

**53A-454 MIL-STD-1553A/B
REAL-TIME BUS CONTROLLER CARD
OPERATING MANUAL**

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53A-454 MIL-STD-1553A/B REAL-TIME BUS CONTROLLER CARD

OPERATING MANUAL

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53A-454 MIL-STD-1553A/B REAL-TIME BUS CONTROLLER CARD

DESCRIPTION

53A-454 Card Overview

The 53A-454 MIL-STD-1553A/B Real-Time Bus Controller Card is a printed circuit board assembly for use in a CDS 53/63 Series System. The card allows the system controller to communicate with other devices through the MIL-STD-1553A/B (called "1553" hereafter) data bus presently in use on military and commercial aircraft.

The 53A-454 Card is programmed and its modes selected by sending ASCII characters to the 53/63 Series System from the system controller. Message sequence information and transmit/receive data are transferred from and to the system controller as binary 8-bit bytes. The 53A-454 Card operates as a programmed MIL-STD-1553 bus controller in "real time". The system controller can output and input data to operate the 1553 bus at the maximum 50-kHz 1553-bus word rate with immediate access to the 1553 data. The card may be used in any real-time simulation if the command and input rate for the system controller satisfy the data-exchange rate required by the simulation.

While operating as a bus controller, the 53A-454 Card can communicate with each of the 32 remote terminals specified by MIL-STD-1553A/B (31 real devices plus broadcast mode). The card is loaded by the system controller with a sequence program of messages, and transmit data for each message. When instructed by the system controller, the 53A-454 Card transmits the programmed messages to the desired RT(s). Any response data received from the RT is stored in on-card memory. The sequence program, transmit data, and receive data are all updatable while the 1553 bus is active.

Up to 1008 transmit/receive message blocks can be programmed in the on-card 64K x 32-bit-wide memory. Messages can be randomly accessed as defined by a sequence program of up to 1024 lines. Message-interval timing, interrupts, and a hardware-strobe signal can be programmed for each step of the program. "Go to" capability, random starting address, breakpoint/continue capability, and conditional jump capability on a specified RT status word are all provided and updatable on-the-fly. On-the-fly updating of the "go to" statement is useful for branching to an alternate program, or bank switching between multiple sets of programs with a single sequence program update. The full sequence program can be programmed to repeat from 1 to 63 times, or to repeat continuously.

A full range of status capability is provided for monitoring the progress of bus traffic and for self test. The current sequence program location can be read at any time to synchronize data update to the card with system-controller or unit-under-test (UUT) operation in simulation applications. A status word may be read to quickly determine if the transmitter is running, whether the receiver has detected any errors in the RT's transmission, and how many repetitions are remaining in the sequence program's repeat counter. All transmit data can be read back either for verification of transfer or for self test.

The transmit-voltage and receive-threshold levels on the card are programmable over a wide voltage range. The maximum transmit voltage into a fully terminated 1553 bus is 28V peak-to-peak on the transformer-coupled output and 10V peak-to-peak on the 55-ohm isolated

direct-coupled output. For UUT receive-threshold testing, a clean transmit level as low as 200 mVs peak-to-peak may be programmed on the direct-coupled output. The low-noise 53A-454 receiver can be programmed true data at levels as low as 220 mV peak-to-peak on the transformer-coupled input or as high as 10V peak-to-peak on the direct-coupled input.

Under program control, the card's transmit waveform can be changed between the trapezoidal shape of MIL-STD-1553B and the sinusoidal shape of McDonnell Douglas Specification MDC A3818.

The 53A-454 Card can introduce controlled errors into its transmitted data stream. These errors include:

- o Incorrect parity
- o Erroneous 1553 Manchester encoding
- o Zero-crossing errors of ± 150 ns
- o Dropped data bits
- o Sixteen different incorrect or invalid 1553 sync patterns
- o Incorrect RT response times
- o Incorrect number of data bits (up to $\pm 7\frac{1}{2}$ bits) in a word
- o Incorrect number of words in a message
- o Interword gap errors
- o Invalid signal levels
- o Gaussian or common-mode noise

On received data, the 53A-454 Card can differentiate and store:

- o Incorrect transition time
- o Manchester errors
- o Dropped data bit errors
- o Bit count errors
- o Parity errors
- o Incorrect sync
- o RT/controller response time errors
- o Interword gap errors

To facilitate initial use of the card, a default message list is loaded on power-up which can be activated with a single trigger command. LEDs are provided at the front edge of the card to visually indicate whether data is being transmitted and received on the 1553 bus. External control of the card and monitoring of the 1553 data stream and errors are enhanced by 17 different TTL input and output hardware interfaces available at the front-edge connector of the card.

1553 Bus Overview

MIL-STD-1553 provides for time-division multiplexed communication by up to 31 avionics units (RTs) through a high-speed, 2-wire, command/data bus. According to the defined protocol, a single bus controller at any time controls information flow among the RTs.

For controller-to-RT transactions, a 16-bit command word is sent that specifies the RT to receive data, and how many data words (up to 32) are to be received; the command and data

words are contiguous. The RT processes the command information and data, then returns a 16-bit status word to the bus controller, containing the RT address and status information.

For RT-to-controller transactions, the bus controller sends a 16-bit command word specifying the RT to transmit, and how many words (up to 32) are to be transmitted. The RT then returns a status word with its address and status followed by the required data; the status and data words are contiguous.

Each word (command, status, or data) is 16 bits, encoded in a Manchester bi-phase format that eliminates the need for separate data and clock lines and rejects any DC voltage component on the 1553 bus. Each 16-bit word is preceded by a sync signal of 3 bit-times, and followed by an odd-parity bit to form the 20-bit-time 1553 word. The sync signal for a command or status word is defined as being high for $1\frac{1}{2}$ bit-times, then low for $1\frac{1}{2}$ bit-times. This signal is inverted (low, then high) for a data word.

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-454 Card's operating environment.

Address-Select Switch

The 53A-454 Card has a miniature 10-position switch labeled "ADDRESS" that selects the 53A-454 Card's address (0-9) in the 53/63 Series System. The switch's cover opens to allow the address to be reselected. A screwdriver with a narrow, flat blade should be used to turn the cam-action wiper to the desired address position.

Power LED

The Power LED provides a valuable diagnostic tool by giving the system programmer a visual indication of the action which the system is currently taking. Whenever the 53A-454 Card is addressed by the system controller, the Power LED goes out. The LED remains out until another function card is addressed. Since only one function card can be addressed at a time, an unlit Power LED indicates the function card with which the system controller is currently communicating. The Power LED being lit not only indicates that the 53A-454 Card is unaddressed, but that all required DC power (5V DC, +15V DC, and -15V DC) is being supplied.

Fuses

The 5V DC, +15V DC, and -15V DC power buses each have a fuse that protects the system from overloads. If a fuse has blown, the Power LED will not light.

Function LEDs and Switches

LEDs

The following LEDs are provided at the top front edge of the 53A-454 Card to indicate the status of the card's operation:

XMT LED

This LED is lit when the 53A-454 Card is actively transmitting.

RCV LED

This LED is lit when the 53A-454 Card is receiving data on the MIL-STD-1553 bus.

MAC LED

This LED is lit when the 53A-454 Card has been programmed for MAC Air operation per McDonnell Douglas Specification MDC A3818. Rise and fall times on the transmitted signal are shaped to approximate sine wave operation per the specification.

ERR LED

This LED is lit whenever the 53A-454 Card's receiver circuitry detects an error in the received 1553 data stream. It is cleared by issuing the F (Flags) command or resetting the card to its power-up condition.

Switches

The following switches are provided to select the proper functions for the 53A-454 Card's operating environment:

Halt Switch

This two-position slide switch is located near the card's backplane edge connector. It selects the state of the 53A-454 Card after an @XH (Halt) or STOP command is received by the 53/63 Series System.

- a. If the Halt Switch is in the ON position, then the 53A-454 Card is reset to its power-up state, all parameters are reset to their default values, and the Power LED is lit.
- b. If the Halt Switch is in the OFF position, then the 53A-454 Card becomes unaddressed, the Power LED is lit, and any programmed parameters of the card remain unchanged.

External Clock Switch

A 1-section rocker switch near the front edge selects either the internal or external data clock. In the C2 position, an internal 16-MHz data clock is selected (16 times the 1553 bus 1-MHz data rate). When the switch is in the C1 position, an external 16-MHz data clock (pin 15) is selected; the external clock and thus the 1553 bus data rate can be varied $\pm 6.25\%$.

External Inputs And Outputs

The front-edge connector on the 53A-454 Card is used as the 1553 bus interface for adding Gaussian and common-mode noise to the 1553A/B signal, and for TTL input and output control signals.

See Appendix B for front-edge connector pin assignments and descriptions.

SPECIFICATIONS

Configuration:

MIL-STD-1553A/B Real-Time Bus Controller.

Word Format:

Manchester bi-phase, self-clocking, 1 MHz, 20-bit word with command/data sync, data, and parity bits; per MIL-STD-1553A/B.

Message Format:

Programmable command word plus user-defined number of data words per message (command, status, data-transmit, and data-response words may add to a maximum of 63 words per message).

Message Capability:

1008 transmit or receive messages may be specified at a given time. Messages may be updated in real time so that 1553A/B bus data can vary continuously. A message requires one 32-bit word for each command, status, or data word transmitted or received.

Message Rate:

(time from start of one message to start of next message): 24 μ s to 65,535 μ s, programmable for each RT transaction. A "contention" condition can be created, if desired, in which the bus controller begins transmitting while the RT is still responding.

Induced Transmitter Errors:

Programmable for each transmit word:

- Sync-pattern error
- ± 150 -ns sync-transition-time error
- ± 150 -ns bit-transition-time error
- Incorrect parity
- Manchester error
- Dropped-bit error
- Incorrect bit count (± 4 bits)

Bit position of Manchester error and dropped-errors can be controlled as part of the 8-bit error description for each word.

Programmable for each message:

- Incorrect terminal-response time
- Incorrect word count
- Incorrect status word RT address

Receiver Error Checking:

Bit-transition-time errors, parity errors, dropped-bit errors, sync-pattern errors, and receiver-response-time errors for each word are detected and stored.

The test value for a response-time error is programmable from 4 μ s to 130 μ s.

Bit-transition-time errors may be masked out under program control.

1553 Bus Coupling:

Direct coupling - 1:1 turns ratio, 55-ohm isolation resistor on each leg.

Transformer stub coupling - 1:0.707 turns ratio.

1553 Analog Input

Maximum Input:

40V PTP differential, direct-coupled.
27V PTP differential, transformer-coupled.

Threshold Level:

Programmable from 314 mV to 10.0V PTP differential in 39.2 mV PTP increments, direct-coupled (220 mV to 7.07V PTP, transformer-coupled).

> 2 kOhm balanced and differential, transformer-coupled.

1553 Analog Output

Transition Time:

Standard: > 100 ns and < 200 ns between 10% and 90% points on output waveform, for output levels above 1.0V PTP.

MAC Air: > 250 ns and < 350 ns between 10% and 90% points on output waveform, for output levels above 1.0V PTP.

Voltage Levels:

Programmable to 256 different levels.

0.20V PTP (minimum effective) to 10.2V PTP (two 70-ohm terminations, direct-coupled).

0.20V PTP (minimum effective) to 17.0V PTP (one 70-ohm termination, direct-coupled).

0.20V PTP (minimum effective) to 29.7V PTP (transformer-coupled output with 70-ohm load).

Current Levels:

290 mA RMS maximum, direct-coupled output.

421 mA RMS maximum, transformer-coupled output.

Auxiliary Inputs (Analog)

Common Mode Voltage:

Used to externally inject common-mode voltage onto 1553 bus. A maximum common mode voltage of 10 Volt DC or peak AC to 5 MHz may be injected. The common mode exactly equals the voltage placed on this input.

Gaussian Noise:

Used to inject Gaussian noise onto 1553 bus, 1.583V RMS into the card 75-ohm load is required to generate the noise levels specified by the noise test of MIL-STD-1553B.

Auxiliary Inputs (TTL):

All TTL input voltages may vary between +7V and -0.5V (anytime). Input current is 200 *uA maximum.

Signal Names:

External Trigger
External Halt
External Halt Line 0
External Clock

Auxiliary Outputs (TTL):

48 mA maximum sink current, 15 mA maximum source current.

Signal Names:

Transmit Data
Transmit Clock
Receive Data
Receive Clock
Transmitter Trigger
Sequence Trigger
Transmit Sync Polarity
Received Sync Polarity
Status Word Message Error Bit
1553 Received Data Error
Transmitter Active
Receiver Active
Receiver Word Trigger

Time Base:

Internal 16-MHz crystal oscillator. Switch-selectable user clock input from front-edge connector. The input frequency for an external clock may vary from 15 MHz to 17 MHz. Frequency tracking of 0.1% to other units on the bus must be maintained to avoid clock-recovery errors on the 53A-454 receiver.

Programmed By:

One ASCII character or an ASCII character followed by binary data byte(s).

System Controller Commands:

Update current sequence line number (or address).

- C Start or continue transmitting at current sequence line number.
- E Arm external-trigger and halt signal.
- F Input status flags (Run, Receive Error) and execution count.
- G Start or continue transmitting at initial sequence line number (line 0).
- J Inhibit bit-transition-time (jitter) error detection in received data.
- K Reset (kill) bus-controller operation, and return to power-up.
- M Output standard 1553 or MAC Air transmit signal.
- N Output number of sequence program cycles.
- P Output receiver pattern and conditional "go to" line for pattern occurrence.
- Q Discontinue (quit) bus-controller operation.
- R Input received data.
- S Output sequence program.
- T Output transmit message data.
- W Input address of current sequence program line.
- X Output new transmit amplitude.
- Y Output new receiver threshold.
- Z Output new RT response-time test-limit value.

Termination Characters:

The system controller may optionally append a <CR><LF> at the end of a command to the 53A-454 Card without affecting card operation.

The 53A-454 Card appends a <CR><LF> to each string input to the system controller.

Interrupt Capability:

The 53A-454 Card may be programmed to interrupt the system controller on any sequence program line.

Power-On and

Reset Initialization Conditions:

All LEDs - Off.
External outputs - Not true (TTL high).
Transmit condition - Not running.
Receiver error flag - No error.
External halt and trigger inputs - Disarmed.
Transmit level - 6.00V PTP across 35-ohm 1553 direct coupled load.
Receive threshold - 1.33V PTP.
Execution count - 0 (continuous transmission).
RT response-time test value - 12 us.
MAC Air mode - Off.
Sequence program - After power-up, a two-line sequence program is in place to transmit a single command word (hexadecimal "0421") every 50 ms following a single character Go command.

Power Requirements:

5V and ± 15 V dc power is provided by the internal Power Supply in the 53/63 Series Card Cage.

Voltage

(5-volt Supply):

4.75 V dc to 5.25 V dc.

Current

(5-volt Supply):

1.7 A, maximum quiescent.
1.7 A, peak.

Voltage

(± 15 -volt Supplies):

+14.5 V dc to +15.5 V dc.
-14.5 V dc to -15.5 V dc.

Current

(± 15 -volt Supplies):

100 mA, maximum quiescent.
124 mA, no load transmission.
220 mA, 35-ohm direct-coupled or 70-ohm transformer-coupled load transmission.

Cooling:

Provided by the fan in the 53/63 Card Cage.

Temperature:

-10 °C to +65 °C, operating (assumes ambient temperature of 55 ° and airflow to assure less than 10 °C temperature rise).
-40 °C to +85 °C, storage.

Humidity:

Less than 95% R.H. noncondensing, -10 °C to +30 °C.
Less than 75% R.H. non-condensing, +31 °C to +40 °C.
Less than 45% R.H. non-condensing, +41 °C to +55 °C.

<u>Dimensions:</u>	197 mm high, 221 mm deep, 21 mm wide. (7.75 in x 8.69 in x 0.8 in).
<u>Dimensions, Shipping:</u>	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping dimensions are: 254 mm x 254 mm x 127 mm. (10 in x 10 in x 5 in).
<u>Weight:</u>	0.69 kg. (1.5 lb).
<u>Weight, Shipping:</u>	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping weight is: 1.50 kg. (3.3 lb).
<u>Mounting Position:</u>	Any orientation.
<u>Mounting Location:</u>	Installs in any function card slot of the 53/63 Card Cage.
<u>I/O Connections:</u>	A 48-pin card-edge hooded connector (53A-780) connects to all front-edge input and output signals.
<u>Required Equipment (not supplied):</u>	53A-780 Hooded Connector.
<u>Equipment Supplied:</u>	53A-454 MIL-STD-1553A/B Real-Time Bus Controller Card. Spare fuse (Part# 42202-52003). Spare fuses (Part# 42202-52001) Qty 2. Operating Manual (Part# 00000-14540). Service Manual (Part# 00000-24540).
<u>Software Revision:</u>	V1.12

OPERATION

Overview

The 53A-454 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-454 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane. The card returns data to the system controller in response to read and status commands.

