53A-453 MIL-STD-1553A/B BUS SIMULATOR CARD

OPERATING MANUAL

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Appendix C describes earlier revision level cards.

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53A-453 MIL-STD-1553A/B BUS SIMULATOR CARD

OPERATING MANUAL

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DESCRIPTION

The 53A-453 MIL-STD-1553A/B Bus Simulator Card is a printed circuit board assembly for use in a CDS 53/63 Series System. It allows the system controller in an ATE system to communicate with other devices via the MIL-STD-1553A/B data bus now being used in many military aircraft and communications systems. The 53A-453 Card may be used in three ways:

1) 1553 Bus Controller (BC) Simulator

2) 1553 single or multiple Remote Terminal (RT) Simulator

3) 1553 Bus Monitor

Mode selection and programming of the 53A-453 Card are accomplished by sending ASCII characters to the 53/63 Series System from the system controller. Data is also returned to the system controller as ASCII characters.

In the Bus Controller Simulator Mode, the 53A-453 has the ability to communicate with each of the 32 remote terminals (31 real devices plus broadcast mode) specified by MIL-STD-1553A/B. The card is loaded by the system controller with a bus controller message sequence list and data lists for each RT to be addressed. When instructed to do so by the controller, the 53A-453 Card transmits the preprogrammed messages to the respective RT(s). Any response data received from the RT is stored in on-card memory.

In the RT Simulator Mode, the 53A-453 Card can simultaneously emulate as many as 31 different RTs. The system controller preloads the 53A-453 with the appropriate response data and status words for each simulated RT. Data received from the 1553 bus by the 53A-453 is stored in on-card memory for later evaluation.

In the Bus Monitor Mode, the 53A-453 Card assumes an essentially passive role; it simply observes and stores all bus traffic. Up to 30,000 data, command, or status words can be stored for later evaluation.

The 53A-453 has the ability to introduce controlled errors into its transmitted data stream. These errors include incorrect parity, erroneous 1553 Manchester encoding, zero crossing errors of ±150 ns, dropped data bits, interword data gaps, incorrect or invalid 1553 sync patterns, incorrect RT response times, incorrect number of data bits per word, incorrect number of words per message, invalid signal levels, and common-mode signal input. On received data, the 53A-453 Card can distinguish among incorrect transition time errors, Manchester errors, dropped data-bit errors, bit count errors, parity errors, incorrect sync errors, terminal/controller response time errors, interword data-gap errors, word count errors, and message format errors such as incorrect RT address, missing RT response, invalid status words, invalid mode code usage, and invalid broadcast mode usage.

The 53A-453 Card also provides a self-test capability, programmable with a single command.

1553 Bus Overview

MIL-STD-1553 provides for time-division multiplexed communication by up to 31 avionics units (RTs) via a high-speed, two-wire, command/data bus. According to the defined protocol, a single bus controller at any time controls the flow of information among the RTs. Each word (command, status, or data) is a 16-bit word encoded in a Manchester bi-phase format that eliminates the need for separate clock lines and ignores any DC voltage component on the common bus. The 16-bit word is always preceded by a sync signal of 3 bit-times and followed by an odd parity bit. The sync signal for a command or status word is defined as being high for 1½ bit-times, then low for 1½ bit-times. This sequence is reversed (low, then high) for a data word.

For bus controller to RT transactions, a 16-bit command word is sent which specifies the RT that is to receive data, and how many data words (up to 32) are to be received. The RT then processes the command information and the data, then returns a 16-bit status word containing the RT address and status information to the bus controller.

For RT to bus controller transactions, the bus controller sends a 16-bit command word specifying the RT that is 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 transmission.

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-453 Card's operating environment.

Address-Select Switch

The 53A-453 Card has a miniature 10-position switch labeled "ADDRESS" that selects the 53A-453 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-453 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-453 Card is unaddressed, but that all required dc power (5V dc, ±15V dc) is being supplied.

Fuses

The 5 Volt dc and ±15 Volt dc power buses each have a fuse that protects the system from overloads. If any 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-453 Card to indicate the status of the card's operation:

COMM LED

The COMM LED lights when the 53A-453 Card has been triggered to begin communication on the 1553 bus. When not lit, the 53A-453 Card is available for data or command transactions with the ATE system controller.

Function LEDs

Three function LEDs are used to indicate which mode of operation has been selected. The CTLR LED is lit when the card is programmed to be in the Bus Controller Simulator Mode, the TERM LED is lit for RT Simulator Mode, and the MON LED is lit for the Bus Monitor Mode.

PTRN LED

The PTRN LED will light immediately after a T command has been issued unless a P command was previously issued to the 53A-453 Card; in this case, it will light when the pattern specified by the P command is received from the 1553 bus.

ERR LED

The ERR LED lights whenever the 53A-453 Card detects a syntax error in the data received from the system controller. After the system controller interrogates the error (with an E command), the light will go out. This indicator is typically used as a debugging aid during software development.

Switches

The following switches are provided to select the proper functions for the 53A-453 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-453 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-453 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-453 Card becomes unaddressed, the Power LED is lit, and any programmed parameters of the card remain unchanged.

External Clock Switch

Located on the larger board at the center top of the board is a 2-position rocker switch used to select either the internal or an external data clock. In the "C1" position, the internal data clock is selected, and the 1553 bus data rate is 1 MHz. When the switch is in the "C2" position, an external 16-MHz data clock (Pin 15) is selected. The external clock can be varied over the frequency range of 15 MHz to 17 MHz, thus allowing the 1553 bus data rate to be varied from 937.5 kHz to 1.0625 MHz. The switch can only be

accessed when the card is not installed. The switch position can be changed without separating the two boards by using a small flat-blade screwdriver. (For Revision Level 06-B and previous, the external clock switch is located at the front edge of the card, below the LEDs.)

MAC Air Switches

Located near the bottom of the front-edge connector is one 1-position slide switch. When the switch is in the OFF position, the rise and fall times of data generated by the 53A-453 Card will be between 150 and 250 nanoseconds with a 35-ohm bus termination. When both switches are in the ON position, the rise and fall times of generated data will be between 220 and 350 nanoseconds with a 35-ohm bus termination. (For Revision Level 06-B and earlier, two switches are used).

Front Connector Inputs And Outputs

The 53A-453 provides a direct-coupled MIL-STD-1553 connection on pins 3 and 4 and a transformer coupled MIL-STD-1553 connector on pins 6 and 7 of the front-edge card connector. In addition, a full complement of seventeen inputs and outputs are provided for external control and monitoring of the 53A-453 Card. The front-connector signals provide connections for common mode signal injection; external clock, triggering and halt control; monitoring of data, clock and data reception; and an output for synchronization of the data stream. Appendix B includes pin assignments and a complete description of each front connector input and output connection.

GLOSSARY

Certain terms used within this manual have very specific meanings in the context of the 53A-453 Card and MIL-STD-1553. A list of these terms is presented below to help the user better understand the concepts and operation of the 53A-453.

Bus Communications Sequence
The 53A-453 Card is said to be performing a Bus Communications Sequence during the time the card is transmitting or receiving data over the 1553 data bus. A Bus Communications Sequence is initiated when the 53A-453 receives a T (Trigger) command from the system controller. In the Bus Controller Simulator Mode, a Bus Communications Sequence is completed when all messages specified by the Bus Controller Sequence List have been transmitted the number of times required by the T command. In the RT Simulator Mode, a Bus Communications Sequence is completed when the total number of messages specified by the T command have been received. In the Bus Monitor Mode, the Bus Communications Sequence is completed when a Q command, or an External Halt Input, is received by the 53A-453.

Bus Controller
The single device attached to the 1553 data bus that is assigned the task of initiating information transfers on the bus.

Bus Controller Sequence List
The Bus Controller Sequence List specifies the order in which messages are transmitted in the Bus Controller Simulator Mode.

Command Word
A 16-bit word sent by the bus controller to identify or address the RT to be involved in a bus transaction. The command word also specifies whether the terminal will be transmitting or receiving data.

Data List
An individual data list is defined for each of 32 transmit buffers provided on the 53A-453 Card. When the card is in the Bus Controller Simulator Mode, an individual data list contains the command and data words to be sent from a specific buffer. When the card is in the RT Simulator Mode, an individual data list contains the status and data words a simulated RT will return to the bus controller.

Data Word
A 16-bit word containing the actual data in a 1553 bus transaction.

Message or Message Block
The combined transaction (command, status, and data) associated with one command word.

Remote Terminal (RT)
One of up to 31 devices connected to the 1553 data bus that is capable of sending data to or receiving data from the bus controller.

RT Response Time List
When the 53A-453 Card functions as an RT simulator, the card is preloaded with a list of RT response times to be used when responding to each command word received from the bus

controller. RT response time values are used from the RT Response Time List in a sequential order, irrespective of the RT numbers addressed by the incoming command words.

RT Response Time or Response Time Gap
The response time of an RT is the time in microseconds between the middle transition of the parity bit of the last command or data word received by the RT and the middle transition of the sync pattern in the status word transmitted by the RT.

Status Word
A 16-bit word returned by an RT after being addressed by the bus controller.

System Controller
The ATE calculator or computer providing control and data information to the 53/63 Series System via a suitable communications link (RS-232, IEEE-488, etc.)

Word
A 1553 word is a sequence of 20 bit-times consisting of a sync pattern of 3 bit-times, followed by 16 bits of data and one bit of parity. Though each word is 20 bit-times in length, a word contains only 16 bits of data and is commonly referred to as a 16-bit word. There are three types of 1553 words: command words, status words, and data words.

SPECIFICATIONS

Configuration: MIL-STD-1553 Bus Controller Simulator, single or multiple RT Simulator, or Bus Monitor.

1553 Bus Coupling

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

Transformer Stub Coupling: 1:0.707 turns ratio.

Operating Modes

Bus Controller Simulator: Programmable for 32 separate data lists.

RT Simulator: Programmable for data collection and response from 32 into separate RT associated buffers.

Bus Monitor: Collects all data on bus in single buffer, receive-only mode.

Buffer Capability: 30,000 22-bit words - 16 bits data, 6 bits error/sync code. Can be allocated between 32 transmit buffers, 32 receive buffers, and a single Bus Controller Sequence List or RT Response Time List. Allocation is totally user-controlled.

1553 Analog Output: Level-programmable to approximately 250 different levels.

NOTE: Analog Output capability in this specification is for hardware Revision Level 07-A and above. See Appendix C for Analog Output specifications for Revision Level 06-B and earlier.

Range: Voltage range depends on the bus loading.

Differential voltage level output range for the following bus loads is:

35 ohms, direct-coupled output 0.20 to 8.20 V ptp
70 ohms, direct-coupled output 0.30 to 13.75 V ptp
1000 ohms, direct-coupled output 0.75 to 34.40 V ptp
70 ohms, transformer-coupled output, 0.60 to 24.2 V ptp
At 1553 bus with two 70 ohm terminators, either direct-coupled direct connection or transformer-coupled through MIL-STD-1553 coupler, 0.20 to 8.20 V ptp.

The above levels are for the MAC Air switch in the OFF position. With the MAC Air switch in the ON position, the peak-to-peak levels are approximately 10% higher than shown.

Accuracy: ±0.2V ptp at the 25 and 70 ohm loads.

Noise Content: 50 mV ptp.

Current Drive: 260 ma RMS maximum, direct-coupled output.
380 ma RMS maximum, transformer-coupled output.

Short Circuit Protection: The direct-coupled output may be shorted for several minutes without degradation of the transmitter.

The transformer-coupled output should not be shorted during transmission.

1553 Analog Input

Maximum Input: 40V ptp differential.

Threshold: Programmable to approximately 250 different levels.

See Appendix C for Analog Input Threshold Specifications for Revision Level 06-B and earlier.

Programmable from 0.50 to 9.00V ptp at direct-coupled input (equivalent to 0.35 to 6.36 V ptp at transformer-coupled input).

Transition Time Error Detection: Time from one threshold crossing to the next threshold crossing is nominally expected to be 0.5, 1.0, 1.5 or 2.0 microseconds per MIL-STD-1553.

The receiver checks that this time is reliably within 62.5 nanoseconds of the nominally expected time.

Version 3.0 53A-453 Firmware and above provides a programmable command (J command) to disable detection of this error.

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 or status word plus user-defined number of data words per message.

Message Capability: Any number of messages may be specified for transmittal or receipt, subject only to a constraint on available buffer memory (30,000 words). A message requires one word for each command, status, or data word transmitted or received. In the Bus Controller Simulator Mode, two

additional words per message are required for system overhead.

Message Rate

Bus Controller Simulator Mode: (Time from the end of one message to the start of the next message). Programmable from 14 microseconds to 65,535 microseconds on an individual message basis.

RT Simulator Mode: (RT response time) Programmable from 4.25 microseconds to 65,535.25 microseconds on an individual message basis.

Bus Monitor Mode: Message rate is defined by active devices on bus.

Message Synchronization: The start of an RT operation in the RT Simulator Mode or the start of data collection in the Bus Monitor Mode may be programmed to start on a user-specified pattern word received from the 1553 bus controller.

Induced Transmitter Errors: Programmable on an individual word basis to give incorrect parity, Manchester error, dropped bit error, sync pattern error, or incorrect bit count (±1 bit). By programming a secondary error mode, programmable on an individual word basis to give ±150-ns bit transition time error, ±150-ns sync transition time error, dropped parity bit, or 1-bit interword gap error. In addition, programmable on an individual message basis to give incorrect RT response time, word count, or status word RT address. Bit position of Manchester, dropped bit, and transition time errors are controllable as a function of the 16-bit word data content.

Receiver Error Checking: Detects and distinguishes bit transition time errors, parity errors, dropped bit errors, sync pattern errors, and receiver response time errors on an individual word basis for subsequent return to system controller. The response-time error test value is programmable from 4 to 31 microseconds.

Detects interword data gap error, word count errors, no RT response, or incorrect RT address on an individual message basis for return to the system controller.

When Version 3.0 of the 53A-453 Firmware is installed, format errors are detected in addition for improper mode code operation, improper broadcast mode operation, and improper use of status word bits.

Time Base: 16-MHz crystal oscillator.
Optional switch-selectable user clock input on front-edge connector for 16 times desired data rate. Optional clock input from 15 MHz to 17 MHz. Frequency tracking of 0.1% to any other units on the bus must be maintained.

Interrupt Capability:	Card may be programmed to interrupt the system controller on completion of a bus communications sequence.
Programmed By:	ASCII characters. Data is transferred between the system controller and 53A-453 Card using either hexadecimal or binary notation.
Hardware:	Z80A microprocessor provides control and data communication between the system controller and the card's interface hardware.
Auxiliary Outputs (TTL Levels):	Reconstructed Received Data and Clock. Transmitted Data and Clock. Pattern Recognition Output. Status Error Output. Data Word Received Output. Data Bus Input Active Output. Position Identification Output.
Auxiliary Inputs (Analog)	
Common-Mode Voltage:	For external injection of common-mode voltage onto 1553 bus.
Auxiliary Inputs (TTL):	External 1553 Data Rate Clock. External Halt Input. External Trigger Input. External Transmitter Enable Input.
Power Up:	Card ready for programming 1 second after power-up. Power LED on, all other LEDs off 0.5 seconds after power-up.
Power Requirements:	5V and ±15V 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):	1.8 A, maximum quiescent. 1.9 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):	0.17 A, maximum quiescent. 0.20 A, peak.
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. non-condensing, -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.
Dimensions:	197 mm High, 221 mm Deep, 23 mm Wide. (7.5" X 8.69" X 0.9")
Dimensions, Shipping:	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 shipping dimensions are: 254 mm X 254 mm X 127 mm. (10" X 10" X 5").
Weight:	0.69 kg. (1.5 lb).
Weight, Shipping:	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 shipping weight is: 1.51 kg. (3.3 lb).
Mounting Position:	Any orientation.
Mounting Location:	Installs in any function card slot of the 53/63 Card Cage.
Input/Output Connections:	A 48-pin hooded connector (53A-780) provides a connection for all front-edge input and output signals.
Required Equipment (Not supplied):	53A-780 Hooded Connector.
Equipment Supplied:	1 - 53A-453 MIL-STD-1553A/B Bus Simulator Card. 1 - Spare fuse (Part # 42202-52003). 2 - Spare fuse (Part # 42202-52001). 1 - Operating Manual (Part # 00000-14530). 1 - Service Manual (Part # 00000-24530).
Software Version Level:	V3.4.

