User Manual

Tektronix

73A-541
Universal Digitizing Counter Module with Time Tag Memory

070-9137-01

This document applies for firmware version 1.00 and above.

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Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070–1000

WARRANTY

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EC Declaration of Conformity

We

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declare under sole responsibility that the

73A-541 and all options

meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 55011 Class A Radiated and Conducted Emissions

EN 50081-1 Emissions:

EN 60555-2 AC Power Line Harmonic Emissions

EN 50082-1 Immunity:

IEC 801-2 Electrostatic Discharge Immunity
IEC 801-3 RF Electromagnetic Field Immunity
IEC 801-4 Electrical Fast Transient/Burst Immunity
IEC 801-5 Power Line Surge Immunity

To ensure compliance with EMC requirements this module must be installed in a mainframe which has backplane shields installed which comply with Rule B.7.45 of the VXIbus Specification.

ERROR CODES

The error code is a 2-digit integer followed by a <CR> <LF>, returned in response to an input request immediately following the ER command. (30)

Message No.	Definition
10	Unknown command.
11	Illegal Command Length - command > 125 characters (a <CR> <LF> is required every 125 characters or less).
12	Integer number > 32768.
13	Minus sign not allowed for this argument.
20-68	Syntax errors - the numeric argument following a 2-letter command was in error. Error code/command relationships are shown on p. 30.
70	AX/AT conflict.
71	BX/BT conflict.
72	Function not available.
73	Binary not available for this function.
74	A multifunction list does not apply in Timing Diagram mode.
75	Invalid entry in the multifunction list.
76	In Digitizing Counter mode, an input request occurred before a JM command triggered a measurement.
77	In Gate Indefinitely mode, an input request occurred before a QM command terminated a measurement.
78	A JM command was issued before the previous commands were completed.
99	No errors.

PROGRAMMING

The programming examples in the manual are written in Microsoft GW BASIC. For programming examples, see page 79.

CALL ENTER (R$, LENGTH%, ADDRESS%, STATUS%) Inputs data into the string R$ from the IEEE-488 instrument whose decimal primary address is in the variable ADDRESS%.

CALL SEND (ADDRESS%, WRT$, STATUS%) Outputs the contents of the string variable WRT$ to the IEEE-488 instrument at ADDRESS%.

END Terminates the program.

FOR/NEXT Repeats the instructions between the FOR and NEXT statements for a defined number of iterations.

GOSUB n Runs the subroutine beginning with line n.

GOTO n Program branches to line n.

IF/THEN Sets up a conditional IF/THEN statement.

REM All characters following the REM command are not executed.

RETURN Ends a subroutine and returns operation to the line after the last executed GOSUB command.

<CR> Carriage Return character, decimal 13.

<LF> Line Feed character, decimal 10.

73A-541 UNIVERSAL DIGITIZING COUNTER QUICK REFERENCE GUIDE

Numbers in parentheses refer to the page(s) in the Operating Manual.

SETUP

Be sure all switches are correctly set. (p. 4)
Follow Installation guidelines. (p. 13)

The default condition of the 73A-541 Module after the completion of power-up self test is as follows:

Mode:	Counter/Timer Mode.
Function:	Frequency A.
External Trigger:	Disabled.
Interrupt Mode:	Disabled.
Read Format:	Decimal format, 5 significant digits.
Input:	Both channels, trigger slope positive, 1 megohm, DC-coupled, trigger levels at 0V DC, A separate B, both channels enabled, both attenuations X1.
Gate Time:	100 events for time-average functions. 1 second for frequency and event functions. 2 events for other functions.

LEDs

When lit, the LEDs indicate the following:

PWR	power supplies functioning
FAILED	module failure
ERR	an error has been found in self test or programming
MSG	module is processing a VMEbus cycle
TRG A/B	input signal on the associated channel exceeds the programmable trigger threshold.
GATE	counter gate is enabled (channels are enabled to count).

SYSTEM COMMANDS

These non-data commands are initiated by the 73A-541's commander. The following VXIbus Instrument Protocol commands will affect the 73A-541:

BYTE AVAILABLE (with or without END bit set)
BYTE REQUEST
BEGIN NORMAL OPERATION
CLEAR
IDENTIFY COMMANDER
READ PROTOCOL
TRIGGER

COMMAND SYNTAX

Commands usually follow one of these formats: (17)

		SS	cSz	cS[s]z
SSz	Scz	SS[z][z]z	cS	

Where S is the command identifier, c specifies the channel, z is a digit 0 through 9, and s is a sign (+, -, or space). [Brackets] indicate an optional parameter. Command protocol and syntax for the 73A-541 is as follows:

1) More than one command may be entered on a line by stringing the commands together. They are read and acted on from left to right.
2) Spaces, null characters, commas, periods, colons and semi-colons may be inserted between commands or command arguments.
3) <CR> and <LF> may optionally be inserted between commands.
4) Command arguments with leading zeros may be transmitted without the leading zeros, with this constraint: the command will not be executed until another command or a <CR> is sent to the card.
5) The maximum command set length between <CR><LF> terminations is 125 characters.

MODULE COMMANDS

The descriptions are divided into three major sections: 1) Commands common to both Timer/Counter and Digitizing Counter Modes, 2) Timer/Counter Mode and 3) Digitizing Counter Mode commands.

Common Commands

cAz specifies AC or DC input coupling for the A or B input channel. (27)
CSz selects the A input to connect to both the A and B input channels or selects separate inputs. (28)
cDz disable the A or B input channel from measurement. (29)
ER reads back the error status and the specific error type. (30)
Hz connects or disconnects counter input A or B, TTLOUT A or B, or GATE input to any of the eight VXIbus TTLTRG lines. (32)
cl[s] read back the trigger level. (34)
JM/QM start/stop a measurement cycle under program control for both A and B channels. (35)
MMz specifies Timer/Counter or Digitizing Counter mode. (36)
cP preset a channel's setup parameters to the power-up state. (37)
cSz specifies a positive or negative trigger slope for the A or B input channel. (38)
SRz enables or disables interrupt generation. (39)
cT[s]z program a desired trigger level for the A or B input channel. (40)
TEST1 performs a test of the memories and counters on the 73A-541 Module. (41)
cU automatically set the trigger level of the A or B channel to a point midway between the input-signal peak-to-peak levels. (42)
cXz selects an X1 or X3 attenuation for the A or B input channel. (43)
Yz selects the source for the 10 MHz clock reference as the VXIbus slot 0 10 MHz ECL clock, an optional on-board 0.5 ppm oven-controlled oscillator, or the 73A-541 front panel EXT CLOCK IN BNC. (44)
cZz select the A or B input impedance. (45)

Timer/Counter Mode Commands

EXz selects 'E' or 'e' for the exponent character in a returned measurement. (46)
FNcz specifies the function whose value is to be returned to the system controller when responding to an input request. (47)
Gcz specify the length of the measurement cycle as a number of Channel A or B events when measuring frequency A or B or count events A or B. (50)
GEz disables or enables the external-gate input's ability to control the opening of the A and B channel gates. (51)
GI the measurement cycle lasts indefinitely until a QM command is issued. (52)
GPz specifies the number of periods for averaging functions FN13 through FN20. (53)
GU/GM/GS specify the length of the measurement cycle in µs, milliseconds, or seconds when measuring Freq. A or B, or Count Events A or B. (54)
IFz specifies the largest integer returned in commands involving integers. (55)
RFz specifies the number of significant floating-point digits the module returns when responding to a system controller input request. (56)

Digitizing Counter Mode Commands

BNz specifies returning data in ASCII Decimal format or in Binary format. (58)
EXz selects 'E' or 'e' for the exponent character in a returned measurement. (61)
Fc allow immediate real-time readback of event count A or B. (62)
FNz specifies the functions whose values are returned to the system controller in response to input requests. (63)
Gcz specify the length of the measurement cycle as a number of A or B channel events. (65)
GEz disables or enables the external-gate input's ability to control the opening of the A and B channel gates. (66)
GI the measurement cycle lasts indefinitely until a QM command is issued. (67)
GU/GM/GS specify the length of the measurement cycle in µs, milliseconds, or seconds when measuring Freq. A or B, or Count Events A or B. (68)
IFz specifies the largest integer number returned in commands involving integer numbers. (69)
RBz in binary format, to specify the number of measurements that are to be blocked into a record. (71)
RFz specifies the number of significant floating-point digits the module returns after the 2-digit function code and comma when responding to a system controller input request. (73)
TMz specifies one of the four sub-modes of processing input data collected in the Digitizing Counter mode. (76)

in Post-Processing/Multifunction mode:

cB define the beginning event number to be read from memory. (57)
cE define the ending event number to be read from memory. (60)
cRz determine the beginning or ending event number available in memory for channel A or B. (70)
RI determine the amount of elapsed time between the beginning and ending event numbers specified for memory readback at the time the last Post-Processing/Multi-function measurement was completed. (74)
RN specify the number of measurements returned. (75)

Table of Contents

Safety Summary

The general safety information in this summary is for both operating and servicing personnel. Additional specific warnings and cautions are found throughout the manual where they apply, and may not appear in this summary.

TERMS

In This Manual

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

CAUTION statements identify conditions or practices that could result in damage to the module or other property.

Marked on the Module

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property, including the module itself.

SYMBOLS

In This Manual

This symbol indicates where applicable cautionary or other information is to be found.

This symbol indicates where special explanatory information is included in the manual. There is no caution or danger associated with the information.

Marked on the Module

DANGER — High Voltage.

Protective ground (earth) terminal.

ATTENTION — Refer to the manual.

Refer to manual before using.

Power Source

This module is intended to operate in a mainframe whose power source does not apply more than 250V rms between the supply conductors or between either supply conductor and ground. A protective ground connection through the grounding conductor in the power cord(s) is essential for safe operation.

Grounding the Module

This module is grounded through the grounding conductor of the mainframe power cord(s). To avoid electrical shock, plug the mainframe power cord(s) into a properly wired receptacle before connecting to the module connectors. A protective ground connection through the mainframe is essential for safe operation.

Danger Arising from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only fuses specified in the module parts list. A replacement fuse must meet the type, voltage rating, and current rating specifications required for the fuse that it replaces.

Do Not Operate in Explosive Atmosphere

To avoid explosion, do not operate the module in an explosive atmosphere.

Do Not Remove Covers or Panels

To avoid personal injury, the module covers should be removed only by qualified service personnel. Do not operate the module without covers and panels properly installed.

73A-541 UNIVERSAL DIGITIZING COUNTER MODULE WITH TIME TAG MEMORY

DESCRIPTION

INTRODUCTION

The 73A-541 Universal Digitizing Counter (UDC) Module with Time Tag Memory is a printed circuit board assembly for use in a card cage conforming to the VXIbus Specification, such as the 73A-021 used in the CDS 73A IAC System. The 73A-541 provides two channels that can measure signals in the sub-Hertz to 10-Mhz frequency range.

The 73A-541 Module incorporates both a Universal Timer/Counter and a Digitizing Counter into a single instrument, operating in either of two modes:

1) The Timer/Counter mode includes the measurement functions associated with a traditional universal counter: frequency, event count, period, period average, pulse width, pulse width average, time interval, time interval average, duty cycle, and duty cycle average.

2) The Digitizing Counter mode using Time Tag Memory has two real-time and two post-processing sub-modes. In this mode, an input signal can be analyzed on a cycle-to-cycle basis by storing the absolute time of each successive transition of the input waveform in a 28-bit by 2048-word memory.

Storing the absolute transition times of a waveform effectively digitizes its time domain information and allows complex analysis, even on one-time phenomena. Some of the measurements that can easily be performed include time-interval relationships between two waveforms, or the frequency, period, pulse width, and duty cycle characteristics of a single waveform, on a cycle to cycle basis.

The real-time sub-modes allow measurement data to be read "in-progress" (during operation) without interrupting new data capture. The post-processing sub-modes allow data to be read after the measurement cycle is complete.

The 73A-541 Module offers several different ways to control the duration of the measurement cycle (or gate duration). For frequency and event-count functions in the Timer/Counter mode, or when using the Digitizing Counter mode using Time Tag Memory, the measurement cycle may be controlled by

- a specified number of A or B events,
- a specified amount of time, from 1 microsecond to 427 seconds,
- direct program control, or
- an external gate.

For averaging functions, the measurement cycle may be specified as the number of occurrences to average. The measurement cycle itself may be triggered either under program control or by an external trigger. Programmable control is also provided for:

- o trigger level or trigger level slope
- o input attenuation
- o A-common-B capability
- o clock reference selection
- o input-signal enable
- o AC or DC coupling
- o attenuation

Two different methods of trigger-level programming are provided, independently programmable for each channel: either a directly programmed level or an automatic trigger-level search. The automatic trigger-level setting may be read back.

A programmable A-common-B capability allows the A channel signal to be input to both channels simultaneously.

The clock reference may be selected from one of three sources: a) the VXIbus slot 0 10 MHz ECL clock, b) a BNC 73A-541 front panel input, or c) an optional internal 0.5 ppm oven controlled oscillator.

The input-signal enable control allows the time tag memory to be used more efficiently in single channel applications.

Under program control, both counter inputs and the gate input may be driven by front panel BNC inputs or by any of the eight TTLTRG lines on the VXIbus backplane. A re-conditioned TTL output for each counter input is provided as a BNC output on the front panel, and each may be connected to any of the eight VXIbus TTLTRG outputs under program control.

Commands are sent to the card as ASCII character strings. Data is returned either as an ASCII character string containing up to nine significant digits, decimal point, and an exponent, or as eight binary 8-bit bytes that may be blocked into records of variable length under program control. Input may be either driven by input requests or interrupts.

Six SMB jacks at the front edge of the card provide easy access for the two input channels, the A-and-B reconditioned TTL outputs (normal and inverted), and the external gate and clock inputs.

Seven LEDs at the front edge of the card visually indicate A and B channel triggering, gate status and operating status, as well as showing that the required power supplies are present, and whether or not the 73A-541 has entered a "Failed" condition. An LED also indicates when the module is processing a VMEbus cycle.

Note that certain terms used in this manual have very specific meanings in the context of a VXIbus System. A list of these terms is presented in the VXIbus Glossary (Appendix C).

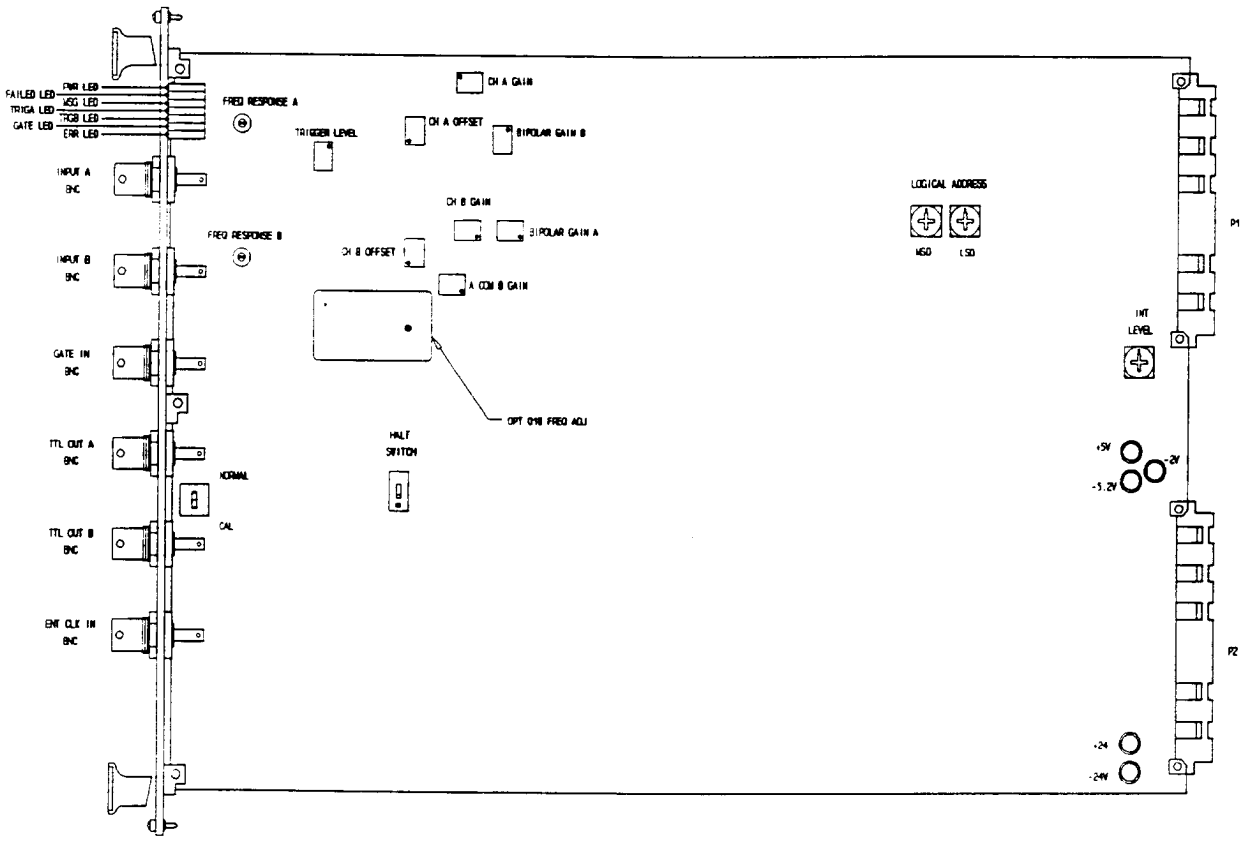


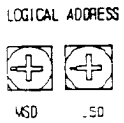
Figure 541-1: 73A-541 Controls and Indicators

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 73A-541 Module's operating environment. See Figure 541-1 for their physical locations.

- **Switches**

Logical Address Switches



Each function module in a VXIbus System must be assigned a unique logical address, from 1 to 255 decimal. The base VMEbus address of the 73A-541 is set to a value between 1 and FFh (255d) by two hexadecimal rotary switches. Align the desired switch position with the arrow on the module shield.

