53A-525 WAVEFORM DIGITIZER/ANALYZER CARD

OPERATING MANUAL

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DESCRIPTION

The 53A-525 Waveform Digitizer/Analyzer Card is a printed circuit board assembly for use in a CDS 53/63 Series System. The 53A-525 is an 8-bit, 40-MHz, A/D converter card that incorporates many features usually found in programmable oscilloscopes.

In addition to providing the capability for capturing waveforms ranging in frequency from dc to 20 MHz, the card also incorporates an extensive suite of software to facilitate performing detailed analyses of captured waveforms. Internal sampling rates are programmable from 0.01 Hz to 40 MHz (100 s to 25 ns), or an external sample rate generator can be used. Input ranges can be set, under program control, from ±1 V to ±40 V in six ranges.

Up to 16,384 measurements can be stored in memory located on the 53A-525 Card. The triggering that controls waveform acquisition supports pre-triggering, center-triggering, post-triggering, or free-running (trigger independent) data collection. The trigger source may be either a programmable input voltage level, a TTL level, or a software command. A time-delayed triggering mode is also provided to delay data collection after the trigger; the delay can be programmed from 500 ns to 32.767 ms.

Data can be rapidly sent from the Waveform Digitizer/Analyzer to the system controller in binary, two's complement binary, ASCII, or ASCII blocks, starting at any point in memory relative to the trigger point.

In addition to collecting and transferring raw data, the 53A-525 Card is configured with an Intel 8087 math coprocessor and embedded software routines. These routines allow the user to preprocess the stored data before returning it to the system controller. Pre-process signal analysis routines are available for such functions as maximum, minimum, average, and rms values; rise and fall times; pulse widths, peak-to-peak voltages; overshoots and undershoots; and fast Fourier transforms (FFT).

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-525 Card's operating environment.

Address Select Switch

The 53A-525 Card has a miniature 10-position switch that selects the 53A-525 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 address position.

Power LED

The Power LED provides a valuable diagnostic tool by giving the system programmer a visual indication of the current system action. Whenever the 53A-525 Card is addressed by the system controller, the Power LED goes out. 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-525 Card is unaddressed, but that all required dc power (5 V dc, ±15 V dc) is being supplied to the system.

Fuses

The 5-volt dc and ±15-volt dc power buses each have a fuse that protects the system from overloads. If any fuse has blown, the power LED will not light.

Function LEDS and Switches

LEDs

The following LEDs are provided at the top front edge of the 53A-525 Card to indicate the status of the card's operation:

MIP (Measurement In Progress)

This LED indicates that sampling is taking place. The LED is turned off whenever the memory is full, the memory is accessed, or when the 53A-525 Card is halted or reset (see Operation section).

SC (Sample Clock)

This LED flashes at half the frequency of the sample clock. For sample rates faster than approximately 30 Hz, the LED appears to be lit continuously.

ERR (Programming Error)

This LED comes on whenever there is a programming error. Receiving a valid E (Error) command or resetting the card turns the LED off.

MC (Measurement Complete)

When lit, this LED indicates that the conversion process is complete. This occurs whenever the memory is full, the memory is accessed, or when the backplane is halted or reset.

CIP/OFW (Calculation In Progress)
This LED blinks on and off when numerically intensive calculations are being performed. On power-up, the 53A-525 Card automatically performs a self test which causes the LED to flash momentarily.

HOLD (Gate Hold)
When lit, this LED indicates that the gate input is active.

ARM (Armed)
When lit, this LED indicates that the card is "armed" and awaiting or processing the trigger. This LED goes out when data sampling is complete.

TRIG (Triggered)
When lit, this LED indicates that the card's trigger has occurred.

Switches
The following switches are provided to select the proper functions for the 53A-525 Card's operating environment:

Halt Switch (S17)
This slide switch is located near the card's backplane edge connector. It selects the state of the 53A-525 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-525 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-525 Card becomes unaddressed, and the Power LED is lit. Any sampling in progress stops. Programmed parameters of the card remain unchanged.

Appendix A fully discusses the @XH and STOP commands.

Coprocessor Enable Switch (S45)
This 2-position slide switch must be set to the ON position. This switch is located near the center of the 53A-525 Card, and is used during factory testing.

Single-ended Input Switch (S61)
When set to the ON position, this 2-position slide switch grounds the VIN-input (J80) for greater noise rejection for single-ended inputs. This switch is located near the front edge connector to the right of J60.

CAUTION:
This switch must be in the OFF position when applying signals to the VIN-input or damage to the equipment may occur.

External Inputs/Outputs

See Appendix C for a complete description of all External Inputs and Outputs.

SPECIFICATIONS

* indicates programmability

*Input Voltage Ranges:	±: 1.0, 2.0, 5.0, 10.0, 20.0, 40.0 V.
*Sampling Frequencies:	40 MHz to 0.01 Hz.
*Sample Intervals:	25 ns. 50 ns to 100 s (in 50-ns increments). External clock (100-ns minimum period).
Signal Input:	
Type:	Differential, single-ended.
Bandwidth:	dc to 20 MHz (-3 dB).
Rolloff:	-12 dB/octave (20-40 MHz).
*Coupling:	ac, dc, ground.
Impedance:	1 Megohm paralleled by < 5pF.
CMRR:	> 55 dB (dc to 1 kHz). (calibrated and tested to 1 KHz) Typical: > 50 dB @ 10 KHz > 42 dB @ 100 KHz > 39 dB @ 1 MHz > 24 dB @ 10 MHz

Resolution (for eight bits):

Nominal/(Actual) Range (V)	Resolution (mV/b)
±40.0(+40.64/-40.96)	320.0
±20.0(+20.32/-20.48)	160.0
±10.0(+10.16/-10.24)	80.0
±5.0(+5.08/-5.12)	40.0
±2.0(+2.032/-2.048)	16.0
±1.0(+1.016/-1.024)	8.0

Accuracy:

DC accuracy (using average function):

Range	Accuracy*
1 V	1.5 + 20mV
2 V	1.5 + 20mV
5 V	1.5 + 40mV
10 V	1.5 + 80mV
20 V	2.0 + 160mV
40 V	2.5 + 160mV

* ±(% full scale + offset)

Dynamic Accuracy - based on least squares fit to idealized 8 bit sine wave and the formula:
Eff. bits = 8 - [$\log_2$ (RMS error actual/RMS error ideal)]

Effective Bits Rel. to 8 Bits*

Range	100 KHz	1 MHz	10 MHz
1 V	>6.5	>6.2	>5.9
2 V	>6.8	>6.6	>5.9
5 V	>6.8	>6.6	>5.9
10V	>6.8	>6.6	>5.9
20V	>6.9	>6.2	--
40V	>6.9	>6.3	--

* 8 bits represents 0.39% of full scale error.

Sample Memory

Depth: 16384 bytes.

*Control: Pre-trigger.
Center-trigger.
Post-trigger.
Free-running.

*Triggering: ±External TTL-level.
±Voltage threshold.
Automatic (on command).

External Trigger Uncertainty: <= 50 ns. (Trigger to first sample).

*Voltage Threshold

Trigger Range: ±0 to +100% full scale.

Voltage Threshold Accuracy: See Accuracy Specifications.

Sample Clock Accuracy: 25 ppm/yr.

External Sample Clock: TTL level, 1 ASTTL load; dc to 10 Mhz; minimum clock high and low time 50 ns.

*Delayed Triggering Range: 500 ns to 32.767 ms (in 500-ns increments).

Delay Uncertainty: <= 500 ns.

Gate Uncertainty: <=50 ns. (Gate transition to sampling).

Data Output

*Formats:	ASCII. Binary. Two's-complement binary. ASCII blocks (DMA).
Transfer Rate:	Up to 500K bytes/s (host dependent).
*Memory Control:	± offset from trigger. Auto-increment. Auto-decrement.

Processor

CPU:	80186 (16-bit, 8-MHz) with 8087 mathematics coprocessor.
Memory:	16K bytes RAM, 128K bytes EPROM.

Embedded Preprocessor Software Routines:	Maximum value. Minimum value. Maximum value since trigger. Maximum positive transition. Maximum negative transition. Average value. RMS value. Ringing. Integrate. Differentiate. Zero crossing. Peak-to-peak. Pulse width. Rise time. Fall time. Distortion (overshoot/undershoot) Fast Fourier Transform (FFT)
I/O Connections:	SMB Jacks (mate with Sealectro 51-024-0000 snap-on or equivalent for RG-188 cable). Two SMB to BNC adapter cables supplied.
Inputs:	J501 - TRIG IN, one TTL load, programmable to active high or low. J502 - CLK IN, one TTL load, negative-edge triggered. Clock high time minimum, 50 ns. Clock low time minimum, 50 ns. J60 - GATE, one TTL load, active low.

Gate high time minimum, 50 ns.
Gate low time minimum, 50 ns.

J70 - VIN+, 140 V peak, absolute maximum.

J80 - VIN-, 140 V peak, absolute maximum.

Outputs (TTL): J30 - CLK OUT, TTL, 1/2 frequency of sample clock, 50% duty cycle.

J40 - TRIG OUT, TTL, active low (trigger detection).

Self Test: The card automatically performs a self test on power-up. The test consists of verifying the CPU and data memory, card's internal buses, and analog input circuitry. Self test may also be performed on command.

Power Requirements: 5 volt and ±15 volt dc power is provided by the internal power supply in the 53/63 Series Card Cage.

Voltage (5-volt Supply): 4.75 V dc to 5.25 V dc.

Current (5-volt Supply): 2.55 A, maximum quiescent.
2.75 A, peak.

Voltage (±15-V Supplies): +14.5 V dc to +15.5 V dc.
-14.5 V dc to -15.5 V dc.

Current +15 Volt Supply: 70 mA, maximum quiescent.
70 mA, maximum peak.

Current (-15-volt Supply): 440 mA, maximum quiescent.
450 mA, peak.

NOTE: The 53A-525 Card requires more 5-volt and -15-volt current than the standard 53A function card. This limits the number and placement of the 53A-525 Cards installed in either the 53A-002, the 53B-003, or the 63A-012 Card Cages.

The limitations are as follows:

53A-002 Card Cage - The total of 5-volt current available to all ten function card slots is 18 A. Function card slots 0 and 1 are additionally limited to a combined total of 4 A. Total 15-volt current available to all cards is 2 A.

53B-003 Card Cage - The total 5-volt current available to all function card slots is 21 A. The total 15-volt current available to all cards is 4 A.

63A-012 Card Cage - The total 5-volt current available to the function card slots 1through 4 is 8.4 A. Function card slot 0 can provide 2.5 A. The total 15-volt current available to all cards is 3 A.

To determine if the peak current requirements for 5-volt will be met for a particular application, add 2.75 A for each 53A-525 Card to be installed together with the amperes of 5-volt peak current required for each other function card to be installed. Refer to the limitations described above to verify that the specified total current is not exceeded.

To determine if the peak current requirements for 15-volt will be met for a particular application, add 450 ma for each 53A-525 Card to be installed together with the amperes of 15-volt peak current required for each other function card to be installed. Refer to the limitations described above to verify that the specified total current is not exceeded.

<u>Cooling</u>:	Provided by the fan in the 53/63 Series Card Cage.
<u>Temperature</u>:	-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.
<u>Humidity</u>:	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.
<u>Dimensions</u>:	197 mm high, 221 mm deep, 13 mm wide. (7.75 in x 8.69 in x 0.5 in).
<u>Dimensions, Shipping</u>:	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping dimensions are: 254 mm x 254 mm x 127 mm. (10 in x 10 in x 5 in).
<u>Weight</u>:	0.48 kg. (1.06 lb).
<u>Weight, Shipping</u>:	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping weight is: 0.82 kg. (1.81 lb).

Mounting Position: Any orientation.

Mounting Location: Installs in any function-card slot of the 53/63 Series Card Cage.

Equipment Supplied:

1 - 53A-525 Waveform Digitizer/Analyzer Card.
1 - Spare fuse (Part # 42202-52001).
1 - Operating manual (Part#00000-15250).
1 - Service manual(Part#00000-25250).
2 - 53A-729 SMB-to-BNC Male Adapter Cable (6ft).

OPERATION

Overview

The 53A-525 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-525 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane. All commands to the 53A-525 Card are ASCII-encoded character strings with both uppercase and lowercase letters accepted. Each command entered must be followed by a delimiter to indicate the end of the command. Valid delimiters for the 53A-525 Card are the carriage-return <CR>, the line-feed <LF>, the colon (:), and the semicolon (;).