To address a function card for the first time, the system command @XY must be issued. X is the card cage address (0-9) selected on the 53A-171 Control Card in the addressed card cage; Y is the 53A-454 Card's address (0-9) within the addressed card cage. The 53A-454 Card's address is selected using the card's Address-select switch. Once a function card is addressed, it remains addressed until the system receives another @ character. Appendix A fully discusses the @XY command and the other 53/63 Series System commands. After the 53A-454 Card is addressed, the commands listed below may be issued until another function card is addressed.

The card commands can be divided into two categories:

Message/Data commands define the order and timing of MIL-STD-1553 messages to be transmitted, the contents of each transmitted message, and how the message response contents are accessed.

Setup commands provide start, stop, and status capability, or define parameters specified at the beginning of a bus transmission that are not typically changed during a transmission.

Message/Data Commands

The 53A-453 Card provides up to 1008 transmit/receive buffers (4 banks of 252 buffers each), with each buffer being 64 words in length. Transmit data is placed in each buffer using the T command. The 53A-454 Card stores response data from the user RT in the same buffer, which can subsequently be accessed by the R command. The transmit and response data for a message occupy the same 64 word buffer. The order in which data from the buffers is transmitted, is defined by the S command.

There are three Message/Data commands, S (Sequence), T (Transmit data), and R (Receive data):

The S command lets you program a sequence of 1553 messages to be sent by the 53A-454 Card. A sequence list of up to 1024 message numbers can be defined. The S command allows branching to any point in the sequence list. The sequence list can be thought of as a program consisting of message numbers and "go to" statements; the sequence program also defines timing between messages.

The T command defines the contents of each message (the 1553 bus controller command and data words, and error impairments for these words).

The R command accesses the response to each message (RT status and data words, and errors) received from the user RT.

Order of Programming

The following steps show how the 53A-454 Card is used in a typical application:

1. A sequence program and message timing are defined with the S command.
2. The contents of all messages listed in the sequence program are then defined by the T command.
3. A G (Go), C (Continue) or E (External) command is issued to begin actual data transmission on the bus. (The G and C commands are described below under SETUP COMMANDS.)
4. You may update the sequence program, transmit data, or read response data at any time regardless of what 1553 bus activity is taking place; in this way, the 53A-454 Card operates in real time.
5. The W (Where) command tells where the bus controller is in its sequence program. When operating in real time, the W command allows the system controller to synchronize itself with the 53A-454 Card, such that desired RT response data is not read before received, or BC transmit data updated before it has been transmitted. (The W command is described below under SETUP COMMANDS.)

The remainder of this section provides an overview of each card command followed by a simple programming example.

S, T, and R Command Programming Overview

The S, T, and R commands have similar programming requirements; all three commands are programmed beginning with a 4-byte header word. In the header word, the first byte contains the S, T, or R character, the second byte contains a word count, and the last two bytes contain a starting sequence line number for the S command or a message number for the T and R commands. The number of bytes sent or received after the header word is four times the word count specified in the header word.

S Command

The S command's header-word bytes are transmitted in the following order, and are formatted as follows:

First Byte Sent byte 3	byte 2	byte 1	Last Byte Sent byte 0
S Character	Word Count	6-Bit Value of 0	10-Bit Starting Sequence Line No.

The 10-bit starting sequence line number is from 0 to 1023, and indicates where in the sequence program to begin loading the sequence-list data that follows the header word.

NOTE: The 53A-454 Card is essentially a memory-mapped card; bytes 1 and 0 (for the S, T, and R commands) define a starting memory location for data access. (See the Memory Map Description that follows.)

Most programs typically start their sequence list at line 0. The starting line number is provided to allow loading of the sequence program sequentially one entry at a time, or to allow editing of lines in the middle of the program without having to reload the entire sequence program.

In the sequence list, the 4-byte words that follow the header word are of two types:

1. A message-number word that specifies the transmit/receive buffer number from which a message is to be transmitted and message timing. A message-number word is formatted as follows:

byte 3	byte 2	byte 1	byte 0
8-Bit Message Number	2-Bit Bank Number	6-Bit Control Word	16-Bit Between Messages (in usec)

Valid message numbers are 4 through 255 and the bank number is a value of 0 through 3, for a total of 1008 messages.

2. A "go to" word that allows looping or branching to any line number in the sequence program. A "go to" word is formatted as follows:

byte 3	byte 2	byte 1	byte 0
6 Bit Value of 0	10-Bit Sequence Line Number	16-Bit "Don't Care"	

Valid sequence line numbers are 0 through 1023 to allow looping to any of the 1024 locations in the sequence program.

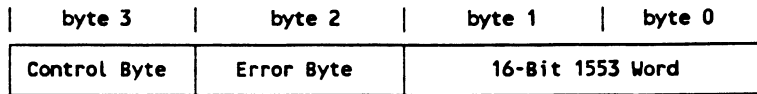
T and R Commands

The T and R commands' header-word bytes are transmitted in the following order, and are formatted as follows:

byte 3	byte 2	byte 1	byte 0	
T or R Character	Word Count	8-Bit Message Number	2-Bit Bank No.	6-Bit Offset

Valid message numbers, as specified above for the S command, are 4 through 255. The bank number is a value of 0 through 3. The offset of 0 to 63 words in byte 0 allows any word within a message's transmit/receive buffer to be randomly accessed.

The 4-byte words that follow the T command's header word, or are returned in response to the R command's header word, are formatted as follows:



Byte 3 specifies information such as command versus data sync pattern and last word of a message. Byte 2 contains transmitted or received error information. Bytes 1 and 0 contain the 16-bit 1553 word (command, status, or data).

Binary Output Programming

Except for the S, T, and R bytes in header words, output bytes use a full eight bits and must be output to and read from the 53A-454 Card in binary mode (a mode in which the line-feed code may be a byte of data rather than a termination character). Therefore, data is not sent as a literal string, but as a sequence of bytes each having a decimal value from 0 to 255, or as a string built with, for example, the CHR\$ function when using BASIC as a system controller programming language.

Setup Commands

The Setup commands are:

- A (Address) - specifies a particular sequence line number at which to begin or continue a sequence program with the C command.
- C (Continue) - starts or continues executing the sequence program at the line defined by a previous A command or at the next line when previously halted by a Q command. A C command initiates 1553 bus activity.
- E (External) - enables the front-edge external signals. The 1553 bus controller starts on External Trigger, and stops on External Halt.
- F (Flag) - allows input of status information. Three types of information are returned:
 1. Current sequence list execution count
 2. Whether or not the 53A-454 Card is transmitting
 3. A detected receive error
- G (Go) - starts executing the sequence program at line 0 and initiates 1553 bus activity.
- J (Jitter) - inhibits or enables receiver bit-transition-time (jitter) error detection.
- K (Kill) - resets the 53A-454 Card to its power-up state, and stops any transmission in progress.
- M (MAC Air) - programs the transmitter to shape the transmitted output signal to provide sinusoidal rise and fall times per McDonnell Douglas Specification MDC A3818.

- N** (Number) - specifies the number of passes through specified sequence line numbers before bus transmission is stopped. This command typically specifies the number of passes through the sequence list; but because any sequence line can be identified for decrementing the pass count, this command is extremely flexible. The N command (with an argument of 0) can also be used to allow the bus to transmit continuously.
- P** (Pattern) - specifies the pattern response word and the sequence program line to execute after a pattern is detected. This command allows an RT status word to be designated to cause a conditional branch to a specified sequence program line.
- Q** (Quit) - suspends transmission without changing parameters already set up. When used together, the Q and C commands cause the sequence program to pause, then continue.
- W** (Where) - allows the current sequence line number to be sent to the system controller; this command is typically used to synchronize input and output data updates to system-controller activity in real-time applications.
- X** (X-value) - specifies an output value for 1553 transmitter amplitude.
- Y** (Y-value) - specifies an output value for 1553 receiver threshold.
- Z** (Z-value) - specifies the maximum RT response time before an error is recorded. The response time is the time between the last mid-parity-bit transition of the bus controller message and the first mid-sync transition of the RT response.

Memory Map Description

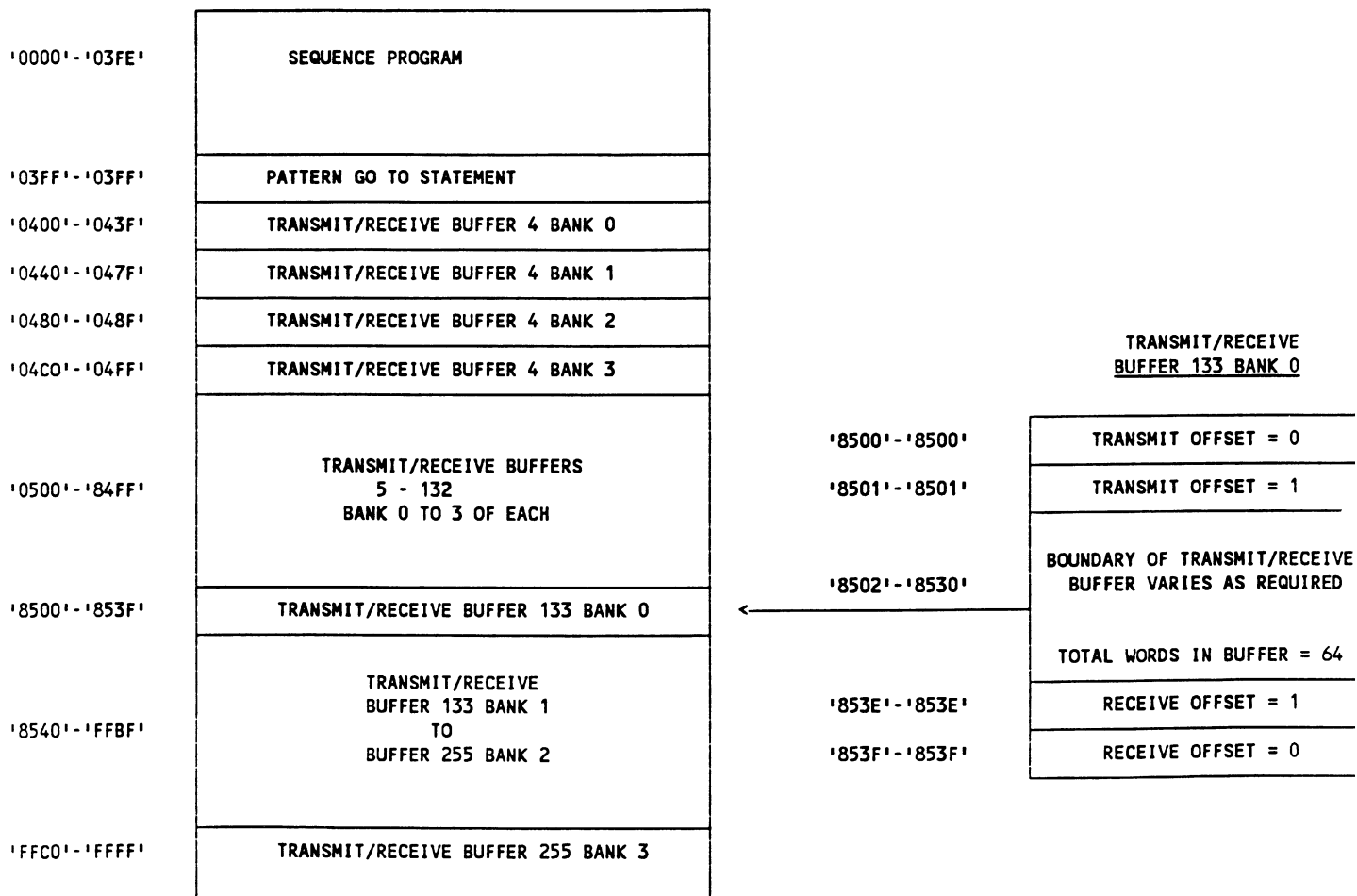
For those readers who have some hardware background, a short explanation of the 53A-454 Card's memory map may help clarify how the S, R, and T commands function.

The 53A-454 Card contains 65,536 words of memory; each word has 32 bits. The first 1024 words in memory ('0000' to '03FF' hexadecimal) contain the sequence program. The last memory location in the sequence program section must be reserved for the pattern command, when used. The remainder of memory contains 1008 transmit/receive buffers of 64 words each. The memory address for a particular sequence line number is equal to bytes 1 and 0 of the S command header. The memory address for a particular message and bank number, and location within the 64 word buffer, is equal to bytes 1 and 0 of the T command header. The 53A-454 Card thus uses bytes 1 and 0 of the S and T command header to determine the memory address at which to load the data following the header.

53A-454 CARD MEMORY MAP

HEXADECIMAL MEMORY MAP 65536 32-BIT LOCATIONS

Hex Address



Bytes 1 and 0 of the T command's header word may be understood as a message and bank number with a 64-word offset as described in the overview, or as a physical memory address.

Bytes 3 and 2 of a sequence program's message-number word (S command) are the same as bytes 1 and 0 of the T command's header word for the first word in the 64-word buffer. The 53A-454 Card uses the byte 3 and 2 message address of the sequence program to access the transmit message and to store the response data.

The R command's header word also points to the receiver data address just as the T command's header word does, except the bottom six bits of the address defining the buffer offset are complimented by the hardware for the R command's address. The receive hardware and the R command address accesses word 0 of a buffer at physical buffer location 63, word 1 at physical buffer location 62, etc. In this way, the transmit and receive buffers share a 64-word buffer.

GETTING STARTED PROGRAM

The following program for setting up a simple transmission sequence sends two messages to RT 3: the first message instructs the RT to receive two data words, and the second message instructs the RT to transmit one data word.

First, a sequence program is created starting at sequence line 0; the program contains two message numbers followed by a "go to line 0" command. Message buffers 4 and 5 in bank 0 are used for this example. The time from the beginning of message 4 to the beginning of message 5 is set to 200 us; the time from the beginning of message 5 to the beginning of message 4 is set to 600 μ s. The contents of messages 4 and 5 are then defined.

After the data is loaded, bus operation starts with a G (Go) command to execute at sequence line 0. The 53A-454 Card then transmits each message in the order defined by the sequence program, with the contents of the bus message defined by the T command. When the branch to line 0 occurs, the card branches back to the first line number. The card spaces the defined messages by the timing in the sequence program, and collects any response data in a common 64-word transmit/receive buffer for each message number. This response data can be accessed at anytime.

The commands to load the sequence program and two transmit messages are listed below. Each command is followed by a diagram showing how that command word is partitioned.

In the examples that follow, the generic term "Output" is used to indicate a system controller output operation rather than the syntax of a specific system controller/programming language. Data shown in quotes is output as the 8-bit equivalent of the specified ASCII character. Data following a comma is output as the 8-bit binary equivalent of the specified decimal number.

Output S,3,0,0

A 3-word sequence program is loaded starting at sequence line 0.

Sequence command header

S	Word Count = 3	6-Bit Value 0	Starting Seq. Line No. = 0
8 Bits First Output Byte	8 Bits	6 Bits	10 Bits Last Output Byte

Sequence list entries one and two are loaded which define the transmit/receive message buffers to be used. The 1st message buffer # = 4 and the 2nd message buffer # = 5

Output 4,0,0,200

Output 5,0,2,88

Message Buffer # = 4	Bank No. = 0	Control Bits =0	Message Spacing = 200 us
Message Buffer # = 5	Bank No. = 0	Control Bits =0	Message Spacing = 600 us
8 Bits First Output Byte 3	2 Bits	6 Bits	16 Bits Last Output Byte 0

For output to buffer 5,

Byte 3 = message buffer number = 5

Byte 2 = 64 * message bank number = 0

*Byte 1 = int (time/256) = 2

*Byte 0 = rmdr (time/256) = 88

* For 600 μ s value, bytes 1 and 0 are determined by dividing 600 by 256. 600 divided by 256 equals 2 with a remainder of 88.

Output 0,0,0,0

The last entry of the sequence list is loaded as a branch back to the first entry.

Go to sequence line 0

0	Go To Line 0	Don't Care
6 Bits First Output Byte	10 Bits	16 Bits Last Output Byte

NOTE: Between the start of the S and the last data byte, carriage-returns, line-feeds, and any other superfluous characters must be suppressed.