The actual physical address of the 73A-541 module is on a 64 byte boundary. If the switch representing the most significant digit (MSD) of the logical address is set to position X and the switch representing the least significant digit (LSD) of the logical address is set to position Y, then the base physical address of the 73A-541 will be [(64d * XYh) + 49152d]. For example:

L.A.	MSD	LSD	Base Physical Addr. (d)
Ah	0	A	(64*10)+49152 = 49792d
15h	1	5	(64*21)+49152 = 50496d

where:
L.A. = Logical Address
MSD = Most Significant Digit
LSD = Least Significant Digit

IEEE-488 Address

Using the 73A-541 Module in an IEEE-488 environment requires knowing the module's IEEE-488 address in order to program it. Different manufacturers of IEEE-488 interface devices may have different algorithms for equating a logical address with an IEEE-488 address.

If the 73A-541 is being used in a MATE system, VXIbus logical addresses are converted to IEEE-488 addresses using the algorithm specified in the MATE IAC standard (MATE-STD-IAC). This algorithm is described in detail in the 73A-156 Operating Manual.

If the 73A-541 is not being used in a CDS IAC System, consult the operating manual of the IEEE-488 interface device being used for recommendations on setting the module's logical address.

VMEbus Interrupt Level Select Switch

Each function module in a VXIbus System can generate an interrupt on the VMEbus to request service from the interrupt handler located on its commander (for example, the 73A-151 RM/IEEE-488 Interface Module in a CDS 73A-IBX System). The VMEbus interrupt level on which the 73A-541 Module generates interrupts is set by a BCD rotary switch. Align the desired switch position with the arrow on the module shield.

Valid Interrupt Level Select switch settings are 1 through 7, with setting 1 equivalent to level 1, etc. The level chosen should be the same as the level set on the 73A-541's interrupt handler. Setting the switch to an invalid interrupt level (0, 8, or 9) will disable the module's interrupts. When using the 73A-541 in a CDS 73A-IBX System, set the interrupt level to the same level chosen on the 73A-151.

Interrupts are used by the module to return VXIbus Protocol Events to the module's commander. Refer to the Operation section for information on interrupts. The VXIbus

Protocol Events supported by the module are listed in the Specifications section.

Halt Switch

This two-position slide switch selects the response of the 73A-541 Module when the Reset bit in the module's VXIbus Control register is set.

If the Halt switch is in the ON position, then the 73A-541 Module is reset to its power-up state and all programmed module parameters are reset to their default values.

If the Halt switch is in the OFF position, the module will ignore the Reset bit and no action will take place.

NOTE: The module is not in strict compliance with the VXIbus Specification when the Halt switch is OFF.

Control of the Reset bit depends on the capabilities of the 73A-541's commander. In a CDS 73A-IBX System, for example, the Reset bit is set when the 73A-151 RM/IEEE-488 Interface Module receives a STOP command via the IEEE-488 bus.

CAL Switch

This two-position rocker switch controls the TTLOUT A and TTLOUT B BNC connections.

During normal operation the switch should be set to C1, which connects the TTLOUT A and TTLOUT B BNCs to the TTLOUT A and TTLOUT B signals.

During module calibration the switch is set to C2. This connects the TTLOUT A BNC to the trigger level test point for channel A, and connects the TTLOUT B BNC to the trigger level test point for channel B.

- **Fuses**

The 73A-541 Module has five fuses, for +5V, -5.2V, -2V, +24V, and -24V. The fuses protect the module in case of an accidental shorting of the power bus or any other situation where excessive current might be drawn.

If the +5V fuse opens, the VXIbus Resource Manager will be unable to assert SYSFAIL INHIBIT on this module to disable SYSFAIL*.

If the +5V fuse opens, remove the fault before replacing the fuse. Replacement fuse information is given in the Specifications section of this manual.

- **LEDs**

The following LEDs are visible at the top of the 73A-541 Module's front panel to indicate the status of the module's operation.

Power LED

This green LED is normally lit and is extinguished if the +5 V, -5.2V, -2V, or ±24-volt buses or the internally regulated ±15 V busses fail, or if the +5V, -5.2V, -2V, or ±24V fuses blow.

Failed LED

This normally off red LED is lit whenever SYSFAIL* is asserted, indicating a module failure. Module failures include failure to correctly complete a self test, loss of a power rail, or failure of the module's central processor.

NOTE: If the module loses any of its power voltages, the Failed LED will be lit and SYSFAIL* asserted. A module power failure is indicated when the module's Power LED is extinguished.

MSG LED

This green LED is normally off. When lit, it indicates that the module is processing a VMEbus cycle. The LED is controlled by circuitry that appears to stretch the length of the VMEbus cycle. For example, a five microsecond cycle will light the LED for approximately 0.2 seconds. The LED will flash if the module is being constantly addressed.

Trigger LEDs

The two LEDs labeled TRG A and TRG B light whenever the input signal on the associated channel exceeds the programmable trigger threshold.

Gate LED

The Gate LED lights whenever the counter gate is enabled (channels are enabled to count).

Error LED

The Error LED lights when a command string containing a syntax error is received by the module. Once lit, it will remain lit until an ER command is received by the card, or until an MM (Measurement Mode) command or a reset resets the module to its power-up condition.

FRONT PANEL BNC

Channel A and B Counter Inputs

The INPUT A and INPUT B connections provide the basic counter inputs for the 73A-541.

Gate Input

The GATE IN BNC connection may be used to control the measurement cycle if the 73A-541 is programmed for external gate use.

TTL OUT A and B Outputs

The TTL OUT A and TTL OUT B BNC connectors are the Counter A and B inputs translated to TTL outputs.

10 MHz Clock Input

The EXT CLK IN BNC connection allows use under program control of a user-supplied 10 MHz system clock reference for the basic time base of the 73A-541 Module.

BITE (Built-In Test Equipment)

Seven LEDs at the front edge of the module visually indicate A and B channel triggering, gate status, and operating status, as well as showing that the required power supplies are present, whether or not the 73A-541 has entered a "Failed" condition, and when the module is processing a VMEbus cycle.

A TEST command is provided to test the internal PROM and RAM memory on the module.

If an input is active on one channel, the TTL output of that channel may be connected to the other counter input via one of the VXIbus TTLTRG lines, and the two channels' data collection compared. This tests the analog input circuitry on the second channel and the TTL counter and memory load circuitry on both channels.

SPECIFICATIONS

No. of Input Channels:	Two.
Functions:	Counter/Timer Mode: Frequency, Period, Pulse Width, Time Interval, Event Count, Duty Cycle, Period Average, Pulse Width Average, Time Interval Average, Duty Cycle Average. Digitizing Counter Mode: Frequency, Period, Pulse Width, Time Interval, Event Count, Duty Cycle.
Returned Data Format:	Programmable for: Floating-point decimal with exponent (ASCII String) - number of digits is programmable. Binary (32-bit integer). Blocked binary. Data followed by carriage-return and line-feed <CR><LF> for all formats.
Input Characteristics:	
Input Impedance:	1 megohm, 30 pF or 50 ohms, program selectable.
Input Coupling:	DC or AC, program selectable.
Attenuator:	X1 or X3, program selectable.
Channel Input:	Separate or common A to B, program selectable.
Dynamic Range:	1 megohm - X1: 100mV to 7V RMS X3: 300mV to 21V RMS 50 Ohm - X1: 100mV t0 7V RMS X3: 300mV to 7V RMS
Input Slope:	Positive or negative, program-selectable for each channel.
Input Protection:	X1, ±125V DC or V RMS, 0 to 100Hz; 20 V RMS, 100Hz to 20kHz; 7V RMS, 20kHz to 10MHz. X3, ±125V DC or V RMS, 0 to 100Hz; 60V RMS, 100Hz to 20kHz; 21V RMS, 20kHz to 10MHz. 50 ohms, 7V RMS.
Trigger-Level Range:	X1, +2.54 to -2.56V DC, 0.02V DC resolution. X3, +7.62 to -7.68V DC, 0.06V DC resolution.
Trigger Accuracy (DC to 10 MHz):	X1, ±(30mV + 0.5% of programmed value). X3, ±(90mV + 0.5% of programmed value).

NOTE: Trigger level is defined as the center point of the trigger hysteresis band (±20mV hysteresis for X1, ±60mV hysteresis for X3).

Gate Time Range: 1 µs to 427 s; 2 events to 4 x 10^9 events of input A or B, programmable start/stop; or external TTL control.

Resolution: 1 µs or 1 event count.

Accuracy: ±(Time Base Stability * Gate time) ±100 ns.

TTL OUT Timing: The time from when the measurement signal crosses the threshold to when the TTL OUT changes state. When using the INPUT A or B BNC, the threshold is the programmed trigger level. When using the VXI TTLTRG lines, the threshold is the high or low logic levels of a 74HCT240 (2.0V high, minimum, and 0.8V low, maximum).

The TTL OUT A or B BNC changes state within (153 nsec + time base period) of the time when the input crosses the threshold. The VXI TTLTRG line goes low within (220 nsec + time base) of the time when the input crosses the threshold on the programmed slope, and remains low for 250 nsec (minimum) to 750 nsec (maximum).

Power-up Status:
Mode: Counter/Timer Mode.
Function: Frequency A.
Input (both channels): trigger slope positive, 1 megohm, DC-coupled, trigger levels at 0V DC, A separate B, both channels enabled, both attenuations X1.
External Trigger: Disabled.
Interrupt Mode: Disabled.
Read Format: Decimal format, 5 significant digits.
Gate Time: 100 events for time-average functions. 1 second for frequency and event functions. 2 events for other functions.

Timer/Counter Mode

Frequency:

Range: 0.0025 Hz to 10 MHz.

Accuracy: $\pm \text{Freq Meas} - \frac{(\text{Freq Meas})(\text{Gate Time}) \text{ Hz}}{\text{Gate Time} + \text{Gate Error}^*}$.

Period:

Range: 0 to 25 s.

Resolution: 100 ns.

Accuracy: ±Gate Error*.

Pulse Width:

Range:	100 ns to 25 s.
Resolution:	100 ns.
Accuracy:	±Gate Error*.

Interval A to B, B to A:

Range:	0 ns to 25 s.
Resolution:	100 ns.
Accuracy:	±Gate Error*.

Event Count:

Range:	0 to 4 X 10^9 counts.
Resolution:	1 count.

Duty Cycle:

Range:	0 to 100%.
Period Range:	200 ns to 25 s.

Accuracy: $\left[\frac{\text{Pulse width}}{\text{Period}} \pm \frac{\text{Pulse width} \pm \text{Gate error*}}{\text{Period - Gate error*}} \right] \times 100\%$

Time Average Functions:

No. of Occurrences in Average:	1 to 1022.
Averaging Time:	200 ns to 25 s.
Accuracy:	$\pm \frac{\text{Gate Error*}}{\text{No. of Occurrences x Average Period}} \%$

Digitizing Counter Mode

Time Range:	0 to 25 s.
Time Tag Resolution:	100 ns.
Time Tag Accuracy:	±Gate Error*.
No. of Events Individually Time Identified:	2047 identified 100-ns time intervals that contain either a positive or negative slope transition of channel A; or a positive or negative slope transition of channel B; or a coincident occurrence of any of the preceding.

Time Base (Option 010):

Frequency:	10 MHz.
Temperature Stability:	< 0.5 ppm, 0°C to 70°C.

Accuracy:	Setable to 0.1 ppm.
Aging Rate:	2 x 10^{-6} first 6 months. < 1 x 10^{-6} for life.
Trim Range:	±6 x 10^{-6}.
Warm-up Time:	< 1 minute.

* Gate Error = ±(Time Base Stability x Gate Time + 100 ns). Time-base stability contribution is negligible for duty cycle measurement.

Power-Up:	The 73A-541 Module is ready for programming 1 second after power-up. The power LED is on, and all other LEDs are momentarily on then off 0.5 seconds after power-up.
VXIbus Compatibility:	Fully compatible with the VXIbus Specification for message-based instruments with the Halt switch in the ON position.
VXI Device Type:	VXI message based instrument, VMEbus slave, Revision 1.2.
VXI Protocol:	Word serial.
VXI Card Size:	C size, one slot wide.
Module-Specific Commands:	All module-specific commands and data are sent via the VXIbus Byte-Available command. All module-specific commands are made up of ASCII characters. Module-specific data may be in either ASCII or binary format.
VMEbus Interface:	Data transfer bus (DTB) slave - A16, D16 only.
Interrupt Level:	Switch selectable, levels 1 (highest priority) through 7 (lowest).
Interrupt Acknowledge:	D16; lower 8 bits returned are the logical address of the module.
VXIbus Data Rate:	Buffered mode write: 200K bytes/sec maximum. Nonbuffered mode write: 20K bytes/sec maximum.
VXIbus Commands Supported:	All VXIbus commands are accepted (e.g. DTACK* will be returned). The following commands have effect on this module; all other commands will cause an Unrecognized Command Event:

BYTE AVAILABLE (with or without END bit set)
BYTE REQUEST
BEGIN NORMAL OPERATION
CLEAR

	IDENTIFY COMMANDER READ PROTOCOL TRIGGER
VXIbus Protocol Events Supported:	VXIbus events are returned via VME interrupts. The following events are supported and returned to the 73A-541 Module's commander: UNRECOGNIZED VXIbus COMMAND REQUEST TRUE (In IEEE-488 systems such as the 73A-541, this interrupt will cause a Service Request (SRQ) to be generated on the IEEE-488 bus.
VXIbus Registers:	ID Device Type Status Control Protocol Response Data Low See Appendix A for definition of register contents.
ID Register Contents:	FDE2h (1s complement of binary value of model number).
Power Requirements:	All required dc power is provided by the Power Supply in the VXIbus Card Cage.
Voltage:	+5 Volt Supply: +4.75 V dc to +5.25 V dc. +24 Volt Supply: +23.5 V dc to +24.5 V dc. -24 Volt Supply: -23.5 V dc to -24.5 V dc. -5.2 Volt Supply: -5.46 V dc to -5.044 V dc -2 Volt Supply: -2.1 V dc to -1.9 V dc
Current (Peak Module, I_{PM}):	+5 volt supply: 3.0 A +24 volt supply: 0.30 A -24 volt supply: 0.16 A -5.2 volt supply: 0.08 A -2.0 volt supply: 0.02 A
Current (Dynamic Module, I_{DM}):	+5 volt supply: 0.10 A PTP +24 volt supply: 0.32 A PTP -24 volt supply: 0.07 A PTP -5.2 volt supply: 0.01 A PTP -2.0 volt supply: 0.01 A PTP
Cooling:	Provided by the fan in the VXIbus card cage. Less than 5°C temperature rise with 1.5 l/s of air at a pressure drop of 0.05 mm of H_2O.

Temperature:	-10°C to +55°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.
VXIbus Radiated Emissions:	Complies with VXIbus Specification.
VXIbus Conducted Emissions:	Complies with VXIbus Specification.
Module Envelope Dimensions:	VXI C size. 262 mm high, 352 mm deep, 31 mm wide. (10.3 in x 13.9 in x 1.2 in).
Dimensions, Shipping:	When ordered with a CDS card cage, this module will be installed and secured in one of the instrument module slots (slots 1 - 12). When ordered alone, the shipping dimensions are: 406 mm x 305 mm x 102 mm. (16 in x 12 in x 4 in).
Weight:	0.69 kg. (1.5 lbs.)
Weight, Shipping:	When ordered with a CDS card cage, this module will be installed and secured in one of the instrument module slots (slots 1-12). When ordered alone, the module's shipping weight is: 1.50 kg. (3.3 lbs.)
Mounting Position:	Any orientation.
Mounting Location:	Installs in an instrument module slot (slots 1-12) of a C or D size VXIbus mainframe.
Front Panel Signal Connections:	Six BNC jack panel connections.
Recommended Cable:	Standard BNC cables (not supplied) may be ordered from other manufacturers.
Equipment Supplied:	1 - 73A-541 Universal Digitizing Counter Module.
Software Version:	V3.2

INSTALLATION

INSTALLATION REQUIREMENTS AND CAUTIONS

The 73A-541 Module is a C size VXIbus instrument module and therefore may be installed in any C or D size VXIbus card cage slot other than slot 0. If the module is being installed in a D size card cage, consult the operating manual for the card cage to determine how to install the module in that particular card cage. Setting the module's logical address switch defines the module's programming address. Refer to the Controls and Indicators subsection for information on selecting and setting the 73A-541 Module's logical address.

CAUTION:

To avoid confusion, it is recommended that the slot number and the logical address be the same.

Tools Required

The following tools are required for proper installation:

Slotted screwdriver set.

CAUTION:

Note that there are two ejector handles on the module. To avoid installing the module incorrectly, make sure the ejector labeled "73A-541" is at the top.

CAUTION:

In order to maintain proper module cage cooling, unused card cage slots must be covered with blank front panels supplied by the card cage manufacturer. Based on the number of IAC modules ordered with a CDS card cage, blank front panels are supplied to cover all unused slots.

CAUTION:

Verify that the card cage is able to provide adequate cooling and power for the 73A-541 Module. Refer to the card cage Operating Manual for instructions on determining cooling and power compatibility.

CAUTION:

If the 73A-541 Module is inserted in a slot with any empty slots to the left of the module, the VME daisy-chain jumpers must be installed on the backplane in order for the 73A-541 Module to operate properly. Check the manual of the card cage being used for jumpering instructions.

If a CDS 73A-021 Card Cage is being used, the jumper points may be reached through the front of the card cage. There are five (5) jumpers that must be installed for each empty slot. The five jumpers are the pins to the left of the empty slot.

INSTALLATION PROCEDURE

CAUTION:
The 73A-541 Module 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.

1) Record the module's Revision Level, Serial Number (located on the CDS label on the top shield of the 73A-541), and switch settings on the Installation Checklist on the next page. Only qualified personnel should install the 73A-541 Module.

2) Verify that the Logical Address and Interrupt Level switches are switched to the correct value. The Halt switch should be in the ON position unless it is desired to not allow the resource manager to reset this module.

   Note that with either Halt switch position, a "hard" reset will occur at power on and when SYSRST* is set true on the VXIbus backplane. If the module's commander is a CDS 73A-151 RM/IEEE-488 Interface Module, SYSRST* will be set true whenever the Reset switch on the front panel of the 73A-151 is depressed. Also note that when the Halt switch is in the OFF position, the operation of this module is not VXIbus compatible.

3) When shipped, this module has been factory calibrated. Recalibration is required at 12 month intervals thereafter. Calibration procedures are given in Appendix D.

4) The module can now be inserted into any slot of the chassis other than slot 0.