The set of valid ASCII characters for the 53A-525 Card is given on the following pages. If any other characters are received, they are ignored. If multiple delimiters are entered (e.g., <CR><LF>), the card ignores the extra character(s), e.g., <LF>. If no delimiter is entered, then the card interprets the next command as being part of the previous command. This causes either an error or an improper setup if the subsequent command is interpreted as a valid part of the previous command.

Commands can be issued at any time. If one of the setup commands (Frequency, Period, Voltage, Trigger Mode, Collect Mode, or Delay) is issued while the card is collecting data, the command will be queued and executed when the next trigger command is received. After a setup command is received, it remains valid until it is respecified or until the card is reset. Any input command (Input, Analyze, or Greatest Value) will terminate collection of data. A Query or Operational Setup command is executed immediately, does not terminate collection, and will give the present status at any time.

If any commands are improperly loaded, the ERR LED comes on. The invalid command and all subsequent commands will be ignored until either the error code is read (see E command), the card is reset (see the R command), or the @XH system halt command is implemented (see Appendix A). If an error occurs, all commands up to the occurrence of the error are still valid unless the card is reset. If input from the card is requested while an error is queued, the card's status (see the Q command's default) will be returned instead of the requested data.

To address a function card for the first time, the @XY system command must be issued. The X is the mainframe address (0-9) selected on the 53A-171 Control Card in the addressed mainframe; the Y is the 53A-525 Card's address (0-9) within the addressed mainframe. The 53A-525 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-525 Card is addressed, the commands described on the following pages may be issued until another function card is addressed. The 53A-525 commands are summarized below. Detailed descriptions of each command are given on the following pages. Where applicable, examples of the responses returned for each command are given.

Numeric Value Formats

When specifying numeric values, fixed or floating-point formats are allowed. No embedded spaces are allowed. All numbers are rounded to the nearest value consistent with their specified range (rounded down if exactly half way), except where otherwise noted in the text. If no sign is specified, the number is assumed to be a positive value.

A number whose absolute value is 5 can be represented by any of the following:

5	+.5E1
+05	-50E-1
-5.0	0.0000000000000005E+16
0.5E+01	

Valid ASCII Characters

The valid ASCII characters for the 53A-525 Card are as follows:

Character(s)	Hexadecimal Equivalent
A through Z	41 through 5A
a through z	61 through 7A
0 through 9	30 through 39
+	2B
,	2C
-	2D
.	2E
/	2F
:	3A
;	3B
<CR>	0D
<LF>	0A

Command Summary

An overview of the commands, listed alphabetically, is as follows:

Command Effect

A Analyze - executes preprogrammed routines to analyze the sampled data.

B Backplane Interrupt - generates an interrupt to the system controller when the conversion process is complete.

C Collect - specifies the data collection mode (pre-trigger, center-trigger, post-trigger, free-run).

D Delay - specifies the time delay between the trigger event and when data collection begins.

E Error - used to examine error conditions.

F Frequency - specifies the sampling frequency.

G Greatest Value - reports the greatest or least value seen since the last trigger.

I Input - sets up the format and addresses of data read from the 53A-525 Card's memory.

J Math Operations - allows the 53A-525 with its high speed floating point coprocessor to be used as a calculator to perform arithmetic operations.

K Calibrate - calculates the offset for a specified voltage range.

M Trigger Mode - specifies the trigger condition for which data collection begins.

O Operational Setup - returns the operational setup parameters of the 53A-525 Card.

P Period - specifies the sampling period.

Q Query Status - returns the current status of the 53A-525 Card.

R Reset - returns the 53A-525 Card to its default, power up state.

S Self Test - causes the 53A-525 Card to execute a self test.

T Trigger - arms the trigger for external triggers and both arms and initiates the trigger for software triggers.

V Voltage - specifies the voltage range and input coupling.

Z Version Level - returns the card number and the current software version level.

Card Commands

Detailed descriptions of the 53A-525 Card's commands, in the same order as listed above, are given in the following pages. Note that except for binary data transfers, all responses from the 53A-525 Card are terminated with <CR><LF>.

Command	Description
A	The A (Analyze) command executes preprogrammed routines for analysis of the stored information. Figure 525-1 (at the end of the A command) illustrates how the data is interpreted. Input requests immediately following an A command return the appropriate information.

Syntax: A[x]

[x] can be any one of the following:

[x]	Definition
A	Average value
B	Ringing high
C	Fast Fourier transform (FFT)
D	Differentiate
E	Ringing low
F	Fall time
H	FFT with Hanning compression
I	Integrate
K	Peak-to-peak voltage
M	Minimum value
N	Maximum negative transition
O	Overshoot
P	Maximum positive transition
R	Rise time
T	True rms value
U	Undershoot
W	Pulse width
X	Maximum value
Z	Zero crossing times

Details of the A[x] Command Descriptions

When using the waveform analysis commands, the signal should be oversampled by a minimum of 8, with an amplitude greater than $\pm10\%$ of the programmed range. That is, the sampling frequency should be a minimum of 8 times the input signal frequency. This applies to the AB, AE, AF, AK, AO, AR, AU, AW, and AZ commands.

Several of the A commands permit or require an A[x]/[y] argument following the command that is defined as follows (unless specified otherwise):

[x] = Optional count from 1 to 16384, specifying the number of samples. If [x] is not specified, it defaults to 16380.

[y] = Optional starting address from -16384 to +16384. If [y] is not specified, it defaults to 0 (the trigger address).

If a response value is followed by a number in parenthesis, that number is the memory location of the response value, relative to the trigger (location 0). An underscore (_) in any example of a command response represents an ASCII space character (20 hex).

All numerical responses to the A[x] command are of the format ±xxx.xxE±xx where x is a decimal digit 0 through 9.

Figure 525-1 (at the end of the A command) gives a graphic example of the measurements taken for many of the A commands. The 0% and 100% points are determined by a complex algorithm that establishes a "steady state" maximum or minimum level or slope, and uses the maximum or minimum (respectively) of that steady state term as the 100% and 0% points. In a perfect sine, square, or triangular wave, the 100% and 0% points will be equal to these maximum and minimum values.

Command	Description
AA[x]/[y]	Average value: This command calculates the average value of the data in memory.

Examples

AA — calculates the average value of 16380 samples beginning at address 0.

AA100 — calculates the average value of 100 samples beginning at address 0.

AA100/3200 — calculates the average value of 100 samples beginning at address 3200.

Example Command Response

Average value of data in memory
AV=_+233.57E-03<CR><LF>

AB

Ringing (high): This command calculates the ringing on the high portion of a signal. The ringing is calculated as the dip below the 100% point following the peak of the signal. The maximum and average values are returned.

Example Command Response

BX = ringing maximum; BA = ringing average

BX=_+400.00E-04_(10380)_BA=_+320.00E-04<CR><LF>

AD[x]/[y]

Differentiate: This command returns the difference between successive data points, where

[x] = the number of samples from 1 to 512, and must be specified;

[y] = optional starting address from -16384 to +16384. If [y] is not specified, it defaults to 0.

Examples

AD10 — returns 10 values, beginning with value 1 - value 0, and ending with value 11 - value 10.

AD2/20 — returns 2 values representing value 21 - value 20, and value 22 - value 21.

Example Command Response

Command = AD3

DV=_-160.00E-04;+240.00E-04;+000.00E-02;<CR><LF>

AE

Ringing (low): This command calculates the ringing on the low portion of a signal. Ringing is calculated as the rise above the 0% point immediately following the valley of the signal. The maximum and average values are returned.

Example Command Response

EX = ringing maximum; EA = ringing average

EX=_+220.00E-03_(12345)_EA=_+120.00E-03<CR><LF>

AF

Fall time: This command calculates the fall times of the sampled signal. The fall time is the time it takes for the signal to complete the transition from 90% to 10% of its steady state value. The maximum, minimum, and average fall times are returned.

Example Command Response

FX = maximum fall time, FM = minimum fall time,
FA = average fall time

FX=_+115.83E-09_(01366)_FM=_+994.05E-10_(00306)_
FA=_+110.57E-09<CR><LF>

AI[x]/[y]

Integrate: This command returns the sum of successive data points.

Examples

AI returns the sum of 16380 samples beginning at address 0.

AI20 returns the sum of 20 samples beginning at address 0.

AI20/100 returns the sum of 20 samples beginning at address 100.

Example Command Responses

IT=_+400.00E-03<CR><LF>

AK

Peak-to-Peak: This command calculates the peak-to-peak voltage of the sampled signal. The peak-to-peak voltage is determined as the difference between the steady-state high of the signal (100% point), and the steady-state low (0% point). The maximum, minimum, and average peak-to-peak voltages are returned.

Example Command Response

KX = maximum peak-to-peak voltage, KM = minimum peak-to-peak voltage,
KA = average peak-to-peak voltage

KX=_+140.80E-01_(01196)_KM=_+132.80E-01_(00336)_
KA=_+138.47E-01<CR><LF>

AM[x]/[y] Minimum voltage: This command returns the minimum voltage stored in memory.

Examples

AM returns the minimum voltage of 16380 samples beginning at address 0.

AM8000 returns the minimum voltage of 8000 samples beginning at address 0.

AM20/-10 returns the minimum voltage of 20 samples beginning 10 samples prior to address 0 (the trigger address) and ending 9 samples after the trigger.

Example Command Response

Minimum value of data in memory

MV=_888.00E-02_(00410)<CR><LF>

AN[x]/[y] Maximum negative transition: This command returns the maximum negative voltage change between any two successive samples in memory.

Examples

AN returns the maximum negative transition found in 16380 samples beginning at address 0.

AN100 returns the maximum negative transition found in 100 samples beginning at address 0.

AN100/300
returns the maximum negative transition found in 100 samples beginning at address 300.

Example Command Response

Maximum negative transition

NT=_-480.00E-02_(01042)<CR><LF>

AO

Overshoot: This command calculates the overshoots of the sampled signal. The overshoot is determined as the difference between the maximum value of a signal and its 100% point. The maximum and average overshoots are returned.

Example Command Response

Overshoot (OX = maximum overshoot, OA = average overshoot)

OX=_+128.00E-02_(00336)_OA=_+710.00E-03<CR><LF>

AP[x]/[y]

Maximum positive transition: This command returns the maximum positive voltage change between any two successive points in memory.

Examples

AP returns the maximum positive transition found in 16380 samples beginning at address 0.

AP100 returns the maximum positive transition found in 100 samples beginning at address 0.

AP100/300
returns the maximum positive transition found in 100 samples beginning at address 300.

Example Command Response

Maximum positive transition

PT=_+328.00E-02_(02082)<CR><LF>

AR

Rise Time: This command calculates the rise times of the sampled signal. The rise time is determined as the time it takes for the signal to complete the transition from 10% to 90% of its steady-state value. The maximum, minimum, and average rise times are returned.

Example Command Response

RX = maximum rise time, RM = minimum rise time,
RA = average rise time

RX=_+143.75E-09_(00466)_RM=_+128.75E-09_(00326)_
RA=_+138.08E-09<CR><LF>

AT[x][y]

True RMS voltage: This command calculates the RMS value of the data in memory. The true RMS (TRMS) is defined as the square root of the sum of the square of each data point divided by the number of samples.

Examples

AT	calculates the TRMS value of 16380 samples beginning at address 0.
AT100	calculates the TRMS value of 100 samples beginning at address 0.
AT100/300	calculates the TRMS value of 100 samples beginning at address 300.

Example True RMS calculation:
The TRMS of three voltages: 0.25 vdc, 0.5 vdc and 0.25 vdc is

sqrt {[(.25 x .25) + (.5 x .5) + (.25 x .25)] / 3} = .35355 vdc

Example Command Response

True RMS value

TR=_+451.34E-02<CR><LF>

AU

Undershoot: This command calculates the undershoots of the sampled signal. The undershoot is determined as the difference between the minimum value of a signal and its 0% point. The maximum and average undershoots are returned.

Example Command Response

Undershoot (UX = maximum undershoot, UA = average undershoot)

UX=_-960.00E-03_(00855)_UA=_-540.00E-03<CR><LF>

AW[x] Pulse width: This command calculates the pulse widths of the sampled signal. The maximum, minimum, and average pulse widths are returned. If [x] = H, then the time the pulse is high is returned. If [x] = L, then the time the pulse is low is returned. If [x] is not specified, then the total time is returned.

Example Command Response

WX = maximum pulse width, WM = minimum pulse width, WA = average pulse width.