OPERATION

Overview

The 53A-453 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-453 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane.

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-453 Card's address (0-9) within the addressed card cage. The 53A-453 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-453 Card is addressed, the commands listed below may be issued until another function card is addressed.

The following descriptions of a typical example of each mode are general in nature, intended to indicate some possible uses and to suggest ideas for using the 53A-453 in other applications. An overview is given for each of the three modes: Bus Controller mode, Remote Terminal mode, and Bus Monitor mode. Each command is described in full in the Detailed Descriptions section.

Order of Commands

The K (preferably) or F command must be the first command issued to the 53A-453 Card after power is applied to the card. Once the F command has been issued, it cannot be reissued unless it is preceded by a K command. After the 53A-453 Card has been programmed to a given mode, other commands can be issued in any order with one exception: a B command must be issued to allocate a buffer before R, S, or D commands can be used to put data into the buffer. New users should follow the order shown in the following mode descriptions until they are thoroughly familiar with the module's operation.

Bus Controller Simulator Mode

Commands available for use in the Bus Controller Simulator mode, in typical programming order, are:

Command	Meaning
K	Kill/Reset
H (Optional)	Hi Speed
F	Function
J (Optional)	Jitter
B	Buffer
S	Bus Controller Sequence List
D	Data
M (Optional)	Error Generation mode
V (Optional)	Transmit Voltage Level/Receive Threshold Level
G (Optional)	Gap
T	Trigger

Q (Optional) Quit
C (Optional) Condition
A (Optional) Accept

Following the K command, an FC command is sent first to place the 53A-453 in BC Simulator mode. After the mode is selected, B commands are issued to allocate buffer space for the Bus Controller Sequence List (see the Glossary for Bus Controller Sequence List definition), and for up to 32 transmit/receive buffers.

Figure 453-3 is a simplified memory map to aid in understanding how the various buffers are set up and interact.

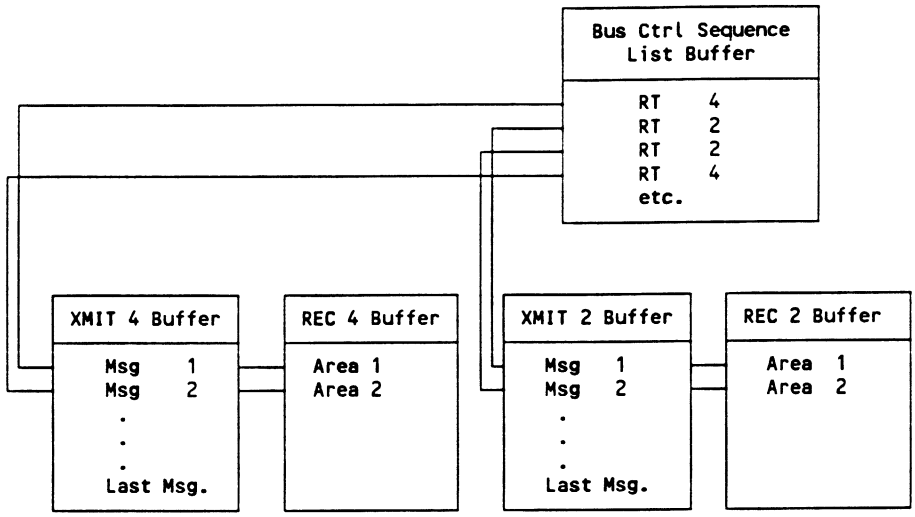


Figure 453-3: Bus Controller Simulator Example

In the Bus Controller Simulator mode, the following sequence of events will take place when a T command is received by the 53A-453 Card:

1) The 53A-453 Card will examine the contents of the Bus Controller Sequence List buffer to determine the proper order in which to use the various buffers. The first buffer in the list is buffer 4, so the first message sent will be the first message (Msg 1) contained in transmit buffer 4. Area 1 in receive buffer 4 will receive and store the response to message 1.

   Buffer numbers are usually associated with an RT number. In the Bus Controller mode, however, this is not absolutely necessary.

   Any valid or invalid command word followed by optional data words may be contained in each message. In addition to storing all response, status, and data words received prior to the next command in the receive buffer, the 53A-453 Card also stores the command word in the receive buffer for reference. The command word is stored before the

response words. (In the case of an RT-RT command, only the first command word is stored).

2) After the transaction for buffer 4 is completed, the 53A-453 Card takes the next item in the Bus Controller Sequence List. In the example in Figure 453-3, this would be buffer 2. The sequence of events described in Step 1 is repeated, and message 1 in transmit buffer 2's transmit buffer is transmitted.

3) The next Bus Controller Sequence List item is buffer 2 a second time. The second message in transmit buffer 2 is then transmitted.

NOTE: Although Figure 453-3 refers to "Area 1" and "Area 2" for the receive buffers, you only need to allocate a total size for each receive buffer. The card will sequentially load consecutive RT responses. That is, message 2 is loaded immediately following message 1, followed by message 3, etc.

4) The next item in the example is buffer 4 again. This instructs the 53A-453 Card to process the next message in transmit buffer 4. Since the last message processed was message 1, message 2 will be the next one handled.

As this example demonstrates, any number of messages can be handled for any number of RTs in any order, limited only by the amount of memory available on the 53A-453 Card.

To use the Bus Controller mode, first determine the number of buffers required and the access order, using the technique shown in the above example. Then, using the notes below, determine the size of each buffer, and allocate the desired buffers.

- The number of words put into the data buffer should exactly equal the number of transmit words allocated by the B command for proper operation.

- Allocation of <u>both</u> a transmit and receive buffer for any RT to be used is required for proper operation.

- The function that the RT is to perform is an important programming consideration, since all 53A-453 Card buffers are "wrap-around" buffers. Attempting to load too much information may cause information at the front of a buffer to be over-written by new information. Normally, the 53A-453 transmit buffers will be relatively large and the receive buffers relatively small if the RT is to receive, and vice versa if the RT is to transmit.

- The command word needs to be accounted for in allocating receive buffer storage.

After the sequence list and transmit and receive buffers have been allocated with the B command, use the following steps to load the desired information into each buffer:

1) Use an S command to specify the order in which buffers will be addressed (Bus Controller Sequence List). The S command is also used to specify the interval between the mid-transition of the parity bit in one message and the mid-transition of the sync pattern in the next message (message pacing).

2) The D command is issued next, to load each transmit buffer in the 53A-453 Card with the proper messages to be sent. An RT receive message consists of a receive command word

followed by one or more data words, while an RT transmit message consists of only a transmit command word. Command and data words can be loaded into each transmit buffer in any order.

The D command is also used to specify the type of induced errors, if any, that are to be placed in the data. Errors may be introduced and tracked on a word-by-word basis. (See the section on Error Handling for a more detailed explanation.)

3) The last word of each message placed in a transmit buffer must be marked with a "last-word flag" in order for the 53A-453 to determine the end of the message and to correlate messages in the transmit buffers with entries in the Bus Controller Sequence List (between MSG1 and MSG2, etc. in the above example).

The preceding steps are the minimum that must be done to program the 53A-453 Card to operate as a bus controller (between MSG1 and MSG2, etc. in the above example).

Other parameters, which are set to default values in normal operation, can also be programmed. For example, the V command may be used to change the output voltage transmission level from the default value (6.38V ptp), or to change the receive voltage threshold from the default value (2.00V ptp). The value against which the RT's response time is checked can be changed from the default value (4 microseconds) using the G command. An alternate set of transmitted data error types can be selected using the M (Error mode) command.

After all the buffers have been allocated, the data loaded, a bus controller sequence established, and the optional parameters (if any) specified, use a T command to initiate the programmed bus communications sequence. Execution can follow one of three courses, as specified by the T command:

1) The programmed bus communi-cations sequence is executed a specified number of times.

2) The 53A-453 Card is placed in an endless loop and the bus communications sequence is continuously executed until the card is halted with a Q command or External Halt Input signal.

3) The bus communications sequence is stepped forward by one or more messages each time a T command is issued.

After a sequence has been executed, you will usually want to examine the results of the run. An A command allows you to examine a given buffer word by word, looking at values for received data and errors (if any). The C command quickly tests whether any errors exist in a specified buffer, without having to examine the buffer contents word by word.

Remote Terminal Simulator Mode

Commands available for use in the RT Simulator mode, in the order they are typically programmed, are:

Command	Meaning
K	Kill/Reset
H (Optional)	Hi Speed
F	Function
J (Optional)	Jitter

B	Buffer
R (Optional)	RT Response Time List
D	Data
M (Optional)	Error Generation mode
P (Optional)	Sync Pattern
V (Optional)	Transmit Voltage Level/Receive Threshold Level
T	Trigger
Q (Optional)	Quit
C (Optional)	Condition
A (Optional)	Accept

The first command sent to the 53A-453 following the K command must be an FR command to place the card in the RT Simulator mode. After the mode selection is made, a B Command is issued to allocate transmit and receive buffer space for each of up to 31 RTs to be simulated. The transmit buffer for each RT is used to store the message (status and data words) that the RT will return to the bus controller, while the receive buffer is used to store messages (command and data words) sent to the RT by the bus controller.

Transmit and receive buffers must be set up for each RT that the 53A-453 Card is to simulate. If the 53A-453 Card receives messages for an RT which has not been defined by a B command, the associated command and data words will be ignored. In the RT Simulator mode, the buffer number must be equivalent to the RT terminal number in the command word sent by the Bus Controller.

Figure 453-4 is a simplified memory map to aid in understanding the operation of the 53A-453 Card in the following example. The block at the top of the figure defines the order in which the bus controller will send messages to the 53A-453 Card in this example.

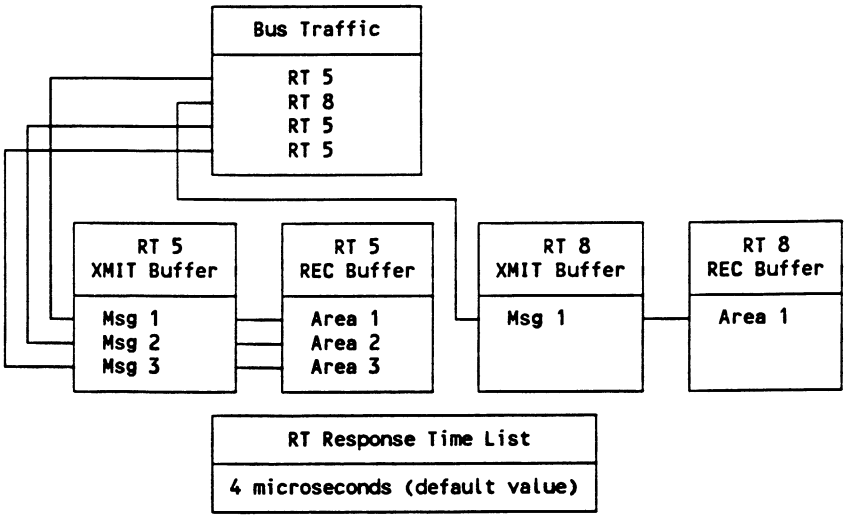


Figure 453-4: RT Simulator Example

Assuming the 53A-453 Card has received a T (Trigger) command, the sequence of events that will take place when the card begins receiving messages from the bus controller is as follows:

1) The first message received by the 53A-453 Card (message 1) is decoded and found to be a transmit command to RT 5. The received message is therefore a single command word, and is stored in RT 5's receive buffer (Area 1 in Figure 453-4).

   Since, in this example, the 53A-453 Card's RT Response Time List was left at its default value of 4 μs for all messages, the 53A-453 Card will transmit the first response message contained in RT 5's transmit buffer with a response time of 4 μs. It is the responsibility of the programmer to load the first response message in RT 5's transmit buffer with a proper status word and the proper number of data words.

2) The next command received instructs the 53A-453 Card to simulate RT 8 in the transmit mode. The received command word will be stored in Area 1 of RT 8's receive buffer. Four μs later, message 1 from RT 8's transmit buffer will be sent to the bus controller. It is the responsibility of the programmer to load the first response message in RT 8's transmit buffer with a proper status word and the proper number of data words.

3) When the third command word is received, a request for RT 5 to transmit again, message 2 in RT 5's transmit buffer is returned to the system controller. The received command word is stored in Area 2 of RT 5's receive buffer.

4) RT 5 is next sent a receive command. The incoming command word and data word(s) will be stored in Area 3 of RT 5's receive buffer. Four μs after the last data word is received, message 3 from RT 5's transmit buffer will be sent to the bus controller. For proper operation, message 3 in buffer 5 must be programmed as a status word and no data words.

Using this pattern, any number of RTs can be simulated to handle any number of messages in any order, limited only by the amount of memory available on the 53A-453 Card.

After the buffers for each simulated RT have been defined with the B command, the next step is to use the D command to load each transmit buffer with the proper status and data words to be returned to the bus controller. The proper status and data words are defined based on the sequence of commands that will be transmitted by the 1553 bus controller. The D command is also used to specify the type of induced errors, if any, that are to be placed in the data. Errors may be introduced and tracked on a word-by-word basis. (See the section on Error Generation for a more detailed explanation.)

These steps represent the minimum setup required to program the 53A-453 Card as an RT simulator. Optional commands are also available which extend the flexibility of the 53A-453 Card by allowing worst- case testing of various 1553 data bus parameters.

In the above example, the 4 μs default RT response time was used when responding to each bus controller command. If desired, a specific RT response time can be associated with each message received by the 53A-453 Card. To do so, a B command is first used to define the size of the RT Response Time List. (The default size is a one-entry list containing a value of four micro-seconds.) The R command is then used to place response time entries in the list.

Each time a message is received, the next available response time from the RT Response Time List will be used to determine the length of time the 53A-453 Card will wait before responding to the received bus controller command. For example, if ten response times were defined, the first response time would be used when processing the first message on the bus, the second response time when processing the second message on the bus, etc. If message 11 was received,

the first response time in the RT Response Time List would be used again, since the RT Response Time List is a "wrap-around" list.

Additional optional commands V, P, and M are available in this mode. The V (Voltage) command is used to set the transmit voltage level and receive threshold voltage level, and functions as previously described for the Bus Controller Simulator mode of operation.

The P (Pattern) command instructs the 53A-453 Card not to begin processing messages immediately after receipt of a T (Trigger) command, but rather to wait until a command word is received that contains the 16-bit data pattern defined by the P command. Message processing will begin with the first command word that contains the required pattern. The P command can also be combined with the External Trigger Input to create various types of 53A-453 Card triggering sequences (see the T command in the Command Description sub-section).

Transmitted data error types can be selected using the M (Error mode) command.

After all of the buffers have been allocated, the data loaded, and the optional parameters (if any) specified, a T command is issued to initiate the programmed bus communications sequence. Execution can follow one of two courses, as specified by the T command:

1) The number of messages specified by the T command are processed.

2) The 53A-453 Card is placed in an endless loop, and messages are processed until the card is sent a Q command or an External Halt.

NOTE: The 53A-453 Card in the RT mode will remain in a bus active mode until the number of messages as specified by the T command is received. If the messages are not sent, a Q command may be required to terminate the Bus Active mode.

After a sequence has been executed, you will normally want to examine the results. An A command allows you to examine a given buffer word by word, looking at values for received data and errors (if any). The C command quickly tests whether any errors exist in a specified buffer, without having to examine the buffer contents word by word.

