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53A-541 UNIVERSAL DIGITIZING COUNTER CARD WITH TIME TAG MEMORY

OPERATING MANUAL

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Printed in U.S.A.

	541SA1	541SA2
07/22/92	8604-03-B	8604-03-B
	through	through
	9105-03-N	8710-03-N

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53A-541 UNIVERSAL DIGITIZING COUNTER CARD

WITH TIME TAG MEMORY

OPERATING MANUAL

DESCRIPTION 1

CONTROLS AND INDICATORS
- Address Select Switch 2
- Power LED 2
- Fuses 2
- Function LEDS and Switches 2

SPECIFICATIONS 4

OPERATION
- Overview 8
- Common Commands 12
- Timer/Counter Mode Commands 17
- Time Tag Memory Mode Commands 23

EXAMPLE PROGRAMS 34

INSTALLATION 38

APPENDIX A
- 53/63 SERIES SYSTEM COMMANDS 39

APPENDIX B
- INPUT/OUTPUT CONNECTIONS 40

APPENDIX C
- ERROR MESSAGES 41

APPENDIX D
- CALIBRATION PROCEDURE 43

53A-541 UNIVERSAL DIGITIZING COUNTER CARD

WITH TIME TAG MEMORY

DESCRIPTION

The 53A-541 Universal Digitizing Counter (UDC) Card with Time Tag Memory is a printed circuit board assembly for use in a CDS 53/63 Series System. Two channels are provided that can measure signals in the sub-Hertz to 10-MHz frequency range. The 53A-541 Card incorporates a universal timer/counter and a digitizing counter into a single instrument operating in two possible modes: the Timer/Counter mode, and the Time Tag Memory mode.

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

The Time Tag Memory mode, consisting of two real-time and two post-processing sub-modes, lets the user analyze an input signal on a cycle to cycle basis. This is accomplished by storing the absolute time of each successive transition of the input waveform in a 28-bit by 2048-word memory. Storing absolute transition times of waveforms lets the user analyze the time-interval relationships between two waveforms, or the frequency, period, pulse width, and duty cycle characteristics of a single waveform from cycle to cycle. The real-time sub-modes allow measurement data to be read "on the fly" without halting the storing of new data. The post-processing sub-modes allow data to be read after the measurement cycle is complete.

There are several different ways to control how long the measurement cycle (or gate duration) lasts. For frequency and event-count functions in the Timer/Counter mode or when using the Time Tag Memory mode, the measurement cycle may be controlled by 1) a specified number of A or B events, 2) by a specified amount of time from 1 microsecond to 427 seconds, 3) by direct program control, or 4) by an external gate. For the averaging functions, the measurement cycle may be specified as the number of occurrences to average. The measurement cycle itself may be triggered under program control or by an external trigger.

Programmable control of input-trigger level, slope polarity, attenuation, AC or DC coupling, and input-signal enable is provided for both channels. The input-signal enable control allows the time tag memory to be used more efficiently in single channel applications. Two different methods of trigger-level programming are provided for each channel: either a programmable level or an automatic trigger-level search. The automatic trigger-level setting may be read back. Finally, a programmable A common B capability allows the A channel signal to be input to both counter channels simultaneously.

Commands are sent to the card as ASCII character strings. Data is returned 1) as an ASCII character string containing up to nine significant digits, decimal point, and an exponent, or 2) 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.

Seven 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.

Four LEDs at the front edge of the card visually indicate A-and-B channel triggering, gate status, and programming errors.

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-541 Card's operating environment.

Address Select Switch

The 53A-541 Card has a miniature 10-position switch which selects the 53A-541 Card's address (0-9) in the 53/63 Series System. Open the switch's cover and use a screwdriver with a narrow, flat blade to turn the cam-action wiper to the desired position.

Power LED

The Power LED provides a valuable diagnostic tool by giving the system programmer a visual indication of the action which the system is currently taking. Whenever the 53A-541 Card is addressed by the system controller, the Power LED goes out. The LED remains out until another function card is addressed. Since only one function card can be addressed at a time, an unlit Power LED indicates the function card with which the system controller is currently communicating. The Power LED being lit not only indicates that the 53A-541 Card is unaddressed, but that all required DC power (5V DC, +15V DC, and -15V DC) is being supplied.

Fuses

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

Function LEDS and Switches

Trigger LEDs

The two LEDs labeled TR A and TR 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 receiv by the 53A-541 Card. The Error LED, once lit, will remain lit until an ER command is received by the card, or until an MM (Measurement Mode) command, a "@XH" command, or a STOP command resets the card to its power-up conditions.

Halt Switch

This two-position slide switch is located near the card's backplane edge connector. It selects the state of the 53A-541 Card after an @XH (Halt) or STOP command is received by the 53/63 Series System.

a. If the Halt Switch is in the ON position, then the 53A-541 Card is reset to its power-up state, all parameters are reset to their default values, and the Power LED is lit.

b. If the Halt Switch is in the OFF position, then the 53A-541 Card becomes unaddressed, the Power LED is lit, and any programmed parameters of the card remain unchanged.

SPECIFICATIONS

General

No. of Input Channels:	2
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. Time Tag Memory Mode - Frequency, Period, Pulse Width, Time Interval, Event Count, Duty Cycle.
Data Returned As:	Programmable for: Floating-point decimal with exponent (ASCII String) - no. of digits 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 center point of 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.

Power-up Condition

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.

Timer/Counter Mode

Frequency

Range: 0.0025 Hz to 10 MHz

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

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:	$\frac{\text{Pulse width}}{\text{Period}} \pm \frac{\text{Pulse width} \pm \text{Gate error*}}{\text{Period} - \text{Gate error*}} \times 100\%$

Time Average Functions

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

Digitizing 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

Frequency:	20 MHz.
Accuracy:	can be set to ±0.1 ppm.
Aging Rate:	<1 x 10^{-7}/month, 1 ppm/year max. @ 25°C
Stability:	<4 X 10^{-8}, 0 to 50°C.

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

Power-Up: The 53A-541 Card 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.

Power Requirements (+5V DC): 5V and ±15V dc power is provided by the Power Supply in the 53/63 Series Card Cage.

Voltage (5-volt Supply):	4.75 V dc to 5.25 V dc.
Current (5-volt Supply):	1.6 A, maximum quiescent. 1.8 A, peak.
Voltage (±15-volt Supplies):	+14.5 V dc to +15.5 V dc. -14.5 V dc to -15.5 V dc.
Current (+15-volt Supplies):	0.045 A, maximum quiescent. 0.055 A, peak.

Current (-15-volt Supplies):	0.075 A, maximum quiescent. 0.090 A, peak.
Cooling:	Provided by the fan in the 53/63 Card Cage.
Temperature:	-10°C to +65°C, operating (assumes ambient temperature of 55° and airflow to assure less than 10°C temperature rise). -40°C to +85°C, storage.
Humidity:	Less than 95% R.H. non-condensing, -10°C to +30°C. Less than 75% R.H. non-condensing, +31°C to +40°C. Less than 45% R.H. non-condensing, +41°C to +55°C.
Dimensions:	197mm high, 221mm deep, 21mm wide. (7.75" X 8.69" X 0.8")
Dimensions, Shipping:	When ordered with a 53/63 Card Cage, this card is installed in one of the card cage's function-card slots. When ordered alone, the shipping dimensions are: 254mm X 254mm X 127mm (10" X 10" X 5")
Weight:	0.69 kg. (1.5 lbs.)
Weight, Shipping:	When ordered with a 53/63 Card Cage, this card is installed in one of the card cage's function-card slots. When ordered alone, the shipping weight is: 1.50 kg. (3.3 lbs.)
Mounting Position:	Any orientation.
Mounting Location:	Installs in any function card slot of the 53/63 Card Cage.
Input/Output Connections:	SMB snap-on connectors. Two SMB-to-BNC male adapter cables supplied.
Equipment Supplied:	1 - 53A-541 Universal Digitizing Counter Card. 2 - 53A-729 SMB-to-BNC male adapter cables. 1 - Spare fuse (Part #42202-52003). 1 - Spare fuse (Part #42202-52001). 1 - Operating Manual (Part #00000-15410). 1 - Service Manual (Part #00000-25410).
Software Version:	V2.9.

OPERATION

Overview

The 54A-541 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-541 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane.

To address a function card for the first time, the system command @XY must be issued. X is the card cage address (0-9) selected on the 53A-171 Control Card in the addressed card cage; Y is the 53A-541 Card's address (0-9) within the addressed card cage. The 53A-541 Card's address is selected using the card's Address Select switch. Once a function card is addressed, it remains addressed until the system receives another @ character. Appendix A fully discusses the @XY command and the other 53/63 Series system commands. After the 53A-541 Card is addressed, the commands listed below may be issued until another function card is addressed.

Upper and lower case ASCII characters may be used interchangeably with the exception of the 'J' and 'Q' characters of the 'JM and 'QM' commands which are decoded by the backplane hardware directly. More than one command to the 53A-541 Card may be entered on a line by simply stringing the commands together; they are scanned and acted on in left-to-right order. Spaces, null characters, commas, periods, colons, and semi-colons may be inserted between commands or command arguments without affecting how the card operates. Carriage-returns <CR> and line-feeds <LF> may be optionally inserted between commands. Command arguments that have leading zeroes may be transmitted without the leading zeroes with the following consideration: the command will not be executed by the 53A-541 Card until another command or a carriage-return <CR> is sent to the card.

The 53A-541 Card provides two basic modes of operation, the Timer/Counter mode and the Time Tag Memory 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 Time Tag Memory mode has four sub-modes to provide for real-time versus post-processing, and multifunction versus timing-diagram output. Also, in the Post-Processing/ Multifunction sub-mode, a set of memory-pointer commands is provided to help use the time tag memory.

Tables I - III summarize the common commands, the Timer/Counter mode commands, and the Time Tag Memory mode commands.

Following the tables is a detailed description of each of the commands. These descriptions are also divided into three major sections: 1) Timer/Counter Mode and Time Tag Memory Mode Common Commands, 2) Timer/Counter Mode Commands, and 3) Time Tag Memory Mode Commands.

TABLE I - COMMON COMMANDS

Command Type	Command	Page No.	Description
Measurement Mode	*MM0	12	Select Basic Timer/Counter Mode
	MM1		Select Time Tag Memory Mode
Channel	*AA0	13	Coupling A DC
	AA1		Coupling A AC
	*BA0	13	Coupling B DC
	BA1		Coupling B AC
	*AS0	13	Set Trigger Slope A to Positive
	AS1		Set Trigger Slope A to Negative
	*BS0	13	Set Trigger Slope B to Positive
	BS1		Set Trigger Slope B to Negative
	*CS0	13	A Separate B
	CS1		A Common B
	AD0	13	Disable A Input
	*AD1		Enable A Input
	BD0	13	Disable B Input
	*BD1		Enable B Input
	*AX1	13	Set Attenuator A to X1
	AX3		Set Attenuator A to X3
	*BX1	13	Set Attenuator B to X1
	BX3		Set Attenuator B to X3
	*ATn(*n=0)	13	Set Trigger Level A to n VDC
	*BTn(*n=0)		Set Trigger Level B to n VDC
	AU	14	Auto-Search for A Trigger Level
	BU		Auto-Search for B Trigger Level
	AI+	14	Input + Peak Level A
	AI		Input Trigger Level A
	AI-		Input - Peak Level A
	BI+	14	Input + Peak Level B
	BI		Input Trigger Level B
	BI-		Input - Peak Level B
	*AP	14	Preset Channel A Setup Commands to Power-Up State
	*BP		Preset Channel B Setup Commands to Power-Up State
	*AZ	15	Channel A 1 Megohm Input Impedance
	AZ1		Channel A 50 Ohm Input Impedance
	*BZ	15	Channel B 1 Megohm Input Impedance
	BZ1		Channel B 50 Ohm Input Impedance
Trigger	JM	15	Initiate Measurement Cycle
	QM		Stop Measurement Cycle
Interrupt Capability	*SR0	16	Disable Interrupt/Service Request Capability
	SR1		Enable Interrupt/Service Request Capability
Error	ER	16	Read Error Code
Self-test	TEST1	16	Self-test and read software version number

* Power-up default setting.

