTS

INTRODUCTION 1

	About This Book	1
	Notice 1	2
	Notice 2	3
	Notice 3	4
	Notice 4	4

FORWARD, SCOPE, & REFERENCED DOCUMENTS 5

	Forward	5
1.	SCOPE	6
1.1	Scope	6
1.2	Application	6
2.	REFERENCED DOCUMENTS	8
2.1	Issue of Document	8

DEFINITIONS 9

3.	DEFINITIONS	9
3.1	Bit	9
3.2	Bit Rate	9
3.3	Pulse Code Modulation (PCM)	9
3.4	Time Division Multiplexing (TDM)	9
3.5	Half Duplex	9
3.6	Word	10
3.7	Message	10

3.8	Subsystem	10
3.9	Data Bus	10
3.10	Terminal	10
3.11	Bus Controller (BC)	11
3.12	Bus Monitor (BM)	11
3.13	Remote Terminal (RT)	11
3.14	Asynchronous Operation	11
3.15	Dynamic Bus Control	11
3.16	Command/Response	12
3.17	Redundant Data Bus	12
3.18	Broadcast	12
3.19	Mode Code	12

GENERAL REQUIREMENTS **13**

4.	GENERAL REQUIREMENTS	13
4.1	Test and Operating Requirements	13
4.2	Data Bus Operation	14
4.3	Characteristics	14
4.3.1	Data Form	14
4.3.2	Bit Priority	15
4.3.3	Transmission Method	16
4.3.3.1	Modulation	16
4.3.3.2	Data Code	16
4.3.3.3	Transmission Bit Rate	18
4.3.3.4	Word Size	18

WORD FORMATS **19**

4.3.3.5	Word Formats	19
4.3.3.5.1	Command Word	19

4.3.3.5.1.1	Sync	21
4.3.3.5.1.2	Remote Terminal Address	22
4.3.3.5.1.3	Transmit/Receive	23
4.3.3.5.1.4	Subaddress/Mode	23
4.3.3.5.1.5	Data Word Count/Mode Code	24
4.3.3.5.1.6	Parity	25
4.3.3.5.1.7	Optional Mode Control	25
4.3.3.5.1.7.1	Dynamic Bus Control	29
4.3.3.5.1.7.2	Synchronize (Without Data Word)	30
4.3.3.5.1.7.3	Transmit Status Word	30
4.3.3.5.1.7.4	Initiate Self Test	31
4.3.3.5.1.7.5	Transmitter Shutdown	32
4.3.3.5.1.7.6	Override Transmitter Shutdown	32
4.3.3.5.1.7.7	Inhibit Terminal Flag (T/F) Bit	33
4.3.3.5.1.7.8	Override Inhibit T/F Bit	34
4.3.3.5.1.7.9	Reset Remote Terminal	34
4.3.3.5.1.7.10	Reserved Mode Codes (01001 to 01111)	34
4.3.3.5.1.7.11	Transmit Vector Word	35
4.3.3.5.1.7.12	Synchronize (With Data Word)	35
4.3.3.5.1.7.13	Transmit Last Command Word	37
4.3.3.5.1.7.14	Transmit Built-In-Test (BIT) Word	37
4.3.3.5.1.7.15	Selected Transmitter Shutdown	39
4.3.3.5.1.7.16	Override Selected Transmitter Shutdown	39
4.3.3.5.1.7.17	Reserved Mode Codes (10110 to 11111)	40
4.3.3.5.2	Data Word	40
4.3.3.5.2.1	Sync	40
4.3.3.5.2.2	Data	43
4.3.3.5.2.3	Parity	43
4.3.3.5.3	Status Word	43
4.3.3.5.3.1	Sync	43

4.3.3.5.3.2	RT Address	44
4.3.3.5.3.3	Message Error Bit	44
4.3.3.5.3.4	Instrumentation Bit	47
4.3.3.5.3.5	Service Request Bit	48
4.3.3.5.3.6	Reserved Status Bits	49
4.3.3.5.3.7	Broadcast Command Received Bit	49
4.3.3.5.3.8	Busy Bit	50
4.3.3.5.3.9	Subsystem Flag Bit	52
4.3.3.5.3.10	Dynamic Bus Control Acceptance Bit	53
4.3.3.5.3.11	Terminal Flag Bit	53
4.3.3.5.3.12	Parity Bit	53
4.3.3.5.4	Status Word Reset	54

MESSAGE FORMATS

55

4.3.3.6	Message Formats	55
4.3.3.6.1	Bus Controller to Remote Terminal Transfers	57
4.3.3.6.2	Remote Terminal to Bus Controller Transfers	58
4.3.3.6.3	Remote Terminal to Remote Terminal Transfers	58
4.3.3.6.4	Mode Command without Data Word	61
4.3.3.6.5	Mode Command with Data Word (Transmit)	61
4.3.3.6.6	Mode Command with Data Word (Receive)	62
4.3.3.6.7	Optional Broadcast Command	62
4.3.3.6.7.1	Bus Controller to Remote Terminal(s) Transfer (Broadcast)	64
4.3.3.6.7.2	Remote Terminal to Remote Terminal(s) Transfers (Broadcast)	65
4.3.3.6.7.3	Mode Command without Data Word (Broadcast)	67
4.3.3.6.7.4	Mode Command with Data Word (Broadcast)	68
4.3.3.7	Intermessage Gap	70
4.3.3.8	Response Time	70
4.3.3.9	Minimum No Response Timeout	72

TERMINAL OPERATION

75

4.4	Terminal Operation	75
4.4.1	Common Operation	75
4.4.1.1	Word Validation	75
4.4.1.2	Transmission Continuity	76
4.4.1.3	Terminal Fail-Safe	76
4.4.2	Bus Controller Operation	77
4.4.3	Remote Terminal	77
4.4.3.1	Operation	77
4.4.3.2	Superseding Valid Commands	78
4.4.3.3	Invalid Commands	79
4.4.3.4	Illegal Command	79
4.4.3.5	Valid Data Reception	80
4.4.3.6	Invalid Data Reception	81
4.4.4	Bus Monitor Operation	82

DATA BUS CHARACTERISTICS

83

4.5	Hardware Characteristics	83
4.5.1	Data Bus Characteristics	83
4.5.1.1	Cable	83
4.5.1.2	Characteristic Impedance	83
4.5.1.3	Cable Attenuation	83
4.5.1.4	Cable Termination	84
4.5.1.5	Cable Stub Requirements	84
4.5.1.5.1	Transformer Coupled Stubs	88
4.5.1.5.1.1	Coupling Transformer	88
4.5.1.5.1.1.1	Transformer Input Impedance	89
4.5.1.5.1.1.2	Transformer Waveform Integrity	91
4.5.1.5.1.1.3	Transformer Common Mode Rejection	92

4.5.1.5.1.2	Fault Isolation	94
4.5.1.5.1.3	Cable Coupling	95
4.5.1.5.1.4	Stub Voltage Requirements	95
4.5.1.5.2	Direct Coupled Stubs	95
4.5.1.5.2.1	Fault Isolation	96
4.5.1.5.2.2	Cable Coupling	96
4.5.1.5.2.3	Stub Voltage Requirements	96
4.5.1.5.3	Wiring and Cabling for EMC	98

TERMINAL CHARACTERISTICS 99

4.5.2	Terminal Characteristics	99
4.5.2.1	Terminals With Transformer Coupled Stubs	99
4.5.2.1.1	Terminal Output Characteristics	99
4.5.2.1.1.1	Output Levels	99
4.5.2.1.1.2	Output Waveform	100
4.5.2.1.1.3	Output Noise	101
4.5.2.1.1.4	Output Symmetry	102
4.5.2.1.2	Terminal Input Characteristics	103
4.5.2.1.2.1	Input Waveform Compatibility	103
4.5.2.1.2.2	Common Mode Rejections	103
4.5.2.1.2.3	Input Impedance	104
4.5.2.1.2.4	Noise Rejection	105
4.5.2.2	Terminals with Direct Coupled Stubs	107
4.5.2.2.1	Terminal Output Characteristics	107
4.5.2.2.1.1	Output Levels	107
4.5.2.2.1.2	Output Waveform	107
4.5.2.2.1.3	Output Noise	109
4.5.2.2.1.4	Output Symmetry	109
4.5.2.2.2	Terminal Input Characteristics	109
4.5.2.2.2.1	Input Waveform Compatibility	110

4.5.2.2.2.2	Common Mode Rejections	110
4.5.2.2.2.3	Input Impedance	110
4.5.2.2.2.4	Noise Rejection	111

REDUNDANT DATA BUS REQUIREMENTS **113**

4.6	Redundant Data Bus Requirements	113
4.6.1	Electrical Isolation	113
4.6.2	Single Event Failures	113
4.6.3	Dual Standby Redundant Data Bus	114
4.6.3.1	Data Bus Activity	114
4.6.3.2	Superseding Valid Commands	114

APPENDIXES **115**

10.	GENERAL	115
10.1	Redundancy	115
10.2	Bus Controller	116
10.3	Multiplex Selection Criteria	119
10.4	High Reliability Requirements	119
10.5	Stubbing	120
10.6	Use of Broadcast Option	121
10.7	Other Related Documents	121
30.	GENERAL REQUIREMENTS	122
30.1	Option Selection	122
30.2	Application	122
30.3	Unique Address	122
30.4	Mode Codes	123
30.4.1	Subaddress/Mode	123
30.4.2	Required Mode Codes	123

30.4.2.1	Remote Terminal Required Mode Codes	123
30.4.2.2	Bus Controller Required Mode Codes	124
30.4.3	Reset Remote Terminal	124
30.4.4	Initiate RT Self Test	124
30.5	Status Word Bits	125
30.5.1	Information Content	125
30.5.2	Status Bit Requirements	125
30.5.3	Busy Bit	126
30.6	Broadcast	127
30.7	Data Wrap-Around	127
30.8	Message Formats	128
30.9	RT to RT Validation	128
30.10	Electrical Characteristics	129
30.10.1	Cable Shielding	129
30.10.2	Shielding	129
30.10.3	Connector Polarity	129
30.10.4	Characteristic Impedance	129
30.10.5	Stub Coupling	130
30.10.6	Power On/Off Noise	130

APPENDIX FIGURES

10.1	Illustration of Possible Redundancy	117
10.2	Illustration of Possible Redundancy	118



introduction



INTRODUCTION

ABOUT THIS BOOK

This document provides an explanation of each part of MIL-STD-1553B on a clause-by-clause basis. Each clause of the Standard is presented for completeness (typed in italics for easy reference) together with appropriate explanation or interpretation wherever necessary. For additional clarification, we have also included both text and figures from MIL-HDBK-1553 (1 November 1988).

Figures and tables taken from the MIL-STD appear in this book labeled (STD), figures taken or derived from the MIL-HDBK appear labeled (HDBK), and figures created by GE appear labeled (GE).

Although the Standard specifies a multiplex data bus for aerospace applications, it is by no means limited to only those applications. MIL-STD-1553B has been widely accepted around the world in such unlikely places as the London underground and some factory locations.

Four notices to the original MIL-STD-1553B (Notice 1 through Notice 4) have been published. Notice 2 supersedes Notice 1. The remainder of this section gives the general scope of each notice.

NOTICE 1

NOTICE 1 IS SPECIFIC TO USAF AND ADDRESSES THE FOLLOWING AREAS:

- The following Mode Commands not to be issued by bus controllers:
 - Dynamic Bus Control
 - Inhibit Terminal Flag
 - Override Inhibit Terminal Flag
 - Selected Transmitter Shutdown
 - Override Selected Transmitter Shutdown
- Broadcast Commands not to be issued by bus controllers
- Mode Indicators 00000 and 11111 both to be usable by bus controllers
- Cable shielding to be 90% minimum
- Shielding of cable coupling to be 90% minimum and continuous
- Direct coupled stubs not allowed
- All buses must be dual standby redundant
- Actual bus impedance to be in range 70-85%

NOTICE 2

Notice 2 has US Tri-service applicability and revisits all these areas yet again but also addresses:

- Terminal addresses to be externally selectable
- A minimum set of mode codes is specified
- The reset remote terminal mode command not to require more than 5 milliseconds to complete
- All transmitted status words shall contain valid information (including on Power Up)
- Status bit requirements defined more fully
- Use of broadcast option restricted to mode codes but broadcast capability required in bus controllers and optional in RT's
- Data wraparound capability introduced
- US Army and Air Force applications would not use direct coupled stubs
- Power on/off noise restriction introduced
- RT to RT message timeout introduced

NOTICE 3

Notice 3 was a Notice of Validation.

NOTICE 4

Notice 4 replaced the Cover Page and page ii.



forward, scope &
referenced documents



FORWARD, SCOPE, & REFERENCED DOCUMENTS

FOREWORD

This standard contains requirements for a digital time division command/response multiplex data bus for use in systems integration. Even with the use of this standard, differences may exist between multiplex data buses in different system applications due to particular application requirements and the designer options allowed in this standard. The system designer must recognize this fact and design the multiplex bus controller hardware and software to accommodate such differences.

These designer selected options must exist to allow the necessary flexibility in the design of specific multiplex systems in order to provide for the control mechanism, architectural redundancy, degradation concept and traffic patterns peculiar to the specific application requirements. Appendix 30 selects those options which shall be required and further restricts certain portions of the standard for use in all dual standby redundant applications for the Army, Navy, and Air Force.

1 SCOPE

1.1 SCOPE

This standard establishes requirements for digital, command/response, time division multiplexing (Data Bus) techniques. It encompasses the data bus line and its interface electronics illustrated on Figure 1 (STD), and also defines the concept of operation and information flow on the multiplex data bus and the electrical and functional formats to be employed.

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 weapon system or subsystem development. The contractor is responsible for invoking all the applicable requirements of this Military Standard on any and all subcontractors he may employ.

The above clauses are largely self-explanatory introducing the Standard and outlining its extent. In highlighting the fact that different implementations of the Standard could be incompatible in some of the options used and the extent to which the Standard is used, system designers are reminded to ensure that they engineer coherent systems.

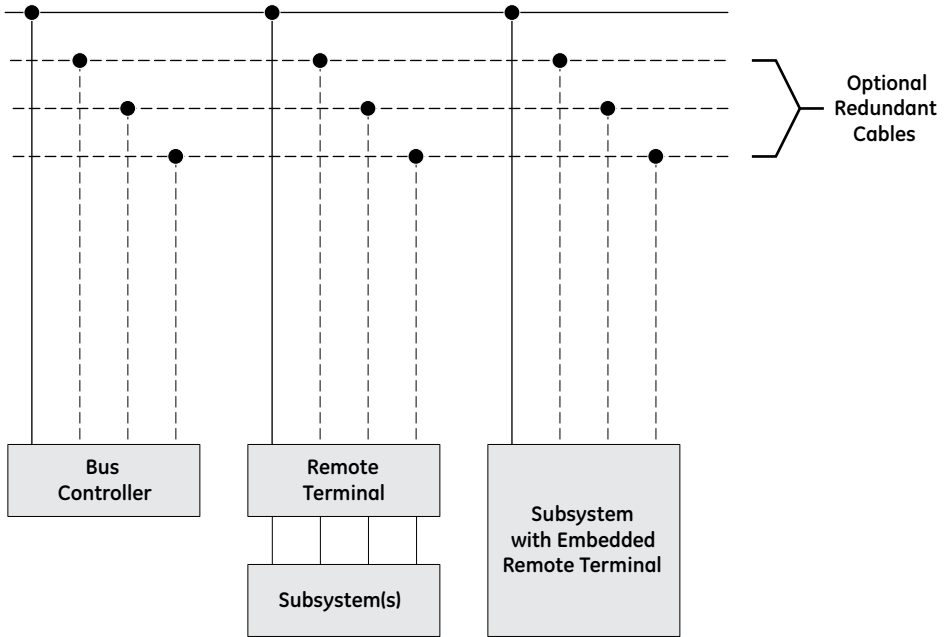


FIGURE 1 (STD) : SAMPLE MULTIPLEX DATA BUS ARCHITECTURE

2 REFERENCED DOCUMENTS

2.1 ISSUE OF DOCUMENT

The following document, of the issue in effect on date of invitation for bid or request for proposal, forms a part of the standard to the extent specified herein.

SPECIFICATION

MILITARY

MIL-E-6051 Electromagnetic Compatibility Requirements, Systems

(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.)



definitions



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 including twisted shielded pair cables, isolation resistors, transformers, etc., required to provide a single data path between the bus controller and all the associated remote 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 (LRU's) 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.