Bus Monitor Mode

Commands available for use in the Bus Monitor mode, in the order they would typically be programmed, are:

Command	Meaning
K	Kill/Reset
H (Optional)	Hi Speed
F	Function
J (Optional)	Jitter
M (Optional)	Error Generation mode
P (Optional)	Sync Pattern
V (Optional)	Transmit Voltage Level/Receive Threshold Level
T	Trigger
Q	Quit
C (Optional)	Condition
A (Optional)	Accept

As in previous modes, an F command must be the first command issued following a K command, to place the 53A-453 Card in the Bus Monitor mode. A 30,000-word buffer is automatically allocated. The 30,000-word buffer takes approximately one second to allocate in the hi-speed mode. If several modules are to be chained together as bus monitor modules using the Position Identification Output and External Trigger Input (see Application Note 453-III in Appendix E), they may all be issued an F command prior to data collection to minimize test execution time.

A T command is issued, followed optionally by an F and a number from 1 to 30000, instructing the 53A-453 Card to begin collecting all 1553 bus data.

If an F does not follow the T command, the 30,000-word buffer will function as a wrap-around buffer containing the last 30,000 words received. If an F follows the T command, the 30,000-word buffer will contain the first 30,000 words received. The optional number following the F specifies the position at which the Position Identification Output pulse will be placed on the Position Identification Output line.

A Q command or an External Halt Input signal must be used to stop data collection. The A and C commands have the same meaning and use as described previously for the Bus Controller Simulator and RT Simulator modes (except that only one buffer, rather than 32 buffers, is defined).

The V, P, and M commands, as described for the Remote Terminal mode, are also available in this mode.

All-mode Commands

The following commands are available in every mode:

Command	Meaning/Purpose
E	Error - Returns an error code to the system controller which describes any syntax error detected during programming.
H	Hi-Speed - Enables optimized versions of the D (Data), T (Trigger) and A (Accept) commands which significantly improves the execution time of each of those commands. The time required to initialize memory in the monitor mode with the FM command is also reduced significantly.
I	Interrupt - Indicates to the 53A-453 Card if an interrupt is to be sent to the system controller upon completion of a sequence of 1553 bus transactions.
J	Jitter - Enables or disables the detection of transition time errors in the 53A-453 receiver circuitry.
K	Kill - Resets card to power-up state with all parameters set to defaults.

Errors

The 53A-453 Card allows several types of errors to be generated to provide for worst-case testing of 1553 bus devices. In addition, errors associated with the 1553 bus can be detected, classified, and stored.

Error Generation

Two different modes of error generation are provided by the M command. Error generation in each mode occurs on an individual word basis. The following types of errors can be generated in the primary error mode:

Sync Error Early - The sync pattern mid-transition will occur one-half bit-time or 500 nanoseconds before the time required by MIL-STD- 1553.

Incorrect Parity - Even parity will be generated rather than odd parity as specified in MIL-STD-1553.

Manchester error - Manchester encoding specifies that the polarity of the data during the first half of a bit-time shall be opposite the polarity of the data during the last half of the bit-time.

When a Manchester error is specified, the data will be either high or low for the full bit-time depending on whether the data bit is a 1 or 0. The bit position of the error is controlled by the value of the last 4 bits of the word. A hexadecimal value of E through 0 in these 4 bits will generate the error in the first through fifteenth data bits respectively. A hexadecimal value of F will generate the error at the last bit-time prior to the parity bit.

Sync Error Late - The sync pattern mid-transition will occur one-half bit-time or 500 nanoseconds after the time required by MIL-STD-1553.

17-bit Word - An additional bit will be added to the transmission prior to the parity bit for a total word time of 21 bits, including sync and parity.

15-bit Word - The last specified bit prior to the parity bit will be omitted from the transmission for a total word time of 19 bits, including sync and parity.

Dropped Bit - Whenever the 1553 bus is active, it is at either a high or low state. If a dropped bit is specified, the bus will go to zero volts for one bit-time at a time other than the 3 sync bit-times or the parity bit-time. The total duration of the word will remain 20 bit-times. The position in the word where the error is generated is controlled in the same manner as that described above for a Manchester error.

An alternate error mode is provided primarily to allow testing a bus controller's or RT's ability to handle bit transitions of ±150 nanoseconds in received data without degradation of receiver performance. The additional error types that can be generated in the alternate error mode are:

Early Sync Transition Time - The sync pattern mid-transition will occur 150 nanoseconds before the time specified by MIL-STD-1553.

Dropped Parity Bit - Whenever the 1553 bus is active, it is at either a high or low state. A Dropped Parity Bit will generate zero volts for the parity bit-time. The total duration of the word will remain 20 bit-times, although if the word is the last word in a message, it will be indistinguishable from a 19-bit word duration.

Late Bit Transition Time - For one bit-time other than the three sync bit-times or the parity bit time, the mid-bit transition will occur 150 nanoseconds late. The position in the word where the error is generated is controlled in the same manner as that described previously for a Manchester error.

Late Sync Transition Time - The sync pattern mid-transition will occur 150 nanoseconds after the time required by MIL-STD-1553.

Single-bit Interword Message Gap - A gap of one μs between two otherwise valid words in a supposedly contiguous message is generated. The gap follows the word for which the error is specified.

14-bit Word/Single-bit Interword Message Gap - This error will generate a word of 2 μs less than normal duration followed by a gap of 1 μs.

Early Bit Transition Time - For one bit-time other than the three sync bit-times or the parity bit-time, the mid-bit transition will occur 150 nano-seconds early. The position in the word where the error is generated is controlled in the same manner as that described previously for a Manchester error.

Only one type of error may be specified for a particular word; however, each word may have a different type of error, as allowed by the programmed error mode, or no error.

Additional message-formatting errors may be generated as follows:

Incorrect Sync errors may be generated by specifying a data sync for a command or status word, or a command sync for a data word in the data list.

Word Count errors may be generated in the Bus Controller Simulator mode by making the number of data words following the command word different from the word count specified in the command word. Similarly, word count errors may be generated in the RT Simulator mode by making the number of words following the status words different from that specified by the incoming command word.

Interword Message Gaps of 14 μs or more may be generated by specifying an end-of-message flag in the middle of a message. In the Bus Controller Simulator mode, the RT for which the error is generated is entered twice in the Bus Controller Sequence List.

An Incorrect RT Address in a status word is generated by specifying an RT address for the status word different than the RT transmit buffer where the status word is contained.

No RT Response may be generated in the RT Simulator mode by programming the response time to an excessive value so that the response is to the following message on the bus. One entry in the RT Response Time List must be deleted, corresponding to the missing response.

The Transmit/Receive Bit may be made incompatible with the direction of data flow. In the Bus Controller Simulator mode, this is accomplished by setting the T/R bit to RT transmit, then sending data words following the command word, or by clearing the T/R bit to indicate RT receive, and then failing to send data word(s) following the command word.

In the RT Simulator mode, transmit/receive bit incompatibility is accomplished by having only a status word prior to the end-of-message flag when the RT is expecting a request to transmit data, or sending data words in addition to the status word when the RT is expecting to receive data.

An error which causes more than 32 words of data to be transmitted, in either the Bus Controller Simulator or RT Simulator mode, can be generated by placing the end-of-message flag in a transmit buffer after more than 32 words.

A Response Time error can be generated by programming an excessive response time (up to 65,535 μs) with the R Command.

Any other errors which are dependent on the command or status word contents or the number of words transmitted may be simulated by defining those invalid words or messages in the transmit buffers. They include improper mode code usage, invalid subaddresses, illegal commands, and improper use of the status word bits.

NOTE: An error condition wherein contiguous data is transmitted forever will result if the end-of-message flag is not programmed at the end of a message. This is not recommended for an automated test system, since the system controller cannot then regain communications with the 53A-453 Card unless power is recycled to the card.

Error Detection

The error types detected by the 53A-453, their decimal assignment (value of second byte in response to the A command) and definitions are:

Excessive Gap Time (1)

If an RT does not respond to a controller command from the 53A-453 Card within the time specified by the G (Gap) command, an Excessive Gap Time error will be recorded. This error is recorded for each word of the RT's response message unless an error of higher priority is detected.

Parity error (2)

If even parity is detected in an otherwise acceptable 20-bit word, a Parity error will be recorded.

Manchester error (3)

An invalid Manchester pattern (signal during the last half of a bit-time is not opposite the level during the first half of the bit-time) that is also not a valid sync pattern (to distinguish this error from a Too Few Bits error) will be recorded as a Manchester error.

Sync error (4)

When an invalid sync pattern that is also not a valid Manchester pattern (to distinguish this error from a Too Many Bits error) occurs at the time when a sync pattern is expected (at the beginning of a transmission or 20 bit-times after the start of the last valid sync

pattern), then a Sync error will be recorded. At the beginning of a transmission, the width of the 1.5 µs first half of the sync pulse is also tested. The width must be from 1.4 to 1.72 µs.

Too Many Bits (5)
Lack of a valid sync pattern or gap (zero level on the bus) within 20 bit-times after the last valid sync pattern will be recorded as a Too Many Bits error. This error will actually be reported on the word following the word in error. When a Single Error bit is detected on the last word of a message, an error may not be reported, since this condition is indistinguishable from permissible noise during transmitter shutdown. When several extra bits are detected on the last word of a message, they will be treated as an additional data word, typically a word with too few bits.

Too Few Bits (6)
A valid sync pattern that occurs less than 20 bit-times following the last valid sync pattern, or a gap (zero level on the bus) that occurs and doesn't recover within 20 bit-times (to distinguish it from a Dropped Bit error) after the last valid sync pattern, will be recorded as a Too Few Bits error.

This error will actually be reported on the word following the word in error unless the condition occurs on the last word of a message, in which case the error is reported on the failing word. In addition, if the error occurs in other than the last word in a message, the sync pattern of the following word will cause a Manchester error to be recorded on the failing word.

Dropped Bit (7)
A gap (zero level on the bus) of one or more bit-times that recovers within 20 bit-times after the start of the last valid sync pattern will be recorded as a Dropped Bit error. The dropped-bit-error latch will not be cleared until the start of the next message and Dropped Bit errors will be recorded on all words remaining in the present message.

Incorrect Bit Transition Time (8)
All 0-to-1 and 1-to-0 transitions of the bus are checked to see whether they are within 62.5 to 125 nanoseconds of the expected transition time. The acceptance window is 187.5 nanoseconds wide, and slides from 62.5 to 125 nanoseconds on either side of the expected transition time depending on the phase relationship between the incoming signal and the internal 53A-453 Card 16-MHz clock.

Once an Incorrect Bit Transition Time error occurs in a message, data may not be recorded correctly until the start of the next message, and the error will be recorded for all words until the end of the message. This error detection may be inhibited with the J command. Crossing times are measured at the receiver threshold point (1.0 and -1.0 volts for a 2.0V ptp receive threshold setting, for example).

Although this is a useful "quality of signal" test when the 53A-453 is closely attached to a unit under test, the error may need to be ignored under actual bus operational conditions (due to bus noise or transmission reflection problems).

Word Count error (9)
In the Bus Controller Simulator mode, a Word Count error will be recorded if an RT does not respond with the number of words requested by the command word.

In the Bus Monitor mode, a word count error will be reported if either the bus controller command or the remote terminal response does not contain the proper number of words. In the RT Simulator mode, a Word Count error will be recorded if the bus controller under test sends a command word that is not consistent with the transmit/receive bit and number of words specified in that command word. A Word Count error will be reported only on the first word of a message.

Message Format error (10)
The message received was not a valid 1553 format for the particular mode selected. The error must be caused by something other than a wrong number of data words. A Message Format error will be reported on each word of the message in error. The error may, of course, be overridden by a higher priority error, on a word-by-word basis. Message format error detection is described in more detail in the Command Checking section.

No Data error (11)
No data has been loaded into the receive buffer.

Interword Gap error (12)
A word is followed by an unexpected gap, or a word is not followed by an expected gap. This error is distinguished from a "word count" error in that the proper number of data words occurred between two command words; but a gap occurred at other than the end of the message, or no gap occurred between messages. The error is reported on a word-by-word basis.

Only one of the above errors will be recorded for a particular word. If more than one error exists in a word, error logging will proceed according to the following priorities:

Highest	-	error type 8
Next highest	-	error type 7
Next highest	-	error type 6, 5
Next highest	-	error type 4
Next highest	-	error type 3
Next highest	-	error type 2
Next highest	-	error type 1
Next highest	-	error type 9
Next highest	-	error type 10
Lowest	-	error type 12

Error types 9, 10, and 12 are reported only when using the formatted hexadecimal format (HF) when accepting data with the A (Accept) command.

In MIL-STD-1553A applications where mode codes and status word bits are less well defined, the HF format should not be used.

A decimal value 11 in the error code field indicates that no more data is available. This does not indicate an error.

Command Checking
Mode code commands are checked for proper presence or absence of a data word and direction of the data word (depending on the mode code), and also for proper use of the broadcast command.

Broadcast commands are checked for absence of a response.

RT-to-RT commands are checked for response by both RT's, consistent RT numbers, proper use of the T/R bit, word count in both command words, and consistent actual word count.

RT-to-RT broadcast commands are checked for no response by a receive RT.

Illegal use of mode codes in an RT-to-RT transfer is checked.

The contents of the status word in both normal and RT-to-RT transfers are checked for the following:

- Reserved bits should not be set.
- The instrumentation bit should not be set in a status word.
- The busy bit should be accompanied by no data words even if data words are requested.
- A message error bit will be marked as a message format error.
- Broadcast received bit and dynamic bus controller acceptance bits are checked to see that they only occur in response to a transmit status mode command.

The C (Condition) command also checks for the above format errors.

NOTE: Proper use of format checking requires that the receive buffer not have been wrapped. The C command also requires that the data be followed by at least one No Data Word indication.

NOTE: Checking of RT-to-RT format errors in the RT Simulator mode is limited. The use of the RT Simulator in RT-to-RT transfer must be restricted to well-defined situations and is discussed further in Application Note 453-IV in Appendix E.

The RT address is not required to agree with the buffer number in the Bus Controller mode, which allows more flexible use of the buffers. For example, buffers might be assigned to different subaddresses of the same RT and the Bus Controller Sequence List used to specify the order in which commands are sent to subaddresses.

In the RT Simulator mode, however, command words are still associated with buffer numbers, since the 53A-453 hardware uses the RT field of an incoming command word to determine which buffer to respond to. As a result, the command will not be received and stored unless the RT number agrees with the buffer number.

Card Commands

The 53A-453 Card is programmed by ASCII characters issued from the system controller to the 53/63 Series System's communications card. The 53A-453 is interfaced to the communications card through the card cage's backplane.

Command protocol and syntax are as follows:

1) The @XY sequence must be issued first to address the 53A-453 Card. The @XY sequence need only be issued again when a new card is to be addressed.

2) Each command consists of a single line of up to 240 characters. Parameters may not be "wrapped around," i.e., continued on the next line. Every command must end with a carriage-return <CR>. Line-feeds <LF> are optional. Line-feeds in some cases significantly slow down operation, and particularly in the case of the Trigger command, the line-feed should be suppressed (not sent).

3) If a given parameter is to be skipped, left at its previous value, or have its default value accepted, its position must still be denoted using consecutive commas.

The following pages list, in alphabetical order, the commands that are recognized by the 53A-453 Card, and provide a complete description of each command. In the examples that follow, the 53A-453 will be assumed to have the card address 5 and to be located in a mainframe with address 0. Although the @05 is shown in every example, the characters are only required if the 53A-453 Card is not already addressed.

Command	Description
@XY	The ADDRESS command is used to select (address) the 53A-453 Card.

@ The @ character is a delimiter used by the 53/63 Series System. The two characters following the @ are mainframe and function card address, respectively. Once a function card is addressed, it will remain addressed until the 53/63 Series System detects a new "@" character.

X The X in the command sequence is the mainframe address (0-9) which has been selected on the 53A-171 Control Card's address select switch.