AW WX=_+100.25E-07_(00646)_WM=_+997.50E-08_(01047)_
WA=_+100.00E-07<CR><LF>

AWH PX=_+502.50E-08_(00646)_PM=_+497.50E-08_(09847)_
PA=_+500.99E-08<CR><LF>

AWL Px=_+502.50E-08_(10046)_Pm=_+497.50E-08_(01247)_
Pa=_+499.04E-08<CR><LF>

AX[x]/[y] Maximum voltage: This command returns the maximum voltage stored in memory.

Examples

AX	returns the maximum voltage of 16380 samples, beginning at address 0.
AX8000	returns the maximum voltage of 8000 samples, beginning at address 0.
AX200/100	returns the maximum voltage of 200 samples, beginning at address 100.

Example Command Response

Maximum value of data in memory

XV=_+952.00E-02_(01850)<CR><LF>

AZ[x] — Zero Crossing Times: This command calculates the time between successive zero crossing points. If [x] = H, then the time the signal is high is returned. If [x] = L, then the time the signal is low is returned. The maximum, minimum, and average values are returned. If the signal does not cross zero, zeros are returned as the values.

Examples

AZH calculates zero crossing high times.

AZL calculates zero crossing low times.

Example Command Response

ZX = maximum, ZM = minimum, ZA = average

AZH ZX=_+125.45E-08_(11111)_ZM=_+120.34E-08_(02000)_
ZA=_+122.34E-08<CR><LF>

AZL Zx=_+125.45E-08_(12345)_Zm=_+120.34E-08_(02100)_
Za=_+122.34E-08<CR><LF>

The memory location relative to the trigger shown in parentheses is the first of the two successive zero crossing points.

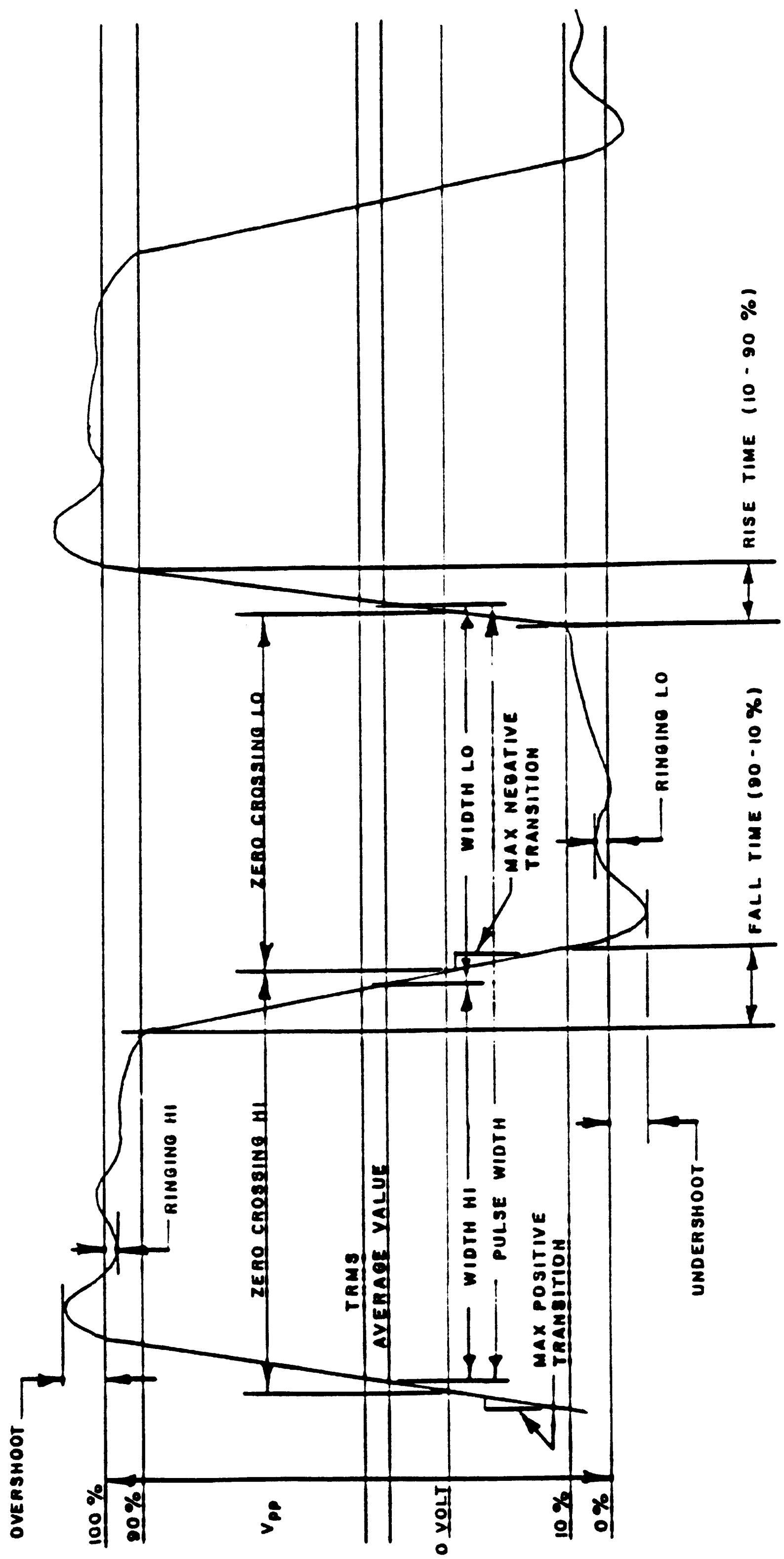


Figure 525-1: A (Analyze) Command Responses

Command	Description
AC	The AC (Analyze-Calculate) command performs a fast Fourier transform (FFT) on the sampled data. (Appendix E provides an overview of Fourier transform theory.)

This command and the Hanning command (AH) described below allow the user to analyze the sampled waveform in the frequency domain. An "N" point FFT is performed, which "slices" the frequency spectrum of the waveform into N/2 frequency components, for a spectrum up to one-half the sampling frequency. Input requests immediately following these commands return the amplitude of each of the frequency components.

Syntax: AC[x][y][z][w]

[x] = V - returns the amplitudes as relative voltage gain P - returns the amplitudes as power.
Not specified: defaults to V

[y] = X - returns the maximum amplitude and its frequency (exclusive of the dc component).
Not specified: Returns the amplitudes of the frequency components.

[z] = 0 to 16383
Optional starting point. If no starting point is specified, the FFT is calculated from the first zero-crossing point found, or from 0 if no zero-crossing is found. When specified, the FFT is performed starting at this offset address.

[w] = Nx where x = 5 to 10
This field specifies the size of the FFT to be performed as a power of 2. For example, if the [w] field is "N10," then a 1024 point transform is done (2**10).
Not specified: Defaults to 10

For [x] = V, the amplitudes are returned in decibels (dB) relative to the programmed input voltage range (VR):

$$\text{Amplitude (dB)} = 20 \log V/V_R$$

For [x] = P, the amplitudes are returned as power in decibels milliwatts (dB mW) into 50 ohms.

$$\text{Amplitude (dB mW)} = (10 \log V^2/R) + 30, \quad R = 50 \text{ ohms}$$

To determine the power in decibel watts, subtract 30 from the returned values. To determine the power into a load other than 50 ohms, add 17 to the returned values, and subtract 10log(RL) where RL equals the resistance of the load.

e.g. The power, in watts, into 100 ohms equals

(returned value) - 30 + 17 - 10log(100)

The frequency resolution of each slice is determined by dividing the sampling frequency by the size of the transform. For example, a waveform sampled at 40 MHz gives a frequency spectrum to 20 MHz.

Using a 1024 point transform, 512 slices are calculated, with the resolution of each of slice being:

40E6/1024 = 39.0625 kHz/slice

The first value returned corresponds to frequency 0 (or dc), the second value corresponds to 39.0625 kHz, the third value corresponds to 78.125 kHz, and so on for each of the 512 slices.

Examples:

ACP100 calculates the FFT starting at address 100, and returns the amplitudes as dBmW. Since no size is specified, it defaults to 1024 (2**10), and a total of 512 values are returned.

ACXN10 would return the maximum voltage in dB and its corresponding frequency. For a 2-volt range and a measured voltage of 1.932V, 20log(1.932/2.01) = -0.29878. (See response example 2 below.)

Responses

ACP100 -163.81E-01;-506.72E-01;...;-279.45E- 01;-302.30E-01;<CR><LF>

Assuming a sampling frequency of 40 MHz (39.0625 KHz/slice), the first value returned, -16.381 dBm, corresponds to frequency 0 (or dc), the second value, -50.672 dBm, corresponds to 39.0625 KHx, etc.

ACXN10 FV=_-298.78E-03;+781.25000E+04;<CR><LF>

indicating a relative voltage gain of -0.29878 dB at 7.8125 MHz.

ACPX FP=_+131.17E-01;+625.00000E+03<CR><LF>

indicating a signal whose maximum amplitude is +13.117 dBm at 625 KHz.

FFT Approximate Execution Times

[w] Field	Transform Size	Execution Time
N5	32	95 ms
N6	64	180 ms
N7	128	375 ms
N8	256	800 ms
N9	512	1.8 s
N10	1024	3.95 s

Command	Description
AH	The AH (Analyze-Hanning) command is identical to the AC command, and calculates a fast Fourier transform (FFT) with Hanning leakage-reduction compensation.

Syntax: AH[x][y][z][w]

The Hanning function reduces the leakage inherent in the fast Fourier transform (see Appendix E).

Each of the time domain points are first multiplied by the following term before it is transformed into the frequency domain:

1/2 - 1/2 (Cos)((2)(pi)(t)/N)

where t = 0 to N, and N = the number of points in the transform (e.g. 1024).

Command Response:
Refer to the AC command response. The AH and the AC command responses are the same format.

Command	Description
B	The B (Backplane interrupt) command generates an interrupt request to the system controller when the data sampling is complete. The card interrupt is cleared when the @XS command is issued (see Appendix A), the card is reset, or the card is rearmed with the Trigger Arm (T) command. Once the B command is issued, it remains valid until the card is reset.

Command	Description
C	The C (Collect) command specifies the relative location of the trigger event in memory by controlling the number of samples taken prior to or after the trigger event.

Syntax: C[x][z][y]

[x] can be any one of the following:

[x]	Definition
C	Center-trigger
F	Free-run
P	Pre-trigger (saves data prior to trigger)
T	Post-trigger (default) (saves data following trigger)
[z] = D	Optional command which delays arming the trigger.

[y] is an optional decimal number from 4 to 8192 that is divisible by 4, and is valid only for [x] = P (pre-trigger) or [x] = T (post-trigger). [y] specifies the number of samples to be collected before a post-trigger event or after a pre-trigger event. If [y] is not specified, then it defaults to 8 for the pre-trigger mode and to 4 for the post-trigger mode. If [y] < 4 (8 for pre-trigger mode) or [y] > 8192, then an error is generated.

Because of a 4 byte pad in memory, the actual number of samples occurring after a pre-trigger event or before a post-trigger event is 4 less than that specified by [y]. (See the Note below.)

Examples:

CC	(center-trigger) collects 8192 samples before and 8188 samples after the trigger event, thus centering the trigger event in memory.
CF	(free-run) collects data independently from any trigger event (data collection stops on any input request command).
CP	(pre-trigger) stops data collection based on the trigger event, so that 16,376 (16384 minus 8) samples are collected before the trigger event. 4 samples will be collected after the trigger event, followed by a 4 byte memory pad. (See the Note below.)
CP100	collects 16,284 (16,384 - 100) samples before the trigger event and 96 samples after the trigger event.
CT	(post-trigger) stops data collection when 16,380 (16384 minus 4) samples have been collected after the trigger event. No samples will be saved before the trigger event. The remaining 4 bytes in memory contain a memory pad. (See the Note below.)
CT100	collects 96 samples before the trigger event and 16,284 (16,384 - 100) samples after the trigger event.

CTD100 same as CT100, except arming of the trigger is delayed to guarantee memory will be filled with sampled data. (See Note 1 below).

CPD100 same as CP100, except arming of the trigger is delayed to guarantee memory will be filled with sampled data. (See Note 1 below).

CCD same as CC, except arming of the trigger is delayed to guarantee memory will be filled with sampled data. (See Note 1 below).

CFD same as CF, except arming of the trigger is delayed to guarantee memory will be filled with sampled data. (See Note 1 below).

Note that the number of samples collected depends on when the T (Trigger arm) command is received, when the trigger occurs, and what the sampling rate is. The 53A-525 Card begins sampling data approximately 100 us prior to arming the trigger, at a maximum of 320 ms following receipt of the T command. If the trigger is already active when the T command is executed, then less data may be collected than expected. For example, if the pre-trigger mode is specified, and the trigger occurs prior to executing the T command, then data will be collected 100 µs prior to the trigger, but only 4 samples of data after the trigger will be collected (only 4 samples followed by a 4 byte pad for the default value of [y]).