Note:

Although the above definitions include some generally accepted terms, definitions of word size, message content, and data bus system terminology are specific to this MIL-STD.



general requirements



4 GENERAL REQUIREMENTS

4.1 TEST AND OPERATING REQUIREMENTS

All specified requirements shall be valid over the environmental conditions in which the multiplex data bus system shall be required to operate.

This clause is included to specify that the environmental conditions in which the bus is to operate are determined by the vehicle in which it is placed. The environmental limits of operation will be largely determined by the terminal components and their enclosure.

4.2 DATA BUS OPERATION

The multiplex data bus system in its most elemental configuration shall be as shown on Figure 1 (STD). 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

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 numerically descending order. Bit packing of multiple quantities in a single data word is permitted.

Single bit data and other parameters which are characterized by bit patterns of fewer than 16 bits will not fill the 16 bits of data allowed in data word format. To use all the bits in a word, two approaches can be considered. The first has the advantage of efficiency, but increases the complexity of the encoding and decoding process. The second has the advantage of simplicity, but comes at the expense of efficiency, i.e. sending as little as one bit per word:

1. Packing multiple parameters in a word
2. Replacing all unused bits with zeros

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.

Baseband modulation was chosen in view of its advantages over carrier modulation techniques which need a greater bandwidth of transmitting media and more complex terminal hardware.

4.3.3.2 DATA CODE

The data code shall be Manchester II bi-phase level. A logic one shall be transmitted as a bipolar coded signal 1/0 (i.e., a positive pulse followed by a negative pulse). A logic zero shall be a bipolar coded signal 0/1 (i.e., a negative pulse followed by a positive pulse). A transition through zero occurs at the midpoint of each bit time (see Figure 2 [STD]).

Like polar Return to Zero (RZ), Bi-phase Level consists of a self-clocking waveform and is well-suited to applications in which bit synchronization cannot be conveyed by other means. Unlike Polar RZ, Bi-phase level is compatible with transformer coupling, and may, therefore, be used to convey data via the primary transmission medium. Bi-phase level is most appropriate for use on short transformer-coupled local buses, or on the transformer-coupled primary transmission medium when bit synchronization information is conveyed by the signaling waveform and cannot be provided via a separate channel.

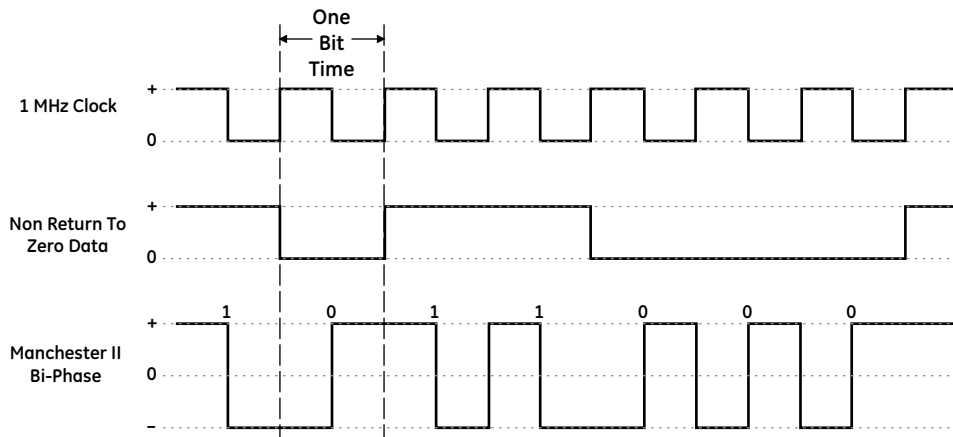


FIGURE 2 (STD): DATA ENCODING

With the Bi-phase Level data code, signal inversion can be caused by reversed connection of the data bus signal conductors.

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 Hertz (Hz)). The short-term stability (i.e., stability over 1.0 second interval) shall be at least 0.01 percent (i.e., ± 100 Hz).

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 bits times as shown on Figure 3 (STD).



word formats



WORD FORMATS

Clauses 4.3.3.5 through 4.3.3.5.4 describe the logical structure of the three basic 1553 words. It is from these three basic word types that you build 1553 messages.

- Command
- Data
- Status

4.3.3.5 WORD FORMATS

The word formats shall be as shown in Figure 3 (STD) for the command, data, and status words.

The 20-bit word size represents the number of bit times for a word of 16 data bits, three bit time sync pattern and one bit time for a single parity bit. The three bit time sync pattern is described in 4.3.3.5.1.1.

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 parity (P) bit (see Figure 3 [STD]).

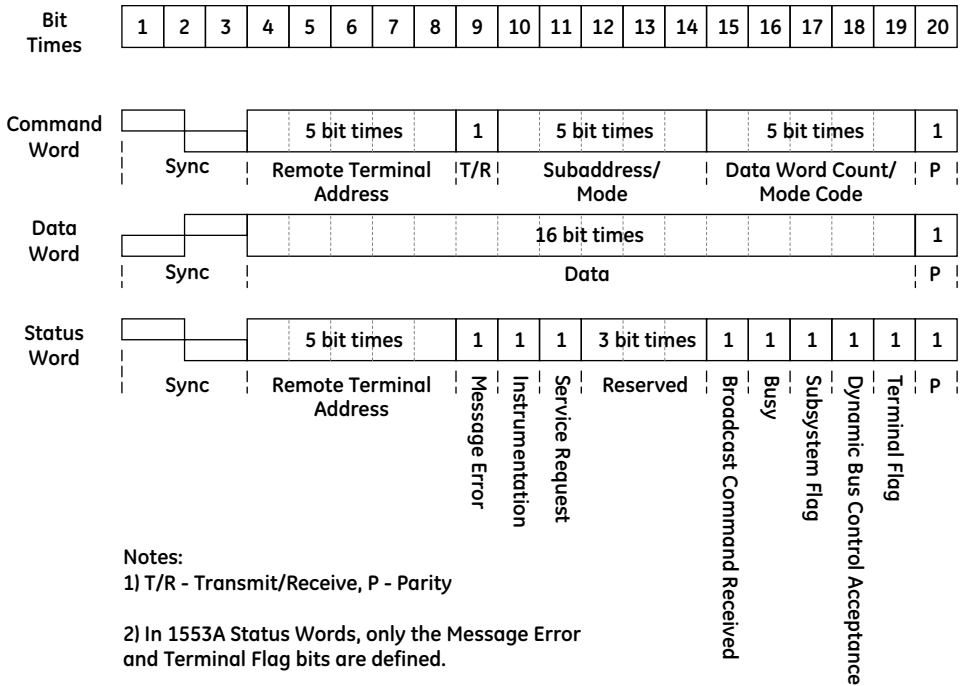


FIGURE 3 (STD): WORD FORMATS

4.3.3.5.1.1 SYNC

The command sync waveform shall be an invalid Manchester waveform as shown on Figure 4 (STD). The width shall be three bit times, with the sync waveform being positive for the first one and one-half bit times, and then negative 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.

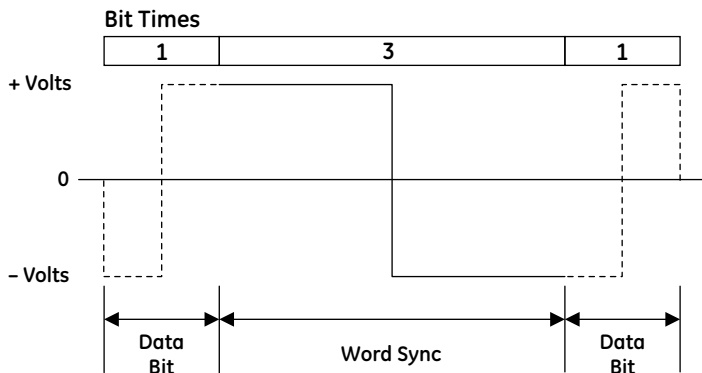


FIGURE 4 (STD): COMMAND AND STATUS SYNC

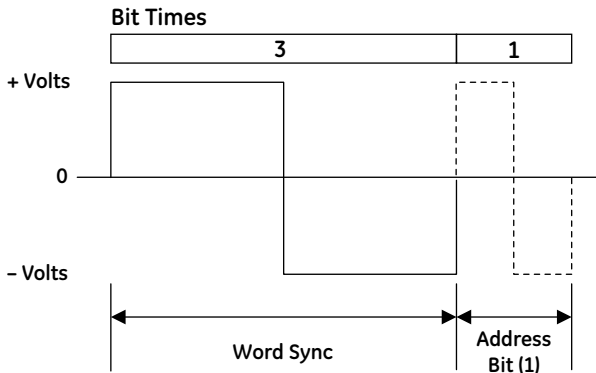


FIGURE 5 (GE): COMMAND AND STATUS SYNC APPARENT WAVEFORM

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 to a unique address. Decimal address 31 (11111) shall not be assigned as a unique address. In addition to its unique address, an RT shall be assigned decimal address 31 (11111) as the common address, if the broadcast option is used.

Each remote terminal is assigned a unique address for which it is responsible to respond when the active bus controller transmits that address as part of a command word on the data bus. It should be noted that decimal address 31 cannot be assigned as a unique address; it has been assigned to all remote terminals as the common address for which they may receive broadcast data if the system uses the broadcast option (see 4.3.3.6.7).

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.

This field has two mutually exclusive functions:

1. It identifies the subaddress of specific messages to a remote terminal.
2. It identifies that a mode command is being transmitted.

The use of either 00000 or 11111 in the subaddress/mode field is decoded to indicate that a mode code command is present in the next five bit fields. In this case, the subaddress range will be limited to 30 unique addresses. It is recommended that 11111 is used to invoke mode control in order to allow distinction to be made between command and status words as described in the explanation of 4.3.3.5.3.4. If the instrumentation bit in the status word is implemented, the subaddress will be limited to 15 unique subaddresses. The requirements for use of the instrumentation bit are defined in 4.3.3.5.3.4.

The subaddress identification can serve to identify one of a number of subsystems connected to a single RT. Alternatively, it may be used as pointer to specific storage locations in a single subsystem. It should be noted that, if the instrumentation bit is not used, a maximum of 30 transmit and 30 receive subaddresses are available by using the T/R bit.

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 1's shall indicate a decimal count of 31, and all 0's shall indicate a decimal count of 32.

This field serves one of two functions, identifying message lengths for data messages, or providing mode codes for managing the information transfer system. The five bit field allows up to 32 data words to be transmitted in a message, or 32 specified mode codes. As zero word count data cannot be sent, five bits can specify up to 32 data words.

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.

The use of single parity bit per word is provided to identify any single or odd bit errors occurring during the transmission and detection of a word.

The total number of bits in any word, including the parity bit, should be odd. Only one parity bit is used as it is considered that this, together with the protection provided by use of Manchester II encoding, and the word synchronization field, gives adequate integrity. However, if a greater degree of integrity is required, additional error checking capability may be incorporated in the data, such as Cyclic Redundancy Checks (CRC) or Checksums.

4.3.3.5.1.7 OPTIONAL MODE CONTROL

For RT's 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 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 STD 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 STD I.

Mode commands are used to manage the data bus system and are considered a necessary overhead to assist in the control of the data flow. The overheads comprise command words and status words. Command and status words are associated with both control messages and data messages. Message formats within this protocol can be transmitted to a single receiver or to multiple receivers based upon the command word address for the message.

Although the Standard states that the optional mode control function should not be used to extract data from or feed data to a functional subsystem, the extent of RT functions and hence those of subsystems can vary. There are also cases where mode commands may reflect back into the subsystem, for instance a broadcast sync command could be used to revert to a specific state or time (e.g., sync to weapon firing mode).

None of the mode codes are mandatory. Some RTs may not handle all mode codes. Use of those not implemented should provide an illegal command response (see 4.4.3.4).

Within the command word, the mode codes provide a data bus management capability. The mode codes have been divided into two groups: mode codes without a data word (00000 - 01111) and mode codes with a data word (10000 - 11111). The use of bit 15 in the command word to identify the two groups was provided to aid in the decoding process. Also, the use of a single data word instead of multiple data words was adopted to simplify the mode circuitry within RTs. Generally, with these two groups of mode command, all management requirements of an information transfer system can be met.

Some mode codes in each of these two groups are reserved for future use (see 4.3.3.5.1.7.10 and 4.3.3.5.1.7.17).

Table STD 1 provides a list of assigned mode codes. The Associated Data Word column indicates whether or not a data word is associated with a particular mode code. In some cases, e.g., transmit last command, the data word is associated with the response from the RT to a receive mode command rather than with the transmit mode command. This is shown in the examples of all types of mode command transfer formats given in Figure 25 (HDBK).

TABLE STD 1: ASSIGNED MODE CODES

T/R Bit	Mode Code	Function	Associated Data Words	Broadcast Command Allowed
1	00000	Dynamic Bus Control	No	No
1	00001	Synchronize	No	Yes
1	00010	Transmit Status	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 to 01111	Reserved	No	TBD*
1	10000	Transmit Vector Word	Yes	No
0	10001	Synchronize	Yes	Yes
1	10010	Transmit Last Command	Yes	No
1	10011	Transmit Built In Test (BIT) Word	Yes	No
0	10100	Selected Transmitter Shutdown	Yes	Yes
0	10101	Override Selected Transmitter Shut-down	Yes	Yes
1 or 0	10110 to 11111	Reserved	Yes	TBD*

* To Be Determined

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.

The dynamic bus control mode command (00000) is provided to allow the active bus controller a means of offering control (using the information transfer system message formats) to a potential bus controller (currently operating as a remote terminal) control of the data bus.

If the receiving remote terminal accepts the request to become a bus controller, then the receiving remote terminal sets the dynamic bus control acceptance bit in the status word (see 4.3.3.5.3.10). If the remote terminal rejects the request, the presently active bus controller must continue offering control to other potential controllers, or it must remain in control. When a remote terminal accepts control of the data bus system by setting the dynamic bus control acceptance bit in the status word, control is relinquished to the new bus controller by the presently active bus controller. On some systems, the bus controller relinquishing control can become a remote terminal.

Note:

The sequence above requires software (or firmware) implementation in all bus controllers

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.

See 4.3.3.5.1.7.12 for explanatory note.

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.

This command would normally be used after a broadcast command or message transfer to determine whether an RT had correctly received the data. Normally, status is reset on receipt of a valid command, but this mode command enables the bus controller to obtain the status word associated with the last valid command word.

In some situations (for example, where the RT does something unexpected after receiving a command) the transmit last command can be used to determine what command the RT received (see 4.3.3.5.1.7.13). It is important to note that the transmit status word mode command will be stored in the RT's last command buffer, and thus the transmit last command mode command should be used first.

Terminal designers must ensure that under no circumstance must the content of the status word be changed from that which was associated with the previous valid command.

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.

The initiate self test mode command (00011) is provided to initiate Built In Test (BIT) circuitry within remote terminals. (Note: Don't confuse the abbreviation BIT with the definition for binary digit. While the abbreviations are the same, the context in which each is used will distinguish them.) The mode code is usually followed, after sufficient time for test completion, by a transmit BIT word mode command yielding the results of the test. The message formats provided for this mode command allow for both individual requests and multiple requests via the Broadcast command. Notice that the initiate self test mode command is associated with the multiplex system terminal hardware only. The level of testing associated with this command depends on the capability of the RT, and no specific requirements for BIT are specified within the Standard. It should also be noted that the status word response required on receipt of the command does not indicate the result of the test, but only that the command has been received.

If a remote terminal cannot respond normally while carrying out a self test operation, the busy bit must be set in the status word. The RT must not go off-line during execution of a self test command.

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 system) 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.

Four mode code commands (see 4.3.3.5.1.7.5, 4.3.3.5.1.7.6, 4.3.3.5.1.7.15, and 4.3.3.5.1.7.16) are provided to control transmitters associated with terminals in a system. These commands can be sent to a single receiver or broadcast to multiple users. The transmitter shutdown and the override transmitter shutdown commands are used in dual redundant systems to shutdown and restart an RT transmitter. The transmitter shut down command would normally be used to disable a “jabbering” transmitter (see 4.4.1.3 for details of the terminal fail-safe mechanism which should also operate in these circumstances). Note that the bus controller must issue this command on the standby bus.

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.

