GUIDE TO STANAG 4153

ALLIED
NAVAL
ENGINEERING
PUBLICATION

ANEP 35
Edition 1

NOVEMBER 1993

NATO INDUSTRIAL ADVISORY GROUP

NIAG SUB-GROUP 45

IMPROVED TECHNIQUES

AND

TECHNOLOGIES FOR SHIPS

ANEP-35
Edition 1

NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULGATION

May 1994

1. ANEP-35(Edition 1) Guide to STANAG 4153 is a NATO UNCLASSIFIED publication.

2. ANEP-35(Edition 1) is effective NATO-wide upon receipt.

3. ANEP-35(Edition 1) contains only factual information. Changes to this publication are not subject to ratification procedure and will be promulgated as necessary by AC/141(IEG/5).

G.B. FERRARI, ITAF
Major General
Chairman MAS

RECORD OF CHANGES

CHANGE DATE	DATE ENTERED	EFFECTIVE DATE	BY WHOM ENTERED
1	10.10.05		A Wilson

FOREWORD

1. This Allied Naval Engineering Publication Number 35 was been prepared by NIAG SG/45 and endorsed by AC/141(IEG/5) on Tactical Contro and Data Handling for use in the intra-ship design process.

2. It should be noted that this document is not an agreed standard, but it is circulated for information and to provide guidance to thos involved in Combat System design.

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GUIDE TO STANAG 4153

1. OBJECTIVE OF THIS APPLICATION DOCUMENT

The objective of this document is to provide an overview of the interface standard and its fibre optic extension and a more detailed explanation of the protocol than that contained in the STANAG. Rationale for the Edition 2 revisions are also included along with a description of the conformance tests and conformance test procedures specified in the STANAG.

2. HISTORICAL

STANAG 4153 was initially developed as a point-to-point serial interface to replace the parallel interface of STANAG 4146. One of the desirable requirements was for functional compatibility between between STANAGS 4153 and 4146 so that older equipments meeting STANAG 4146 could be easily adapted to STANAG 4153. Concurrently with the development of STANAG 4153, combat system designers recognized the need for distribution networks (such as a data bus) that would interconnect a large number of users, including computers, displays and sensors. Thus, the interface also found useage as a connection to a distribution network and the necessary network addressing protocols were described in application documents or the manufacturer's specifications for the equiipment.

STANAG 4153 has found extensive use in the combat data systems for the Canadian and U.S. Navies. In the Canadian Patrol Frigrate it is used as both a point-to-point interface and as a connection to the Integrated Processor and Display System (SHINPADS) network. The U.S. Navy uses the interface both as a point-to-point interface in combat systems as and as a network connection to the Shipboard Data Multiplex System (SDMS).

The U.S. Navy implementation added features to the STANAG that improved its throughput and system integrity. The NFR 90 program in its consideration for selection of STANAG 4153 as the combat system serial interface recommended that these enhancements be added to the STANAG. In addition, in 1989, the U.S. Navy requested that, as part of this revision, the input impedance and reflection requirements be clarified as they had experienced some problems in implementing the interface due to high reflection voltages on the line. Accordingly, in 1990 NIAG Sub-Group 6 was tasked to revise STANAG 4153 and also its Fibre Optic Extension and reissue the STANAG and its Fibre-Optic Extension as STANAG 4153 (Edition 2).

This ANEP is an up-date of ANEP 1 including the consolidation of ANEP 9 "Fibre-Optic Interface Parameters", ANEP 12 "Throughput Improvement Features" and ANEP 13 "System Integrity Features".

3. APPLICABLE DOCUMENTS

A. PARAMAX Systems Document for Shipboard Integrated Processor and Display System (SHINPADS)

"Prime Item Product Function Specification for Serial Data Bus System [SHINPADS] AN/UYC-501 [V]"

B. U.S. Navy Specification

"Data Multiplex System DMS - 500.3
Prime Item Product Specification for the AN/USQ-82 (CV)"

4. STANAG 4153 AS A POINT-TO-POINT INTERFACE

4.1 Cabling

The transfer system interconnect diagram is shown in Figure 1. The transfer system uses two channels in which a channel uses one cable for transferring information words from Unit A to B and a second cable for transferring information words from B to A. Each channel sends information frames in one direction but tranfers control frames associated with the exchange protocol in both directions. The unit which sends information frames is known as the Source and the unit which receives them as the Sink. Most units are interconnected by two channels for two-way flow of information. Some simple peripherals may only require a single channel for one-way transfer of information.

4.2 Information Words

The information is sent over the channel from Source to Sink in the form of binary bits grouped as two types of 32 bit words defined as Data or Command/Interrupt words. Words are typically stored in buffers prior to transfer as shown in the interface architecture diagram of Figure 2.

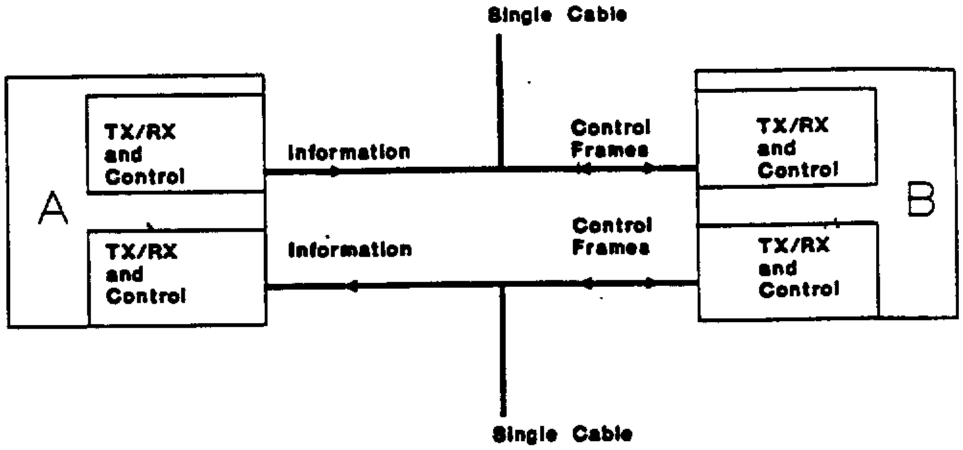
Data Word: A Data Word is used to transfer data from Source to Sink.

Command/Interrupt Word: A Command/Interrupt Word is used to transfer commands or status from Source to Sink and is always sent as a single word information frame.

4.3 Control Frames

Control frames are used to control the transfer of information words over the channel. There are two types of control frames: The Source Status Control Frame (SOS) originating at the Source, and the Sink Status Control Frame (SIS) originating at the Sink.

The Source Status Control Frame (SOS) advises on the



Note that A or B is either a Source or Sink depending upon which cable is being considered.

Figure 1 Interconnection Between Units

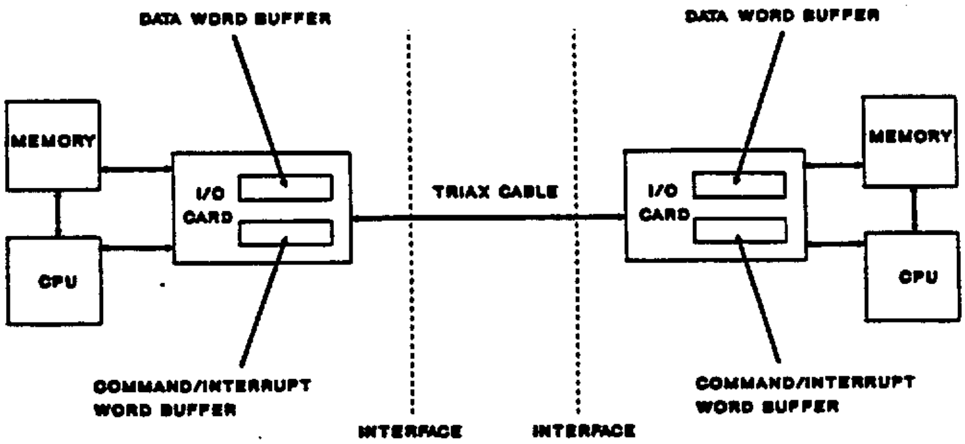


Figure 2 Typical Interface Architecture

availability of an Information Word at the Source for transmission to the Sink. The Sink Status Control Frame (SIS) advises on the acceptability of an Information Word by the Sink.

4.4. Protocol

Information transfer is achieved through a "handshake mechanism" in which Control Frames are continually exchanged between the Source and Sink prior to the transfer of Information Frames. The Control Frames convey the status at the Source and Sink interfaces relative to the availability of Information Words awaiting transfer at the Source and the readiness of the Sink to accept them. STANAG 4153 provided for the transfer of Information Frames in two modes of single word transfer, in which each word was acknowledged by the Sink prior to the transfer of the next word. Edition 2 added a third mode in which a block of words is transferred as a single burst and the block of words (burst) is then acknowledged by the Sink.

The three modes of transfer in which information is transferred in single or in multiple word groups are defined as follows:

> Single Word Transfer (SWT) Transfer of a single word Information Frame (IF) through an exchange of control frames for each IF.
>
> Single Word Block Transfer (SWBT) Transfer of a block of single words through an exchange of control frames at the initiation of each block followed by single word transfers acknowledged by the Sink until the block is completed.
>
> Burst Transfer (BT) A multi-data word transfer in a single frame through an exchange of control frames for each Information Frame.

Single Word or Single Word Block Transfer is determined by the ability of the Source to generate and transfer the words at the rate the Sink is able to accept them or the ability of the Sink to accept the words at the rate the Source is able to transfer them. SWT is used when either the Source or Sink require time to internally transfer Information Words prior to sending or receiving the next Information Word. The BT transfer mode is used when the channel is designated a Burst Transfer channel, in which case the Sink is equipped to receive multi-word frames at the rate the Source is able to transmit them.

4.3.1 Handshake Mechanism

The Control Frames are 4 bits in length and the status of each bit is defined in the STANAG. The 4th bit was undefined in STANAG 4153 but was defined in Edition 2 to identify the Control Frame as a Source or Sink Frame. The Handshake Mechanism is the process by which Information Words are exchanged and can be described through a series of examples illustrating the three tranfer modes as follows: (Refer to simplified Flow Diagram in Figure 3)

A. Single Word Transfers (Slow Response Sink Interfaces)

This is the mode which automatically occurs when the time to transfer words from the Sink Interface Buffer to Memory is slower than the transit time for the Sink to send the SIS reply and receive back the next Information Frame from the Source. The Sink in executing the handshake will continue to send "Not Ready" SIS Frames until it is ready to receive an Information Receive.