In addition, the time needed to initially fill the 53A-525 Card's memory after receiving the T command is 16,384 x the sampling rate. At a slower sampling rate, for example, 25 µs/sample, this time is 16,384 x 25 us, or approximately 410 ms. Therefore, an additional 410 ms of time must be allowed after the T command is executed (prior to a pre-trigger or after a post-trigger) to fill the memory. (See Appendix E).

NOTE: Because the memory is recirculating, there is a transition point between the oldest and the most recent data stored in memory. This transition point is framed within the 4 bytes immediately preceding the stop of data collection and provides a pad to prevent overwriting of the trigger event. For example, if CP300 were programmed, these 4 bytes would reside at addresses 296 through 299. If CT100 were programmed, they would reside at addresses 16284 through 16287 (or -100 to -97). If CC were programmed, they would be at addresses 8188 through 8191. Excluding these 4 bytes in data analysis will prevent any possible misinterpretation of the signal.

Note 1:

The normal sequence of events which occurs when a trigger ("T") command is issued is: (1) Data memory is cleared. (2) Hardware is set up. (3) The card is armed (begins sampling data). (4) Approximately 100 µs after the card is armed, the trigger is armed. If the [z] = D command option is given, the time between when the card is armed (actively sampling data), and the time the trigger is armed is adjusted to guarantee memory will be filled with sampled data. This time period is:

(sampling period)*(number of samples taken prior/after the trigger)*(1.1)

For example, if the sampling period is 50 µs, and "CTD100" were programmed, then (50 µs * 100 * 1.1) = 5.5 ms of data would be sampled before the trigger is armed. If "CPD100", then [50 µs * (16384 - 100) * .1] = 895.6 ms of data would be sampled before the trigger is armed. "CCD" ould collect (50 µs * 8196 * 1.1) = 450.8 ms of data. "CFD" would collect µs * 16384 * 1.1) = 901 ms of data. The maximum time period which n be delayed is 6.55 seconds.

Command	Description
D	The D (Delay) command specifies the time delay between the trigger event and the time that the data collection begins. The delay command is valid only for the post-trigger mode (see "C" command), and is ignored if specified in any other mode.

Syntax: D[x]

[x] is a real number (fixed or floating point) that specifies the delay in seconds, as follows:

[x]	Delay
0.0	No delay (default)
500E-9 to 32.767E-3	Delay (in 500-ns increments)

If [x] is greater than 32.767 ms, then an error is generated.

The last delay value programmed will remain in effect until a new delay value is programmed or the card is reset.

Examples:

1. D0.0 (or simply D) specifies no delay.
2. D150E-6 specifies a 150 μs delay.
3. D0.032767 specifies a 32.767 ms delay.

Command	Description
E	The E (Error) command is used to examine error conditions. Input requests immediately following this command return the error information. Issuing this command and reading the error information clears the error. Since all succeeding commands are ignored following an error condition, only the first error is recorded and returned. The Error command is most useful during the initial program development. Appendix F lists the error codes and the corresponding messages for all error conditions.

Syntax: E[x]

[x] can be any one of the following:

[x]	Definition
A	An ASCII error message is returned.
N	The numeric value of the error code is returned.
Not specified	Defaults to N.

Example Command Response

Command	Response
EA	THRESHOLD EXCEEDS RANGE<CR><LF>
EN	08<CR><LF>

Error Codes

The error codes and corresponding error messages which may be returned by the 53A-525 Card are as follows:

Error Code	Error Message
00	NO ERRORS
01	CPU MEMORY FAILURE
02	DATA MEMORY FAILURE
03	COMMAND EXCEEDS 128 BYTES
04	INVALID VOLTAGE
05	INVALID COMMAND "X"
06	NUMBER ABOVE MAXIMUM FOR "X" COMMAND
07	NUMBER BELOW MINIMUM FOR "X" COMMAND
08	THRESHOLD EXCEEDS RANGE
09	ADDRESS COUNTER FAILURE
10	CHIP SELECT REGISTER FAILURE
11	COMPARATOR FAILURE
12	(Reserved)
13	CALIBRATION ERROR

Error Code	Error Message
14	CONVERSION ERROR, NO NUMBER WAS FOUND
15	CONVERSION ERROR, NO EXPONENT FOUND
16	CONVERSION ERROR, (> 18) DIGITS FOUND
17	EXPONENT WAS TOO BIG +/-4930 MAXIMUM
18	CONVERSION ERROR, INVALID ARGUMENTS
19	(Reserved)
20	CONVERSION ERROR, INDEFINITE RESULT
21	CONVERSION ERROR, + NOT A NUMBER
22	CONVERSION ERROR, - NOT A NUMBER
23	CONVERSION ERROR, + INFINITY
24	CONVERSION ERROR, - INFINITY
25	INVALID MATH OPERATION
26	DIVIDE BY 0
27	OVERFLOW

NOTE: For error codes 05 through 07, X is replaced by the first character of the invalid command.

Command	Description
F or P	The F (Frequency) and P (Period) commands are interchangeable; they specify the frequency or sampling period (frequency = 1/period).

Syntax: F[x] or P[x]

[x] must be specified as a real number or as E. As a real number (fixed or floating point), it specifies the frequency in Hertz, or period in seconds, in one of the following ranges:

25 ns (40 MHz) (default)
50 ns (20 MHz) to 100 s (0.01 Hz) in 50-ns increments

All values are rounded to the nearest period value increment.

To specify an external clock, set [x] = E, and E is then followed by the frequency or period of the external clock. The external clock then defines the sampling frequency or period. See example 3 below.

If [x] is not specified, then an error is generated.

Examples:

1. P100E-9 specifies a period of 100 ns (10 MHz).

2. F20E+3 specifies a frequency of 20 kHz (50 ms).

3. PE125E-9 specifies an external clock with a period of 125ns (8MHz).

4. F25E+6 specifies a frequency of 20 MHz. The 25 MHz value sent corresponds to a 40 nsec period which, when rounded to the nearest period value increment of 50 nsec, results in a 20 MHz sampling frequency.

Command	Description
G	The G (Greatest value) command reports the greatest or least value seen for the programmed voltage range since the last T (Trigger arm) command. If a positive threshold or other trigger is specified, the greatest value is reported. If a negative threshold is specified, the least value is reported. If a threshold trigger is programmed, the G command returns the threshold value if the trigger event has not occurred. Issuing a G command immediately halts any data collection in process. Input requests immediately following this command return the value. Example Command Response GV=_+100.00E-01<CR><LF>

Command	Description
I	The I (Input request) command specifies the address control, the address (relative to the trigger), and the format for data reporting. Input requests immediately following this command return the data. Additional input requests automatically address the next appropriate location. An I command immediately stops any data collection in process. Therefore, an I command should not be issued before the desired data has had time to collect following the Trigger command.

Syntax: I[x][y][z]

[x], the address control, can be any one of the following:

[x]	Definition
D	Automatic decrement to the next address
I	Automatic increment to the next address
Not specified	Defaults to I

[y], the address relative to the trigger, can be any one of the following:

[y]	Definition
+0 to +16384	Positive offset from trigger
-0 to -16384	Negative offset from trigger
Not specified	Defaults to +0

[z], the data reporting format, can be any one of the following:

[z]	Definition
A	ASCII transfer
B	Binary transfer
K[b]	ASCII block transfer, where [b] is the block size (1 to 512)
T	Two's-complement, binary transfer
Not specified	Defaults to A

ASCII Transfer
Data is automatically scaled for ASCII transfers, based on the programmed input range, and reported as seven ASCII characters followed by <CR><LF> in the following format:

Sxx.xxx<CR><LF>

where:	S	=	+ or -
	x	=	Decimal digit (0-9)
	.	=	Decimal point
	<CR>	=	Carriage return
	<LF>	=	Line feed

Example: +12.237<CR><LF> or -00.250<CR><LF>

Binary Transfer
If a binary transfer is specified, then the data is reported in its raw form with no <CR><LF> characters in between or at the end of the transfer. For binary transfers, hexadecimal 00 represents negative full scale, hexadecimal 80 represents 0, and hexadecimal FF represents positive full scale. For two's-complement binary transfers, hexadecimal 80 represents negative full scale, hexadecimal 00 represents 0, and hexadecimal 7F represents positive full scale. A binary transfer is terminated by issuing a new command to the card.

ASCII Block Transfer
For ASCII block transfers, <CR><LF> characters are inserted only at the end of a block, and each value in the block is separated by a semicolon (;).

Examples:

1. II+0A (or simply I) specifies an ASCII transfer with auto-increment and an offset of +0. Input requests following this command return the data in the ASCII format, starting with the data at the trigger event. This is the default mode.

   Example Response

   +00.000E-02<CR><LF>

2. ID-10A specifies an ASCII transfer with auto-decrement starting 10 samples before the trigger event. The input requests following this command return the data in ASCII format.

3. II-5K10 reports ten values (including the trigger value), in the ASCII block format starting five samples before the trigger event and ending four samples after the trigger event.

4. ID10K5 reports five values in the ASCII block format starting ten samples after the trigger event and ending six samples after the trigger event. The command is: input, auto-decrement, start 10 locations after the trigger event, and return 5 ASCII values in a block, for example:

   -01.296;+00.032;+00.784;+01.024;+01.704;<CR><LF>

5. IB returns one byte of binary data for each input request, starting at the trigger address.

Command	Description
J	The J (Math Operations) command allows the 53A-525 to be used as a calculator to perform arithmetic operations. All responses are of the format:

±XXX.XXXXE±XX<CR><LF>

where X is a decimal digit 0 through 9. For the commands below, [x] and [y] must be in a valid numeric format, as described in the Operation section above. Variables and arithmetic operations are not permitted for the command arguments.

Command	Function	Note
JC[x]	cosine	[x] is an angle in radians
JE[x]	exponential (base e)	e^[x]
JF[x]	hyperbolic sine	[x] is an angle in radians
JG[x]	hyperbolic cosine	[x] is an angle in radians
JH[x]	hyperbolic tangent	[x] is an angle in radians
JJ[x]	truncate	truncates the fractional part of [x] (5.23 is truncated to 5.00)
JK[x]	round	rounds [x] to the nearest integer (rounds up for .500...)
JL[x]	log base 10	log [x]
JM[x]/[y]	mod [x][y]	returns the fractional part of [x]/[y] as an integer (returns the integer remainder for a division)
JN[x]	natural log (base e)	ln [x]
JP[x]	arc sine	returns the angle whose sine is equal to [x] radians. Results are in the range -pi/2 to pi/2.
JQ[x]	arc cosine	returns the angle whose cosine is equal to [x] radians. Results are in the range 0 to pi.
JR[x]	arc tangent	returns the angle whose tangent is equal to [x] radians. Numbers are chosen between -pi/2 and pi/2.

Command	Function	Note
JS[x]	sine	[x] is an angle in radians
JT[x]	tangent	[x] is an angle in radians
JX[x]/[y]	exponential (any base)	[x]^[y]

Examples

Command	Response
JL20	+130.1030E-02<CR><LF>
JX10/1.30103	+200.0000E-01<CR><LF>
JM5/3	+200.0000E-02<CR><LF>
JJ-17.43	-170.0000E-01<CR><LF>

Command	Description
K	The K (Calibrate) command calculates the offset for the voltage range specified by [x]. Input requests immediately following this command return the offset value. If [x] is not specified, an error is generated.

Syntax: K[x]

The Calibrate command is used in two ways:

First, during a manual calibration, the command may be used to aid in quickly making offset adjustments (see Appendix C). The offset is read while the adjustment is being made to return a reading as close to 0 V dc as possible.

Second, the command may be used for software calibration during operation. By taking an offset reading at the voltage range of interest, the offset can be compensated for in subsequent measurements by subtracting the offset reading from the measurement value to get a more accurate measurement value. This technique can be used to compensate for long term drift or temperature drift.

Example: K1 selects the 1-volt input range and returns the following calibration data.

KV=_+429.37E-05<CR><LF>

Command	Description
M	The M (trigger Mode) command specifies the trigger condition which starts data collection following a T command.