Output T,3,4,0

Transmit/receive buffer 4 header is output.

Transmit message # 4 header

T	Word Count = 3	Message # = 4	Bank No. = 0	Offset = 0
8 Bits First Output Byte	8 Bits	8 Bits	2 Bits Last Output Byte	6 Bits Last Output Byte

The first of three 4-Byte words, a MIL-STD-1553 command word for RT # 3 to receive two words at subaddress 1 (see MIL-STD-1553 for details of command word format), is loaded into transmit/receive buffer 4.

Output 32,0,24,34

Control Byte				Error Byte	16-Bit 1553 Word			
00	1	0000	0	Error Code = 0	00011	0	00001	00010
cmd sync			end of msg		RT #	T/R = R	subadd	word count
First Output Byte 3							Last Output Byte 0	

Byte 3 = (32 * command sync bit) + (last word bit) = 32
 Byte 2 = No Errors = 0
 Byte 1 = (8 * RT address) + (4 * T/R bit) + (top 2 bits of subaddress) = 24
 Byte 0 = (32 * bottom 3 bits of subaddress) + (word count) = 34

Two MIL-STD-1553 data words are loaded into transmit/receive buffer 4. The two data words have hex values "1111" and "2222".

Output 0,0,17,17
Output 1,0,34,34

Control Byte				Error Byte	16-Bit 1553 Word			
00	0	0000	0	Error Code=0	0001	0001	00001	0001
00	0	0000	1	Error Code=0	0010	0010	00010	0010

data sync	end of msg		data contents
First Output Byte 3			Last Output Byte 0

Bytes 1 and 0 = 16 + 1, for 1111 = 17
 Bytes 1 and 0 = 32 + 2, for 2222 = 34

NOTE: Between the start of the T command and the last data byte, carriage-returns, line-feeds, and any other superfluous characters must be suppressed.

Output T,1,5,0

Transmit/Receive buffer 5 header is output.

Transmit message # 5 header

T	Word Count = 1	Message # = 5	Bank No. = 0	Offset = 0
8 Bits	8 Bits	8 Bits	2 Bits	6 Bits
First Output Byte 3				Last Output Byte 0

Output 33,0,28,33

A single MIL-STD-1553 command word is loaded into transmit/receive buffer 5.

Command word for RT # 3 to transmit one word from subaddress 1.

Control Byte				Error Byte	16-Bit 1553 Word			
00	1	0000	1	Error Code = 0	00011	1	00001	00001
cmd sync		end of msg		RT #	T/R = R	subadd	word count	
First Output Byte 3						Last Output Byte 0		

$$\text{Byte 3} = 32 + 1 = 33$$

$$\text{Byte 2} = \text{No Errors} = 0$$

$$\text{Byte 1} = (3 \times 8) + 4 = 28$$

$$\text{Byte 0} = 32 + 1 = 33$$

NOTE: Between the start of the T command and the last data byte, carriage-returns, line-feeds, and any other superfluous characters must be suppressed.

Finally, a G command is sent to start continuous transmission on the 1553 bus of the above two messages, using the default transmit and receive voltage levels.

Output G

CARD COMMAND DESCRIPTIONS

This section describes in detail the commands used to program the 53A-454 Card as a MIL-STD-1553 Real Time Bus Controller. Prior to issuing commands to the card, the card must be addressed.

To address a function card for the first time, the system command @XY must be issued; X is the mainframe address (0-9) selected on the 53A-171 Control Card for that mainframe, and Y is the card address (0-9) within that mainframe. The address of the 53A-454 Card is selected using the card's address-select switch. Once a function card is addressed, it remains addressed until the system receives another @ character at the completion of any valid 53A-454 Card command. Appendix A fully discusses the @XY command and the other 53/63 Series System commands. After the 53A-454 Card is addressed, multiple commands may be issued without readdressing the card until another function card is addressed. The commands are described in the following pages in alphabetical order.

If the system controller requests input from the 53A-454 Card following an R, F or W command, the number of bytes defined by that command are returned followed by a carriage-return <CR> and a line-feed <LF> character.

If the system controller requests input prior to issuing an R, F, or W command to prepare the card for input, a single character <CR> or <LF> is returned to the system controller. A carriage-return indicates that the 53A-454 Card is not active on the 1553 bus. A line-feed indicates the 53A-454 is active on the 1553 bus.

All legal commands have defined lengths that must be maintained; sending incorrect lengths of binary data streams can cause the system to hang up if the protocols for these lengths are not maintained (the @ character for readdressing other cards may be misinterpreted). Characters such as spaces, nulls, commas, carriage-returns, and line-feeds do not affect card operation if they occur between and not in the middle of legitimate command sequences.

<u>Command</u>	<u>Description</u>
----------------	--------------------

A	The A (Address) command outputs a sequence program line number for start of transmission, and is used in conjunction with the C (Continue) command.
---	---

Syntax: AZ

Z is two bytes long and specifies a 10-bit line number from 0 through 1023 (physical memory addresses, hexadecimal 0000 through 03FF).

When bus controller operation is started, the first instruction of the sequence program is at the line number specified by this command. After power-up or system controller reset, the sequence program line number is automatically set to 0. If bus controller operation is started and then stopped, the next line number of the sequence program is the next higher address after the last line number accessed.

The A command must be followed by a C (Continue) or E (External) command and not a G command to start transmission at the sequence line number defined by the A command.

Example:

It is desired to start transmitting at the message defined in line 512 of the sequence program (i.e., start the sequence program at line 512):

Send the ASCII character A, followed by two bytes with the values 2 and 0, followed by the ASCII character C. (Note that these two values are not the same as the ASCII characters 2 and 0. Most computer languages allow you to build these bytes in a string such as the expression A + CHR\$(2) + CHR\$(0) + C). Transmission on the bus starts immediately after the C is sent with the message number specified by line 512 of the sequence program.

<u>Command</u>	<u>Description</u>
----------------	--------------------

C	The C (Continue) command starts bus controller operation at the current line number of the sequence program. The line number is set at 0 (hexadecimal 0000) at power-up and at reset. The current line number may be specified by the A (Address) command.
---	--

The C command may be used in conjunction with the Q (Quit) command, or External Halt front-edge-connector input, or byte 2 bit 3 of a sequence program message word (see S command) for a pause (i.e., breakpoint) and continue capability.

Example 1:

Send the character Q (Quit command) to the 53A-454 Card. Assume the card is transmitting the message defined by sequence program line number 31. If a Q is issued during this period, operation on the 1553 bus stops just prior to execution of sequence program line number 32 (allowing time for any RT response to be collected and stored). The current sequence line is then 32.

Send the character C to the 53A-454 Card at some subsequent time. Transmission on the 1553 bus commences immediately with the message defined in sequence program line number 32.

Example 2:

Assume byte 2 bit 3 (breakpoint bit) in line 730 of the sequence program is set. The 53A-454 Card transmits the message defined by line 729, waits for the response, and then terminates transmission on the 1553 bus just prior to transmitting the message defined by line 730.

Send the character C to the card at some subsequent time after transmission has halted. Transmission on the 1553 bus commences immediately with the message defined in line 730 of the sequence program. If the C command is sent to the card prior to it halting at line 729 of the sequence program, the C command will be ignored.

<u>Command</u>	<u>Description</u>
E	The E (External) command arms the External Trigger, External Halt, and External Halt/Reset to line 0 input signals on the front-edge connector of the 53A-454 Card. These signals control the starting and stopping of bus controller operation via external hardware inputs. See Appendix B, pins 20 through 22 for a detailed description of how each input functions. This command remains in effect unless cancelled by a Q (Quit) command, a K (Kill) command or by a system controller reset.

NOTE: The E command prepares the bus controller to transmit awaiting an External Trigger. The transmission will begin with the buffer specified in the first sequence instruction (S command), which will be the instruction at location 0 or the location specified previously by an A command. If a system controller interrupt is desired to indicate that the external trigger signal has occurred, the sequence instruction which follows the first instruction would be programmed with the RFI bit set to 1.

<u>Command</u>	<u>Description</u>
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F	The F (Flag) command requests status from the 53A-454 Card.
---	---

An 8-bit (1-byte) value is returned by the 53A-454 Card in response to a system controller input following the F command. Bit definition of the returned value is as follows:

- Bit 7 - Transmitter off, bus controller stopped = 1
- Bit 6 - Error detected in received RT data, error = 1 (bit is cleared after byte Z₁ is returned)
- Bits 5 through 0 - Execution count remaining

Example:

Send the character F to the 53A-454 Card. The command may, optionally, be followed by a carriage-return and line-feed.

Input from the 53A-454 Card. A single 8-bit byte, followed by a carriage-return and line-feed, is returned. Assume, for example, that the 8-bit value returned is 9. The binary equivalent of 9 is 00001001. Bit 7 is not set, indicating that the 53A-454 Card is actively executing a sequence program (i.e., not paused or halted). Bit 6 is clear, indicating that there are no errors on received data. Bits 5 through 0 contain the value 9, indicating that nine passes remain in the execution count.

Subsequent input requests return a single carriage-return character if the transmitter is off, or a single line-feed character if the transmitter is active on the bus.

<u>Command</u>	<u>Description</u>
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G	The G (Go) command starts bus controller operation at sequence line number 0.
---	---

The G and C (Continue) commands both start execution of the sequence program and transmission on the 1553 bus. The G command differs from the C command in that it resets the sequence program counter to 0 before starting execution, instead of leaving the sequence program counter as it was.

The G command is useful for restarting the same sequence program repeatedly, starting at sequence program line number 0 each time.

Example:

Send a Q (Quit) command to a 53A-454 Card which is actively transmitting the message defined by sequence program line number 10. The card terminates transmission on the bus just prior to transmitting the message specified by sequence program line number 11.

Send a G command to the card. The card does not start transmitting sequence program line number 11; but instead, resets the sequence program counter to 0, and starts transmitting the message specified by sequence program line number 0.

<u>Command</u>	<u>Description</u>
J	The J (Jitter) command inhibits or enables the transition-time (jitter) error detection of the 53A-454 Card's 1553 receiver.

Syntax: JZ

Z specifies one of two values:

An odd value (ASCII 1 or hexadecimal FF for example) enables jitter error detection.

An even value (ASCII 0 or hexadecimal 00 for example) disables jitter error detection.

When this error condition is enabled, the 1553 bit-transition times of responding RT units must be the proper number of 500 ns increments from the last mid sync pattern transition as required by MIL-STD-1553, within the following tolerance. If the transition time is within 62.5 ns of where it should be with respect to the last mid-sync transition, it will not cause a transition-time error. If the transition time is more than 187.5 ns from where it should be with respect to the last mid-sync transition, it will always generate a transition-time error. If the transition time is between these two limits, it may generate a transition-time error, depending on the phase relationship between the incoming RT signal and the 53A-454 Card's internal 16-MHz clock. When a transition time error is detected, it is noted and stored as a part of the received RT response word (see the R command).

When jitter detection is disabled, the transition time of received RT data is not checked. In either case, i.e., jitter error enabled or inhibited, all other RT error conditions are checked.

When the jitter error condition is enabled and a transition-time error occurs, it is stored in the receive buffer and as a receiver error for the F (Flag) command; it also lights the ERR LED. When transition time detection is inhibited, transition-time errors are not stored in the receiver buffer, or the Flag status word, and the ERR LED is not lit for that particular error.

The 53A-454 Card powers up with the jitter error condition enabled.

Example 1:

Send the character J, followed by a binary byte value of 0, to inhibit the jitter error condition.

Example 2:

Send the character string J1 or the character string J + CHR\$(255) (as defined by BASIC language syntax) to the 53A-454 Card to enable the jitter error condition. The J command may, optionally, be terminated by carriage-return and line-feed characters, if desired.

<u>Command</u>	<u>Description</u>
K	The K (Kill) command resets the 53A-454 Card. Bus controller operation ceases immediately, and all card parameters are restored to their power-up state. See the <u>Specifications</u> section for a definition of the 53A-454 Card's state on power-up.

Example 1:

If the card is transmitting a sequence of messages at a level of 10V PTP on the direct-coupled bus with the card programmed for the MAC Air mode and the character K is sent to the card, the 53A-454 Card stops transmitting, the transmit level is reprogrammed to 6V PTP, the MAC Air mode is turned off, and the sequence program is replaced by the single-message power-on sequence program.

Example 2:

If the character K is sent to the card in the midst of the data bytes that are part of a T (Transmit) command, the K is not recognized as a Kill command but as the next byte of data in the T command. S and T commands must transmit the full number of data words defined in their header words before another card command can be issued.

Command Description

M **The M (MAC Air) command programs the 53A-454 Card for transmitter operation per McDonnell Douglas Specification MDC A3818.**

Syntax: MZ

Z is one byte long. An odd value (ASCII 1 or hexadecimal 01 for example) specifies MAC Air transmitter operation. An even value (ASCII 0 or hexadecimal 00 for example) specifies standard MIL-STD-1553A/B transmitter operation.

The receiver for the 53A-454 Card is designed to receive either waveform when the card is programmed for either mode.

For MAC Air operation, the transmit waveform is filtered with a two-pole filter. A nominal rise and fall time (10% to 90%) of 320 ns, provides a compatible waveform for the MAC Air bus.

The peak-to-peak transmit and receive levels programmed by the X (X-value) and Y (Y-value) commands, respectively, are applicable in both the MIL-STD-1553 and MAC Air modes.

The card powers up in the MIL-STD-1553 mode. If the MAC Air specification is being implemented, an M command should be issued after every power-on/off sequence, K command, or system controller reset.

Example:

The character string M + CHR\$(1), as defined by BASIC language syntax, or the character string M1 is sent to the card. This programs the transmitter to output a waveform for use with McDonnell Douglas Specification MDC A3818.

<u>Command</u>	<u>Description</u>
----------------	--------------------

N	<p>The N (Number) command outputs an execution count for the sequence program. When bus controller operation is started, the execution count is decremented each time the sequence program encounters a sequence message instruction with the execution-count bit set to 1. If the execution count is 0 when bus controller operation begins, the execution count remains 0, and transmission continues forever or until a Q(Quit), K (Kill), or non-zero N command is sent.</p>
---	--

Syntax: NZ

Z specifies the initial count before decrementing. The value can be set at 0 to transmit forever or, if an automatic stop function is desired, between 1 and 64 (hexadecimal 40).

After transmission on the bus is completed, the execution count is at 0; a new N command must be issued before each transmission if a non-zero value is again required.

The current remaining execution count can be read at any time with the F (Flag) command.

On power-up, system controller reset, or following a K command, an execution count of 0 is programmed on the card.

Example 1:

The character string N + CHR\$(1) using BASIC language syntax is sent to the 53A-454 Card, and the message-number word in line 10 of the sequence program has the execution-count bit set to 1. A trigger or G (Go) command to the card executes the sequence program through line 10, decrements the execution count to 0, and stops transmission on the 1553 bus.

Example 2:

A 10-line sequence program has the execution-count bit set to 1 in lines 3 and 9, and a go to line 0 command in line 10. The character string N + CHR\$(34) using BASIC language syntax is sent to the card, followed by a G (Go) command. The execution count is decremented each time the sequence program passes through lines 3 and 9. Following the 17th transmission of the message specified in line 9, the execution count decrements to 0, and transmission stops. If another G command is issued immediately, the card will transmit forever because the execution count is still at 0 following completion of the previous transmission.

<u>Command</u>	<u>Description</u>
----------------	--------------------

P	The P (Pattern) command, along with the pattern-armed bit of a sequence-message instruction, arms conditional branching of the sequence program to an alternate specified sequence line number on occurrence of a specified RT status word. As incoming RT status words are received, they are compared to the pattern specified by this command. A subsequent pattern match causes the sequence program to go to the sequence program line number defined by this command.
---	---

Syntax: PZ₁Z₂

Z₁ is two bytes in length and specifies the sequence program line number (2 bytes) that is executed following recognition of the pattern match. The 53A-454 Card inserts this line number in a go to command at line 1023 (hexadecimal 03FF), the last line of the sequence program; the user must reserve this location for that purpose by not using sequence program line 1023 if the pattern command is to be used.

Z₂ is two bytes in length and specifies the RT status word, a 16-bit (2-byte) pattern.

Example 1:

The sequence program has already been programmed with the pattern-armed bit set to 1 in lines 7, 8, and 14. The command string P + CHR\$(0) + CHR\$(20) + CHR\$(204) + CHR\$(0) using BASIC language syntax is sent to the card, followed by a G (Go) command. If an RT status word of hexadecimal value 'CC00' is sent back from an RT in response to the message sent out at line 7, 8, or 14, the sequence program goes to line 20, and transmits the message specified in that line.