TABLE II - TIMER/COUNTER MODE COMMANDS

Command Type	Command	Page No.	Description
Function	*FN01	17	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		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
Gate	GAn	19	Gate for n Channel A Events
	GBn		Gate for n Channel B Events
	GUn	19	Gate for n Microseconds
	GMn		Gate for n Milliseconds
	*GSn		Gate for n Seconds (*n=1)
	GI	20	Gate Indefinitely
	GPn	20	Gate for n Periods for Averaging (*n=100)
External Gate	*GE0	20	Disable External Gate
	GE1		Enable External Gate
Format	*RFn(*n=5)	21	Define No. of Digits, Real Number
	*EX0	21	Define Exponent Character - Uppercase "E"
	EX1		Define Exponent Character - Lowercase "e"
	*IFn(*n=15)	22	Define Largest Integer Number

* Power-up default setting.

TABLE III - TIME TAG MEMORY MODE COMMANDS

Command Type	Command	Page No.	Description
Function	FN00	23	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
Function Event	FA	24	Event Count A Immediate
	FB		Event Count B Immediate
Gate	GAn	24	Gate for n Channel A Events
	GBn		Gate for n Channel B Events
	GUn		Gate for n Microseconds
	GMn		Gate for n Milliseconds
	*GSn(*n=1)		Gate for n Seconds
	GI		Gate Indefinitely
External Gate	*GE0	25	Disable External Gate
	GE1		Enable External Gate
Time Tag Memory Mode			
	*TM0	26	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
Memory Pointer Commands			
	AR0	28	Read Channel A Beginning Event No.
	BR0		Read Channel B Beginning Event No.
	AR1		Read Channel A Ending Event No.
	BR1		Read Channel B Ending Event No.
	ABn	29	Define Channel A Beginning Event No.
	BBn		Define Channel B Beginning Event No.
	AEn	29	Define Channel A Ending Event No.
	BEn		Define Channel B Ending Event No.
	RN	29	Read No. of Measurements to be Returned
	RI		Read Time Interval
Read Format	*RFn(*n=5)	30	Define No. of Digits, Real Number
	EX0	31	Define Exponent Character - Uppercase "E"
	EX1		Define Exponent Character - Lowercase "e"
	*IFn(*n=15)	31	Define Largest Integer Number
	*BN0	31	ASCII Format
	BN1		Binary Format
	*RBn(*n=1)	33	Block n Binary Measurements for Return of Data

*Power-up default setting.

Commands common to Timer/Counter Mode And Time Tag Memory Mode

MM

The MM (Measurement Mode) command specifies the basic Timer/Counter mode or the Time Tag Memory mode for the 53A-541 Card.

Syntax: MMZ

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

Z	Measurement Mode
0	Basic Timer/Counter mode
1	Time Tag Memory mode

In the basic Timer/Counter mode, the 53A-541 Card, when triggered to start a measurement, measures the input signal and returns a single measurement value specified by the Function command. The measurement is returned in response to an input request when the measurement is complete. An input request automatically triggers a measurement if a trigger hasn't been issued.

In the Time Tag Memory Modes, 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 Time Tag Memory data.

In the Time Tag Memory mode, commands can generally be issued "on the fly" (while measurement 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, because input messages are sometimes processed early and are already waiting in a buffer to speed data transfers.

The power-up default states, which apply if the Time Tag Memory 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.

Channel Commands

AAZ/BAZ

The AA and BA (Coupling Select) commands specify AC or DC input coupling for the A or B input channel.

"Z" is the 1-digit integer 0 or 1. "0" specifies DC coupling. "1" specifies AC coupling.

ASZ/BSZ

The AS and BS (Slope Select) commands specify a positive or negative trigger slope for the A or B input channel.

"Z" is the 1-digit integer 0 or 1. 0 specifies a positive slope. 1 specifies a negative slope.

CSZ

The CS (A Common/Separate B) command optionally selects the A input to connect to both the A and B input channels.

"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.

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

ADZ/BDZ

The AD and BD (Disable) commands disable the A or B input channel from measurement to protect against noise when looking at a single channel.

Z is the 1-digit integer 0 or 1. "0" disables the input channel. "1" enables the input channel.

AXZ/BXZ

The AX and BX (Attenuator) command selects an X1 or X3 attenuation for the A or B input channel.

"Z" is the 1-digit decimal integer 1 or 3, and programs the specified input channel for an attenuation of 1X or 3X.

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 AT/BT commands precede AX1/BX1 commands, and by having AT/BT commands follow AX3/BX3 commands.

ATn/BTn

The AT and BT (Trigger Level Set) commands program a desired trigger level for the A or B input channel.

"n" is a 3-digit integer (000 to 768) preceded by an optional "+" or "-" sign and specifies the desired trigger level voltage.

The range of values permitted depends on which input attenuation is selected. For X1 attenuation, the trigger level may be set between -256 and +254 (-2.56V and +2.54V). For X3 attenuation, 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 card is 0.02V DC in the X1 attenuation mode and 0.06V DC in the X3 attenuation. The card automatically sets 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 waveform exceeding 40mV and the B channel to trigger on a negative-going waveform dropping below -2.00V.

AU/BU

The AU and BU (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.

The AU and BU commands do a binary search to determine the input-signal peak-to-peak levels. The search typically takes 10 input-event times 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 using the input signal available when the command is issued.

The AU and BU commands do not automatically change the attenuation programmed if the trigger level found is at the maximum or minimum value. A maximum or minimum value is then set for that situation.

AI/BI

The AI and BI (Input Trigger Level) commands read back the trigger level.

A single input request directly after issuing the AI or BI 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 to 7.62 for the X3 attenuation mode. If the AI/BI command is followed by a "+" or a "-", then the value returned is the positive or negative peak voltage found by the last AU/BU command.

AP/BP

The AP and BP (Preset) commands presets the channel-setup parameters for channel A or B to the power-up state.

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	Coupling A DC
AZ0	Set 1-megohm input impedance for A

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 DC
BZ0	Set 1-megohm input impedance for B

AZn/BZn

The AZ and BZ (Input Impedance Select) commands select the A or B input impedance.

"n" is the 1-digit integer 0 or 1. 0 specifies 1-megohm input impedance. 1 specifies a 50-ohm input impedance.

Trigger Commands

JM/QM

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. These commands bypass the on-card microprocessor to open and close the gate within 5 µs from the time when the commands are received by the 53A-541 Card. The JM command is effective immediately only if it is issued after the on-card processor has completed executing all previous commands. 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 cards error buffer. If the measurement data is then requested from the card without clearing the error condition, (see ER command) a value of -1 is returned.

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

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 duration time and can immediately stop the measurement cycle. The QM command is effective immediately unless the Gate External (GE) command is in effect (See GE Command).

Interrupt Capability Command

SRZ

The SR (Interrupt/Service Request Capability) command enables or disables the generating of interrupts. Detecting and handling vectored priority interrupts are described in the 53A-171 Control Card Operating Manual.

"Z" is the 1-digit integer 0 or 1 defined as follows:

Z	Function
0	Disables the generating of interrupts.
1	Generates an interrupt when a measurement is available.

Appendix A further discusses using interrupts in the 53/63 System.

Error Command

ER

The ER (Error) command reads back the error status of the 53A-541 Card and the specific error type.

Errors are generated if the 53A-541 Card is programmed incorrectly. Only the first error detected is returned.

The error code is a 2-digit integer followed by a carriage-return and a line-feed (<CR/LF>) and is be returned in response to an input request immediately following the ER command. The ER command clears the ERR LED and any error conditions.

See appendix C for a list of error codes. Error code 99 indicates no errors.

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

Self Test Command

TEST1

The TEST1 (Self Test) command performs a test of the memories and counters on the 53A-541 Card. The 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,V2.4". If the test fails, the "541" is replaced in the message by the suspect part designator, e.g., "U17,V2.4".

Timer/Counter Mode Commands

Function Commands

FNn

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

"n" is a 2-digit decimal integer (01 to 20) that specifies one of the following functions:

n	Function	Measurement Units
01	Frequency A	Hz
02	Frequency B	Hz
03	Event Count A	Events
04	Event Count B	Events
05	Period A	Seconds
06	Period B	Seconds
07	Pulse Width A	Seconds
08	Pulse Width B	Seconds
09	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	%

Definitions of the above functions are as follows:

FN01/FN02

Frequency A or B - The number of A events 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 how long the measurement cycle is for this function.

FN03/FN04

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

FN05/FN06

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.

FN07/FN08 — Pulse Width A or B - The leading portion of the waveform 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.

FN09 — 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 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 A or B divided by Period 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 periods of Period A or Period B measurements, where n is specified by the GP command (see below).

FN15/FN16 — Pulse Width A or B Average - The average during the first n periods of Pulse Width A or B measurements, where n is specified by the GP command (see below).

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 argument n of the GP command (see below).

FN18 — Time Interval A to B Average - This measurement averages Time Interval A to B occurrences during the measurement cycle. The number of values averaged depends on the number of occurrences of Time

Interval A to B during the first n periods of B. The measurement cycle is defined by argument n of the GP command (see below).

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

Gate Commands

NOTE: An input timeout is provided for the Gate Events, Gate External, or Gate Indefinitely commands (see below) so that the 53A-541 Card does not hang up on input if the events do not occur or the measurement cycle is not terminated. The last Gate Time command (see below) issued defines this 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. (See GEZ command if external gating is used.)

GAn/GBn — The GA and GB (Gate Events) commands specify the length of the measurement cycle as a number of Channel A or Channel B transitions in the direction specified by the last SZ or BSZ command when measuring Frequency A or B or Count Events A or B.

"n" is a 10-digit decimal integer from 0000000002 to 4278190080 (or 2^{32}-2^{24}) and specifies the number of transitions of channel A or B for which the measurement cycle lasts. Leading zeroes may be omitted if "n" 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.

GUn/GMn/GSn — The GU, GM, and GS (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. The character U, M, or S specifies the gate-time units of measure as microseconds, milliseconds, or seconds.

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

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

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

GI

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

GPn

The GP (Gate Periods) command specifies the number of periods for averaging functions FN13 through FN20.

"n" 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 "n" is followed by another valid command or a carriage-return <CR>; "n" should be no larger than 510 if both CHA and CHB have similar inputs to prevent exceeding the memory limit of 2047 total edges for both channels which causes a data value of "-1" to be returned.

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. If "n" is 1022, only one period of channel B can occur during 1022 periods of channel A without overwriting the 2048 word memory; the Time Interval average consists of the average of only one Time Interval value for this case.

External Gate Command

GEZ

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

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

Z	Functions
0	Disables the external gate
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 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 the external-gate time and the programmed-gate time must complete to end the measurement cycle, this allows the external-gate input to function 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).

Read Format Commands

RFn

The RF (Read Format) command specifies the number of significant floating-point digits the card returns when responding to a system controller input request.