Syntax: M[x]

[x] can be any one of the following:

[x]	Definition
A	Software trigger; card begins digitizing on T command. This is the default condition.
E+	External trigger, positive, TTL level
E-	External trigger negative, TTL level
P ±0 to ±40	Positive threshold trigger, level in volts (e.g., P+10.250)
N ±0 to ±40	Negative threshold trigger, level in volts (e.g., N+10.250)

Examples:

1. ME+ specifies a positive external trigger.

2. MP+1 specifies a positive threshold trigger of +1 V.

For a threshold trigger, the 53A-525 Card begins digitizing when the input voltage is greater than the programmed threshold for the MP command, or when the input voltage is less than the programmed threshold for the MN command. The threshold value may be positive or negative for both cases. If a threshold level is defined outside the voltage range, an error is generated when the T command is received.

The actual threshold value is based on the per-bit value of the range programmed, and rounded to the nearest increment. The per-bit values are given in the Specifications section of this manual under Resolution.

Example:
If a voltage range of +20V is programmed, and the command MP+10.3 is given, then the threshold value is calculated as follows:

10.3 V / (160.0 mV/bit) = 64.375 bits

Rounded to 64 bits, the threshold value is calculated as follows:

(64 bits) x (160.0 mV/bit) = 10.24 V

Command	Description
O	The O (Operational setup) command gives the operational-setup parameters for the 53A-525 Card in the following format:

M=_[m];C=_[c];V=_[v];P=_[p];L=_[l];D=_[d];<CR><LF>

where:			
	[m]	=	Trigger Mode (A_, E+, E-, P_, N_)
	[c]	=	Collect (C, F, P, T)
	[v]	=	Voltage range/Input coupling (1, 2, 5, 10, 20, 40, A/D)
	[p]	=	Period
	[l]	=	Threshold level
	[d]	=	Delay
	;	=	Semicolon
	<CR>	=	Carriage return
	<LF>	=	Line feed

The default operational setup parameters are:

M = A (Software-trigger mode)
C = T (Post-trigger data collection)
V = 40D (±40-volt range, dc-coupled)
*P = 250.00000E-10 (25-ns period, 40-MHz frequency)
L = -400E-01 (Threshold level, i.e., peak detector at -40V, negative full scale)
D = +000.000E-02 (No delay)

The format for the P response is xxx.xxxxxE±xx;
The format for the L response is ±xxxE±xx;
The format for the D response is ±xxx.xxxE±xx;
where x is a decimal digit from 0 to 9.

The O command returns the actual rounded values set up in the 53A-525 Card and reflects the latest commands received by the card.

Example Command Response

M=_A_;C=_T;V=_40D;P=_250.00000E-10;
L=_-400.00E-01;D=_+000.000E-02;<CR><LF>

* Although only eight significant digits are returned with the O command, the sampling period is stored internally as a double precision number to handle the significant digits required (99.999999995).

Command	Description
Q	The Q (Query status) command returns the current status of the 53A-525 Card for the next input request to the card.

The Q command can request the status of a single condition, or the summation of all five individual conditions. All responses to the command are preceded by the ASCII character S (unique to the status response).

Syntax: Q[x]

[x] can be any one of the following:

[x]	Definition
S	1 = Self-test failed 0 = Self-test passed
E	1 = Programming error 0 = No programming errors
P	1 = Measurement in progress 0 = No measurement in progress
T	1 = Triggered 0 = Not triggered
M	1 = Memory full 0 = Memory not full
Not specified	The default lists all five above conditions (preceded by S) in the order SEPTM. The default presents the current situation for each condition.

Once a Q command is received, all subsequent input requests respond with the specified information until another input type command is received. To query the status of all five conditions, enter the default Q, or query any one of the conditions by entering QS, QE, QP, QT, or QM.

Example Command Response

Q Response while the card is actively collecting data:
S00110<CR><LF>

This command response indicates that the self test was passed; that there are no programming errors; that the measurement is in progress; that it is triggered; and that the memory is not full.

QE Response after the card has been programmed and no programming errors were found:
S0<CR><LF>

Command	Description
R	The R (Reset) command resets the 53A-525 Card to its default power-up state.

The default operational-setup parameters are:

M	=	A (software-trigger mode)
C	=	T (Post-trigger data collection)
V	=	40D (±40-volt range, dc-coupled)
P	=	250.00000E-10 (25-ns period, 40-MHz frequency)
L	=	-400E-01 (Threshold level, i.e., peak detector at -40V, negative full scale)
D	=	+000.000E-02 (No delay)

Command	Description
S	The S (Self Test) command causes the 53A-525 Card to execute a self-test and return to its power-up state. The results of the self test can be obtained by issuing the Q (Query status) or E (Error) command.

Command	Description
T	The T (Trigger arm) command arms the trigger through the following sequence: 1) Data memory is cleared. 2) Hardware is set up, based on previously loaded commands or their defaults. 3) 53A-525 Card is armed. 4) Data collection begins following the T command as specified by the Trigger Mode command (see the M command). All future T commands repeat the above sequence until the card is reset. There is a maximum latency of 290 ms between the time the T command is received and when the card is armed.
TF	The TF (Trigger Arm Fast) command performs the same sequence as the "T" command, except that data memory is not cleared. This reduces the maximum latency to 22 ms. If ac coupling is specified in the V command, an additional 500 ms is added to the trigger latency time for both time T and TF commands.

Command	Description
V	The V (Voltage range) command specifies the input coupling and the voltage range.

Syntax: V[x][y]

[x] can be any one of the following:

[x]	Definition
A	ac coupling
D	dc coupling
Not specified	dc coupling

[y] is a 1- or 2-digit decimal number that specifies the voltage range, as follows:

[y]	Definition
1	±1 V
2	±2 V
5	±5 V
10	±10 V
20	±20 V
40	±40 V (default)

If a voltage range other than one of the above is specified, an error is generated.

Example:

1. VD10 specifies a dc-coupled, ±10-volt range.

2. VA5 specifies an ac-coupled, ±5-volt range.

3. V1 specifies a dc-coupled, ±1-volt range.

Command	Description
Z	The Z (Version Level) command returns the card number and the current software version level. The format of the response is: CDS_53A-525_VX.X<CR><LF> where X.X is the current software version level (for example, 1.0).

INSTALLATION

The 53A-525 Card is a function card; therefore, it may be plugged into any blue card slot. Setting the Address Select switch defines the card's programming address. To avoid confusion, it is recommended that the slot number and the programming address be the same.

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

a. Match the keyed slot on the card to the key in the backplane connector (the component side should be to the right).

b. There are two ejectors on the card. Make sure the ejector marked "53A-525" is at the top for the 53A System, and to the left for the 63A System.

CAUTION:
The 53A-525 Card requires more +5-volt dc current than the standard 53A function card, limiting the number and placement of 53A-525 Cards in the 53A, the 53B, and the 63A Card Cage installations. Refer to the Power Requirements under the Specifications section for more information.

CAUTION:
Make sure the single-ended Input Switch (S61) is in the OFF position before making any connection to the bottom connector (see page 525-3).

CAUTION:
The 53A-525 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. The 53A-525 Card response to the @XS command is defined by the Backplane (B) command. If the B command has been issued, the 53A-525 Card will generate an interrupt when the sampling is completed.
@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. If the Halt switch is ON, then the 53A-525 Card resets to its power-up state. If the switch is off, any activity in progress stops, but all operational setup parameters remain at the same value. 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 Series System's communications card in each card cage. When the system controller issues a STOP command, each function card (including the 53A-525 Card) reacts as if it had received the @XH command described above. How the system controller executes the 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

EXTERNAL INPUTS/OUTPUTS

Analog Input (VIN+ (J70); VIN- (80)

These connectors provide the signal interface to the 53A-525 Card. VIN+ corresponds to the high side of the differential signal, and VIN- for the low side. Single-ended signals should use VIN+ as the signal input, with VIN- connected to the ground. For test configurations which use only single-ended inputs, the single-ended input switch (see page 525-3) can be used to ground VIN-.

CAUTION:

This switch must be in the OFF position when applying signals to the VIN- input or damage to the 53A-525 or to the equipment being measured may occur.

Gate Input (GATE (J60))

The Gate input is used to inhibit triggering and sampling of the 53A-525 Card. If active when the card is armed, the gate input disables the trigger of the 53A-525 Card. Once the card has been triggered, the Gate input can be used to inhibit sampling of the data. Used in conjunction with the various trigger modes of the 53A-525 Card and the external clock input, very precise control of the sampled data can be achieved. The Gate input is an active low TTL signal.

External Clock Input (CLK IN (J502))

The external clock input allows the user to control the sampling rate of the 53A-525 Card. The clock can be varied up to a maximum frequency of 10MHz. Any duty cycle is permitted, with the constraint that the minimum clock-high and clock-low times are 50 ns each. Data is sampled on the high-to-low transition of the clock. The external clock is a TTL level input, and can be optionally terminated using the J1 pads located immediately to the right of J502.

The external clock is internally synchronized to the 53A-525 40 MHz internal clock. This creates a 25 ns uncertainty which could cause a phase shift in the sampled data. The amount of phase shift (in degrees) is equal to:

(25 ns x 360)/(period of the external clock)

At 100 KHz this is equivalent to a 0.9 degree shift; at 1 MHz, a 9 degree shift in phase.

External Trigger Input (TRIG IN (J501))

The external trigger input allows the user to control when the 53A-525 Card begins sampling data. This is a TTL level triggered signal, with the active state programmable to either high or low.

Trigger Out (TRIG OUT (J40))

The trigger out signal is an active low TTL output indicating that the 53A-525 Card trigger event has occurred. This signal remains low until the 53A-525 Card is re-armed.

Clock Out (CLK OUT (J30))

The clock out signal corresponds to one-half the frequency of the sampling clock. Clock out is a 50% duty cycle, TTL level signal, and is active only while the 53A-525 Card is sampling data.

APPENDIX C

CALIBRATION PROCEDURE

The 53A-525 Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibration should be carried out in an environment where the temperature is between 21 °C and 25 °C.

Required Test Equipment:

- 4 1/2 digit voltmeter (DVM)
- 1 MHz function generator
- Dual channel oscilloscope with invert and add features
- Two BNC-to-SMB connectors
- One BNC-to-microclip adaptor
- One BNC "T" connector

Procedure:

Refer to Figure 525-2: The 53A-525 Card Assembly Drawing, for the locations of the test points and the potentiometers.

NOTE: The J70 and J80 connector bodies may be used as a ground reference.

Perform each of the following steps, in sequence:

1. Allow the unit to warm up for 10 minutes.

2. Analog Voltage Reference:

   a. Connect the DVM to test point TP11 located to the left of L1041 (See note above for ground reference).

   b. Adjust the analog reference potentiometer (R941) so that the DVM reads -2.04 V dc (±4.0mV).

3. Positive offset adjustment:

   a. Connect the DVM to test point TP4 located to the right of U90.

   b. If the DVM reads outside of ±100 mV, then adjust the offset potentiometer (R912) until the DVM reads 0.0 V (±5mV).

   NOTE: This step performs a coarse adjustment only. Step 6 performs the vernier adjustment.