The inhibit terminal flag mode code (00110) is used to set the terminal flag bit in the status word to an unfailed condition regardless of the actual state of the terminal flag being addressed. This mode code is used primarily to prevent continued interrupts to the error handling and recovering system when the failure has been noted and the system reconfigured as required. Using this mode code prevents reporting of future failures which would normally be reported via the terminal flag in each subsequent status word response. The message format associated with this mode code allows for both single receivers and broadcast receivers to respond. No data word is required with this mode code. Depending on the implementation, this command may be registered in the returned status word, but it should not be registered until the next status word. Therefore, to be positive, it is advisable to interrogate the status word with a separate command.

Note:

The terminal flag, which is used to indicate an RT fault condition, is implicitly limited to faults within the terminal.

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.

The override inhibit T/F bit mode command (00111) negates the inhibit function, thus allowing the T/F bit in the status response to report the present condition of the terminal. Note: It is advisable to interrogate the status word with a separate command in this case. This mode code can be transmitted by the bus controller to both single and broadcast receivers.

There is no data word associated with this mode code.

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.

If a remote terminal cannot respond normally while undergoing reset, the busy bit must be set in the status word. The RT must be capable of receiving the next valid command.

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.

The transmit vector word mode code (10000) is associated with the service request bit in the status word and is used to determine specific service being required by the terminal. The service request bit and the transmit vector word are the only means available for the terminal to request the scheduling of a periodic message. The message format for this single receiver operation contains a data word associated with the terminal's response. Figure 6 (HDBK) illustrates the use of this mode command in association with the service request bit.

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.

Synchronize mode commands (see also 4.3.3.5.1.7.2) inform the terminal(s) of an event time to allow coordination between the active bus controller and receiving terminals. Synchronization information may be implicit in the command word (mode code 00001), or a data word (mode code 10001) may be used to follow the command word to provide the synchronization information. If a data word is used, the definition of the bit meanings is the responsibility of the system designer. These may not necessarily be associated only with the management of data flow, they may also be used as system control functions.

Single Receiver Only – Bus Controller to Remote Terminal

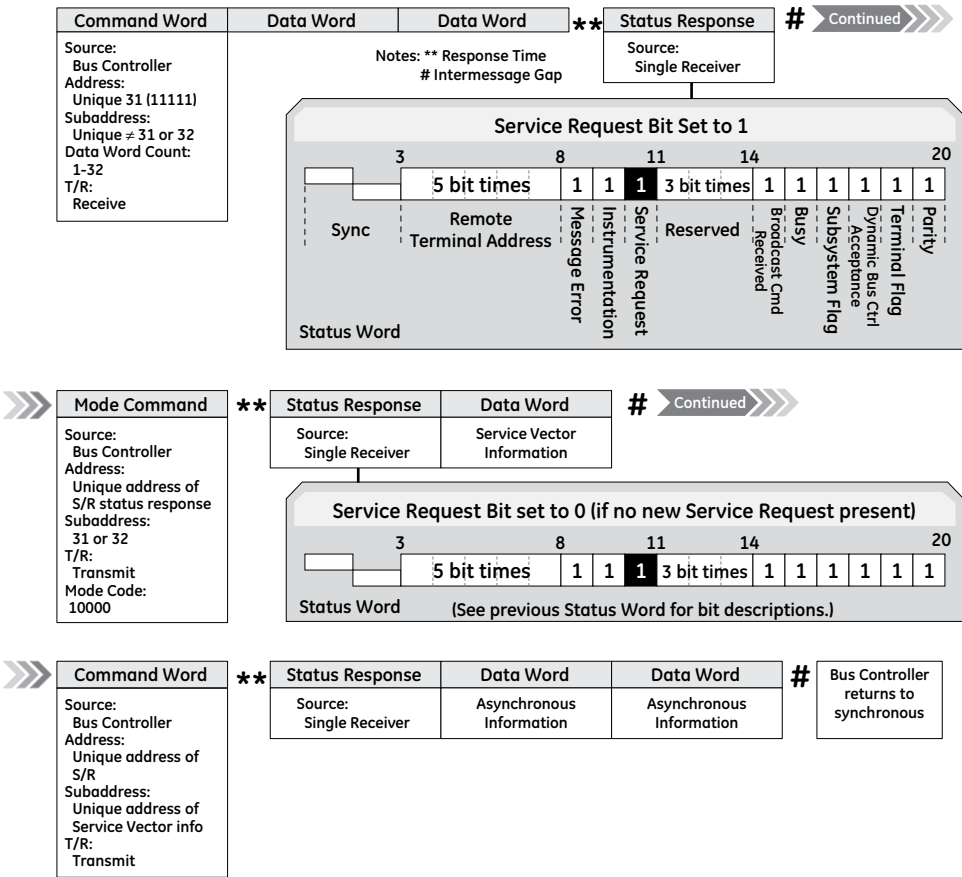


FIGURE 6 (HDBK): TRANSMIT VECTOR WORD TRANSFER FORMAT

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.

The bus controller uses the transmit last command mode code (10010) in the error handling and recovery process to determine the last valid command received by the remote terminal, just prior to this mode code. Note that this mode code will not change the contents of the last command, or the status word. A remote terminal receiving this mode command will transmit the previous status word, followed by a data word which contains the previous 16-bits of the last valid command word received. This mode command will not alter the state of the receiving terminal's status word, thus allowing this mode command to be used in error handling and recovery operation without affecting the status word which itself can have added error data.

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).

The transmit BIT word mode code (10011) provides the bus controller with the BIT results available from a remote terminal, as well as the status word. Obviously the bus controller must not issue this as a broadcast command. The contents of the BIT data word are provided to supplement the appropriate bits already available via the status word for complex terminals, and designers are free to use these as required. Notice that the contents of the BIT word within the remote terminal "...shall not be altered by the reception of a transmit last command or a transmit status word mode code". This allows error handling and recovery procedures to be used without changing the error data recorded in this word. However, the RT will only save the last command; the status code field (of the status word) will not be changed if transmit last command or transmit status word mode commands are transmitted. However, if any other transmissions are made to the RT, the status code field may change, for example, if a message error occurred during the transmission. See 4.3.3.5.1.7.3 and 4.3.3.5.1.7.13.

It's important to consider that RT BIT data "shall not be used to convey BIT data from the associated subsystem(s)." Subsystem fault investigation, when indicated by the subsystem flag, is not specified or otherwise restricted by MIL-STD-1553. System designers must therefore make the necessary provisions.

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.

Four mode code commands are provided to control transmitters associated with terminals in a system (see 4.3.3.5.1.7.5, 4.3.3.5.1.7.6, 4.3.3.5.1.7.15, and 4.3.3.5.1.7.16). These commands can be sent to a single receiver or broadcast to multiple users. Care should be taken to ensure that all RT's are aware of the bus numbering convention.

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.

Updated issues of the Standard will notify you of any future use of reserved mode codes

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 [STD]).*

4.3.3.5.2.1 SYNC

The data sync waveform shall be an invalid Manchester waveform as shown on Figure 7 (STD). The width shall be three bit times, with the waveform being negative for the first one and one-half bit times, and then positive 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.

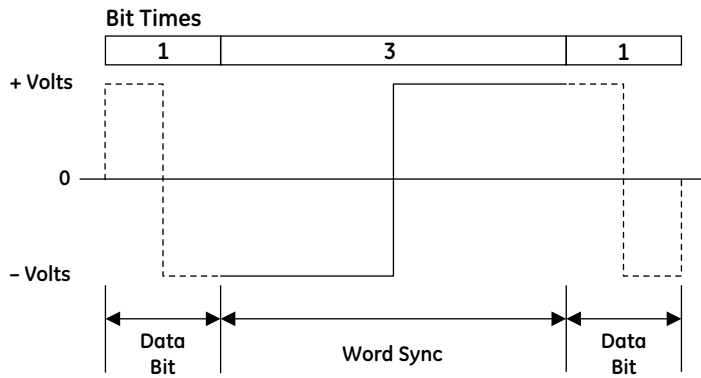


FIGURE 7 (STD): DATA SYNC WAVEFORM

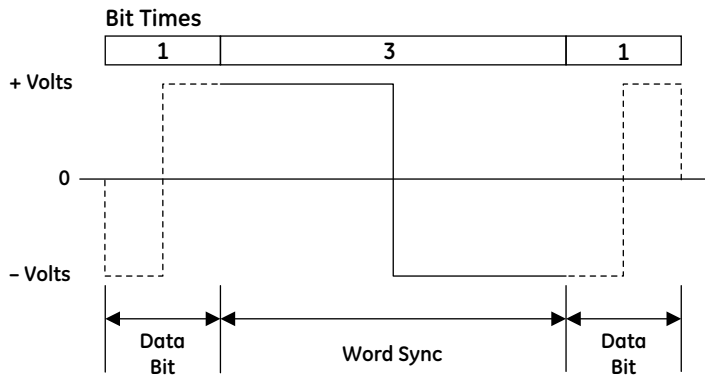


FIGURE 8 (GE): DATA SYNC APPARENT WAVEFORM

Note that the term **invalid Manchester waveform** refers to the description of the waveform in terms of the Manchester bi-phase encoding. Being a defined part of the message, it is actually valid for detection purposes.

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.

Data words are distinguished from command and status words by their inverted 3-bit sync pattern. Both packed and unpacked data may be transmitted in the 16-bit data field. Odd parity on the data field provides a data integrity check identical to the command and status word formats.

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 [STD]) 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 RT's shall implement the message error bit.

When one or more of the data words associated with the preceding received message has failed to pass the message validity test, the remote terminal sets the message error bit to a logic one. The message validity test requirements are:

- Word Validation: Word begins with valid sync, Manchester II code correctly transmitted, 16 data bits plus parity, and word parity odd. Invalid commands should not set the message error bit.
- Continuous words within a message.
- Address Validation: Matches address to unique terminal or broadcast address. Messages with incorrect addresses should be treated as being invalid.

Terminals that do detect illegal commands set the message error bit and transmit the status word (see 4.4.3.4). Illegal commands should not be confused with invalid command (see 4.4.3.3).

If the message meets the validity requirements, the status word will be transmitted as shown in the data and mode code message formats shown in Figure 6 (HDBK) and Figure 9 (HDBK). When a message error occurs in a broadcast message format, the message error bit will be set in the status word and the status response withheld as required by broadcast message format. It should be noted that any error condition renders the entire message invalid.

Multiple Receivers

Active Bus Controller to Remote Terminal

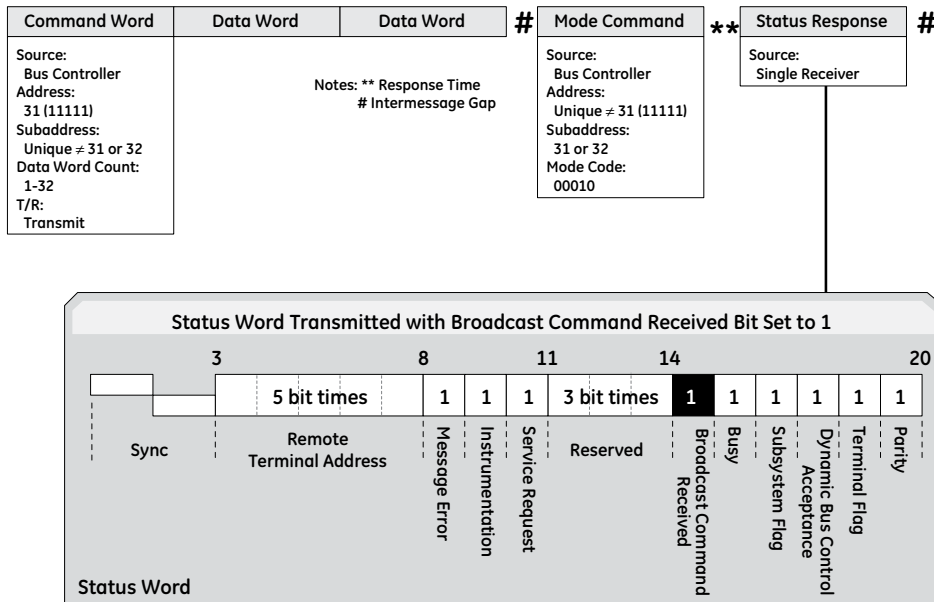


FIGURE 9 (HDBK): BROADCAST COMMAND RECEIVED BIT

4.3.3.5.3.4 INSTRUMENTATION BIT

The status word at bit time ten (see Figure 3 [STD]) 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.

Since the sync field (3 bits) is used to distinguish command/status words from data words on the bus, a mechanism is also required to enable passive monitoring equipment to distinguish between command and status words so as to interpret the bus traffic correctly. If your system uses this bit, the Standard specifies setting bit 10 in the command word to a logic one which can then be distinguished from the corresponding bit 10 in the status word (instrumentation bit) which is always set to logic zero. However, the use of the instrumentation bit results in the loss of fifteen usable subaddresses, 00001 to 01111, and 00000 for mode command identification.

An alternative method exists which involves only the loss of one usable subaddress. For this method you must prohibit the use of subaddress codes 01000 and 00000 in the command word. As a result, examination of bits 10, 12, 13, and 14 would reveal only logic zeros if the word in question was a status word. This method works because this combination of zero bits can no longer occur in any command word thus providing immediate and correct separation of command and status words. Either one of the above two methods of distinguishing between command and status words could be used.

4.3.3.5.3.5 SERVICE REQUEST BIT

The status word bit at bit time eleven (see Figure 3 [STD]) 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.

The service request bit provides an indication to the active bus controller that a remote terminal requests service. When this bit in the status word is set to logic one, the active bus controller uses a mode command (transmit vector word) to identify the specific request (Figure 6 [HDBK]). The message format for acquiring this is discussed under transmit vector word mode command (see 4.3.3.5.1.7.11).

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.

The broadcast command received bit is set to logic one when the preceding valid command word was a broadcast command (address 31). Since the broadcast message format requires the receiving remote terminals to suppress their status words, the broadcast command received bit is set to identify that the command was received properly.

If the bus controller requires broadcast message validity, it uses the message format illustrated on Figure 9 (HDBK) to determine this information. The broadcast command received bit will be reset when the next valid (non-broadcast) command is received by the remote terminal, unless the next valid command is a transmit status word or a transmit last command mode command.

4.3.3.5.3.8 BUSY BIT

The status word bit at bit time sixteen (see Figure 3 [STD]) 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.

The busy bit in the status word (see Figure 10 [HDBK]) is set to logic one to indicate to the active bus controller that the remote terminal is unable to move data to or from the subsystem in compliance with the bus controller's command. It should be noted that allowing the system to become "busy" and thereby setting the busy bit should be restricted to that of an exception basis, e.g., periods of high loads in subsystems. Setting the busy bit is not to be used as means of overcoming problems associated with slow acting remote terminals.

A busy condition can exist within a remote terminal at any time, causing it to be non-responsive to a command to send data or to be unable to receive data. This condition can exist for all message formats. In each case, except for broadcast message formats, the active bus controller will be informed within the status response of the busy condition. In the case of broadcast message formats, this information will not be made known unless the receiving terminals are polled, after the broadcast message, requesting their status. If the status word has the broadcast received bit set, the message was received and the terminal was not busy.

Single Receiver Active Bus Controller to Remote Terminal

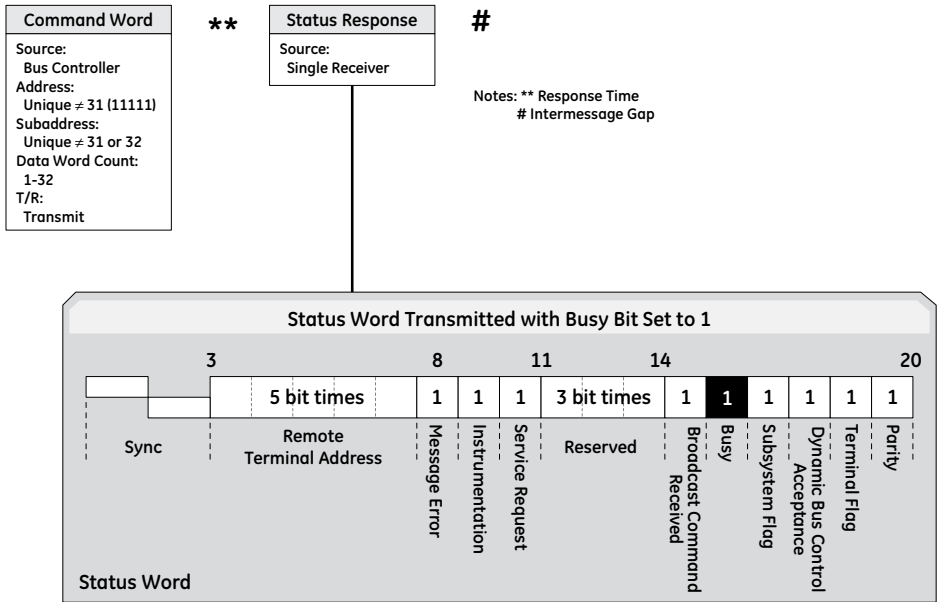


FIGURE 10 (HDBK): BUSY BIT

4.3.3.5.3.9 SUBSYSTEM FLAG BIT

The status word bit at bit time seventeen (see Figure 3 [STD]) 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.