Source Has No Information Words To Send

Upon initiation the Source sends a Source Status Frame (SOS) indicating it has nothing to send. The Sink will reply with a Sink Status Frame (SIS) indicating its state of readiness to receive Information Frames as follows:

State	SIS Encoding
Not ready	1001
Ready to Accept Data Word	1101
Ready to Accept Command/Interrupt Word	1011
Ready to Accept Either Type Word	1111

If the reply is "not ready" the Source will continue to send SOS Frames until it receives a SIS Frame indicating the Sink is ready for receipt of Information Frames. The Source will then send the Information Frame and the Sink will acknowledge receipt of the Information Frame by replying with a "Not Ready" SIS. This completes the single word exchange and the cycle will repeat by the Source sending a SOS frame. Note, that although it is typical for the Source to send the Information Frame upon receipt of a SIS indicating the Sink is ready to receive it, the Source is not commited to send the Information Frame. Instead, it may abort the sequence and send a SOS advising the Sink of an alternative status. The Source may find that its internal priority system causes it to select some other action between the instant of transmission of the SOS and the time of receipt of the SIS. In this operation mode, all of the transfers are single word transfers and always initiated by the Source sending a SOS frame indicating SOS status. After receipt of an Information Frame, the Sink always responds with a "Not Ready" to insure that the Input Interface Buffer is clear and ready to receive another Information Frame. This mode is used primarily to accommodate slow peripherals as most computer interfaces employ techniques or are of sufficient speed to transfer words out of the Sink Interface Buffer to Memory before receipt of the next frame. Typically, the Sink Interface design will

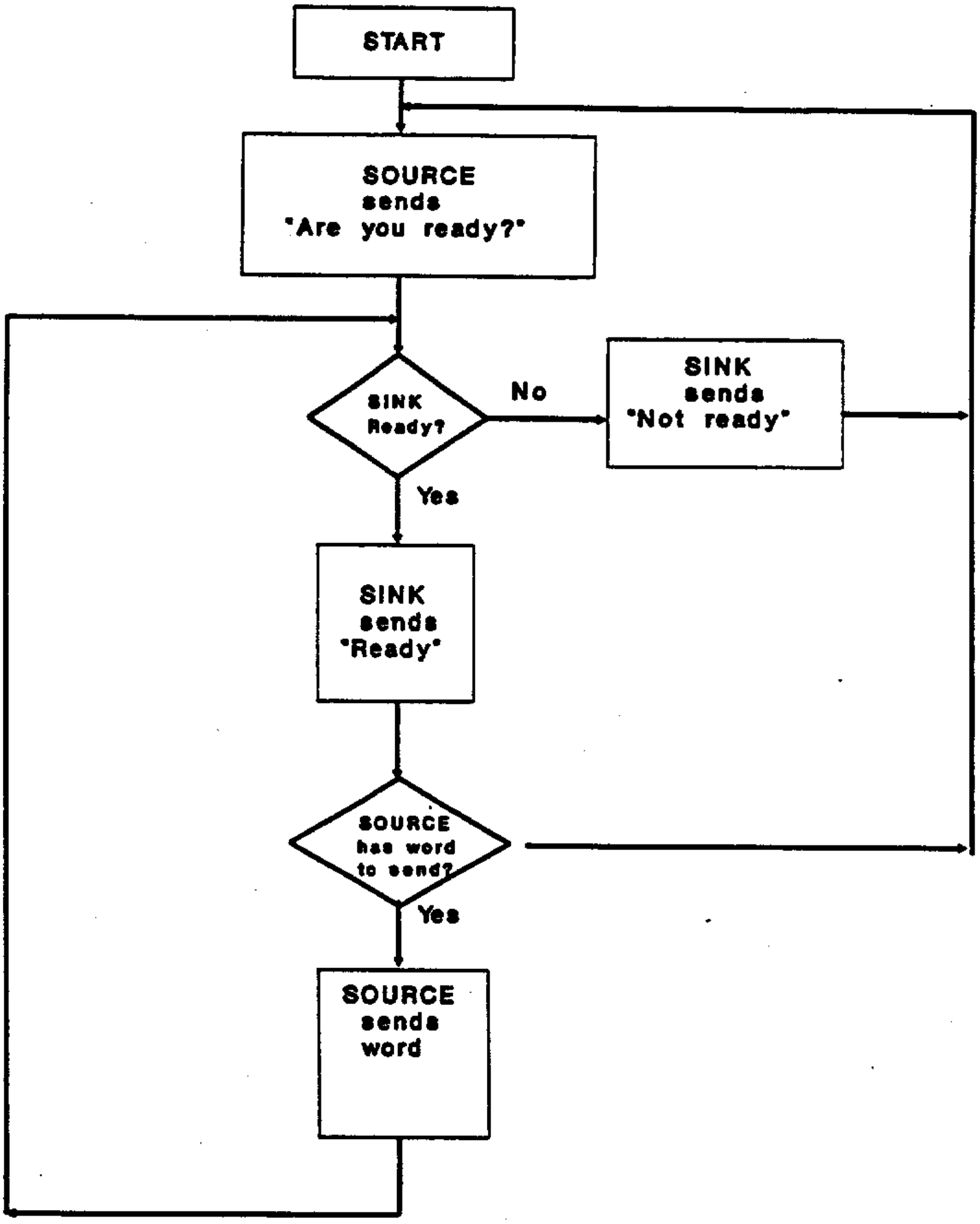


Figure 3 Simplified Flow Diagram

provide for delaying the SIS response until it is able to accept another Information Frame. In these cases it will not respond with a "Not Ready" unless there is a parity error or it knows through prior knowledge that it has received the last word of a message.

A typical transfer in this mode is as follows:

Source to Sink: "Are you ready to accept an information word?"

Sink to Source: "Ready"

Source to Sink: (Sends word #1)

Sink to Source: "Not Ready"

Source to Sink: "Are you ready to accept an information word?"

Sink to Source: "Ready"

Source to Sink: (Sends word #2)

Sink to Source: "Not Ready"

Source to Sink: "Are you ready to accept an information word?"

Sink to Source: "Ready"

etc......

In this protocol, the response of the Sink to the Source Status Control Frame (SOS) is an acknowledgement that the Sink has received the Control Frame. Note that the Sink is a slave to the Source and will not respond until requested by the Source. The rate of information transfer, however, is controlled by the Sink because it will not send a "Ready" response until the it can accept a word transfer. If the Source has no information words to send, the Source and Sink are continually exchanging control frames wherein the Source sends a SOS indicating it has no information words to send and the Sink responds with a SIS indicating it is ready, and the cycle repeats. This process is referred to as "Ping-ponging" and is an indication of the activity status of both the Source and the Sink and the continuity of the line interconnecting them.

The Source is required to respond to a SIS within a one millisecond interval. If it is unable to send the intended Information Frame within one millisecond, then it is required to repeat the SOS. It should be noted that in the case when the SOS is repeated that the subsequent SIS which is received may differ from the previous one to which the Source was preparing to respond. In this case, the SOS would continue to be repeated until the proper "Ready" SIS was received.

B. Single Word Block Transfers (Fast Response Interfaces)

This is the most commonly used mode where the circuitry controlling the transfer of words between the Interface Buffers and Memory is of sufficient speed to insure that the process is complete before the next Information Frame is received or sent. The implication is that the Sink is always ready for receipt of an Information Frame and will not reply with a "Not Ready" SIS, unless there is a failure within the Interface Buffer transfer. Further, in this mode of operation, the exchange is speeded up by the Sink continually advising the Source of its status so that SOS frames requesting status can be minimized and upon the availability of a word at the Source interface the Information Frame can be sent immediately without the Source polling the Sink for status.

A typical transfer in this mode is as follows:

Source to Sink: "Are you ready to accept an information word?"

Sink to Source: "Ready"

Source to Sink: (Sends word #1)

Sink to Source: "Ready"

Source to Sink: (Sends word #2)

Sink to Source: "Ready"

etc......

In this mode, the question "Are you ready to accept a (further) information word?" is considered to be implicit in any Information Frame sent. Moreover, since the Sink is continually responding with its status, the Source is aware of the Sink status and does not have to go through the "Are you ready to accept an information word/"Ready" cycle. This mode essentially eliminates two cyles of the Single Word Transfer Mode with a significant improvement in throughput.

A comparison of the throughput of the Single Word and Burst Transfer modes is shown in Figure 4. Also included for reference is the throughput of the parallel interfaces of STANAG 4146 (Types A, B, and C). Throughput is defined as the number of data words that are transmitted over the channel per unit of time. It is expressed in kilowords/second and is based on a 32 bit word length. Thoughput includes all time delays caused by handshaking and other overhead functions.

The graph ranks STANAG 4146 channels in order of their maximum thoughput rates. This graph shows the dependency of of maximum channel throughput as a function of cable length. The hash mark serves as a reminder that the curve is the maximum rate achieveable and that implementations of actual equipment may be below these values.

The curves for STANAG 4153 interface versus cable length shows that the Burst Transfer mode provides the highest throughput and is the least dependent on cable length. Also, increasing the number of words transmitted in a block or burst improves the throughput as the overhead associated with each word is reduced. This is illustrated in Tables 1 and 2 for the Single Word Block Transfer and Burst Transfer modes, repectively, where the maximum throughput that can be achieved is a function of the size of the block and cable length.

C. Burst Word Transfers (Requires Multi-Word Interface Buffers)

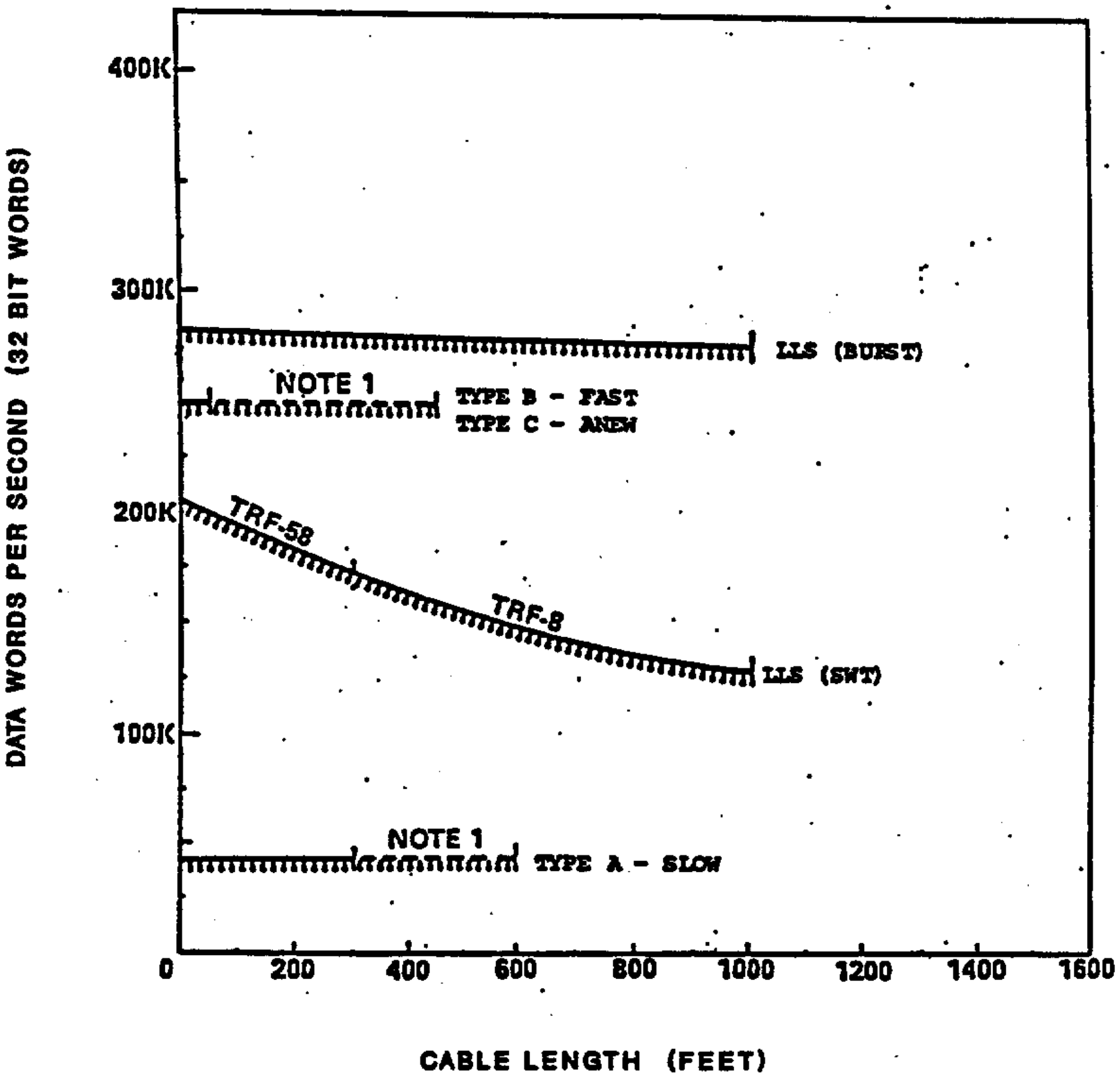
Burst Transmission mode provides for transfer of multiple Data Words within an Information Frame. The exchange of Control Frames is identical to that for single word transfers. The end of the frame is detected by the cessation of data bits being received. Some implementations may advise the Sink of the number of words in the frame or provide an indication that the end of the frame is approaching. The transfer is applicable to transfer of Data Words only; Command/Interrupt Words must be transferred as single words. In addition, the words within the frame must be contiguious with no gaps between words.