Y The Y in the command sequence is the 53A-453 Card address (0-9) which has been selected by the 53A-453 Card's address select switch.

NOTE: If input is requested by the system controller from the 53A-453 Card prior to issuing an A, C, or E command to prepare the card for input, a "?" (Octal 77), followed by carriage-return/line-feed <CR><LF>, will be returned to the system controller.

NOTE: The 53A-453 Card does not permit the use of superfluous null or space characters within or at the end of a command. Consult your system controller user's manual to make sure the format being used does not automatically issue spaces or nulls to fill some specified field.

Command	Description
A	The A (Accept) command specifies the data which the 53A-453 Card is to pass back to the system controller in response to the next system controller input request, and the format for this data.

Syntax: Az_1,z_2,z_3

In the Bus Controller Simulator mode or RT Simulator mode, z_1 specifies the number of the receive buffer (0-31) from which the data and error information are to be collected. In the Bus Monitor mode, z_1 must be an asterisk (*, Octal 52), indicating the single large receive buffer allocated in the Bus Monitor Mode.

z_2 is a number from 1 to 30000 that specifies the location within the selected receive buffer for the start of data and error collection. Data will be read back starting at that location in the buffer.

z_3 is an ASCII H, HF, HE, B or BL which specifies the format of the returned data:

H = Hexadecimal
HF = Hexadecimal with Message Format Checking
HE = Hexadecimal with Extended Message Format Checking
B = Binary
BL = Blocked Binary

After the Accept command is issued, the system controller normally begins requesting input from the 53A-453 Card. If z_3 is specified as H, HF, or HE, the system controller will receive six hexadecimal characters, followed by <CR> and <LF> for each input request.

Format	Functions Performed
H	only word level checking.
HF	word level checking, checks for word count and message format errors.
HE	word level checking, checks for word count and message format errors, identifies command versus status words, and indicates whether a gap in data bus activity follows the word.

If z_3 is specified as B, the system controller will receive three 8-bit binary bytes followed by <CR> and <LF> characters. If z_3 is specified as BL, the system controller will receive the three 8-bit binary bytes with no <CR> or <LF> until a No-Data Word is detected. The No-Data Word three bytes will then be followed by <CR> and <LF> characters. If a No-Data word is not detected (the receive buffer has wrapped), the system controller may terminate input in the Blocked Binary mode at any time by issuing a new output command to the card.

The complete syntax of the returned data for each format is as follows:

H and HF Format:

1st character -
0 indicates a data word.
1 indicates a status or command word.

2nd character - Error Code/No Data

Value	Error
0	No Errors
1	Excessive Response Time
2	Incorrect Parity
3	Manchester Error
4	Sync Error
5	Too Many Bits
6	Too Few Bits
7	Dropped Bit Error
8	Bit Transition Time Error
9	Word Count Error*
A	Message Format Error*
B	No Additional Data
C	Interword Gap Error*

* Available only when z_3 is specified as HF or HE

For a complete description of error types, see the Error Handling subsection.

3rd through 6th characters -
Hexadecimal equivalent of the 16 data bits in the command, status, or data word. The MSB of byte 3 is the first data bit transmitted on the bus. The LSB of byte 6 is the last data bit transmitted on the data bus.

7th character - Carriage-return <CR>.

8th character - Line-feed <LF>.

HE Format:

The data is formatted the same as the HF format for characters 3 through 8. For the HE format, the first and second characters are redefined as follows:

1st character -

Value	Word Type	Gap Following
0	Data Word	No
1	Command Word	No
2	RT-RT Transmit Command	No
3	Status Word	No
4	Data Word	Yes
5	Command Word	Yes
6	RT-RT Transmit Command	Yes
7	Status Word	Yes

2nd character -

Codes 0 through C are the same as the HF format. An additional code D has been added for the HE format, which indicates that no data was received because the Trigger command to the module was aborted by a Q (Quit), K (Kill) or external Halt input before the trigger actually occurred.

B and BL Format:

1st Byte -

The three most significant bits are set to 0. The next bit is 0 if the word is a data word and 1 if the word is a status or command word. The four least significant bits contain the error code, defined as follows:

Low Order Four Bits	Error/No Data
0000	No Errors
0001	Excessive Response Time
0010	Incorrect Parity
0011	Manchester Error
0100	Sync Error
0101	Too Many Bits
0110	Too Few Bits
0111	Dropped Bit Error
1000	Bit Transition Time Error
1011	No Additional Data

For a complete description of error types, see the Error Handling subsection.

2nd and 3rd Bytes -

These bytes contain the 16 data bits of the command, status, or data word. The MSB of the second byte is the MSB of the 16-bit data word and the first data bit transmitted on the bus. The LSB of the third byte is the LSB of the 16-bit data word and the last data bit transmitted on the bus.

Using the Accept Command

The Accept command is a required command. If an Accept command, Condition command, Error command, or TEST command is not sent before requesting a response from the 53A-453, a ?<CR><LF> will be returned in response to an Input Request.

When the A command is used to return binary or hexadecimal data to the system controller, keep in mind that each data buffer is a wrap-around buffer. The 53A-453 Card will continue sending data to the system controller from the specified buffer until the system controller stops requesting input.

For example, if a given buffer is 50 words long, and the system controller requests 100 words, the buffer will be transmitted twice. If each buffer is specified to be slightly larger than the expected amount of data to be received into the buffer, then the No Additional Data code can be used by the system controller to determine when to stop requesting input from the 53A-453 Card.

In the Blocked Binary Accept command format, the No Additional Data code is used to append a <CR> and <LF>. In IEEE-488 systems, the <LF> may be used to generate an EOI and automatically terminate input following the first No Data word.

Tutorial: Derivation of MIL-STD-1553B Command Word Content From Hexadecimal Data

MIL-STD-1553B requires a specific format for the bus controller command word. The first five bits transmitted are the RT Terminal Address, the sixth bit is the Transmit/Receive bit, the next five are the RT sub-address, and the last five bits are the word count. As an example, the command word content of "D423h" would be derived as follows:

1. Write down the bit pattern corresponding to the hexadecimal value, D423: 1101 0100 0010 0011

2. Reblock the bits in groups of 5, 1, 5 and 5 bits to correspond to the command word format: 11010 1 00001 00011

3. Determine the decimal value of each block. For example, 11010 equals decimal 26.

The resulting command word contents for this example are:

RT Address	26
T/R bit	Set
Sub-address	1
Word Count	3

Example:
To obtain data beginning at the start of the buffer associated with RT 26, using hexadecimal data format, the following Accept command would be issued: A26,1,H

If buffer 26 contained a status word and three data words, with the second data word containing an incorrect parity bit, the following might be returned to the system controller if input was requested five times from the 53A-453 Card:

Input	Data Returned:	
Request	H, HF, HE Format	B Format
1st Byte	2nd Byte	3rd Byte
1st	10D100 <CR><LF>	<00001000><11010001><00000000><CR><LF>
2nd	00B6AD <CR><LF>	<00000000><10110110><10101101><CR><LF>
3rd	02B6AF <CR><LF>	<00000010><10110110><10101111><CR><LF>
4th	0008F6 <CR><LF>	<00000000><00001000><11110110><CR><LF>
5th	0B0000 <CR><LF>	<00001011><00000000><00000000><CR><LF>

Command	Description

B

The B (Buffer) command is used to allocate 53A-453 Card buffers.

Syntax: Bz_1,z_2

The Buffer command allocates the size of the 32 transmit and receive buffers in the Bus Controller and Remote Terminal modes. It also allocates the size of the Sequence List buffer in the Bus Controller mode and the Response Time List buffer in the Remote Terminal mode. The Buffer command is a required command.

Misuse of the Buffer command is the most common cause of improper operation in new applications. Careful attention to the Buffer Specification Rules on the required parameters for the Bus Controller and Remote Terminal modes on the next page will help minimize problems in using this command.

Bus Controller Simulator Mode:

In the Bus Controller Simulator Mode, the B command is used to allocate the 32 transmit and receive buffers as well as a buffer for the Bus Controller Sequence List.

If a transmit or receive buffer is to be allocated, z_1 is the buffer number (0 to 31).

When transmit or receive buffers are being sized, setting z_1 equal to an "*" (Octal 52) will size all 32 transmit or receive buffers to the same size.

Transmit and receive buffer numbers are very often associated with RTs of the same number. However, in the Bus Controller Simulator mode, this is not absolutely necessary. In this mode, buffers may also be used for subaddresses, or to agree with the sequence of messages (buffer 0 for the first message, buffer 1 for 2nd message, etc.), for example.

If a transmit buffer is being allocated, z_2 is a T followed by the decimal size of the buffer. If a receive buffer is being allocated, z_2 is an R followed by the decimal size of the buffer.

If a Bus Controller Sequence List buffer is to be allocated, z_1 is an S followed by the decimal size of the Bus Controller Sequence List. z_2 is not used when a Bus Controller Sequence List is being allocated.

RT Simulator Mode:

In the RT Simulator Mode, the B command is used to size the receive and transmit buffers for each simulated RT and the optional RT Response Time List buffer, if required.

If an RT transmit or receive buffer is to be allocated, z_1 is the RT number (0 to 31).

When RT transmit or receive buffers are being sized, setting z_1 equal to an "*" (Octal 52), will size the transmit or receive buffers in all 32 RTs to the same size.

If an RT transmit buffer is being allocated, z_2 is a T followed by the decimal size of the buffer. If an RT receive buffer is being allocated, z_2 is an R followed by the decimal size of the buffer.

In the RT Simulator Mode, the 53A-453 Card detects the RT address of an incoming command word and uses that to select the buffer number to respond from. The buffer number therefore must be associated with an RT (buffer 8 used to respond to RT 8 command words, etc.) in the RT Simulator Mode. An incorrect RT address in a status word may be simulated, however. The buffer number only has to agree with the RT address of the incoming command word. The status word RT address may be different than the buffer number.

If an optional RT Response Time List buffer is to be allocated, z_1 is an R followed by the decimal buffer size. z_2 is not used when an RT Response Time List buffer is being allocated.

Bus Monitor Mode:

The B command is not required in the Bus Monitor Mode. In the Bus Monitor Mode, a single 30,000 word receive buffer is automatically allocated by the 53A-453 Card.

Buffer Specification Rules:

The buffers allocated by the B command are wrap-around buffers, so if additional data are written into a full buffer, the additional data will be stored starting back at the first location in the buffer.

If the sequence list is to execute more than once, or if a transmit buffer is to be transmitted more than once, it must be allocated exactly equal to the number of words to be loaded by the commands that define the contents of the buffer (the Sequence or Data commands). Otherwise, improper transmission will result. The 53A-453 Card, when triggered, will transmit any undefined data when it reaches the end of the defined data. Only when it reaches the end of the buffer will it return to the top of the buffer.

Transmit and receive buffers must be allocated in pairs. Improper operation will result if a transmit buffer is allocated for a given buffer without also allocating a receive buffer. If received data is not of interest, then a one-word receive buffer may be allocated and the data ignored.

In the Bus Controller mode, the bus controller command word is stored in the receive buffer for easy correlation of command and response. So, when sizing the receive buffer, allow one additional location for each command/response.

Examples:

Bus Controller Simulator Mode:

To set up a Bus Controller Sequence List with space for one entry, a transmit buffer of one word for buffer 17, and a receive buffer of 34 words for buffer 17, the following three commands would be issued:

```
BS1
B17,T1
B17,R34
```

These allocations would be appropriate for a 32 data word transmit message to Remote Terminal 17, for example. The 34 word receive buffer allows storage of the command word (which is stored in the receive buffer on transmission), the returned status word, and 32 data words.

RT Simulator Mode:

To set up transmit buffers of 33 words each and receive buffers of two words each for RTs 23 and 9 (representing, for example, one status word and 32 data words in the transmit buffer, and one command word followed by a No Data word in the receive buffer), the following four commands would be issued:

```
B23,T33
B23,R2
B9,T33
B9,R2
```

In this example, it is assumed that the default RT Response Time List of a single word is acceptable. If a different response time is desired for RT9 and RT 23, use the command BR2 to allocate an RT Response Time List of 2 words.

Command	Description

C

The C (Condition) command is used to examine all data stored in the 53A-453 Card memory for a given RT buffer, on a block-by-block basis, to determine if any message block contains an error.

Syntax: Cz_1, Cz_2

z_1 is a decimal number (0 to 31) which specifies the buffer for which a condition check is to be made. In the bus monitor mode, the z_1 parameter is ignored and may be omitted.

z_2 is a decimal number (0 or 1) which disables or enables additional message format error checking for the subsystem flag and terminal flag bits. If z_2 equals 1, the presence of a subsystem or terminal flag bit will be recognized as a message format error. If z_2 is 0 or missing, the additional testing is not disabled.

After issuing the C command, the system controller will request input from the 53A-453, and receive a response consisting of a single digit (0, 1 or 2) followed by a <CR> and <LF>. The response digit indicates the state of the receive buffer for the specified RT:

0 Indicates that the buffer contains no data words with errors.

1 Indicates that the buffer contains at least one word containing one of the following errors:

- Too few bits
- Incorrect parity
- Too many bits
- Excessive response time
- Sync error
- Manchester error
- Dropped bit error
- Bit transition time error
- Word count error
- Message format error
- Interword gap error

2 Indicates that condition checking is not possible because the number of words received exceeded the size of the specified buffer, causing the 53A-453 Card to wrap memory and overwrite messages at the beginning of the buffer, or that the received data exactly filled the buffer and the 53A-453 Card was unable to positively indicate that the data was valid. To use the C command, receive buffers should be sized to allow at least one No Additional Data word at the end of a buffer.

Normally, the C command will be used when the 53A-453 Card is programmed to process a finite number of messages. It indicates to the system controller whether or not it is necessary to issue an A command and examine each word in the receive buffer.

See the Error Detection subsection for a complete description of what the detected errors mean, including a discussion of the types of errors included as message format errors.

Command	Description

D

The D (Data) command specifies the data list for any one of the 32 transmit buffers in the Bus Controller or Remote Terminal modes.

Syntax: $Dz_1,z_2,z_3,z_4,...$

z_1 specifies the number (0 to 31) of the buffer to which the data list applies.

z_2 is a number in the range of 1 to 30000 that specifies the starting buffer position for the data list. The z_2 value is provided to allow definition or update of data values in the buffer without having to start at the top of the buffer.

z_3 is either H (Hexadecimal) or B (Binary), specifying the format for the data.

z_4 is the actual data list.

If the 53A-453 Card is functioning as a bus controller simulator, the D command loads into memory the command and data words to be sent from the specified buffer.

When the 53A-453 is functioning as an RT simulator, the D command loads into memory the status and data words that a specific RT will send to the bus controller in response to a command word with an RT address equal to the RT buffer number as specified by z_1.

The D command allows an end of message flag to be programmed and can therefore be used to program multiple messages in a buffer.

Hexadecimal Format:

If z_3 is an H, then the format of z_4 is groups of six ASCII characters as defined below. Each six character value is separated by commas, and each message is separated or terminated with a semicolon. Examples are given below.

1st Character -

0 Indicates a data word.

1 Indicates a command or status word.

2 Indicates a data word to be followed by a low TTL pulse on the Position Identification Output. The TTL pulse occurs during the sync pattern of the following word.

3 Indicates a command or status word to be followed by a low TTL pulse on the Position Identification Output. The TTL pulse occurs during the sync pattern of the following word.

If the last word in a message is programmed with a 2 or 3, the Position Identification Output pulse will be generated during the beginning of the next transmitted command word for that RT.

2nd Character - Error code, 0 through 7.