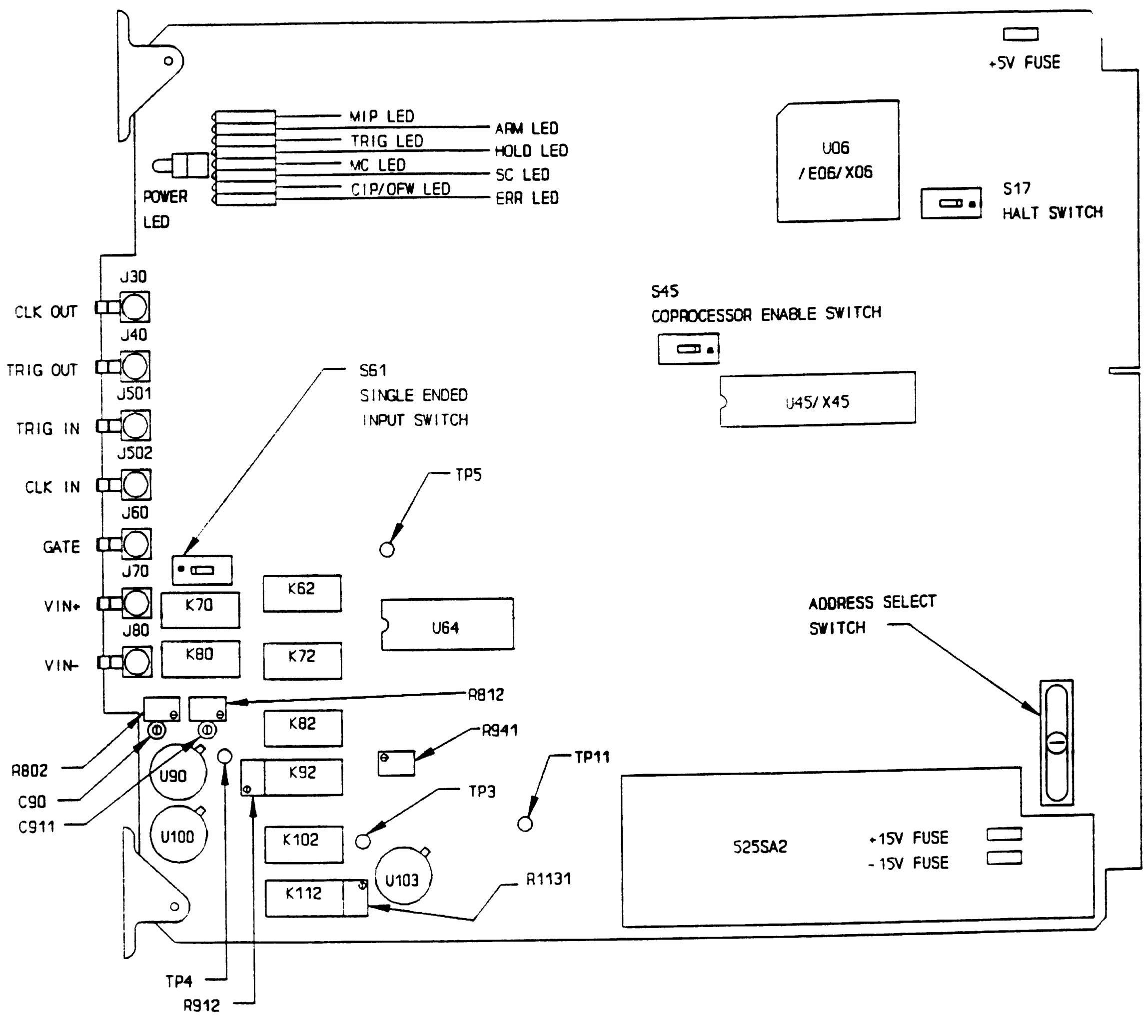


Figure 525-2: 53A-525 Card Assembly Drawing

4. Analog Signal Reference:

   a. Connect the DVM to test point TP3 located to the left of U103.

   b. If the DVM reads outside of -1.0 V ±100 mV, then adjust the reference potentiometer (R1131) until the DVM reads -1.0 V (±10mV).

   NOTE: This step performs a coarse adjustment only. Step 6 performs the vernier adjustment.

5. Disconnect the DVM from the 53A-525 Card.

6. Bias Adjustment:

   a. Send the following command string to the 53A-525 Card; and read back the offset voltage from the card.

      @XYK1;

      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-525 Card's address select switch.

      An example of the data returned from this command is

      KV= +123.70E-04<CR><LF>

      indicating 12.37 mV. [<CR> is the ASCII carriage return character (0D hex), and <LF> is the ASCII line feed character (0A hex)].

   b. Repeat step 6a, adjusting potentiometer R912 until the calibration value returned is 0.0 V ±4 mV for three sequential runs.

   c. Send the following calibration command string to the 53A-525 Card, and read back the offset voltage from the card.

      K40;

   d. Repeat step 6c, adjusting potentiometer R1131 until the calibration value returned is within 0.0 V ±100 mV for three sequential runs.

   e. Repeat steps 6a through 6d until the values from 6a and 6c are both within specifications.

7. Coarse positive signal adjustment:

   a. Set up the function generator to output a square wave at 100 KHz ±10 KHz, with a positive peak at +0.5V ±50 mV and a negative peak at -0.5V ±50 mV. Connect the function generator to channel 1 of the oscilloscope, and to J70 of the 53A-525 Card. Connect channel 2 of the oscilloscope to test point TP5 located to the left of U541 (or to U64 pin 24 for revision level 8703) on the 53A-525 Card. Make sure there is no connection to J80, then set the single ended input switch located to the right of J60 to the ON position.

b. Send the following command string to the 53A-525 Card:

CF;V1;T;

c. Use the invert and add features of the scope to display the difference signal between the two channels. The display will appear as a series of spikes corresponding to the propagation delay between the two channels. Adjust the distortion (C90) and gain (R802) so that the difference signal between the spikes returns to zero in an exponential fashion.

Figure 525-3 shows representative displays of properly and improperly adjusted signals.

NOTE: This step performs the coarse adjustment only for R802. The vernier adjustment is performed in step 11.

NOTE: Make sure that both channels of the scope and probes are calibrated. Set the two channels of the scope to 100 mV/div, and to ac coupling.

8. Coarse negative signal adjustment:

a. Set the single ended input switch located to the right of J60 to the OFF position. Move the BNC-to-SMB connector from J70 to J80 of the 53A-525 Card.

b. Send the following command string to the 53A-525 Card:

CF;V1;T.

c. Observe the oscilloscope.

NOTE: The invert switch of the scope should not be used when displaying the difference signal for this step.

Adjust the distortion (C911) and gain (R812) so that the difference signal between the spikes returns to zero in an exponential fashion.

NOTE: This step performs the coarse adjustment only for R812. The vernier adjustment is performed in step 14.

9. Disconnect the function generator and the scope from the 53A-525 Card.

10. Repeat step 6, and then proceed to step 11.

11. Fine positive gain adjustment:

a. Connect the function generator to the DVM, and to J70 of the 53A-525. Set the single-ended input switch located to the right of J60 to the ON position.

b. Set up the function generator to output +4.5 V ±100 mV dc. (Be sure this voltage is dc.)

c. Send the following command string to the 53A-525 Card:

CT;V5;T;

d. Determine the average value in memory by sending the following command string to the 53A-525 Card, and reading the results back.

AA;

An example of the data returned from this command is

AV= +455.40E-02<CR><LF>

e. Repeat steps 11c and 11d, adjusting potentiometer R802 until the average value returned is within ±5 mV of the value read on the DVM for three sequential runs.

f. Set up the function generator to output -4.5 V ±100 mV dc. (Be sure this voltage is DC.)

g. Repeat steps 11c and 11d. Calculate the deviation range as the difference between the absolute value of the DVM reading and the absolute value of the measurement from this step.

<u>Example</u>:
DVM Reading = -4.53 V.
Reading from step 11d = -4.57 V.
Difference = Absolute value (-4.53) - Absolute value (-4.57) = -40 mV.
Deviation Range = Absolute value (-40 mV/2) + 10 mV = 30 mV.

h. Repeat steps 11b through 11d, alternating between the positive and negative level inputs for step 11b, and adjusting R802 until both average values are within their respective DVM readings plus or minus the deviation range calculated in step 11g. The goal is to get one reading high by the same amount the other reading is low.

12. Repeat step 7, adjusting for distortion (C90) only, and then proceed to step 13. At this point, minimum distortion should appear as a low-level square wave for the difference signal.

13. Repeat step 11, and then proceed to step 14.

14. Common Mode Rejection:

a. Set the single-ended input switch located to the right of J60 to the OFF position. Using the T connector, connect the function generator to both J70 and J80 of the 53A-525 Card. Connect channel 1 of the oscilloscope to test point TP5 on the 53A-525 Card, and set to ac coupling. Set up the function generator to output a 20 Vpp ±200 mV sine wave at 1 kHz ±100 Hz, referenced about 0 VDC.

b. Send the following command string to the 53A-525 Card:

CF;V1;T;

c. Ideally, the scope would display a straight line (or noise) at its lowest [illegible]ge. A low-level sine wave will be observed at 1 KHz. Adjust potentiomete[illegible] 812 to minimize the amplitude of the sine wave.

15. Repeat step 6 to complete the calibration.

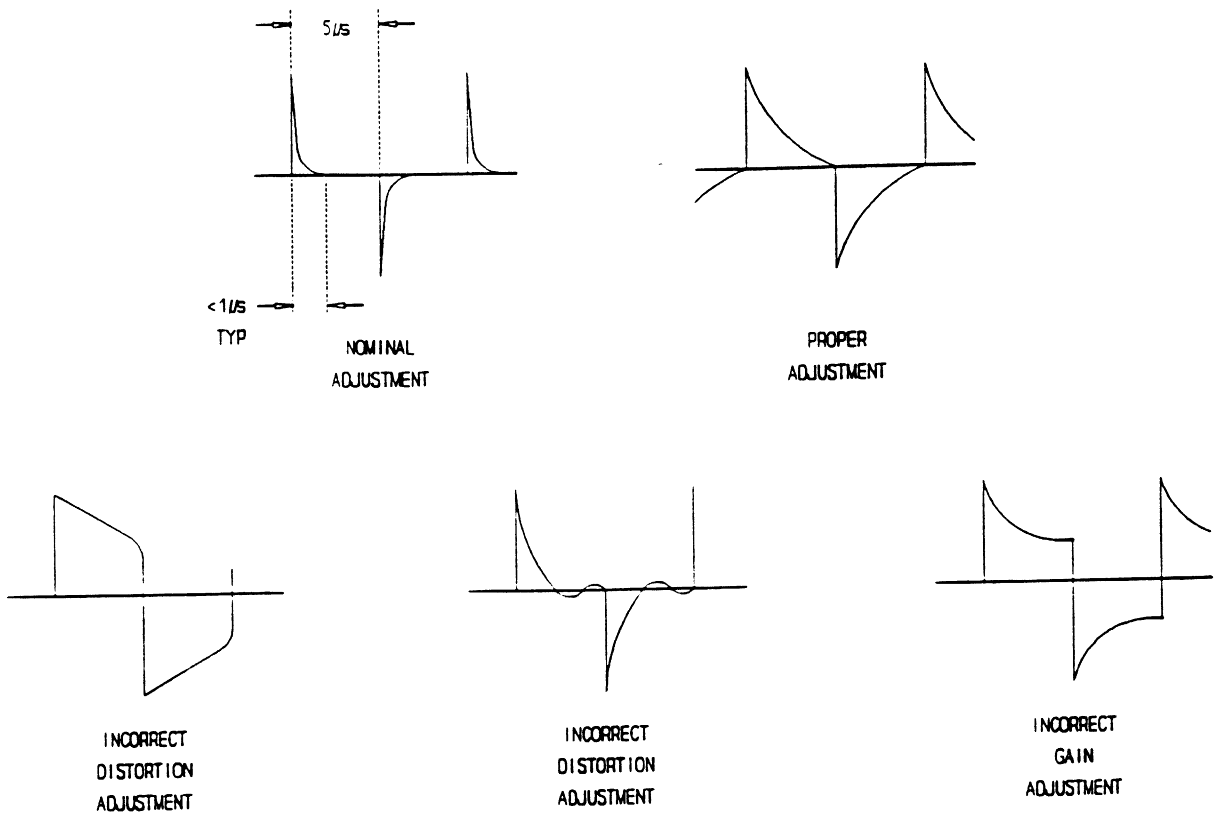
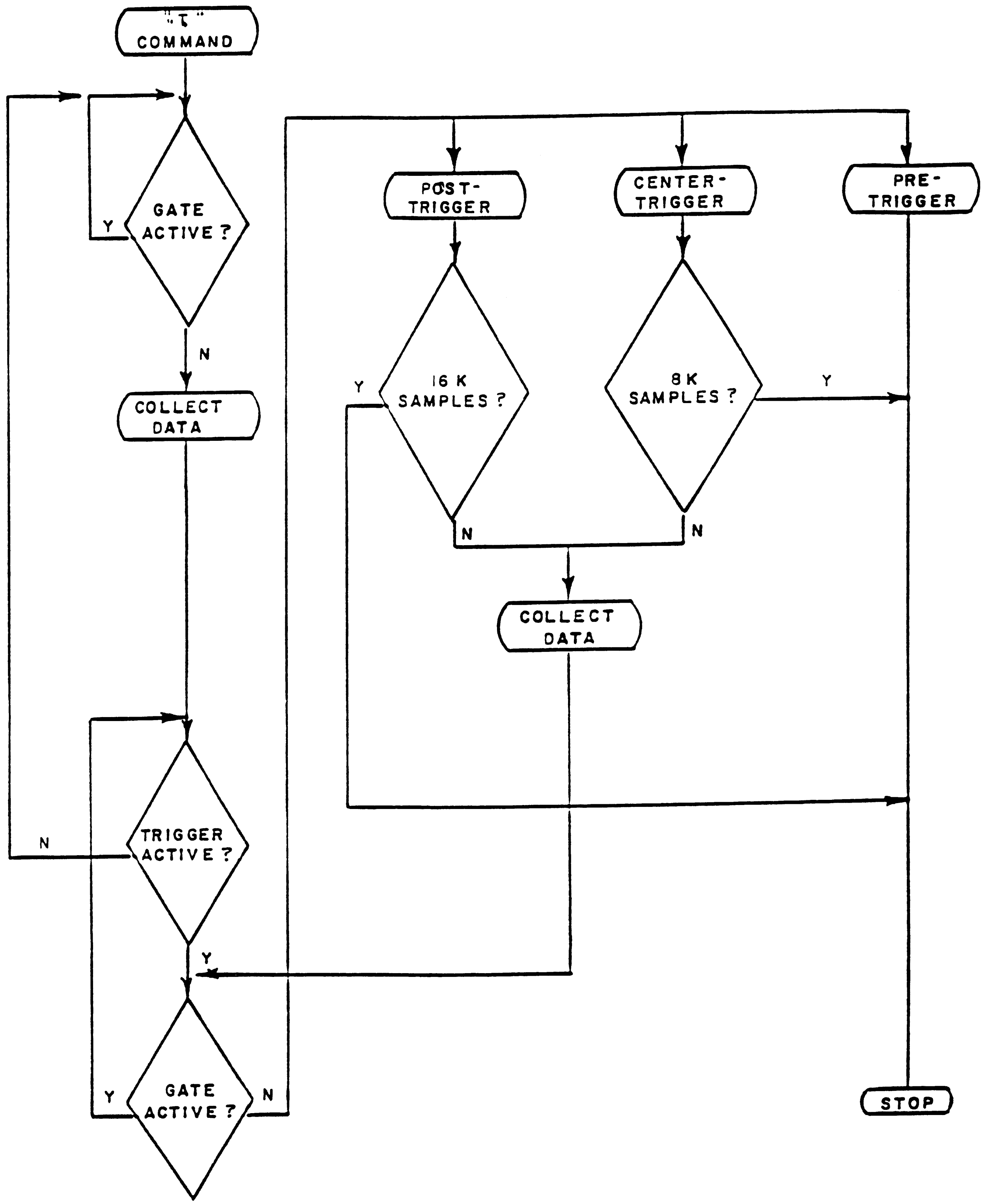