At the Source, as in the other modes, the Frame is configured to start the transmission with the Synchronization Bit followed by the Word Identifier Bit and the first Data Word. Subsequent Data Words would be appended to the first Data

Word Block Size*	Throughput (Kilo-words/second) 0 Cable Length	300 m Cable Length
5 words	204.90	122.02
10	206.61	122.93
25	207.64	126.74
50	207.99	127.35

* 32 Bit Word

Table 1 Throughput as Function of Cable Length and Word Block Size for SWBT Mode



Note 1. Maximum length is unspecified

Figure 4 Comparison of Channel Throughput as Function of Transfer Modes

Word Block Size*	Throughput (Kilo-words/second) 0 Cable Length	 300 m Cable Length
32 words	306.50	293.52
64	307.10	296.11
96	307.30	296.98

* 32 Bit Word Length

Table 2 Throughput as Function of Cable Length and Word Block Size for Burst Transfer Mode

Word until the frame is complete. The protocol for this mode of transmission is identical to that of Single Word Block Transfer.

D. Forced Command

Forced Command is a variation of the protocol which was used in STANAG 4146 (parallel interface) installations and carried over to STANAG 4153 to enable STANAG 4153 to replace the earlier STANAG 4146. Specifically, Forced Command is used only in system configurations where a peripheral (such as a magnetic tape unit) is shared by two computers. In this configuration, the peripheral is under control of one of the computers and the 2nd computer cannot gain access to the peripheral until the control is released by the 1st computer. Normally, the protocol is identical to that of a dedicated Source/Sink channel and a Forced Command is not issued. However, if the computer which had control of the peripheral should fail, the 2nd computer could not gain control of the peripheral. The use of the Forced Command enables the 2nd computer to gain control of the peripheral as follows:

A Source which has a Forced Command function has the capability of sending a CIW word in the Information Frame even if the previous SIS had indicated it was "not ready for CIW". In addition to the Source being able to issue a Forced Command, the Sink must be configured to accept the Forced Command. This command would then transfer control of the peripheral (SINK) to the computer (Source) issuing the command. Normally, the 2nd computer would not issue a Forced Command unless it had been determined that the 1st computer had failed. The use of Forced Command is application dependent in which monitoring of the system status is part of the implementation.

Note that the use of Forced Command, although a violation of a portion of the Source/Sink protocol does not negate all of the System Integrity Features as it applies only to the issue of a CIW word. The system would still register a protocol error if the Source sent a Data Word in response to a SOS frame indicating the Sink was "Not ready for data".

4.3.2 Timing Requirements

Timing between frames is specified in Table 3.

4.4 System Integrity Features

4.4.1 General

The system integrity features provide for error detection, failure notification and provisions for reconfiguration.

4.4.2 Transmission System Loss/Errors in Transmission

Parity, word length, protocol errors and time-outs are specified to determine loss of the transmission system or errors in transmission. These include errors due to the following:

Excessive Line Noise - Causes extraneous bits which are detected by parity error or invalid word length.

High Reflection Voltages - Causes parity errors or invalid word lengths.

Broken Cable - Detected by loss of Control Frame exchange (Ping-ponging) or error in 4th bit designation.

Protocol Errors - Detected by activation of time-outs.

Three types of communication loss detected by the system integrity features are as folows:

A. No SIS Response from Sink

Source sends SOS Control Frame indicating it has Command/Interrupt or Data Word Frame to send but receives no response from the Sink indicating failure at the Sink interface or broken cable.

B. SIS "Not Ready" Response From Sink

This response would indicate failure at the Sink Interface or terminal as it is unable to receive Information Frames.

C. No SOS From Source

The Source is required to transmit a Control Frame or Information

Table 3 Timing Intervals

Parameter	Period	Value
Sink response to SOS or Information Frame	From trailing edge of SOS or IF to leading edge of SIS	500 ns min 150 us max
Source response to SIS	From trailing edge of SIS to leading of SOS or IF	500 ns min 1 ms max*
Reinitiation (Transmission of SOS frames in the absence of SIS responses)	End of SOS frame to beginning of next SOS frame	300 us +/- 100 us
Source Time Out at Initialization	Set at 200 us after transmission of a SOS indicating Source has a either a CIW or Data Word to send. Reset upon receipt of a SIS or after completion of error notification.	Application dependent
Sink Time Out for SOS start mode	From the end of transmission of a SIS indicating the Sink is ready to receive a CIW or Data Word until the receipt of a SOS or Information Frame. Reset upon receipt of a SOS or Information Frame within the 1.5 ms period.	1.5 ms
Sink Time Out for SIS start mode	At Power, on from the beginning of the time the Sink is ready to receive a CIW or Data Word until the receipt of a SOS or Information Frame. Subsequently, from the end of transmission of a SIS indicating the Sink is ready to receive a CIW or Data Word until the receipt of a SOS or Information Frame. For both cases, reset upon receipt of a SOS or Information Frame within the 1.5 ms period or after completion of error notification.	1.5 ms

Frame within 1 milli-second after receiving a SIS indicating the Sink is able to accept an Information Frame. Activiation of the SOS time-out would indicate a failure at the Source Interface.

4.4.3 Cable Reflection Errors

A broken or damaged cable will cause high reflection voltages which will cause parity or protocol errors. In Edition 1 of the STANAG, a broken cable may cause SOS Control Frames to be misinterpretted as valid responses from the Sink. For example, a SOS indicating that both Command/Interrupt or Data Words are available for transmission would be reflected back as a SIS indicating the Sink could accept C/I or Data Words. This has been corrected in the 2nd Edition by specifying that the 4th Bit of the Control Frame designates the the origin of the Control Frame (Source or Sink). Thus, a reflected SOS or SIS would be recognized by an invalid coding of the 4th bit of the Control Frame.

4.4.4 Forced Command Errors

A Forced Command implementation permits the Source to send a Command/Interupt Word regardless of the status of the Sink. However, this applies only to Information Frames which contain C/I words within the Frame. If a Data Word Information Frame was transmitted as a forced transmission, this would be an error in the protocol and recognized as a failure within the Source interface.

4.5 System Integrity Features Implementation

4.5.1 Channel Status Registers

Monitoring of the channel status shall be through the use of registers indicating the status of each interface. Bits shall be set in these registers when errors occur. The action to be taken when errors occur and the procedure for clearing the registers is at the option of the systems designer. A minimum set of registers is defined and described in subsequent paragraphs for the folowing:

a. Sink Parity Error
b. Source Time-Out Error
c. Sink Time-Out Error
d. Sink Word Length Error
e. Sink Illegal Condition

4.5.2 Sink Parity Error

Parity is implemented on Information Frames only by appending the parity bit as the last bit of the Frame. This is bit 35 for Single Word Transfers and bit 33 for Word 2 through N on Burst Transfer. The Frame Formats are illustrated in Figure 5. Note that parity is not used on SOS or SIS Frames. If a parity error occurs, a parity error bit shall be set in the channel register.

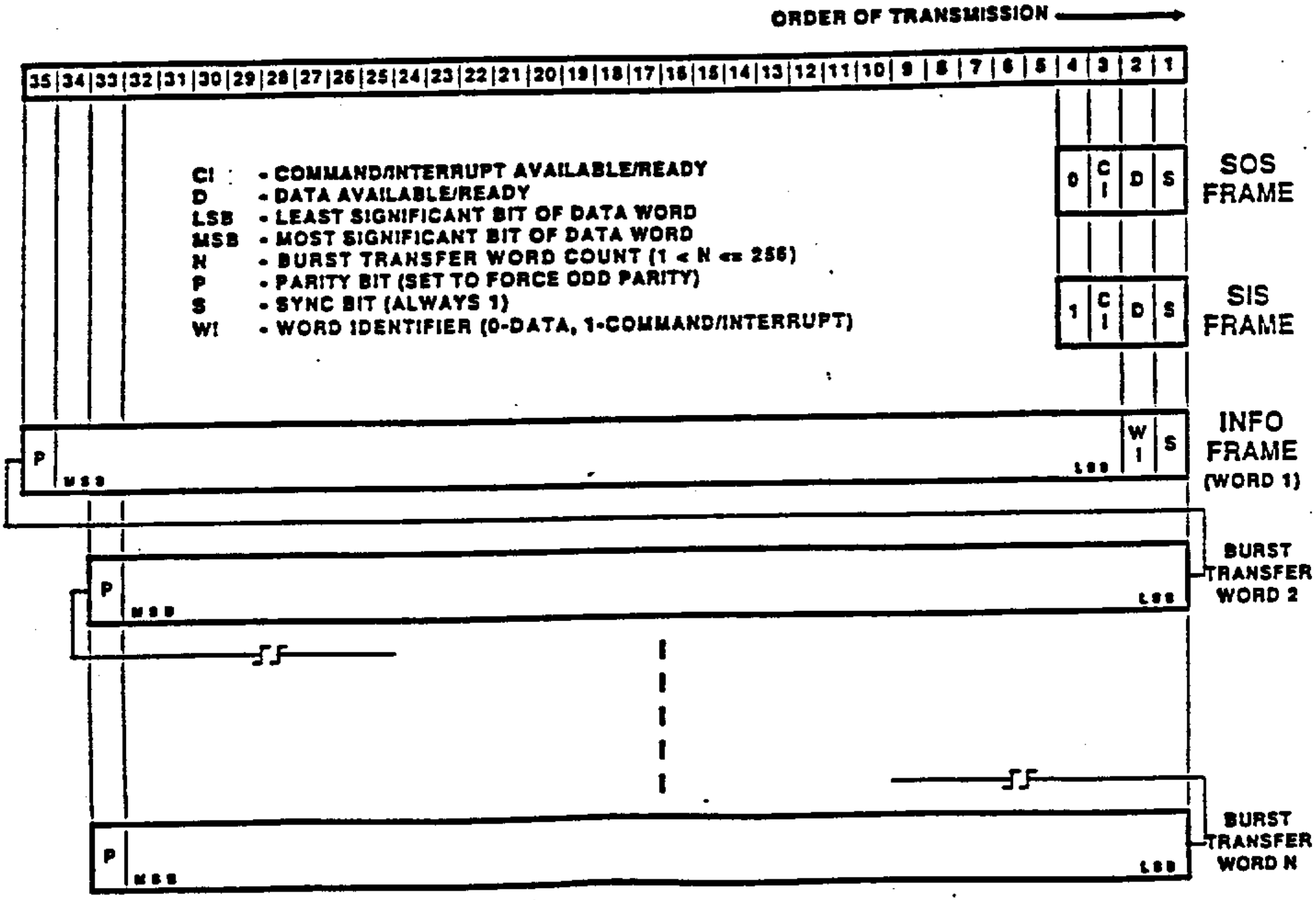


Figure 5 Frame Formats

4.5.2 Channel Time-out

Protocol errors are detected by the activation of timers indicating failures in the protocol occuring at the Source or Sink interface. The following error indications are based on Source Initiated Transfers which are most common in use.