In building the above command string, CHR\$(0) and CHR\$(20) represent the 2-byte line number 20. CHR\$(204) 'CC' is as follows; $12 * (16) + 12 = 204$. CHR\$(0) represents hexadecimal '00' which completes the pattern 'CC00'.

The pattern 'CC00' is a status word response from RT 25 with the message-error bit set (see MIL-STD-1553).

Example 2:

The pattern-armed bit is set to 1 in sequence program line 9, but no pattern command has been sent since the last K (Kill) command or reset. In this case, no pattern match occurs because the P command and the pattern-armed bit set to 1 are both required arming conditions.

<u>Command</u>	<u>Description</u>
Q	<p>The Q (Quit) command stops bus controller transmission on the bus without altering or erasing the sequence program, transmit-message data, receive-message data, or setup parameters. The sequence program completes its current transmit/receive instruction, and ceases all 1553 activity at the end of the sequence time programmed for that message (which allows any response data to be collected). The F (Flag) command may be used to determine the stopped condition.</p> <p>The Q command does not alter the sequence program's address pointer, and a C (Continue) command may subsequently be issued to continue the sequence program where it left off.</p>

Command Description

R The R (Receive) command prepares the 53A-454 Card to return an RT response to the system controller, including data and errors as received from the 1553 bus. All received data, contiguous or not, prior to the next transmission, are collected as long as the buffer length is not exceeded.

Syntax: RZ₁Z₂Z₃

Z₄ represents the data returned to the system controller, four bytes for each of the number of MIL-STD-1553 words specified by Z₁. R, Z₁, Z₂ and Z₃ are the four bytes sent to the 53A-454 Card that make up the header word for the R command. Z₄ is the data returned to the system controller; its length is specified by Z₁. The header word is an output from the system controller, and Z₄ is input from the 53A-454 Card to the system controller. A carriage-return and line-feed character may, optionally, be sent after the header word, prior to the input of Z₄.

R First Output Byte	Z ₁	Z ₂	Z ₃ Last Output Byte	
R Character	Word Count	8-Bit Message Number	2-Bit Bank No.	6-Bit Offset

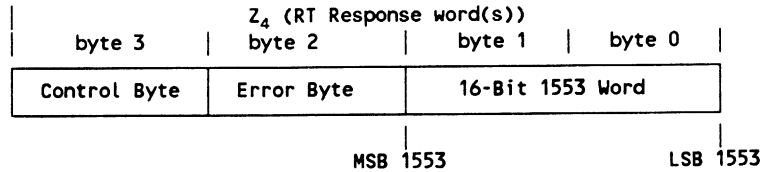
Z₁ is one byte long, and specifies the word count. Legal RT message responses may not exceed 33 words including the status word. If an illegal response is sent by the RT, the response length may not exceed 59 words with the next word indicating the end of the response buffer. If the message length must be confirmed, an additional 1553 word should be input after the RT response message and the last-word indication verified using the control bits returned with the four byte 1553 word. (The last buffer word follows the last RT response word.) The total of all RT response words plus transmit-message words in a transmit/receive buffer may not exceed 63.

Z₂ is a single 8-bit byte that specifies the message buffer number from which data is to be read. The message buffer number will be the same as for the transmit buffer number which contained the command word causing the response that is to be read by this R command.

Z₃ is a single 8-bit byte that contains the 2-bit bank number in the two most significant bits and a 6-bit offset value in the six least significant bits. The offset value permits random access of any receive word in the buffer. An offset value of 0 will start reading at the first word received. An offset value of 4 will cause the read to start at the fourth response word in the buffer.

NOTE: A memory test may be implemented by outputting with the T command to each buffer, and reading back from the same buffer. The 6-bit offset address for reading back the memory test is the 6-bit two's complement of the 6-bit offset address for transmitting (data sent to address '3700' would be read from address '373F').

Z_4 specifies the data returned to the system controller, four bytes for each MIL-STD-1553 data word returned. The number of MIL-STD-1553 words returned is equal to Z_1 , the word count. The number of bytes equals 4 times Z_1 . Each RT response word includes the 1553 data, the polarity of the sync pattern of the word, receive errors detected for the word, and control bits indicating last word in the receive buffer, last word in the 1553 message, and response time in excess of the value programmed by the Z command. The data returned is formatted as follows.



Definition of the four bytes for each word is as follows; byte 3 is returned first:

Byte 3 - Control byte

- Bit 7 - Status sync = 1; data sync = 0
- Bit 6 - Response-time error = 1
- Bit 1 - Interword gap following 20-bit word time = 1
- Bit 0 - No response data in buffer = 1

Byte 2 - Error byte (See Appendix C for detailed error descriptions).

- Bit 7 - Sync error
- Bit 6 - Too many bits
- Bit 5 - Too few bits
- Bit 4 - Parity error
- Bit 3 - Incorrect transition time (jitter)
- Bit 2 - Manchester error
- Bit 1 - Dropped bit error
- Bit 0 - No error

NOTE: Error(s) occurred when specified bit is set to 1.

Bytes 1 & 0 - 16-bit MIL-STD-1553 word content. The MSB of byte 1 is 1553 data bit 4, the LSB of byte 0 is 1553 data bit 19. Per MIL-STD-1553, a word is described as 20 bits in length. Bits 1 to 3 are the sync pattern. Bits 4 through 19 are the 16 bits of data and bit 20 is the parity bit. Bit 1 is transmitted first. Bits 4 through 19 of MIL-STD-1553 word therefore correspond to bits 7 to 0 of byte 1 and bits 7 to 0 of byte 0 returned from the 53A-454 Card.

<CR><LF> is returned by the 53A-454 Card after Z_4 is sent to the system controller. The word count Z_1 defines when <CR><LF> is sent by the card. The system controller should not terminate input on carriage-return <CR> or line-feed <LF> when reading response data though, because the data may contain a byte equivalent to either of these termination characters. Instead, input should be terminated based on the byte count specified by Z_1 (the byte count equals the 1553 word count or Z_1

on the byte count specified by Z₁ (the byte count equals the 1553 word count or Z₁ times four). Reading the terminating <CR><LF> sent by the 53A-454 Card is optional.

If the amount of data in the response buffer is unknown, the word count may be programmed for the maximum value of 63, and words read back until a 1553 word is returned with byte 3, bit 1, set to a 1. The additional bytes may be read and ignored, or the R command may be terminated by outputting a new command to the card.

Example 1:

This example reads the response data in message buffer 230 of bank 2. One status word and one data word are expected in the buffer, so three words are read to make sure there are only two words in the buffer. (The starting memory address of receive buffer 230 bank 2 is hexadecimal 'E680').

Send the 4-byte header-word string shown below in BASIC language syntax:

R + CHR\$(3) + CHR\$(230) + CHR\$(128)

Read back 14 bytes from the card. The decimal values for the 14 bytes could be, for example, 128, 1, 48, 0, 32, 1, 2, 2, 1, 0, 0, 0, 13, and 10, indicating the following:

- Byte 1 - Status sync polarity
- Byte 2 - No errors
- Bytes 3,4 - Hexadecimal '3000', a no-error status word from RT 6 (see MIL-STD-1553)
- Bytes 5-8 - Data word with an interword gap following it, no errors, and a hexadecimal value of '0202'.
- Byte 9 - Previous word was last word in response buffer
- Bytes 10-12 - Don't care values
- Bytes 13,14- <CR><LF> termination sent by 53A-454 Card after the three words specified by Z₁ are sent

The values 48 and 0 in bytes 3 and 4 convert to hexadecimal '3000' as follows. 48 = 00110000 = '30' hex; 0 = 00000000 = '00' hex.

Command Description

S The S (Sequence) command is used to send sequence program instructions to the 53A-454 Card sequence list buffer that specify the order in which messages contained in the cards transmit buffers will be sent on the 1553 bus. The two types of sequence program instructions are message sequence instructions and go to instructions. Message and go to instructions both may be programmed in a single S command.

Syntax: SZ₁Z₂Z₃

S, Z₁, and Z₂ are a total of four bytes long, and make up the header word for the S command. Z₃ is the actual program content (message and go to instructions); its length is specified by Z₁.

S byte 3	Z ₁ byte 2	Z ₂ byte 1	Z ₂ byte 0
S Character	Word Count	6-Bit Value of 0	10-Bit Starting Sequence Line No.

Z₁ is a single 8-bit binary byte with a value from 1 to 63 which specifies the word count for the sequence program data in Z₃. Each word in Z₃ is a 4-byte message instruction or go to instruction; therefore, the number of bytes in Z₃ is, four times the value of Z₁.

Z₂ is two bytes long, and specifies a 16-bit value. This value is the starting sequence program line number at which to load the program information supplied in Z₃. The starting sequence line number is a value from 0 to 1023 (hexadecimal 0000 to 03FF). (The physical memory address of a sequence program line number is the same value as the line number, so Z₂ is also specifying the physical memory location at which to start loading the program information in Z₃.) The two bytes of Z₂ are each an 8-bit binary value. The first byte sent consists of the most significant eight bits of the 16-bit line number value, and the second byte transmitted consists of the least significant eight bits of the line number. The top six bits of the first byte are always 0's because the maximum line number (memory location) is 1023.

Z₃ has two different 4-byte formats, one for message instructions, and the other for go to instructions. These two formats are described separately below, but they may be intermixed within the same Z₃ block of data. The first byte of Z₃ must follow Z₂ without any carriage-returns, line-feeds, or other extraneous characters between. Also, consecutive words (four bytes each) of Z₃ must not be separated by any extraneous characters. The number of words (each consisting of 4-bytes) must exactly equal Z₁, to allow the 53A-454 Card to differentiate between sequence program instructions and a new command following the S command. A carriage-return and line-feed may, optionally, follow the complete S command.

For a message-instruction word, Z₃ specifies the message number of the transmit/receive buffer of a message to be transmitted, timing between this message and the next, and control bits active during the time the message is being transmitted. The four bytes for a message-instruction word are described below; byte 3 is transmitted first:

Z ₃ (Message-Instruction Word)			
byte 3	byte 2		byte 1
8-Bit Message Number	2-Bit Bank No.	6-Bit Control Word	16-Bit 1553 Word Messages (in microseconds)

Byte 3 - 8-bit transmit/receive buffer number. Valid buffer numbers are 4 through 255.

Byte 2 - Bank number (upper two bits), control byte (lower six bits).

Bit 7-6	-	Bank number
00		Bank 0
01		Bank 1
10		Bank 2
11		Bank 3
Bit 5	-	Request for interrupt (RFI) = 1
Bit 4	-	Decrement execution count = 1
Bit 3	-	Breakpoint = 1
Bit 2	-	Sequence message trigger at card edge = 1
Bit 1	-	Pattern armed = 1
Bit 0	-	Undefined

The control bits provide the following functions:

Request for interrupt: The system controller is interrupted when an instruction with this bit set to 1 is the next instruction to be implemented.

Decrement execution count: If a non-zero value has been loaded as the execution count (see N command), the value is decremented towards 0 when a control word is encountered with this bit set to 1. The message instruction which decrements the value to 0 is the last instruction carried out before terminating 1553 data transmission. The current execution count value can be determined with the F (Flag) command. If the Pattern is armed and detected for a particular sequence, and the execution count decrements to 0 for the same instruction, 1553 bus transmission will stop and the program will not sequence to the P command line number.

Breakpoint: 1553 Bus transmission stops after to transmitting this sequence message when the bit is set to 1. Transmission may be resumed with the C (Continue) command.

Sequence trigger: The sequence trigger TTL output on the front card edge cycles low for 18 us, coincident with the start of transmission of the first word in the transmit message.

Pattern armed: If this bit is set to 1 and a P (Pattern) command has been previously programmed, the program sequences to the alternate sequence line number programmed by the P command when the RT status word received matches the pattern programmed by the P command. This provides a conditional branching capability for the 53A-454 Card based on the RT status response. If the pattern match occurs, a minimum delay of 30 microseconds will occur before the 53A-454

Card begins transmitting the message pointed to by the P command. If the pattern match does not occur or the programmed delay following the Status Word exceeds the minimum, timing is not affected.

Bytes 1,0 - Sequence time. A 16-bit value specifies the message time in microseconds. The most significant bit is in byte 1. Byte 1 is transmitted first. The maximum value is 65535 microseconds. The minimum value is 24 microseconds. The time is specified from the start of this message to the start of the next message. Additional timing capability (for timing greater than 65 msec, or a delay prior to the first message for dual-redundant bus controller A delay B or B delay A applications) at the beginning of a sequence is provided by error F (no transmit error) in the error byte of data for the T command (see T command).

For a "go to" instruction word, Z₃ specifies a sequence program go to line number as four bytes. Each sequence go to word contains the 10-bit line number of the next sequence program instruction. Valid "go to" line numbers are 0 through 1023. Location 1023 is used by the P command when programmed and should be reserved if the P command is to be used. The four bytes are defined as follows:

Z ₃ (Go To Instruction)			
byte 3	byte 2	byte 1	byte 0
6-Bit Value of 0	10-Bit Sequence Line Number	16-Bit Don't Care	

Byte 3 - The most significant two bits of the next sequence program address (line number). These two bits are the least significant two bits of this 8-bit byte; the most significant six bits of this byte are all 0's.

Byte 2 - The least significant eight bits of the next sequence program address (line number).

Bytes 1,0 - (Not used at this time)

NOTE: The 53A-454 Card differentiates between a message instruction and a go to instruction by the contents of byte 3. The most significant six bits of byte 3 are always non-zero for a message instruction (message numbers are always 4 or greater), and zero for a go to instruction.

Example 1:

This example programs a single message (message number 4 in bank 0) followed by a go to line 0 instruction in sequence program locations 0 and 1 respectively. The time from the start of one transmission of message 4 to the start of the next transmission is 1 ms (1000 us). A go to instruction is always required if a program is to be executed more than once without further commands.

NOTE: In the examples shown below, BASIC language syntax has been used to show how data strings to be sent to the 53A-454 Card are constructed.

Send the following 4-character header word to the card to specify a sequence program two lines long, to be loaded starting at line 0:

$S + \text{CHR}\$(2) + \text{CHR}\$(0) + \text{CHR}\$(0)$

Immediately following the header word, without any carriage-return, line-feed, or other extraneous characters in between, send the following four bytes: $\text{CHR}\$(4) + \text{CHR}\$(0) + \text{CHR}\$(3) + \text{CHR}\(232) .

$\text{CHR}\$(4)$ specifies message number 4. $\text{CHR}\$(0)$ specifies bank 0 and no control bits set to 1.

$\text{CHR}\$(3) + \text{CHR}\(232) specifies a message spacing of 1000 us ($3 * 256 + 232 = 1000$). The two bytes may be determined by dividing 1000 by 256 which equals 3 with a remainder of 232.

Immediately following the above four bytes, without any carriage-return, line-feed, or other extraneous characters in between, send the four bytes:

$\text{CHR}\$(0) + \text{CHR}\$(0) + \text{CHR}\$(0) + \text{CHR}\(0) which specify a go to line 0 instruction.

Example 2:

This example programs a 3-message sequence, starting at location 300, with a go to line 300 instruction at the end of the program. The message/buffer numbers for the transmission sequence are message number 5, 6, and 100, all in bank 1. The message spacing is 2.5 ms between messages 5 and 6, 5 ms between messages 6 and 100, and 12.5 ms between messages 100 and 5. To decrement the execution count, the execution-count bit is set to 1 in line 302 when message 100 is transmitted.

NOTE: In the examples shown below, BASIC language syntax has been used to show how data strings to be sent to the 53A-454 Card are constructed.

The resulting S command is the following 20-byte character string. The derivation of each byte's value is left as an exercise for the reader:

The header word is:

$S + \text{CHR}\$(4) + \text{CHR}\$(1) + \text{CHR}\$(44)$

The string specifying the three message numbers, message times, and decrement-execution-count bit is:

$\text{CHR}\$(5) + \text{CHR}\$(64) + \text{CHR}\$(9) + \text{CHR}\$(196) +$
 $\text{CHR}\$(6) + \text{CHR}\$(64) + \text{CHR}\$(19) + \text{CHR}\$(136) +$
 $\text{CHR}\$(100) + \text{CHR}\$(80) + \text{CHR}\$(48) + \text{CHR}\(212)

For the third message, $\text{CHR}\$(80)$ specifies a value of 64 plus 16. The 64 specifies bank 1 and the 16 specifies decrement-execution-count bit.