When a subsystem of a single RT has a fault, it sets this optional bit to indicate to the active bus controller that a subsystem fault exists and data sent from the subsystem may be invalid. The subsystem flag bit may be set in any transmitted status word.

4.3.3.5.3.10 DYNAMIC BUS CONTROL ACCEPTANCE BIT

The status word bit at bit time eighteen (see Figure 3 [STD]) 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.

4.3.3.5.1.7.1. discusses the use of dynamic bus control.

4.3.3.5.3.11 TERMINAL FLAG BIT

The status word bit at bit time nineteen (see Figure 3 [STD]) shall be reserved for the terminal flag function. The use of this bit is optional. This bit, when used, shall flag an 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.

It is to be noted that:

1. Status is constructed on a message-by-message basis on receipt of each valid command word. Remote terminals are required to store the status word between valid command words so that it is available for interrogation using the transmit status word mode code.
2. It is recommended that the terminal flag bit and subsystem flag bit, having once been set, should remain set until a reset remote terminal mode command is received, or a power-up initialization occurs.
3. The inhibit terminal flag mode code locally suppresses the terminal flag bit in the status word so preventing the RT from reporting a potential failure.

The above three items allow the bus controller to accomplish an orderly error handling and recovery approach using the information associated with error analysis data contained within the status word, or other data associated with the RT (e.g., last command word and BIT word).



message formats



MESSAGE FORMATS

4.3.3.6 MESSAGE FORMATS

The messages transmitted on the data bus shall be in accordance with the formats on Figure 11 (STD) and Figure 12 (STD). 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.

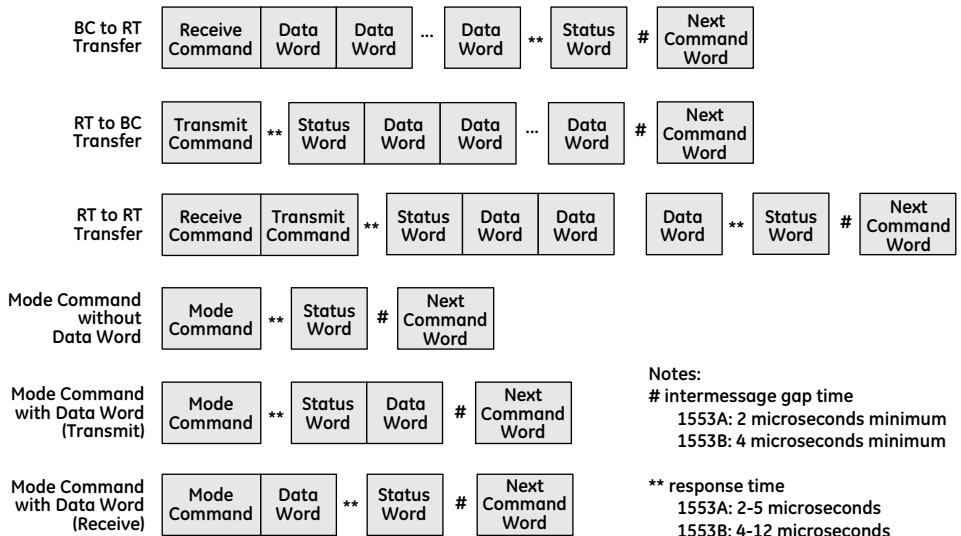


FIGURE 11 (STD): INFORMATION TRANSFER FORMATS

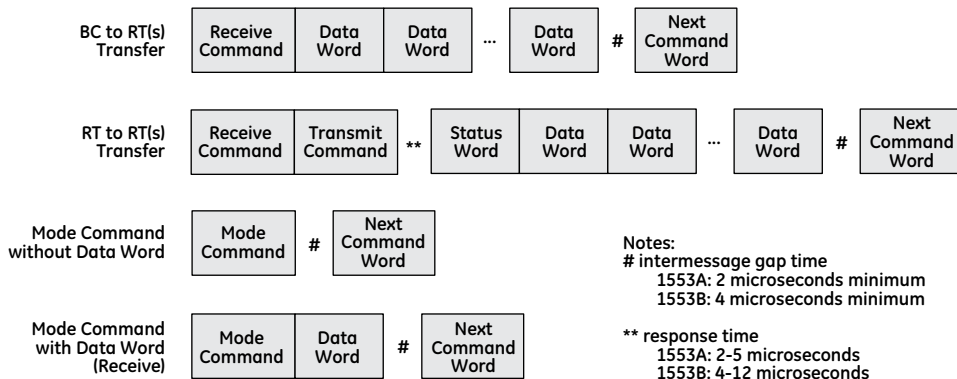


FIGURE 12 (STD): BROADCAST INFORMATION TRANSFER FORMATS

The command/response protocol provides two types of message formats, control messages and data messages. Control messages are identified by the subaddress/mode field in the command word being set to 31 (11111) or 0 (00000). All control messages originate with the active bus controller and are received by a single receiver, or by multiple receivers (broadcast). A terminal address value of 31 (11111) in the command word indicates a broadcast message, while any other terminal addresses are to identify unique messages to a terminal on the bus. The mode command information is contained completely in the mode code/word count field of the command word. 4.3.3.5.1.7 contains a more general discussion of the use of mode commands.

The various legal mode commands with and without data word are illustrated in Figure 25 (HDBK).

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 in a contiguous fashion with no interword gaps.

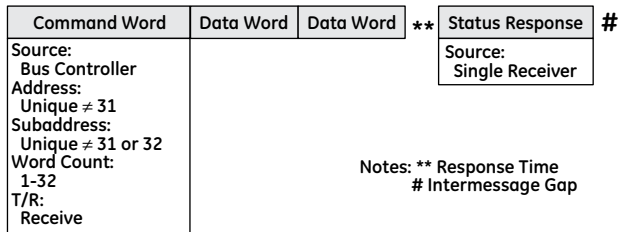


FIGURE 13 (HDBK): BUS CONTROLLER TO REMOTE TERMINAL

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.

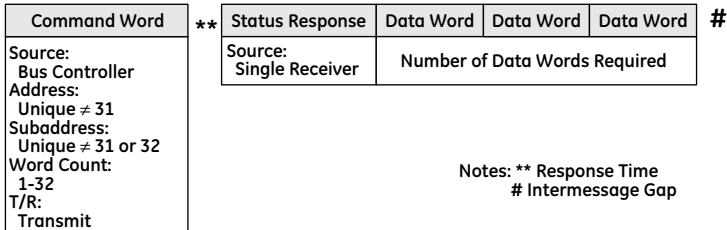


FIGURE 14 (HDBK): REMOTE TERMINAL TO BUS CONTROLLER

4.3.3.6.3 REMOTE TERMINAL TO REMOTE TERMINAL TRANSFERS

The bus controller shall issue a receive command to RT A followed contiguously 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.

See 4.3.3.8 for a description of the specified time period.

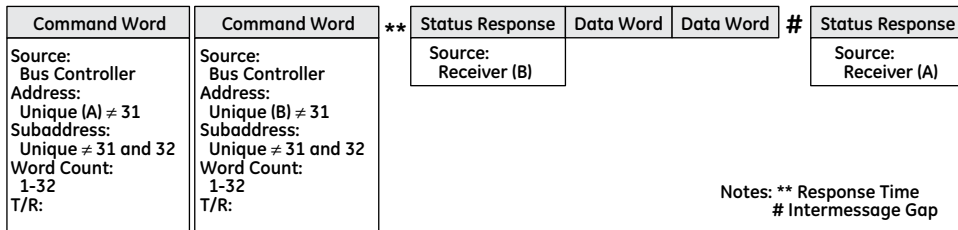


FIGURE 15 (HDBK): REMOTE TERMINAL TO REMOTE TERMINAL

For the above three types of message transfers, it should be noted that successive message transfers to or from the same RT causes a high throughput. It is preferred that if the subsystem is unable to handle the required message rate, the busy bit should be set as necessary to ensure data is not lost.

A summary of single receiver data message formats appears in Figure 16 (HDBK).

For broadcast (multiple) receiver data message formats, see Figure 22 (HDBK).

Bus Controller to Remote Terminal

Command Word	Data Word	Data Word	**	Status Response	#
Source: Bus Controller Address: Unique ≠ 31 Subaddress: Unique ≠ 31 or 32 Word Count: 1-32 T/R: Receive				Source: Single Receiver	

Notes: ** Response Time
Intermessage Gap

Remote Terminal to Bus Controller

Command Word	**	Status Response	Data Word	Data Word	Data Word	#
Source: Bus Controller Address: Unique ≠ 31 Subaddress: Unique ≠ 31 or 32 Word Count: 1-32 T/R: Transmit		Source: Single Receiver	Number of Data Words Required			

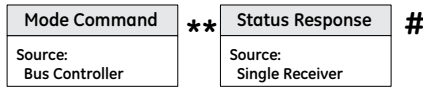
Remote Terminal to Remote Terminal

Command Word	Command Word	**	Status Response	Data Word	Data Word	#	Status Response
Source: Bus Controller Address: Unique (A) ≠ 31 Subaddress: Unique ≠ 31 and 32 Word Count: 1-32 T/R:	Source: Bus Controller Address: Unique (B) ≠ 31 Subaddress: Unique ≠ 31 and 32 Word Count: 1-32 T/R:		Source: Receiver (B)				Source: Receiver (A)

FIGURE 16 (HDBK): SUMMARY OF SINGLE RECEIVER DATA MESSAGE FORMATS

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 STD I. The RT shall, after command word validation, transmit a status word.

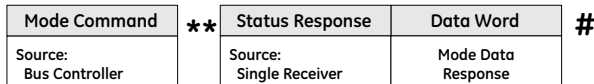


Notes: ** Response Time
Intermessage Gap

FIGURE 17 (HDBK): MODE COMMAND WO/DATA WORD TO A SINGLE RECEIVER

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 STD 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.

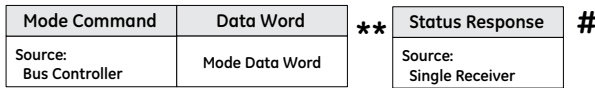


Notes: ** Response Time
Intermessage Gap

FIGURE 18 (HDBK): TRANSIT MODE COMMAND W/DATA WORD TO A SINGLE RECEIVER

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 STD 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.



Notes: ** Response Time
Intermessage Gap

FIGURE 19 (HDBK): RECEIVE MODE COMMAND W/DATA WORD TO A SINGLE RECEIVER

4.3.3.6.7 OPTIONAL BROADCAST COMMAND

See 10.6 for additional information on the use of the broadcast command.

This mode allows one transmission to be simultaneously received by more than one RT, but no status word reply will be made by any RT.

The broadcast mode provides a mechanism for a bus controller or remote terminal to transmit information to multiple remote terminals with a single message. When a broadcast message is transmitted, the bus controller initiates an RT to RT transfer message using address 31 (11111) rather than a unique terminal address.

All addresses other than 31 can be assigned to remote terminals. Since multiple RTs receive a broadcast message, the responding status word must be suppressed. By choosing the address method to accomplish the broadcast mode, only BC to RT, and Mode commands are available for use. Broadcast messages can be used with subaddresses and mode codes. The subaddress in a broadcast message can allow multiple RTs with broadcast reception capability to sort out specific broadcast messages transmitted, if given this capability in hardware or software. Therefore, multiple sets of broadcast messages can be defined. In addition, the broadcast format can be used with some mode codes, allowing simultaneous reception of these mode codes by remote terminals.

Designers must carefully weigh the benefits of discarding the commandresponse format, in which all message completion failures are known to the bus controller, against the benefits of using broadcast message transfers. Broadcast use may increase system operation complexity, since subaddresses of broadcast address and addressed terminal are not likely to be the same, increasing the need for additional subaddresses.

Proper use of the broadcast mode may yield benefits by allowing simultaneous communication with remote terminals and may also serve to reduce bus traffic.

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.

Command Word	Data Word	Data Word	Data Word	#
Source: Bus Controller Address: 31 Subaddress: Unique ≠ 0 or 31 Word Count: 1-32 T/R: Receive				

Notes: ** Response Time
Intermessage Gap

FIGURE 20 (HDBK): BUS CONTROLLER TO REMOTE TERMINALS

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.

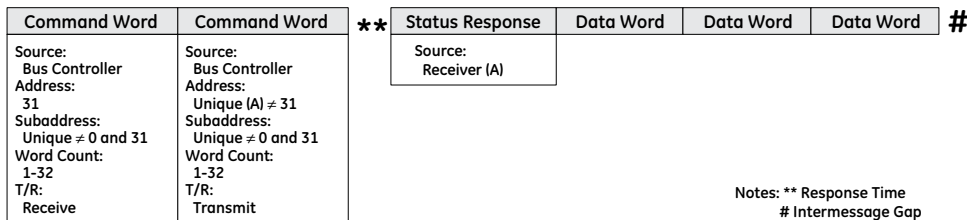


FIGURE 21 (HDBK): REMOTE TERMINAL TO REMOTE TERMINAL

A summary of broadcast (multiple) receiver data message formats appears in Figure 22 (HDBK).

For single receiver data message formats, see Figure 16 (HDBK).

Bus Controller to Remote Terminals

Command Word	Data Word	Data Word	Data Word	#
Source: Bus Controller Address: 31 Subaddress: Unique ≠ 0 or 31 Word Count: 1-32 T/R: Receive				

Notes: ** Response Time
Intermessage Gap

Remote Terminal to Remote Terminals

Command Word	Command Word	**	Status Response	Data Word	Data Word	Data Word	#
Source: Bus Controller Address: 31 Subaddress: Unique ≠ 0 and 31 Word Count: 1-32 T/R: Receive	Source: Bus Controller Address: Unique (A) ≠ 31 Subaddress: Unique ≠ 0 and 31 Word Count: 1-32 T/R: Transmit		Source: Receiver (A)				

FIGURE 22 (HDBK): SUMMARY OF MULTIPLE RECEIVER DATA MESSAGE FORMATS

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 STD 1. 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.

Mode Command	#
Source: Bus Controller	

Note: # Intermessage Gap

FIGURE 23 (HDBK): TRANSMIT MODE COMMAND WO/DATA WORD TO MULTIPLE RECEIVERS

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 STD 1, 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.

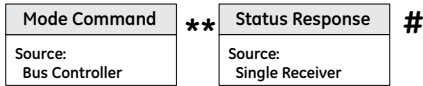
Mode Command	Data Word	#
Source: Bus Controller	Mode Data Word	

Note: # Intermessage Gap

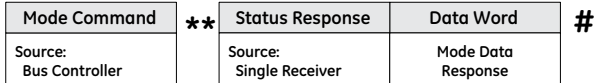
FIGURE 24 (HDBK): TRANSMIT MODE COMMAND W/DATA WORD TO MULTIPLE RECEIVERS

A summary of mode command transfer formats appears in Figure 25 (HDBK).

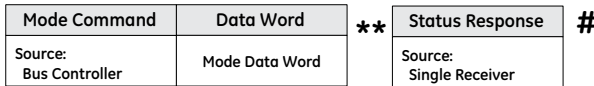
Mode Command without Data Word to a Single Receiver



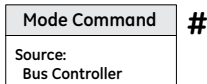
Transmit Mode Command with Data Word to a Single Receiver



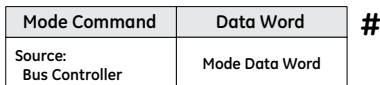
Receive Mode Command with Data Word to a Single Receiver



Transmit Mode Command without Data Word to Multiple Receivers



Transmit Mode Command with Data Word to Multiple Receivers



Notes: ** Response Time
Intermessage Gap

FIGURE 25 (HDBK): MODE COMMAND TRANSFER FORMAT SUMMARY

4.3.3.7 INTERMESSAGE GAP

The bus controller shall provide a minimum gap time of 4.0 microseconds (μs) between messages as shown on Figure 11 (STD) and Figure 12 (STD). This time period, shown as T on Figure 26 (STD), is measured at point A of the bus controller as shown on Figure 27 (STD) or Figure 28 (STD). The time is measured from the mid-bit zero crossing of the last bit of the preceding message to the mid-zero crossing of the next command word sync.