5) **Installation of Cables**
Use a standard BNC cable for connection to any of the BNC front panel connectors. If the module is being installed in a CDS 73A Series card cage, route the cable from the front panel of the module down through the cable tray at the bottom of the card cage and out the rear of the card cage.

INSTALLATION CHECKLIST

Installation parameters may vary depending on the card cage being used. Be sure to consult the card cage Operating Manual before installing and operating the 73A-541 Module.

Revision Level: _____

Serial No.: _____

Card Cage Slot Number: _____

Switch Settings:

VXIbus Logical Address Switch: _____

Interrupt Level Switch: _____

Halt Switch: _____

Performed by: _____ Date: _____

OPERATION

OVERVIEW

The 73A-541 Module is programmed by ASCII characters issued from the system controller to the 73A-541 Module via the VXIbus card cage backplane. The module is a VXIbus Message Based Device and communicates using the VXIbus Word Serial Protocol. Refer to the manual for the VXIbus device that will be the 73A-541 Module's commander for details on the operation of that device.

If the module is being used in a CDS 73A-IBX System card cage, the module's commander will be the 73A-151 Resource Manager/IEEE-488 Interface Module. Refer to the 73A-151 Operating Manual and the programming examples in the Operation section of this manual for information on how the system controller communicates with the 73A-151.

The 73A-541 Module provides two basic modes of operation, the Timer/Counter mode and the Digitizing Counter mode. The MM (Measurement Mode) command selects one of the two modes.

A set of common commands can be applied to both modes: the mode-initializing commands, the preset commands, the slope commands, the A separate/common B command, the attenuator commands, the trip-level commands, the trigger commands, and the interrupt-mode commands.

Each mode has a separate set of function-select commands, gate commands, and read-format commands.

The Digitizing Counter mode has four sub-modes to provide for real-time versus post-processing, and multifunction versus timing-diagram output. A set of memory-pointer commands is provided in the Post-Processing/Multifunction sub-mode to help use the Time Tag Memory.

Commands are provided for selection of a clock reference source and for attaching the counter inputs, gate or TTL outputs to the VXIbus TTLTRG lines.

When the module is first powered up, a set of default conditions is in effect which allows easy use of the 73A-541 for frequency measurements on channel A. If no commands are sent to the 73A-541, reading from the module will return a frequency measurement on channel A with a default gate time of one second and a trigger threshold setting of zero volts. The measurement will automatically be triggered by the reading request, and the 73A-541 will hold off the system controller for one second, until the reading is complete. (If you have a system controller or VXIbus resource manager with a timeout function, make sure the timeout value is set greater than one second.)

The format of the returned reading is a five significant digit floating point number with exponent, terminated with a carriage return and line feed. For example, the numerical string 2.5000E+06<CR><LF> would be returned for a 2.5 MHz reading. This value can be read into either a numerical variable or a string variable.

The module's extensive command set facilitates many other applications. For example, a period measurement on channel B may be taken simply by sending an "FN6" command, then taking a reading. The reading will automatically be triggered, will have a gate time of one second, a threshold of zero volts (on channel B), and return a floating point format of five significant

digits (4.0000E-07<CR><LF> for the 2.5 MHz example above, a 400 nanosecond period).

The gate time may be reduced to 100 milliseconds with a "GM100" command. If the trigger threshold is unknown, the 73A-541 will do an automatic trigger level search and then use that trigger level in all subsequent measurements by sending an auto trigger command, "AU" or "BU" for channel A or channel B.

If automatic measurement initiation is not desired, a Measurement Initiate (JM) command may be sent. The advantage of commanded measurement initiation is that the system controller is free to perform other tasks while the measurement is being performed. This is particularly useful in applications with long gate times, where the system controller needs to be used efficiently.

More sophisticated applications of the 73A-541 use the time tag memory modes, available by using the Measurement Mode command (MM1) and a TM command to select one of the four Digitizing Counter modes. The Time Tag command mode summary at the end of the Summary section shows some of the capabilities of this mode, and shows some measurement return examples.

POWER-UP

The 73A-541 Module will complete its self test and be ready for programming five seconds after power-up. The VXIbus Resource Manager may add an additional one or two second delay to this time. The Power LED will be on, and all other LEDs off. The MSG LED will blink during the power-up sequence as the VXIbus Resource Manager addresses all modules in the card cage. The default condition of the module after power-up is described in the SYSFAIL, Self Test and Initialization subsection.

SYSTEM COMMANDS

Although these non-data commands are initiated by the 73A-541's commander (for example, the 73A-151 Module in a CDS 73A-IBX System) rather than the system controller, they have an effect on the 73A-541 Module. The following VXIbus Instrument Protocol Commands will affect the 73A-541:

Command	Effect
Clear	The module clears its VXIbus interface and any pending commands. Current module operations are unaffected.
Trigger	The trigger may be used as a gate input under program control.
Begin Normal Operation	The module will begin operation if it has not already done so.
Read Protocol	The module will return its protocol to its commander.

MODULE COMMANDS

A summary of the 73A-541's Module's commands is listed below. This is followed by detailed descriptions of each of the commands. Sample BASIC programs using these commands are shown at the end of this section.

Command protocol and syntax for the 73A-541 Module are as follows:

1) More than one command may be entered on a given line by stringing the commands together. They are read and acted on from left to right.

2) Spaces, null characters, commas, periods, colons and semi-colons may be inserted between commands or command arguments without affecting module operation.

3) Carriage-returns <CR> and line-feeds <LF> may optionally be inserted between commands.

4) Command arguments that have leading zeros may be transmitted without the leading zeros, but with the following constraint: the command will not be executed until another command or a <CR> is sent to the card.

5) The maximum command set length between <CR><LF> terminations is 125 characters.

- **Summary**

Summaries of the Common commands, the Timer/Counter mode commands, and the Digitizing Counter mode commands are given on the following pages. The detailed descriptions of each of the commands are divided into three major sections: 1) Commands common to both Timer/Counter Mode and Digitizing Counter Mode, 2) Timer/Counter Mode Commands, and 3) Digitizing Counter Mode Commands. Command descriptions are in alphabetical order within each section. The Quick Reference Guide lists page numbers for each command.

In the following summaries and descriptions, commands use one of these formats:

SS	cSz	cS[s]z
SSz	Scz	SS[z][z]z
cS		

where S is the command identifier, c specifies the channel (A or B), z is a number (one or more digits), and s is a sign character (space, + , or -). [Brackets] indicate an optional parameter. * indicates the power-up default setting.

COMMON COMMANDS

Command	Description

cAz specifies AC or DC input coupling for the A or B input channel.

AA0*	Coupling A DC
AA1	Coupling A AC
BA0*	Coupling B DC
BA1	Coupling B AC

CSz selects the A input to connect to both the A and B input channels or selects separate inputs.

CS0*	A Separate B
CS1	A Common B

cDz disable the A or B input channel from measurement.

AD0	Disable A Input
AD1*	Enable A Input
BD0	Disable B Input
BD1*	Enable B Input

ER reads back the error status and the specific error type.

Hz connects or disconnects counter input A or B, TTLOUT A or B, or the GATE input to any of the eight VXIbus TTLTRG lines. It also connects the GATE input to the front panel GATE BNC or to the VXIbus TRIGGER command.

cI[s] read back the trigger level.

AI+	Input + Peak Level A (channel A, positive peak input level, measured at last auto trigger level command)
AI	Input Trigger Level A
AI-	Input - Peak Level A (channel A, negative peak input level, measured at last auto trigger level command)
BI+	Input + Peak Level B
BI	Input Trigger Level B
BI-	Input - Peak Level B

JM/QM start/stop a measurement cycle under program control for both A and B channels.

JM	Initiate Measurement Cycle
QM	Stop Measurement Cycle

MMz specifies either Timer/Counter or Digitizing Counter mode.

MM0*	Select Basic Timer/Counter Mode
MM1	Select Time Tag Memory Mode

cP preset a channel's setup parameters to the power-up state.

AP*	Preset Channel A Setup Commands to Power-Up State
BP*	Preset Channel B Setup Commands to Power-Up State

cSz specifies a positive or negative trigger slope for the A or B input channel.

AS0*	Set Trigger Slope A to Positive
AS1	Set Trigger Slope A to Negative
BS0*	Set Trigger Slope B to Positive
BS1	Set Trigger Slope B to Negative

SRz enables or disables interrupt generation.

SR0*	Disable Interrupt/Service Request Capability
SR1	Enable Interrupt/Service Request Capability

cT[s]z program a desired trigger level for the A or B input channel.

ATz*	Set Trigger Level A to z VDC (*z=0)
BTz*	Set Trigger Level B to z VDC (*z=0)

TEST1 performs a test of the memories and counters on the 73A-541 Module.

cU automatically set the trigger level of the A or B channel to a point midway between the input-signal peak-to-peak levels.

AU	Auto-Search for A Trigger Level
BU	Auto-Search for B Trigger Level

cXz selects an X1 or X3 attenuation for the A or B input channel.

AX1*	Set Attenuator A to X1
AX3	Set Attenuator A to X3
BX1*	Set Attenuator B to X1
BX3	Set Attenuator B to X3

Yz selects the source for the 10 MHz clock reference as either the VXIbus slot 0 10 MHz ECL clock, an optional on-board 0.5 ppm oven-controlled oscillator, or the 73A-541 front panel EXT CLOCK IN BNC.

Y0*	VXIbus Slot 0 10 MHz
Y1	Clock source Optional 10 MHz oven oscillator
Y2	10 MHz Front panel external clock input

cZz select the A or B input impedance.

AZ0*	Channel A 1 Megohm Input Impedance
AZ1	Channel A 50 Ohm Input Impedance
BZ0*	Channel B 1 Megohm Input Impedance
BZ1	Channel B 50 Ohm Input Impedance

TIMER/COUNTER MODE COMMANDS

Command Description

EXz specifies "E" or "e" for the exponent character in a returned measurement.

EX0*	Define Exponent Character - Uppercase "E"
EX1	Define Exponent Character - Lowercase "e"

FNz specifies the function whose value is to be returned to the system controller when responding to an input request.

FN1*	Frequency A
FN2	Frequency B
FN3	Event Count A
FN4	Event Count B
FN5	Period A
FN6	Period B
FN7	Pulse Width A
FN8	Pulse Width B
FN9	Time Interval B to A
FN10	Time Interval A to B
FN11	Duty Cycle A
FN12	Duty Cycle B
FN13	Period A Average
FN14	Period B Average
FN15	Pulse Width A Average
FN16	Pulse Width B Average
FN17	Time Interval B to A Average
FN18	Time Interval A to B Average
FN19	Duty Cycle A Average
FN20	Duty Cycle B Average

Gcz specify the length of the measurement cycle as a number of Channel A or Channel B events when measuring Frequency A or B or Count Events A or B.

GAz	Gate for z Channel A Events
GBz	Gate for z Channel B Events

GEz disables or enables the external-gate input's ability to control the opening of the A and B channel gates.

GE0*	Disable External Gate
GE1	Enable External Gate

GI the measurement cycle lasts indefinitely until a QM command is issued.

GPz specifies the number of periods for averaging functions FN13 through FN20 (*z=100).

GU/GM/GS specify the length of the measurement cycle in μs, milliseconds, or seconds when measuring Freq. A or B, or Count Events A or B.

GUz	Gate for z Microseconds
GMz	Gate for z Milliseconds
GSz*	Gate for z Seconds (*z=1)

IFz* Specifies the largest integer value returned in commands involving integers (*z=15, ie: $2^{15} - 1$)

RFz* Specifies the number of significant floating-point digits the module returns when responding to a system controller input request (*z=5).

DIGITIZING COUNTER MODE COMMANDS

Command	Description

BNz specifies returning data in ASCII Decimal format or in Binary format.

BN0*	ASCII Format
BN1	Binary Format

EXz specifies "E" or "e" for the exponent character in the returned measurement.

EX0*	Define Exponent Character - Uppercase "E"
EX1	Define Exponent Character - Lowercase "e"

Fc allow immediate real-time readback of event count A or B.

FA	Event Count A Immediate
FB	Event Count B Immediate

FNzz specifies the functions whose values are returned to the system controller in response to input requests.

FN00	All Functions Off
FN01	Frequency A
FN02	Frequency B
FN03	Event Count A
FN04	Event Count B
FN05*	Period A
FN06	Period B
FN07	Pulse Width A
FN08	Pulse Width B
FN09	Interval B to A
FN10	Interval A to B
FN11	Duty Cycle A
FN12	Duty Cycle B

Gcz specify the length of the measurement cycle as a number of A or B channel events.

GAz	Gate for z Channel A Events
GBz	Gate for z Channel B Events

GEz disables or enables the external-gate input's ability to control the opening of the A and B channel gates.

GE0*	Disable External Gate
GE1	Enable External Gate

GI the measurement cycle lasts indefinitely until a QM command is issued.

GU/GM/GS specify the length of the measurement cycle in μs, milliseconds, or seconds when measuring Freq. A or B, or Count Events A or B.

GUz	Gate for z Microseconds
GMz	Gate for z Milliseconds
GSz	Gate for z Seconds (*z=1)

IFz specifies the largest integer value returned in commands involving integer numbers.

IFz*	Define Largest Integer Number (*z=15, ie: $2^{15} - 1$)

RBz in binary format, to specify the number of measurements that are to be blocked into a record.

RBz*	Block z Binary Measurements for Return of Data (*z=1)

RFz specifies the number of significant floating-point digits the module returns after the 2-digit function code and comma when responding to a system controller input request.

RFz*	Define No. of Digits, Real Number (*z=5)

TMz specifies one of the four sub-modes of processing input data collected in the Digitizing Counter mode.

TM0*	Real Time/Multifunction Sub-Mode
TM1	Real Time/Timing Diagram Sub-Mode
TM2	Post-Processing/Multifunction Sub-Mode
TM3	Post-Processing/Timing Diagram Sub-Mode

in Post-Processing/Multifunction mode:

cBz define the beginning event number to be read from memory.

ABz	Define Channel A Beginning Event No.
BBz	Define Channel B Beginning Event No.

cEz define the ending event number to be read from memory.

AEz	Define Channel A Ending Event No.
BEz	Define Channel B Ending Event No.

cRz determine the beginning or ending event number available in memory for channel A or B.

ARz	Read Channel A Beginning Event No.
BRz	Read Channel B Beginning Event No.
AR1	Read Channel A Ending Event No.
BR1	Read Channel B Ending Event No.

RI determine the amount of elapsed time between the beginning and ending event numbers specified for memory readback at the time the last Post-Processing/Multi-function measurement was completed.

RN specify the number of measurements returned.

Memory Pointer Commands Example

The Memory Pointer commands (cRz, cBz, cEz, RN, and RI) are provided for the Post-Processing/Multifunction sub-mode to determine if memory has been overwritten and to find what events are available in memory. A first set of Memory Pointer commands is used to determine the first and last events available in memory. A second set of Memory Pointer commands can then specify a subset of the available measurements to read from memory, and find how many measurements are in this subset and the elapsed time they cover.

The following example shows a use of the five Memory Pointer commands. The example assumes a 500 kHz square wave is being measured by channel A of the 73A-541 Module. Note

that every read will result in the string shown plus the terminator characters 13 (carriage return) and 10 (line feed). The terminator characters are not shown in the example.

MM1TM2GIIF32

Set the 73A-541 Module to Digitizing Counter Mode, Post-Processing/Timing Sub-Mode, Gate indefinitely, and return integer values up to $2^{32} - 1$.

FN00FN05FN11

Clear the multifunction list, set the list to Period of Channel A, and Duty Cycle of Channel A.

JM

Trigger the measurement.

QM

Stop the measurement. Begin using the Memory Pointer commands.

AR0

Program the 73A-541 to return the beginning event number available in Channel A memory. Read the data. The module will return

1487193

Event number 1487193 is the first event available in memory. Events before event number 1487193 were written over.

AR1

Program the 73A-541 to return the ending event number available in Channel A memory.

Read the data. The module will return

1488216

Event number 1488216 is the last event available in memory. The total number of events available to read are:

```
   1488216
-  1487193
      1023
```

AB1488000AE1488005

Program the 73A-541 to return all measurements between events 1488000 and 1488005, inclusive.

RN

Program the 73A-541 to return the number of measurements between event 1488000 and 1488005 on the next read. This will return

10

10 is the number of measurements asked for by the RN command. The 10 measurements are the period and duty cycle of channel A for the 5 events.

RI

Program the 73A-541 to return the elapsed time between events 1488000 and 1488005. The module will return

1.0000E-05

This is the elapsed time, 5 events at 500 kHz (2 μsec), or 10 μsec.

To obtain this measurement data, read the 73A-541 Module ten times to obtain the ten measurements, plus two additional reads:

```
00,2.9760E+00
05,2.0000E-06
11,5.0000E-01
05,2.0000E-06
11,5.0000E-01
05,2.0000E-06
11,5.0000E-01
05,2.0000E-06
11,5.0000E-01
05,2.0000E-06
11,5.0000E-01
99,0.0000E+00
```

The data returned consists of a two-digit function code which specifies the type of data, followed by measurement values. 00,2.9760E+00 is the time from the trigger (JM command) to event number 1488000. The function code "00" indicates missing data. 99,0.0000E+00 indicates that the last of the measurements has been read. "99" is the function code for 'no more data'.

A detailed description of each command, in alphabetical order within each section, is given on the following pages.

- **Common Command Descriptions**
  Commands Common To Timer/Counter And Digitizing Counter Modes

Command: A (Input Coupling Select)

Syntax: cAz

Purpose: The Coupling Select commands specify AC or DC input coupling for the A or B input channel.

Description: c selects the channel, A or B.

z is the 1-digit integer 0 or 1.

0 = DC coupling.
1 = AC coupling.

DC input coupling is selected on power-up.

Command: CS (A Common/Separate B)

Syntax: CSz

Purpose: The A Common/Separate B command selects the A input to connect to both the A and B input channels or selects separate inputs.

Description: z is the 1-digit integer 0 or 1. 0 programs A and B input as separate inputs to the A and B input channels. 1 programs the A input as a common input to both the A and B input channels.

The module is programmed for separate A and B inputs at power-up.

Set BXZ to match AXZ when using CS1 (A common B).

Command: D (Disable)

Syntax: cDz

Purpose: The Disable commands disable the A or B input channel from measurement. Since the Time Tag memory is shared by inputs A and B, this command may be used to prevent wasting the Time Tag memory on an unused noisy input.