The string to specify the go to line 300 instruction is:

$\text{CHR}\$(1) + \text{CHR}\$(44) + \text{CHR}\$(0) + \text{CHR}\(0)

300 divided by 256 equals 1 with a remainder of 44.

Command Description

T The T (Transmit) command is used to send messages to individual 53A-454 Card transmit buffers that describe the data and errors to be sent on the 1553 bus.

Syntax: TZ₁Z₂Z₃Z₄

The order in which transmit buffer messages are sent out on to the 1553 data bus is determined by the cards message sequence list buffer (see S command). A message buffer may be accessed more than once in a sequence program.

T, Z₁, Z₂, and Z₃ make up the 4-byte header word for the T command. Z₄ is the transmit data; its length is specified by Z₁.

T byte 3	Z ₁ byte 2	Z ₂ byte 1	Z ₃ byte 0	
T Character	Word Count	8-Bit Message Number	2-Bit Bank No.	6-Bit Offset

Z₁ is one byte long, and specifies the word count. Legal bus controller messages may not exceed 33 words including the command word. If an illegal message of greater length is to be sent, the message may be as long as 62 words if the RT response is one word. The total of all transmit words plus RT response words in a buffer may not exceed 63.

Z₂ is a single 8-bit byte that specifies the message buffer number for which transmit data is to be defined in this command. Valid message buffer numbers are 4 through 255. The response data sent by an RT in response to the command word in this buffer will be accessed using the R command and specifying this same buffer number.

Z₃ is a single 8-bit byte that specifies the 2-bit bank number for the message (most significant 2-bits) and a 6-bit buffer offset (least significant 6-bits). The 6-bit buffer offset may be used to randomly update any word in the buffer without having to reload all data from the top of the buffer. For example, the 20th word in the buffer (data word 19 in a 1553 message) could be updated by itself by setting the 6-bit buffer offset to 20 and the word count in byte Z₁ to 1.

Z₄ specifies the transmit words, four bytes each. The number of words is equal to Z₁, the word count. The number of bytes equal 4 times Z₁. Each transmit word includes the 1553 data, the polarity of the sync pattern of the word, error codes defining the transmission error(s), and control signals for the 53A-454 Card that are active during word transmission. The four bytes of each word are defined as follows:

Z ₄ (transmit words(s))			
byte 3	byte 2	byte 1	byte 0
Control Byte	Error Byte	16-Bit 1553 Word	
		MSB 1553	LSB 1553

Byte 3 - Control byte

- Bit 6,7- Don't care
- Bit 5 - Command or status sync = 1; data sync = 0
- Bit 4,3- Don't care
- Bit 2 - Transmit word trigger at front connector = 1
($\frac{1}{2}$ μ sec low pulse coincident with the beginning of the word)
- Bit 1 - Don't care
- Bit 0 - Last word of message = 1

NOTE: The last 1553 data word in a given message buffer must have bit 0 of its control byte set to a 1. Failure to do so may result in continuous transmission of additional random 1553 data words on the 1553 bus.

- Byte 2 - Error code (See Appendix C for details). The error code below is contained in the most significant four bits, followed by four bits which further characterize the error:

Error Number	Error	Bits 7,6,5,4	Bits 3,2,1,0
1	Manchester error	0001	XXXX
2	Dropped bit	0010	XXXX
3	Early bit-transition time	0011	XXXX
4	Late bit-transition time	0100	XXXX
5	Intermessage gap	0101	XXXX
6	Too few bits	0110	XXXX
7	Too many bits	0111	XXXX
8	Parity bit	1000	XXXX
9	Sync signal	1001	XXXX
F	No transmit	1111	0000

Bits 3 through 0 are described in Appendix C.

For error F, the transmit signal will be suppressed during the transmitted word interval. This capability may be used to create a No Operation cycle on the 1553 data bus for an entire sequence cycle. This is useful for creating message spacings of greater than 65,535 milliseconds and for creating an initial transmit delay time so that two cards started by the same external trigger may be delayed with respect to each other by an accurately specified amount of time.

Bytes 1 & 0 - 16 bit MIL-STD-1553 word content. The MSB of byte 1 is 1553 data bit 4, the LSB of byte 0 is 1553 data bit 19. Per MIL-STD-1553, a word is described as 20 bits in length. Bits 1 to 3 are the sync pattern. Bits 4 through 19 are the 16 bits of data and bit 20 is the parity bit. Bit 1 is transmitted first. Bits 4 through 19 of MIL-STD-1553 therefore correspond to bits 7 to 0 of byte 1 and bits 7 to 0 of byte 0 on the 53A-454 Card.

The first byte of Z_4 must directly follow Z_3 , without any carriage-returns, line-feeds, or other extraneous characters between. Also, consecutive words (four

bytes each) of Z_4 must not be separated by extraneous characters. The number of words in Z_4 must exactly equal Z_1 to allow the 53A-454 Card to differentiate between transmit data and a new command following the T command. A carriage-return and line-feed may, optionally, follow the complete T command.

Example:

This example programs message number 18 in bank 1 (memory location hexadecimal 1240) with a command word and three data words.

The command word is for RT 5, subaddress 3, with the T/R bit clear and word count = 3. The binary representation for the 16 data bits of the command word is 0010100001100011 (see MIL-STD-1553) or hexadecimal '2863'.

The three data words are hexadecimal '1234', '5678', and '9ABC'. The second data word is programmed with incorrect parity (see Appendix C). The resulting string is 20 bytes long; the header word is four bytes, the command word is four bytes, and the three data words are four bytes each.

Using BASIC language syntax, the 4-byte header-word string is:

`T + CHR$(4) + CHR$(18) + CHR$(64)`

The second byte specifies that four words follow. The third and fourth bytes specify message 18 and bank 1.

Again using BASIC language syntax, the command-word string is:

`CHR$(32) + CHR$(0) + CHR$(40) + CHR$(99)`

The first byte specifies a command sync, the second byte specifies no errors, and the third and fourth bytes specify hexadecimal 2863 ($2*16 + 8 = 40$, $6*16 + 3 = 99$).

The three data-word strings are:

`CHR$(0) + CHR$(0) + CHR$(18) + CHR$(52) + CHR$(0) + CHR$(129) +
CHR$(86) + CHR$(120) + CHR$(1) + CHR$(0) + CHR$(154) + CHR$(188)`

The first byte of the first two words specifies a data sync; the first byte of the last word specifies a data sync, and that this is the last word in a 1553 message.

The second byte of each word specifies its error condition; no errors for the first and last words, incorrect parity for the second word.

The third and fourth bytes of each word specify the 1553 word contents.

The 20 bytes must be transmitted without any extraneous characters in between. A carriage-return and line-feed may, optionally, follow the last byte.

Command

Description

W

The W (Where) command is used to request the value of the current sequence program line number being executed by the 53A-454 Card. The command permits synchronization of the system controller program to the sequence program so that memory changes can be made without causing partial word or message errors while the real-time bus controller is operating.

The current 10-bit line number is returned by the 53A-454 Card as two bytes in response to a system controller input following the W command. The 10-bit value is in the least significant ten bits of the two bytes; the high byte is sent first. The binary values returned will range from '0000' hex to '03FE' hex. The bytes will be terminated with <CR><LF>.

Example:

A sequence program with 27 messages has been programmed on the card, and is executing continuously every 50 ms. Through an analysis of the message spacing and the system controller speed, it has been determined that input to the system controller and output of new transmit data should start when the 53A-454 Card begins transmitting the message at line 20 in the sequence program. All required responses can then be read back by the system controller without reading any responses before they are available; and the transmit buffers for all 27 messages can be updated with a single system controller DMA transfer prior to the start of the next 50-ms cycle.

Set up a loop which sends a W character and reads back two bytes. As soon as the 2-byte binary response indicates 0 in the first byte and decimal 20 in the second byte, the desired data update can start.

NOTE: If, for some reason, a W command cannot be sent continuously and the system controller has fast interrupt processing, you can program byte 2, bit 5, of a message-instruction word to generate an interrupt at the start of any sequence program line.

If after inputting the current 10-bit line number followed by <CR><LF>, successive input requests are made to the card without issuing a W command prior to each input, a line-feed character will be returned if the card is transmitting data on the 1553 bus and a carriage-return character will be returned if it is not.

Command Description

X The X (X-value) command defines the peak-to-peak voltage setting for the 53A-454 transmitter.

Syntax: XZ

Z specifies the 8-bit (1-byte) amplitude that provides 255 steps of programming resolution.

The peak-to-peak voltage varies according to the value Z, the bus loading, and where the output voltage level is measured in the users test system. On power-up, a 6V PTP level on the direct-coupled output into a 35-ohm load is programmed.

Voltage testing is explained in detail in Appendix D in the application note, MIL-STD-1553 Production Electrical Testing. The following voltage ranges and programming step values are provided for the indicated conditions. The first three voltage cases are measured directly at the output of the 53A-454 Card with the specified loads. The fourth condition is on the actual 1553 bus.

<u>Condition</u>	<u>Range</u>	<u>Resolution</u>
Direct-coupled output, 35 ohm	.06 - 10.2V PTP	.040V PTP
Direct-coupled output, 70 ohm	.10 - 17.0V PTP	.066V PTP
Transformer-coupled output, 70 ohm	.17 - 29.7V PTP	.116V PTP
1553 bus - terminated and connected to per MIL-STD-1553 (assuming 70-ohm bus terminations)	.06 - 10.2V PTP	.040V PTP

Example:

A peak-to-peak voltage of 20V is to be programmed on the transformer-coupled output. The maximum output of 29.7V is equivalent to the maximum X-value of 255. The minimum output of 0.17V is equivalent to the minimum X-value of 0.

$$Z_1 = (20.0 - .17)(255) / (29.7 - .17) = 171.2$$

Using BASIC language syntax, send the 2-byte character string X + CHR\$(171) to program the transmit level at 19.97V PTP.

Command Description

Y The Y (Y-value) command programs the receiver voltage threshold.

Syntax: YZ

Z specifies the 8-bit (1-byte) receive threshold amplitude; 255 steps with 39.2 mV resolution for each step are provided. Voltage testing is explained in detail in Appendix D in the application note titled MIL-STD-1553 Production Electrical Testing.

The programmed peak-to-peak threshold must be reliably exceeded by the input voltage to be detected as data. The threshold voltage can vary between 0.314V PTP and 10.00V PTP, in 248 steps according to the value of Z. Allowable values of Z are 8 through 255. On power-up, 1.333V PTP is programmed.

The above Y-values are referenced to the 53A-454 Card direct-coupled input. To determine the receive threshold in terms of the 53A-454 transformer-coupled input, multiply the voltage programmed by 0.707. For example, a Y-value of 25 programs a receive threshold of approximately 1.00V peak-to-peak on the direct-coupled input and .707V peak-to-peak on the transformer-coupled input.

A value of Z less than 8 will be accepted by the 53A-454 Card. However this level is starting to approach the receive noise level of the 53A-454 Card and is not recommended for reliable operation.

On power-up, after a system controller reset, or after a K command, the receive threshold is set to 1.33V peak-to-peak (referenced to the direct-coupled input).

Example:

Program the receive threshold for 2.35V peak-to-peak.

The maximum Y-value of 255 corresponds to a maximum receive threshold of 10.00V PTP.

For a receive threshold of 2.35V PTP:

$$Z = (2.35/10.00)(255) = 59.9$$

Using BASIC language syntax, send the 2-byte character string Y + CHR\$(60) to the card to program a receive threshold of 2.35V PTP.

<u>Command</u>	<u>Description</u>
Z	The Z (Z-value) command programs the maximum measured response time allowed for an RT response by the 53A-454 Card.

Syntax: Zz

Response time is defined as the time between the last mid-parity-bit transition of each bus controller transmission and the mid-sync transition of the RT response; MIL-STD-1553B specifies this interval as 4 μ s through 12 μ s, inclusive. If the measured interval exceeds the value set, a response-time error is indicated for the first word of the RT response. The value is set at 12 μ s at power-up.

z specifies the 8-bit (1-byte) interval output that defines the interval in 1/2-us increments. Values from 4 us (hexadecimal 08) to 127 us (hexadecimal FF) may be programmed.

Example:

MIL-STD-1553A specifies an 18-us maximum response time instead of the 14-us maximum response time specified by MIL-STD-1553B. To provide some operational margin for the unit under test, it is desired to program the maximum response time at 17.5 us on the 53A-454 Card.

The value is specified in $\frac{1}{2}$ μ s increments.

$$Z = (17.5/0.5) = 35.0$$

Using BASIC language syntax, send the 2-byte character string Z + CHR\$(35) to the 53A-454 Card to program the card to generate a response-time error when the RT response time exceeds 17.5 μ s.

APPENDIX A

53/63 SERIES SYSTEM COMMANDS

<u>Command</u>	<u>Description</u>
@XY	<p>The @XY command addresses a function card in the 53/63 Series System.</p> <p>The @ is a delimiter used by the 53/63 Series System. The X is a mainframe address (0-9) defined by the address-select switch on the 53A-171 Control Card in that mainframe; the Y is a function card address (0-9) defined by the address-select switch on the function card. Once a mainframe and function card combination is addressed, it remains addressed until the 53/63 Series System detects a new @ character.</p>
@XS	<p>The @XS (Status) command provides the status of all function cards within the mainframe defined by X. The mainframe backplane interrupt status of all function cards in the addressed mainframe is latched into the 53A-171 Control Card when the @XS command is issued. All function cards in all mainframes become unaddressed after the @XS command. The 53A-171 Control Card Operating Manual describes the @XS command in detail. The 53A-454 Card may be programmed to set the interrupt in the 53/63 Series System with a bit in the control byte of a sequence program message word (see S command).</p>
@XH	<p>The @XH (Halt) command halts all function cards within the mainframe defined by X. The command does not affect function cards in other mainframes. How a function card reacts to the @XH command depends on the card. In all cases, an addressed function card (Power LED out) becomes unaddressed (Power LED lit).</p> <p>On the 53A-454 Card, the position of the Halt Switch causes the @XH command to have the following effect: if the Halt Switch is ON, the 53A-454 Card resets to its power-up state; if the Halt Switch is OFF, the 53A-454 Card is simply unaddressed.</p>
STOP	<p>The STOP command is not a string of ASCII characters. The command is hard-wired from the system controller (calculator or computer) to the 53/63 Series System communications card in each mainframe.</p> <p>When the system controller issues a STOP command, each function card, including the 53A-454 Card, reacts as if it received the @XH command described above. On the 53A-454 Card, if a STOP command is issued during the middle of a Sequence, Transmit or Receive command and the halt switch is off, the card will become unaddressed and the data transfer aborted. The data transfer would have to be re-started for valid data transfer. If the halt switch was on, the card would become unaddressed, the data transfer aborted and the card returned to initial power-up conditions.</p> <p>How the system controller executes the STOP command depends on the communications card used. With the 53A-128 IEEE-488 Card, for example, a STOP command is executed when the system controller asserts the IEEE-488 bus line IFC (Interface Clear) true.</p>

APPENDIX B

FRONT-EDGE CONNECTOR PINS

PIN ASSIGNMENTS

<u>Pin Number</u>	<u>Function</u>
1	Transformer-coupled Output Hi
2	Transformer-coupled Output Lo
3	Direct-coupled Output Hi
4	Direct-coupled Output Lo
5	Common Mode Voltage Input
7	Gaussian Noise Input
8	Transmit Word Trigger
9	Reconstructed Received Data Output
10	Reconstructed Received Clock Output
11	Message Trigger
12	Buffered Transmitted Data Output
13	Buffered Transmitted Clock Output
14	Transmit Sync Polarity Output
15	External Clock Input
16	Receive Sync Polarity Output
17	Received Word Trigger
18	Receive Active Output
19	Transmit Active Output
20	External Halt and Reset to Line 0 Input
21	External Halt Input
22	External Trigger Input
23	Message Error Output
24	RT Response Error
H-BB	53/63 Series System Ground

PIN DESCRIPTIONS

1553 Bus Signals (Transformer-coupled: pins 1, 2; Direct-coupled: pins 3, 4)

Transformer-coupled and direct-coupled 1553 data bus signals available at the front-edge connector of the 53A-454 Card.

Common Mode Voltage Input (pin 5)

Through the Common Mode Voltage Input, the user can inject a common-mode voltage onto the 1553 data bus when the 53A-454 Card is direct-coupled to the data bus. See the Specification Section for required input signal levels and resulting Common Mode Output Voltages.