The purpose of this clause is to clearly identify that the bus controller shall not transmit contiguous messages. There must be an intermessage gap so that any voltage build-up can dissipate (see explanatory note for 4.3.3.8). Since there is no maximum gap time specified, the bus controller may issue messages with gap times greater than or equal to 4 μs .

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 μs . This time period, shown as T on Figure 26 (STD), is measured at point A of the RT as shown on Figure 27 (STD) or Figure 28 (STD). The time is measured from the mid bit zero crossing of the last word as specified in 4.3.3.6 and as shown on Figure 11 (STD) and Figure 12 (STD) to the mid-zero crossing of the status word sync.

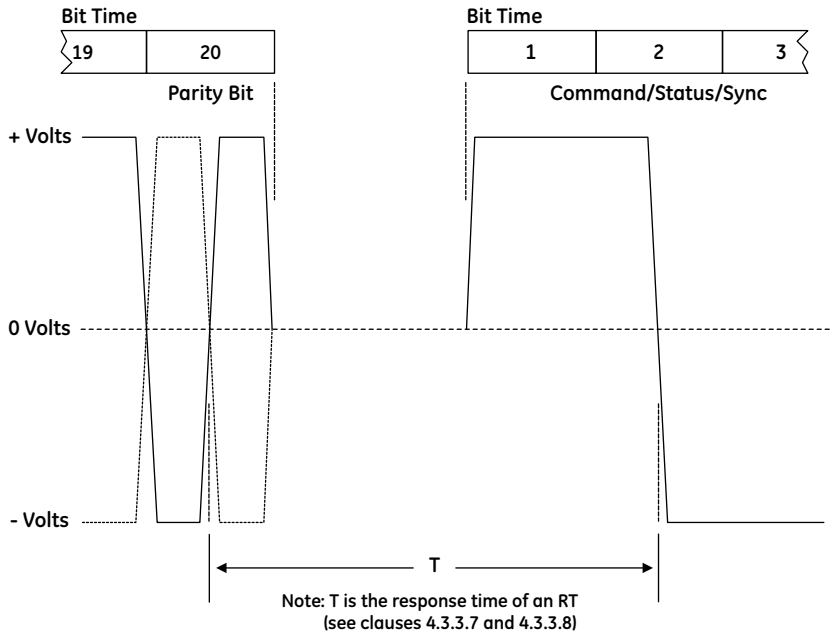


FIGURE 26 (STD): INTERMESSAGE GAP AND RESPONSE TIME

The point of measurement of response time appears in Figure 26 (STD) using the previous mid-bit zero crossing and the next mid-bit crossing. Values of 4 and 12 μs would equate to 2 and 10 μs , respectively of bus quiet time.

4.3.3.9 MINIMUM NO RESPONSE TIMEOUT

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 μs . The time is measured from the mid-bit zero crossing of the last bit of the last word to the mid-zero crossing of the expected status word sync at point A of the terminal as shown on Figure 27 (STD) or Figure 28 (STD).

The main intention of this clause is to specify the minimum time that a bus controller shall wait after sending a command before it concludes that the addressed remote terminal is not going to respond before sending a subsequent command.

This clause can also be interpreted to apply to the receiving RT in an RT to RT transfer to check for the correct response from the transmitting RT. This condition should, if detected, prevent the receiving RT from remaining “open” to data from another source if the transmitting RT does not respond to its command in time, and should cause the RT to abort any operations associated with the first receive command.

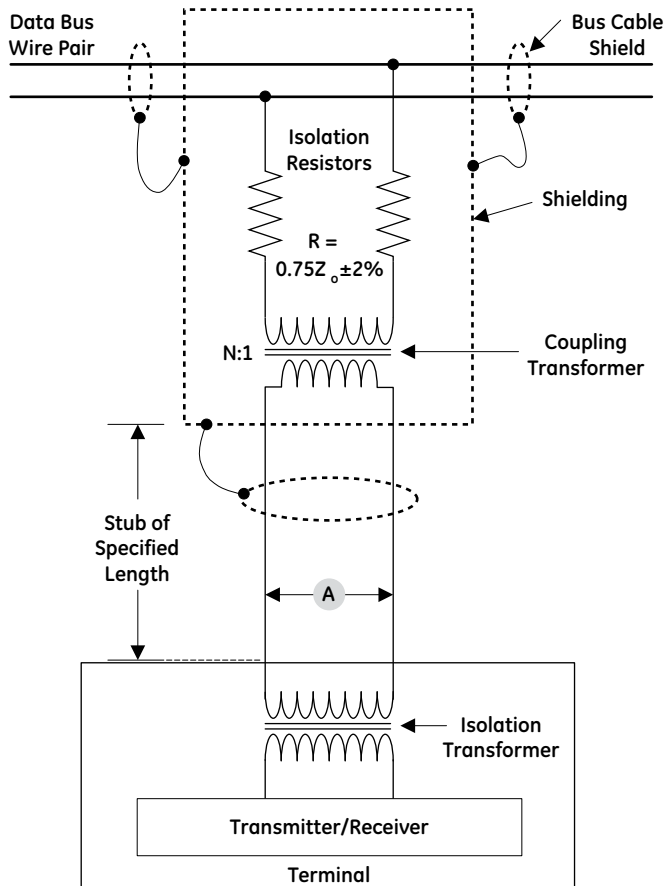


FIGURE 27 (STD): DATA BUS INTERFACE USING TRANSFORMER COUPLING

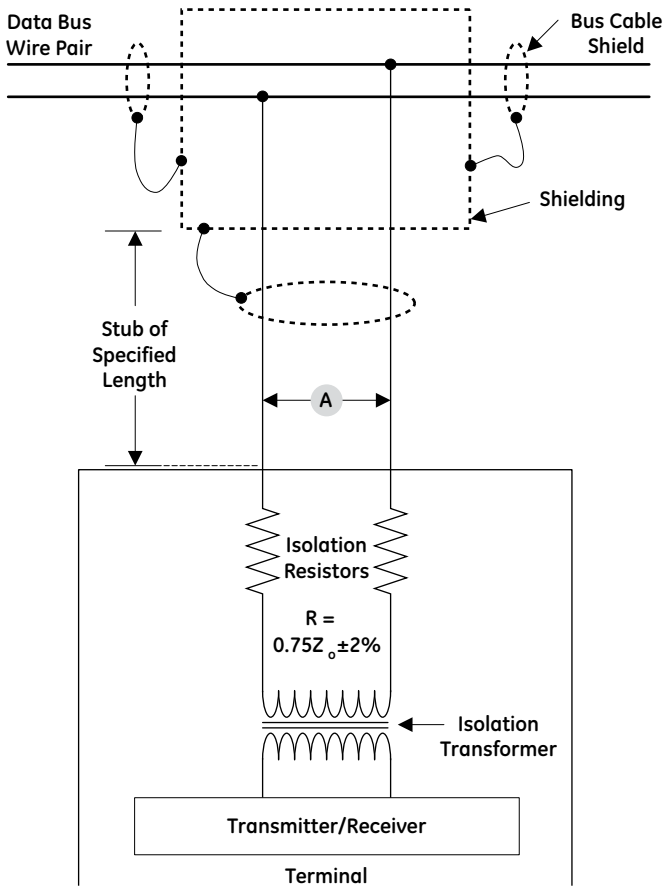


FIGURE 28 (STD): DATA BUS INTERFACE USING DIRECT COUPLING

The image features a central, dark blue sphere with a lighter blue, stylized eye icon. The eye has a thick, curved eyelid and a small, spiral-shaped pupil. This central element is surrounded by a radial pattern of light blue, curved lines that resemble the blades of a fan or a turbine. The background is a dark, almost black, gradient. Overlaid on the lower-left portion of the sphere is the text "terminal operation" in a white, sans-serif font.

terminal operation



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 ensure 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.

In this context, improperly timed data syncs relate to 4.5.2.1.1.2 and 4.5.2.2.1.2 in respect to the zero crossing accuracy expected for a transmitter.

For contiguous words, the required time interval from the last zero crossing of one word to the first zero crossing of the next word, measured at the transmitter into a test load, is $2 \mu\text{s} \pm 25 \text{ ns}$. Given normal transmission characteristics, this will result in a corresponding time interval at the receiver within $2 \mu\text{s} \pm 150 \text{ ns}$. This interpretation is based on the timing detail given in 4.5.2.1.1.2 and 4.5.2.2.1.2.

4.4.1.3 TERMINAL FAIL-SAFE

The terminal shall contain a hardware implemented timeout to preclude a signal transmission of greater than $800.0 \mu\text{s}$. This hardware shall not preclude a correct transmission in response to a command. Reset of this timeout function shall be performed by the reception of a valid command on the bus on which the timeout has occurred.

The above clauses describe the common operating capabilities that all terminals must have, whether operating as a bus controller, bus monitor, or as a remote terminal. A timeout function should be associated with each individual transmitter.

The purpose of the fail-safe timer is to protect the data bus by preventing a terminal from transmitting for longer than 800 μ s per message.

Note that under such transmitter fault conditions, a terminal will produce an 800 μ s transmission every time the terminal receives a valid command. In such circumstances, the Bus Controller must take appropriate action to overcome this problem.

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.

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 transmissions 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.

The above clause is intended to clarify the superseding valid command requirement particularly in respect of the gap time issue. If a bus controller fails to wait at least 12 μ s for an expected status word response from an RT, there is a possibility that a second command transmitted by the bus controller would coincide with the status word. Furthermore, if the controller should replace a data word in a contiguous message (controller to RT transfer) with a valid command word to the receiving remote terminal, the RT should ignore it, deem the message to have failed, and suppress the status word response.

The intended purpose for this requirement is to allow the bus controller to reissue an identical transmission when an RT fails to respond to a command on that bus or issue a new transmission in similar circumstances.

The minimum no response timeout requirement is specified in 4.3.3.9. By insertion of the specified delay, the bus controller is assured that the RT is not responding and thus a new command on the same bus will not be corrupted.

The comments made above only relate to activity on the same bus, and it should be noted that with dual or multi-bus configurations, 4.6.3.2 applies, which does not require the controller to wait for activity to cease on the current bus before sending a new command on a redundant bus.

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.

Illegal commands are commands that have passed the validation test but are beyond the capability of the terminal. These include command words where the subaddress/mode field, data word/mode code field, or the T/R bit are set such that they represent conditions not allowed in the system. An illegal command may be a combination of the above fields that is restricted or undefined by 1553B, or by the terminal designer. Since the BC is responsible for all command and response message content, the system designer must carefully consider the design of the BC so it does not transmit illegal commands.

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.

This requirement identified that a status word is transmitted only if the command word is valid, the data words are valid and contiguous, and that the proper number of data words are received. It should be noted that other message formats also produce a status word response, e.g., mode code without data word transmitted to a specific RT (not broadcast).

It must also be noted that when using the broadcast command option, status word response from RT's implementing this option are suppressed (see 4.3.3.6.7).

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.

When considering RT validation procedures, it should be remembered that an RT is always required to listen to the traffic on any bus to which it is connected, except when transmitting on that bus. Also, all command words must pass the validation criteria described in 4.4.3.1 before an RT recognizes their existence, including mode commands without data words. It is absolutely essential that an RT ignore invalid commands. Once the command word has been validated, if one or more data words are contained in the message, the RT must check such words for their validity as described in 4.4.3.6.

In all cases except broadcast mode, suppression or non-return of the status word alerts the bus controller of malfunction. The level of error recovery that must occur will depend on the bus controller's message error algorithms. Options available might include request for the RT status word or last valid command word.

Note:

In the event any errors are detected, the Standard requires that the entire message 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.

A terminal generally operates as a bus monitor either as a stand-alone unit, taking no active part in the bus operation, apart from listening, or as part of a remote terminal performing a monitoring function for potential use as a backup bus controller in the event of a primary bus controller failure. The unique feature of this terminal is that it has the ability to decode and accept for data storage any or all messages transmitted on the data bus without the knowledge of, or without affecting the operation of, the multiplex system or the terminals attached to the bus. A bus monitor can be made to respond by assigning a specific address to which it would respond, in which case it would act as an RT for that address, and as a bus monitor for all the others.

For further details of operation as a bus monitor, see the explanatory note for 4.3.3.5.3.4.



data bus characteristics



DATA BUS CHARACTERISTICS

4.5 HARDWARE CHARACTERISTICS

4.5.1 DATA BUS CHARACTERISTICS

4.5.1.1 CABLE

The cable used for the main bus and all stubs shall be a two conductor, twisted, shielded, jacketed cable. The wire-to-wire distributed capacitance shall not exceed 30.0 picofarads per foot (99.4 pF/meter). The cables shall be formed with not less than four twists per foot (13.1 twists/meter) where a twist is defined as a 360 degree rotation of the wire pairs; and, the cable shield shall provide a minimum of 75.0 percent coverage.

4.5.1.2 CHARACTERISTIC IMPEDANCE

The nominal characteristic impedance of the cable (Z_0) shall be within the range of 70.0 ohms to 85.0 ohms at a sinusoidal frequency of 1.0 megahertz (MHz).

4.5.1.3 CABLE ATTENUATION

At the frequency of 4.5.1.2, the cable power loss shall not exceed 1.5 decibels (dB)/100 feet (ft).

1.5 decibels (dB)/100 ft = 4.92 dB/100 m

4.5.1.4 CABLE TERMINATION

The two ends of the cable shall be terminated with a resistance, equal to the selected cable nominal characteristic impedance (Z_0) ± 2.0 percent.

Since the specification figures quoted in this part of the Standard represent worst cases, in most practical applications improvements should be sought wherever possible.

4.5.1.5 CABLE STUB REQUIREMENTS

The cable shall be coupled to the terminal as shown on Figure 27 (STD) or Figure 28 (STD). The use of long stubs is discouraged, and the length of a stub should be minimized. However, if installation requirements dictate, stub lengths exceeding those lengths specified in 4.5.1.5.1 and 4.5.1.5.2 are permissible.

Stubbing is the method by which a separate cable is connected between the primary data bus and a terminal. The two methods of connecting stubs to the data bus appear in Figure 27 (STD) and Figure 28 (STD). However, the preferred method of connecting stubs to the data bus is to use transformer coupling (Figure 27 [STD]); this method provides increased DC isolation, increased common mode protection, and less mix-matching to the data bus.

Lengths of all stubs should be kept as short as possible.

To minimize reflections due to transmission line mismatch, the main data bus is terminated at each end in the cable characteristic impedance.

With no stubs attached, the main bus looks like an infinite length transmission line, and thus there are no disturbing reflections. When stubs are added for connection of the terminals, the bus is loaded locally and a mismatch occurs with resulting reflections. The degree of mismatch and signal distortion due to reflections are a function of the impedance (Z) presented by the stub and terminal input impedance. In order to minimize signal distortion, it is desirable to maintain a high stub impedance reflected back to the main bus. At the same time the impedance needs to be kept low so that adequate signal power will be delivered to the receiver input. A trade-off and compromise between these conflicting requirements is necessary to achieve the specified signal to noise ratio and system error rate performance. Two methods for coupling a terminal to the main bus are defined, transformer coupling and direct coupling (Figure 27 [STD] and Figure 28 [STD]).

Transformer coupling is usually used with long stubs (1 to 20 ft) and requires a coupler box, separate from the terminal, incorporating the junction of the main bus and stub. Direct coupling is usually limited to use with stubs of less than one foot. Fault isolation resistors (R) are included to provide protection for the main bus in case of a short circuit in the stub or terminal. The coupling transformer characteristics defined in 4.5.1.5.1.1, provide a compromise for the signal level and distortion characteristics delivered to the terminals. The coupling transformer turns ratio ($\sqrt{2}$ to 1) provides beneficial impedance transformation for both terminal reception and transmission. The direct coupling option is provided for use in small and relatively simple systems where the cost of using transformer coupling becomes significant; however, the technical trade-offs made when using direct coupling must be considered.

Figure 29 (GE) shows a plot of the calculated first order magnitude stub impedance (Z) against stub length. From this it is evident that the stub impedance is significantly increased by the use of the coupling transformer.