Description: c selects the channel, A or B.

z is the 1-digit integer 0 or 1:

0	disables the input channel.
1	enables the input channel. (default)

Command: ER (Error)

Syntax: ER

Purpose: The Error command prepares the module to return the error status and the specific error type the next time input is requested from the 73A-541 Module.

Description: Errors are generated if the 73A-541 Module is programmed incorrectly.

The error code is a 2-digit integer followed by a carriage-return and a line-feed <CR><LF> and is returned in response to an input request immediately following the ER command. The input request clears the ERR LED and any error conditions. Only the first error detected is returned. Any additional errors will not be saved or returned.

A measurement value of -1 is returned when no measurement data is available due to a programming error, or when an input timeout has occurred and the measurement is not yet completed.

Message No.	Definition
10	Unknown command.
11	Illegal Command Length - command > 125 characters (a <CR><LF> is required every 125 characters or less).
12	Integer number > 32768.
13	Minus sign not allowed for this argument.
20-68	Syntax errors - the numeric argument that followed a 2-letter command was in error. The error code/command relationships are shown below:

20 - AA	36 - BI	52 - GB	
21 - AB	37- BN	53 - GE	
22 - AD	38 - BP	54 - GI	
23 - AE	39 - BR	55 - GM	
24 - AI	40 - BS	56 - GP	
25 - AP	41 - BT	57 - GS	
26 - AR	42 - BU	58 - GU	
27 - AS	43 - BX	59 - IF	
28 - AT	44 - BZ	60 - JM	
29 - AU	45 - CS	61 - MM	
30 - AX	46 - ER	62 - QM	
31 - AZ	47 - EX	63 - RB	
32 - BA	48 - FA	64 - RI	
33 - BB	49 - FB	65 - RF	
34 - BD	50 - FN	66 - RN	
35 - BE	51 - GA	67 - SR	68 - TM

Syntax errors result for missing digits, too few digits, too many digits, wrong digits, or numeric values outside the range allowed.

70 AX/AT conflict - the requested trigger level for channel A is not in the available range for the selected input attenuation.

71 BX/BT conflict - the requested trigger level for channel B is not in the available range for the selected input attenuation.

72 Function not available - the function requested is not available in the Digitizing Counter mode.

73 Binary not available for this function.

74 A multifunction list does not apply in Timing Diagram mode.

75 Invalid entry in the multifunction list.

76 During Digitizing Counter mode, an input request occurred before a JM command triggered a measurement.

77 During Gate Indefinitely mode, an input request occurred before a QM command terminated a measurement.

78 A JM command was issued before the previous commands were completed. An ER command followed by an input request, issued before the JM command, prevents this error.

99 No errors.

Command: H (TTLTRG lines)

Syntax: Hz

Purpose: The VXIbus TTLTRG lines command connects or disconnects counter input A or B, TTLOUT A or B, or the GATE input to any of the eight VXIbus backplane TTLTRG lines.

Description: z is a five digit integer number - $d_1d_2d_3d_4d_5$. Each of the five digits corresponds to one of the five module signals.

d_1 selects the source for the Counter/Timer A input as follows:

d_1 value	Counter/Timer A Source
0	TTLTRG0*
1	TTLTRG1*
2	TTLTRG2*
3	TTLTRG3*
4	TTLTRG4*
5	TTLTRG5*
6	TTLTRG6*
7	TTLTRG7*
8	Front panel CHAN A INPUT BNC

d_2 is the same as d_1, but for the Counter/Timer B input.

d_3 selects the TTLTRG destination of the TTL OUT A active low signal as follows:

d_3 value	Destination
0	TTLTRG0*
1	TTLTRG1*
2	TTLTRG2*
3	TTLTRG3*
4	TTLTRG4*
5	TTLTRG5*
6	TTLTRG6*
7	TTLTRG7*
8	No Connection

In all cases the TTL OUT A active high signal is connected to the front panel TTL OUT A BNC.

d_4 is the same as d_3, but for TTL OUT B.

d_5 selects the source of the gate input as follows:

d_5 value	Gate Input Source
0	TTLTRG0*
1	TTLTRG1*
2	TTLTRG2*
3	TTLTRG3*
4	TTLTRG4*
5	TTLTRG5*
6	TTLTRG6*
7	TTLTRG7*
8	Front Panel Gate Input BNC
9	VXIbus TRIGGER command

Multiple signals may be connected to the same TTLTRG line if desired.

If a TTLTRG line is the source for a channel of the Counter/Timer, the threshold level is not programmable. Rather, the threshold levels are those of a 74HCT240 (2.0 V high, minimum, and 0.8V low, maximum).

If a TTLTRG line is the destination of a TTL OUT A or B, a low pulse will occur at the TTLTRG line within (220 nsec + time base period) of the time when the input crosses the threshold level on the programmed slope. The line will remain low for 250 nsec (minimum) to 750 nsec (maximum).

The power-up default setting for the TTLTRG command is all five signals connected only to the 73A-541 front panel BNC connector (H88888).

The polarity of the TTL OUT A and B signals is dependant on the slope programmed by the AS or BS slope command (see the description of Input/Output Signals in Appendix B).

The TTLTRG command bypasses the 73A-541 software command queuing and may not be activated in the sequence sent with other commands. To insure that all commands sent prior to the H command have completed, send an ER (Error) command and read the response before sending an H command. The response should be 99 (no errors).

Example: "H01885" programs the VXIbus TTLTRG0 line as the channel A input and the VXIbus TTLTRG1 line as the channel B input. VXIbus TTLTRG5 is programmed as the gate source.

Command: I (Input Trigger Level)

Syntax: cI[s]

Purpose: The Input Trigger Level commands read back the specified channel's trigger level.

Description: c selects the channel, A or B.

[s] is an optional sign. An I command followed by a "+" or a "-" returns the positive or negative peak voltage found by the last Auto Search Trigger Level (AU/BU) command.

A single input request directly after issuing the I command returns the A or B trigger level in volts DC. The value contains three significant digits with a period and optional minus sign. The value is in the range -2.56 to 2.54 for the X1 attenuation mode, and in the range -7.68 to7.62 for the X3 attenuation mode.

Examples: "AX3AUAI+" programs channel A for X3 attenuation. An auto trigger is then performed, and the module is programmed to input the positive peak voltage found by the last auto trigger command. Reading the 73A-541 would yield the peak positive value of the signal on channel A.

Command: JM (Initiate Measurement) and
QM (Stop Measurement)

Syntax: JM QM

Purpose: The JM (Initiate Measurement) and QM (Stop Measurement) commands start and stop a measurement cycle under program control for both the A and B channels.

Description: These commands bypass the on-card microprocessor and open or close the counter input gates of both channels within 5 µs after the commands are received by the 73A-541 Module. The JM command is effective immediately only if it is issued after the on-card processor has completed executing all previous commands.

If a JM command is to be issued immediately following module set-up commands, first issue an ER command and then wait for the ER command response before issuing the JM command. The ER command response will not be returned until all pending commands have been processed.

If the JM command is issued while other commands are being processed, the JM command is aborted, the Error LED is set and error 78 is placed in the module's error buffer. If the measurement data is then requested from the module without clearing the error condition (see ER command), a value of -1 is returned.

If an input request is issued without a preceding JM command, a JM command is then issued automatically and, when in the Timer/Counter mode, data is then returned as soon as it is available.

The QM command can override a previously programmed measurement duration time and stop the measurement cycle. The QM command is effective immediately.

Command: MM (Measurement Mode)

Syntax: MMz

Purpose: The Measurement Mode command specifies either the basic Timer/Counter mode or the Digitizing Counter mode for the 73A-541 Module.

Description: z is the 1-digit decimal integer 0 or 1 that specifies the following:

z	Measurement Mode
0	Basic Timer/Counter mode (power-up default state)
1	Digitizing Counter mode

When the module is triggered to start a measurement in the basic Timer/Counter mode, it measures the input signal and returns a single measurement value specified by the FN (Function) command. The measurement is returned in response to the next input request after the measurement is complete. An input request automatically triggers a measurement if a trigger hasn't been issued.

In the Digitizing Counter Mode, the A and B input channel transitions, both positive and negative, are collected into a 2048-location memory buffer and time-tagged to the closest 100-ns time interval.

Real-time and post-processing measurements, and multifunction and timing diagram measurements access the Digitizing Counter data.

In the Digitizing Counter mode, commands can generally be issued 'in-progress' (while data is being collected). However, those commands that affect data collecting, for example, input slope or trigger level, immediately stop the measurement cycle. Other commands, such as input format changes, may appear delayed by one input message, since input messages are sometimes processed early and are already waiting in a buffer to speed data transfers.

The basic Timer/Counter mode should be used when making a simple function measurement of 1 to 500 data samples or when doing a basic event counter measurement. Basic Timer/Counter measurements are typically performed with a simple input request and without a trigger command.

The Digitizing Counter mode should be used to perform multiple measurement functions on the same data or to analyze a waveform on a period-to-period basis. Digitizing Counter mode measurements are typically triggered to start data collection.

Data collected in the basic Timer/Counter mode may be subsequently evaluated in the Digitizing Counter mode by issuing MM1 and TM commands without retriggering the module.

Command: P (Preset)

Syntax: cP

Purpose: The Preset commands preset the channel-setup parameters for channel A or B to the power-up state.

Description: c selects the channel, A or B.

The AP (Preset A) command issues the following commands:

AS0	Set Slope A Positive
AD1	Enable A Input
AX1	Set Attenuator A to X1
AT000	Set Trigger Level A to 0V DC
AA0	Set Coupling A to DC
AZ0	Set input impedance A to 1-megohm

The BP (Preset B) command issues the following commands:

BS0	Set Slope B Positive
BD1	Enable B Input
BX1	Set Attenuator B to X1
BT000	Set Trigger Level B to 0V DC
BA0	Coupling B to DC
BZ0	Set input impedance B to 1-megohm

Command: S (Slope Select)

Syntax: cSz

Purpose: The Slope Select commands specify a positive or negative trigger slope for the A or B input channel.

Description: c selects the channel, A or B.

z is the 1-digit integer 0 or 1.

0 = positive slope.
1 = negative slope.

Positive slope is selected on power-up.

Slope selection also determines the polarity of the signal at TTL BNC outputs to the 73A-541 front panel and to the VXIbus TTLTRG as follows:

For positive slope selection:

Front panel output - high for an input signal higher than the threshold; low for an input signal lower than the threshold.

VXIbus TTLTRG - active low for an input signal higher than the threshold; high for an input signal lower than the threshold.

For a negative slope selection, the polarities at the output are just the opposite. The front panel output is high for an input signal lower than the threshold. The TTLTRG line is active low for an input signal lower than the threshold.

Since the output polarities change with slope selection, it is important to program the desired slope before any device being triggered by these outputs is armed to accept the trigger.

Command: SR (Interrupt/Service Request Capability)

Syntax: SRz

Purpose: The Interrupt/Service Request Capability command enables or disables generating a Request True interrupt on the VXIbus.

Description: z is the 1-digit integer 0 or 1 defined as follows:

z	Function
0	Disables the generating of interrupts. (default)
1	Generates an interrupt when a measurement is available.

A Request True interrupt to the 73A-541's interrupt handler will alert the handler that the 73A-541 requires service. In a typical system controlled by a system controller over the IEEE-488 interface, the 73A-541's interrupt handler will be located on its commander (for example, the CDS 73A-151 IEEE-488/Resource Manager), and the commander will generate an IEEE-488 Service Request (SRQ) to the system controller. If the system controller then issues a serial poll command to the 73A-541, the 73A-541 will return an eight bit serial poll value of 64 if an interrupt has been generated, or a serial poll value of 0 if the 73A-541 has not generated an interrupt since its interrupt was last serviced.

Example: The command "SR1" enables VXIbus Request True interrupt generation when a measurement from the 73A-541 has completed. The 73A-541's interrupt handler, typically located on the 73A-541's commander, will then service the interrupt. See the manual for the 73A-541's interrupt handler for information on how the handler makes the interrupt status available to the system.

Command: T (Trigger Level Set)

Syntax: cT[s]z

Purpose: The Trigger Level Set commands program a desired trigger level for the A or B input channel.

Description: c selects the channel, A or B.

[s] is an optional + or - sign.

z is a 3-digit decimal integer from 000 to 768 which specifies the desired trigger level voltage. At power-up, z is set to 000.

The range of values permitted depends on which input attenuation is selected by the X command. For X1 attenuation, the trigger level may be set between -256 and +254 (-2.56V and +2.54V). For X3 the trigger level may be set between -768 and +762 (-7.68V and +7.62V). If a value outside the permitted range is issued, an error is indicated.

The value programmed is in volts DC. The actual resolution provided by the module is 0.02V DC in the X1 attenuation mode and 0.06V DC in the X3 attenuation. The module automatically selects the closest available value to the one programmed.

Example: The command sequence "AS0AT+004BS1BT-200" programs the A channel to trigger on a positive-going wave-form exceeding 40mV, and programs the B channel to trigger on a negative-going waveform dropping below -2.00V.

Command: TEST1 (Self Test)

Syntax: TEST1

Purpose: The Self Test command performs a test of the memories and counters on the 73A-541 Module.

Description: The front panel LEDs "ripple" as this test progresses. An input request after this test returns the board type number and the software version number, e.g., "541,V2.6".

If the test fails, the board type portion of the response is replaced in the message by the suspect part designator. For example, "541" is replaced with "U24", indicating that the suspected part designator is a bad memory IC on the module. The part designators should be cross referenced using the following table:

Reported Designator	73A-541 Designator
U24	U135
U34	U134
U44	U132
U54	U133

If the module does not report the software version number, the module should be returned to CDS for repair.

Command: U (Auto Search Trigger Level)

Syntax: cU

Purpose: The Auto Search Trigger Level commands automatically set the trigger level of the A or B channel to a point midway between the input-signal peak-to-peak levels.

Description: c selects the channel, A or B.

The U command does a binary search to determine the input-signal peak-to-peak levels. The search typically takes 10 input signal transitions to determine the high and low levels. Execution time for low-frequency inputs should, therefore, be considered. The GU, GM, and GS (Gate Time) commands may be used to set the maximum time the auto-search waits for an event at each level. The auto-search is performed once when the command is issued.

The U command does not automatically change the attenuation programmed if the trigger level found is at the maximum or minimum value. If the input signal level is unknown, the channel should first be programmed for X3 attenuation level before programming an AU or BU command. The resulting trigger level may then be read with an AI or BI (Input Trigger Level) command, and the appropriate attenuation then programmed.

Command: X (Attenuator)

Syntax: cXz

Purpose: The Attenuator command selects either X1 or X3 attenuation for the A or B input channel.

Description: c selects the channel, A or B.

z is the 1-digit decimal integer 1 or 3 which programs the specified input channel for an attenuation of X1 or X3. The power-up default is X1.

If X1 attenuator mode is programmed and the present trigger level for a channel is outside the X1 range, the attenuation does not change and an error is indicated. Attenuator/trigger level conflict errors may be avoided when switching attenuation by having T (Trigger Level Set) commands precede cX1 commands, and by having T commands follow cX3 commands.

Example: "AX3AT400" programs the input attenuation of channel A to X3 and then programs the trigger level for channel A to +4.00 volts.

Command: Y (Time Base Source)

Syntax: Yz

Purpose: The Time Base Source command selects the source for the 10 MHz clock reference as either the VXIbus slot 0 10 MHz ECL clock, an optional on-board 0.5 ppm oven-controlled oscillator, or the 73A-541 front panel EXT CLOCK IN BNC.

Description: z is a one digit decimal number from 0 to 2 which specifies the clock source as follows:

z	Clock Source
0	VXIbus slot 0 10 MHz
1	Optional oven-controlled oscillator
2	73A-541 front panel EXT CLOCK IN BNC

The 10 MHz clock source is used to generate the basic 73A-541 on-board clock signal through a phase locked loop.

If the oven-controlled oscillator or front panel BNC is selected and a clock source is not present, the 73A-541 will operate off a 10 MHz crystal in the phase-locked loop.

The power-up default setting for the clock source is the VXIbus slot 0 clock. If the module is used in a system without a VXIbus slot 0 card, the phase locked loop 10 MHz crystal will be the power-up default clock source.

If no signal is available to the 73A-541 Phase Lock Loop (PLL), the 73A-541 PLL circuit will lock to the lowest frequency of the lock range. The resulting typical accuracy and stability is ±1000 Hz, worst case ±4000 Hz. The purpose of this mode is to maintain communication between the 73A-541 and the VXI interface. It is NOT intended to be an accurate frequency source.

Command: Z (Input Impedance Select)

Syntax: cZz

Purpose: The Input Impedance Select commands select the A or B channel input impedance.

Description: c selects the channel, A or B.

z is the 1-digit integer 0 or 1:

0 specifies 1-megohm input impedance. (default)
1 specifies a 50-ohm input impedance.

- **Timer/Counter Mode Command Descriptions**

Command: EX (Exponent)

Syntax: EXz

Purpose: The Exponent command specifies an uppercase "E" or a lowercase "e" for the exponent character in a returned measurement. The power-up default is "E".

Description: z is the 1-digit decimal integer 0 or 1, defined as follows:

z	Function
0	Return data in ASCII format with an uppercase "E" used for exponential notation. (default)
1	Return data in ASCII format with a lowercase "e" used for exponential notation.

The exponent value range is from +12 to -12.

Example: If a Read Format command of nine significant characters is specified, the format of the measurement returned is as follows:

z	Format
0	1.23456789E±01
1	1.23456789e±01

Command: FN (Function)

Syntax: FNz

Purpose: The Function command specifies the function whose value is to be returned to the system controller when responding to an input request.

Description: z is a 1- or 2-digit decimal integer (1 to 20) that specifies one of the following functions:

z	Function	Measurement Units
1	Frequency A	Hz (default)
2	Frequency B	Hz
3	Event Count A	Events
4	Event Count B	Events
5	Period A	Seconds
6	Period B	Seconds
7	Pulse Width A	Seconds
8	Pulse Width B	Seconds
9	Time Interval B to A	Seconds
10	Time Interval A to B	Seconds
11	Duty Cycle A	%
12	Duty Cycle B	%
13	Period A Average	Seconds
14	Period B Average	Seconds
15	Pulse Width A Average	Seconds
16	Pulse Width B Average	Seconds
17	Time Interval B to A Average	Seconds
18	Time Interval A to B Average	Seconds
19	Duty Cycle A Average	%
20	Duty Cycle B Average	%

These functions are defined as follows:

FN1/FN2 Frequency A or B -
The number of A or B events counted during the measurement cycle divided by the time elapsed during the measurement cycle. Any of the gate commands, except the GP command, may be used to control the length of the measurement cycle for this function.