Gaussian Noise Input (pin 7)

For worst-case testing of bus devices, the Gaussian Noise Input lets the user input an external Gaussian noise source with a bandwidth of 1 kHz to 4 MHz onto the 1553 data bus. Gaussian noise of 1.581V RMS must be supplied to this input to generate the noise level specified by the noise test of MIL-STD-1553B. The power required for the Gaussian noise source to reach this level is 17 dBm (50 mW into a 50-ohm load). (The 53A-253 Gaussian Noise Generator Card provides noise signal outputs compatible with the 53A-454 Card input.)

Transmit Word Trigger and Message Trigger (pins 8, 11)

Individual output signals pulse low, if armed, for a specified transmit word or message. The TTL output on pin 8 pulses low for 1/2 usec if the Transmit Word Trigger bit is encountered in a transmit word (see T command, Z₄, byte 3 bit 2); the TTL output on pin 11 pulses low for 18 usec if the Message Trigger bit is set and encountered in the sequence program (see S command, Z₃, byte 2, bit 2). Both pulses start coincident with the beginning of the word or message.

Reconstructed Received Data/Clock Output (pins 9, 10)

Manchester-encoded TTL data received by the 53A-454 Card from the 1553 data bus is available at pin 9 as NRZ serial data. A reconstructed TTL clock is provided at pin 10 that transitions high when the data on pin 9 is stable. The clock transitions 16 times for each 1553 word (once for each data bit). The output is high for a Manchester one, low for a Manchester zero.

Buffered Transmitted Data/Clock Output (pins 12, 13)

Manchester-encoded data transmitted by the 53A-454 Card is also output as TTL-level NRZ serial data on pin 12. A TTL-level data clock is provided on pin 13 that transitions high when data is stable. The clock transitions 16 times for each 1553 word (once for each data bit). The output is high for a Manchester one, low for a Manchester zero.

Transmit/Receive Sync Polarity Output (pins 14, 16)

Individual outputs indicate command or data sync for the current 1553 transmit word, or status or data sync for the current 1553 receive word. The controller sync value is valid at pin 14 for all 16 transitions of the transmit clock on pin 13. The RT sync output at pin 16 is stable for all 16 transitions of the received clock on pin 10. The sync outputs are high for a data sync and low for a command or status sync.

External Clock Input (pin 15)

The External Clock Input lets the user vary the bit rate on the 1553 data bus by supplying an external clock signal. The external clock signal must be provided at a

frequency 16 times the desired bit rate. The external clock may vary between 15 MHz and 17 MHz, resulting in a bit rate between 937.5 kHz and 1.0625 MHz. The duty cycle of the clock input must be from 30% to 70%.

Received Word Trigger (pin 17)

During the sync signal of each received word, this signal cycles low to indicate a received word. The output cycles low for 16 us at bit-time 4 of the received word.

Receive/Transmit Active Outputs (pins 18, 19)

Individual outputs go to active-low when the receive or transmit cycle begins.

External Halt and Reset to Line 0 Input (pin 20)

This input provides the same function as the External Halt Input (pin 21), but returns the sequence program to line 0. This input must first be armed with the E command.

External Halt Input (pin 21)

The External Halt Input can be used to externally halt a 1553 bus communications sequence. When the External Halt Input is cycled low, the 53A-454 Card completes the message in progress on the 1553 bus including the time for RT response until the start of the next message, and returns control of the 53A-454 Card to the External Trigger Input. An External Trigger Input continues the sequence program at the next location following where the External Halt occurred. The External Trigger Input must first be armed with an E command.

External Trigger Input (pin 22)

The External Trigger Input is armed by an E command, and initiates bus controller operation when the signal is cycled low. Within 2 us after receiving the External Trigger Input signal, the 53A-454 Card begins communicating on the 1553 bus.

Message Error Output (pin 23)

The Message Error Output line pulses low each time an RT status word is received with bit 9 (Message Error) set. If there is a message error, the RT is reporting an error from the bus controller (the 53A-454 Card). This output can be used to switch bus controllers. Bit 9 is defined per MIL-STD-1553B. It corresponds to bit 2 of byte 1 of the 16 bit word as accessed by the 53A-454 Card R command.

RT Response Error (pin 24)

If a received RT word is accompanied by an error, a receiver error condition is latched and the RT Response Error output pin goes low. The RT error condition is cleared (RT Response Error output pin returned high) when the bus controller examines the error condition (F command).

Ground (pins G-BB)

53/63 Series system ground. All card input/output signals except for the 1553 Transformer and Direct Coupled inputs/outputs are referenced to this ground.

The shield of any 1553 data cables may also be connected to this point.

APPENDIX C

ERROR CODES

TRANSMIT ERRORS

Transmit errors, if desired, are specified in byte 2 of each Z_n transmit word (T command). One error may be generated on any word. The error code consists of two nibbles; the most significant 4-bit nibble indicates the type of error, and the least significant 4-bit nibble contains a qualifier for the error type. There are two types of errors: bit errors and word errors; the qualifier indicates the bit number for bit errors, and an error descriptor for word errors. A third type of error permits a no transmit condition. All codes are in hexadecimal notation.

<u>Bit Error Codes</u>	<u>8 Bit Error Byte</u>
Error 1 - Manchester error	0001XXXX

Manchester encoding specifies that the polarity of the data during the second half of a bit-time be opposite the polarity during the first half of the bit-time. When a Manchester error is specified, the data remains high or low for the full bit-time depending upon whether the data bit is a 1 or a 0, respectively. The lower nibble (XXXX) specifies the bit number for the error. Bit numbers start with bit 0 for the least significant (last transmitted) data bit, and increment up to bit F for the most significant (first transmitted) data bit.

Error 2 - Dropped bit	0010XXXX
-----------------------	----------

Whenever the 1553 bus is active, the voltage is either positive or negative. If a dropped bit is specified, the bus voltage goes to zero for the duration of the bit indicated by the lower nibble. The lower nibble (XXXX) specifies the bit number for the error. Bit numbers start with bit 0 for the least significant (last transmitted) data bit, and increment up to bit F for the most significant (first transmitted) data bit.

Error 3 - Early bit transition time	0011XXXX
-------------------------------------	----------

The mid-bit transition occurs 150 ns early. This transition represents the worst case for a valid early bit transition at the RT receiver. The lower nibble (XXXX) specifies the bit number for the error. Bit numbers start with bit 0 for the least significant (last transmitted) data bit, and increment up to bit F for the most significant (first transmitted) data bit.

Error 4 - Late bit transition time	0100XXXX
------------------------------------	----------

The mid-bit transition occurs 150 ns late. This transition represents the worst case for a valid late bit transition at the RT receiver. The lower nibble (XXXX) specifies the bit number for the error. Bit numbers start with bit 0 for the least significant (last transmitted) data bit, and increment up to bit F for the most significant (first transmitted) data bit.

Error 5 - Intermessage gap**0101XXXX**

The sync signal of each 1553 data word must be contiguous with the parity bit of the previous 1553 data word for an error-free message. If an error is to be generated for the next data word, a no-data gap time may be inserted between the parity bit of the transmit word containing this error and the sync signal of the next transmit word. The duration of the gap is encoded in the lower nibble (XXXX) accompanying this error; the value of the lower nibble (in hexadecimal notation) indicates the gap duration in 1/2-bit increments, counting from a 1/2-bit gap to 7 1/2 bit-times (7.5 us) as the nibble value increases from 1 to F. A value of 0 indicates no error. An RT response may be simulated by the 53A-454 Card with a response time of 4 us to 9 1/2 us by programming a 2-us to 7 1/2-us gap.

Error 6 - Too few bits**0110XXXX**

The word length can be decreased to create a bit-count error. The lower nibble accompanying this error (XXXX) is encoded in 1/2-bit increments. The word length can be varied from 1/2 bit shorter (lower nibble = 1) to 7 1/2 bits shorter (lower nibble = F).

Error 7 - Too many bits**0111XXXX**

The word length can be increased to create a bit-count error. The lower nibble (XXXX) accompanying this error is encoded in 1/2-bit increments. The word length can be varied from 1/2 bit longer (lower nibble = 1) to 7 1/2 bits longer (longer nibble = F).

Error 8 - Parity bit**1000XXX**

A 1553 word ends with an odd parity bit (the sum of the 16 data bits plus the parity bit is an odd-value). The following parity errors may be defined:

<u>Parity Error</u>	<u>Lower Nibble Parameter</u>
Incorrect (even) parity	0001
Manchester error on parity bit	0100
Dropped parity bit (no data during parity)	0101
150-ns early transition*	0110
150-ns late transition*	0111
* of parity bit mid-bit transition	

Error 9 - Sync signal**1001XXXX**

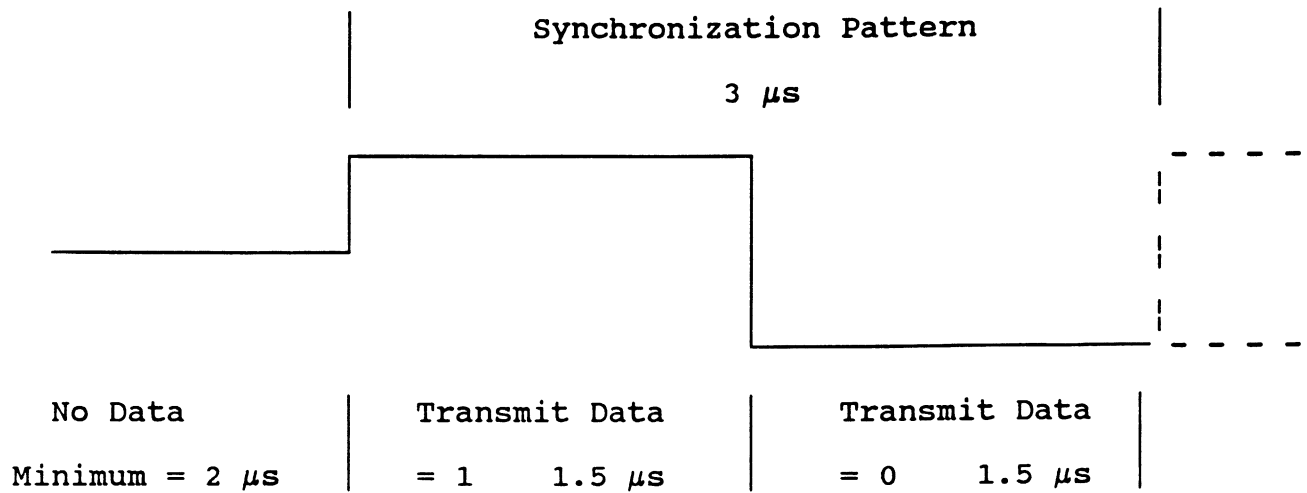
The 1553 sync signal can be distorted in various ways. Individual waveforms for sync errors are shown on the following pages; the exact sync error is defined by the lower nibble (XXXX) accompanying this error:

<u>Sync Error</u>	<u>Lower Nibble Parameter</u>
1.0 μ s early transition	0001
0.5 μ s early transition	0010
150-ns early transition	0011
1.0 μ s late transition	0100
0.5 μ s late transition	0101
150-ns late transition	0110
Early extra transition	0111
Late extra transition	1000

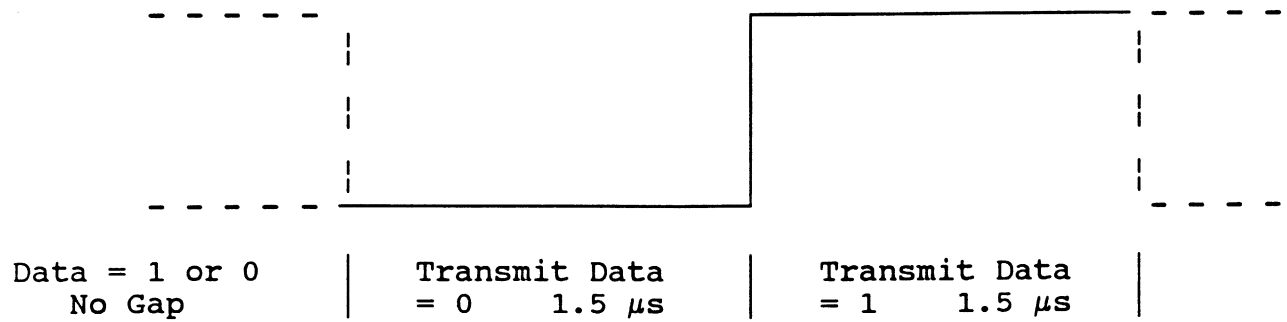
In addition, the type of sync signal for a particular word may be specified incorrectly (byte 3, bit 5 of T command the Z_4 transmit word). The first word of each message must have command sync, and subsequent data words must have data sync in order for the addressed RT to receive error-free words.

1553A/B TRANSMIT SYNC PATTERNS

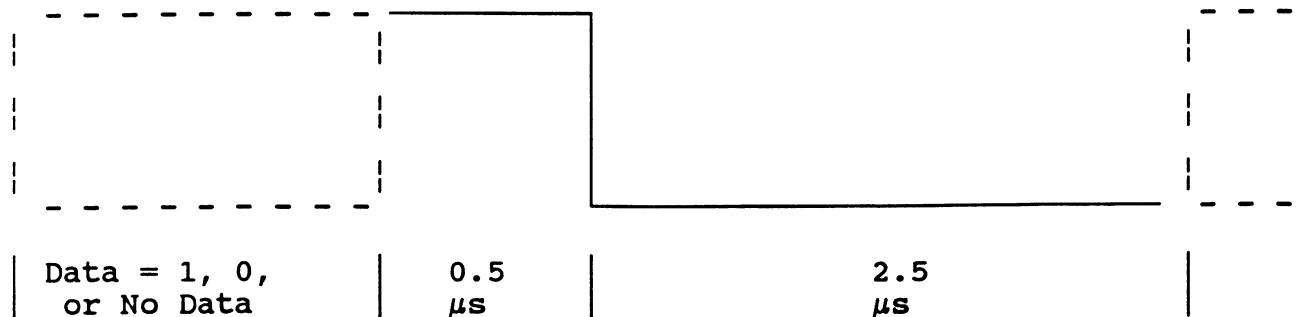
(No Error) Command:



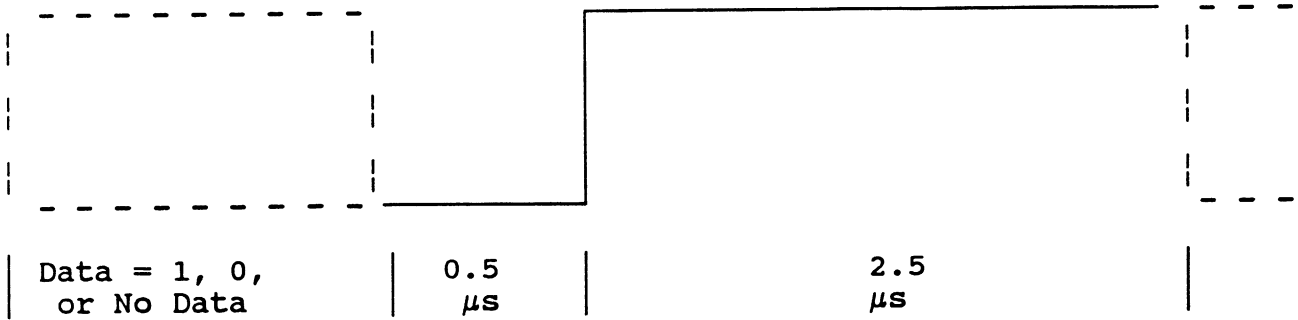
(No Error) Data:



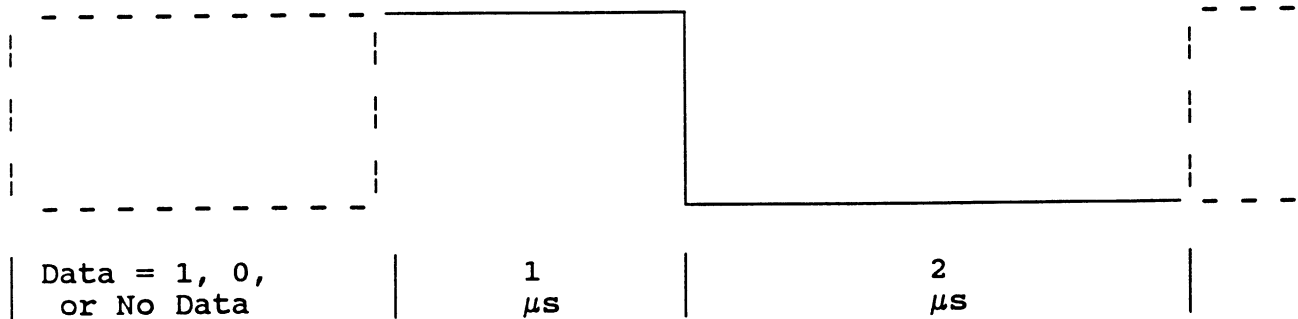
Command Sync Error 1:
(1 μ s early)