A. Source Time-out

In a Source Initiated Transfer in which the Source has sent a SOS to the Sink indicating it has an Information Frame to send, the Source shall start a timer after it has transmitted the 2nd SOS to the Sink requesting Sink Status. If it does not receive the SIS response within 200 usec, it shall set an error bit in the channel status register. In addition, the timer may also be started upon receipt of a SIS indicating the Sink will not accept either C/I or Data Word Frames. In either case, the error indication is a notification of a failure at the Sink interface. The timer shall be reset if an Information Frame is sent before reaching the timeout value. Separate timers may be used for C/I and Data Word Frames.

B. Sink Time-out

In Source Initiated Transfer, the Sink shall await the receipt of a SOS or Information Frame prior to responding with a SIS. If the SIS is ready to receive an Information Frames, it shall start a 1.5 msec timer upon transmitting a SIS. If neither a SOS nor Information Frame is recieved within the 1.5 msec interval it shall set an error bit in the channel status register. If a SOS or Information Frame is received within the 1.5 msec interval, the timer shall be reset.

C. Sink Word Length Errors

The Sink shall monitor the length of Information Frames for compliance with the correct number of bits in accordance with the Frame Format of Figure 5. Receipt of more or less than the correct number of bits shall cause an error bit to be set in the channel status register.

D. Sink Illegal Condition

If Forced Command is not used, the Sink shall monitor the receipt of Information Frames from the Source. If the Source sends an Information Frame after having received a SIS indicating that the Sink is not ready for receipt of an Information Frame, then this is indication of a failure at the Source interface and the Sink shall set an error bit in the channel status register.

4.6 Source or Sink Initiated Transfer Options

The protocol permits the handshake to be initiated by either the Source or the Sink. In a Source Initiated Transfer, the Source starts the transfer by advising the Sink of its status and the Sink does not response until it receives a request from the Source. In a Sink Initated Transfer, the Sink starts the transfer by advising the Source of its Status, and the Source responds with the appropriate response. The selection option may be application independent, and in some cases may favor one over the other or totally preclude one option. For example, some networks may require a Source Intiated Transfer in order for the User to gain access to the Network.

4.7 System Implementation Agreements

Implementation of the interface between two users requires agreement on a number of the controllable characteristics of the interface as follows:

a. Source or Sink Initated
b. Use of Burst Mode
c. Implementation of System Integrity Features (Including action to be taken when Time-out errors occur)
d. Use of 4th Bit of Control Frame (For interoperability of the Edition 2 User Interface with Edition 1 of the STANAG, the System Integrity Features and use of the 4th bit shall be disabled in the Edition 2 user interface.)
e. Maximum Length of a Burst Transmission Frame
f. Use of Forced Command

5. Connection to Data Networks

5.1 Application Documents

The following manufacturer's specifications describe the use of STANAG 4153 for accessing distribution networks which are in service:

a. Interfacing to the SHINPADs Serial Data Bus Using the Standard Interface Described in STANAG 4153

b. STANAG 4153 Interfaces to the Shipboard Multiplex System (SDMS)

5.2 General Requirements

An addressing function is required in order for STANAG 4153 to be used as an interface to a distribution network such as a data bus or a switch. There are generally two modes of operation for transferring data on a distribution network which pertain to the addressing function as follows:

a. Point-to-point mode

An addressing mode, which causes a specific destination node and no other node to accept a message and pass it on to its user.

b. Broadcast mode

An addressing mode which causes a message transmitted on the network to be accepted by one or more destination nodes and passed on to their users.

The address is usually contained within the first command frame sent from the user to the network node. Since most networks share the media amongst the users, buffering of the message at the network node is normally required since the channel and/or time slot may be busy. Thus, the system must be able to hold the word or message that it is desired to send in a buffer until such time as there is a free channel on the network. Ideally, this should be done at the user device to permit up-dating of the data up to the moment that the channel becomes available. Some networks may also require buffering at the network access node. Where such buffering exists, its impact on data staleness and throughput should be recognized by the system designer.

6.0 Rationale for STANAG 4153 Edition Revisions

6. 1 General

The Edition 2 revisions consist primarily of incorporating the enhancements to the interface as described in ANEPs 12 & 13 (Throughput Improvement and System Integrity Features, respectively) and revisions to reduce the susceptibility of the interface to voltage reflections and other noise. ANEP 12 increased throughput by adding a multi-word transfer protocol. ANEP 13 added system integrity features which included parity, timeouts and protocol error detection and reporting. The principal changes to the electrical parameters of the interface are summarized as follows:

a. Specifying reflected voltage in absolute terms and defining a conformance test.
b. Reducing the envelope extremes of the transmitted waveform. (Maximum and minimum voltage, minimum rise/fall time).
c. Increasing the minimum receiver threshold sensitivity from 130 to 150 mV.
d. Narrowing the tolerance on the receiver blanking period from 300 ns to 500 ns to 350 ns to 500 ns.
d. Broadening the input impedance characteristic and defining the impedance in terms of a return loss characteristic over a 1 MHz to 100 MHz range.
e. Adding a composite channel noise requirement.

This section provides rationale for the proposed changes and description of the conformance test requirements. Paragraph reference is to STANAG 4153 (Edition 2) in which the specification paragraphs are repeated for ease of reference.

1.6 Information Frames

There are two types of Information Frames (IF):

Single Word Information Frame (SWIF): Consists of a Synchronization bit, a Word-Identifier bit (WI) and one Information Word. The WI distinguishes a Data Word from a Command/Interrupt Word (CIW).

Multi-Word Information Frame (MWIF): Consists of a Synchronization bit, a WI bit and multiple Data Words. The WI always indicates Data Words (i.e. no CIW can be present in this type frame.

Rationale:

A Multi-Word Information Frame has been added as defined in ANEP 12 and provides for both Single Word Block Transfers in which each word is acknowledged upon receipt by the Sink and for Burst Transfers in which the entire frame containing the block of words is acknowledged upon receipt by the Sink. The multi-word capability increases the throughput of the system.

3.1 Interconnection between Units

3.1.1 Information is transferred in single or in multiple word groups in which the transfer is controlled by an exchange of groups of pulses known as control frames. There are three modes of information transfer as follows:

Single Word Transfer (SWT) One SWIF at a time transfer through an exchange of control frames for each IF.

Single Word Block Transfer (SWBT) One SWIF at a time transfer of a block of SWIF words through an exchange of control frames at the initiation of each block followed by SWIF word transfers acknowledged by the Sink until the block is completed.

Burst Transfer (BT) A multi-data word transfer in a single MWIF through an exchange of control frames for each Information Frame.

Rationale:

The SWBT and BT modes have been added to enhance the throughput as described in ANEP 12.

3.1.2 Single Word or Single Word Block Transfer is determined by the ability of the Source to generate and transfer the words at the rate the Sink is able to accept them or the ability of the Sink to accept the words at the rate the Source is able to transfer them. SWT is used when either the Source or Sink require time to internally transfer Information Words prior to sending or receiving the next Information Word. The BT transfer mode is used when the channel is designated a Burst Transfer channel, in which case the Sink is equipped to receive MWIFs at the rate the Source is able to transmit them. Both the SWBT and BT modes improve the system throughput over Edition 1 of STANAG 4153 as described in ANEP 12.

Rationale:

Addition of the SWBT and BT modes increases throughput and improves the applicability of the interface to systems requiring the transfer of large blocks of data.

3.3 Control Frames Length and Format

Control Frames are 4 bits in length. The coding of the SIS is determined solely by the condition of the Sink to accept Information Words. The coding of the SOS is determined solely by the availability of Information Words for transmission. The code in the SIS Control Frame is used by the Source to decide whether a word may be sent and which type word. The SOS Control Frame is used at the Sink to trigger the next SIS Frame. Decoding of the 4th bit of the SOS and SIS Control Frames serves to identify the control frame as a valid SOS or SIS and provides a monitoring and diagnostic feature as to the status of the channel.

Rationale:

Using the 4th bit to identify the control frame serves as a means of identifying a cable failure, as a damaged or open cable will reflect a SOS or SIS Control Frame in which the frame will be recognized as invalid because the 4th bit is in error. This had been a problem in the original STANAG as an open cable could reflect a SOS which could be erroneously interpreted as a valid SIS response.

3.3.3 Status of 4th Bit

Implementation of the diagnostic features through monitoring of the 4th bit to verify SIS and SOS Control Frames shall be programmable or enabled through a strapping option on the I/O card so that backward compatibility with equipment complying with Edition 1 of STANAG 4153 is maintained.

Rationale:

It was a tasking requirement that inter-operability of the revised STANAG with its predecessor be maintained.

3.4 Information Frame Length and Format

3.4.1 The standard word length not including parity is 32 bits.

The parity bit follows the 32nd bit of the word.

3.4.2 An Information Frame (IF) shall consist of N+2 contiguous bits where N is 33 bits for SWIFs and a multiple of 33 bits for MWIFs.

Rationale:

The parity bit was added as part of the diagnostic features described in ANEP 13.

3.4.4. The length of an Information Frame is 1 word for SWIFs and shall not exceed 256 words for MWIFs plus a parity bit for each word and the Synchronization bit and Word Identifier bit at the beginning of the frame. Simple peripherals that operate on an 8 bit word length or equipments with less than 32 bit words may use the 32 bit word length in which up to 24 of the bits may not be used. The frame format for both Control and Information Frames is shown in Figure 2.

Rationale:

The maximum frame length was increased to 256 words to increase the throughput for large block transfers.

3.4.5 The end of a frame is determined by a signal envelope detector. Thus, in the BT mode, the Sink recognizes the end of a frame by the loss of signal and it is not necessary to establish the length of a BT frame as a precondition for its transfer.