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

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

n	Format
1	1.E ±01
2	1.2E ±01
3	1.23E ±01
4	1.234E ±01
5	1.2345E ±01
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>.

EXZ

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

"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.
1	Return data in ASCII format with a lowercase "e" used for exponential notation.

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

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

IFn

The IF (Integer Format) command specifies the largest integer returned by the 53A-541 Card in commands involving integers.

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 53A-541 Card.

"n" is a 2-digit decimal integer from 10 to 32, and defines the largest integer. The largest integer equals the value 2^n-1. The power-up default for "n" is 15.

Example:
The command string IF15 sent to the 53A-541 Card 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, a value (largest integer) equal to the greatest number of events 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.

Function Command

FNn

The FN (Function) command specifies the functions whose values are returned to the system controller in response to input requests.

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

n	Function
00	All Functions Off
01	Frequency A
02	Frequency B
03	Event Count A
04	Event Count B
05	Period A
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 (Function) command only applies to the multifunction sub-modes (real time and post-processing). It does not apply to the timing-diagram sub-modes.

The All Functions Off command (FN00) is provided to use the multifunction capabilities of the Time Tag Memory mode. The command FN00 pre-clears all functions from a multi-function list so that a new list of functions can be specified.

Example:
The command sequence "FN00FN05FN06FN10" 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.

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 each Period A or Period B 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 A just completed. 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.

Function Event Commands

FA/FB — The FA or FB (Function Event) commands are special input request commands for event count A or B to allow immediate real-time readback of event count A or B anytime.

With the FN03 and FN04 (Event Count) commands, the event count may only be read back after an event occurs.

A single input request immediately following the FA or FB command returns Event Count A or B as a single number in ASCII decimal format. Additional input request then reverts back to the last programmed Time Tag Memory input mode.

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

Gate Commands

NOTE: An input timeout is provided for the Gate Events, Gate External, or Gate Indefinitely commands (see below) so that the 53A-541 Card does not hang up on input if the events do not occur or the measurement cycle is not terminated. The last Gate Time command (see below) issued defines this timeout value. An input timeout returns a data value of "99,0.0000E+00". The measurement cycle may be terminated with a QM (Stop Measurement) command, or additional input requests can be made until the measurement is complete.

GAn/GBn

The GA and GB (Gate Events) commands specify the length of the measurement cycle as a particular number of A channel or B channel transitions in the direction specified by the last ASZ or BSZ command.

"n" is a 10-digit decimal integer from 0000000002 to 4278190080 (2^{32} - 2^{24}) and specifies the number of events of channel A or B for which the measurement cycle lasts. Leading zeroes of the 10-digit integer may be omitted if "n" 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.

GUn/GMn/GSn

The GU, GM, and GS (Gate Time) commands specify, in micro- seconds, milliseconds, or seconds, the length of the measurement cycle. The character U, M, or S specifies the gate-time units of measure as microseconds, milliseconds, or seconds.

"n" 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 "n" is followed by another valid command or a carriage-return (<CR>).

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

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

GI

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

External Gate Command

GEZ

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

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

Z	Action
0	Disables the external gate
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 the external-gate time and the programmed-gate time must complete to end the measurement cycle, this allows the external-gate input to function 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).

Time Tag Memory Mode

TMZ

The TM (Time Tag Memory Mode) command specifies one of the four sub-modes of processing input data collected in the Time Tag Memory mode.

"Z" is the 1-digit decimal integer from 0 to 3 and specifies the following:

Z	Sub-Mode
0	Real-Time/Multifunction
1	Real-Time/Timing Diagram
2	Post-Processing/Multifunction
3	Post-Processing/Timing Diagram

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 various functions in the Real-Time/Multifunction mode are available 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.

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.

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 (input timeout).

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 numbers together, for example, FN09 is equal to FN01 plus FN08.

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, these modes are recommended to 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 where it applies.

If the measurement cycle is still in progress, and input is requested before a measurement is available, the 53A-541 Card holds the 53A/63A 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:

First, no data is returned until the measurement cycle is complete.

Second, 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 53A-541 Card 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, again, for different functions (TM2) or a timing diagram (TM3).

Memory Pointer Commands

The Memory Pointer commands are provided for the Post-Processing/Multifunction sub-mode (TM2) to determine if memory has been overwritten and to find what events are available in memory. A first set of Memory Pointer commands are 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.

ARZ/BRZ — The AR and BR (Read Event Number) commands are provided in the Post-Processing/Multifunction sub-mode (TM2) 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.

"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 an integer between 1 and 2^{32}-1.

ABn/BBn

The AB and BB commands (Beginning Event Number) are used in the Post-Processing/Multifunction sub-mode (TM2) to define the beginning event number to be read from memory.

"n" is the 10-digit decimal integer 0000000000 to 4294967295 (or 2^{32}-1) and specifies the beginning event number. Leading zeroes may be omitted if "n" 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. The beginning event must be either an A or B event, not one of each. An AB or BB command supersedes all previous AB and BB commands.

AEn/BEn

The AE and BE commands (Ending Event Number) are used in the Post-Processing/Multifunction sub-mode (TM2) to define the ending event number to be read from memory.

"n" 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 "n" 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.

RN

The RN (Read Number of Measurements) command is provided in the Post-Processing/Multifunction sub-mode (TM2) to determine 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 TM2, AB, AE, BB, or BE command was completed.

RI

The RI (Read Time Interval) command is used in the Post-Processing Multifunction sub-mode (TM2) to determine the amount of elapsed time between the beginning and ending event numbers specified for memory readback at the time the last TM2, AB, AE, BB or BE command was completed.

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.

Read Format Commands

RFn

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

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

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

n	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
6	01,1.23456 ±E01
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>.

EXZ

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

"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.
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

IFn

The IF (Integer Format) command specifies the largest integer number returned by the 53A-541 Card in commands involving integer numbers.

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 53A-541 Card, and the Memory Pointer commands returning event counts, ARZ/BRZ.

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

Example:
The command "IF15" sent to the 53A-541 Card 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.

BNZ

The BN (Binary) command specifies returning data in ASCII Decimal format or in Binary format. The power-up default is ASCII Decimal format.

"Z" is the 1-digit decimal integer 0 or 1, and specifies the following:

Z	Format
0	ASCII Decimal
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 Time Tag Memory 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. The binary values are returned most significant byte first.

A block command (see RB command) should be programmed for the 53A-541 Card whenever the Binary format is programmed. The last measurement returned is followed by a carriage-return and a line-feed <CR><LF>.

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

RBn

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

"n" represents a 3-digit decimal integer from 001 to 999and 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.

EXAMPLE PROGRAMS

The following program examples are written in XYBASIC for the 53/63 ACX System:

```
10   '53A-541 Universal Digitizing Counter Example Program 1
20   '
30   'Issuing a "JM" (trigger) command too soon after any setup command
40   'results in an error code 78 and the trigger is aborted.
50   'This program demonstrates using the "ER" command to avoid this error.
60   'Reading the error number after setup commands insures that those commands
70   'are processed before triggering a measurement
80   '
90   'Address the 53A-541 Universal Digitizing Counter and send these setup commands:
100  '@01       - Address the card (card cage 0, card address 1)
110  'AX3       - Channel A attenuation X 3
120  'AT140     - Channel A trigger level 1.4 volts for TTL-level input
130  'ER        - Read the error number to wait for setup before triggering
140  '
150  PRINT @BPI,'@01AX3AT140ER'      'send out setup commands
160  INPUT @BPI,ERRNUM$              'read the error number
170  PRINT @BPI,'JM'                 'trigger the measurement
180  INPUT @BPI,FRQNCY$              'read the measurement
190  PRINT 'Frequency measurement is: ',FRQNCY$
200  END
```

```
10  '53A-541 Universal Digitizing Counter Example Program 2
20  '
30  'The Service Request mode allows the system controller
40  'to do other useful functions while the 53A-541 is taking measurements.
50  'After issuing a "JM" (Trigger) command to the 53A-541, the system
60  'controller can determine when a measurement is finished by sensing
70  'a service request either on an interrupt basis or by polling the
80  'interrupt status. This avoids keeping the backplane and the system
90  'controller busy throughout the measurement waiting for a response to
100 'an input request.
110 '
120 'Address the 53A-541 Universal Digitizing Counter and send these setup commands:
130 '@01            - Address the card (card cage 0, card address 1)
140 'AX3            - Channel A attenuation X 3
150 'AT140          - Channel A trigger level 1.4 volts for TTL-level input
160 'SR1            - Enable Service Requests
170 'ER             - Read the error number to wait for setup before triggering
180 '
190 ENABLE 290,'01'                          'execute subroutine after receiving interrupt
                                             from card at address 01

200 PRINT @BPI,'@01AX3AT140SR1ER'            'send the setup commands
210 INPUT @BPI,ERRNUM$                       'read the error number
220 PRINT @BPI,'JM'                          'trigger the measurement
230 RDFLAG=0                                 'clear RDFLAG until measurement read
240 PRINT 'Waiting for SRQ'
250 IF RDFLAG=0 THEN GOTO 240                'or use time to perform other functions
260 GOTO 330
270 '
280 'Read frequency measurement when 53A-541 sends the interrupt
290 INPUT @BPI,FRQNCY$                       'read the frequency measurement
300 PRINT FRQNCY$
310 RDFLAG=1                                 'set flag indicating measurement taken
320 RETURN                                   'return from interrupt servicing routine
330 END
```

```
10   '53A-541 Universal Digitizing Counter Example Program 3
20   '
30   'This program demonstrates using service requests and binary data
40   'transfer and conversion
50   '
60   'Address the 53A-541 Universal Digitizing Counter and send these setup commands:
70   '@0H          - Send a halt command to reset the 53A-541 Card
80   '@01          - Address the card (card cage 0, card address 1)
90   'AX3          - Channel A attenuation X 3
100  'AT140        - Channel A trigger level 1.4 volts for TTL-level input
110  'MM1          - Select Time Tag Memory Mode
120  'TM2          - Select Post Processing Multifunction Mode (FN05, Period A, by
                       default)
130  'BN1          - Select binary output
140  'RB999        - Block the output into 999 blocks of 8-bytes per block
150  'GA1000       - Gate for 1000 channel A events
160  'BD0          - Disable channel B
170  'SR1          - Enable Service Requests
180  'ER           - Read the error number to wait for setup before triggering
190  '
200  DEF INT A-Z : DEF FLP P              'have all variables not starting in P integer

210  ENABLE 500,'01'                      'execute subroutine after receiving interrupt
220  PRINT @BPI,'@0H@01AX3AT140MM1TM2BN1RB999GA1000BD0SR1ER'
                                          'send setup commands
230  INPUT @BPI,ERRNUM$                   'read the error number
240  PRINT @BPI, 'JM'                     'trigger the measurement
250  NMSRMNTS=999                         'number of measurements to be taken
260  RDFLAG=0                             'clear RDFLAG until measurement read
270  'Prepare a backplane buffer to read a block of data from the 53A-541 consisting
280  'of 999 measurements followed by a carriage return & line feed. The format
290  'of the measurements is an 8-byte data item with the first four bytes being
300  'a function number depending on the type of measurement and the last four
310  'bytes an unsigned binary integer giving the measurement.
320  OPEN @1,BBUF,INPUT,(999*8+2)/256+1   'open backplane buffer 1, size in 256 byte
                                              increments
330  DIM PERIODS(NMSRMNTS)                'array to store period measurements
340  PRINT                                'waiting for SRQ'
350  IF RDFLAG=0 THEN GOTO 340
360  FOR I=1 TO NMSRMNTS
370  LINPUT @1,SIZE 8,D$                  'read in 8-byte block from buffer 1
380  'Check the function code in the fourth byte
390  IF ASC(MID$(D$,4,1)) <> 5 THEN PRINT 'Error in measurement number ';J : STOP
400  'Extract the measurement in the remaining four bytes. *
410  MSW=LSHIFT(ASC(MID$(D$,5,1)),8)+ASC(MID$(D$,6,1))
                                          'most significant word
420  LSW=LSHIFT(ASC(MID$(D$,7,1)),8)+ASC(MID$(D$,8,1))
                                          'least significant word
430  PERIODS(I)=MSW*65536+LSW)*1E-7       'return period in seconds
440  PRINT 'Measurement ';I;' is ';PERIODS(I);' seconds'
450  NEXT
```

```
460 CLOSE @1                          'close the backplane buffer
470 GOTO 550
480 '
490 'Read frequency measurement when 53A-541 sends the interrupt
500 PRINT @BPI,'SR0'
510 PRINT 'Reading data block'
520 BPREAD @1                         'read the block of data from backplane to
                                      buffer 1

530 RDFLAG=1                          'set flag indicating measurement taken
540 RETURN                            'return from interrupt servicing routine
550 END
```

* Those with XYBASIC versions 2.0 and later may delete lines 410 and 420 and replace line 430 with the command:

```
430 PERIODS(I)=BIN2FP(RIGHT$(D$,4),0)*1E-7
```

INSTALLATION

The 53A-541 Card is a function card; therefore, it may be installed in any blue card slot. Setting the Address Select switch defines the card's programming address. To avoid confusion, it is recommended that the slot number and the programming address be the same.