FN3/FN4 Event Count A or B -
The number of A or B events counted during the measurement cycle. Any of the gate commands, except the GP command, may be used to control the length of the measurement cycle for this function.

FN5/FN6 Period A or Period B -
The time between the first two successive triggers of the channel A or B input. The transition polarity of the triggers is specified by the AS or BS command. These are single measurement functions; the gate commands do not apply.

FN7/FN8 Pulse Width A or B -
The leading portion of the wave form for Period A or B as described above. Measurement time is from a leading edge of the polarity specified by the AS or BS command to the next trailing edge of the opposite polarity. These are single measurement functions; the gate commands do not apply.

FN9 Time Interval B to A -
The time interval starting with the first transition of the channel B input (of the polarity specified by the BS command) and ending with the first transition of the A channel input (of the polarity specified by the AS command) that follows or coincides with the first B transition. This is a single measurement function; the gate commands do not apply. The data is gated for up to 32 A channel events, and put into Time Tag Memory for this measurement. A "-1" measurement may be returned for this function if no B events or too many B events (causing overwriting of the 2048-word memory) occur.

FN10 Time Interval A to B -
The same as Time Interval B to A with the functions of channel A and channel B reversed.

FN11/FN12 Duty Cycle A or B -
Pulse width of channel A or B divided by Period of channel A or B. These are single measurement functions; the gate commands do not apply.

FN13/FN14 Period A or B Average -
The average of the first n occurrences of Period A or Period B measurements, where n is specified by the GP command.

FN15/FN16 Pulse Width A or B Average -
The average during the first n occurrences of Pulse Width A or B measurements, where n is specified by the GP command.

FN17 Time Interval B to A Average -
This measurement averages Time Interval B to A occurrences during the measurement cycle. The number of values averaged depends on the number of occurrences of Time Interval B to A during the first n periods of A. The measurement cycle is defined by arguments of the GP command.

FN18 Time Interval A to B Average -
The same as Time Interval B to A Average with the functions of channel A and channel B reversed.

FN19/FN20 Duty Cycle A or B Average -
Pulse Width A or B average divided by Period A or B average.

Gate Commands

An input timeout is provided for the G (Gate Events) or GE (Gate External) commands so that the 73A-541 Module does not "hang up" on input if the events do not occur or the measurement cycle is not terminated. The last Gate Time command (GU, GM, GS) issued defines the timeout value. An input timeout returns a data value of "-1". The measurement cycle may be terminated with a QM (Stop Measurement) command, or additional input requests can be made until the measurement is complete.

Command: G (Gate Events)

Syntax: Gcz

Purpose: The Gate Events commands specify the length of the measurement cycle as a number of Channel A or Channel B events when measuring Frequency A or B or Count Events A or B.

Description: c selects the channel, A or B.

z is a 10-digit decimal integer from 0000000002 to 4278190080 (or $2^{32} - 2^{24}$) and specifies the duration of the measurement cycle as the number of events of channel A or B. Leading zeroes may be omitted if z is followed by another valid command or a carriage-return <CR>.

The GA or GB command supersedes any active GU, GM, GS or GI commands.

Examples: The string "GM10GA10000GB2100" will cause channel A to gate for 10000 events at the channel A input, and channel B to gate for 2100 events on the channel B input. If either 10000 events do not occur on channel A or 2100 events do not occur on channel B within 10 msec of the trigger, the gate will time out, and reading the 73A-541 Module will yield a "-1", indicating no data available.

Command: GE (Gate External)

Syntax: GEz

Purpose: The Gate External command disables or enables the external-gate input's ability to control the opening of the A and B channel gates.

Description: The external gate source is programmably selected, using the H command, to be either the front panel External Gate BNC, the VXIbus TRIG command, or one of the eight TTLTRG lines.

z is the 1-digit decimal integer 0 or 1 defined as follows:

z	Functions
0	Disables the external gate (default)
1	Enables the external gate

When the external gate is enabled, the JM (Initiate Measurement) command changes from a trigger command to an arm command. The JM command or an input request is required to arm the measurement cycle before an external-gate signal is received. A negative transition on the external-gate input then triggers a measurement. The measurement cycle continues until 1) the time specified by the GU, GM, or GS commands expires and the external-gate signal returns high, 2) the number of events specified by the Gc command occurs and the external-gate signal returns high, or 3) a QM command is issued and the external-gate signal returns high.

Because both the external-gate time and the programmed-gate time must complete to end the measurement cycle, the external-gate input can function either as an external trigger input (by supplying a short external-gate pulse), or as an external gate (by programming a gate time shorter than the external-gate pulse).

Refer to Example 3 in the Programming Examples for an example of the GE command.

Command: GI (Gate Indefinitely)

Syntax: GI

Purpose: The Gate Indefinitely command specifies that the measurement cycle lasts indefinitely until a QM (Stop Measurement) command is issued.

Description: The GI command provides a programmable measurement stop capability for measuring Frequency A or B or Count Events A or B.

The GI command supersedes any active GA, GB, GU, GM, or GS command.

Example: "MM0GIFN01" selects the Timer/Counter mode, programs the gate to last until a QM is received, and programs the module to measure the frequency of the signal on channel A.

The command "JM" starts the measurement. The module counts events on channel A until a "QM" is received, which stops the measurement. Reading the module would yield the number of events recorded during the gate time divided by the time elapsed between the JM and QM commands.

Command: GP (Gate Periods)

Syntax: GPz

Purpose: The Gate Periods command specifies the number of periods for averaging functions FN13 through FN20.

Description: z is a 4-digit decimal integer from 0001 to 1022 that specifies the number of periods of the function to average. Leading zeroes may be omitted if z is followed by another valid command or a carriage-return <CR>; z should be no larger than 511 if both CHA and CHB have similar inputs, to prevent exceeding the memory limit of 2047 total edges for both channels. The power-up default value of z is 100.

The number of periods for the Period Average A or B, Pulse Width Average A or B, and Duty Cycle Average A or B functions is the number of periods for the specified channel (A or B). For Time Interval B to A, the number of periods is the number of channel A periods. For Time Interval A to B, the number of periods is the number of channel B periods.

Examples: "GP300FN19" programs the 73A-541 to gate for 300 periods of the channel A input and measure the average duty cycle of the 300 periods of the channel A input.

Command: GU, GM, and GS (Gate Time)

Syntax: GUz GMz GSz

Purpose: The Gate Time commands specify the length of the measurement cycle in microseconds, milliseconds, or seconds when measuring Frequency A or B, or Count Events A or B.

Description: The character U, M, or S specifies the gate-time units of measure as microseconds, milliseconds, or seconds.

z is a 5-digit decimal integer from 00001 to 99999 that specifies the length of the measurement cycle. The "GS" argument must not exceed 427 seconds. Leading zeroes may be omitted if z is followed by another valid command or a carriage-return <CR>.

A Gate Time command supersedes any active GA, GB, or GI gate command.

The Gate Time is set to one second on power-up.

Example: The character string "GU01300" programs a measurement cycle of 1300 µs or 1.3 ms.

Command: IF (Integer Format)

Syntax: IFz

Purpose: The Integer Format command specifies the largest integer value returned by the 73A-541 Module in commands involving integers.

Description: z is a 2-digit decimal integer from 10 to 32 which defines the largest integer. The largest integer equals the value $2^z - 1$. The power-up default for z is 15.

This command can be used to optimize system controller computation performance for applications with limited event sizes. Returning integer values only allows use of single-precision system controller numeric variables which typically optimizes system controller performance. Both of the Event Count commands are affected by this command. They are FN03 and FN04 for reading Event Count A and B from the 73A-541 Module.

Example: The command string "IF15" sent to the 73A-541 Module allows a maximum event count of 32767 to be returned for Channel A or B.

When the greatest number of events is reached as specified by the IF command, the maximum value specified by the IF command is returned for that channel until the event count exceeds 4,294,967,296, at which time the event counter overflows and returns to a count of zero.

Command: RF (Read Format)

Syntax: RFz

Purpose: The Read Format command specifies the number of significant floating-point digits the module returns when responding to a system controller input request.

Description: z is a 1-digit decimal integer from 1 to 9 that specifies the number of significant digits. The power-up default setting of z is 5.

The format of the measurement returned for the nine values of z is as follows:

z	Format
1	1.E ±01
2	1.2E ±01
3	1.23E ±01
4	1.234E ±01
5	1.2345E ±01 (default)
6	1.23456E ±01
7	1.234567E ±01
8	1.2345678E ±01
9	1.23456789E ±01

The measurement value is followed by a carriage-return and line-feed <CR><LF>.

- **Digitizing Counter Mode Command Descriptions**

Command: B (Beginning Event Number)

Syntax: cBz

Purpose: The Beginning Event Number commands are used in the Post-Processing/ Multifunction sub-mode to define the beginning event number to be read from memory.

Description: c selects the channel, A or B.

z is the 10-digit decimal integer 0000000000 to 4294967295 (or 2^{32} - 1) which specifies the beginning event number. Leading zeroes may be omitted if z is followed by another valid command or a carriage-return <CR>.

If an AB or BB command is not issued before input, the first measurement available in memory is assumed. Any cBz command supersedes all previous cBz commands.

Example: See the example given at the end of the Command Summary section.

Command: BN (Binary/Decimal Format)

Syntax: BNz

Purpose: The Binary/Decimal Format command specifies returning data in ASCII Decimal format or in Binary format. The power-up default is ASCII Decimal format.

Description: z is the 1-digit decimal integer 0 or 1, and specifies the following:

z	Format
0	ASCII Decimal (default)
1	Binary

In both formats, the data returned consists of a function code and a measurement value. A function code of "00" is returned when a Digitizing Counter overwrite occurs, and the measurement value returned is the amount of time elapsed for which data is not available because it has been overwritten.

In the ASCII Decimal format, a function code and measurement value are returned on each input request, separated by a comma and followed by carriage-return and line-feed characters. The function code consists of two digits for the measured parameter. A leading zero is sent for any function code less than 10. The measurement value is in the format specified by the RF, EX, and IF commands.

In the Binary format, the function code is 4 bytes and the measurement value is 4 bytes. No comma separates the two values. The total number of bytes returned is a function of the RB (Read Block) command. The function code is represented as an integer. The measurement value is a 32-bit positive-polarity integer representing the event count or a 32-bit multiple of 100 ns, depending on the parameter. Only functions 03 through 10 are available in the Binary format (see FN command). Other functions will generate an error (see E command).

A block command should be programmed for the 73A-541 Module whenever the Binary format is programmed. The last measurement returned is followed by a carriage-return and a line-feed <CR><LF>. See the RB command for an example of the use of the BN command.

The parameters available and the units of measurement for the ASCII Decimal and Binary formats are as follows:

Function Code	Function	Decimal Units	Binary Units
1. Multifunction Sub-Modes			
00	Missing Data	Seconds	100ns
01	Frequency A	Hz	N/A
02	Frequency B	Hz	N/A
03	Count Events A	Events	Events
04	Count Events B	Events	Events
05	Period A	Seconds	100 ns
06	Period B	Seconds	100 ns
07	Pulse Width A	Seconds	100 ns
08	Pulse Width B	Seconds	100 ns
09	Time Interval B to A	Seconds	100 ns
10	Time Interval A to B	Seconds	100 ns
11	Duty Cycle A	%	N/A
12	Duty Cycle B	%	N/A
99	No more data	Value=0	Value=0
2. Timing Diagram Sub-Modes			
00	Missing Data	Seconds	100 ns
01	A Transition	Seconds	100 ns
02	A Transition, inverted	Seconds	100 ns
04	B Transition	Seconds	100 ns
08	B Transition, inverted	Seconds	100 ns
99	No more data	Value=0	Value=0

See the RB (Read Block) command description for an example using the Binary command.

Command: E (Ending Event Number)

Syntax: cEz

Purpose: The Ending Event Number commands are used in the Post-Processing/ Multifunction sub-mode to define the ending event number to be read from memory.

Description: c selects the channel, A or B.

z is the 10-digit decimal integer 0000000001 to 4294967295 (or 2^{32} - 1) and specifies the ending event number. Leading zeroes may be omitted if z is followed by another valid command or a carriage-return <CR>.

If an AE or BE command is not issued before input, the last measurement available in memory is assumed. The ending event must be either an A or B event, not one of each. However, the beginning event may be a channel A event and the ending event channel B, or vice versa, if desired. An AE or BE command supersedes all previous AE and BE commands.

Example: See the Memory Pointer Commands Example at the end of the Summary section.

Command: EX (Exponent)

Syntax: EXz

Purpose: The Exponent command specifies an uppercase "E" or a lowercase "e" for the exponent character in returned decimal format measurement data. The power-up default is "E".

Description: z is the 1-digit decimal integer 0 or 1 defined as follows:

z	Function
0	Return data in ASCII format with an uppercase "E" used for exponential notation. (default)
1	Return data in ASCII format with a lowercase "e" used for exponential notation.

Example: If a Read Format command of nine significant characters is specified, the format of the measurement returned is as follows:

z	Format
0	05,1.23456789E±01
1	05,1.23456789e±01

Command: F (Function Event)

Syntax: Fc

Purpose: The Function Event commands are special input request commands to allow immediate real-time readback of the A or B event count while a measurement is still in progress.

Description: c selects the channel, A or B.

A single input request immediately following the FA or FB command returns Event Count A or B as a single multi-digit number in ASCII decimal format. An additional input request then reverts back to the last programmed Digitizing Counter input mode.

The greatest value for the event count is defined by the IF (Integer Format) command.

The Function Event command serves several useful purposes in the Digitizing Counter mode.

In the two post-processing modes, no measurement can be read from the card until the entire measurement cycle is complete. The F command allows reading the event count during the measurement cycle to see how the measurement is progressing.

In the two real-time multi-function modes, the number of events may be read back if either FN03 or FN04 is one of the multi-functions programmed. However, if no events have occurred, the reading will time out or return a 'no data available' response (because the time tag memory is empty). Using the Function Event command, the count is read directly from the hardware counter, which permits reading the event count even if no events have occurred. This can be used, for example, as a test to check when counter activity has actually started. A value of 0 will be returned if no events have occurred.

This command is also useful in any of the Digitizing Counter modes as a display update. For example, the command could be issued in the real-time or post-processing modes twice a second to update a display, without having to include the event count in the function list for those modes.

Example: While the 73A-541 Module is digitizing a signal in the real-time mode, an F command can be sent to find out how many events have occurred since the trigger. If the string "FA" is sent to the 73A-541 and then read back, a count from 0 to the maximum integer (set by the IF command) is returned.

Command: FN (Function)

Syntax: FNz

Purpose: The Function command specifies the functions whose values are returned to the system controller in response to input requests.

Description: z is a 2-digit decimal integer from 00 to 12 that specifies the following functions:

z	Function
00	All Functions Off
01	Frequency A
02	Frequency B
03	Event Count A
04	Event Count B
05	Period A (default)
06	Period B
07	Pulse Width A
08	Pulse Width B
09	Time Interval B to A
10	Time Interval A to B
11	Duty Cycle A
12	Duty Cycle B

The FN command only applies to the multifunction sub-modes (real time and post-processing). It does not apply to the timing-diagram sub-modes.

In the multi-function sub-modes (entered with TM0 and TM2 commands), the module can be programmed to return multiple measurement functions when data is requested. Multiple measurement functions are enabled by repeatedly sending FN commands to the module. The command FN00 pre-clears all functions from a multifunction list so that a new list of functions can be specified.

The functions FN01 through FN12 are defined as follows:

FN01/FN02 Frequency A or B -
The reciprocal of Period A or B.

FN03/FN04 Event Count A or B -
Event Count A or B equals the accumulated number of triggers of input A or B, of the polarity specified by the AS or BS command, from the time the measurement cycle starts.

FN05/FN06 Period A or B -
The time between two successive triggers of the channel A or B input. The transition polarity of the triggers is specified by the AS or BS command.

FN07/FN08 Pulse Width A or B -
The leading portion of the wave form for each Period A or Period B measurement time, as described under FN05/FN06, is from the triggered leading edge (of the polarity specified by the AS or BS command) to the trailing edge of the opposite polarity.

FN09 Time Interval B to A -
Time Interval B to A measurements are returned when a transition of the specified slope in channel A occurs, and a B transition of the specified slope for channel B occurs during the period just completed on channel A. The measurement starts with the B transition and ends with the A transition. If multiple transitions of B occur during Period A, the first B transition starts the measurement.

FN10 Time Interval A to B -
The same as Time Interval B to A with the functions of channel A and channel B reversed.

FN11/FN12 Duty Cycle A or B -
Duty cycle A or B is equal to Pulse Width A or B divided by Period A or B.

Example: The command sequence "FN00FN05FN06FN10" first clears the multifunction list, then specifies that Period A, Period B, and Time Interval A to B measurements are to be returned. The format of the data returned for both the binary and ASCII cases is described under the BN command.

Command: G (Gate Events)

Syntax: Gcz

Purpose: The Gate Events commands specify the length of the measurement cycle as a number of A channel or B channel events.

Description: c selects the channel, A or B.

z is a 10-digit decimal integer from 0000000002 to 4278190080 ($2^{32} - 2^{24}$) which specifies the duration of the measurement cycle as a number of events of channel A or B. Leading zeroes of the 10-digit integer may be omitted if z is followed by another valid command or a carriage-return <CR>.

The GA or GB command supersedes any active GU, GM, GS or GI commands.

Example: The string "GA1024GB2048" will cause the 73A-541 Module to gate channel A for 1024 events and gate channel B for 2048 events.

Command: GE (Gate External)

Syntax: GEz

Purpose: The Gate External command disables or enables the external-gate input's ability to control the opening of the A and B channel gates. The external gate source is selected, using the H command, to be either the front panel External Gate BNC, the VXIbus TRIG command, or one of the eight TTLTRG lines.