Rationale:

This facilitates the BT mode of operation.

3.6.1 Timing Requirements at the Source

Table 1. Source Frame Transmission Rules

(Revised to show encoding of the 4th bit of Control Frames)

Rationale:

See response to paragraph 3.3.3.

3.7 System Integrity Features (SIFs)

(Contained in paragraphs 3.7.1 through 3.7.4.6 and are adapted from ANEP 13.)

Rationale:

These features improve the diagnostic capability of the interface.

4. ELECTRICAL REQUIREMENTS

In general, in order to maintain backwards compatibility with Edition 1 of the STANAG, the principal changes to the electrical requirements reflect a reduction in the parameter tolerances from those of Edition 1. The changes reduce the susceptibility of the interface to voltage reflections and other noise. Conformance test requirements and procedures have been included to insure compliance in critical areas.

4.2 Interface Circuits

There shall be one transmitter-receiver circuit at the terminal end of each cable. The output-input circuits shall not be damaged by open or short circuits (line-to-line), or short circuits to voltage sources of zero to 50 volts peak, line to ground.

Rationale:

This revision eliminated the first sentence which implied terminating resistors were a requirement. The standard need only specify performance, not give design guidance.

4.2.1 Output Circuit Characteristics

Measurement of output circuit voltage, waveform distortion, output noise, etc., shall be made differentially, line-to-line, at the equipment input/output connector when the output is terminated at the input/output connector with an impedance of 50 +/- 5 ohms. Conformance testing is required at the 45 and 55 ohm extremes.

Rationale:

Since the Sink input impedance may vary over this range, this requirement was broadened to insure that the output circuit provides the specified drive over the entire range.

4.2.1.4 Transmitter Output Noise

Transmitter output noise when not transmitting but power is on, shall be no greater than 30 mV peak-to-peak.

Rationale:

This parameter is reduced from 35 to 30 mV and is based on worst case tests on current cards. Specifically, in a dual channel card implementation, the possibility of cross coupling noise from the Source Transmitter to the adjacent Sink Receiver exists. In end-around testing, the Sink receiver is receiving data from the Source transmitter on the card so the probability of interference is the greatest. It is also present in applications where both the Input and Output channel pair are active at the same time.

4.2.2.1 Input Circuit Compatibility

The input circuit shall be compatible with the incoming signals as specified in Figure 7.

Rationale:

The electrical parameters of the STANAG as shown in the attached Figures 6 & 7 have been revised to reduce the tolerances of the transmitted waveform which correspondingly limits the tolerances on the input waveform to the receiver. Since the revised waveforms are within the limits of Edition 1, compatibility with systems built to Edition 1 of the STANAG is maintained. The changes to the waveform parameters are as follows:

Figure 6. Waveform Tolerances

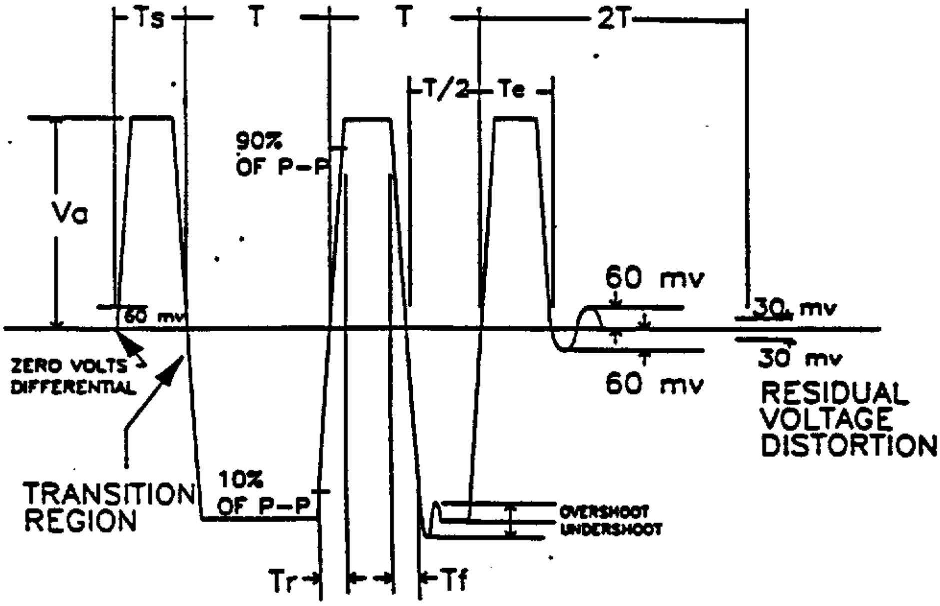
a. The minimum rise/fall time rate on the transmitted signal has been decreased from .3 V/nsec to .18 V/nsec. On a maximum amplitude waveform this increases the minimum rise time from 5 nsec to 7 nsec.
b. Minimum received signal rise/fall time has been increased to 7 nsec to correspond with the reduced minimum rise/falltime of the transmitted waveform.
c. Ts "45 to 65 ns" was changed to "45 to 60 ns"
d. Te "30 to 80 ns" was changed to "30 to 70 ns"

Figure 7. Transmitted Waveform Envelope

a. The maximum voltage envelope has been reduced from +/- 800 mV to 750 mV.
b. The minimum leading edge of the transmitted signal has been increased from +\- 450 to 500 mV.
c. The minimum rise/fall time rate has been decreased from .3 V/nsec to .18 V/nsec.

Rationale:

Constraining/reducing the envelope of the transmitted waveform, particularly the minimum rise and fall time and maximum voltage, limits the high frequency components of the transmitted waveform and significantly reduces the reflected voltage from the receive input connector/circuitry. Reducing the maximum voltage and the minimum rise/fall time increases the tolerance of the interface to reflected voltages. Reduction of the Ts and Te requirements is consistent with the reduction in the tolerances



TRANSMITTED SIGNAL

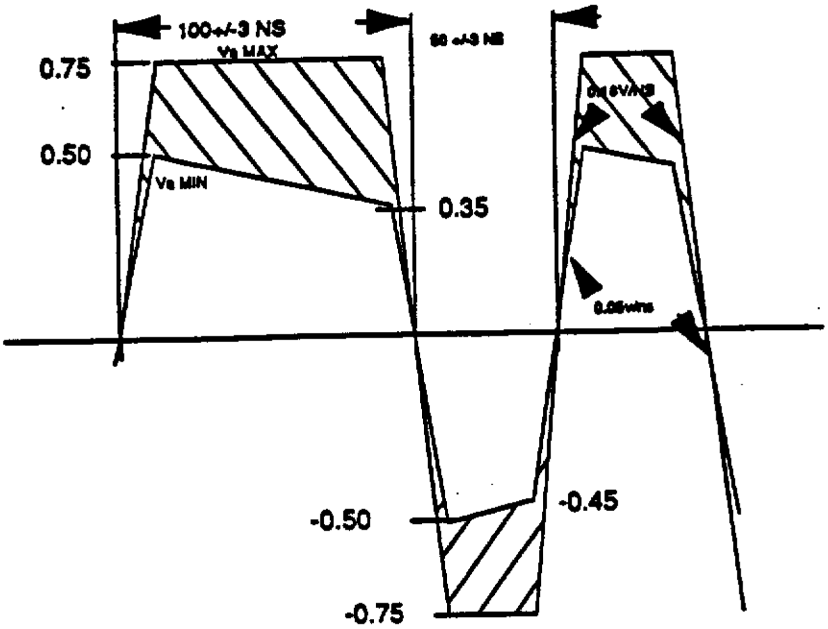
Va	0.6 V nominal
Ts	45 to 60 ns
T	100 +/- 3 ns
T/2	50 +/- 3 ns
Te	47 to 65 ns
Tr	.05 to .18 V/ns
Tf	.05 to .18 V/ns
Ts	width of the 1st positive half bit
Te	width of the last half-bit (positive or negative)

RECEIVED SIGNAL

Va	0.220 V minimum for 5 ns minimum
Ts	30 to 70 ns
T	90 to 130 ns
T/2	30 to 60 ns
Te	30 to 100 ns
Tr	7 ns min (10 to 90%)
Tf	7 ns min (90 to 10%)
Tr	35 ns max (-200 to 200 mV)
Tf	35 ns max (-200 to 200 mV)

Note: The 30 ns receiver minimum pulse width (Ts, T/2 & Te) need not occur concurrently with maximum rise and fall times of 35 ns

Figure 6 Revised Waveform Tolerances (Figure 7 of 4153)



Includes Overshoot/Undershoot. Timing Not Applicable To First Pulse And Last Pulse.

Figure 7 Revised Transmitted Waveform Envelope (Figure 8 of 4153)

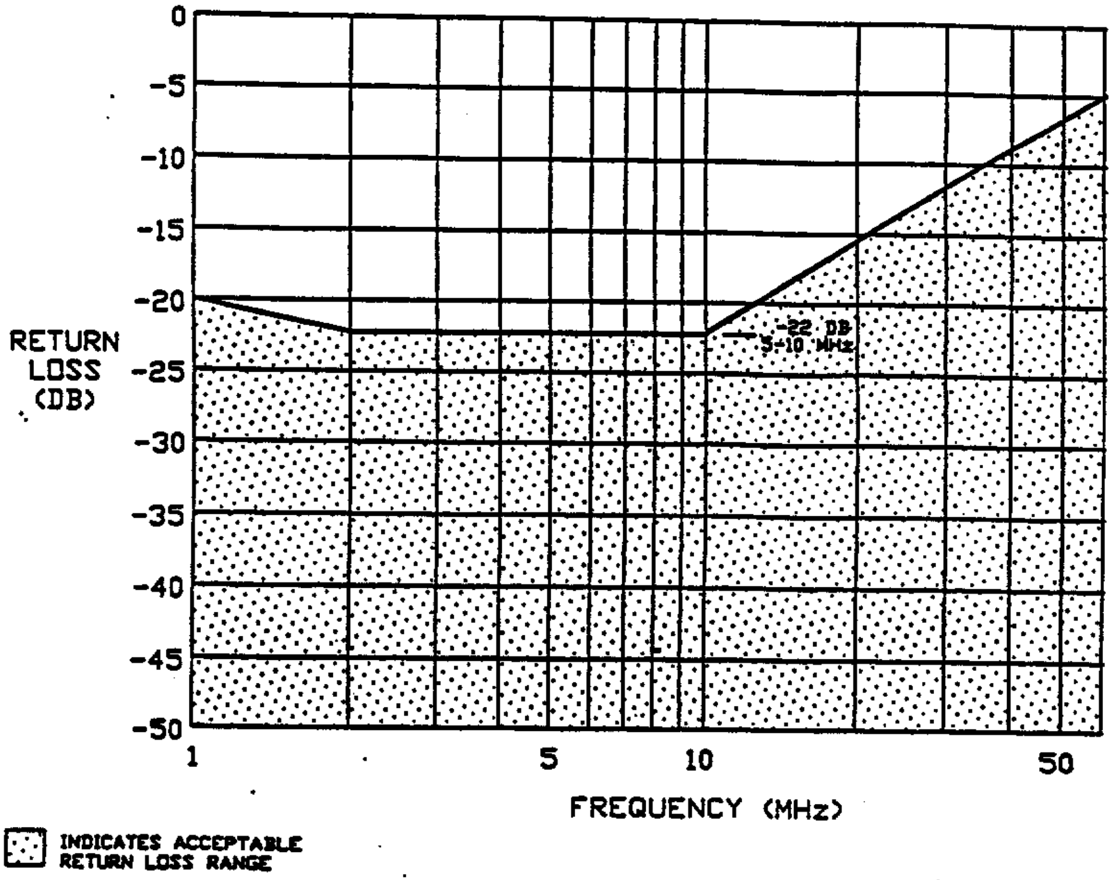


Figure 8 Input Impedance Return Loss Characteristic

on the transmitted waveform envelope. The higher minimum voltage requirement on the leading edge of the transmitted signal from +\- 450 to 500 mV provides an increase in the received signal margins for operation at maximum cable lengths.