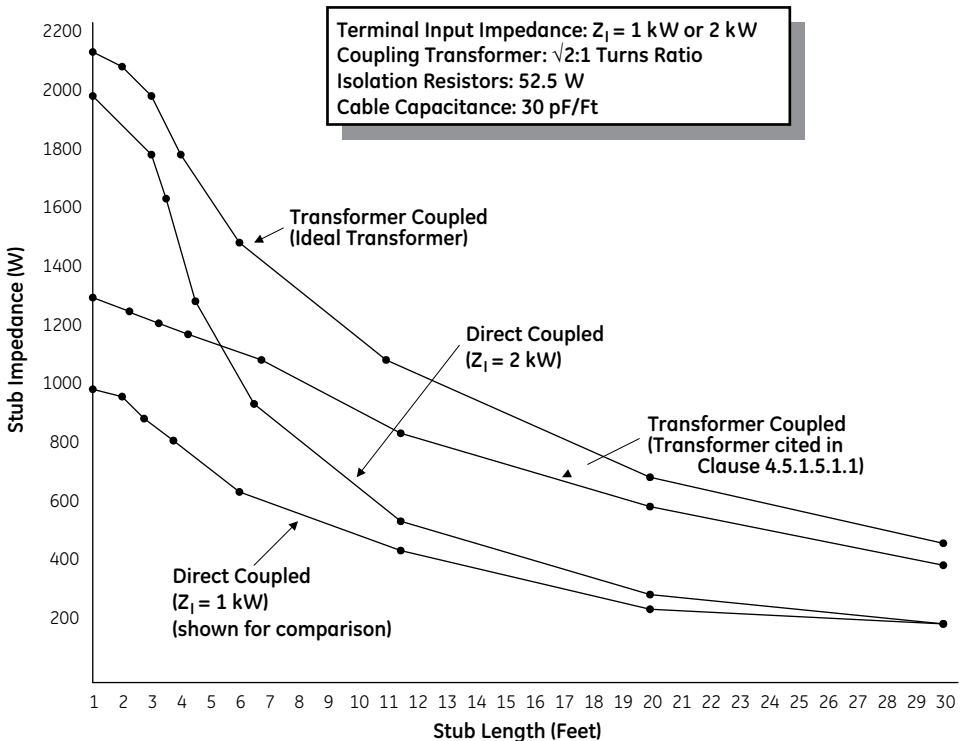


FIGURE 29 (GE): STUB IMPEDANCE VS. LENGTH VARIATION (CALCULATED)

The major differences between the requirements of transformer and direct coupled stubs are the positioning of the isolation resistors for the direct coupled (short stub) connection, and the characterization of the coupling transformer in the transformer coupled (long stub) connection. With the isolation resistors located in the terminal for the direct coupled case, the need for a separate coupler box is eliminated as long as a reliable, screened connection can be made. In most cases, the bus connections can be spliced in the cable connector which mates with the terminal connector.

The coupling transformer characteristics are very important to the signal integrity and noise performance of the data bus system. The purpose of this form of coupling is to:

1. Provide isolation of the main bus from fault conditions on the stub or in the terminal
2. Provide reduced signal distortion effects by increasing the effective stub impedance
3. Provide termination of the stub when transmitting from the terminal
4. Prevent common mode noise on the data bus from entering the stub so that the stub transformer has only to reject locally induced common mode noise

The isolation resistors and the transformer turns ratio ($\sqrt{2}:1$) provide the benefits listed above.

4.5.1.5.1 TRANSFORMER COUPLED STUBS

The length of a transformer coupled stub should not exceed 20 feet. If a transformer coupled stub is used, then the following shall apply.

4.5.1.5.1.1 COUPLING TRANSFORMER

A coupling transformer, as shown on Figure 27 (STD), shall be required. This transformer shall have a turns ratio of 1:1.41 ± 3.0 percent, with the higher turns on the isolation resistor side of the stub.

The use of transformers provides electrical isolation, impedance matching, and rejection of common mode noise. However, incorrectly designed transformers can cause considerable problems, e.g., signal distortion, line reflection, and high bit error rates.

As indicated above, the $\sqrt{2}$:1 transformer provides termination of the stub for transmission of signals from the terminal to the main bus when the impedance at point B in Figure 30 (STD) looking into the stub ZB is:

1. $Z_B = (Z_O/2) + 2R$

Where $R = 0.75 Z_O$

2. $Z_B = 0.5Z_O + 1.5Z_O = 2Z_O$ ohms

The reflected impedance, Z_R , from the bus to the stub due to the transformer impedance transformation is:

3. $Z_R = (Z_B/\sqrt{2}) = (2Z_O/2) = Z_O$

Therefore, the coupling transformer specified provides the characteristics desired for reducing reflections and maintaining signal levels for systems where long stubs are required.

4.5.1.5.1.1.1 TRANSFORMER INPUT IMPEDANCE

The open circuit impedance as seen at point B on Figure 30 (STD) shall be greater than 3000 ohms over the frequency range of 75.0 kilohertz (kHz) to 1.0 megahertz (MHz), when measured with a 1.0V root-mean-square (RMS) sine wave.

The transformer open circuit impedance (ZOC) is required to be greater than 3 kilohms. The measurement is made looking into the higher turns winding with a 75 kHz to 1 MHz sine wave signal.

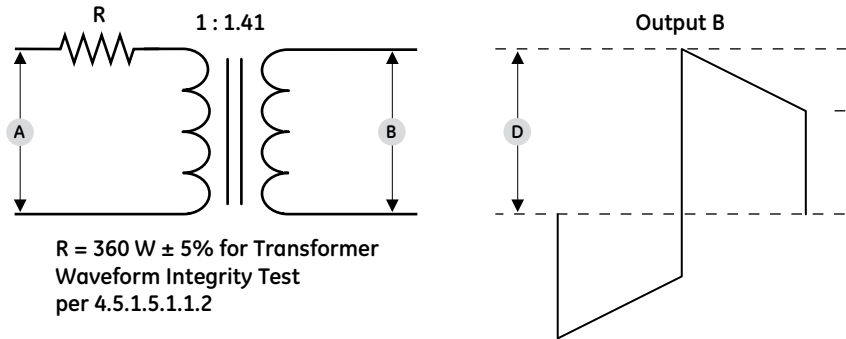


FIGURE 30 (STD): COUPLING TRANSFORMER

The test amplitude at the transformer winding is adjusted to 1 VRMS. The critical factors in achieving the 3 kilohms ZOC is the distributed capacitance of the windings and the transformer primary inductance. The inductance of the transformer must be large enough to provide the open circuit impedance at 75 kHz while the distributed capacitance should be small enough to maintain the open circuit impedance at the 1 MHz test frequency. Note that because these transformers have a resonant point in the frequency range 75 kHz to 1 MHz, over which input impedance peaks, it is important to take such measurements above that range of frequencies. The inductance may obviously be increased by increasing the number of turns on the transformer. This technique, however, tends to increase the distributed capacitance, degrading high frequency performance and therefore causing waveform integrity and common mode rejection to suffer.

The transformer is a very important element in determining the transceiver characteristics such as input impedance, signal waveform integrity, and common mode rejection required by 1553. The considerations for transformer and associated input/output circuit design are:

- Provide the specified input impedance at high frequencies (terminal input impedance 1 kilohms or 2 kilohms at 1 MHz)
- Maintain waveform integrity and low percentage droop for the lower frequency conditions (less than 20% for 250 kHz square wave)
- Design for low interwinding capacitance to help achieve the common mode rejection figure specified for the receiver (45 dB CMR at ± 10 V p, DC to 2 MHz)

These considerations are also directly applicable to the design of the transceiver transformer. In addition to the transformer characteristics, other considerations for maintaining the terminal input impedance specification are as follows:

- Minimize stray capacitance of wiring from the external connector and on the circuit card to the buffer amplifier (every 100 pF results in approximately 1.6 kilohms shunt impedance at 1 MHz).
- Maintain high impedance at the receiver limiter and filter circuit inputs, and transmitter driver outputs in the off state. This impedance must be maintained with the terminal (transceiver) power off.

4.5.1.5.1.1.2 TRANSFORMER WAVEFORM INTEGRITY

The droop of the transformer using the test configuration shown on Figure 30 (STD) at point B, shall not exceed 20.0 percent. Overshoot and ringing as measured at point B shall be less than ± 1.0 V peak. For this test, R shall equal 360.0 ohms ± 5.0 percent and the input A of Figure 30 (STD) shall be a 250.0 kHz square wave, 27.0 V peak-to-peak, with a rise and fall time no greater than 100 nanoseconds (ns).

The ability of the coupler transformer to provide a satisfactory signal is specified in the droop, overshoot and ringing requirements shown on Figure 30 (STD) and Figure 31 (HDBK). Droop is specified at 20% maximum when driving the transformer with a 250 kHz, 27 V peak to peak square wave about zero. The test for the droop characteristic is made by driving the low turns winding through a 360 ohm resistor and measuring the signal at the open circuited high side winding.

The droop of the transformer is determined mainly by the primary inductance. Since the primary inductance also provides the 3 kilohms open circuit impedance, the inductance should be made as high as possible without degrading the high frequency performance of the transformer. Ringing and overshoot on the transformer signal appears in Figure 31 (HDBK). The ± 1 V limit on these high frequency perturbations can be achieved through careful attention to leakage inductance and transformer capacitance.

4.5.1.5.1.1.3 TRANSFORMER COMMON MODE REJECTION

The coupling transformer shall have a common mode rejection ratio greater than 45.0 dB at 1.0 MHz.

The common mode rejection of the isolation transformer must be greater than 45.0 dB. The common mode test shown in Figure 34 (STD) and Figure 32 (HDBK) consists of driving the low turns winding with approximately 2 V while measuring the differential signal across the high turns winding. Common mode rejection can be improved by minimizing the interwinding capacitance and the core to winding capacitance.

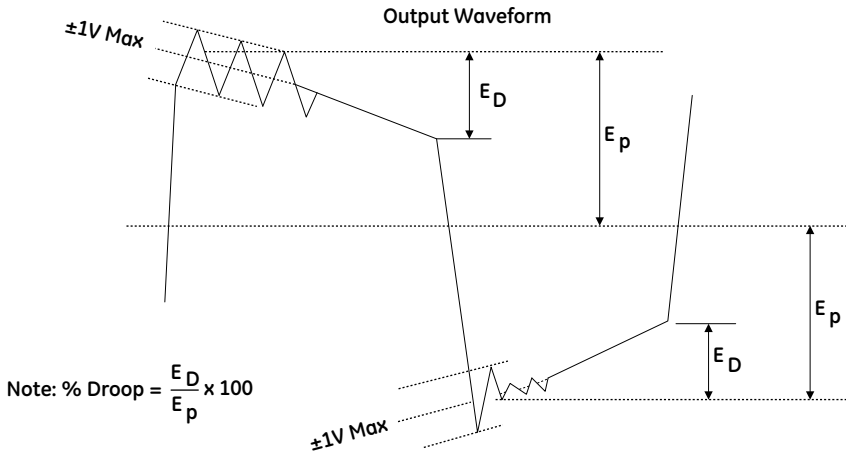
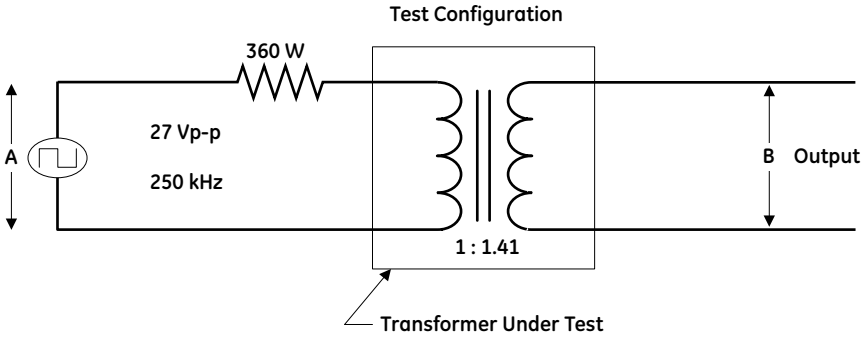
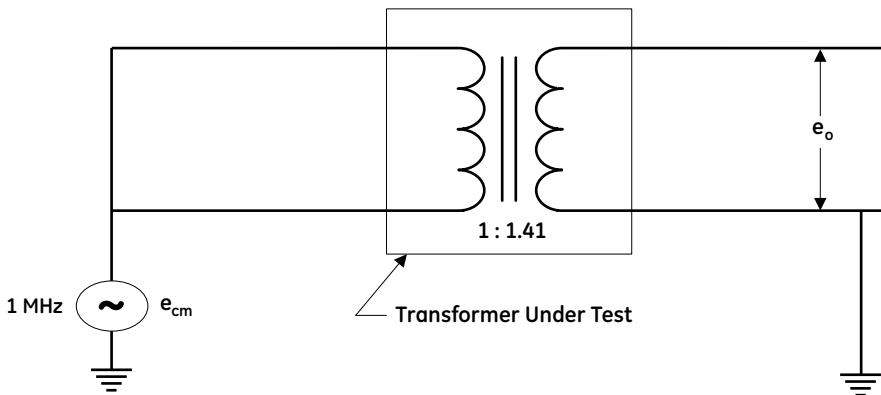


FIGURE 31 (HDBK): WAVEFORM TEST

4.5.1.5.1.2 FAULT ISOLATION

An isolation resistor shall be placed in series with each connection to the data bus cable. This resistor shall have a value of $0.75 Z_0$ ohms plus or minus 2.0 percent, where Z_0 is the selected cable nominal characteristic impedance. The impedance placed across the data bus cable shall be no less than $1.5 Z_0$ ohms for any failure of the coupling transformer, cable stub, or terminal transmitter/receiver.



Notes:

1. Common mode rejection (CMR) > 45 db

FIGURE 32 (HDBK): COMMON MODE TEST

4.5.1.5.1.3 CABLE COUPLING

All coupling transformers and isolation resistors, as specified in 4.5.1.5.1.1 and 4.5.1.5.1.2, shall have continuous shielding which will provide a minimum of 75 percent coverage. The isolation resistors and coupling transformers shall be placed at minimum possible distance from the junction of the stub to the main bus.

4.5.1.5.1.4 STUB VOLTAGE REQUIREMENTS

Every data bus shall be designed such that all stubs at point A of Figure 27 (STD) shall have a peak-to-peak amplitude, line-to-line within the range of 1.0 and 14.0 V for a transmission by any terminal on the data bus. This shall include the maximum reduction of data bus signal amplitude in the event that one of the terminals has a fault which causes it to reflect a fault impedance specified in 4.5.1.5.1.2 on the data bus. This shall also include the worse case output voltage of the terminals as specified in 4.5.2.1.1.1 and 4.5.2.2.1.1.

4.5.1.5.2 DIRECT COUPLED STUBS

The length of a direct coupled stub should not exceed 1 foot (305 mm). Refer to 10.5 for comments concerning direct coupled stubs. If a direct coupled stub is used, then the following shall apply.

See 4.5.1.5.2.1, 4.5.1.5.2.2, and 4.5.1.5.2.3.

4.5.1.5.2.1 FAULT ISOLATION

An isolation resistor shall be placed in series with each connection to the data bus cable. This resistor shall have a value of 55.0 ohms plus or minus 2.0 percent. The isolation resistors shall be placed within the RT as shown on Figure 28 (STD).

4.5.1.5.2.2 CABLE COUPLING

All bus-stub junctions shall have continuous shielding which will provide a minimum of 75 percent coverage.

4.5.1.5.2.3 STUB VOLTAGE REQUIREMENTS

Every data bus shall be designed such that all stubs at point A of Figure 28 (STD) shall have a peak-to-peak amplitude, line-to-line within the range of 1.4 and 20.0 V for a transmission by any terminal on the data bus. This shall include the maximum reduction of data bus signal amplitude in the event that one of the terminals has a fault which causes it to reflect a fault impedance of 110 ohms on the data bus. This shall also include the worst case output voltage of the terminals as specified in 4.5.2.1.1.1 and 4.5.2.2.1.1.

Figure 33 (HDBK) gives explanatory details on cable stubs and for a diagrammatic comparison of the two types of stub interface to the data bus.