CAUTION:

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

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

b. There are two ejectors on the card. Make sure the ejector marked "53A-541" is at the top for a 53 Series Chassis and to the left for a 63 Series Chassis.

CAUTION:

The 53A-541 Card is a piece of electronic equipment and therefore has some susceptibility to electrostatic damage (ESD). ESD precautions must be taken whenever the module is handled.

APPENDIX A

53/63 SERIES SYSTEM COMMANDS

Command	Description
@XY	The @XY (Address) command addresses a function card in the 53/63 Series System. @ is a delimiter used by the 53/63 Series System. X is a card cage address (0-9) defined by the Address Select switch on the 53A-171 Control Card in the addressed card cage. Y is a function-card address (0-9) defined by the Address Select switch on the function card. Once a card cage/function-card combination is addressed, it remains addressed until the 53/63 Series System detects a new @ character.
@XS	The @XS (Status) command provides the interrupt status of all function cards within the card cage defined by X. The interrupt status of all function cards in the addressed card cage is latched into the 53A-171 Control Card when the @XS command is issued. All function cards in all card cages become unaddressed after the @XS command is issued. For the 53A-541 Card, when the Service Request mode is enabled, an interrupt is generated when a measurement is available (see SRZ command). The 53A-171 Control Card Operating Manual describes the "@XS" command in detail.
@XH	The @XH (Halt) command halts all function cards within the card cage defined by X. This command does not affect function cards in other card cages. How a function card reacts to the @XH command depends on the particular card. On the 53A-541 Card, the position of the Halt switch causes the "@XH" command to have the following effect: if the Halt switch is on, the 53A-541 Card resets to its power-up state; if the Halt Switch is off, the 53A-541 Card is simply unaddressed. In all cases, an addressed function card (Power LED out) becomes unaddressed (Power LED lit).
STOP	The STOP command is not a string of ASCII characters. This command is hard-wired from the system controller to the 53/63 System's communications card in each card cage. When the system controller issues a STOP command, each function card (including the 53A-541 Card) reacts as if it had received the @XH command described above. How the system controller executes a STOP command depends on the communications card used. For example, when using the 53A-128 IEEE-488 Communications Card, a STOP command is executed whenever the system controller asserts the IEEE-488 bus line IFC (Interface Clear) true.

APPENDIX B

INPUT/OUTPUT CONNECTIONS

Snap-on SMB connectors are used for Input/Output connectors. The Input/Output connectors from top to bottom are as follows:

Channel A Input
Channel A TTL Output Complement
Channel A TTL Output - Reconditioned Channel A TTL Output

Channel B Input
Channel B TTL Output Complement
Channel B TTL Output - Reconditioned Channel B TTL Output

External Gate Input - TTL-level compatible

Two 53A-729 SMB-to-BNC adapter cables are provided with the card. Additional 53A-729 adapter cables may be ordered.

APPENDIX C

ERROR MESSAGES

Message No.	Definition
10	Unknown command.
11	Length commands > 125 characters.
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 - AA	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

Check your programming syntax for missing digits, too few digits, too many digits, wrong digits, or numeric values out- side 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 Time Tag Memory 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 Time Tag Memory 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. If an ER command followed by an input request is issued before the JM command, this error is then prevented.
99	No errors.

APPENDIX D

CALIBRATION PROCEDURE

The 53A-541 Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibrate the 53A-541 Card in an environment where the temperature is between 21° and 25°C. If this is not feasible, or the card 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 53A-541 Card:

1. One (1) 4½-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 10-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. (HP 3325A or equivalent).

3. One (1) 53A-729 SMB-to-BNC Adapter Cable (supplied with the 53A-541 Card).

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

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

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

7. Two (2) BNC cables.

8. One (1) 53A-850 Extender Card.

SETUP PROCEDURE

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

1. Install the 53A-541 Card on the 53A-850 Extender Card

2. Close the Halt switch on the 53A-541 Card.

3. Connect the signal generator's output to J31 (Channel A Input) on the 53A-541 Card using one of the BNC cables, the BNC "T" connector, and the SMB-to-BNC adapter cable.

4. Connect the signal generator's signal ground to the DVM's negative input using one of the BNC-to-clip lead adapters at the BNC "T" connector.

5. Connect the DVM's positive input to TPA (W2) on the 53A-541 Card using the BNC-to-banana plug adapter, the second BNC cable, and the second BNC-to-clip lead adapter.

CALIBRATION PROCEDURE

Eight potentiometers are adjusted during this procedure, beginning with R032 which is located at the top of the card, toward the rear. The adjustments proceed, in order, through all eight potentiometers, first along the top of the card from back to front, then down the front of the card from top to bottom, and finally along the bottom of the card from front to back. After the potentiometers are adjusted, the frequency-response capacitors for channels A and B (C31 and C81, respectively) are adjusted. (See the assembly drawing in the 53A-541 Card's service manual for the locations of the potentiometers and capacitors on the card.)

Perform each of the following steps, in the order given:

1. Send the following sequence of commands to the card:

   @XH
   @XYAT-256BT-256

   where: X = Mainframe address (0-9) selected on the 53A-171 Control Card in the addressed mainframe

   Y = Card address (0-9) selected on the 53A-541 Card's Address Select switch

2. Adjust the DAC offset potentiometer (R032) so that the sum of the voltages on TPA (W2) and TPB (W1) is -5.12 V ± 0.020 V, and record the voltages on TPA and TPB as V_A and V_B, respectively.

3. Send the following command to the card:

   @XYAT254BT254

   X and Y are the same as in step 1.

4. Adjust channel A's DAC gain potentiometer (R031) so that the voltage on TPA is:

   $[(-V_A \bullet 2.54) / 2.56] \pm 0.001$ V (approximately +2.54 V)

5. Adjust channel B's DAC gain potentiometer (RO2) so that the voltage on TPB is:

   $[(-V_B \bullet 2.54) / 2.56] \pm 0.001$ V (approximately +2.54 V)

6. Send the following command to the card:

   @XYAT0BT0GP300AZ1FN19AD1BD0CS0

   X and Y are the same as in step 1.

7. Remove the BNC-to-clip lead adapters, and connect the DVM to the BNC "T" connector.

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

9. Measure the actual offset voltage of the signal, and record the offset voltage as V_O.

10. Continuously input and display the average duty-cycle reading from the card (it should be approximately 50%).

11. Adjust channel A's offset potentiometer (R21) until it has a duty cycle reading of (0.5 - V_O) ±0.001 V.

12. Send the following command to the card:

    @XYBZ1FN20BD1AD0

    X and Y are the same as in step 1.

13. Move the signal generator's output from J31 (Channel A Input) to J71 (Channel B Input).

14. Continuously input and display the average duty-cycle reading from the card as in step 10.

15. Adjust channel B's offset potentiometer (R71) until it has a duty cycle reading of (0.5 - V_O) ± 0.001 V.

16. Send the following command to the card:

    @XYAD1BD0FN19

    X and Y are the same as in step 1.

17. Move the signal generator's output from J71 (Channel B Input) back to J31 (Channel A Input).

18. Send the following command to the card:

    @XYAT250BT250

    X and Y are the same as in step 1.

19. Add a +2.5-V offset to the 1.0-V ptp, 10.0-kHz, triangular waveform.

20. Measure the offset voltage on the DVM, and record the actual offset voltage as V_O.

21. Input the average duty-cycle reading from the card, and record (2.5-V_O + reading) as Y.

22. Send the following command to the card:

    @XYAT-250BT-250

    X and Y are the same as in step 1.

23. Change the offset voltage on the 1.0-V ptp, 10.0-kHz, triangular waveform to -2.5 V.

24. Measure the offset voltage on the DVM, and record the actual offset voltage as V_O.

25. Input the average duty-cycle reading from the card, and record (-2.5V - V_O + reading) as X.

26. Adjust channel A's gain potentiometer (R1122), and repeat steps 18-25 until X - Y = 0.0 ± 0.002 V.

NOTE: A procedure programmed to automatically send the messages, change the offset voltage, reprogram the trigger voltages, input the duty-cycle readings, and display (X - Y), can make this adjustment much easier because R1122 would then only need to be adjusted until the display goes to 0.0 ± 0.002 V.

27. Send the following command to the card:

    @XYAD0BD1FN20

    X and Y are the same as in step 1.

28. Move the signal generator's output from J31 (Channel A Input) to J71 (Channel B Input).

29. Adjust channel B's gain potentiometer (R1131), and repeat steps 18-25 until X - Y = 0.0 ±0.002 V.

30. Send the following command to the card:

    @XYCS1

    X and Y are the same as in step 1.

31. Move the signal generator's output from J71 (Channel B Input) back to J31 (Channel A Input).

32. Adjust the A-common-B gain potentiometer (R1132), and repeat steps 18-25 until X - Y = 0.0 ± 0.002 V.

33. Send the following command to the card:

    @XYCS0GM10FN01AX3BX3AD1BD0

    X and Y are the same as in step 1.

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

35. Send the following command to the card:

    @XYAUAI+

    X and Y are the same as in step 1.

36. Input the positive (+) peak level from the 53A-541 Card, and record the reading as U.

37. Send the following command to the card:

    @XYAI-

    X and Y are the same as in step 1.

38. Input the negative (-) peak level from the 53A-541 Card, and record the reading as V.

NOTE: A procedure programmed to automatically perform steps 35-38 can make the following adjustments easier.

39. Set the signal generator to output a 100-kHz, 10.0-V ptp, sine wave with a 0.0-V offset, and record U - V as W.

40. Repeat steps 35-38 while adjusting C31 until U - V = W ± 0.07 volts.

41. Send the following command to the card:

    @XYAD0BD1FN02RF9GS1

    X and Y are the same as in step 1.

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

43. Move the signal generator's output from J31 (Channel A Input) to J71 (Channel B Input).

44. Send the following command to the card:

    @XYBUBI+

    X and Y are the same as in step 1.

45. Input the positive (+) peak level from the 53A-541 Card, and record the reading as U.

46. Send the following command to the card:

    @XYBI-

    X and Y are the same as in step 1.