Description: z is the 1-digit decimal integer 0 or 1 defined as follows:

z	Action
0	Disables the external gate (default)
1	Enables the external gate

When the external gate is enabled, the JM (Initiate Measurement) command changes from a trigger command to an arm command. The JM command must be issued to arm the measurement cycle before an external-gate signal is received. A negative transition on the external-gate input then triggers a measurement. The measurement cycle continues until 1) the time specified by the GU, GM, or GS commands expires and the external-gate signal returns high, 2) the number of events specified by the GA, GB command occurs and the external-gate signal returns high, or 3) a QM command is issued and the external-gate signal returns high.

Because both the external-gate time and the programmed-gate time must complete to end the measurement cycle, the external-gate input can function either as an external trigger (by supplying a short external-gate pulse), or as an external gate (by programming a gate time shorter than the external-gate pulse).

Refer to Example 3 in the Programming Examples for an example of the GE command.

Command: GI (Gate Indefinitely)

Syntax: GI

Purpose: The Gate Indefinitely command specifies that the measurement cycle lasts indefinitely until a QM (Stop Measurement) command is issued.

Description: The GI command allows a measurement cycle to start and stop under program control using the JM (Initiate Measurement) command and the QM (Stop Measurement) command.

The GI command supersedes any active GA, GB, GU, GM, or GS command.

Command: GU, GM, and GS (Gate Time)

Syntax: GUz GMz GSz

Purpose: The Gate Time commands specify the length of the measurement cycle in micro-seconds, milliseconds, or seconds. The character U, M, or S specifies the gate-time units of measure as microseconds, milliseconds, or seconds.

Description: z is a 5-digit decimal integer from 00001 to 99999 that specifies the length of the measurement cycle. The "GS" argument must not exceed 427 seconds. Leading zeroes of the 5-digit integer may be omitted if z is followed by another valid command or a carriage-return <CR>.

A Gate Time command supersedes any active GA, GB, or GI command.

The Gate Time is set to one second on power-up.

Example: The command characters "GU07300" set the gate time to 7300 μs or 7.3 ms.

Command: IF (Integer Format)

Syntax: IFz

Purpose: The Integer Format command specifies the largest integer number returned by the 73A-541 Module in commands involving integer numbers.

Description: All of the event count commands are affected by this command. They are FN03, FN04, FA, and FB, for reading Event Count A and B from the 73A-541 Module, and the Memory Pointer commands returning event counts, ARN/BRN.

z is a 2-digit decimal integer from 10 to 32, and defines the largest integer value to be returned. The largest integer equals the value 2^z - 1. The power-up default value of z is 15.

Example: The command "IF15" sent to the 73A-541 Module allows a maximum event count of 32767 to be returned for Channel A or B and a maximum of 32767 events specified in the Gate Event A or B command.

When the number of events counted is greater than that allowed by the IF command, a value equal to the largest number allowed by the IF command is returned until the event count exceeds 4,294,967,296 at which time the event counter overflows and returns to a count of zero.

Command: R (Read Event Number)

Syntax: cRz

Purpose: The Read Event Number commands are provided in the Post-Processing/ Multifunction sub-mode to determine the beginning or ending event number available in memory for channel A or B. The command is especially useful when the 2048-word memory has been written over.

Description: c selects the channel, A or B.

z is the 1-digit decimal integer 0 or 1 defined as follows:

z	Action
0	Read beginning event number available in memory on next input request.
1	Read ending event number available in memory on next input request.

The value returned for the beginning event number is an integer between 0 and 4294967295 (or 2^{32}-1). The value returned for the ending event number is also an integer between 1 and 2^{32}-1.

See the Memory Pointer Commands at the end of the Summary section for an example of how this command is used.

Command: RB (Read Block)

Syntax: RBz

Purpose: The Read Block command is used in the binary format to specify the number of measurements that are to be blocked into a record.

Description: z represents a 3-digit decimal integer from 001 to 999 and specifies the number of measurements to be blocked into a record. The default value for the RB command is 001. Each complete record is terminated with a carriage-return and a line-feed <CR><LF>.

The total number of bytes returned in a block is:

8 * (number of measurements) + 2

That is, each measurement is represented by 4 bytes of function code plus 4 bytes of binary data with carriage-return and line-feed <CR><LF> characters appended to the block.

Examples: The following example shows a use of the BN and RB commands. The example assumes that a 500 kHz square wave is being measured on Channel A, and that the IEEE-488 Interface Card is not set to terminate reads on an End Of String byte (this is important because if the 73A-541 Module sends a byte of data that is equal to the EOS byte the read will terminate before all of the data has been read by the controller).

MM1TM2GM10

Program the 73A-541 Module to the Digitizing Counter Mode, the Post-Processing Multifunction Sub-Mode, and a 10 msec gate time.

FN00FN05FN07

Clear the Multifunction List and program the 73A-541 to make a Period Channel A and Pulse Width Channel A multifunction measurement.

JM Trigger a measurement.

BN1RB006

Program the 73A-541 Module to return the data in a 6 measurement block of binary data. The binary data is returned as a single block of 6 measurements, or 50 bytes. For example, the data returned might be as follows, where the 50 binary bytes are shown in ASCII hex:

```
00 05 00 14
00 07 00 0A
00 05 00 14
00 07 00 0A
00 05 00 14
00 07 00 0A
0D 0A
```

When the 73A-541 Module is read, this is the data (shown here in hex format) returned from the module:

0 0 0 5 is the first function code returned, Period A.
0 0 1 4 is the number of 100 nsec units of the period, or 2000 nsec.
0 0 0 7 is the second function code returned, Pulse Width A.
0 0 0 A is the number of 100 nsec units of the pulse width, or 1000 nsec.

The two measurements are repeated in the next 32 bytes.

A carriage return (0D) and line feed (0A) terminate the returned data.

Command: RF (Read Format)

Syntax: RFz

Purpose: The Read Format command specifies the number of significant floating-point digits the module returns after the 2-digit function code and comma when responding to a system controller input request.

Description: z is a 1-digit decimal integer from 1 to 9 that specifies the number of significant digits. The power-up default setting of z is 5.

The format of the measurement returned for the nine values of z for a function code of 01 is as follows:

z	Format
1	01,1.E ±01
2	01,1.2E ±01
3	01,1.23E ±01
4	01,1.234E ±01
5	01,1.2345E ±01 (default)
6	01,1.23456E ±01
7	01,1.234567E ±01
8	01,1.2345678E ±01
9	01,1.23456789E ±01

The measurement value is followed by a carriage-return and line-feed <CR><LF>.

Command: RI (Read Time Interval)

Syntax: RI

Purpose: The Read Time Interval command is used in the Post-Processing Multifunction mode to determine the amount of elapsed time between the beginning and ending event numbers specified for memory readback at the time the last Post-Processing/Multi-function measurement was completed.

Description: The first input request after the RI command is issued returns the time elapsed between the most recently specified A or B beginning event number and the most recently specified A or B ending event number.

If no events as specified by the AB, BB, AE, and BE commands are available in the current contents of memory, or if the ending event number occurs before the beginning event number, a "-1" is returned.

Example: See the Memory Pointer Command Example at the end of the Summary section for an example of how this command is used.

Command: RN (Read Number of Measurements)

Syntax: RN

Purpose: The Read Number of Measurements command is provided in the Post-Processing/Multifunction sub-mode to specify the number of measurements that are returned.

The first input request issued following an RN command returns the number of measurements to be returned resulting from the AB, AE, BB, and BE commands. If no events specified by AB, AE, BB, and BE are available in the current contents of memory, or if the specified ending event number occurs before the beginning event number, a "0" is returned.

The measurements counted include all functions in the active multifunction list that are either concurrent with the specified beginning or ending event number or between the two events at the time the last Post-Processing/Multifunction measurement was completed.

Example: See the Memory Pointer Command Example at the end of the Summary section for an example of how this command is used.

Command: TM (Digitizing Counter Mode)

Syntax: TMz

Purpose: The Digitizing Counter Mode command specifies one of the four sub-modes of processing input data collected in the Digitizing Counter mode.

Description: z is a 1-digit decimal integer from 0 to 3 which specifies the following:

z	Sub-Mode
0	Real-Time/Multifunction (default)
1	Real-Time/Timing Diagram
2	Post-Processing/Multifunction
3	Post-Processing/Timing Diagram

Each of the four sub-modes is described below. The power-up default states, which apply if the Digitizing Counter mode is selected immediately after power-up, are as follows:

Real-Time Multifuction sub-modes:
On input, period A measurements (FN05) are returned.

Post-Processing sub-modes:
AB, BB, AE, and BE commands default to the first and last measurements available in memory at the end of the measurement cycle.

Following the description of the Real-Time/Timing Diagram sub-mode is additional information that can be applied to both the Real-Time/ Multifunction and Real-Time/Timing Diagram modes. See Example 2 in the Programming Examples for an example of the TM command.

Real-Time/Multifunction Sub-Mode

The Real-Time/Multifunction sub-mode returns data as it is acquired for all enabled functions. Multiple functions can be enabled in this mode by sending successive FN (Function) commands for each function to be enabled. An FN00 command pre-clears the multifunction list.

The data is returned for this mode as two items for each measurement, starting with the first measurement. The first value returned for each measurement is the 2-digit function code to indicate which of the multiple functions is being returned. The second value returned for each measurement is the measurement value. The format for the values returned is specified by the Read Format commands.

The accessible functions and their availability in the Real-Time/ Multifunction mode are as follows:

Event Count is available when the event occurs.

Period, Frequency, and Duty Cycle are available on the trailing edge of the period.

Pulse Width is available before the period completes at the trailing edge of the first portion of the period waveform.

Time Interval B to A and A to B are available at the trailing edge of the measurement.

In general, measurements are available as soon as it is possible to determine their value. For each input transition, all programmed functions that apply are returned in numerical order, lowest function number first.

Real-Time/Timing Diagram Sub-Mode

The Real-Time/Timing Diagram sub-mode returns the delta time of occurrence of any transition on either channel since the last transition on either channel.

Measurements are returned in the order they occur. Two values are returned for each occurrence. The first value is the function code defined as follows:

00 Missing data - input frequency too high for continuous real-time operation.

01 Channel A, transition polarity specified by AS command.

02 Channel A, transition polarity inverted.

04 Channel B, transition polarity specified by BS command.

08 Channel B, transition polarity inverted.

99 No more data in memory.

The second value returned is the delta time value since the last transition. The time is tagged to the nearest 100-ns increment. If more than one type of transition occurs in the same 100-ns window, the two or more measurements are returned simultaneously by adding their function codes together. For example, a function code of 9 indicates that a function code of 01 and a function code of 08 both occurred on a particular transmission.

The first measurement value returned in the Timing Diagram sub-mode is for the first transition. The measurement value is the time from the start of the measurement cycle to the first transition.

Using The Real-Time Sub-Modes

The Real-Time sub-modes are intended for real-time continuous monitoring of relatively slow signals. Depending on the read format and speed of the user's system controller, it is recommended that these modes be used for applications with less than 100 measurements returned each second. Otherwise, the 2048-location memory may be written over faster than memory is read, resulting in block loss of up to 2048 events. The function code of 00 is provided to indicate when this situation occurs. To avoid overwriting memory, limit the measurement cycle to less than 2048 events, or use the Post-Processing mode instead.

If the measurement cycle is still in progress and input is requested before a measurement is available, the 73A-541 Module holds the system in the input-request state until data is available, the measurement cycle completes, or the time specified in the last gate time command elapses. After the measurement cycle has completed and all measurements have been taken, a function code of 99 and a measurement value of 0 is returned for any additional input requests.

Post-Processing/Multifunction and Post-Processing/Timing Diagram Sub-Modes

The Post-Processing/Multifunction and Post-Processing/Timing Diagram sub-modes are the same as the Real-Time/Multifunction and Real-Time/ Timing Diagram sub-modes with the following two exceptions:

- no data is returned until the measurement cycle is complete.
- if memory has been written over, only data that can be reconstructed from the last 2048 writes to memory can be accessed.

As long as the 73A-541 Module has not been re-triggered, a Post-Processing sub-mode command TM2 or TM3 may be issued to review the data stored in memory by the last measurement cycle. Repeated TM2 or TM3 commands can be issued to look at the same data in a different format for different functions (TM2) or a timing diagram (TM3).

SYSFAIL, SELF TEST, AND INITIALIZATION

The 73A-541 Module monitors the +5V dc, ±24V dc, -5.2V dc, -2V dc, and its own internal ±15V dc supplies continuously.

If all power supplies are valid, on power-up:

1) The SYSFAIL* (VME system-failure) line will never be set active, and the Failed LED will not be lit. If any of the supplies fails, either at power-up or during operation, the SYSFAIL line will be set active and the Failed LED will be lit and remain lit.

2) The module enters the VXIbus PASSED state (ready for normal operation) on power-up if all power supplies are valid.

The default condition of the 73A-541 Module after completion of the power-up self test is as follows:

Mode: Counter/Timer Mode.

Function: Frequency A.

Input: Both channels, trigger slope positive, 1 megohm, DC-coupled, trigger levels at 0V DC, A separate B, both channels enabled, both attenuations X 1.

External Trigger: Disabled.

Interrupt Mode: Disabled.

Read Format: Decimal format, 5 significant digits.

Gate Time: 100 events for time-average functions. 1 second for frequency and event functions. 2 events for other functions.

SYSFAIL* Operation

SYSFAIL* becomes active during power-up, hard or soft reset, self test, or if the module loses any of its power voltages. When the card cage Resource Manager detects SYSFAIL* set, it will attempt to inhibit the line. This will cause the 73A-541 Module to deactivate SYSFAIL* in all cases except when +5 volt power is lost.

PROGRAMMING EXAMPLES

This section contains example programs which demonstrate how the various programmable features of the 73A-541 are used. The examples are written in BASIC using an IBM PC or equivalent computer as the system controller.

- **Definition of BASIC Commands**

The programming examples in this manual are written in Microsoft GW BASIC, using the GW BASIC commands described below. If the programming language you are using does not conform exactly to these definitions, use the command in that language that will give the same result.

Command Result

CALL ENTER (R$, LENGTH%, ADDRESS%, STATUS%)

The CALL ENTER statement inputs data into the string R$ from the IEEE-488 instrument whose decimal primary address is contained in the variable ADDRESS%. Following the input, the variable LENGTH% contains the number of bytes read from the instrument. The variable STATUS% contains the number '0' if the transfer was successful or an '8' if an operating system timeout occurred

in the PC. Prior to using the CALL ENTER statement, the string R$ must be set to a string of spaces whose length is greater than or equal to the maximum number of bytes expected from the 73A-541.

CALL SEND (ADDRESS%, WRT$, STATUS%)

The CALL SEND statement outputs the contents of the string variable WRT$ to the IEEE-488 instrument whose decimal primary address is contained in the variable ADDRESS%. Following the output of data, the variable STATUS% contains a '0' if the transfer was successful and an '8' if an operating timeout occurred in the PC.

END Terminates the program.

FOR/NEXT

Repeats the instructions between the FOR and NEXT statements for a defined number of iterations.

GOSUB n

Runs the subroutine beginning with line n. EX: GOSUB 750 - runs the subroutine beginning on line 750. The end of the subroutine is delineated with a RETURN statement. When the subroutine reaches the RETURN statement, execution will resume on the line following the GOSUB command.

GOTO n

Program branches to line n. EX: GOTO 320 - directs execution to continue at line 320.

IF/THEN

Sets up a conditional (IF/THEN) statement. Used with other commands, such as PRINT or GOTO, so that IF the stated condition is met, THEN the command following is effective. EX: IF I = 3 THEN GOTO 450 - will continue operation at line 450 when the value of variable I is 3.

REM

All characters following the REM command are not executed. REM statements are used for documentation and user instructions. EX: REM **CLOSE ISOLATION RELAYS**

RETURN

Ends a subroutine and returns operation to the line after the last executed GOSUB command.

<CR>

Carriage Return character, decimal 13.

<LF>

Line Feed character, decimal 10.

Programming Examples In BASIC

The following sample BASIC programs show how commands for the 73A-541 might be used. These examples assume that the 73A-541 has logical address 12 and is installed in a VXIbus card cage that is controlled via an IEEE-488 interface from an external system controller, such as an IBM PC or equivalent using a Capital Equipment Corporation IEEE-488 interface. The VXIbus IEEE-488 interface is assumed to have an IEEE-488 primary address of decimal 21 and to have converted the 73A-541 Module's logical address to an IEEE-488 primary address of decimal 12.

The command sequence terminator character <TM> used in the example programs is a line feed character which is appended to output data strings using the BASIC command CHR$(10). That is, DATA# = "....." + CHR$(10).

Following each example, the data returned from the module is shown underlined.