For primary error mode (no M command, or M0 command programmed):

Value	Error
0	No errors
1	Sync transition 500 ns early
2	Incorrect parity
3	Manchester error
4	Sync transition 500 ns late
5	17-bit word
6	15-bit word
7	Dropped bit

If the alternate error mode has been programmed (M1 command):

Value	Error
0	No errors
1	Mid-sync transition 150 ns early
2	Dropped parity bit
3	Mid-bit transition 150 ns late
4	Mid-sync transition 150 ns late
5	1-μs gap following word
6	14-bit word followed by 1-μs gap
7	Mid-bit transition 150 ns early

3rd through 6th Characters -
The 16-bit command, status, or data word, which is represented by four hexadecimal digits. The MSB of the first hexadecimal digit is the first bit transmitted on the MIL-STD-1553 bus following the sync pattern. The LSB of the fourth hexadecimal digit is the last bit of the 16-bit word transmitted before the parity bit.

The delimiters following z_4 must be commas (,) unless z_4 is the last word of a message. If z_4 is the last word of a message, then a semicolon (;) must be used. This convention must be followed even if z_4 is the last word of a line of data. Remember that a line of data is restricted to a maximum of 240 characters.

A colon rather than a semicolon may be used to separate messages and end the last message. Leading zeros are assumed if less than six hexadecimal digits are specified.

Binary Format:

If z_3 is a B, then each command, sync, or data word consists of three 8-bit bytes. The first byte is formatted as follows:

8th Bit (MSB)
: Set to 1 if this is the last word to be loaded by this D command; allows <CR> or <LF> characters to be sent again to the 53A-453 Card.

7th Bit
: Set to 1 if this word is to be followed by a low TTL pulse at the Position Identification Output; set to 0 otherwise.

6th Bit
: Set to 1 if this is the last word of a 1553 bus message.

5th Bit
: Set to 1 if this is a command or status word; set to 0 if this is a data word.

4th through 1st Bits
: The low order four bits are used to contain the error code.

For primary error mode (no M command, or M0 command programmed):

Low Order Four Bits	Error
0000	No errors
0001	Sync transition 500 ns early
0010	Incorrect parity
0011	Manchester error
0100	Sync transition 500 ns late
0101	17-bit word
0110	15-bit word
0111	Dropped-bit error

For alternate error mode (M1 command programmed):

Low Order Four Bits	Error
0000	No errors
0001	Mid-sync transition 150 ns early
0010	Dropped parity bit
0011	Mid-bit transition 150 ns late
0100	Mid-sync transition 150 ns late
0101	1 µs gap following word
0110	14-bit word followed by 1 µs gap
0111	Mid-bit transition 150 ns early

The second and third bytes contain the 1553 bus data word. The MSB of the second byte is the first bit of the 16-bit word transmitted following the sync pattern. The LSB of the third byte is the last bit of the 16-bit word transmitted prior to the parity bit.

In the binary format, the restriction of 240 characters per line does not apply. A line may be of any length. If desired, the binary transfer can be separated into smaller transfers by using bit 7 of byte 1 to indicate the end of the transfer, and z_2 of the D command to position the start of the next transfer.

Example 1:

If the 53A-453 Card is functioning as a bus controller simulator, and you wish to load the command word and three data words shown below into transmit buffer 26 (used for RT 26 in this example), beginning at buffer position 1, use the following D command:

Hexadecimal Format:
D26,1,H,10D023,05B6AD,00B6AF,0008F6;

Type Word	Binary Data MSB LSB	Hex. Data	Errors
CMD	1101000000100011	D023	None
DATA	1011011010101101	B6AD	17-bit word
DATA	1011011010101111	B6AF	None
DATA	0000100011110110	08F6	None

To load the same data to RT 26 using binary format, use the following D command:

Binary Format: D26,1,B,d1d2d3d4...d12

Where d1 through d12 represent 12 8-bit bytes (3 8-bit bytes for each of 4 words) sent to the 53A-453 Card. The binary values of the bytes d1 through d12 are shown below:

Byte	Value	Notes
1	00010000	Cmd Word
2	11010000	D0
3	00100011	23
4	00000101	Data w/err 5
5	10110110	B6
6	10101101	AD
7	00000000	Data/No Errors
8	10110110	B6
9	10101111	AF
10	10100000	Data/End of Msg/Last 3 Bytes
11	00001000	08
12	11110110	F6

In the BASIC programming language, binary data is often transmitted by using the CHR$ function to build a string. A string WRT$, for the example above, would be created as follows:

```
WRT$ = "D26,1,B," + CHR$(16) + CHR$(208) + CHR$(35) + CHR$(5) +
CHR$(182) + CHR$(173) + CHR$(0) + (CHR$(182) + CHR$(175) + CHR$(160)
+ CHR$(8) + CHR$(246)
```

Note that byte 10 above has bit 8 and bit 6 both set to indicate end of message and also to indicate the end of the binary transfer.

Example 2:

This example illustrates how to derive a four character hexadecimal command word for a desired command per MIL-STD-1553. Assume an RT address of 27, the T/R bit set, a subaddress of 1, and a word count of 17. The 16 bit pattern required for this command word is as follows:

RT 27	T/R Bit Set	Subaddr 1	Word Count 17
11011	1	00001	10001

Combine the bits and separate into groups of four as follows:

1101 1100 0011 0001

The resulting four hexadecimal characters are DC31.

Command	Description

E

When the 53A-453 Card receives a command from the system controller that it is unable to recognize, the ERR LED on the front edge of the module is lit. Use the E command to determine the type of error that caused the ERR LED to light.

Syntax: E

The E command instructs the 53A-453 Card to return the appropriate two-digit syntax error code as a response to the next input request to the 53A-453 Card.

The possible error codes are:

Value	Error
00	No error
01	Unrecognizable command
02	Command line too long
03	Memory full
04	Invalid A (Accept) command
05	Invalid B (Buffer) command
06	Invalid C (Condition) command
07	Invalid D (Data) command
08	Invalid E (Error) command
09	Invalid F (Function) command
10	Invalid G (Gap) command
11	Invalid I (Interrupt) command
12	Invalid M (Error Mode) command
13	Invalid P (Pattern) command
14	Invalid Q (Quit) command
15	Invalid R (Response Time) command
16	Invalid S (Sequence) command
17	Invalid T (Trigger) command
18	Invalid V (Voltage) command
19	Invalid input request

When the error code is returned following the E command, the error code is cleared and the ERR LED is turned off.

In an ATE system, it may be useful to determine if a syntax error has occurred, especially during program development. The E command may be sent after each command to determine if the command caused a programming error. If no error has occurred, then error code 00 will be returned, indicating no syntax error.

If an E, A, C, or TEST command is not sent before requesting a response from the 53A-453, a ?<CR><LF> will be returned in response to an input request to the module.

Command	Description
F	The F (Function) command selects the 53A-453 Card's function: bus contr simulator, RT simulator, or bus monitor.

Syntax: Fz

z is one of the following:

C - Bus Controller Simulator
R - RT Simulator
M - Bus Monitor

The K (preferable) or F command must be the first command issued to 53A-453 Card after power is applied to the card. After the F command been issued, the F command cannot be reissued unless it is preceded by command.

An FM command requires approximately 1 second to allocate a 30,000-w buffer. If multiple cards are to be chained together in the Bus Monitor M to achieve continuous collection of more than 30,000 words, the F comm should be issued to all cards before sending the T command to the first c in the chain.

If the card is not in the high speed mode (see H command), allocation of buffer requires approximately 7 seconds.

Example:
The command FM will cause the MON LED to light and the 53A-453 Car function as a bus monitor.

Command	Description
G	When the 53A-453 Card is functioning as a bus controller simulator, it automatically checks the response time of each RT with which it communicates. The G command specifies the time in microseconds against which each RT's response time will be checked. Syntax: Gz z is a 1- or 2-digit decimal number from 4 to 31 that specifies the value of the response time gap in microseconds. (See the Glossary for a definition of RT Response Time.) If an RT responds, but fails to respond in the time programmed by the G command, the response-time error will be logged along with the first word (status or data) received from the RT. If the RT does not respond at all, there will simply be no data in the respective RT's receive buffer. If the RT waits to respond until the 53A-453 Card has begun outputting its next message, a "data collision" or "bus crash" will occur on the bus, and data may be garbled. (A "data collision" is defined as two devices attempting to transmit on the 1553 bus at the same time.) In the event of a "data collision" under these circumstances, the offending RT's receive buffer will contain no additional data, since the receive logic on the 53A-453 Card is disabled while the card is transmitting data. Example: The command sequence G12 would set the response time gap test value to 12 microseconds as specified in MIL-STD-1553B.

Command	Description
H	The H (High Speed) command optimizes the execution time of the F (Function), D (Data), T (Trigger), and the A (Accept) commands.

Syntax: Hz

z is a decimal number (0 or 1) which specifies:

0 - Disable high speed operation
1 - Enable high speed operation (default)

On power-up, the high speed mode will be disabled.

The set of commands chosen for optimized performance allows use of the modules in applications where one or two small messages may need to be updated in response to the results of a previous message in a 50 millisecond time frame.

The high speed operation is not intended to accommodate complex Real Time simulation applications. The 53A-454 MIL-STD-1553 Real Time Bus Controller Simulator Card is available for those applications.

The High Speed mode also speeds up the allocation of the 30,000 word receive buffer during the FM command from 7 to 1 seconds.

Example:
The command sequence H1 enables high speed operation.

Command	Description
I	The I (Interrupt) command enables the interrupts from the 53A-453 Card.

Syntax: Iz

z is a decimal number (0 or 1) which specifies:

0 - Disable interrupt generation (default)
1 - Enable interrupt generation

If the interrupt mode is enabled, the 53A-453 Card will generate an interrupt when a 1553 bus communications sequence is completed. The interrupt is cleared when the system controller requests input from the 53A-453 Card.

The interrupt generates a VXI interrupt at the level set by the Interrupt Level Select switch (see Switches subsection). In IEEE-488 applications, this interrupt may be used to generate a Service Request (SRQ), assuming the Interrupt Level Select switch on the handler module for the 53A-453 is set at the same level as the Interrupt Level Select switch on the 53A-453.

Example:
The command sequence I1 enables interrupts.

Command	Description

J

The J (Jitter) command disables transition time error detection by the receiver of the 53A-453 Card.

Syntax: Jz

z is a decimal number (0 or 1) which specifies:

0 - Enable transition time error detection
1 - Disable transition time error detection

At power-up and following a K (Kill) command the transition time error detection is enabled.

The transition time detection measures the time from one threshold crossing to the next threshold crossing, which is nominally expected to be 0.5, 1.0, 1.5 or 2.0 microseconds, per MIL-STD-1553.

The receiver checks that this time is reliably within 62.5 nanoseconds of the nominally expected time (threshold crossing points are +1.0V and -1.0V for rising and falling signals respectively when the receiver threshold is programmed to 2.0V ptp.).

A receiver transition time error (Error 8) may be generated when the time from one threshold crossing to the next is out of tolerance by more than 62.5 nsec.

Although this is a useful "quality of signal" test when the 53A-453 is closely attached to a unit under test, the error may need to be ignored under actual bus operating conditions, due to transmission reflection problems by the time the signal reaches the 53A-453 receiver.

Example:
Issuing the command sequence J1 will disable the transition time error detection until another K (Kill) command is issued.

Command	Description

K

The K command instructs the 53A-453 Card to restore its power-up conditions.

Syntax: K

The status of the 53A-453 after a K command is as follows:

Interrupt:	Disabled (I command)
Transmit Level:	6.38V ptp (V command)
Equivalent Bus Load for Transmit Level:	70 ohms (V command)
Receive Threshold:	2.00V ptp (V command)
Response Gap:	4 μs (R command)
Pace Interval:	1,000 μs (S command)
RT Response Time Test Value:	12 μs (G command)
Mode:	Undefined (F command)
Pattern Trigger:	Disabled (P command)
Error Mode:	Primary error set selected (M command)
RT Response Time List:	Unallocated (B command)
RT Sequence List:	Unallocated (B command)
Transmit and Receive Buffers:	Unallocated (B command)
Hi Speed Mode:	Disabled (H command)
Transition Time Error Detection:	Enabled (J command)

Example:
Issuing the K command at any time will restore the 53A-453 Card to its initial power-up condition as defined above.

NOTE: The Q and K commands are the only commands that can be issued to the 53A-453 Card while a bus communications sequence is in progress without hanging up the system controller. For a further discussion of how to avoid hanging up the system controller during bus communications sequences, see the note following the T command.

Command	Description
M	The M (Error Mode) command selects one of two different sets of transmitted error conditions.

Syntax: Mz

z is a decimal number (0 or 1) which specifies:

0 - Primary transmit error set selected (default)
1 - Alternate transmit error set selected

See the D command for the types of errors included in the primary and alternate transmit error set. The Error Generation subsection gives a complete description of both the primary and alternate error types.

Example:
The command sequence M1 would enable the alternate error set. An error code of 2 in all data lists transmitted thereafter would generate a dropped parity bit rather than an incorrect parity bit (also see DATA command).

Command	Description
P	The P (Pattern Recognition) command is an optional command, available only in the RT Simulator and Bus Monitor modes, which is used to program a pattern-recognition word. When the P command is programmed, the 53A-453 Card will not begin operation following a T (Trigger) command until a command or status word is received that matches the pattern-recognition word. Syntax: Pz z is a 4-character hexadecimal string which defines the bit pattern (16 bits) of the received command word, after which the RT mode will begin collecting and responding with data, or the monitor mode will begin collecting data. If the characters CLR are sent for the z string, the 53A-453 Card will disable the P command and will thereafter receive and process the first command following a T command. On power-up, or after receipt of a HALT command, z is set to CLR. In the RT Simulator mode, the P command is typically used to synchronize the 53A-453 Card with the 1553 data stream so that a desired sequence of responses will be given as a result of a bus controller's sequence of command words. In the Bus Monitor mode, the P command and the External Trigger Input give additional flexibility in determining when the start of 1553 bus data capture will begin. Example: The command "PD020" would hold operation of the 53A-453 Card until a command word with the bit pattern 1101000000100000 was received (receive command word to RT 26 at subaddress 1 for 32 words).

Command	Description
Q	The Q (Quit) command allows the system controller to terminate a bus communications sequence at any time. It also allows the ATE system controller to regain control of a 53A-453 Card that cannot finish its bus communication sequence because the unit under test (UUT) is not communicating with the 53A-453 Card.

Syntax: Q

The Q command is the only way to terminate the Bus Monitor collection mode and still preserve the collected data. In the Bus Monitor or Remote Terminal mode, the Q command terminates bus activity as soon as a gap in data traffic occurs. It terminates bus activity in the Bus Controller mode at the time when the next message would have started.

Example:
If a bus communications sequence is in progress, issuing the Q command to the 53A-453 Card will halt the bus communications sequence and resume command/response communications with the 53A-453 Card. All previously programmed card parameters such as Receiver Threshold Level, Response Time Gap Value, etc., will be unchanged. Any data programmed into buffers, or collected from the 1553 bus and stored into buffers, will also remain unchanged.

NOTE: The Q and K commands are the only commands that can be issued to the 53A-453 Card while a bus communications sequence is in progress to resume command/response communications with the 53A-453 Card. Any other commands sent during a bus communications sequence will be lost.

Command	Description
R	The R (RT Response Time List) command is an optional command used only in the RT Simulator Mode. The R command associates a specific RT response time (other than the 4-µs default value) with each message received by the 53A-453 Card.

Syntax: $Rz_1,z_2;z_2;...z_2$

Before the R command can be used, a B (Buffer) command must be issued to establish the size of the RT Response Time List buffer.

z_1 is a decimal number between 1 and the maximum number of possible entries in the RT Response Time List buffer as defined by the B command. z_1 defines the starting position in the RT Response Time List into which the first response time will be loaded.

z_2 represents the response time in microseconds to be entered into the RT Response Time List. z_2 may range in value from 4 to 65535.

The actual response time measured between the transition of the received parity bit and the mid-transition of the response sync pattern when programmed from 4 to 65,535 microseconds is nominally 4.25 to 65,535.25 microseconds. The accuracy of the crystal on the 53A-453 Card is 0.01%. For precise long response times, these two possible sources of error should be taken into account.