47. Input the negative (-) peak level from the 53A-541 Card, and record the reading as V.

NOTE: A procedure programmed to automatically perform steps 44-47 can make the following adjustments easier.

48. Set the signal generator to output a 100-kHz, 10.0-V ptp, sine wave with a 0.0-V offset, and record U - V as W.

49. Repeat steps 44-47 while adjusting C81 until U - V = W ± 0.07 volts.

50. Set the signal generator to output a 5.0-MHz (± 0.01 ppm), 10.0-V ptp, sine wave with an offset of 0.0V.

51. Continuously input and display the 53A-541 Card's reading, and adjust Y107 (R1061 for voltage tuned oscillators) to read exactly 5 MHz for at least ten consecutive readings.

SERVICE MANUAL

53A-541

UNIVERSAL COUNTER TIMER CARD

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REV 9105-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
	541SA1	1	BOTTOM BOARD FOR 53A-541	0026	541SA1
	541SA2	1	TOP BOARD FOR 53A-541	0026	541SA2
	53A-729	2	ADAPTER CABLE BNC MALE TO SMB SNAP-ON PLUG	0026	53A-729
	53A-729-10	2	10 FT CABLE LENGTH	0026	53A-729-10

541SA1 BOTTOM BOARD FOR 53A-541

REV 8803-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
C03,041,042,05,07,1051,1061,1131 1141,1161,96	20128-10006	11	CAP FXD CER .1UF 20% 50VDCW	0058	C322C104M5U5CA
C55	21018-15009	1	CAP FXD ELECT 150UF 75% -10% 16VDCW	0025	NLW150-16
C77	22022-10008	1	CAP FXD TA 10UF 10-20% 25VDC	0106	199D106X9025CA1
CR77	32000-04148	1	DIODE SILICON 75V 1A 5%	0078	1N4148
DS01	32000-00103	1	DIODE LIGHT EMITTING RED 50MA	0039	550-0406
DS111,112,113,114	32000-02003	4	DIODE LIGHT EMITTING RED WITH RESISTOR 0	0039	547-2003
E1	40401-00541	1	STAMP 53A-541 STYLE B BLUE	0026	40401-00541
E2	40401-10059	1	STAMP UDC STYLE D BLUE	0026	40401-10059
E3	45050-03289	1	DCL LED 4POS DRW 00000-00555 1-85	0026	45050-03289
E4	45050-03248	1	DCL LED 4POS BLK DRW 00000-00478	0026	45050-03248
E51,61,71,81,91	92201-00001	5	STAND-OFF 4-40 X .562	0183	1638-440-A
E52,53,62,63,72,73,82,83,92,93	92300-00440	10	WASHER SPLITRING 4-40 3-16 OD	0137	4R
E54,55,64,65,74,75,84,85,94,95	92300-75440	10	SCREW PHIL PNHD 4-40X.25 ZINC	0137	4-40X.25 PHIL PNHD
F07	42202-52003	1	FUSE SUB-MIN 3AMP	0061	251003
F107,117	42202-52001	2	FUSE SUB-MIN 2AMP	0061	251002
J05,55,95	45001-12100	3	CONNECTOR SIP 12 PIN	0026	45001-12100
L1061	27051-33007	1	INDUCTOR 3.3UH 10% 150MW	0175	1840-18
PCB	41530-54100	1	P.C. BOARD VERSION 4L 8803	0498	41530-54100
R771	10117-47004	1	4.7K RES COMP 1-4W 5%	0087	R25J-4.7K-5%
R772	10117-33004	1	3.3K RES COMP 1-4W 5%	0087	R25J-3.3K-5%
R773	10117-33003	1	330 OHM RES COMP 1-4W 5%	0087	R25J-330-5%

REV 8803-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
R86	10117-10007	1	1M RES COMP 1-4W 5%	0087	R25J-1M-5%
R871	10117-68005	1	68K RES COMP 1-4W 5%	0087	R25J-68K-5%
R872	10117-33005	1	33K RES COMP 1-4W 5%	0087	R25J-33K-5%
R873	10117-51004	1	5.1K RES COMP 1-4W 5%	0087	R25J-5.1K-5%
R97	10117-10005	1	10K RES COMP 1-4W 5%	0087	R25J-10K-5%
S77	42050-10010	1	SWITCH 10POS.	0101	C42315-A61-A11
S87	42050-10101	1	SWITCH DIP 1POS SPST	0093	JS-8794-01
U03,04,103,104,113,114,63,64,73 74,83,84,93,94	71209-74593	14	IC TTL LS 8-BIT BINARY	0107	74LS593
U06,25,47,56	73005-74574	4	IC HCT OCTAL TRISTATE LATCH NON-INVERT	0107	74HCT574
U07,45	79008-74138	2	IC HCT 3-TO-8 LINE DECDR DEMULTIPLEXER	0107	74HCT138
U115,97	77816-07432	2	IC HCT QUAD 2-INPUT OR GATE	0088	74HCT32
U116	76606-07400	1	IC HCT QUAD 2-INPUT NAND GATE	0088	74HCT00
U117	71208-74390	1	IC HCMOS DUAL 4-BIT DECADE COUNTER	0107	74HC390
U13,23,33,43,53	73001-74652	5	IC HCT TRANSCEIVER WITH LATCHES	0107	74HCT652
U14	73309-74244	1	IC HCT OCTAL BUFFER NON-INVERTING	0107	74HCT244
U16	79802-00080	1	IC CMOS Z80 CPU 4 MHZ 4 MHZ	0173	TMPZ84C00AP
U17	79813-00018	1	PROGRAMMED PROM U17 53A-541	0026	79813-00018
U24,34,44,54	79805-00128	4	IC CMOS 2K X 8 SRAM 45NS	0218	CY7C128-45PC
U35	79814-00051	1	PAL PROGRAMMED EP310-2 REV A 53A-541	0026	79814-00051
U37	79805-06116	1	IC CMOS 2K X 8 SRAM 120NS	0387	UMC6116-3L 90NS
U57	73309-74240	1	IC HCT OCTAL BUFFER INVERTING	0088	74HCT240

541SA1 BOTTOM BOARD FOR 53A-541

REV 8803-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
U66	79814-00038	1	PAL PROGRAMMED EP310-2 REV A 53A-541	0026	79814-00038
U67	79814-00039	1	PAL PROGRAMMED EP310-2 REV B 53A-541	0026	79814-00039
U76	79814-00025	1	PAL PROGRAMMED EP310-2 REV A 53A-541	0026	79814-00025
U77	73300-07406	1	IC TTL HEX INVERTER BUFFER-DRIVER	0107	7406
U85	79814-00040	1	PAL PROGRAMMED EP310-2 REV A 53A-541	0026	79814-00040
U86	78404-07414	1	IC HEX SCHMITT INVERTING BUFFER	0088	74HC14
U87	78403-07414	1	IC HCT HEX SCHMITT INVERTING BUFFER	0088	74HCT14
U96	76905-07402	1	IC HCT QUAD 2-INPUT NOR GATE	0088	74HCT02
X01,02	45010-08100	2	SOCKET SIP 8 PIN	0032	CAS-08VSC-12B
X16	45012-40100	1	SOCKET 40-PIN DIP LOW PRO	0089	ICO-406-S8A-TG
X17	45012-28100	1	SOCKET 28-PIN DIP LOW PRO	0089	ICO-286-S8A-TG
Y107	89499-20007	1	CRYSTAL OSC 20.000MHZ 5PPM ADJ	0365	7400D4A1 20.0000

541SA2 TOP BOARD FOR 53A-541

REV 9105-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
C04,05,1022,1023,1131,1151,44 522,624,742,955	20128-10006	11	CAP FXD CER .1UF 20% 50VDCW	0058	C322C104M5U5CA
C1021,142,521,622,92,952,954	22022-10008	7	CAP FXD TA 10UF 10-20% 25VDC	0106	199D106X9025CA1
C1031,831,921	21528-10003	3	CAP FXD MICA 100PF 5% 500VDCW	0025	CD10FD101J03
C141,15	20128-15004	2	CAP FXD CER .0015UF 10% STABLE 100VDCW	0106	1C10X7R152M050B
C221,621	21528-20004	2	CAP FXD MICA 2000PF 5% 500VDCW	0012	DM-19-202J
C31,81	25028-20002	2	CAP VAR CER 2.3-20PF	0057	9308
C41,91	25072-22006	2	CAP FXD POLYSTY .22UF 10% 250VDCW	0106	730P224X9250
C42,82	21528-10002	2	CAP FXD MICA 10PF 5% 100VDCW	0012	DM15-100D
C741,942,943	21528-30001	3	CAP FXD MICA 3PF .5 PF TOL 500VDCW	0025	CD5CC030C03
C841,941,951,953	20128-47006	4	CAP FXD CER .47UF 20% 50VDCW	0075	RPE123Z5U474M50V
CR1021,1022,1023,1024,23,33,521 522,621,622,623,624,631,632,633 634,921,922	32000-04148	18	DIODE SILICON 75V 1A 5%	0078	1N4148
J1011,31,41,51,71,81,91	45002-51053	7	CONNECTOR SMB RT. ANGLE PC BD MOUNT	0287	R114665
K32,421,422,72,82,92	83000-20006	6	RELAY REED SPDT 500OHMS 3.8V	0111	220-001-5M
L1031,1051,1052,23	27051-00200	4	INDUCTOR WIDE-BAND FERRITE CHOKE	0042	VK 200 10-3B
P05,55,95	45002-03107	3	CONNECTOR 12PIN WAFERASSY DOUBLEHEADER	0133	1102-14-112-107
PCB	41530-54101	1	P.C. BOARD VERSION 4L 9105	0498	41530-54101
R02,031	15117-10004	2	1K RES VAR CER 22TRN 1W 100PPM	0105	43P-102
R032,1122,1131,1132	15117-10005	4	10K RES VAR CER 22TRN 1W 100PPM	0105	43P-103