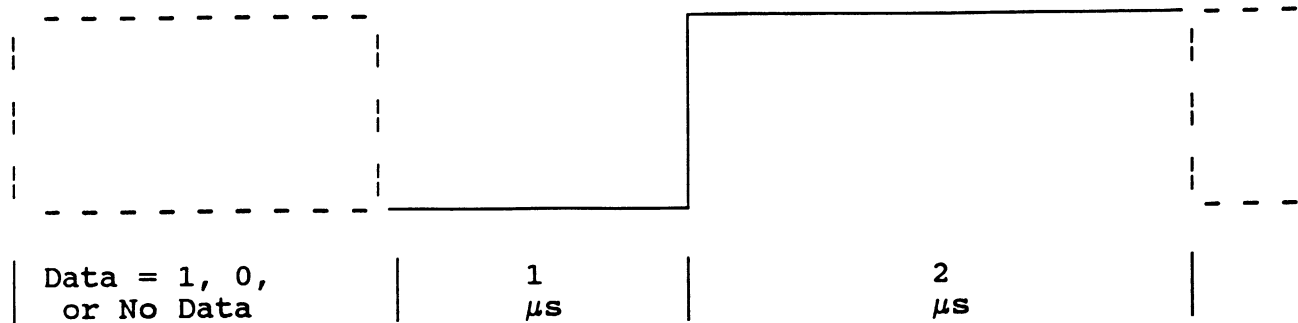
Data Sync Error 1:
 (1 μ s early)



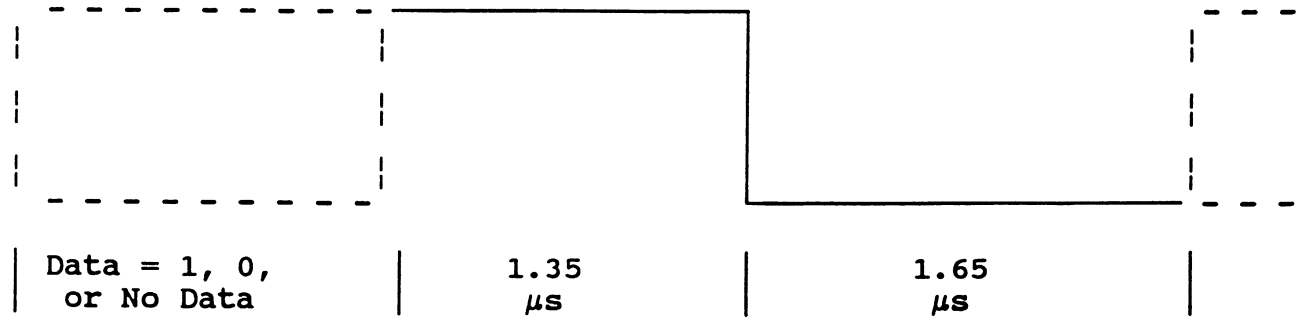
Command Sync Error 2:
 (0.5 μ s early)



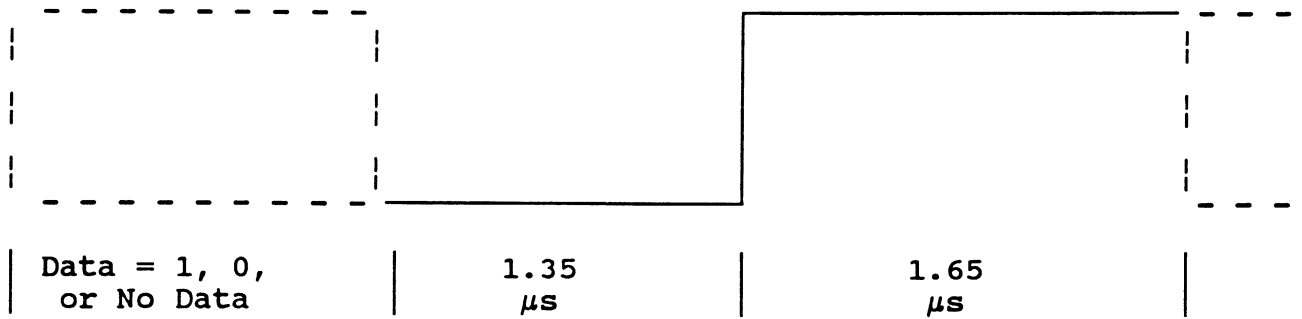
Data Sync Error 2:
 (0.5 μ s early)



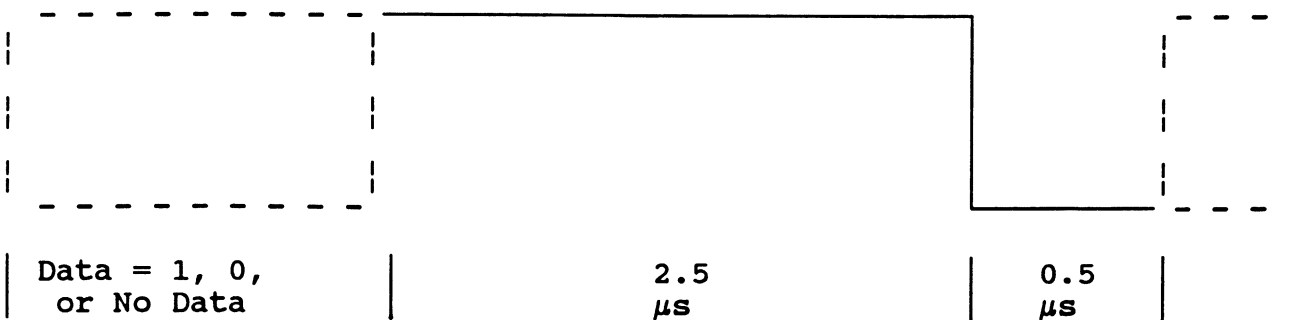
Command Sync Error 3:
(150 ns early)



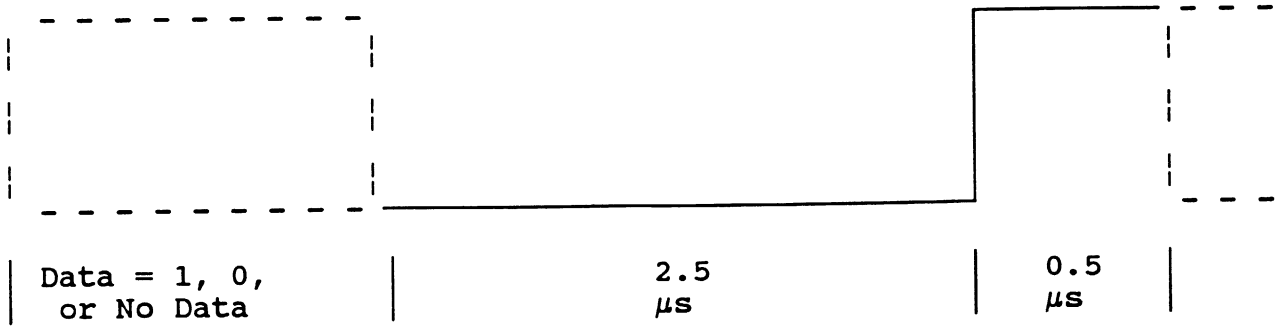
Data Sync Error 3:
(150 ns early)



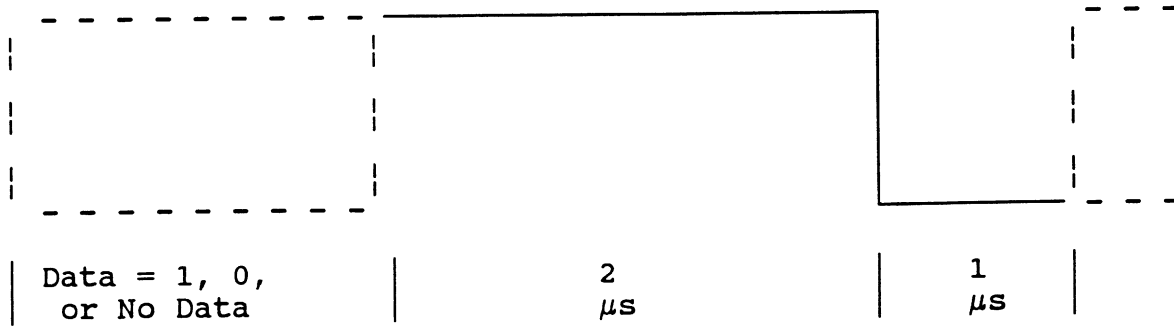
Command Sync Error 4:
(1 μs late)



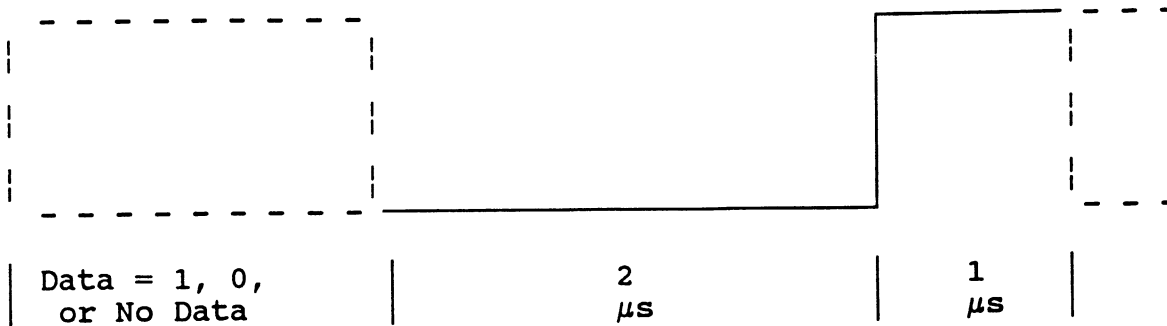
Data Sync Error 4:
(1 μ s late)



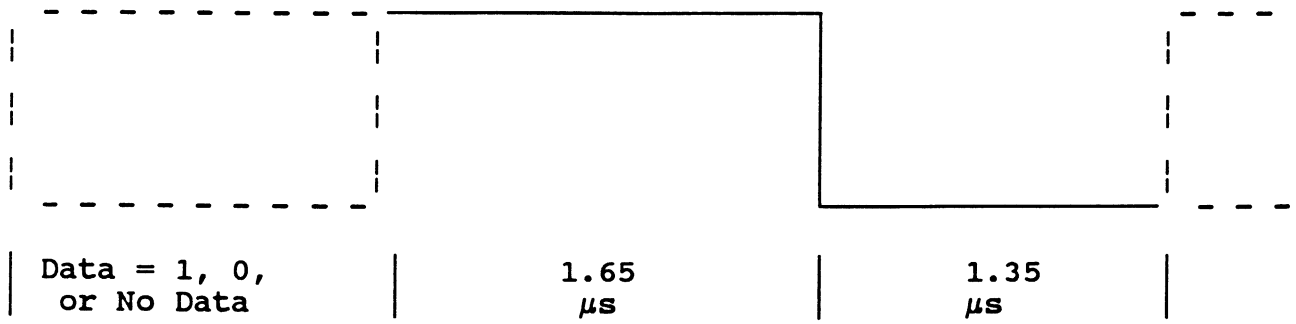
Command Sync Error 5:
(0.5 μ s late)



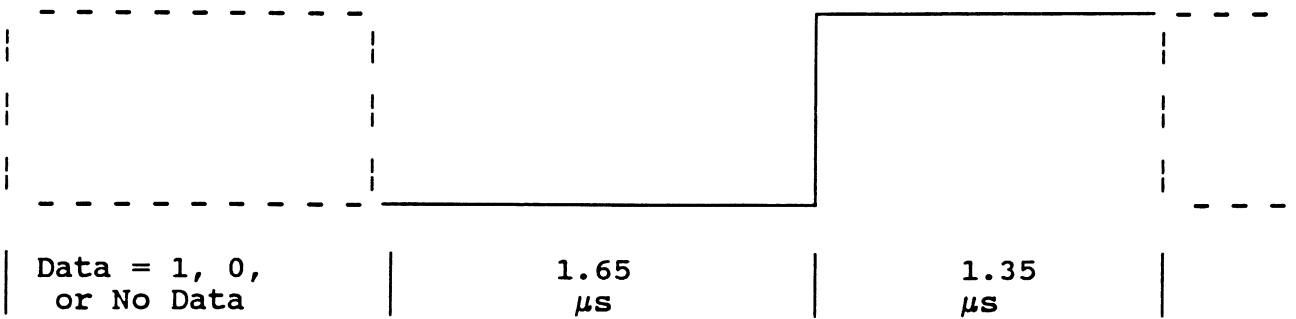
Data Sync Error 5:
(0.5 μ s late)



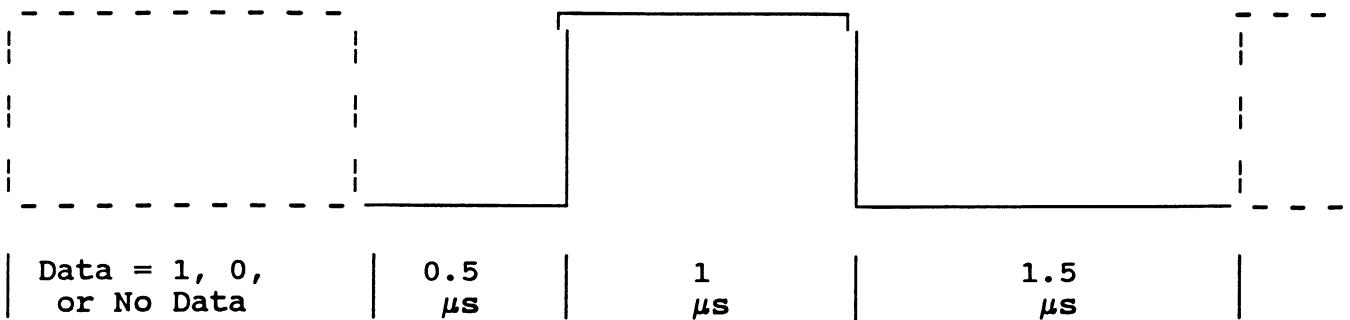
Command Sync Error 6:
(150 ns late)



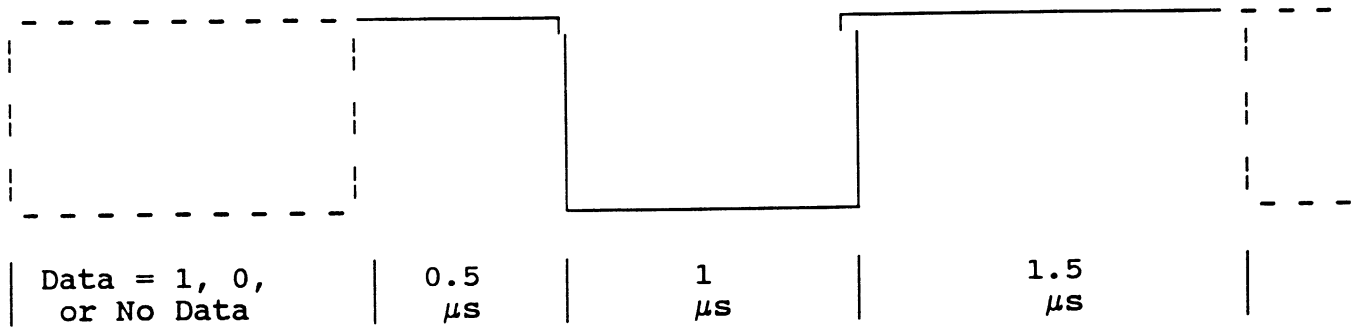
Data Sync Error 6:
(150 ns late)



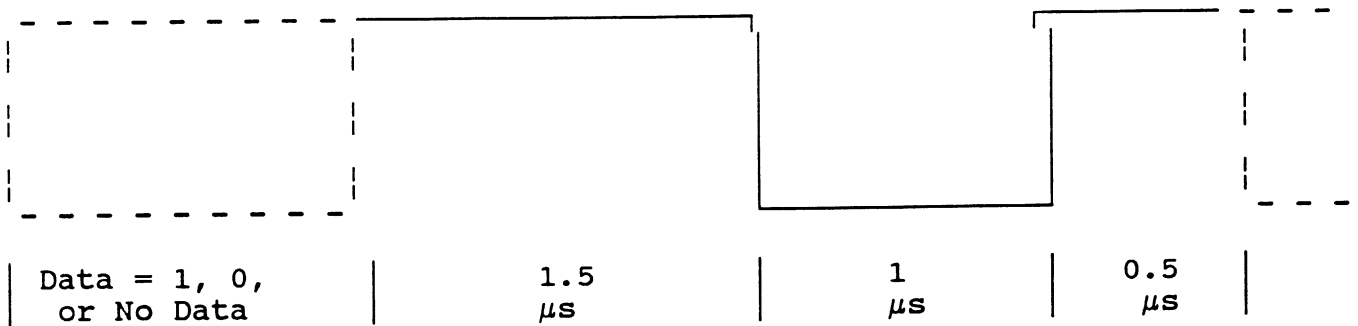
Command Sync Error 7:
(Early extra transition)