The R command can be used to generate a no-response condition by programming a value that would cause the response to occur as if responding to the following message. The response would originate from the transmit buffer associated with the last RT addressed. When using the R command in this manner, one less entry should be specified in the RT Response Time List for each response skipped.

Example:
When more than one response-time entry is contained in the RT Response Time List, the next available response time from the list determines how long the 53A-453 Card will wait before responding to a bus controller command word.

If the R command R1,5;10;8;9 were issued, the response times associated with the first nine received bus controller commands would be:

	Terminal Response
Command Word	Time Used
1st	5 μs
2nd	10 μs
3rd	8 μs
4th	9 μs
5th	5 μs
6th	10 μs
7th	8 μs
8th	9 μs
9th	5 μs

Note that the RT Response Time List applies to the order in which bus command words are received, and not to the RTs addressed to respond.

A BR4 Buffer Allocation command is required prior to the R command for the above example.

Command	Description

S

The S (Sequence List) command is used in the Bus Controller Simulator Mode ONLY. The S command specifies the order in which transmit buffers will send their messages; the messages themselves are taken from the data list associated with each buffer.

The S command is also used to specify the "pace" interval, or time between messages transmitted by the 53A-453 Card. The pace interval is defined as the time between the last parity transition of one message and the first sync transition in the following message transmitted by the 53A-453 Card.

Syntax: $Sz_1,z_2[,z_3];z_2[,z_3];...z_2[,z_3]$

z_1 is a decimal number from 1 to 30000 that specifies the location in the Bus Controller Sequence List where loading of buffer numbers is to begin.

z_2 is a decimal number from 0 to 31 that specifies the transmit buffer number to be loaded into the Sequence List.

z_3 is an optional parameter in the range of 14 to 65535 which specifies the pace interval in microseconds. If z_3 is not specified, the default value is 1000.

NOTE: The value of the z_3 parameter corresponding to a z_2 parameter specifies the interval prior to that message. To obtain the fastest response to an external trigger, the first z_3 in the message list should be set to 14.

When pace intervals of less than 1,000 microseconds are chosen, care must be taken to insure that the pace interval is long enough to allow for the RT response message plus the RT response time of the prior message. The following equation can be used to calculate the minimum z_3 pace interval:

$$z_3 = 20 \bullet A + B + 2$$

where:

A = total number of words including the status word in the RT response message

B = maximum RT response time in microseconds

If the pace interval is less than the minimum time specified in the above equation, a "data collision" on the 1553 bus may occur. A "data collision" will result in garbled data since two devices, the 53A-453 Card and the RT, will be transmitting at the same time. Whatever RT data is received prior to the data collision will be stored in the receive buffer.

Interval gaps of a minimum of 14 microseconds within a message can be generated as an error condition by specifying (in the data list in the D command) an end-of-message flag before the required number of words are sent, and specifying the buffer number twice in the S command. The second entry should have the pace value set to the desired gap duration between the two partial messages.

Example:
To send messages from buffers 3, 8, 21, 3, and 9 in that order, the command sequence S1,3;8;21;3;9 would be used. The messages would be automatically paced at the default value of 1,000 microseconds. Later, to send the third message from buffer 16 instead of buffer 21, and to decrease the pace interval between the second and third messages to 670 microseconds, the command sequence S3,16,670 would be sent to the 53A-453 Card. This redefines the 3rd entry in the test only.

Command	Description
T	The T (Trigger) command initiates a 1553 bus communications sequence.

Syntax: $Tz_1[,z_2]$

Bus Controller Simulator Mode:

z_1 specifies the number of times the Bus Controller Sequence List must be executed to complete a bus communications sequence. If z_1 is a decimal number between 1 and 32767, the entire Bus Controller Sequence List will be executed the number of times specified, beginning with the first entry in the list. If z_1 is an "*" (Octal 52), the 53A-453 Card will repeatedly execute the entire list until a K or Q command, or External Halt Input signal is received by the card.

If z_1 is the letter S followed by a number in the range 1 to 32767, then the 53A-453 Card will step through the Bus Controller Sequence List, counting messages, until the indicated number of messages has been processed. The first TS Command will begin counting with the first entry in the list. Subsequent TS commands will continue counting from the point where the previous command stopped. If z_1 is omitted, then its default value is S1.

z_2 is an optional parameter which enables or disables External Trigger Input, as follows:

z_2	External Trigger Input
0	Input disabled (default)
1	Input enabled - bus communications will not proceed until an External Trigger Input is received by the 53A-453 Card

RT Simulator Mode:

z_1 specifies the number of messages that must be processed by the 53A-453 Card to complete a bus communications sequence. If z_1 is a decimal number between 1 and 32767, the number of messages specified must be processed before the 53A-453 Card will complete the current bus communications sequence. If z_1 is an "*" (Octal 52), the 53A-453 Card will continuously process messages until a K or Q command, or External Halt Input signal is received by the card.

The z_2 parameter function is the same as described above for the Bus Controller Simulator Mode.

Bus Monitor Mode:

The z_1 parameter is optional in the Bus Monitor Mode. If z_1 is not present, the 53A-453 Card continuously collects bus traffic in its 30,000-word buffer, wrapping the buffer as necessary, and saving the last 30,000 words of data.

If z_1 is an F, the 53A-453 Card will collect only the first 30,000 words of bus traffic. If the F is followed by a number from 1 to 30000, a low-going TTL pulse will be output on the Position Identification Output pin after the corresponding buffer position has been filled. This pulse can be used to externally trigger an additional monitor card.

When the T command is issued in the Bus Monitor Mode, the 53A-453 Card begins continuously collecting 1553 bus data until a K or Q Command, or External Halt Input signal is received by the module. Or, if the TF command is sent, until 30000 words are collected.

The z_2 parameter function is the same as described above for the Bus Controller Simulator Mode. If the External Trigger Input is used, then the unused z_1 position must be indicated by a comma, i.e., T,1.

Using the Trigger Command:

When a bus communications sequence is initiated with a T (Trigger) command, internal control of the 53A-453 Card is passed from the module's Z80A microprocessor to the 1553 transmitter/receiver interface. After the transmitter/receiver has control of the 53A-453 Card, the card will not respond to any commands issued to it except for the Q (Quit), K (Kill), or an External Halt Input signal, until the bus communications sequence initiated by the T command is complete. If any command other than a Q, K, or Halt is issued to the card while a bus communications sequence is in progress, the 53A-453 Card will ignore the commands.

To avoid sending commands which will be ignored during a bus communications sequence, the 53A-453 Card's interrupt capability (I command) should be enabled before the T command is issued. With its interrupt enabled, the 53A-453 Card will generate a Request True event when the bus communications sequence is complete (generates an SRQ on IEEE-488 controlled systems), indicating that commands will be accepted.

The next command that is normally issued to the 53A-453 Card following a T command is an A or C command. To avoid having the command ignored, structure the system controller's software so that an A or C command is not issued to the 53A-453 Card until an interrupt is received.

Both the External Trigger and Pattern command conditionally trigger a card and can be active at the same time. Figure 453-5 shows the triggering hierarchy when the External Trigger Input and/or P command are used.

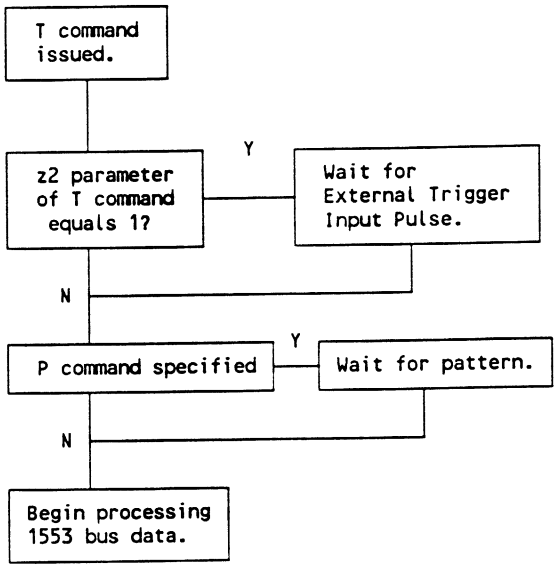


Figure 453-5: Triggering Hierarchy

The source for the external trigger is either pin 13 of the DB25P connector on the front panel, or the VXIbus word serial command Trigger. The VXIbus Trigger command is typically generated by Group Execute Trigger in IEEE-488 controlled systems.

Examples:
In the Bus Controller Simulator Mode, to execute the programmed Bus Controller Sequence List 27 times, the 53A-453 Card would be triggered using the command sequence T27. Following completion of the bus communications sequence, the first message to the first terminal in the Bus Controller Sequence List could be transmitted again by issuing the command T1.

If the 53A-453 Card was in the RT Simulator Mode and the command T326,1 was given, the module would wait for an external trigger, then respond to 326 command words by sending simulated RT messages to the controller for processing.

Command	Description
V	The V (Voltage) command programs the 53A-453 Card's peak-to-peak transmit voltage level and receive voltage threshold level.

Syntax: $Vz_1[,z_2]$

When the peak-to-peak transmit voltage level is being programmed, z_1 is the character T followed by a 2- to 4-digit decimal number from 20 to 3440. The decimal number specifies the peak-to-peak transmit voltage level from 0.20V to 34.40V in 0.01V steps which are then rounded off to the nearest of up to 250 levels.

To program the receive voltage threshold level, z_1 is the character R followed by a decimal number in the range of 50 to 900. The decimal number specifies a peak-to-peak receive voltage threshold level of 0.50V to 9.00V in 0.01V steps rounded off to the nearest of up to 250 levels.

z_2 is optional, used with transmit voltage commands only. If used, it is a 2- to 4-digit number from 35 to 1000, which specifies the equivalent impedance at the 1553 bus interface, assuming a 55-ohm isolation impedance in each leg of the connection to the bus interface.

The voltages programmed by the V command are the peak-to-peak voltages occurring on a 1553 bus for a load of z_2 ohms for either a direct-coupled or transformer-coupled connection, as shown below. The voltage programmed by the V command corresponds to V volts peak-to-peak in the following diagram.

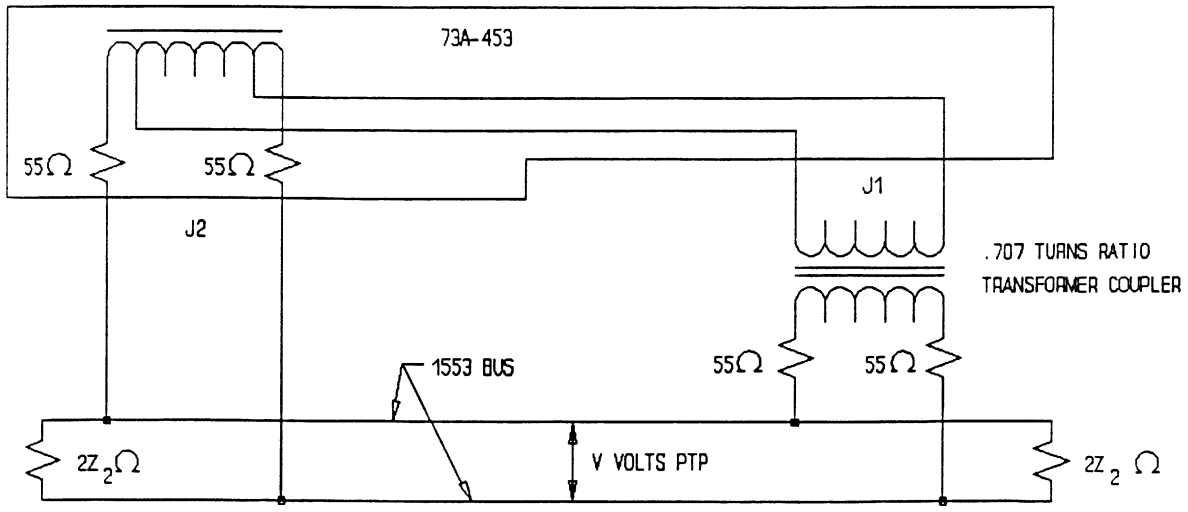


Figure 453-6: Direct- and Transformer-Coupled Circuit Connections

Approximate voltage ranges and nominal increment levels for some representative bus impedances are as follows:

Bus Impedance	Voltage Range
35 ohms	0.20V to 8.20V in 0.033V ptp steps
70 ohms	0.30V to 13.75V in 0.055V ptp steps
1000 ohms	0.75V to 34.40V in 0.138V ptp steps

To determine approximate maximum output levels for other impedances than those listed above, use the formula:

$$V_{MAX} = 38.9z_2 / (z_2 + 132)$$

If an unacceptable voltage level is programmed with the V command, the ERR LED will light, and the command will be ignored. The default voltage will be programmed instead. The default voltage settings on power-up are a transmit level of 6.38V ptp into 70 ohms and a 2.00V ptp receive threshold level. Successful programming of the transmit or receive level may be checked with the E (Error) command.

For transformer coupled connections to the 53A-453, the voltage (V) specified is that which would result on the bus side of a coupler, as shown in Figure 453-6 above. The voltage at the transformer-coupled output (J2) of the 53A-453 Card is approximately $0.707Vz_2 / (110 + z_2)$.

The V command provides an easily programmable method of specifying the output level for various loads. The normal 1553 bus is loaded with two 70 ohm terminators, or 35 ohms. Waveform characteristics of the 53A-453 Card are not noticeably degraded for a 35-ohm to 1,000-ohm impedance range.

NOTE: The 53A-453 Card is not internally loaded, and a minimum load of 1000 ohms is usually required for proper operation.

For applications where electrical testing of a UUT is not being performed, it is recommended that a VT1375 or VT820,35 command be issued following the Function commands (FC or FR; Bus Controller or Remote Terminal). This will provide optimum transmit levels for protocol testing.

The optimum receive level is typically between 1.0 and 3.0V PTP (VR100 to VR300).

The receive level should not be set at the exact peak-to-peak value of the incoming signal. Since the 53A-453 Card looks for adequate signal above the programmed level, unreliable data transfer will occur if the receive level is programmed equal to the peak-to-peak value.

Example:
The command sequence VT500,35 would program the transmit voltage level to 5.00V ptp, assuming a normal 1553 bus terminated at each end with 70 ohms. Using the command VR200 would set a receive voltage threshold level of 2.00V ptp.

CAUTION:

Connection of the 53A-453 Card's transformer-coupled outputs to anything other than a 1553 coupling transformer with isolation resistors on the bus interface side is NOT recommended, since there are no isolation resistors on the 53A-453 Card's transformer-coupled outputs to protect the circuitry against sustained bus collisions.

Command	Description
TEST	The SELF TEST command is used to self-test the PROM and RAM memory with a single command. It takes approximately 30 seconds to run. Test in progress is visually indicated by binary counting on five of the six LEDs at the top front of the card.

Syntax: TEST

The results of the test are obtained by issuing an input request to the card.

Result formats are as follows:

For a successful test: OK,Vx.x

Vx.x indicates the version and revision level of the firmware.

For a RAM error: RAM,xxxx-x,xx,xx
The arguments following RAM provide additional information on the failure (memory page and location within page).

For a PROM error: PROM,Uxx
Uxx identifies which of two PROM memory chips on the 53A-453 Card failed.

The self test reports only the first error detected.

INSTALLATION

The 53A-453 Card is a function card; therefore, it may be plugged into any blue card slot. Setting the Address Select switch defines the card's programming address. To avoid confusion, it is recommended that the slot number and the programming address be the same.

CAUTION:

To avoid plugging the card in backwards, observe the following:

a. The smaller board, without edge connectors, is to the right. The larger board, with the front- and rear-edge connectors, must be installed in the card guides.

b. Match the keyed slot on the card to the key in the backplane connector. The component side should be to the right for a 53 Series Chassis and to the top for a 63 Series Chassis.

c. There are two ejectors on the card. Make sure the ejector marked "53A-453" is at the top for a 53 Series Chassis and to the left for a 63 Series Chassis.