541SA2 TOP BOARD FOR 53A-541

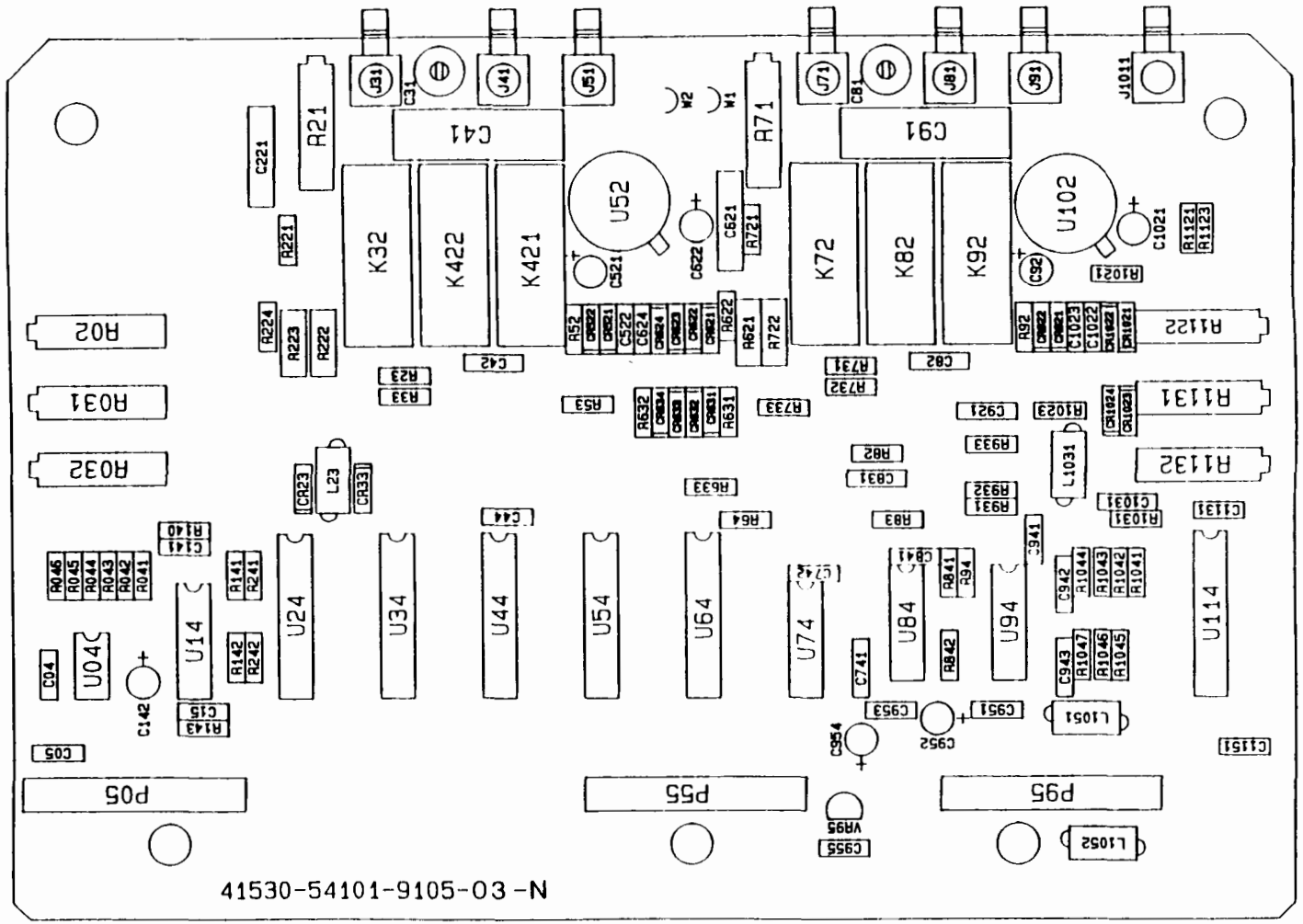
REV 9105-03-N

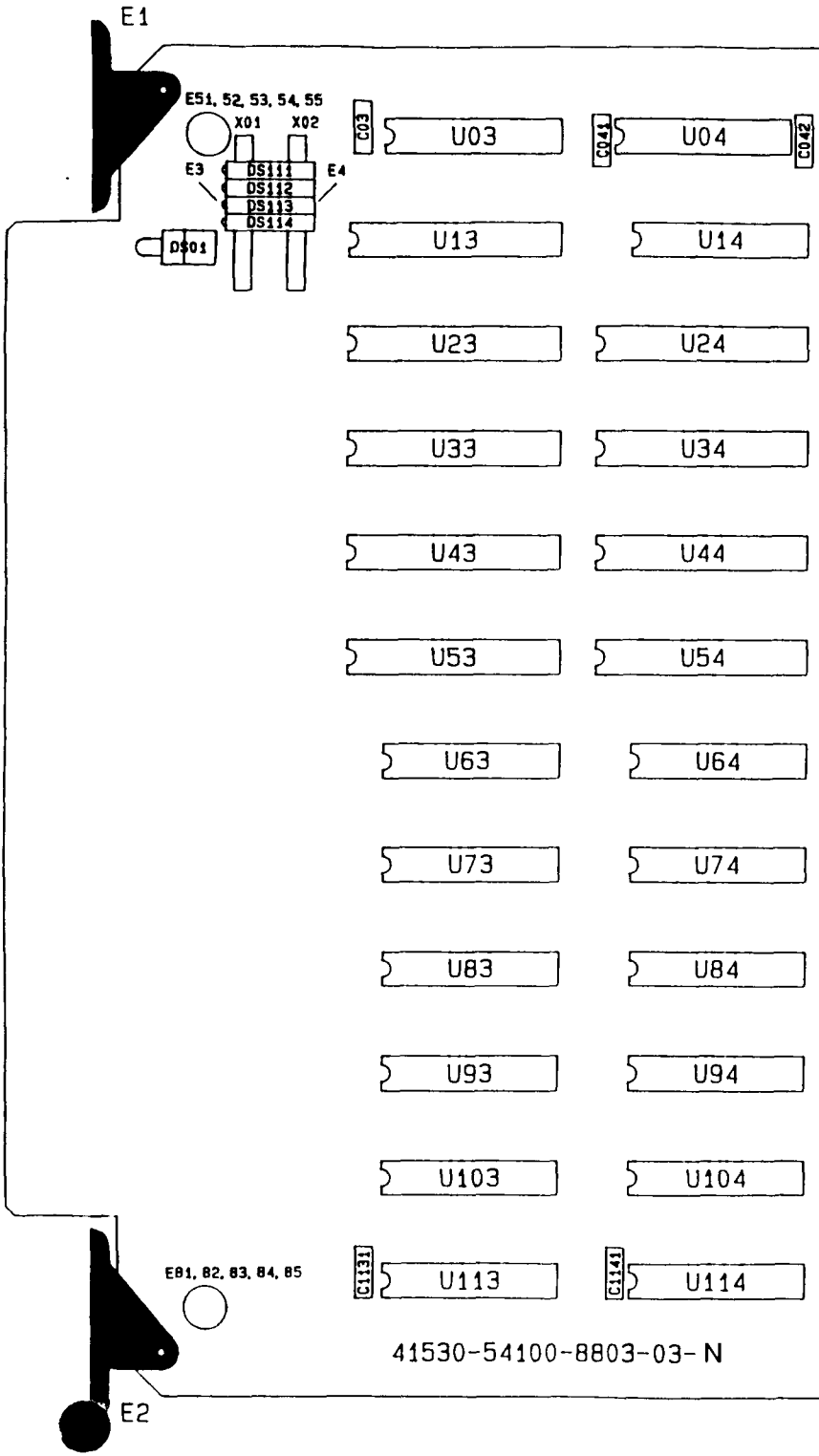
REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
R041,046	14036-20005	2	20K RES FILM 1-4W .1% 25PPM	0069	RN55E2002B
R042,043,044,045,142,242	14036-10005	6	10K RES FILM 1-4W .1% 25PPM	0069	RN55E1002B
R1021,1023,53,631,632,733	14024-30104	6	3.01K RES FILM 1-4W 1% 100PPM	0069	RN55D3011F
R1031,1121,82,933	10117-10005	4	10K RES COMP 1-4W 5%	0087	R25J-10K-5%
R1041,633,64	10117-10002	3	10 OHM RES COMP 1-4W 5%	0087	R25J-10-5%
R1042,1045,94	10117-15004	3	1.5K RES COMP 1-4W 5%	0087	R25J-1.5K-5%
R1043,1046,841	10117-39003	3	390 OHM RES COMP 1-4W 5%	0087	R25J-390-5%
R1044,1047,842	10117-27005	3	27K RES COMP 1-4W 5%	0087	R25J-27K-5%
R1123	10117-10004	1	1K RES COMP 1-4W 5%	0087	R25J-1K-5%
R140,143	10117-10003	2	100 OHM RES COMP1-4W 5%	0087	R25J-100-5%
R141,241	10117-33003	2	330 OHM RES COMP 1-4W 5%	0087	R25J-330-5%
R21,71	15117-20003	2	200 OHM RES VAR CER 22TRN 1W 100PPM	0105	43P-201
R221,721	10117-10007	2	1M RES COMP 1-4W 5%	0087	R25J-1M-5%
R222,223,621,722	14054-10003	4	100 OHM RES FILM 1-2W 1% 100PPM	0069	RN60D1000F
R224,23,33,622,731,732	14036-34006	6	340K RES FILM 1-4W .1% 25PPM	0069	RN55E3403B
R52,92	10117-20003	2	200 OHM RES COMP 1-4W 5%	0087	R25J-200-5%
R83,931,932	10117-68005	3	68K RES COMP 1-4W 5%	0087	R25J-68K-5%
U04	52200-00001	1	REFERENCE 10V 20MA 0-25 PPM	0082	REF01CP
U102,52	61000-00033	2	OP AMP FAST BUFFER AMP	0078	LH0033CG
U114	79814-00024	1	PAL PROGRAMMED EP310-2 REV B 53A-541	0026	79814-00024
U14	61000-00347	1	OP AMP FET QUAD	0078	LF347
U24	20100-07528	1	IC DUAL D-A 8-BIT DO NOT SUB PMI	0011	AD7528JN