4.2.2.2 Receiver Input Sensitivity

The receiver shall respond to an input signal amplitude from plus or minus 0.900 volts peak, down to plus or minus 0.220 volts peak. The receiver shall not respond to input signals of 0.000 volts to plus or minus 0.155 volts peak, or to input signals having a VT product equal to or less than 10 exponent (-9) volt-seconds.

Rationale:

The maximum receive voltage has been increased from .88 volts to .90 volts in order to insure that the receiver can decode signals in the presence of the maximum allowable reflected voltage and noise. Specifically, the .90 volts value is based on the maximum transmitted voltage of .75 volts plus a .15 volt margin for the presence of residual noise and reflected voltages which could be additive to the transmitted voltage.

The receiver minimum threshold sensitivity level has been increased from 130 mV to 155 mV to increase the tolerance to reflected voltage and noise. This still leaves a range of 65 mV for setting the receiver threshhold which is considered an acceptable range for manufacturing tolerances.

4.2.2.3 Receiver Pulse Width

The input circuit shall provide for correct decoding of the received signal pulse widths specified in Figure 7.

Rationale:

The revision increases the minimum rise and fall times from 5 to 7 ns corresponding to the reduction in the minimum rise and fall time of the transmitted waveform. This is a relaxation in the receive bandwidth requirements which improves the immunity of the interface to high frequency interference/noise.

4.2.2.4 Input Circuit Impedance

With the transmitter not transmitting and with D.C. power on or off, the magnitude of the complex input impedance Z (R +/- JX), with respect to the load it presents to the far end transmitter, shall be such that the return loss characteristic does not exceed the levels specified in Figure 9 as measured over a 1 MHz to 60 MHz range.

Rationale:

This is a more precise definition of impedance as it extends the range of measurement up to 60 MHz which includes harmonics of the fundamental frequencies of the transmitted waveform. The return loss limits of Figure 8 are consistent with the specified reflection value.

4.2.2.5 Reflections

The input impedance to the voltage waveform of Figure 7, shall be such that with the use of the specified cable, the reflected voltage from an incident waveform with a peak amplitude of +/- .75 volts and rise time equal to or less than 7 nanoseconds (10 to 90%) shall not shall not be greater than 250 mV peak to peak amplitude as observed at the source interface after the 300 ns receiver disabling period. Conformance to this requirement is met by the following test:

With the transmitter not transmitting and with D.C. power on or off, a 4 bit input Manchester II waveform (conforming to a 1101 bit pattern) at 10 MHz and repetition rate of 100 KHz, with a peak amplitude of +/- .75 volt and rise/fall times equal to or less than 7 ns (10 to 90%) shall be applied to the interface connector through a 36 meter length of Mil-C-17/135 (TRF 8) 50 ohm cable. The amplitude of the reflected voltage, measured 200 ns after the zero voltage crossing in the middle of the last bit, shall not exceed 250 mV peak-to-peak amplitude. (See Figure 10)

Rationale:

The reflected voltage requirement has been revised to specify it as a maximum allowable voltage based on the maximum value of the transmitted waveform rather than a percentage of the incident voltage. The specified maximum reflected voltage of 250 mV peak-to-peak provides a margin of 60 mV peak-to-peak between the maximum reflected voltage and the 310 mV peak-to-peak sensitivity minimum threshold of the receiver. The 60 mV peak-to-peak margin provides an allowance for transmitter output noise, residual noise, and other noise sources which may add to the reflected voltage. The bit pattern has been revised to include frequency components corresponding to both 5 and 10 MHz. The revised Figure 10 Reflection Test Set-up is included as Figure 9 of this document.

4.2.2.6 Composite System Channel Noise

The composite system channel noise at the cabinet connector interface due to all causes (reflections, transmitter output noise, transmitter residual noise, etc), 350 ns after the transmission of the last bit of a frame and until transmission of the next frame, shall not exceed 200 mV peak-to-peak.

Conformance to this requirement is met by one of the following system tests depending upon the card configuration.

a. Single Channel Card (End-to-End test of cards installed in the host terminals)
b. Dual Channel Card (End-around test of the card installed in the host terminal)

The Source and Sink interfaces are connected through a 60 meter length of Mil-C-17/135 (TRF 8) 50 ohm cable. Control Frames are exchanged between the Source and Sink and the reflected voltage measured at the Source Connector interface. The amplitude of the composite noise, existing 400 ns after the zero voltage crossing in the middle of the last bit, shall not exceed 200 mV peak-to-peak amplitude. (See Figure 11.)

Rationale:

This test (Figure 10) insures that a system installation of the interface has sufficient tolerance to a composite of the noise sources. The cable length has been selected so that the residual voltage adds to the reflected voltage to produce a worst case condition. The maximum allowable composite noise is 230 mV which is less than the sum of the specified maximum individual noise parameters if tested independently at the worst case conditions. In order to meet this test, the interface card should be designed to meet the nominal parameters. Cards which are designed to the extremes of the waveform envelope and input impedance would be rejected by this test. Specifically, a card design in which the transmitter waveform was near the maximum amplitude and minimum rise time of the waveform envelope (.75 volts and 7 ns, respectively) in combination with a receiver input impedance which produced a maximum return loss would be rejected by this test. The 200 mV requirement provides a 110 mV margin below the minimum receiver threshhold of 310 mV. This test also insures that the card is backward compatible with a system designed to the predecessor specification, where the minimum receiver threshold was 260 mV peak-to-peak.

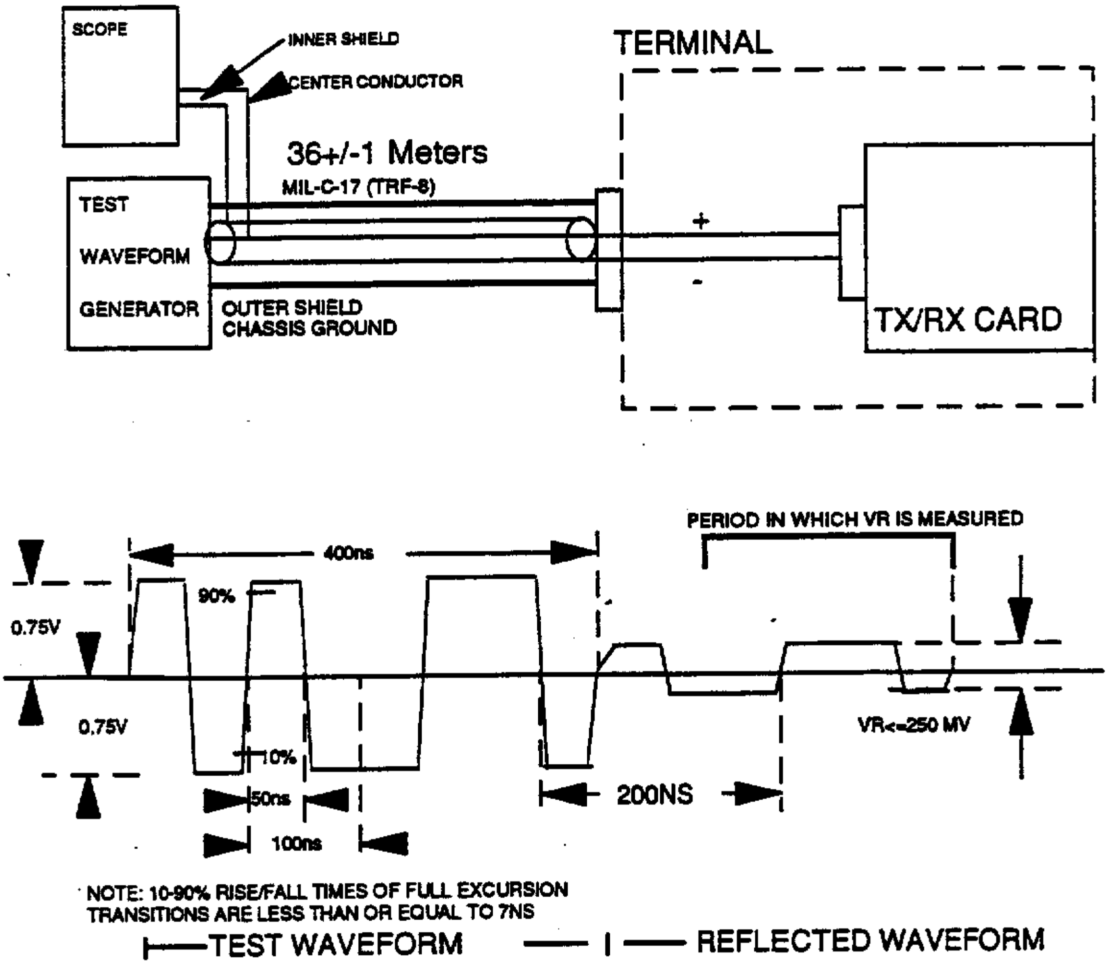


Figure 9 Reflection Test Set-Up (Figure 10 of 4153)