Figure 525-3: Difference Voltages

APPENDIX D

TRIGGERING COLLECTION CONTROL



APPENDIX E

USING THE FOURIER TRANSFORM FOR SAMPLED SIGNALS

The following is a brief discussion of the basic principles of Fourier transform theory. For more information on the subject refer to The Fast Fourier Transform by E. Oran Brigham, published in 1974 by Prentice-Hall, Incorporated.

The Fourier transform is a method for converting a time domain sample signal into the frequency domain to provide a spectral representation of the sample signal. The spectral representation is determined by decomposing a waveform into a sum of sinusoids of different frequencies. The Fourier transform identifies the different frequency sinusoids (and their respective amplitudes) which combine to produce a waveform.

The discrete Fourier transform approximates the continuous Fourier transform for sampled signals. The fast Fourier transform is a method of performing a series of computations to compute the discrete Fourier transform more quickly.

The discrete Fourier transform approximates the continuous transform when the sampling interval T is sufficiently small. If T is chosen too large, distortion of the Fourier transform occurs. This distortion is known as aliasing, and occurs because the time function was not sampled at a sufficiently high rate to accurately represent the signal. Aliasing introduces invalid frequency components into the transform. To minimize aliasing, the sampling frequency F must be chosen to be a minimum of twice the frequency of the highest frequency component f(c) of the signal. This may be written

$$F = 1/T = 2f(c)$$

where sampling frequency F is known as the Nyquist sampling rate, and the Fourier transform is said to be band-limited at the highest frequency f(c). In other words, the Fourier transform is ideally zero for frequencies above f(c). It should be noted that rarely can a waveform be band-limited. To minimize aliasing effects, the signal should be sampled at a rate such that aliasing becomes negligible; and low pass filtered, to the extent possible, to approach band-limiting.

Since the discrete transform is considered over infinity, it becomes necessary to truncate the sampled signal for digital analysis, because only a finite number of samples N can be taken. The effect of this truncation is to convolve a sin(x)/x factor into the transform, which causes leakage into the frequency components of the adjacent cells. By increasing N, the sin(x)/x factor more closely approximates an impulse, and less error is introduced.

Also note that since the Fourier transform is periodic, the discrete transform also requires periodicity. In order to best approximate the continuous transform, an integral number of cycles of the time domain waveform needs to be contained within the sample period. If the truncation interval is a multiple of the period, the frequency domain sampling function will coincide with the zeros of the sin(x)/x function, canceling its effect.

To summarize, the class of waveforms for which the discrete and continuous Fourier transforms are approximately the same requires that

1. the sampling rate be at least twice the frequency of the highest frequency component of the time function;

2. the time function be band-limited (i.e., no frequencies must exist above one-half the sampling frequency);

3. the time function be periodic; and

4. an integer multiple of the cycles of the time function be within the sample period.

If the signal is band-limited and periodic, but the truncation interval is not equal to an integer multiple of the time period, the following errors result:

1. The frequency function has an impulse at zero frequency representing the average value of the truncated waveform. This occurs because the signal does not average out to zero over time, and causes a dc component to appear in the spectrum.

2. The frequency function no longer appears as a single impulse, but rather as a continuous function of frequency, with a local maximum centered at the original frequency, and a series of other peaks termed sidelobes. These sidelobes are introduced by the sin(x)/x factor, and are responsible for the additional frequency components which occur in the spectral representation. This effect is termed leakage, and is inherent in the discrete transform because of time domain truncation. To reduce this leakage, it is necessary to employ a time domain truncation function which has sidelobe characteristics of smaller magnitude than those of the sin(x)/x function. The smaller the sidelobes, the less leakage in the discrete transform. The Hanning function is a particularly good truncation function, and is given by

$$x(t) = 1/2 - 1/2(\cos((2)(pi)(t) / T(c))$$

   where t is the relative time of the sample, and T(c) the truncation interval. This significantly reduces the leakage. The tradeoff for reducing the leakage is that the non-zero frequency components are considerably broadened or smeared with respect to the impulse function.

APPENDIX F

PROGRAMMING EXAMPLES

The sample program below is written in Advanced BASIC (BASICA) for an IBM PC. The PC is connected to the CDS 53/63 Series Card Cage using a 53A-903 Card installed in the PC. The 53A-903 I/O Card provides an IEEE-488 interface between the PC and the CDS Card Cage. The 53A-525 Card has been set to address 9. The address of the 53/63 Card Cage containing the 53A-525 Card is address 1.

The following sample program reads the status of the card, programs the trigger and data collection modes, programs the voltage range and sampling period, and sets the status of the card for completion of data collection. It then reads back a number of parameters concerning the data, including the maximum value, maximum transition peak-to-peak values, average values, and pulse width and zero crossing data. The signal input is a 100 Khz sine wave at 8 Vpp, with a 500 mV offset.

For this program, PCX is a variable containing the IEEE-488 address of the CDS 53/63 Series Card Cage, and GPIB0 is a variable containing the IEEE-488 address of the 53A-903 I/O card. The 53A-903 commands used in this program are:

IBFIND Returns a unit descriptor associated with the name of the device.

IBTMO Sets the device timeouts.

IBWRT Writes the contents of a string variable to the 53/63 Series Card Cage.

IBRD Reads data bytes from the 53/63 Series Card Cage and stores them in string variables.

Sample BASIC Program

In this program listing, lines which are indented and not preceded by a line number are not part of the BASIC program. They are inserted here as comments to explain what the program is doing at each numbered line.

NOTE: Lines 1 through 50 are included in the program to initialize the 53A-903 IEEE-488 interface card in the PC. In this example program, RD$ is filled with spaces prior to each IBRD statement. The number of spaces used is equal to the number of data bytes to be received. This is done to show the exact number of data bytes returned at each input statement.

```
1    CLEAR  ,60000!

2    IBINIT1 = 60000!

3    IBINIT2 = IBINIT1 + 3
```

4 IBLOAD "BIB.M",IBINIT1:KEY OFF

5 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)

6 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
IBCMDA,IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
IBWRTI,IBRDIA,IBWRTIA,IBSTA%,IBERR%,IBCNT%)

10 BDNAME$="PCX":CALL IBFIND (BDNAME$,PCX%)
Find the IEEE-488 devices.

20 BDNAME$="GPIB0":CALL IBFIND(BDNAME$,GPIB0%)

30 CALL IBSIC(GPIB0%):CALL IBCLR(PCX%)
Reset the IEEE-488 devices.

40 TIMEOUT%=0
Disable the device timeouts.

50 CALL IBTMO(PCX%,TIMEOUT%):CALL IBTMO(GPIB0%,TIMEOUT%)

60 TERM$ = CHR$(13) + CHR$(10)
Set the terminator for the card to be the ASCII carriage return and line feed characters.

70 WRT$ = "@19O" + TERM$:CALL IBWRT(PCX%,WRT$)
Initially address the mainframe and the 53A-525 card, and request the card's current Operational Status. Since this is the state of the card following power up, the data returned is the default setup of the card. In the comment fields, <CR><LF> represents the ASCII carriage return and line feed characters.

80 RD$ = SPACE$(68):CALL IBRD(PCX%,RD$)

90 PRINT "53A-525 DEFAULT SETUP"

100 PRINT LEFT$(RD$,66)

The data returned is
M= A ;C= T;V= 40D;P= 250.00000E-10;L= -400.00E-01;
D= +000.000E-02;<CR><LF>

This response indicates the trigger mode (M = A) is set to trigger on command. The collect mode (C = T) is set to post-trigger, so that 16380 samples will be collected after the trigger occurs. The voltage range is set to ±40 volts, direct coupled. The sampling period is 25 nS (40 Mhz). The greatest value comparator is set to minus full scale, and no delay is active.

110 WRT$ = "V5;T" + TERM$:CALL IBWRT(PCX%,WRT$)
This command sets the voltage range to ±5 volts, and triggers the card.
Remember that <CR>, <LF>, ; , and : are all valid delimiters for the 53A-525, so

the ; following V5 delimits the VOLTAGE command, and the <CR> of TERM$ delimits the Trigger command.

120 WRT$ = "Q" + TERM$:CALL IBWRT(PCX%,WRT$)
The QUERY command returns the current active status of the card.

130 RD$ = SPACE$(8):CALL IBRD(PCX%,RD$)

140 PRINT "CURRENT STATUS -> ";:PRINT LEFT$(RD$,6)

The data returned is S00011<CR><LF>

The S indicates this is a status response, and is the only response returned by the card with a leading S. The left-most 0 indicates the card self test passed, the next zero indicates there are no programming errors, the next zero indicates that no measurements are being taken, the next 1 indicates the card has triggered, and the final 1 indicates that memory is full.

Since sampling is complete, commands can now be issued to look at the data sampled. The following lines return and print the maximum value of the data stored in memory using the Analyze command.

150 WRT$ = "AX" + TERM$:CALL IBWRT(PCX%,WRT$)

160 RD$ = SPACE$(25):CALL IBRD(PCX%,RD$)

170 PRINT "MAXIMUM VALUE -> ";

180 PRINT LEFT$(RD$,23)

Example data returned from the above sequence is
XV= +452.00E-02 (00408)<CR><LF>
indicating the maximum value is 4.52 V at location 408.

190 OFFSET$ = MID$(RD$,18,5)
To look at the data at the maximum value location, the Input command is used with the offset determined by reading in the location value from the AX response.

200 WRT$ = "I" + OFFSET$ + TERM$:CALL IBWRT(PCX%,WRT$)

210 RD$ = SPACE$(9):CALL IBRD(PCX%,RD$)

220 PRINT "DATA VALUE LOCATION " + OFFSET$ + " -> ";

230 PRINT LEFT$(RD$,7)

Example data returned is +04.520<CR><LF>

To look at the data at the next location, issue another read.