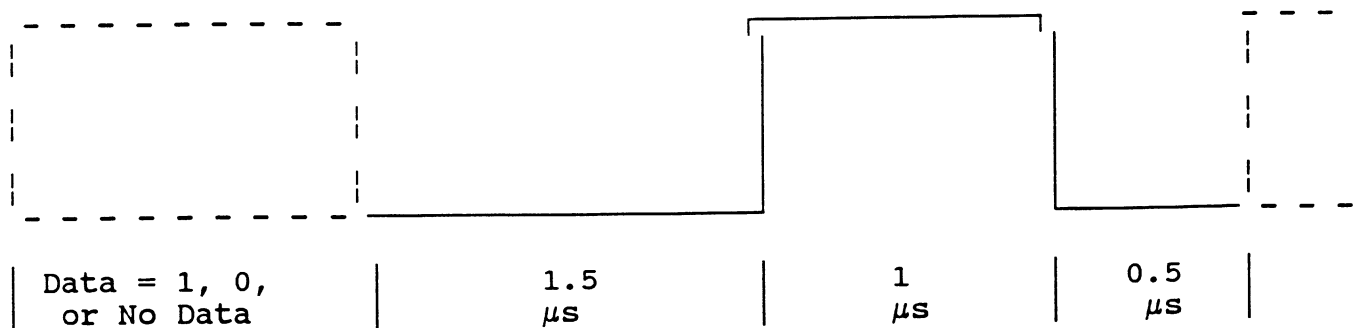
Data Sync Error 7:
(Early extra transition)



Command Sync Error 8:
(Late extra transition)



Data Sync Error 8:
(Late extra transition)



Error F - No Transmit Condition 11110000

The transmit signal will be suppressed during this transmitted word interval. This capability may be used to create a No Operation cycle on the 1553 data bus for an entire sequence cycle. This is useful for creating message spacings of greater than 65,535 milliseconds and for creating an initial transmit delay time so that two cards started by the same external trigger may be delayed with respect to each other by an accurately specified amount of time.

RECEIVE ERRORS

Received RT data and error status is contained in the four byte word(s) returned to the system controller from the 53A-454 Card in response to the card receiving an R command from the system controller. The error information is contained in the second byte of the four byte data word (see R command). The following errors are detected by the 53A-454 receiver circuitry. Multiple errors may be detected for each word by setting multiple bits in the error word.

Bit 7 - Sync error

If an invalid sync signal is detected 20 bit-times after the previous sync signal, this error is stored with the data following the spurious sync signal.

Bit 6 - Too many bits

If a second valid sync signal is detected more than 17 intermediate data bit-times after the previous valid sync signal, this error is stored for the unterminated word.

Bit 5 - Too few bits

If a second valid sync signal is detected prior to 17 intermediate data bit-times, this error is stored for the shortened word.

Bit 4 - Parity error

If the parity bit of the received word does not create an odd sum when added to the other 16 bits of the 1553 word, a parity error is stored.

Bit 3 - Incorrect transition time (jitter)

If a bit transition occurs more than the allowed time before or after the ideal transition time (see J command), a clock-recovery error is shown to indicate suspicious data.

Bit 2 - Manchester error

If the data during the second half of each bit in the word is not opposite in polarity to the first half of the bit, a Manchester error is stored.

Bit 1 - Dropped bit

If the 1553 bus voltage does not exceed the receiver threshold voltage (see Y command) for a single bit time, a dropped-bit error is stored. Data is not collected unless the no-data condition is limited to one bit-time.

Bit 0 - No error flag

This bit is set if the word is received error free.

The system controller must determine whether any message errors occur by examining the data and control contents. Incorrect sync polarity, word count, inappropriate gaps, or message format errors are not specifically marked in the 53A-454 Card's RT response buffer; the system controller must process the response data to determine such errors.

APPENDIX D

APPLICATION NOTES

The following topics are included in this appendix:

PASSIVE SYSTEM CONTROLLER INTERFACE (62)
DYNAMIC SYSTEM CONTROLLER INTERFACE (62)
MIL-STD-1553 PRODUCTION ELECTRICAL TESTING (64)
REDUNDANT BUS CONTROLLER OPERATION (66)

PASSIVE SYSTEM CONTROLLER INTERFACE

The simplest use of the 53A-454 Card is to transmit a fixed sequence of messages until the bus controller operation is halted. Received RT response data may be read by the system controller, or the 53A-454 Card can continue without further commands while other 1553 devices are tested.

The user outputs a sequence program listing each transceiver buffer whose contents are to be sent on the 1553 data bus. Each transceiver buffer corresponds to a unique transmit message for a particular RT and the RTs response to that message. The sequence program output uses the S (Sequence) command. The contents of each transmit message are programmed with the T (Transmit) command.

The card may be programmed to transmit continuously or for a specified number of execution cycles through the sequence command list with the N (Number) command. The starting address of the sequence program execution may be set to other than address 0 with the A (Address) command.)

Transmit and receive voltage levels are set to a specified value at power up. The levels can be changed with the X (X-value) and Y (Y-value) commands. Error reporting can be modified with the J (Jitter) and Z (Z-value) commands, or normal reporting can be retained.

After the board is initialized, a G (Go), C (Continue), or E (External) command starts operating the bus controller; for the E command, front-edge connector signals control actual starting and stopping of MIL-STD-1553 bus activity. If bus controller operation must be stopped by the system controller, a Q (Quit) command stops the operation without disturbing any data, and a K (Kill) command stops the operation and restores the cards power-up conditions.

The R (Receive) command examines RT response data while the bus controller is either operating or stopped. The F (Flag) command examines the cards 1553 bus run/stop status, received data error status and execution count remaining.

DYNAMIC SYSTEM CONTROLLER INTERFACE

When data from the bus controller is to be continuously changing because of RT responses received, a dynamic system controller interface between the 53A-454 Card sequence program and the transmit messages to be continuously updated must be established. For this to occur, the commands previously

listed for the passive interface must be accompanied by a synchronous method of updating the 53A-454 Card memory to avoid partial message errors.

A partial message error is caused when an unsynchronized system controller command changes a memory word while the card circuitry is accessing the same word. Since the system controller change consists of several byte operations, this type of error can easily occur. Additional problems that are application dependent may occur if the end of a particular RT's message is not compatible with the beginning of a message.

The 53A-454 Card addresses this problem by providing two methods of synchronizing the system controller to the bus controller:

1. An interrupt may be generated by the RFI bit (S command) in a particular message instruction.
2. The W (Where) command can determine the sequence program line number the card is currently processing.

In either case, the current sequence program line number should be well separated in time from sequence program instructions that are to be changed and from any transmit messages that must change. This is typically accomplished by updating data for a message as soon as possible after the data required to update the message is available, and assuring that sufficient time is available to perform any computations and output the new data for that message before it is transmitted. The RFI capability or the W command can be used to determine when a particular message containing the required data for updating is complete. In some applications, the system controller may need to supply the master frame timing. This can also be easily accommodated by using a sequence program that executes once and then stops, and based on system controller timing, sending a G (Go) or C (Continue) command; or sending an external hardware trigger to execute the program again with updated data.

Another category of dynamic applications requires sending a message sequence repeatedly, and on system controller command, switching to successive new sequences. The 53A-454 Card provides a powerful bank-switching capability for those applications which allows asynchronous stepping through sequences without having to use the RFI or W command, or having to worry about data integrity when the sequence switch is made.

If sequence program instructions are grouped within the same 256 lines (the high byte of the sequence program address is the same), a sequence go to instruction that jumps to one sequence program instruction in the group may be changed to cause it to jump to another instruction in the group asynchronously. This is because only one byte of the sequence vector (byte 2) has a changed value, and the sequence program either goes to the old sequence line or the new sequence line and cannot take an invalid jump.

Whether or not an asynchronous or synchronous interface is chosen, system timing can be improved by selecting sequence program and message buffer locations to enable bank switching. Message buffers may be grouped into active and inactive categories; the active category includes buffers which are accessed in the active sequence program. Sequence program lines may also be grouped into active and inactive categories; an active sequence program line is accessed during the course of the ongoing sequence program. All major changes are made in inactive message buffers and on inactive sequence program lines. When these changes are complete, the inactive memory locations can be activated with a single sequence program change for optimal system timing. The sequence "go to" instruction is used to effect this change.

MIL-STD-1553 PRODUCTION ELECTRICAL TESTING

The high output levels of the transmitter and the low noise levels of both the transmitter and receiver of the 53A-454 Card allow it to be used for full parametric input amplitude testing of RTs.

The card can generate the maximum 10.2V peak-to-peak direct-coupled and 29.7V peak-to-peak transformer-coupled voltage levels to allow testing of RTs at maximum level input with actual bus loading. Bus components and cabling can also be tested at maximum level input.

The card can output signal levels as low as 0.20V peak-to-peak on the direct-coupled output with a low enough noise level to test both the no-response and minimum response levels of both the RT's direct- and transformer-coupled receiver inputs. The noise level while the bus is transmitting at this low level is less than 20 mV RMS. The signal to noise ratio can be improved further by using the General Resistor Pad configuration recommended in Figure 1A of the MIL-HDBK-1553 RT Validation Test Plan. With this configuration, the tester out-put levels may be raised by a factor of 6 to 1, improving the signal-to-noise ratio by a factor of 6, further improving testability at these low levels.

The receiver threshold is programmable over a wide range of from 0.314 volts peak-to-peak to 10V peak-to-peak on the direct coupled input of the 53A-454 Card (or 0.222 volts peak-to-peak to 7.07V peak-to-peak on the transformer coupled input) for testing of maximum/minimum allowed output level of an RT and for testing in actual installation, for lower levels that might appear at the end of a cabling system. The low noise level of the 53A-454 receiver circuitry (70mV RMS of equivalent 1553 bus noise) effectively eliminates the test equipment receiver as a source of noise errors.

For other electrical parametric testing, including output amplitude, rise and fall time, overshoot, distortion, and zero crossing, the CDS 53A-525 40-MHz Waveform Digitizer Card has been specifically designed with MIL-STD-1553 waveform analysis in mind.

To simplify software development, the CDS model 2553 MIL-STD-1553 RT Electrical Tester uses the 53A-454 and 53A-525 capabilities to provide a complete turnkey production and validation electrical test per the MIL-HDBK-1553 RT Production and Validation Test Plans.

Use of the X and Y commands to control transmit levels and receive thresholds on the 53A-454 Card is described below.

The values programmed by the X command control the peak-to-peak voltages occurring on a 1553 bus when the bus controller is transmitting. The values programmed by the Y command set received voltage thresholds that must be exceeded to detect the signal when the bus controller is receiving 1553 RT response data.

Direct Coupled Voltage Levels

To conduct these tests, the user must determine the 1553 bus loading and the bus voltages desired. A standard 1553 bus has two 70-ohm (approximately) terminating resistors at opposite ends of the bus; if RT loading is considered minor, the resulting transmitter load is 35 ohms. A standard 1553 interface requires 55-ohm resistors in series on each direct leg. In addition to the 55-ohm resistors, the 53A-454 Transmitter has a source impedance of about 20-ohms, and the output can be represented by a 130-ohm resistor in series with the bus load to calculate the desired 53A-454 Card transmit voltage level. The 48.5V maximum (open circuit) output results in a voltage across the 35-ohm load according to classic series-resistor calculations:

$$V \text{ load} = (48.5V \times R \text{ load}) / (130 \text{ ohms} + R \text{ load})$$
$$V \text{ load} = (48.5 \times 35) / (130 + 35) = 10.2V$$

Therefore, the maximum voltage (FF) across a 35-ohm load is 10.2V. The actual voltage across the load can be varied from the maximum 48.5V open circuit value, which is the value obtained from the above equation, to a .285V open circuit value by using the X command and an integer representing one of 256 steps between the two voltages. The 48.5V open-circuit voltage is output if an X character is output, followed by the integer FF represented in binary. If the FF integer is changed to 00, the minimum voltage of .285V results; each incremental step between 00 and FF results in a 189-mV increase in the open-circuit voltage.

Example: A 6V PTP signal is required with a 300-ohm load.

The maximum voltage across 300 ohms is $(48.5 \times 300) / 430$ or 33.8V. The minimum voltage is $(.285 \times 300) / 430$ or 0.199V. Interpolating between 0 and 255, a value $(255)(6.00-.199)/(33.8-.199)$ or 44 would give close to 6.00V peak-to-peak output into a 300 ohm load. This value could be programmed using the BASIC language character string X + CHR\$(44).

The receiver threshold is set at 1.33V when the card is reset. The user may program higher or lower thresholds depending on what the testing conditions demand. The maximum receiver threshold is 10.0V when the Y-value output is hexadecimal FF; the minimum may be reduced to 0V with a Y-value of hexadecimal 00. Intermediate voltage steps of 39.2 mV may be implemented by outputting a Y command, followed by the appropriate integer as an 8 bit binary number. The smallest effective receive level that should be programmed to minimize susceptibility to noise on the bus is 314 mV peak-to-peak or a Y-value of 8. Since the input impedance of the 53A-454 Card receiver is quite high in relationship to the impedance of a 1553 data bus, loading effects of the 53A-454 Card can be ignored.

Transformer Coupled Voltage Levels

The maximum transformer-coupled output at the front-edge connector is less load-dependent than the direct-coupled output. The 55-ohm isolation resistors are not present, but the effective 20-ohm source impedance still is. The transformer has a winding ratio of 0.707. The output is therefore 0.707 times the outer transformer winding output, and the reflected impedance to the voltage transmitter is $1/(0.707)(0.707)$ or twice the load impedance. The maximum output level is calculated as

$$V_{\text{MAX}} = (48.5)(0.707)(2R_L)/(2R_L + 20)$$

For $R_L = 70$ -ohms, V_{MAX} is approximately 29.7V peak-to-peak.

Transformer Coupled Voltage Levels On The 1553 Bus

For actual voltage levels on the bus when the transformer coupled output of the 53A-454 Card is connected through a standard 1553 transformer coupler to the bus, the voltage peak-to-peak on the bus is calculated with the same formula described above for direct coupling. This is because the transformer-coupled output of the 53A-454 Card is .7 times the open-circuit voltage; the coupler itself on the bus multiplies that voltage by 1.4, and is isolated by 55-ohm resistors in the coupler. The same R load / (110 ohms + R load) divider network described above for direct coupled outputs therefore still applies. R load in this case will almost always be about 35 ohms, but could be 70 ohms if only one of the two bus terminators is connected.

REDUNDANT BUS CONTROLLER OPERATION

Dual- or multiple-redundant 1553 buses are implemented with two or more 53A-454 Cards. This provides complete flexibility in configuring a system to unusual requirements; e.g., a dual triple-redundant system can be simulated with six 53A-454 Cards.

If simultaneous transmission is not required on multiple buses, fewer cards may be used together with relay switching (a CDS 53A-352 Relay Switching Card, for example). However, if simultaneous transmission is required, that option is also available with multiple 53A-454 Cards.

Several inputs and outputs on the 53A-454 Card front-edge connector are provided which allow automated bus switching in certain applications.

The message-error output lets the user initiate 1553 bus communications through a second preprogrammed 53A-454 Card when an RT detects a bus controller error. To accomplish this, the message-error output of the first 53A-454 Card is connected to the external-trigger input of the second 53A-454 Card and to the external-halt input of the first card.

The external-trigger input of the 53A-454 Card is useful in applications where a delayed transmission is required on one bus with respect to another bus. A delay may be created by programming a No-Transmit Error (see the T command) for the only word in a message buffer and sending that message first in the sequence program with a desired message delay specified as the message timing for that sequence line (see the S command). Two different delay values, for example, may be programmed on two 53A-454 Cards. By arming the external trigger on both cards (see E command) and triggering the two cards simultaneously with the same external trigger signal, a delay between start of transmission of the two cards which is equal to the difference of the two programmed delay values will result.