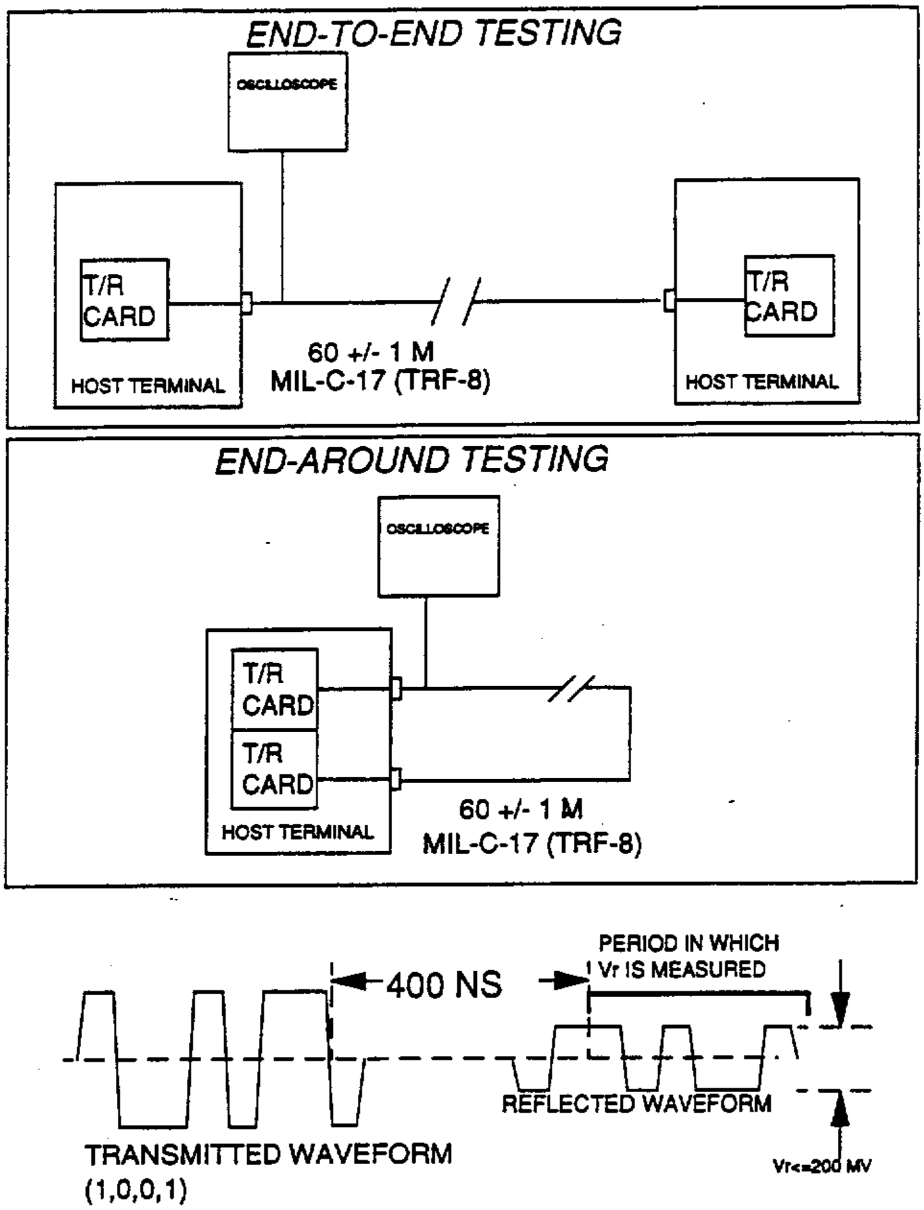


Figure 10 Composite Noise Test Set-Up (Figure 11 of 4153)

7.0 Conformance Test Procedures

7.1 Input Impedance Return Loss Conformance Test

Conformance to the Input Impedance requirement of 4.2.2.4 shall be demonstrated by performing a return loss test. The recommended procedure for performing this test is as follows.

a. Connect a 50 ohm signal divider network (HP 35676A Reflection/Transmission Test Kit or equivalent) to the output reference and input ports of a network analyzer (HP 35677A/B or equivalent).
b. Configure the network analyzer for a log frequency sweep from 1 MHz to 100 MHz, a sweep time of 2 seconds, a bandwidth of 1 KHz, and a signal amplitude of +/-200 mV open-circuit or +/-100 mV terminated (50 ohms) at the output of the signal divider or S-Parameter Test Set. The display should be configured for linear magnitude at a scale of 5 dB per vertical division.
c. Connect a short (approximately 5 feet or 1.5 meters) 50 ohm coaxial test cable to the output port of the signal divider network or Port 1 of the S-Parameter Test Set using an N-to-BNC adapter connector. Attach a BNC-to-triaxial connector to the far end of the cable.
d. With the coaxial test cable and all adapter connectors in place, perform a one-port reflection calibration in accordance with the instructions provided with the specific network analyzer being used. This normally involves calibration with the test cable open-circuited and then terminated with a precision 50 ohm load.
e. Connect the far end of the test cable to the interface connector of the device under test. Observe the resulting return loss profile displayed by network analyzer and compare it with the acceptable return loss profile of Figure 8. Perform this test with the device power on and off.

The device under test shall meet the return loss specification over the 1 MHz to 60 MHz range. Return loss values which exceed -5 dB in the 60 MHz to 100 MHz, although not a requirement, may indicate deficiencies in the design. The final determination of acceptability is meeting the reflection test requirments of paragraph 4.2.2.5 of the STANAG.

7.2 Reflection Conformance Test

Conformance with the reflection requirements of paragraph 4.2.2.5 shall be demonstrated using the confromance test set-up shown in Figure 8. Special test equipment may be needed to generate the specified 4 bit waveform in the conformance test set-up of Figure 8. It could be a custom I/O card tailored to meet the output waveform and could be installed in host equipment which contains the "Handshake" control frames of the interface protocol. The output of the test waveform generator shall be connected to a 36 meter length of TRF-8 cable which is terminated in the input connector of the device under test. The amplitude of the reflected waveform shall not exceed 250 mV peak-to-peak as measured in accordance with the test set-up of Figure 8.

7.3 Composite Sytem Channel Noise Test

Conformance with the composite system channel noise requirements of paragraph 4.2.2.6 shall be demonstrated using the test set-up shown in Figure 9. Single Channel cards shall use the end-to-end test configuration and Dual Channel cards the end around test configuration. The test procedure is as follows:

a. Connect the source and sink interface together through a 60 meter length of Mil-C-17/135 (TRF-8) 50 ohm triaxial cable.
b. Control frames shall be exchanged between the source and the sink.
c. The reflected voltage shall be measured at the source transmitting connector interface.
d. The following transmitted control frames shall tested:

    (1) Source Control frames of 1000 and 1010.
    (2) Sink Control frames of 1011 and 1001.

The amplitude of the reflected waveform as measured in accordance with the test set-up shall not exceed 200 mV peak-to-peak.

8. FIBRE OPTIC EXTENSION

8.1 General

This section gives general guidance to system designers who are interested in up-grading current electrical media installations of the STANAG to fibre optics. The intent of the Fibre Optic Extension is to provide a fibre optic media version of the STANAG with minimum changes to the electrical parameters. The parameters are based on two applications of the interface as follows:

a. An embedded interface in which the electrical circuitry within the host would drive either a transformer for the triax cable or a fibre optic transmitter for the optical cable.

b. Use of an external converter driven by the electrical interface. The converter may be located either at the host interfaces or at an intermediate point in the interconnection. The objective is to extend the length of the connection between the host equipment interfaces through the use of fibre optic cable in which the signal is transmitted with much less distortion and loss. The interconnection may consist of a combination of triax and optical cable in which the converters may be located between the host interfaces.

The Fibre Optic Extension of the STANAG defines the optical parameters at the connector interface enabling replacement of the triaxial electrical cable with fibre optic cable. Thus, the interface protocol is transparent to the use of either electrical or fibre optic media. The concept of the Extension is that of uni-directional light transmission on each fibre in which the Manchester coded signal corresponding to the electrical signal modulates a light emitting device internally connected to an optical fibre which ends at the Source/Sink connector receptacle of Unit A of the interconnected units. The transmit interface is defined at the connector receptacle of the unit A as shown in Figure 11. The channel then continues through theinterconnecting fibre to the connector receptacle of the receiving unit B which is its entry point and the point at which the receiving interface is defined. The light then enters an optical fibre internally connected within the receiving equipment to a light detector; thus completing the light transmission channel.

The characteristics of the links have been chosen so that they can be implemented by means of LEDs and PIN diodes. The application is nominally specified for a 300 meter interface but the power budget is sufficient to extend this to 1000 meters. To provide for future growth the optical parameters are also specified for a 100 MB/s data rate.

8.2 Interconnection between Units

Most units will be interconnected by 2 channels for 2-way flow of information. In this case, it is a user option as to whether a dual channel cable (4 fibres) or two single channel cables (2 fibres) be used for the 2-way link. Some simple peripherals may only require a single channel for 1-way transfer of information. Channel implementation and pin connections for single and dual channel cables are shown in Figure 12.

8.3 Modulation

The modulation is on-off keying using baseband Manchester II coding, whereas the STANAG for the electrical transmission system specifies a bipolar three-level modulation. For compatibility with both point-to-point and bus systems, there shall be no emission while the channel is idle.

For ease of implementation, it is desirable that the electrical three-level modulators/demodulators operate with either the triaxial cable or the fibre optic cable. This requires logic conversion of the bipolar signal used in the electrical system to unipolar for the optical system. In practice, this affects only

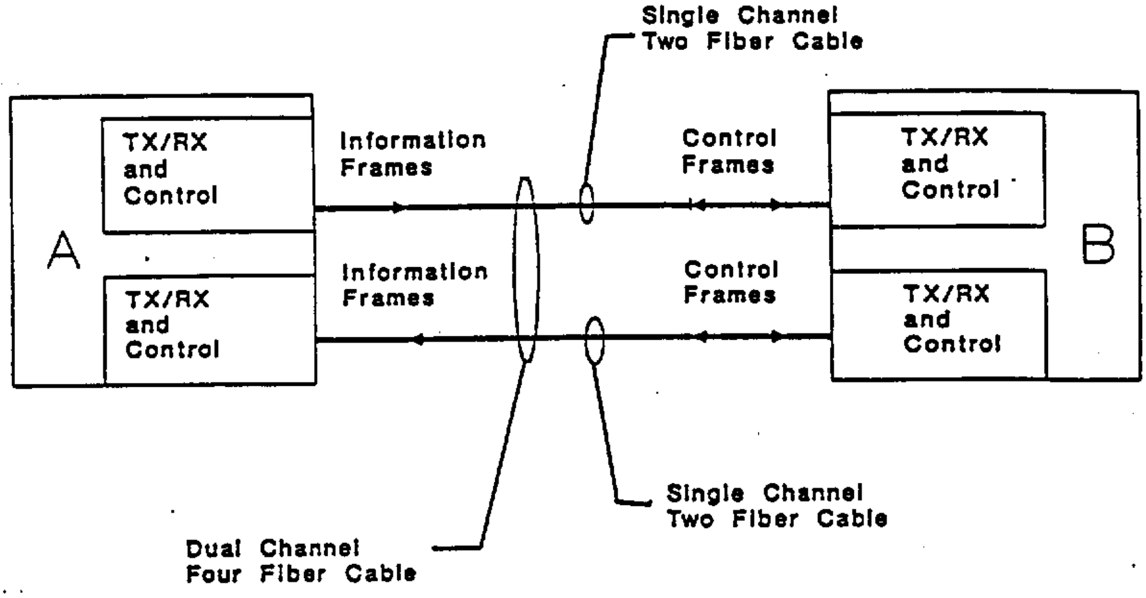


Figure 11 Interconnections Between Units

the first and last bits of a frame since the formats are identical for the intervening bits. Since the STANAG 4153 specifies the first bit of a frame as synchronization bit and is coded as a "1", the link is driven from its quiescent value to high state on the first transition. This is compatible with the three level modulation so only the last bit of the frame need be converted to unipolar logic. For last bit codings for "0", in which the link is driven from a low to high state, it is necessary for the unipolar logic circuitry to return the link to the low state at the end of the transmission (recognized by the absence of further transitions). Typically, this introduces a delay of two to three clock cycles for detection of the end of the message to be transmitted. The relationship between the electrical signals which are transmitted over the triaxial cable and the optical waveform on the fibre optic cable is shown in Figure 13.