CAUTION:

The 53A-453 Card is a piece of electronic equipment and therefore has some susceptibility to electrostatic damage (ESD). ESD precautions must be taken whenever the module is handled.

APPENDIX A

53/63 SERIES SYSTEM COMMANDS

Command	Description
@XY	The @XY command addresses a function card in the 53/63 Series System. @ is a delimiter used by the 53/63 Series System. X is a card cage address (0-9) defined by the Address Select switch on the 53A-171 Control Card in the addressed card cage. Y is a function-card address (0-9) defined by the Address Select switch on the function card. Once a card cage/function-card combination is addressed, it remains addressed until the 53/63 Series System detects a new @ character.
@XS	The @XS (Status) command provides the interrupt status of all function cards within the card cage defined by X. The interrupt status of all function cards in the addressed card cage is latched into the 53A-171 Control Card when the @XS command is issued. All function cards in all card cages become unaddressed after the @XS command is issued. For the 53A-453 Card, when the Interrupt mode is enabled, an interrupt is generated when the bus communications sequence is complete (see the Card Commands subsection in the Operation section of this manual for details of the I command). The 53A-171 Control Card Operating Manual describes the @XS command in detail.
@XH	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). On the 53A-453 Card, the position of the Halt switch causes the "@XH" command to have the following effect: if the Halt switch is ON, the 53A-453 Card resets to its power-up state; if the Halt switch is OFF, the 53A-453 Card is simply unaddressed.
STOP	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. When the system controller issues a STOP command, each function card, including the 53A-453 Card, reacts as if it received the "@XH" command described above. How the system controller executes the STOP command depends on the communications card used. With the 53A-127 IEEE-488 Card, for example, a STOP command is executed when the system controller asserts the IEEE-488 bus line IFC (Interface Clear) true.

APPENDIX B

INPUT/OUTPUT CONNECTIONS

The 1553 data bus is connected to the 53A-453 Card using a 53A-780 Hooded Connector. The signal assignments are listed below:

53A-780 Pin Number/Letter	Signal
2	Data Word Received Output, TTL, 1-μs high pulse at end of each received word, will drive 6 LSTTL loads.
3	1553 Direct-Coupled Bus High
4	1553 Direct-Coupled Bus Low
6	1553 Transformer-Coupled Bus High
7	1553 Transformer-Coupled Bus Low
8	Position Identification Output, TTL, Low True, 0.5-us minimum width, will drive 6 LSTTL loads.
9	Reconstructed Received Data Output, TTL, NRZ, High True, Serial, will drive 4 LSTTL loads. Data is valid on rising edge of reconstructed clock. (Note: Revision Level 06-B and previous is low true).
10	Reconstructed Received Data/Clock Output, TTL, will drive 6 LSTTL loads.
11	Transmitter Enable, TTL, 1 TTL load.
12	Reconstructed Transmitted Data High Output, TTL, NRZ, Low True, Serial, will drive 6 LSTTL loads. Data is valid on rising edge of transmit clock.
13	Reconstructed Transmitted Data/Clock Output, TTL, will drive 4 LSTTL loads.
14	Transmitted Data Low Output, TTL, NRZ, Low True, Serial, will drive 6 LSTTL loads. Data is valid on rising edge of transmit clock.
15	External Clock Input, TTL, 16 times 1553 data rate, will drive 1 TTL load.
17	Common Mode Voltage Input.

18	Data Bus Input Active Output, open collector, 1OK pull up, 5-mA sink capability.
20	Pattern Recognition Output, will drive 10 LSTTL loads, Low True.
21	External Halt Input, TTL, Low True, Minimum pulse 50-ns width.
22	External Trigger Input, TTL, Low True, Minimum pulse 50-ns width.
23	Status Error Output, TTL, Low True, 125-ns width, minimum, will drive 10 LSTTL loads.
24	Ground.
B through BB	Ground.

CAUTION:

When using the Common Mode Voltage Input, be sure that the sum of the programmed output signal level plus the input common-mode voltage is less than the maximum receive level of the device connected to the 53A-453 Card.

Data Word Received Output (Pin 2)

The Data Word Received Output generates a 1-microsecond TTL high pulse each time a command, status, or data word is received. This output is active in the Bus Controller Simulator, RT Simulator, and Bus Monitor Modes.

1553 Bus Signals (Direct Coupled - Pins 3, 4; Transformer Coupled - Pins 6, 7)

Both direct coupled and transformer coupled 1553 data bus signals are available at the front-edge connector of the 53A-453 Card.

Position Identification Output (Pin 8)

The Position Identification Output provides a low TTL pulse associated with any specified transmit word in either the Bus Controller Simulator or RT Simulator Mode. The width of this pulse is between 62.5 and 450 microseconds. The pulse will occur during the sync pattern of the transmitted word after the specified transmit word for the same RT. This output is useful for triggering an oscilloscope in a large, repeating message sequence. The Position Identification Output also provides a low TTL pulse at any one specified position in the bus monitor collection buffer. In the Bus Monitor Mode, this output can be used to indicate memory is nearly full and to externally trigger data collection on another 53A-453 Card programmed to the Bus Monitor Mode (see Applications Note 453-III).

Reconstructed Received Data/Clock Output (Pins 9 and 10)

Manchester encoded data received by the 53A-453 Card from the 1553 data bus is made directly available at TTL levels after conversion to NRZ serial data. A reconstructed TTL-level clock is provided which transitions high when data is stable.

XMIT Enable Input (Pin 11)

The XMIT Enable Input enables or disables the 1553 bus transmitter logic on the 53A-453 Card. A TTL high input enables the transmitter and a TTL low input disables it. If the input is not connected, then the transmitter will be enabled by default.

Reconstructed Transmitted Data/Clock Output (Pins 12 and 13)

Manchester encoded data transmitted by the 53A-453 Card is available directly as TTL-level NRZ serial data. A TTL-level data clock is provided which transitions high when data is stable.

External Clock Input (Pin 15)

The External Clock Input varies the 1553 data bus bit rate by supplying an external clock signal. The external clock signal must be provided at a frequency of sixteen times the desired 1553 data bus bit rate. The external clock may vary between 15 MHz and 17 MHz, resulting a 937.5 kHz to 1.0625 MHz bit rate on the 1553 data bus.

Common Mode Voltage Input (Pin 17)

The Common Mode Voltage Input injects a common-mode voltage onto the 1553 data bus. When using the Common Mode Voltage Input, be sure that the sum of the programmed output signal level plus the input common-mode voltage is less than the maximum receive level of the devices connected to the 53A-453 Card.

Data Bus Input Active Output (Pin 18)

The Data Bus Input Active is an output that is active high to indicate that data is being received by the 53A-453 Card.

The Data Bus Input Active outputs from more than one 53A-453 Card may be connected together and will indicate an active high if all cards so connected are simultaneously receiving data. The output may be used for detection of simultaneous transmission in dual-redundant bus systems.

Pattern Recognition Output (Pin 20)

This output is used when the 53A-453 Card is in the RT Simulator Mode or the Bus Monitor Mode. The output will be set low when a received command word matches the 16-bit word programmed by the P command. It will remain low until a new bus transaction sequence is initiated with the T command.

External Halt Input (Pin 21)

The External Halt Input can be used to terminate a 1553 bus communications sequence. When a halt input is received, the 53A-453 Card will terminate all communications with the 1553 bus and return control of the 53A-453 Card to the ATE system controller. This input is the hardware equivalent of the Q command. The External Halt Input signal will be examined, and the halt request honored, as described for the Q command.

External Trigger Input (Pin 22)

The External Trigger Input is only active when the Z_2 parameter of the T command is a 1. In this case, the 53A-453 Card will not initiate a 1553 bus communications sequence until an External Trigger Input is received. After receiving the External Trigger Input signal, the 53A-453 Card will begin communication on the 1553 bus within 100 microseconds. Repeatability of the time is + or - 3.5 microseconds.

Message Error Output (Pin 23)

The Message Error Output is only active when the 53A-453 Card is functioning as a bus controller. The Message Error Output line will pulse low each time a status word is received with bit 6 (Message Error) set.

The Message Error Output is provided to allow the user to initiate 1553 bus communications via a second preprogrammed 53A-453 Card when an RT detects a message error. To accomplish this, the Message Error Output of the first 53A-453 Card is connected to the External Trigger Input of the second 53A-453 Card. In addition, if the user wishes to terminate bus communications between the RT and the first 53A-453 Card, the Message Error Output of the first 53A-453 Card can be connected to the External Halt Input of the first card.

NOTE: Revision 07-E and earlier of the 53A-453 Card provided a front connector Gaussian noise input. An improved version of the 53A-263 Gaussian Noise Card has eliminated the need for this input on the 53A-453. The latest 53A-253 Card provides for connections directly to the MIL-STD-1553 Bus, with an improved 4 MHz bandwidth filter bus impedance matching and a transformer coupled output.

APPENDIX C

TRANSMIT AND RECEIVE LEVEL SPECIFICATIONS

FOR REVISION LEVELS PRIOR TO 07-A

1553 Analog Output

Range: 35 ohms, direct-coupled output, 0.30 to 5.80V ptp.
70 ohms, direct-coupled output, 0.30 to 9.90V ptp.
1000 ohms, direct-coupled output, 0.90 to 31.60V ptp.
70 ohms, transformer-coupled output, 0.60 to 22.00V ptp.

At 1553 bus with two 70-ohm terminators, either direct-coupled direct connection or transformer-coupled output through a MIL-STD-1553 coupler, 0.30 to 5.80V ptp.

Accuracy: ±0.5V ptp at the 35 and 70 ohm levels.

Noise Content: 200 mV ptp.

Current Drive: 130 mA RMS maximum, direct-coupled output.
190 mA RMS maximum, transformer-coupled output.

1553 Analog Input

Threshold: Programmable from 05.0 to 9.00V ptp at direct-coupled input (equivalent to 0.25 to 6.36 V ptp at transformer-coupled input).

APPLICATION NOTES

453-I: BASIC PROGRAM FOR THE 53A-453 CARD

This application note presents a program listing for programming the 53A-453 Card as a Bus Controller in a Continuous Mode so that the resulting data stream can be viewed on an oscilloscope. Following that, a program is presented for programming one card as a bus controller and a second as a remote terminal, handling a two-message sequence between them, and examining the received data in each card.

The program assumes the use of a calculator with an IEEE-488 interface. The 53A System is set to an IEEE address of 24 and cabled to port 7 of the calculator. For other controllers, determine the proper output instruction and transfer the characters within quotes to the 53A System.

The 53A-171 Control Card has its Address switch set to "1" and the 53A-453 Card has its Address switch set to "2".

1:wrt 724,"@12K"	Reset the 453 card at address "12"
2:wrt 724,"FC"	Set the card to bus controller mode
3:wrt 724,"BS2"	Allocate a two-word Terminal Sequence List buffer.
4:wrt 724,"S1,15;15,200;"	Load the Terminal Sequence List such that the two messages sent by the 453 Card will be from the transmit buffer for RT#15, with the first message preceded by a 1000 usec delay (default value) and the second preceded with a 200 µsec delay.
5:wrt 724,"B15,R99"	Allocate a 99-word receive buffer to store responses from RT#15. Note: Any time either a transmit or receive buffer is allocated for an RT, both must be allocated for proper operation of the card.
6:wrt 724,"B15,T4"	Allocate a 4-word transmit buffer for RT#15
7:wrt 724,"D15,1,H,107C24;107822,1111,2222;"	Load two messages in the transmit data list buffer for RT#15. The first message requests RT#15 to transmit 4 words. The second message requests RT#15 to receive 2 words of data whose hexadecimal contents are "1111" and "2222"
8:wrt 724,"T*"	Trigger the 453 Card to continuously execute the Terminal Sequence List.

Measure across Pins 3 and 4 of the front connector differentially using an oscilloscope with a suitable bus load. If the oscilloscope has a 50 ohm termination, it may be used.

The two messages should now be observable on the oscilloscope, separated by a 200 microsecond gap with 1 millisecond between successive message pairs. The peak-to-peak amplitude of the signal will be about 6.38 V ptp for a 70 ohm bus load ranging down to 3.2 V ptp for a 35 ohm load or up to about 16 V ptp for a 1000 ohm bus load.

If a second 53A-453 Card is available, the following program listing shows how the second card can be set up as RT#15 to respond to messages sent from the first 53A-453 Card. The two command messages above are sent one time and the received data in each card's receive buffer is examined.

```
0:  dim A$[20]                  Dimension a 20-character string variable
1:  wrt 724,"@11K"              Reset the 53A-453 card at address "11"
2:  wrt 724,"FR"                Program it as a remote terminal
3:  wrt 724,"B15,R99"           Allocate a 99-word receive buffer for RT address 15
4:  wrt 724,"B15,T6"            Allocate a 6-word transmit buffer for RT address 15
5:  wrt 724,"D15,1,H,107800,3333,4444,5555,6666;107800;"
6:  wrt 724,"T2"                Program card to accept and respond to 2 messages
7:  wrt 724,"@12K"              Program card at address "12" as a bus controller the
                                same as in the preceding example
8:  wrt 724,"FC"
9:  wrt 724,"BS2"
10: wrt 724,"S1,15;15,200;"
11: wrt 724,"B15,R99"
12: wrt 724,"B15,T4"
13: wrt 724,"D15,1,H,107C24;107822,1111,2222;"
14: wrt 724,"T1"                Send the two-message sequence one time
15: wrt 724,"A15,1,HF"          Program card to acquire RT 15 received data back to
                                53A system controller
16: For I=1 to 9                Print first 9 words in receive buffer
17: red 724,A$;prt A$
18: next I
19: wrt 724,"@11A15,1,HF"       Program RT card to look at data received from bus
                                controller card
```

```
20:  For I=1 to 5              Print first 5 words in buffer

21:  red 724,A$;prt A$

22:  next I

23:  stp
```

The printout from the bus controller card includes the two command words sent out. They are stored by the 53A-453 Card in the receive buffer as part of its normal function to allow correlation of commands with responses. The printout of the 9 words from the bus controller receive buffer should be as follows:

107C24	First bus controller command word
107800	RT status word
003333	RT data words
004444	
005555	
006666	
107822	Second bus controller command word
107800	RT status word
0B0000	No more data

The printout of the 5 words from the RT receive buffer should be as follows:

107C24	First bus controller command word
107822	Second bus controller command word
001111	Bus controller data words
002222	
0B0000	No more data

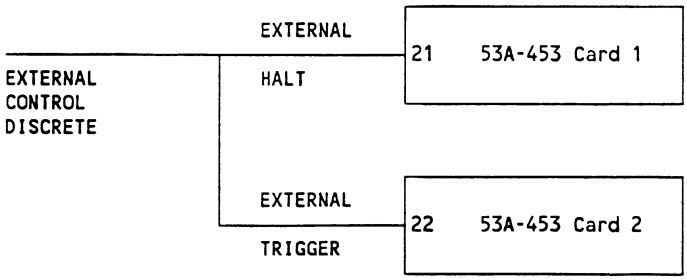
453-II: USING TWO CARDS AS DUAL REDUNDANT BUS CONTROLLERS

Two 53A-453 Cards can be used to simulate a dual redundant MIL-STD-1553 Bus Controller. Several hardware interface lines are provided on the 53A-453 Card to aid in flexibly switching between the two bus controller cards. The techniques described below can be extended to three or four 53A-453 Cards to handle triple or quad redundant Bus Controller applications.

The 53A-453 Card is programmed by ASCII character strings from a calculator, computer or some other type of controller. The 53A-453 Card contains an on-board microprocessor which, before it allows transmission on the 1553 bus in response to a T command, does some setup compatibility tests of the buffer allocation, sequence, and data commands. Since the time it takes to perform these checks is application dependent, it is difficult to time the start or completion of one card's operation with respect to an event on the other card totally through software control.