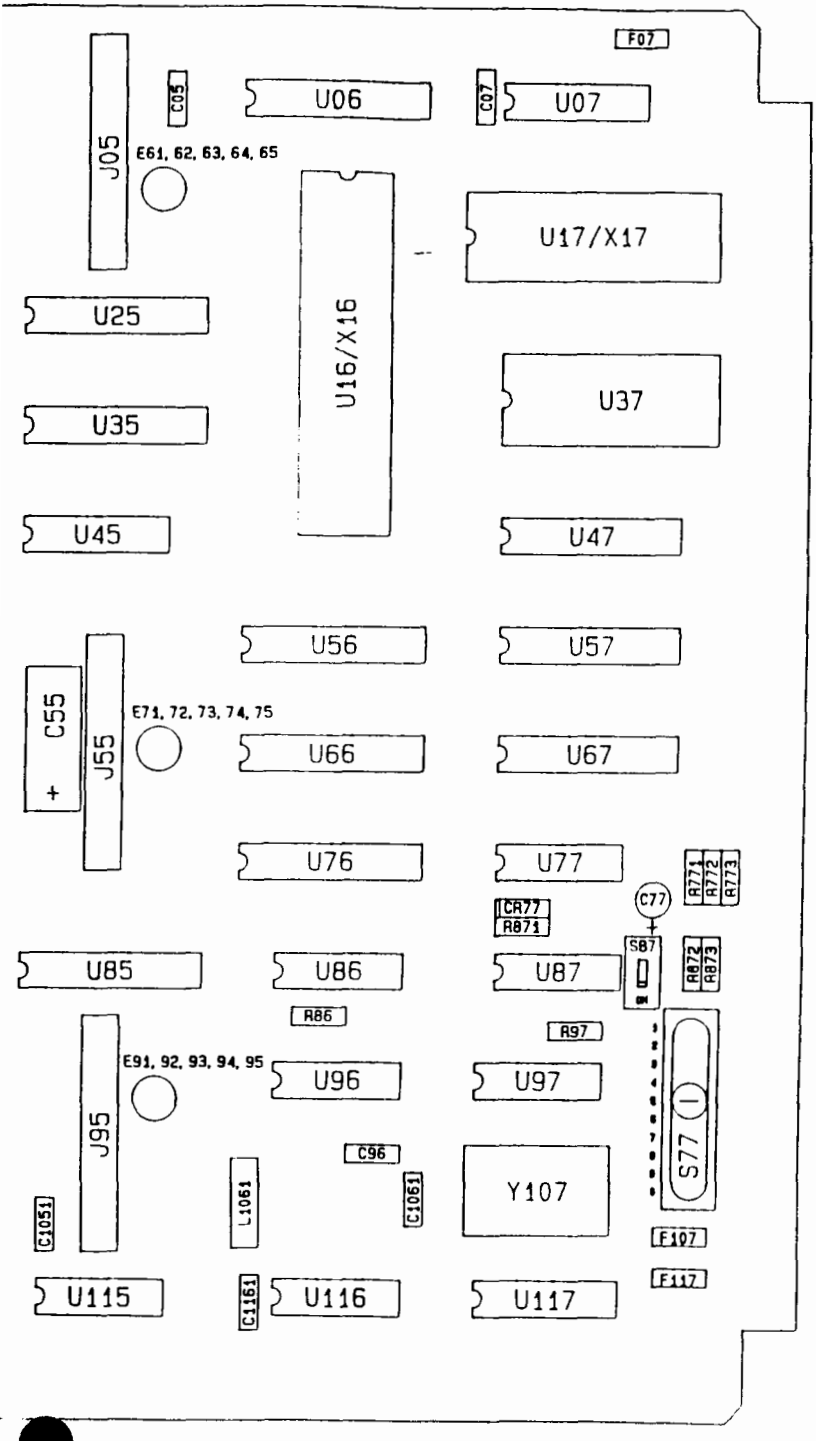
541SA2 TOP BOARD FOR 53A-541

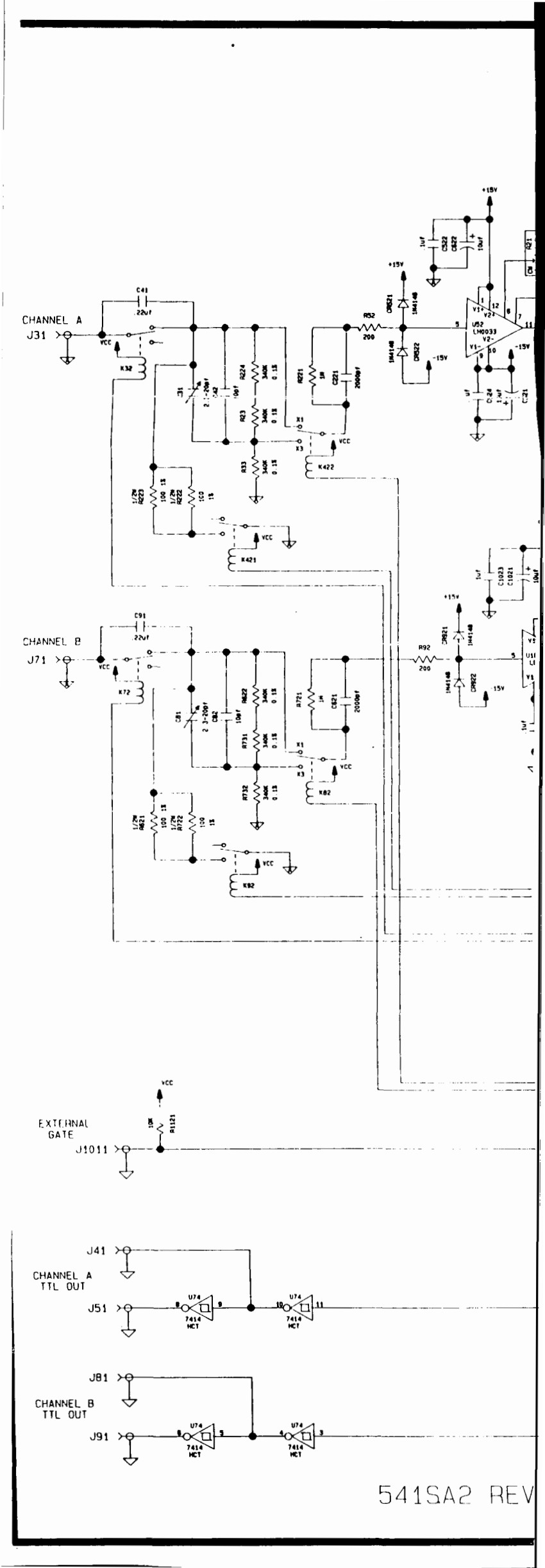
REV 9105-03-N

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
U34,44	73005-74574	2	IC HCT OCTAL TRISTATE LATCH NON-INVERT	0107	74HCT574
U54,64	79814-00023	2	PAL PROGRAMMED EP310-2 REV A 53A-541	0026	79814-00023
U74	78403-07414	1	IC HCT HEX SCHMITT INVERTING BUFFER	0088	74HCT14
U84,94	61010-00521	2	IC HIGH SPEED DUAL COMPARATOR	0092	NE521N
VR95	52000-17905	1	VOLTAGE REGULATOR -5V 100MA 5%	0074	MC79L05ACP
W1,2	90000-06022	0.10	WIRE 22 GA UNINSULATED	0017	QQ-W-343D

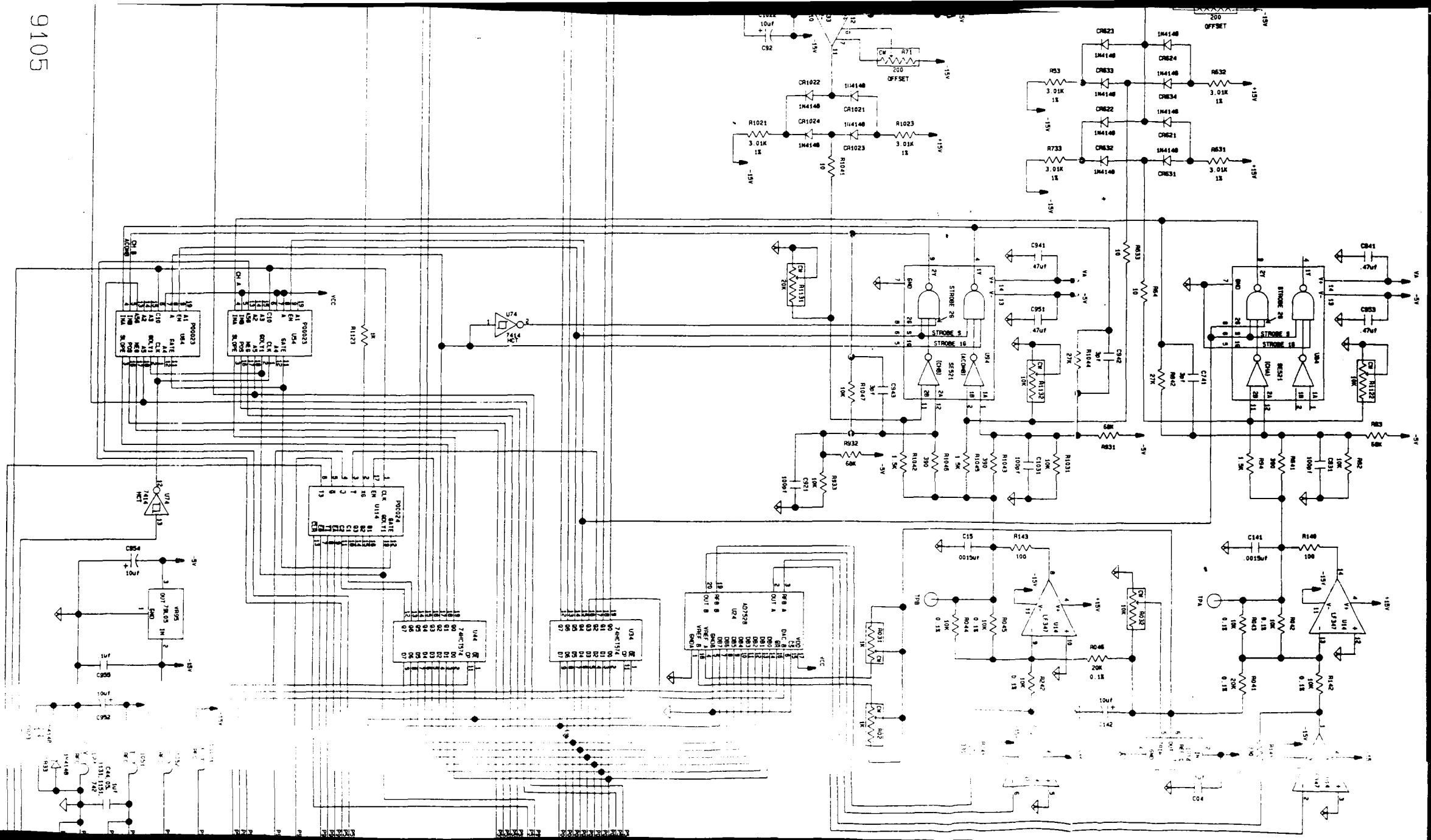

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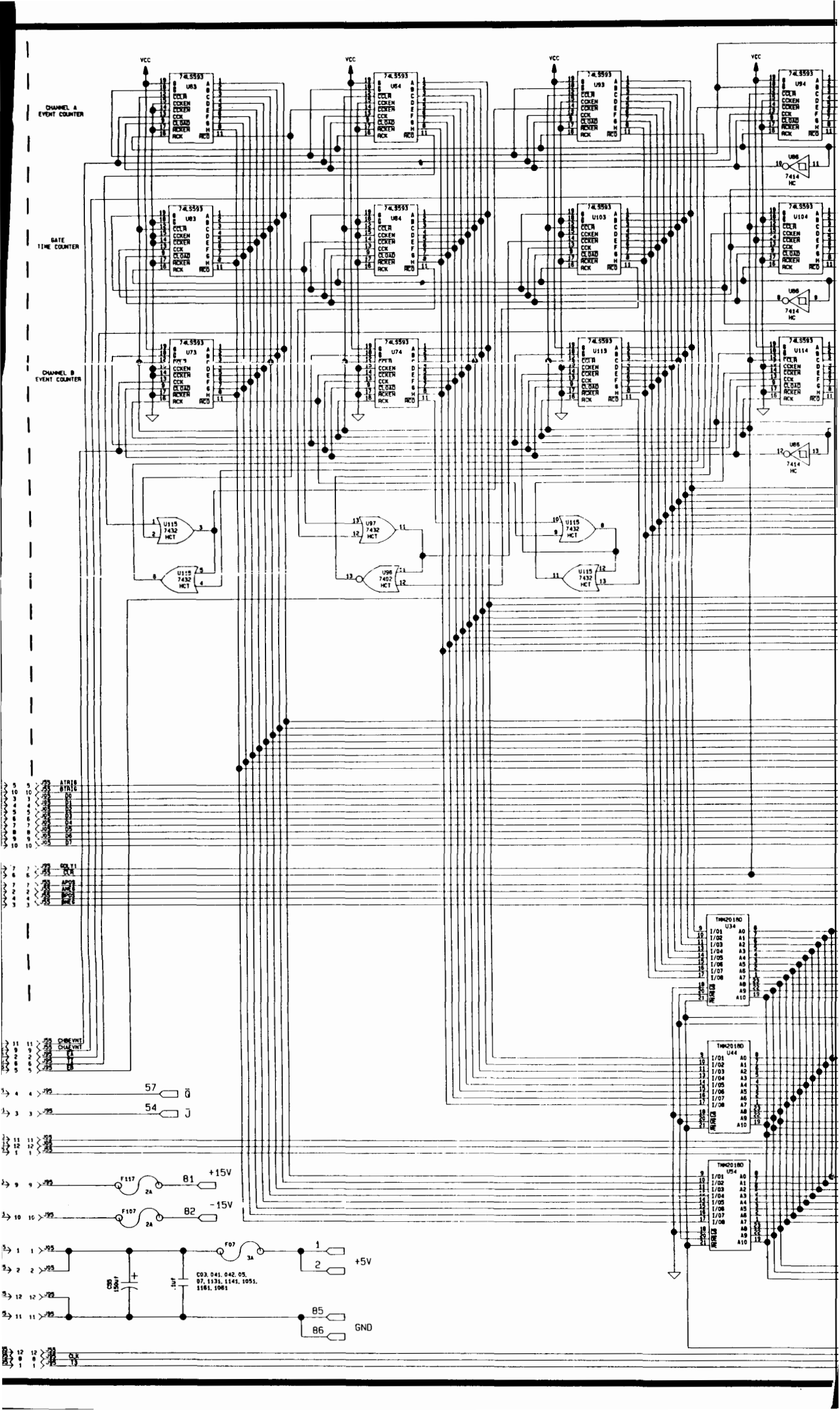