Example 1

The following program for the 73A-541 determines the average duty cycle of a TTL signal for 100 periods of the signal.

```
100 DEF SEG = &HC400
```

Lines 100 through 130 initialize the PC's IEEE-488 interface module as a system controller with an IEEE-488 address of decimal 21.

```
110 INIT = 0 : SEND = 9 : ENTER = 21
120 ADDRESS% = 21 : CONTROL% = 0
130 CALL INIT(ADDRESS%, CONTROL%)
140 ADDR541% = 12
```

Line 140 sets the variable ADDR541% to the decimal IEEE-488 address of the 73A-541 Module.

```
150 CLS
```

Line 150 clears the display screen.

```
200 WRT$ = "MM0APAX3AT+140BD0GP100FN19" + CHR$(13) + CHR$(10)
```

Line 200 sets the 73A-541 as follows:
The "MM0APAX3AT+140BD0" characters program the basic counter/timer mode, presets channel A to the power-up default state, selects X3 attenuation for channel A, with a trigger level of +1.4 volts, and disables channel B. The "GP100FN19" characters program the module for an average duty cycle measurement of 100 periods.

```
210 CALL SEND (ADDR541%, WRT$, STATUS%)
```

Line 210 sends the command string (WRT$) to the 73A-541 Module.

```
220 GOSUB 2000
```

Reading the 73A-541 Module's error status can accomplish two things, first if a programming error was made reading the error status will indicate the type of error made. Second, reading the error status gives the 73A-541 enough time to complete the command just programmed. This is especially important if the module is triggered for measurement immediately following the command string and the 73A-541 microprocessor has not finished setting up the module. Refer to the JM command for more information.

```
230 RD$ = SPACE$(50)
```

Line 230 initializes RD$ to 50 spaces.

```
240 CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
```

Line 240 triggers the measurement by requesting data from the module, and returns the data when the measurement is complete.

```
250 PRINT "DUTY CYCLE: ";RD$;
260 END

2000 WRT$ = "ER" + CHR$(13) + CHR$(10)
2010 CALL SEND (ADDR541%, WRT$, STATUS%)
2020 RD$ = SPACE$(10)
2030 CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
2040 IF VAL(RD$) <> 99 THEN PRINT "ERROR: ";VAL(RD$) : STOP
2050 RETURN
```

If a 50% duty cycle TTL signal (square wave) is applied to the INPUT A BNC the returned data will be: 5.0000E-01

Example 2

The following program provides readings of period, pulse width, and duty cycle of the first five periods of TTL signal in the Time Tag memory mode.

```
100 DEF SEG = &HC400
```

Lines 100 through 130 initialize the PC's IEEE-488 interface card as a system controller with an IEEE-488 address of decimal 21.

```
110 INIT = 0 : SEND = 9 : ENTER = 21
120 ADDRESS% = 21 : CONTROL% = 0
130 CALL INIT(ADDRESS%, CONTROL%)
140 ADDR541% = 12
```

Line 140 sets the variable ADDR541% to the decimal IEEE-488 address of the 73A-541 Module.

```
150 CLS
```

Line 150 clears the display screen.

```
200 WRT$ = "MM1APAX3AT+140BD0TM0FN00FN05FN07FN11" + CHR$(13) + CHR$(10)
```

"MM1" specifies the Time Tag mode, "APAX3AT+140" presets channel A to it's default conditions and sets X3 attenuation and a trigger level of +1.4 volts. "BD0" disables channel B. "TM0FN00" set the Real Time/Multifunction sub-mode and clears the multifunction list. "FN05FN07FN11" specifies that Period, Pulse Width, and Duty Cycle of channel A are to be measured.

```
210 CALL SEND(ADDR541%, WRT$, STATUS%)
220 WRT$ = "GP6RF5" + CHR$(13) + CHR$(10)
```

"GP6" specifies that 6 periods are to be measured. "RF5" specifies that data is to be returned in the format: "01,1.2345E±01" (refer to the RF command for more information).

```
230 CALL SEND(ADDR541%, WRT$, STATUS%)
240 GOSUB 2000
```

Read 541 error status

```
250 WRT$ = "JM" + CHR$(13) + CHR$(10)
260 CALL SEND(ADDR541%, WRT$, STATUS%)
```

Line 260 triggers the measurement.

```
270 PRINT "PULSE WIDTH    PERIOD        DUTY CYCLE"
```

Line 270 prints a data header on the display screen.

```
280 FOR RDGNBR = 1 TO 5
```

Read the measurements of 5 periods.

```
290   RD$ = SPACE$(15)
```

Line 290 initializes RD$ to 15 spaces.

```
300   CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
```

Line 300 reads the first available measurement of a single measured period, the pulse width.

```
310   PRINT MID$(RD$, 4, 10);"      ";
```

Line 310 prints the pulse width.

```
320   CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
```

Line 320 reads in the second available measurement of a single measured period, the period.

```
330   PRINT MID$(RD$, 4, 10);"      ";
```

Line 330 prints the period.

```
340   CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
```
Line 340 reads in the third available measurement of the first period measured, the duty cycle.
```
350   PRINT MID$(RD$, 4, 10)
```
Line 350 prints the duty cycle.
```
360 NEXT RDGNBR
```
Lines 280 through 360 are then repeated four more times to obtain the measurement data for the next four cycles of the input signal.
```
370 END

2000 WRT$ = "ER" + CHR$(13) + CHR$(10)
2010 CALL SEND (ADDR541%, WRT$, STATUS%)
2020 RD$ = SPACE$(10)
2030 CALL ENTER (RD$, LENGTH%, ADDR541%, STATUS%)
2040 IF VAL(RD$) <> 99 THEN PRINT "ERROR: ";VAL(RD$) : STOP
2050 RETURN
```

If this program was run with a repetitive TTL signal applied to the INPUT A BNC having a pulse width of 100 μseconds and a period of 400 μseconds the resulting data would be:

PULSE WIDTH	PERIOD	DUTY CYCLE
1.0000E-04	5.0000E-04	2.0000E-01
1.0000E-04	5.0000E-04	2.0000E-01
1.0000E-04	5.0000E-04	2.0000E-01
1.0000E-04	5.0000E-04	2.0000E-01
1.0000E-04	5.0000E-04	2.0000E-01

Example 3

The following program illustrates the use of VXIbus TTLTRG lines using the 73A-270 VXIbus Pulse/Pattern Generator Module to gate the 73A-541. The 73A-541 will count TTL events at the INPUT A BNC during the gated period.

```
100 DEF SEG = &HC400
```
Lines 100 through 130 initialize the PC's IEEE-488 interface card as a system controller with an IEEE-488 address of 21.
```
110 INIT = 0 : SEND = 9 : ENTER = 21
120 ADDRESS% = 21 : CONTROL% = 0
130 CALL INIT(ADDRESS%, CONTROL%)
140 AD541% = 12 : AD270% = 13
```
Line 140 sets the variables AD541% and AD270% to the decimal IEEE-488 addresses of the 73A-541 and 73A-270 Modules to decimal 12 and 1, respectively.
```
150 CLS
```
Line 150 clears the display screen.
```
200 WRT$ = "0S3R0A1C5005LL08T"
```
Line 200 sets the pattern to be output by the 73A-270 Module. This pattern will be a single high pulse whose duration is 50 milliseconds. This command does not actually cause the pattern to be transmitted. Line 400 does that.
```
210 CALL SEND (AD270%, WRT$, STATUS%)
```

```
230 WRT$ = "MM0APAX3AT+140FN3" + CHR$(13) + CHR$(10)
```
"MM0" set the Timer/Counter mode of the 73A-541 Module. "APAX3AT+140" sets channel A to default conditions, sets input attenuation to X3, and sets the channel A trigger level to +1.4 volts. "FN3" sets the function to Event Counter, Channel A.

```
240 CALL SEND (AD541%, WRT$, STATUS%)
```
Sends the command in the string variable WRT$ to the 73A-541 Module.

```
250 WRT$ = "GE1GM1H88880" + CHR$(13) + CHR$(10)
```
"GE1" sets the gate mode to external gate. "GM1" set the gate time to 1 millisecond. "H88880" sets the external gate source to the VXIbus backplane TTLTRG0 line. This will cause the 73A-541 to gate after a "JM" command (line 350) is received and at the high going edge of the TTLTRG0 line and remain gated until the TTLTRG0 line goes low and the 1 millisecond gate time has elapsed.

```
260 CALL SEND (AD541%, WRT$, STATUS%)
270 WRT$ = "IF20" + CHR$(13) + CHR$(10)
```
"IF20" sets the highest integer value to be returned by the 73A-541 Module to just over 1.04 million (2^{20} - 1). The default is 32767 (2^{15} - 1).

```
280 CALL SEND (AD541%, WRT$, STATUS%)
290 GOSUB 2000
```
Read 541 error status.

```
300 WRT$ = "JM" + CHR$(13) + CHR$(10)
310 CALL SEND (AD541%, WRT$, STATUS%)
```
The 73A-541 is armed for measurement when line 310 is executed.

```
320 GOSUB 3000
```
Pause for about 500 msec.

```
330 WRT$ = "0B" + CHR$(13) + CHR$(10)
```
Triggers the 73A-541 Module to output a single 50 millisecond pulse on the VXIbus TTLTRG0 line.

```
340 CALL SEND (AD270%, WRT$, STATUS%)
350 GOSUB 3000
```
Pause for about 500msec.

```
360 RD$ = SPACE$(20)
```
Initia[illegible]es RD$ to 20 spaces.

```
370 CALL ENTER (RD$, LENGTH%, AD541%, STATUS%)
```
Reads the 73A-541 Module, the data being the number of events that occurred while the TTLTRG0 line was high and the gate time (1 millisecond) had not elapsed.

```
380 PRINT "EVENT COUNT CHANNEL A: ";RD$;
390 WRT$ = "QM" + CHR$(13) + CHR$(10)
400 CALL SEND (AD541%, WRT$, STATUS%)
```
Lines 390 and 400 stop the 73A-541 measurement.

```
410 END


2000 WRT$ = "ER" + CHR$(13) + CHR$(10)
2010 CALL SEND (AD541%, WRT$, STATUS%)
2020 RD$ = SPACE$(10)
2030 CALL ENTER (RD$, LENGTH%, AD541%, STATUS%)
2040 IF VAL(RD$) <> 99 THEN PRINT "ERROR: ";VAL(RD$) : STOP
2050 RETURN
2990 '
3000 T1=TIMER
```

```
3010 WHILE TIMER - T1 < .5 : WEND
          This routine loops for 0.5 seconds at line 3010, then returns.
3020 RETURN
```

If the 73A-541 had a 1MHz TTL square wave applied to the INPUT A BNC when this program was run, the resulting display would be:

50000

Or, due to the timing difference between the 73A-541 clock and the 1 MHz signal:

49999

APPENDIX A - VXIbus OPERATION

The 73A-541 Module is a C size single slot VXIbus Message-Based Word Serial device. It uses the A16, D16 VME interface available on the backplane P1 connector and does not require any A24 or A32 address space. The module is a D16 interrupter.

The 73A-541 Module is neither a VXIbus commander nor VMEbus master, and therefore it does not have a VXIbus Signal register. The 73A-541 is a VXIbus message based servant.

The module supports the Normal Transfer Mode of the VXIbus, using the Write Ready and Read Ready bits of the module's Response register.

A Normal Transfer Mode Read of the 73A-541 Module proceeds as follows:

1. The commander reads the 73A-541's Response register and checks if the Write Ready bit is true. If it is, the commander proceeds to the next step. If not, the commander continues to poll the Write Ready bit until it becomes true.

2. The commander writes the Byte Request command (0DEFFh) to the 73A-541's Data Low register.

3. The commander reads the 73A-541's Response register and checks if the Read Ready bit is true. If it is, the commander proceeds to the next step. If not, the commander continues to poll the Read Ready bit until it becomes true.

4. The commander reads the 73A-541's Data Low register.

A Normal Transfer Mode Write to the 73A-541 Module proceeds as follows:

1. The commander reads the 73A-541's Response register and checks if the Write Ready bit is true. If it is, the commander proceeds to the next step. If not, the commander continues to poll the Write Ready bit until it becomes true.

2. The commander writes the Byte Available command which contains the data (0BCXX or 0BDXX depending on the state of the End bit) to the 73A-541's Data Low register.

The 73A-541 Module has no registers beyond those defined for VXIbus message based devices. All communications with the module are through the Data Low register, the Response register, or the VXIbus interrupt cycle. Any attempt by another module to read or write to any undefined location of the 73A-541's address space may cause incorrect operation of the module.

CAUTION:

If the card cage has other manufacturer's computer boards operating in the role of VXIbus foreign devices, the assertion of BERR* (as defined by the VXIbus Specification) may cause operating problems on these boards.

As with all VXIbus devices, the 73A-541 Module has registers located within a 64 byte block in the A16 address space.

The base address of the 73A-541 device's registers is determined by the device's unique logical address and can be calculated as follows:

Base Address = V * 40H + C000H

where V is the device's logical address as set by the Logical Address switches.

73A-541 Configuration Registers.

Below is a list of the 73A-541 Configuration registers with a complete description of each. In this list, RO = Read Only, WO = Write Only, R = Read, and W = Write. The offset is relative to the module's base address.

REGISTER DEFINITIONS

Register	Address	Type	Value (Bits 15-0)
ID Register	0000H	RO	1011 1111 1111 1100 (BFFCh)
Device Type	0002H	RO	See Device Type definition below
Status	0004H	R	1X11 1111 1111 1111 (BFFFh or FFFFh)
Control	0004H	W	0111 1111 1111 110X (7FFCh or 7FFDh)
Offset	0006H	WO	Not used
Protocol	0008H	RO	1111 1111 1111 1111 (FFFFh)
Response	000AH	RO	Defined by state of the interface
Data High	000CH		Not used
Data Low	000EH	W	See Data Low definition below
Data Low	000EH	R	See Data Low definition below

BIT DEFINITIONS

Register	Bit Location	Bit Usage	73A-541 Value	73A-541 Usage
ID	15-14	Device Class	10	Message Based
	13-12	Address Space	11	A16 only
	11-0	Manufact. ID	1111 1111 1100	Colorado Data Systems
Device Type	15-0	Device Type	1111 1101 1110 0010	Ones comp. of 541
Status	15	A24/32 Active	1	Not used
	14	MODID*	1	MODID line not active
			0	MODID line active
	13-4	Device dependent	11 1111 1111	Not used
	3	Extended*	1	Not used
	2	Passed	1	Always passed
	1-0	Device dependent	11	Not used

BIT DEFINITIONS (continued)

Register	Bit Location	Bit Usage	73A-541 Value	73A-541 Usage
Control	15	A24/32 Enable	1 or 0	Not used
	14-2	Device dependent	111 1111 1111 11	Not used
	1	SYSFAIL Inhibit	1 or 0	Not used
	0	Reset	1	Reset
			0	Not reset
Protocol	15	CMDR*	1	Servant only
	14	Signal Reg.*	1	No Signal Reg.
	13	Master*	1	Slave only
	12	Interrupter	1	Interrupter
	11	FHS*	1	No Fast Handshake capability
	10	Shared Memory*	1	No Shared Memory capability
	9-4	Reserved	11 1111	Not used
	3-0	Device dependent	1111	Not used
Response	15	Defined value of 0	0	Per VXI
	14	Reserved	1	Per VXI
	13	DOR	1	Not used
	12	DIR	1	Not used
	11	ERR*	1	Not used
	10	Read Ready	1 or 0	Indicates that the instrument portion of the module has data available to be read. It is set by the instrument following a "Byte Request" command. It is cleared on a read from the Data Low register or on reset.
	9	Write Ready	1 or 0	Cleared upon receipt of a "Byte Available" command. Set when the instrument is ready to receive a data byte or on reset.
	8	FHS Active*	1	Not used
	7	Locked*	1	Not used
	6-0	Device dependent	111 1111	Not used

Data High - not implemented.

Data Low (read/write)

A write to the Data Low register causes this module to execute some action based on the data written. This section describes some of the commands this module responds to and the results of these commands.

Read Protocol Command:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1

If the Data Low register is read after this command, the contents are as follows:

VXIbus Version Level:
Bit 15
0 VXIbus Version 1.2 device

Device dependent (unused):
Bits 14 13 12 11
1 1 1 1

Reserved:
Bits 10 9 8 7 6 5
1 1 1 1 1 1

Triggered*: (supports trigger command)
Bit 4
0 This module supports the trigger command.

I4*: (supports VXIbus 488.2 Instrument protocol)
Bit 3
1 This module does not support 488.2 protocol.

I*: (supports VXIbus Instrument protocol)
Bit 2
0 This module supports instrument protocol.

ELW*: (supports Extended Longword Serial protocol)
Bit 1
1 This module does not support ELW protocol.

LW*: (supports Longword Serial protocol)
Bit 0
1 This module does not support LW protocol.

73A-541 Interrupts

The 73A-541 will interrupt its commander with the following "events" if it does not recognize a VXIbus Word Serial command:

Unrecognized Command Event:

```
15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
 1  1  1  0  1  1  1  1  <--Logical Address--->
```

This event is generated by this module in response to any command sent to the Data Low register other than the following:

Byte Available Command
Byte Request Command
Begin Normal Operation Command
Clear Command
Read Protocol Command

Request True:

```
15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
 1  1  1  1  1  1  0  1  <--Logical Address--->
```

This event is generated as programmed by the SR command (interrupt enable or disable control).

APPENDIX B - FRONT PANEL INPUT/OUTPUT CONNECTIONS

Six BNC connector jacks on the 73A-541 front panel are used for Input/Output connectors. The Input/Output connectors from top to bottom are labeled on the front panel and supply the following signals:

Signal	Description
CHAN A INPUT	Channel A Counter/Timer Input
CHAN B INPUT	Channel B Counter/Timer Input
GATE INPUT	External Gate Input - TTL-level compatible
TTL A OUT	Channel A TTL Output - Reconditioned Channel A TTL Output
TTL B OUT	Channel B TTL Output - Reconditioned Channel B TTL Output
EXT CLK IN	External Clock Input

These connectors mate with standard BNC cables.

APPENDIX C - VXIbus GLOSSARY

Certain terms used in this manual have very specific meanings in the context of a VXIbus System. A list of these terms is presented below.

Commander

A VXIbus device that has bus master capability and has VXIbus servants under it in the system hierarchy. A commander may be a servant as well.

Fast Handshake

Compared to the Normal Transfer Mode of the VXIbus, the Fast Handshake Transfer Mode reduces the number of VMEbus data transfer cycles by 50%. Upon receipt of a request for data, a fast handshake module is able to return data in less than 20 µs, so that the VXIbus fast handshake protocol can be used by the module's commander. Using fast handshake protocol, data can be written and read without checking the Ready bits in the module's Response register.

Hard Reset

This is the state of the module when the SYSRESET* line is true. While in this state, the module is inactive and its Status and Control registers are cleared. The SYSFAIL* line is driven low, and the Failed LED is lit. In the case of a CDS 73A-IBX card cage, for example, a module hard reset occurs when the card cage is powered-up or the Reset switch on the front panel of the 73A-151 Resource Manager/IEEE-488 Interface Module is depressed.

Interrupt Handler

The module in the VXIbus system that generates the hardware interrupt acknowledge for a particular VME interrupt level. The software interrupt handler may or may not be on the same module as the hardware interrupt handler. In the case of CDS instrument modules, both the hardware and software interrupt handlers reside on the commander module of a given servant module.

Logical Address

A unique 8 bit number which identifies each VXIbus device in a system. It defines the device's A16 register addresses, and indicates the device's commander/servant relationship.

Reset Bit

Bit 0 in the Control register of the module. When set to a one (1) by the module's commander or resource manager, the device is forced into a reset state.

Resource Manager

A message based commander located at logical address 0, which provides configuration management services, including self test, address map configuration, commander/servant mapping, and diagnostic management. In CDS systems, the Resource Manager function is co-located with the VMEbus controller, the slot 0 timing functions, and the system controller interface.