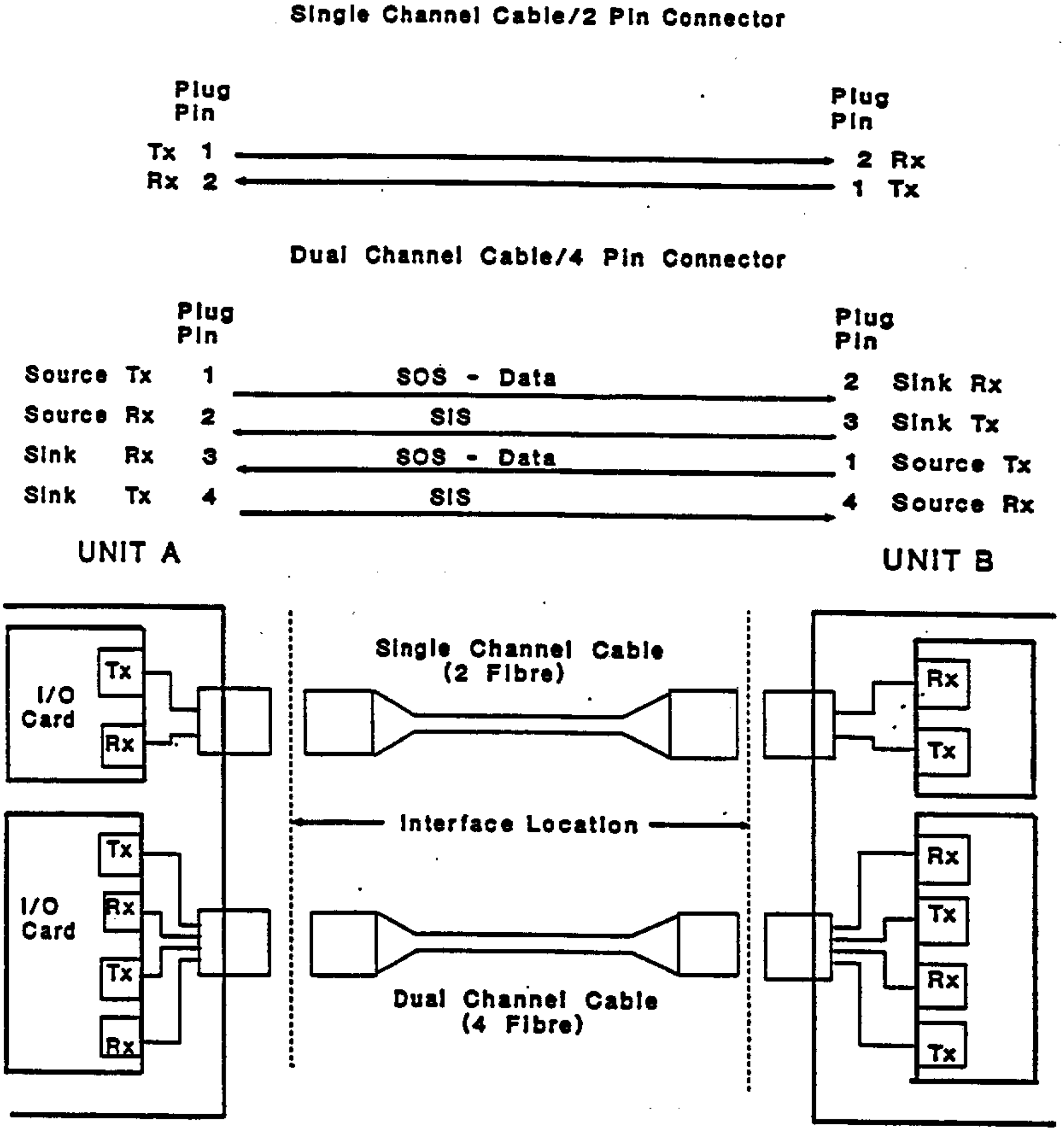


Figure 12 Channel Implementation and Location of Interfaces

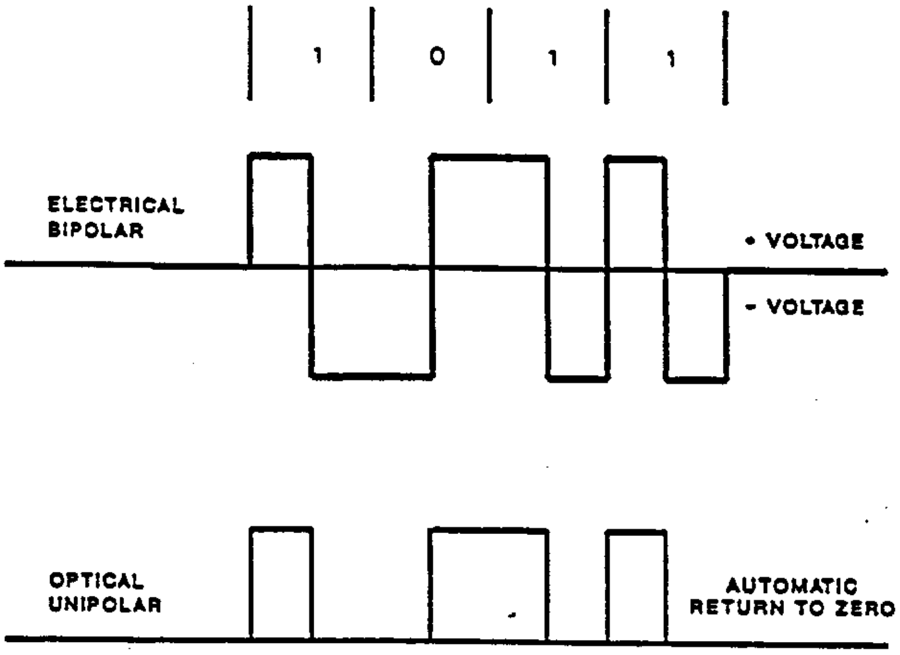


Figure 13 Interface Waveforms

8.4 Optical Power Output

The transmitter shall be capable of coupling optical power into the mating fiber of the output optical connector within the ranges and timing specified in the STANAG. The power levels have been chosen to enable use of commercially available LED type transmitters..

8.5. Optical Output Waveform

The transmitter shall be capable of producing the modulated optical signal waveform shown in Figure 13 . For baseband modulation (On-off signalling), the low state optical power level should be below the - 31 dBm sensitivity level of the receiver and is specified at -40 dBm.

8.6 Combined Overshoot/Undershoot

The combined optical pulse over/undershoot shall not exceed 15% percent of the Peak Transmitted Power.

8.7 Receiving Optical Interface

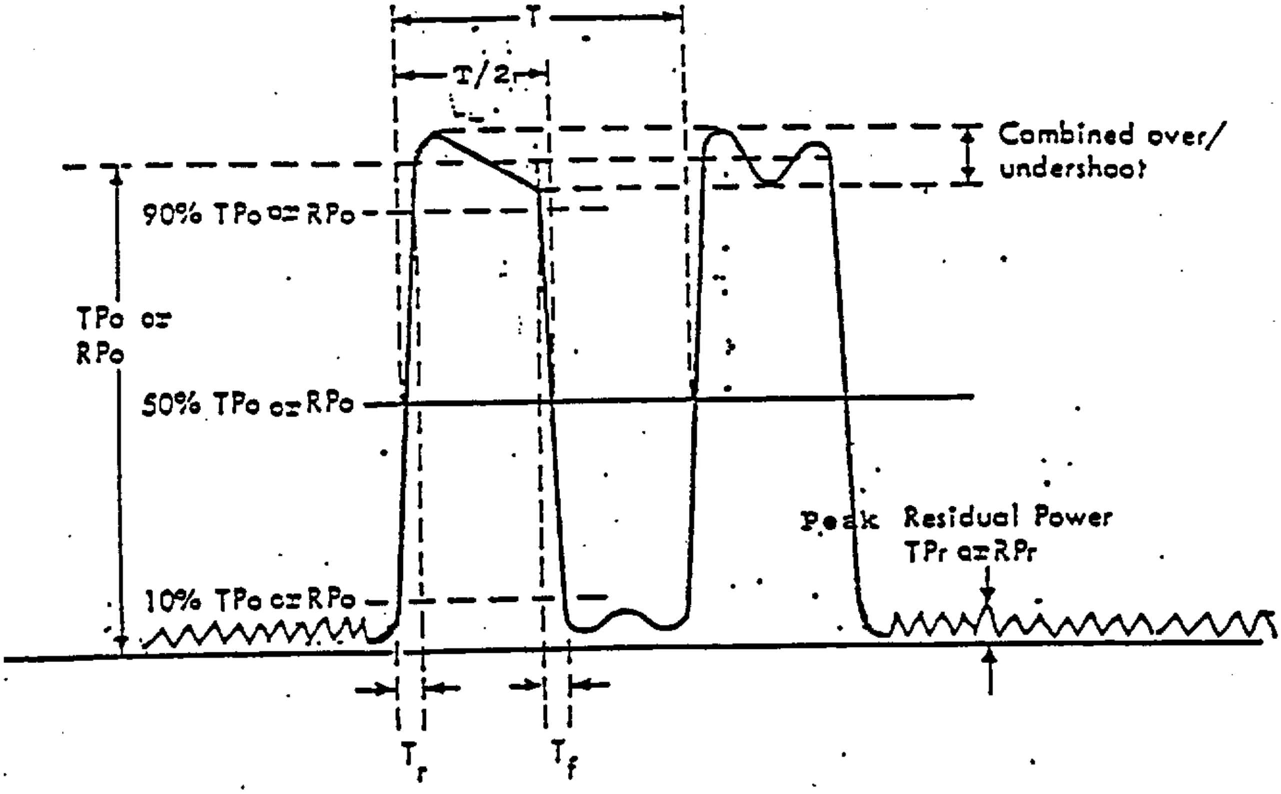
The receiving device shall be capable of decoding the input optical signal as shown in Figure 14 at the specified timing and power levels. The rise and fall times of the received optical signal have been choosen so as to enable decoding of signals from a system in which the converter may be located at the end of a 300 meter electrical interface. Thus, it includes the signal degradation resulting from transmission over both the electrical and optical cable. The specified combined overshoot/undershoot value of 20% of the peak value of the received optical signal provides a 5% margin over the worst case value of the transmitted optical signal.

8.8 Jitter Requirements

Pulse edge jitter requirements have been adapted from IEEE 802.5 Token Ring specifications and are included to enable network connections in which the signal is regenerated at the connection to the network access point.

8.9 Link Loss

The link loss is defined as the difference between the optical power coupled into the transmitter interface fibre at the cabinet connector and that coupled into the receiver interface connector and sha 15 dB. The link losses include fibre attenuation, inline connector losses and splice lossess. For a system in which a 6 dB margin is imposed, this would allow 9 dB for fibre, connector and splice losses.



T = Pulse Interval
T/2 = Pulse Width
Tr = Rise Time (10% to 90% TPo or RPo)
Tf = Fall Time (90% to 10% TPo or RPo)
TPr = Peak Residual Power at Transmitterr
RPr = Peak Residual Power at Receiver
TPo = Peak Value of Transmitter Power
RPo = Peak Value of Received Power

Figure 14 Optical Waveform