E1
E51, 52, 53, 54, 55
X01
X02
E3
E4
DS111
DS112
DS113
DS114
DS01
C03
U03
C041
U04
C042
U13
U14
U23
U24
U33
U34
U43
U44
U53
U54
U63
U64
U73
U74
U83
U84
U93
U94
U103
U104
E81, 82, 83, 84, 85
C1131
U113
C1141
U114
41530-54100-8803-03- N
E2

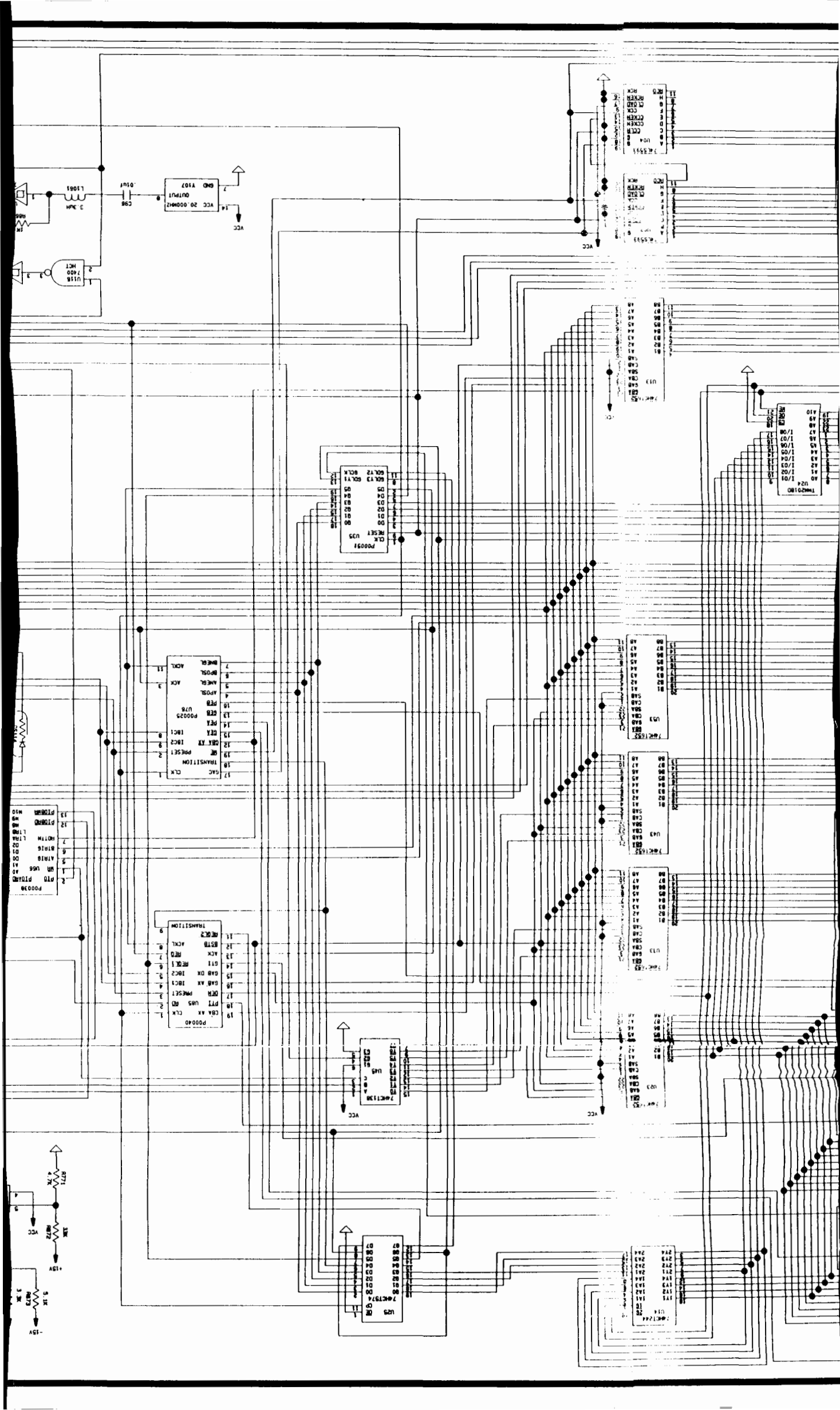

F07
J05
C05
U06
C07
U07
E61, 62, 63, 64, 65
U17/X17
U16/X16
U25
U37
U35
U45
U47
U56
U57
C55
+
J55
E71, 72, 73, 74, 75
U66
U67
U76
U77
R771
R772
R773
C77
CR77
R871
S87
R872
R873
U85
U86
U87
R86
R97
J95
E91, 92, 93, 94, 95
U96
U97
S77
C96
Y107
L1061
C1061
C1051
F107
F117
U115
C1161
U116
U117

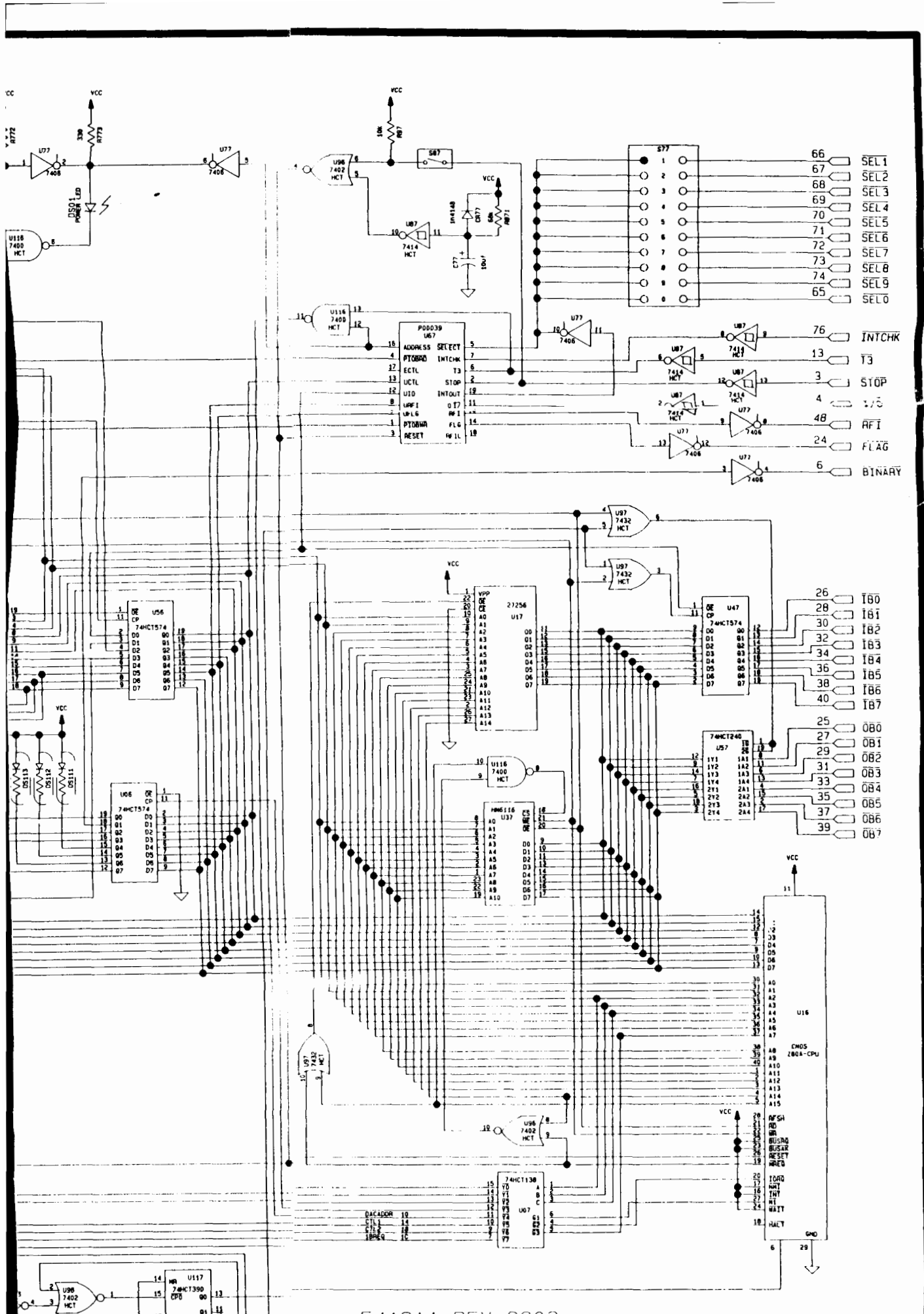

CHANNEL A
J31
C41
.22uf
VCC
K32
C31
2.1-20pf
C32
10pf
R234
340K
0.1%
R23
340K
0.1%
R33
340K
0.1%
R221
1M
C221
2000pf
X1
X3
VCC
K422
1/2W
R223
100
1%
1/2W
R222
100
1%
VCC
K421
R52
200
+15V
CR521
1N4148
CR522
1N4148
-15V
1uf
C522
C522
10uf
U52
LM0033
V2+
V1-
V1+
V2-
C24
1uf
C521
CHANNEL B
J71
C91
.22uf
VCC
K72
C81
2.1-20pf
C82
10pf
R822
340K
0.1%
R731
340K
0.1%
R732
340K
0.1%
R721
1M
C821
2000pf
X1
X3
VCC
K82
1/2W
R821
100
1%
1/2W
R722
100
1%
VCC
K82
R92
200
+15V
CR821
1N4148
CR822
1N4148
-15V
C1023
C1021
EXTERNAL
GATE
J1011
VCC
10K
R1121
J41
CHANNEL A
TTL OUT
J51
U74
7414
HCT
U74
7414
HCT
J81
CHANNEL B
TTL OUT
J91
U74
7414
HCT
U74
7414
HCT

541SA2 REV




CHANNEL A EVENT COUNTER
GATE TIME COUNTER
CHANNEL B EVENT COUNTER
VCC
74LS593
U83
U84
U93
U94
U103
U104
U73
U74
U113
U114
U86
7414 HC
U115 7432 HCT
U97 7432 HCT
U96 7402 HCT
THM20180
U34
U44
U54
J95
ATRIG
BTRIG
D0
D1
D2
D3
D4
D5
D6
D7
GOLY1
CLK
APOS
ANEG
BPOS
BNEG
CHBEVNT
CHAEVNT
EA
EB
57
54
Q̄
J̄
F117
2A
81
+15V
F107
82
-15V
F07
3A
1
2
+5V
C93, 041, 042, 05, 07, 1131, 1141, 1051, 1161, 1061
85
86
GND
CLK





9105-03-N

REVISION LEVEL	ECO #
8603-01-A	
8603-01-B	
8604-02-A	
8604-03-A	
8604-03-B	477
8710-03-G	592
8803-03-H	650
8803-03-K	

COLORADO DATA SYSTEMS

PART NO.: 53A-541

DESCRIPTION: UNIVERSAL DIGITIZING COUNTER WITH TIME TAG MEMORY

P.C.B. NUMBER: 41530-54100

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