Servant

A VXIbus device that may or may not have bus master capability, that is under control of a commander in the VXIbus system hierarchy. A servant may also be a commander.

Soft Reset

This state is entered when the reset bit in the module's Control Register is set to one (1) by the module's commander. While in this state a device is inactive, interrupts which are pending are unasserted, all pending bus requests are unasserted, and the on-board processor is halted. While in this state the device's VMEbus slave interface is active; however, the device is incapable of responding to any commands other than Reset and SYSFAIL INHIBIT. In the case of a CDS 73A-IBX card cage, for example, a module soft reset occurs when the card cage's 73A-151 Resource Manager/IEEE 488 Interface Module receives a STOP command over the IEEE-488 bus that is addressed to the 73A-541.

SYSFAIL INHIBIT

Bit 1 in the Control register of the module. When set to a one (1) by the VXIbus Resource Manager, the device is disabled from driving the SYSFAIL* line. CDS modules are designed so that the SYSFAIL INHIBIT bit will work under all conditions except when the +5V power is lost.

VXI Commands

These are commands passed from a commander to a servant within the VXIbus environment. A command may or may not be stimulated by an external event. For example, an IEEE-488 Group Execute Trigger will generate a trigger command to all addressed devices. However, a Begin Normal Operations command is generated by the VXIbus resource manager and has no external source.

VXI Events

Events are passed from a servant to a commander. They may be generated by the servant either in response to a command (for example, unrecognized command event) or due to a condition detected in the module (internal error).

VXI Message Based Instrument

An intelligent instrument that implements the defined VXIbus registers and, at a minimum, the word serial protocol. All CDS instruments are message based.

VXI Word Serial Protocol

The simplest required communication protocol supported by Message Based devices in a VXIbus system. It utilizes the A16 communications registers to transfer data using a simple polling handshake method. All CDS instruments implement the word serial protocol.

488-VXIbus Interface

An IEEE-488 to VXIbus Interface Device is a message based device which provides communication between the IEEE-488 bus and VXIbus instruments.

APPENDIX D - PHASE LOCKED LOOP VERIFICATION AND ADJUSTMENT

The 73A-541 uses a Phase Locked Loop (PLL) to generate its internal time base and its microprocessor clock signals. If the PLL is not 'locked', or synchronized, to the time base clock (the VXIbus CLK10 signal, the EXT CLK in signal at the face plate BNC, or, the optional on-board oven oscillator) time measurements made by the 73A-541 will be inaccurate. This is due to the PLL running at its highest frequency, usually much higher than the nominal frequency of 10 MHz. While this will cause inaccurate time measurements, the instrument will still communicate. The PLL can be adjusted so that it will lock to the full range of the VXIbus CLK10 (9.999 MHz to 10.001 MHz). The PLL needs to be adjusted only if it will not lock to this full range of frequencies. The following procedure describes how to verify performance of the PLL and how to adjust the PLL for optimum performance.

Required Test Equipment

The following test equipment is required for verification or adjustment of the 73A-541 Module's PLL:

1. One (1) 4-digit voltmeter (DVM) with a dc accuracy of ±0.05% of reading (HP 3456A or equivalent).

2. One (1) signal generator capable of generating a 1.0 V ptp sine wave from 9.999 MHz to 10.001 MHz into a 10-kOhm load.

3. Two (2) BNC cables.

4. One (1) BNC-to-clip lead adapter.

5. One (1) BNC-to-banana plug adapter.

6. One (1) 73A-850 Extender Module.

6. One (1) oscilloscope and two (2) probes capable of observing simultaneously two 10 MHz TTL signals.

Setup Procedure

Before beginning the PLL verification or adjustment below, the following steps must be performed:

1. Remove the front shield (the shield with adjustment holes) of the 73A-541 Module.

2. Install the 73A-541 Module on the 73A-850 Extender Module.

3. Close the Halt switch on the 73A-541 Module (Halt switch set to ON).

4. Set the generator to output a 1 V ptp, 10 MHz sine wave.

5. Connect a BNC from the generator output to the 73A-541 Module's EXT CLK IN BNC.

6. Connect a BNC cable from the BNC-to-banana plug adapter to the BNC-to-clip lead adapter. Connect the BNC-to-banana plug adapter to the DVM input jacks. Be sure the ground wire ('-' lead) is connected to the DVM's negative input. Set the DVM to measure DC volts.

PLL VERIFICATION

1. Be sure the 73A-541 does not have power applied. Attach channel B of the oscilloscope to U91 pin 11 and channel A to U1052 pin 13. Be sure the probe grounds are connected to the 73A-541 ground (U91 pin 8 and U1052 pin 8 are ground). Set the scope to display TTL signals on both channels simultaneously.

2. Power up the 73A-541 Module.

3. Send the following command to the module:
   Y2

4. Signals should appear on both scope channels. Sync to the signal on scope channel A. The signal on channel B should be in sync with the signal on scope channel A. If they are not in sync, the PLL needs to be adjusted. Proceed to the PLL ADJUSTMENT section.

5. Change the frequency from the generator to 9.999 MHz.

6. The signals on scope channels A and B should remain in sync. If the signals do not remain locked, the PLL needs to be adjusted. Proceed to the PLL ADJUSTMENT section.

7. Change the frequency from the generator to 10.001 MHz.

8. The signals on scope channels A and B should remain in sync. If the signals do not remain locked, the PLL needs to be adjusted. Proceed to the PLL ADJUSTMENT section.

9. Remove power from the 73A-541 Module.

10. Move scope channel B to U91 pin 9. Apply power to the 73A-541 Module.

11. The signals should be in sync and remain synced to each other once the module has been powered up.

12. Repeat steps 10 and 12 five times. If the signals come up in sync all five times, the PLL is working and does not require any adjustment.

PLL ADJUSTMENT

1. Be sure the 73A-541 does not have power applied. Attach channel B of the oscilloscope to U91 pin 11 and channel A to U1052 pin 13. Be sure the probe grounds are grounded to the 73A-541 (U91 pin 8 and U1052 pin 8 are ground). Set the scope to display TTL signals on both channels simultaneously.

2. Locate R81 on the 73A-541. Attach a DVM across R81, the '+' lead toward the face plate, and the '-' lead toward the backplane.

3. Power up the 73A-541 Module.

R81?

4. Adjust R821 so that the DVM reads -1.0 V ±0.05 V.

5. Remove the DVM probes from R81.

6. Set the generator to output a 10 MHz, 1 V ptp sine wave.

7. Send the following command to the module:
   Y2

NOTE: The adjustments in steps 8 through 12 are much easier if the generator is set to sweep in frequency from 9.999 MHz to 10.001 MHz.

8. Slowly adjust C913 so that the signal on scope channel B is in sync with the signal on scope channel A. If the signals will not sync when C913 is adjusted, proceed to step 16.

9. Adjust the generator frequency to 10.001 MHz (minimum).

10. The signals on scope channel A and channel B should remain synced. If the signals do not remain synced, proceed to step 15.

11. Adjust the generator frequency to 9.999 MHz (maximum).

12. The signals on scope channel A and channel B should remain synced. Adjust C913 if necessary. If the signals remain in sync, the PLL is adjusted correctly. Proceed to step 16 if C913 will not bring the PLL into lock.

13. Remove power from the 73A-541. Attach channel B of the oscilloscope to U91 pin 9 and channel A to U1052 pin 13. Be sure the probe grounds are grounded to the 73A-541 (U91 pin 8 and U1052 pin 8 are ground).

14. Power up the 73A-541 Module. After power-up, the two signals on the scope should remain locked. Repeat steps 12 and 13 a few times to ensure the PLL will power up with the PLL locked to the CLK10 signal. If the PLL does not power up in a locked condition, repeat steps 6 through 14.

15. Remove power from the 73A-541 Module, remove the module from the extender, and re-attach the shield.

16. If by adjusting C913 the PLL will not lock throughout the 9.999 MHz to 10.001 MHz range, R821 can be adjusted. R821 should not be adjusted so that the voltage across R81, as measured in step 2, is less than -0.5 V or greater than -3.0 V.

APPENDIX E - CALIBRATION

The 73A-541 Module must be calibrated every 12 months in order for the module to meet its published accuracy specifications. Calibrate the 73A-541 Module at the temperature at which it will be operating. If this is not feasible, or the module will be operating under a wide temperature variation, consult the temperature drift specifications. Allow a ten minute warm-up period before performing the calibration.

Required Test Equipment

The following test equipment is required for calibrating the 73A-541 Module:

1. One (1) 4-digit voltmeter (DVM) with a dc accuracy of ±0.05% of reading.

2. One (1) signal generator capable of generating a 1 KHz triangular waveform of 1.0 V ptp with a dc offset of up to +2.5 V into a 50-Ohm load. The generator must also be capable of outputting a 5 MHz (±0.1 ppm) sine wave at 10.0 V ptp into a 50-Ohm load. equivalent).

3. Three (3) BNC cables.

4. Two (2) BNC-to-clip lead adapters.

5. One (1) BNC "T" connector.

6. One (1) BNC-to-banana plug adapter.

7. One (1) 73A-850 Extender Module.

Setup Procedure

Before beginning the calibration procedure below, the following steps must be performed:

1. Install the 73A-541 Module on the 73A-850 Extender Module.

2. Close the Halt switch on the 73A-541 Module (Halt switch is set to ON).

3. Set the CAL switch to C2.

4. Connect a BNC cable from the signal generator to a BNC "T" connector and connect the BNC "T" connector to the INPUT A BNC on the 73A-541 Module.

5. Connect a BNC cable from the TTL OUT A BNC on the 73A-541 Module to the BNC-to-banana adapter and connect the adapter to the DVM. Be sure the 73A-541 ground is connected to the DVM's negative input.

Calibration Procedure

Eight potentiometers and two variable capacitors are adjusted during this procedure. See the assembly drawing in the 73A-541 Module's service manual for the locations of the potentiometers and capacitors on the module.

Allow a ten minute warm-up period before performing the calibration. Then perform each of the following steps in the order given:

1. Send the following command to the 73A-541 Module:
   AT-256BT-256

2. Adjust the TRIGGER LEVEL pot (R311) so that the sum of the voltages at TTL OUT A and TTL OUT B is -5.12 V ±0.020V. (The BNC "T" cable will have to be moved from the TTL OUT A BNC to the TTL OUT B BNC as needed. Be sure the CAL switch is at the CAL position.) Record the adjusted voltage values of TTL OUT A and TTL OUT B as VA and VB, respectively.

3. Send the following command to the module:
   AT254BT254

4. Move the BNC "T" connector to the TTL OUT A BNC.

5. Adjust the BIPOLAR GAIN A pot (R232) so that the voltage at the TTL OUT A BNC is:

   [(-VA X 2.54) / 2.56] ±0.001 V (approximately + 2.54 V)

6. Move the BNC "T" connector to the TTL OUT B BNC.

7. Adjust the BIPOLAR GAIN B pot (R239) so that the voltage at the TTL OUT B BNC is:

   [(-VB X 2.54) / 2.56] ±0.001 V (approximately + 2.54 V)

8. Send the following command to the module:
   AT+000BT+000GP300AZ1AD1BD0CS0FN19

9. Move the BNC cable from the TTLOUT B BNC to the BNC "T" connector at the INPUT A BNC on the 73A-541 Module.

10. Set the signal generator to output a 10.0-kHz triangular waveform with 1.0 V ptp and an offset of 0.0 V.

11. Measure the actual offset voltage of the signal with the DVM, and record the measured offset voltage as VO.

12. Continuously request input from the 73A-541 and display the average duty cycle reading from the module [it should be about 50% (5.000E-1)].

13. Adjust the CH A OFFSET pot (R225) until the reading is
    (0.5 - VO) ±0.001.

14. Send the following command to the module:
    BZ1BD1AD0FN20

15. Move the BNC "T" connector with cables to the INPUT B BNC.

16. Continuously input and display the average duty cycle reading from the 73A-541 Module as in step 12.

17. Adjust the CH B OFFSET pot (R524) until the reading is
    (0.5 - VO) ±0.001.

18. Send the following command to the module:
    AD1BD0FN19

19. Move the BNC "T" connector with cables to the INPUT A BNC.

20. Send the following command to the module:
    AT+250BT+250

21. Set the signal generator to output a 10.0 KHz triangular waveform with 1.0 V ptp and an offset of +2.5 V.

22. Measure the actual offset voltage of the signal with the DVM, and record the measured offset voltage as VO.

23. Continuously input and display the average duty cycle reading from the 73A-541 Module and record (2.5 - VO + reading) as Y.

24. Send the following command to the module:
    AT-250BT-250

25. Set the signal generator to output a 10.0-kHz, triangular waveform with 1.0 V ptp and an offset of -2.5 V.

26. Measure the actual offset voltage of the signal with the DVM, and record the measured offset voltage as VO.

27. Continuously input and display the average duty cycle reading from the 73A-541 module and record (2.5 + VO + reading) as X.

28. Adjust the CH A GAIN pot (R032) and repeat steps 20 - 27 until X - Y = 0.0 ±0.002.

NOTE: If R032 is adjusted fully CCW the X-Y result will become erratic. If this happens, turn R032 CW until the X-Y becomes stable.

NOTE: A procedure programmed to automatically send the messages, change the offset voltage, reprogram the trigger voltages, input the duty cycle reading, and display (X - Y) can make this adjustment much easier because R032 would then only need to be adjusted until the display goes to 0.0 ±0.002.

29. Send the following command to the module:
    AD0BD1FN20

30. Move the signal generator's output and DVM's input to the INPUT B BNC.

31. Continuously input and display the average duty cycle reading from the 73A-541 Module and record (2.5 - VO + reading) as X.

32. Adjust the CH B GAIN pot (R531) and repeat steps 20 - 27 until X - Y = 0.0 ±0.002.

NOTE: If R531 is adjusted fully CCW the X-Y result will become erratic. If this happens, turn R531 CW until the X-Y becomes stable.

33. Send the following command to the module:
    CS1

34. Move the signal generator's output and DVM's input to the INPUT A BNC.

35. Continuously input and display the average duty cycle reading from the 73A-541 Module and record (2.5 - VO + reading) as X.

36. Adjust the A COM B GAIN pot (R63) and repeat steps 20 - 27 until X - Y = 0.0 ±0.002.

NOTE: If R63 is adjusted fully CCW the X-Y result will become erratic. If this happens, turn R63 CW until the X-Y becomes stable.

37. Send the following command to the module:
    CS0GM10FN01AX3BX3AD1BD0

38. Set the signal generator to output a 1-kHz, sine wave with 10.0 V ptp and an offset of 0.0 V.

39. Send the following command to the module:
    AUAI+

40. Input the positive (+) peak level from the 73A-541 Module, and record the reading as U.

41. Send the following command to the module:
    AUAI-

42. Input the (-) peak level from the 73A-541 Module, and record the reading as V.

NOTE: A procedure programmed to automatically perform steps 39-42 can make the following adjustments easier.

43. Set the signal generator to output a 100 KHz sine wave with 10.0 V ptp and an offset of 0.0 V and record U - V as W.

44. Repeat steps 39-41 while adjusting the FREQ RESPONSE A cap (C111) until U - V = W ±0.07 v.

45. Send the following command to the module:
    AD0BD1FN02RF9GM10

46. Set the signal generator to output a 1-KHz sine wave with 10.0 V ptp and an offset of 0.0 V.

47. Send the following command to the module:
    BUBI+

48. Input the positive (+) peak level from the 73A-541 Module, and record the reading as U.

49. Send the following command to the module:
    BUBI-

50. Input the positive (+) peak level from the 73A-541 Module, and record the reading as V.

NOTE: A procedure programmed to automatically perform steps 47-49 can make the following adjustments easier.

51. Set the signal generator to output a 100-KHz sine wave with 10.0 V ptp and an offset of 0.0 V and record U - V as W.

52. Repeat steps 47 through 51 while adjusting the FREQ RESPONSE B cap (C41) until U - V = W ±0.07 v.

If the 73A-541 Module has Option 010 (the 10-MHz Oven Crystal) installed, the following steps should be performed.

1. Set the signal generator to output a 5 MHz (±0.1 ppm) sine wave with 10.0 V ptp and an offset of 0.0 V.

2. Send the following command to the module:
   APAA1AZ1AX3BD0CS0FN1GS3RF9Y1

3. Continuously input and display the 73A-541 Module's frequency reading, and adjust the OPT 010 FREQ ADJ screw to read exactly 5 MHz for at least 10 consecutive readings. Each reading will take about 3 seconds.

Disconnect the test equipment from the 73A-541, power down the system, and move the CAL switch to position C1.

Appendix F
User Service

This appendix contains service-related information that covers the following topics:

- Preventive maintenance
- User-replaceable Parts

Preventive Maintenance

You should perform inspection and cleaning as preventive maintenance. Preventive maintenance, when done regularly, may prevent malfunction and enhance reliability. inspect and clean the module as often as conditions require by following these steps:

1. Turn off power and remove the module from the VXIbus mainframe.
2. Remove loose dust on the outside of the instrument with a lint-free cloth.
3. Remove any remaining dirt with lint-free cloth dampened in a general purpose detergent-and-water solution. Do not use abrasive cleaners.

User-Replaceable Parts

Replacement parts are available through your local Tektronix field office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available. Therefore, when ordering parts, it is important to include the following information in your order.

- Part number
- Instrument type or model number
- Instrument serial number
- Instrument modification number, if applicable.

User-Replaceable Parts

Part Description	Part Number
User Manual	070-9137-XX
Label, Tek CDS	950-4525-00
Label, VXI	950-4524-00
Fuse, Micro 4 Amp 125 V Fast	159-0374-00
Fuse, Micro 2 Amp 125 V Fast	159-0128-00
Fuse, Micro 1 Amp 125 Fast	159-0116-00
Collar Screw, Metric 2.5 × 11 Slotted	950-0952-00
Shield, Front	950-4759-00
Screw, Phillips Metric 2.5 × 4 FLHD SS	211-0867-00

Appendix G
Option 10

Option 10 adds an oven controlled oscillator

Frequency: 10 MHz

Stability: $<0.5 \times 10^{6}$, 0° C to 70° C

Acuracy: Can be set to 0.1 ppm

Aging Rate: 2×10^{6} first 6 months. $<1 \times 10^{6}$ for life.

Warm-up Time: <1 minute.