For this reason, two external front connector 53A-453 Card inputs are provided to aid in this timing control. Pin 21 is an external halt input that will halt transmission at the point where the next transmission would have started. Any data received up to that point will be collected and available for inspection. Pin 22 is an external trigger input that will trigger a 53A-453 Card that has been preloaded with data and triggered with a pre-trigger option of the "T" Command. Transmission will start a minimum of 100 microseconds after the active low input has been applied (actual time depends on the application and the Version level of the 53A-453 Firmware). Transmission initiation can be programmed for longer times by setting the pace value for the first message in the sequence command to longer than the minimum 14 microsecond value. There is an uncertainty of ±3.5 microseconds in the trigger time.

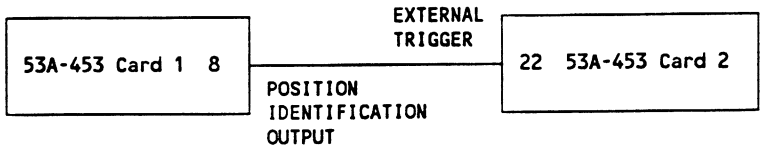
An external discrete may therefore be used to halt one channel and start the next channel with a delay time repeatability of ±3.5 microseconds.



A second method of transferring control from one card to another involves using a known event on the first card to trigger the second card. This is accomplished by transmitting a finite message sequence on the first card and using an output of that card called the position identification output (Pin 8). A low TTL pulse may be output on this pin on a software specified word near the end of the transmit list using a capability of the "D" Command.

This output can be fed to the external trigger input of the second card. Utilizing the timing control technique described above, the second card's transmission can follow an event in the first card's transmission by 100 microsecond or more with a delay time repeatability of ±3.5 microseconds. By programming the position identification pulse to occur at least 100 microseconds before the second card's desired starting time, this allows programming the econd

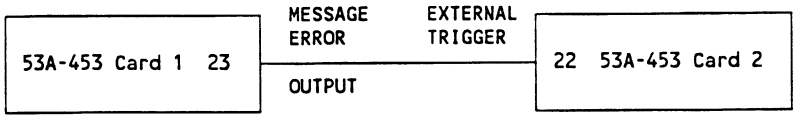
card to start within 4 microseconds of the first card completion. An application of this would be to experimentally set up the delay on the oscilloscope to a nominal 7 microsecond delay. Because of the ±3.5 microsecond random uncertainty in triggering the second card, running this test many times allows testing a dual redundant RT's response to a superseding command from 3.5 to 10.5 microseconds following a previous message on the first bus. The uncertainty and randomness of the delay is an excellent test of an RT's superseding command operation.



A third method for triggering the card uses the message error bit returned in the status word by a remote terminal. The 53A-453 Card contains a hardware output that supplies a low pulse any time the message error bit is detected by the card when in the Bus Controller Mode.

For applications where it is desired to test transfer of an RT to its redundant bus following an error transmitted by the bus controller this output is useful.

For example, if an RT detects an error on a data word following a valid command word such as Manchester error or parity error, the RT will not respond to the command error, and sets the message error bit in response to a transmit status mode code in the following command. The 53A-453 Card can be programmed as a bus controller to output a data error followed by a request for status mode code. When the status word comes back with the message error bit set, the message error bit output can be used to trigger the second card to transmit. The second card's transmission can be programmed to follow the status word message error bit detection a minimum of 100 microseconds later with a predictability of ±3.5 microseconds.



453-III: BUS MONITOR CARD CHAINING

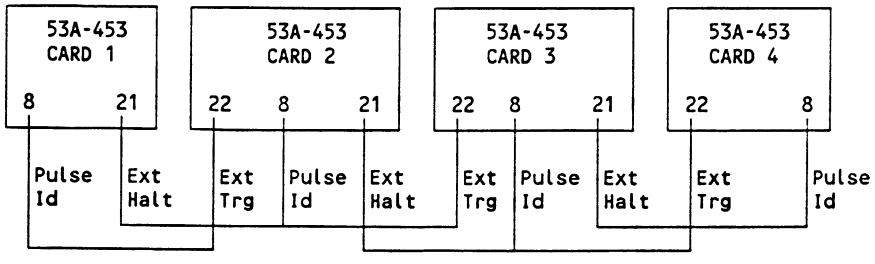
The 53A-453 Card provides a position identification output (Pin 8) which will output a low TTL pulse at a user-specified position in the 30000-word bus monitor receive buffer. This output can be used to trigger an already set up additional monitor card via its external trigger input.

The external trigger input takes approximately 100 microseconds after being activated before collection of data starts. Collection of data also does not start until a word with a command sync pattern appears on the bus. To guarantee that no data is missed during transfer from one card to another the following is required. The maximum message length of 33 words plus an additional 4 words to accommodate the 70 microseconds must be still collected on the first card following the output of the position identification pulse. This means the position identification pulse should be programmed at least 33 words before the end of the 30000 word buffer.

The 53A-453 Card in the Bus Monitor Mode requires a Q command or External Halt input to take it out of the Bus Interface Mode so that the system controller can read the data from the card. The card does not indicate to the system controller when it is full. Using the "Q" Command is not practical unless some means of knowing when the card will be full and providing compatible software timing is available.

The best way of taking the Bus Monitor off the bus is to connect the external halt pin of the card to the position identification pulse of the next card in the chain. This ensures that the receiver on the card will not be deactivated until the next card has started collection. Connecting a card's position identification output to its own external halt line can cause the loss of one or two messages of data during the 70-microsecond trigger delay of the next card. However, if there is only one monitor card or the card is the last in the chain then connecting the card's position identification output to its external halt input does no harm.

The following diagram shows a connection of four 53A-453 Cards as a 120,000 word buffer.



The following program would program triggering and collection of the data on the above four cards. The program assumes the cards have a 53A ADDRESS of "11", "12", "13" and "14" and that the system controller is an IEEE-488 controller communicating with a 53A-IBX at IEEE-488 ADDRESS 24.

```
0:  dim A$[20]                  Dimension an input character string variable

1:  wrt 724,"@11K"              Reset and program all 4 cards to bus monitor
                                mode. A write binary format is
2:  wtb724,"FM",13              used for the mode command to suppress
                                Line-Feed. A Line-Feed, if it doesn't
3:  wrt724,"@12K"               occur soon enough after the Carriage-
                                Return will hang up the bus until the
4:  wtb 724, "FM",13                memory has been initialized on each card
                                    which takes 6 seconds per card. This
                                    program initializes
5:  wrt 724, "@13K"             the 4 cards in parallel.

6:  wtb 724, "FM",13

7:  wrt 724, "@14K"

8:  wtb 724, "FM",13

9:  wrt 724, "@11PXXXX"         Optional command to start collection at a
                                user-specified command word pattern.

10: wrt 724, "@11TF29900"       Program 1st card to start collection, putting a
                                position identification pulse on the 29,900th
                                word.

11: wrt 724, "@12TF29900,1"

12: wrt 724, "@13TF29900,1"

13: wrt 724, "@14TF29900,1"     Cards 2 through 4 are additionally programmed
                                to start based on the external trigger.

14: wrt 724, "@11A,1,H"         Start collection on Card 1 when the card has
                                been externally halted.

15: for I=1 to 30000

16: red 724,A$

17: gsb "STORE"                 User subroutine to utilize data as desired.

18: next I

19: wrt 724, "@12A,1,H"         Same for Card 2

20: for I=1 to 30000

21: red 724,A$

22: gsb "STORE"
```

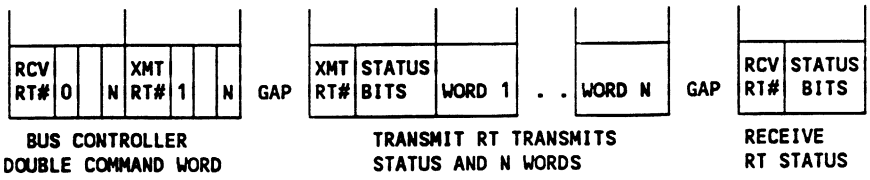
```
23:  Next I
      .
      .
      .                          Repeat for Cards 3 and 4
33:  stp                         Stop program.
```

PING-PONGING BUS MONITOR CARDS

Ping-ponging two 53A-453 Cards as bus monitors for continuous data collection is usually not practical because of limitations in the 53A-453 Card-to-system controller transfer rate. In the Binary Read Mode, the 53A-453 Card is capable of 2000 words per second. To support this rate, the system controller must request a new word within 165 microseconds of receiving the Line-Feed from the previous word and request a new character within a word within a microsecond of the previous character's reception. If the system controller is capable of doing whatever is necessary with the data and responding at these rates, a further requirement exists. The 1553 bus traffic must be under 4.0% of maximum capability to get one card's 2000 words back to the system controller while the other card is filling up with present data bus traffic.

453-IV: RT-TO-RT TRANSFERS

This application note describes the programming of a 53A-453 Card as the Bus Controller, transmitting RT, or the receiving RT in an RT-to-RT transfer. The format of an RT-to-RT transfer on the MIL-STD-1553 bus is as follows:



The following program lists the commands that would be sent to a 53A-453 Card simulating RT#3 as a transmitting RT, to a 53A-453 Card simulating RT#9 as a receiving RT and to a 53A-453 Card simulating a Bus Controller in an RT-to-RT transfer of 5 words.

If only one or two of the three RT-to-RT participants are being simulated by a 53A-453 Card and the remainder by user's actual hardware, then, of course, only those one or two cards would need to be programmed.

The programming of the 53A-453 Card as a Bus Controller or transmitting RT in an RT-to-RT Transfer is straightforward. The programming of the 53A-453 Card as a receiving RT in an RT-to-RT transfer, however, requires some special consideration relating to the 53A-453 Card design.

Looking at the following program for the receiving RT in lines 7 to 13, the transmit status word has been loaded in RT#3's buffer of the 53A-453 Card, even though the receiving RT is really at RT address 9. Also, the response time has been programmed to 130 microseconds rather than the normal 4 to 12 microseconds. This is because the 53A-453 programmed as an RT is designed to irrevocably start its response time counter at the occurrence of the first gap it sees following a command stream on the bus. This is the gap following the transmit RT command word from the bus controller. The 130 microsecond response time will, therefore, accommodate the time for the transmitting RT's status word and 5 data words plus some gap time before responding with the status word.

The reason for placing the status word in the buffer for RT#3 is that when a 53A-453 Card programmed as an RT does respond, it uses the last valid word with a command sync to select which RT buffer from which to transmit. Since the last valid command or status word is the status word from the transmitting RT (which has RT address 3 in the RT# bit locations), the RT's status word response must be in buffer 3.

Programming

The following program assumes an IEEE-488 controller using port 7 to address 53A-IBX System at IEEE-488 address 24.

```
0:  dim A$[20]                          Dimension a 20-character string variable for
                                        input
```

The following statements program a transmitting RT at 53A address 11.

```
1:  wrt 724,"@11K"                      Reset card

2:  wrt 724,"FR"                        Program card as an RT

3:  wrt 724,"B3,R99"                    Allocate a receive buffer at RT address 3

4:  wrt 724,"B3,T6"                     Allocate a transmit buffer of 6 words

5:  wrt 724,"D3,1,H,101800,1111,2222,3333,4444,5555;"
                                        Load transmit buffer with status word and 5
                                        data words.

6:  wrt 724,"T1"                        Trigger card to handle one message on bus.
```

The following statements program a receiving RT at 53A address 12.

```
7:  wrt 724,"@12K"                      Reset card

8:  wrt 724,"FR"                        Program card as an RT

9:  wrt 724,"R1,130"                    Program a response time of 130 usec.

10: wrt 724,"B3,R99"                    Allocate a receive buffer at RT address3.

11: wrt 724,"B3,T1"                     Allocate a transmit buffer for word 1 status.

12: wrt 724,"D3,1,H,104800;"            Load transmit list with status word. The
                                        characters 48 define the status word to be from
                                        RT 9.

13: wrt 724,"T1"                        Trigger card to handle one message on bus.
```

The following statements program a bus controller at 53A address 19.

```
14: wrt 724,"@19K"                      Reset card

15: wrt 724,"FC"                        Program card as bus controller

16: wrt 724,"BS1"                       Allocate a message buffer size of 1

17: wrt 724,"B3,R99"                    Allocate a receive buffer at RT address 3

18: wrt 724,"B3,T2"                     Allocate transmit buffer for 2 card words

19: wrt 724,"S1,3"                      Specify message to come from RT#3 buffer
```

```
20:  wrt 724,"D3,1,H,104825, 101C25;"
                                        Load transmit list with 2 contiguous command
                                        words.

21:  wrt 724,"T1"                       Cause card to transmit RT-to-RT command on
                                        bus

22:  wrt 724,"A3,1,H"                   Program bus controller card to return receive
                                        buffer contents in hexadecimal.

23:  prt ""                             Space printer

24:  for I=1to9                         Read 9 words

25:  red 724,A$;prtA$

26:  next I

27:  prt""                              Space printer

28:  wrt 724,"@11A3,1,H"                Program transmitting RT to return received
                                        data

29:  for I=1to2                         Read 2 words

30:  red 724,A$;prtA$

31:  next I

32:  prt ""                             Space printer

33:  wrt 724,"@12A3,1,H"                Program receiving RT to return received data

34:  for I=1to8                         Read 8 words

35:  red 724,A$;prtA$

36:  next I

37:  stp                                Stop program
```

The following data will be returned from the bus controller receiver.

```
104825                                  First command word stuffed by 453 Card in
                                        receive buffer.

101800                                  Transmit RT status word

001111                                  Transmit RT data words

002222
```

003333	
004444	
005555	
104800	Receive RT status word
0B0000	No more data

The following data will be returned from the transmitting RT receive buffer.

101C25	The second command word from the bus controller.
0B0000	No more data. An RT only collects command or status words with an RT address the same as the buffer numbers plus any data words following that command word.

The following data will be returned from the receiving RT receive buffer:

101C25	The second command word from the bus controller.
101800	The status word from the transmitting RT
001111	Data words
002222	
003333	
004444	
005555	
0B0000	No more data

An additional card programmed as a bus monitor would collect all 9 words involved in the transaction.

RT-to-RT Timeout Test

A special requirement for RTs supporting RT-to-RT transfer capability is that a receiving RT timeout when looking for a transmitting RT message occur between 54 and 60 microseconds following the parity transition of the second command word in the bus controller RT-to-RT command sequence. This requirement is to prevent the receiving RT from getting hung up because of a malfunctioning transmitting RT. One card can be used for this test because the transmitting RT responds more than 14 microseconds after the command sequence. If the transmitting RT needed to respond 4 microseconds after the bus controller command sequence, a second card programmed as the transmitting RT would be required. The following program

using one 53A-453 Card to simulate the bus controller and transmitting RT tests this requirement.

```
0:   dim A$[20]

2:   wrt 724,"@11K"          Reset card program as bus controller and transmitting
                             RT.
3:   wrt 724,"FC"

4:   wrt 724, "BS2"

5:   wrt 724,"B3,R99"

6:   wrt 724,"B3,T5"

7:   wrt 724,"S1,3;3,54"     Set interval between controller command and RT
                             command and data to 54 usec

8:   wrt 724,"D3,1,H,104822,101C22;101800,1111,2222;"
                             Program command and transmitting RT message

9:   wrt 724,"T1"            Trigger sequence

10:  wrt 724,"A3,3,H"             Look at third word in receive buffer.

11:  red 724,A$                   If not receiving RT status, fail unit.

12:  if A$[2,5]#"4822";prt"UNIT TIMEOUT TOO SOON";goto "END"

13:  wrt 724,"S2,3,60;"           Reprogram interval to 60 usec

14:  wrt 724,"T1"

15:  wrt 724,"A3,3,H"             Read 3rd word in buffer

16:  red 724,A$                   If not a no-response, fail unit.

17:  if A$[1,6]#"0B0000;prt"UNIT TIMEOUT TOO LATE"

18: "END":end
```