240 CALL IBRD(PCX%,RD$)

```
250 PRINT "NEXT DATA VALUE -> ";:PRINT LEFT$(RD$,7)

260 WRT$ = "AP" + TERM$:CALL IBWRT(PCX%,WRT$)
```

Determine the maximum positive transition in memory.

```
270 RD$ = SPACE$(25):CALL IBRD(PCX%,RD$)

280 PRINT "MAXIMUM POSITIVE TRANSITION -> ";

290 PRINT LEFT$(RD$,23)
```

Example data returned is PT= +240.00E-03 (01508)<CR><LF>

```
300 OFFSET$ = MID$(RD$,18,5)
```

To look at four data values beginning at the maximum transition, the Input Block command can be used, again getting the address from the response.

```
310 WRT$ = "I" + OFFSET$ + "K4" + TERM$:CALL IBWRT(PCX%,WRT$)

320 RD$ = SPACE$(4 * 8 + 2):CALL IBRD(PCX%,RD$)

330 PRINT "POSITIVE TRANSITION DATA -> ";:PRINT LEFT$(RD$,4* 8)
```

Example data returned is +00.320;+00.560;+00.800;+01.040;<CR><LF>

```
340 WRT$ = "AK" + TERM$:CALL IBWRT(PCX%,WRT$)
```

To look at the peak-to-peak values, the AK command is used. Note that the CIP/OFW LED blinks while the command is being executed.

```
350 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

360 PRINT "PEAK TO PEAK VOLTAGES"

370 PRINT LEFT$(RD$,63)
```

Example data returned is

KX= +804.00E-02 (00408) KM= +796.00E-02 (06800)
KA= +800.42E-02<CR/LF>

The peak-to-peak maximum (KX) is 8.04 Volts at location 408, the minimum (KM) is 7.96 volts at location 6800, and the average (KA) is 8.0042 volts.

```
380 WRT$= "AA" + TERM$:CALL IBWRT(PCX%,WRT$)
```

To look at the average value of the data, use the AA command.

```
390 RD$ = SPACE$(17):CALL IBRD(PCX%,RD$)

400 PRINT "AVERAGE VALUE -> ";

410 PRINT LEFT$(RD$,15)
```

Example data returned is AV= +499.32E-03<CR><LF>

indicating the 0.5 volt offset of the input signal.

The next set of commands determines the pulse widths and zero crossing times. Note that because of the 0.5 volt offset, the two are not the same. The pulse width uses the difference between the maximum and minimum values in memory as its reference, whereas the zero crossings use absolute zero.

```
420 WRT$ = "AW" + TERM$:CALL IBWRT(PCX%,WRT$)

430 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

440 PRINT "PULSE WIDTHS"

450 PRINT LEFT$(RD$,63)

460 WRT$ = "AWH" + TERM$:CALL IBWRT(PCX%,WRT$)

470 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

480 PRINT "PULSE WIDTH HIGHS"

490 PRINT LEFT$(RD$,63)

500 WRT$ = "AWL" + TERM$:CALL IBWRT(PCX%,WRT$)

510 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

520 PRINT "PULSE WIDTHS LOWS"

530 PRINT LEFT$(RD$,63)

540 WRT$ = "AZH" + TERM$:CALL IBWRT(PCX%,WRT$)

550 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

560 PRINT "ZERO CROSSING HIGHS"

570 PRINT LEFT$(RD$,63)

580 WRT$ = "AZL" + TERM$:CALL IBWRT(PCX%,WRT$)

590 RD$ = SPACE$(65):CALL IBRD(PCX%,RD$)

600 PRINT "ZERO CROSSING LOWS"

610 PRINT LEFT$(RD$,63)
```

An alternative method of determining the frequency of the signal is to use the Fourier Transform commands. The transform splits the sampled signal into 512 individual frequencies from dc to half the sampling frequency. To center the waveform in the frequency spectrum for a known input frequency, the data should be sampled at 4 times the input frequency. AC coupling is also specified in this example to eliminate the effects of the dc offset.

```
620 WRT$ = "VA5;F400E3;T" + TERM$

630 CALL IBWRT(PCX%,WRT$)

640 WRT$ = "QM" + TERM$:CALL IBWRT(PCX%,WRT$)
```

To ensure the transform command is not issued prior to memory being filled, the QM command is used.

```
650 RD$ = SPACE$(4)

660 CALL IBRD(PCX%,RD$):IF MID$(RD$,2,1) = "0" THEN GOTO 660

670 WRT$ = "ACVX" + TERM$:CALL IBWRT(PCX%,WRT$)

680 RD$ = SPACE$(75):CALL IBRD(PCX%,RD$)

690 PRINT "MAXIMUM VOLTAGE (dB) = ";

700 PRINT MID$(RD$,5,11)

710 PRINT "FREQUENCY = ";

720 PRINT MID$(RD$,17,14)

730 INPUT "type enter to end program", DUMMY$

740 END
```

APPENDIX G

PERFORMANCE VERIFICATION

The following procedure may be performed between calibrations to verify that the 53A-525 meets the published accuracy specifications. The 53A-525 Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. The calibration procedure is detailed in Appendix C.

Required Test Equipment:

- 4½ digit voltmeter (DVM)
- 1 MHz function generator
- Dual channel oscilloscope with invert and add features
- Two BNC-to-SMB connectors
- One BNC-to-microclip adaptor
- One BNC "T" connector

Procedure:

Refer to Figure 525-2: The 53A-525 Card Assembly Drawing, for the locations of the test points.

NOTE: The J70 and J80 connector bodies may be used as a ground reference.

Perform each of the following steps, in sequence:

1. Allow the unit to warm up for 10 minutes.

2. Analog Voltage Reference Verification:

   a. Connect the DVM to test point TP11 located to the left of L1041 (See note above for ground reference).

   b. Verify that the DVM reads -2.04 V dc ±10 mV.

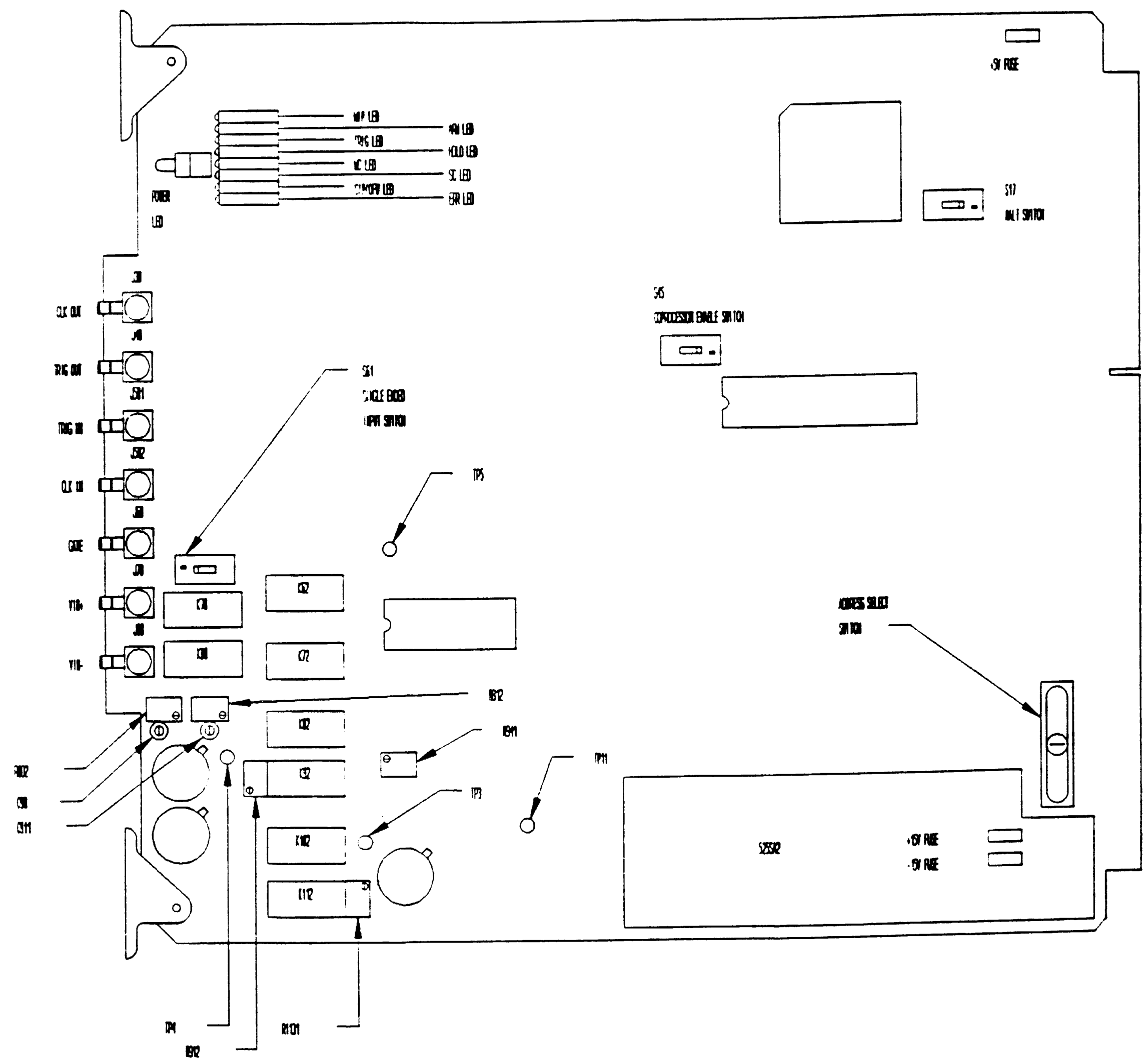


Figure 525-2: 53A-525 Card Assembly Drawing

3. Bias Verification:

a. Send the following command string to the 53A-525 Card; and read back the offset voltage from the card.

@XYK1;

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-525 Card's Address Select switch.

An example of the data returned from this command is

KV= +123.70E-04<CR><LF>

indicating 12.37 mV. [<CR> is the ASCII carriage return character (0D hex), and <LF> is the ASCII line feed character (0A hex)].

b. Verify that the value returned is 0.0 V ±18 mV for three sequential runs.

c. Send the following calibration command string to the 53A-525 Card, and read back the offset voltage from the card.

K40;

d. Verify that the value returned is 0.0 V ±150 mV for three sequential runs.

4. Positive Signal 100 KHz Verification:

a. Set up the function generator to output a square wave at 100 KHz ±10 KHz, with a positive peak at +0.5V ±50 mV and a negative peak at -0.5V ±50 mV. Connect the function generator to channel 1 of the oscilloscope, and to J70 of the 53A-525 Card. Connect channel 2 of the oscilloscope to test point TP5 located to the left of U541 (or to U64 pin 24 for revision level 8703) on the 53A-525 Card. Make sure there is no connection to J80, then set the single ended input switch located to the right of J60 to the ON position.

b. Send the following command string to the 53A-525 Card:

CF;V1;T;

c. Use the invert and add features of the scope to display the difference signal between the two channels. The display will appear as a series of spikes corresponding to the propagation delay between the two channels. Verify that the difference signal between the spikes returns to zero in an exponential fashion. Verify that the pulse width at +0.5V and -0.5 V is 50 ±25 nanoseconds. Verify that the plus and minus pulses return to 0 ±30 mV.

5. Negative Signal 100 KHz Verification:

   a. Set the single ended input switch located to the right of J60 to the OFF position. Move the BNC-to-SMB connector from J70 to J80 of the 53A-525 Card.

   b. Send the following command string to the 53A-525 Card:

      CF;V1;T.

   c. Observe the oscilloscope.

   NOTE: The invert switch of the scope should not be used when displaying the difference signal for this step.

   Verify that the difference signal between the spikes returns to zero in an exponential fashion. Verify that the pulse width at +0.5V and -0.5 V is 50 ±25 nanoseconds. Verify that the plus and minus pulses return to 0 ±30 mV.

6. Disconnect the function generator and the scope from the 53A-525 Card.

7. Gain Verification:

   a. Connect the function generator to the DVM, and to J70 of the 53A-525. Set the single-ended input switch located to the right of J60 to the ON position.

   b. Set up the function generator to output +4.5 V ±100 mV dc. (Be sure this voltage is dc.)

   c. Send the following command string to the 53A-525 Card:

      CT;V5;T;

   d. Determine the average value in memory by sending the following command string to the 53A-525 Card, and reading the results back.

      AA;

      An example of the data returned from this command is

      AV= +455.40E-02<CR><LF>

   e. Verify that the average value returned is within ±90 mV of the value read on the DVM for three sequential runs.

   f. Set up the function generator to output -4.5 V ±100 mV dc. (Be sure this voltage is DC.)

   g. Verify that the average value returned is within ±90 mV of the value read on the DVM for three sequential runs.

8. Common Mode Rejection Verification:

a. Set the single-ended input switch located to the right of J60 to the OFF position. Using the T connector, connect the function generator to both J70 and J80 of the 53A-525 Card. Connect channel 1 of the oscilloscope to test point TP5 on the 53A-525 Card, and set to ac coupling. Set up the function generator to output a 20 Vpp ±200 mV sine wave at 1 kHz ±100 Hz, referenced about 0 VDC.

b. Send the following command string to the 53A-525 Card:

   CF;V1;T;

c. Ideally, the scope would display a straight line (or noise) at its lowest range. A low-level sine wave will be observed at 1 KHz. Verify the amplitude of the sine wave is less than 100 mV peak-to-peak.