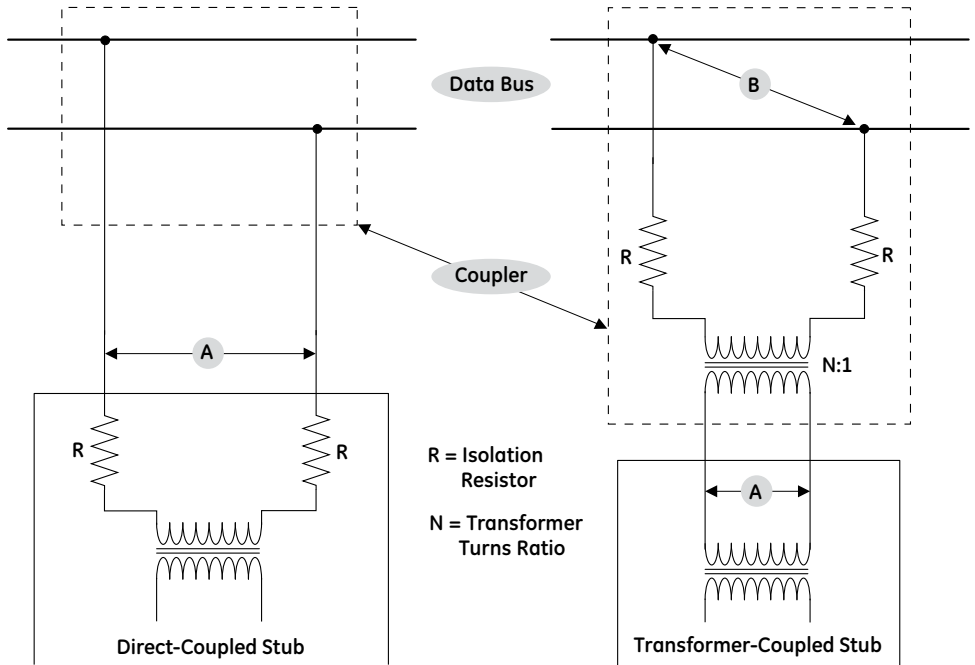


FIGURE 33 (HDBK): STUB INTERFACES TO THE DATA BUS

4.5.1.5.3 WIRING AND CABLING FOR EMC

For purposes of electromagnetic capability (EMC), the wiring and cabling provisions of MIL-E-6051 shall apply.

The image features a central dark blue sphere with a light blue yin-yang symbol. This sphere is surrounded by a complex, radial structure of light blue, curved blades or vanes, resembling the internal components of a turbine engine. The entire scene is set against a dark blue background.

terminal characteristics



TERMINAL CHARACTERISTICS

4.5.2. TERMINAL CHARACTERISTICS

4.5.2.1 TERMINALS WITH TRANSFORMER COUPLED STUBS

4.5.2.1.1 TERMINAL OUTPUT CHARACTERISTICS

The following characteristics shall be measured with R_L , as shown on Figure 34 (STD), equal to 70.0 ohms ± 2.0 percent.

4.5.2.1.1.1 OUTPUT LEVELS

The terminal output voltage levels shall be measured using the test configuration shown on Figure 34 (STD). The terminal output voltage shall be within the range of 18.0 to 27.0 V, peak-to-peak, line-to-line, when measured at point A on Figure 34 (STD).

The driving requirements for both direct and transformer coupled configurations are so arranged as to provide the same nominal bus voltage.

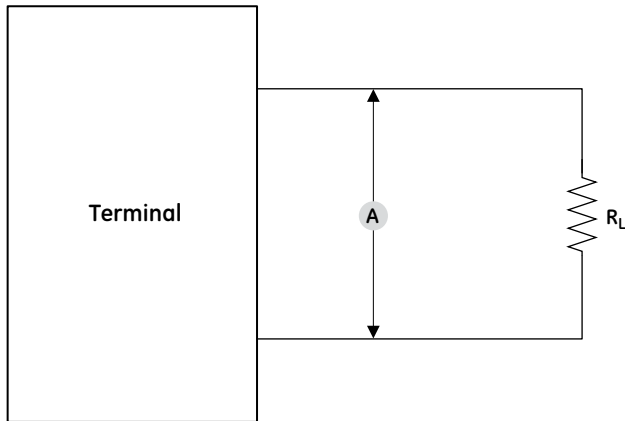


FIGURE 34 (STD): TERMINAL INPUT/OUTPUT CHARACTERISTICS FOR TRANSFORMER AND DIRECT COUPLED STUBS

4.5.2.1.1.2 OUTPUT WAVEFORM

The waveform, when measured at point A on Figure 34 (STD) shall have zero crossing deviations which are equal to, or less than, 25.0 ns from the ideal crossing point, measured with respect to the previous zero crossing (i.e., $0.5 \pm 0.025 \mu\text{s}$, $1.0 \pm 0.025 \mu\text{s}$, $1.5 \pm 0.025 \mu\text{s}$, and $2.0 \pm 0.025 \mu\text{s}$). The rise and fall time of this waveform shall be from 100.0 to 300.0 ns when measured from levels of 10 to 90 percent of full waveform peak-to-peak, line-to-line, voltage as shown on Figure 35 (STD). Any distortion of the waveform including overshoot and ringing shall not exceed ± 900.0 millivolts (mV) peak, line-to-line, as measured at point A, Figure 34 (STD).

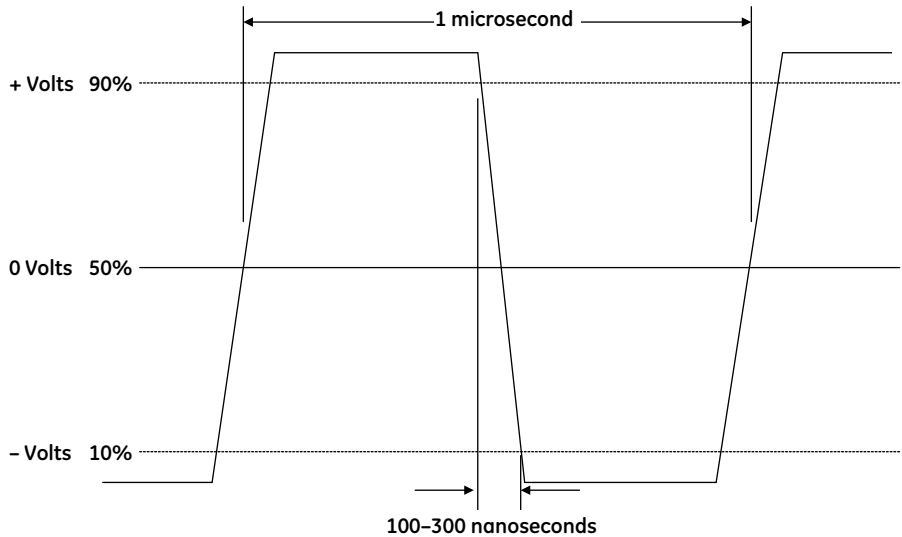


FIGURE 35 (STD): OUTPUT WAVEFORM

4.5.2.1.1.3 OUTPUT NOISE

Any noise transmitted when the terminal is receiving or has power removed, shall not exceed a value of 14.0 mV, RMS, line-to-line, as measured at point A, Figure 34 (STD).

Since peak noise is normally difficult to measure, it's usually specified as an RMS value. The output RMS noise for the transformer coupled and direct coupled cases are specified in 4.5.2.1.1.3 and 4.5.2.2.1.3 and are consistent with the required system performance and practical terminal hardware design. The requirement for low output noise of either 14 mV RMS, or 5 mV RMS when not transmitting, also places significant constraints on the length and routing of input/output wiring due to the induced power supply and logic noise generated in the terminal.

4.5.2.1.1.4 OUTPUT SYMMETRY

From the time beginning 2.5 μ s after the mid-bit crossing of the parity bit of the last word transmitted by a terminal, the maximum voltage at point A of Figure 34 (STD) shall be no greater than ± 250.0 mV peak, line-to-line. This shall be tested with the terminal transmitting the maximum number of words it is designed to transmit, up to 33. This test shall be run six times with each word in a contiguous block of words having the same bit pattern. The six word contents that shall be used are 800016, 7FFF16, 000016, FFFF16, 555516, and AAAA16. The output of the terminal shall be as specified in 4.5.2.1.1.1 and 4.5.2.1.1.2.

An ideal waveform is perfectly balanced so that signal energies on both sides of the zero (off) level are identical. If the positive and negative energy are not equal, problems can develop in the coupling transformers, and the transmission line can acquire a charge which appears as a tail with overshoot and ringing when a transmission terminates. These considerations require that the symmetry of the transmitted waveform be controlled as far as possible within practical limits. This is accomplished by specifying the signal level from a time beginning 2.5 μ s after the mid-bit zero crossing of the parity bit of the last word in a message transmitted by the terminal under test. The test messages contain the maximum number of words and defined bit patterns.

4.5.2.1.2 TERMINAL INPUT CHARACTERISTICS

The following characteristics shall be measured independently.

4.5.2.1.2.1 INPUT WAVEFORM COMPATIBILITY

The terminal shall be capable of receiving and operating with the incoming signals specified herein, and shall accept waveform varying from a square wave to a sine wave with a maximum zero crossing deviation from the ideal with respect to the previous zero crossing of ± 150 ns, (i.e., $2.0 \pm 0.15 \mu\text{s}$, $1.5 \pm 0.15 \mu\text{s}$, $1.0 \pm 0.15 \mu\text{s}$, $0.5 \pm 0.15 \mu\text{s}$). The terminal shall respond to an input signal whose peak-to-peak amplitude, line-to-line, is within the range of 0.86 to 14.0 V. The terminal shall not respond to an input signal whose peak-to-peak amplitude, line-to-line, is within the range of 0.0 to 0.20 V. The voltages are measured at point A on Figure 27 (STD).

4.5.2.1.2.2 COMMON MODE REJECTIONS

Any signals from direct current (DC) to 2.0 MHz, with amplitudes equal to or less than ± 10.0 V peak, line-to-ground, measured at point A on Figure 27 (STD), shall not degrade the performance of the receiver.

The response/no response threshold levels chosen for a particular system should be consistent with the noise environment for that system.

4.5.2.1.2.3 INPUT IMPEDANCE

The magnitude of the terminal input impedance, when the RT is not transmitting, or has power removed, shall be a minimum of 1000.0 ohms within the frequency range of 75.0 kHz to 1.0 MHz. This impedance is that measured line-to-line at point A on Figure 27 (STD).

As indicated in the data bus network requirement, input impedance is required to be maintained at a reasonable level to reduce the signal distortion effects when terminals are connected to the bus. Terminal input impedance is determined primarily by the:

1. Transformer Impedance - Maintains inductance required to support low frequency component of signal while controlling interwinding capacitance for high frequencies.
2. Terminal Wiring Capacitance - Controlling stray capacitance wiring from terminal connector to receiver.
3. Secondary Impedance Transformation - For the transformer coupled case, a transformer with a turns ratio of $1:\sqrt{2}$ is implied. The impedance at the secondary is reflected to the terminal input reduced by a factor of 2.

The factor of 2 difference in the impedance specified for the transformer coupled and direct coupled cases is based primarily on the effect of (3) above. The frequency range was set with its lower limit of 75 kHz to assure that adequate transformer volt-time product (inductance) is available to support the lower frequencies of the signal without approaching saturation.

4.5.2.1.2.4 NOISE REJECTION

The terminal shall exhibit a maximum word error rate of one part in 10⁷, on all words received by the terminal, after validation checks as specified in 4.4, when operating in the presence of additive white Gaussian noise distributed over a bandwidth of 1.0 kHz to 4.0 MHz at an RMS amplitude of 140 mV. 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 word error rate shall be measured with a 2.1 V peak-to-peak, line-to-line, input to the terminal as measured at point A on Figure 27 (STD). The noise tests 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, as specified in Table STD 2. All data words used in the tests 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.

The specified test conditions of signal and noise (measured at the half power points i.e., 3 dB) were selected to produce a value of word error rate (WER) which is sufficiently low (10⁻⁷) to permit performance verification of a terminal receiver within a reasonable test period. The number of detected errors is to be measured using a test configuration typical of that shown on Figure 36 (GE).

A diagrammatic representation of Table STD 2, showing the criteria for RT acceptance or rejection for the noise test appears in Figure 37 (GE). Note that this is a physical test to assess the quality of specific terminal hardware, not an indication of system performance.

The noise rejection is a figure of merit test and can be performed in a normal laboratory environment using the terminal's data bus connection. In this case, the number of no responses must be counted to give the number of detected error events. For the purpose of the test, the message error condition can be accepted as the number of word errors, since the probability of having 2 errors in any single message is extremely low.

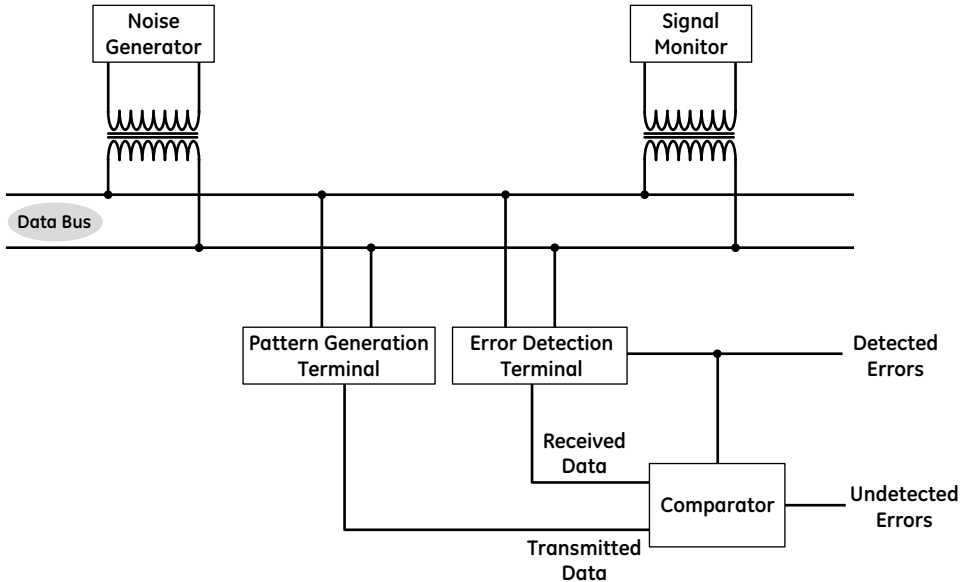


FIGURE 36 (GE): TYPICAL NOISE REJECTION TEST SETUP

4.5.2.2 TERMINALS WITH DIRECT COUPLED STUBS

4.5.2.2.1 TERMINAL OUTPUT CHARACTERISTICS

The following characteristics shall be measured with R_L , as shown on Figure 34 (STD), equal to 35.0 ohms \pm 2.0 percent.

4.5.2.2.1.1 OUTPUT LEVELS

The terminal output voltage levels shall be measured using the test configuration shown on Figure 34 (STD). The terminal output voltage shall be within the range of 6.0 to 9.0 V, peak-to-peak, line-to-line, when measured at point A on Figure 34 (STD).

4.5.2.2.1.2 OUTPUT WAVEFORM

The waveform, when measured at point A on Figure 34 (STD), shall have zero crossing deviations which are equal to, or less than, 25.0 ns from the ideal crossing point, measured with respect to the previous zero crossing (i.e., $0.5 \pm 0.025 \mu\text{s}$, $1.0 \pm 0.025 \mu\text{s}$, $1.5 \pm 0.025 \mu\text{s}$ and $2.0 \pm 0.025 \mu\text{s}$). The rise and fall time of this waveform shall be from 100.0 to 300.0 ns when measured from levels of 10 to 90 percent of full waveform peak-to-peak, line-to-line, voltage as shown on Figure 35 (STD). Any distortion of the waveform including overshoot and ringing shall not exceed ± 300.0 mV peak, line-to-line, as measured at point A on Figure 34 (STD).

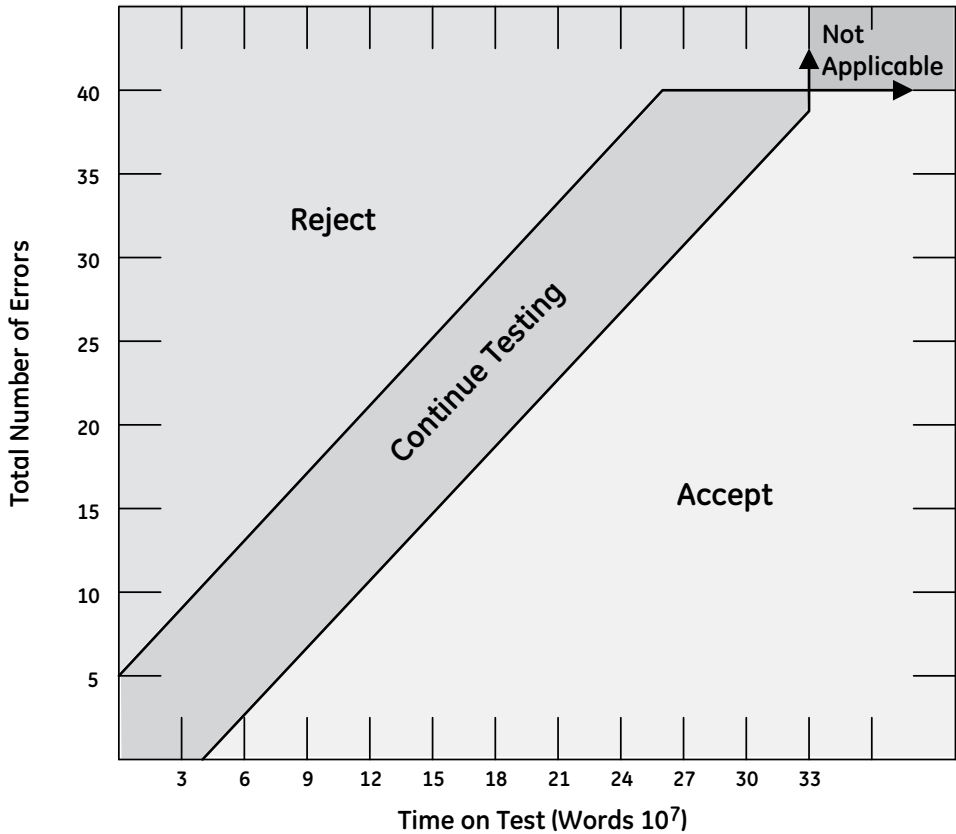


FIGURE 37 (GE): TEST CHART SHOWING CRITERIA FOR ACCEPTANCE OR REJECTION OF A REMOTE TERMINAL FOR THE NOISE TEST

4.5.2.2.1.3 OUTPUT NOISE

Any noise transmitted when the terminal is receiving or has power removed, shall not exceed a value of 5.0 mV, RMS, line-to-line, as measured at point A on Figure 34 (STD).

See 4.5.2.1.1.3 for explanatory detail.

4.5.2.2.1.4 OUTPUT SYMMETRY

From the time beginning 2.5 μ s after the mid-bit crossing of the parity bit of the last word transmitted by a terminal, the maximum voltage at point A on Figure 34 (STD), shall be no greater than ± 90.0 mV peak, line-to-line. This shall be tested with the terminal transmitting the maximum number of words it is designed to transmit, up to 33. This test shall be run six times with each word in a contiguous block of words having the same bit pattern. The six word contents that shall be used are 800016, 7FFF16, 000016, FFFF16, 555516, and AAAA16. The output of the terminal shall be as specified in 4.5.2.2.1.1 and 4.5.2.2.1.2.

See clause 4.5.2.1.1.4 for explanatory detail.

4.5.2.2.2 TERMINAL INPUT CHARACTERISTICS

The following characteristics shall be measured independently.

4.5.2.2.2.1 INPUT WAVEFORM COMPATIBILITY

The terminal shall be capable of receiving and operating with the incoming signals specified herein, and shall accept waveform varying from a square wave to a sine wave with a maximum zero crossing deviation from the ideal with respect to the previous zero crossing of plus or minus 150 ns, (i.e., $2.0 \pm 0.15 \mu\text{s}$, $1.5 \pm 0.15 \mu\text{s}$, $1.0 \pm 0.15 \mu\text{s}$, $0.5 \pm 0.15 \mu\text{s}$). The terminal shall respond to an input signal whose peak-to-peak amplitude, line-to-line, is within the range of 1.2 to 20.0 V. The terminal shall not respond to an input signal whose peak-to-peak amplitude, line-to-line, is within the range of 0.0 to 0.28 V. The voltages are measured at point A on Figure 28 (STD).

4.5.2.2.2.2 COMMON MODE REJECTIONS

Any signals from DC to 2.0 MHz, with amplitudes equal to or less than ± 10.0 V peak, line-to-ground, measured at point A on Figure 28 (STD), shall not degrade the performance of the receiver.

See 4.5.2.1.2.2 for explanatory detail.

4.5.2.2.2.3 INPUT IMPEDANCE

The magnitude of the terminal input impedance, when the RT is not transmitting, or has power removed, shall be a minimum of 2000.0 ohms within the frequency range of 75.0 kHz to 1.0 MHz. This impedance is that measured line-to-line at point A on Figure 28 (STD).

4.5.2.2.4 NOISE REJECTION

The terminal shall exhibit a maximum word error rate of one part in 10⁷, on all words received by the terminal, after validation checks as specified in 4.4, when operating in the presence of additive white Gaussian noise distributed over a bandwidth of 1.0 kHz to 4.0 MHz at an RMS amplitude of 200 mV. 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 word error rate shall be measured with a 3.0 V peak-to-peak, line-to-line, input to the terminal as measured at point A on Figure 28 (STD). The noise tests 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, as specified in Table STD 2. All data words used in the tests 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.

See 4.5.2.1.2.4 for explanatory detail.

TABLE STD 2: CRITERIA FOR ACCEPTANCE OR REJECTION OF
A TERMINAL FOR THE NOISE REJECTION TEST

TOTAL NUMBER OF WORDS RECEIVED $\times 10^7$

No. of Errors	Reject (equal or less)	Accept (equal or more)	No. of Errors	Reject (equal or less)	Accept (equal or more)
0	N/A	4.40	21	12.61	21.43
1	N/A	5.21	22	13.42	22.24
2	N/A	6.02	23	14.23	23.05
3	N/A	6.63	24	15.04	23.86
4	N/A	7.64	25	15.85	24.67
5	N/A	8.45	26	16.66	25.48
6	0.45	9.27	27	17.47	26.29
7	1.26	10.08	28	18.29	27.11
8	2.07	10.89	29	19.10	27.92
9	2.88	11.70	30	19.90	28.73
10	3.69	12.51	31	20.72	29.54
11	4.50	13.32	32	21.53	30.35
12	5.31	14.13	33	22.34	31.16
13	6.12	14.94	34	23.15	31.97
14	6.93	15.75	35	23.96	32.78
15	7.74	16.56	36	24.77	33.00
16	8.55	17.37	37	25.58	33.00
17	9.37	18.19	38	26.39	33.00
18	10.18	19.00	39	27.21	33.00
19	10.99	19.81	40	28.02	33.00
20	11.80	20.62	41	33.00	N/A



redundant data bus
requirements



4.6 REDUNDANT DATA BUS REQUIREMENTS

If redundant data buses are used, the requirements as specified in the following shall apply to those data buses.

See 4.6.1, 4.6.2, and 4.6.3.

4.6.1 ELECTRICAL ISOLATION

All terminals shall have a minimum of 45 dB isolation between data buses. Isolation here means the ratio in dB between the output voltage on the active data bus and the output voltage on the inactive data bus. This shall be measured using the test configuration specified in 4.5.2.1.1 or 4.5.2.2.1 for each data bus. Each data bus shall be alternately activated with all measurements being taken at point A on Figure 34 (STD) for each data bus.

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.

Both physical and electrical considerations should be taken into account.

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 SUPERSEDING VALID COMMANDS

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.

This clause allows the controller to interrupt activity to or from a remote terminal by sending a valid command to the same remote terminal on a redundant bus. In this case, it does not have to meet the minimum no response timeout requirement specified in 4.3.3.9 in relation to superseding valid commands on the same bus (see 4.4.3.2).



appendixes



APPENDIXES

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 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. Figure Append 10.1 (STD) and Figure Append 10.2 (STD) 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 the 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 timeout, 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 a general purpose 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.

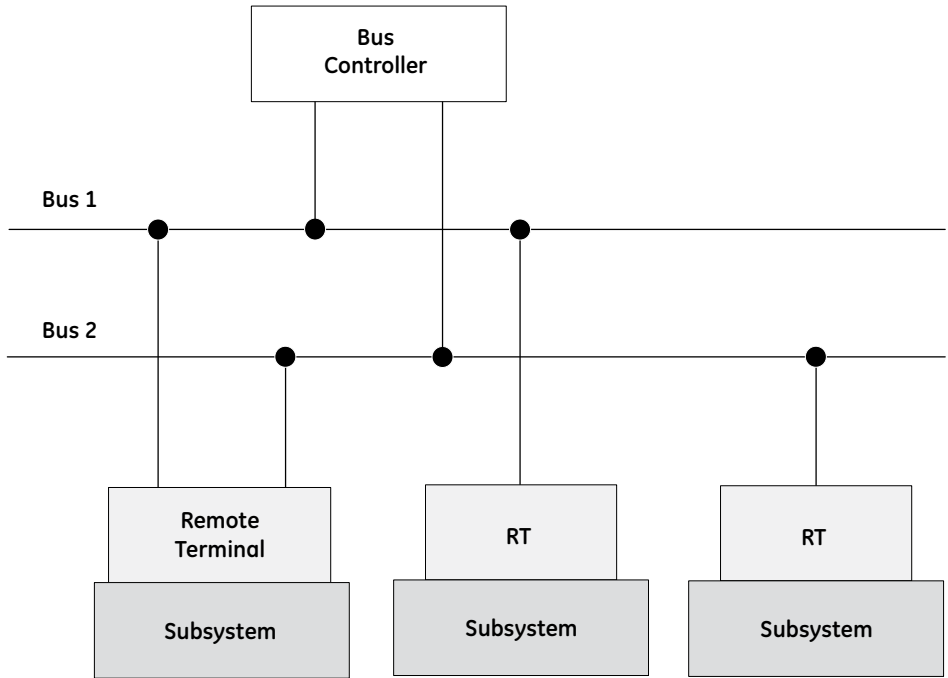


FIGURE APPEND 10.1 (STD): ILLUSTRATION OF POSSIBLE REDUNDANCY

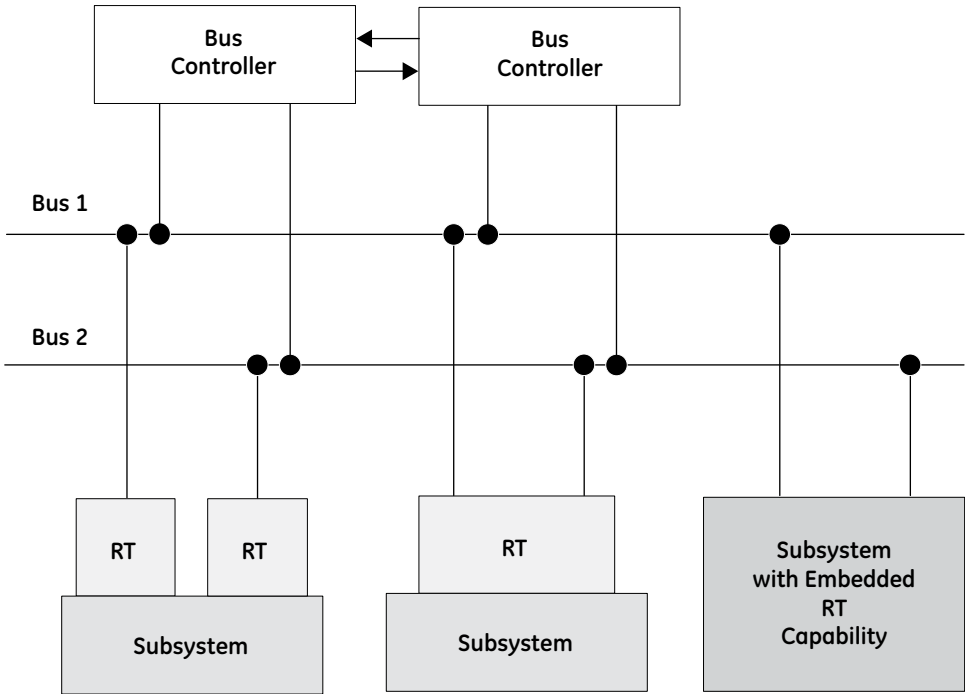


FIGURE APPEND 10.2 (STD): ILLUSTRATION OF POSSIBLE REDUNDANCY

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 3 kHz 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 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 empirical evidence indicates that an undetected bit error rate of 10⁻¹² can be expected from a practical multiplex system built to this standard. 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 provide appropriate error detection and correction encoding/decoding and employ 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 STUBBING

Stubbing is a method wherein a separate line is connected between the primary data bus line and a terminal. The direct connection of a stub line causes a mismatch which appears on the waveforms. This mismatch can be reduced by filtering at the receiver and by using bi-phase modulation. Stubs are often employed not only as a convenience in bus layout but as a means of coupling a unit to the line in such a manner that a fault on the stub or terminal will not greatly affect the transmission line operation. In this case, a network is employed in the stub line to provide isolation from the fault.

These networks are also used for stubs that are of such length that the mismatch and reflection degrades bus operation. The preferred method of stubbing is to use transformer coupled stubs, as defined in 4.5.1.5.1. This method provides the benefits of DC isolation, increased common mode protection, a doubling of effective stub impedance, and fault isolation for the entire stub and terminal. Direct coupled stubs, as defined in 4.5.1.5.2 of this standard, should be avoided if at all possible. Direct coupled stubs provide no DC isolation or common mode rejection for the terminal external to its subsystem. Further, any shorting fault between the subsystems internal isolation resistors (usually on a circuit board) and the main bus junction will cause failure of that entire bus.

It can be expected that when the direct coupled stub length exceeds 1.6 feet, that it will begin to distort the main bus waveforms. Note that this length includes the cable runs internal to a given subsystem.

10.6 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 option. If system designers 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.

10.7 OTHER RELATED DOCUMENTS

Several documents exist which are related to this standard. MIL-HDBK-1553 describes implementation practices for this standard and other related data. This standard is embodied in or referenced by the following international documents: NATO STANAG 3838, ASCC Air Standard 50/2, and UK DEF STAN 00-18 (PART 2)/Issue 1.

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 parentheses are to paragraphs in this standard which are affected.

30.2 APPLICATION

Section 30 of this appendix shall apply to all dual standby 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 Figure 27 (STD) and Figure 28 (STD).

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 Figure 27 (STD) and Figure 28 (STD).

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 (4.3.3.5.3.3) - 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 has the capability for self test, then this bit shall be required.*
- *Dynamic bus control acceptance bit (4.3.3.5.3.10) - 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)

The only broadcast commands allowed to be transmitted on the data bus by the bus controller shall be the broadcast mode commands identified in Table STD 1. The broadcast option may be implemented in remote terminals. However, if 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 still reserved for broadcast and shall not be used for any other purpose.

30.7 DATA WRAP-AROUND (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 wrap-around receive subaddress followed by a valid transmit command to the data wrap-around transmit subaddress, with the same word count and without any intervening valid commands to that RT, shall cause the RT to respond with each data word having the same bit pattern as the corresponding received data word. A data wrap-around receive and transmit subaddress of 30 (11110) is desired.

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 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 an RT to RT transfer (receive) to the same subaddress. 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 4.3.3.6, 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 first expected data word at point A as shown on Figure 27 (STD) and Figure 28 (STD). 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.

30.10 ELECTRICAL CHARACTERISTICS (4.5)

30.10.1 CABLE SHIELDING (4.5.1.1)

The cable shield shall provide a minimum of 90.0 percent coverage.

30.10.2 SHIELDING (4.5.1)

All cable to connector junctions, cable terminations, and bus-stub junctions shall have continuous 360 degree shielding which shall provide a minimum of 75.0 percent coverage.

30.10.3 CONNECTOR POLARITY

For applications that use concentric connectors or inserts for each bus, the center pin of the connector or insert shall be used for the high (positive) Manchester bi-phase signal. The inner ring shall be used for the low (negative) Manchester bi-phase signal.

30.10.4 CHARACTERISTIC IMPEDANCE (4.5.1.2)

The actual (not nominal) characteristic impedance of the data bus cable shall be within the range of 70.0 ohms to 85.0 ohms at a sinusoidal frequency of 1.0 megahertz.

30.10.5 STUB COUPLING (4.5.1.5)

For Navy applications, each terminal shall have both transformer and direct coupled stub connections externally available. For Navy systems using these terminals, either transformer or direct coupled connections may be used. For Army and Air Force applications, each terminal shall have transformer coupled stub connections, but may also have direct coupled stub connections. For Army and Air Force systems, only transformer coupled stub connections shall be used. Unused terminal connections shall have a minimum of 75 percent shielding coverage.

30.10.6 POWER ON/OFF NOISE

A terminal shall limit any spurious output during a power-up or power-down sequence. The maximum allowable output noise amplitude shall be ± 250 mV peak, line-to-line for transformer coupled stubs and ± 90 mV peak, line-to-line for direct coupled stubs, measured at point A of Figure 34 (STD).





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