53A-519B DATA ACQUISITION SUBSYSTEM

OPERATING MANUAL

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DESCRIPTION

The 53A-519B Data Acquisition Subsystem (DAS) is a printed circuit board assembly for use in a CDS 53/63 Series System. The DAS implements the following functions associated with multi-channel data acquisition on a single card:

- o Multiplexer
- o Ranging
- o 12-bit Analog/Digital Converter (A/D)
- o Microprocessor
- o Memory
- o Pre/Post Processing

The DAS internal input multiplexer can select any one of 16 differential voltage input channels for measurement. The voltage input ranges are: bipolar ±99.95V, ±9.995V, and ±0.9995V; or ±9.995V, ±0.9995V, and ±0.09995V. The DAS input voltage ranges and the measurement sampling rate are programmable. The DAS also allows an external sampling rate generator.

The DAS can digitize single channel input voltage levels at a rate of 37,037 (12-bit) readings per second and store the data in a 15,000 word (12-bit) memory. Randomly multiplexed input voltage channels can be scanned and digitized at a rate of 33,333 (12-bit) readings per second. Collected data is stored in an on-card 15,000 word (12-bit) memory. Since the DAS has built-in microprocessor and memory, it can continue to collect data while the system controller is performing other tasks.

The internal microprocessor provides full program control of operating parameters, further freeing up the host computer for other tasks:

- a voltage trigger level may be programmed on each channel,

- storage of digitized input voltage levels may be delayed until the programmed voltage level threshold is crossed, and

- the DAS memory may be configured as a circular buffer to allow measurement data capture both before and after a trigger event.

Once a measurement sequence is completed, the system controller can request that each measurement taken be returned, or it can instruct the DAS to first pre-process the measurements before returning them. Pre-process commands are available for mean, standard deviation, minimum/maximum of measurement values, and RMS value of measurements stored.

The 53A-519B is a single card upgrade to the 53A-519 two card data acquisition product. It is designed to be backward compatible with both hardware and software of the previous product, allowing use of the newer product in existing applications.

Built-in-Test-Equipment (BITE) for the DAS is provided by a series of LEDs that indicate the status of the measurement in process, triggers, preprocessing, ranges, channel selection, and errors.

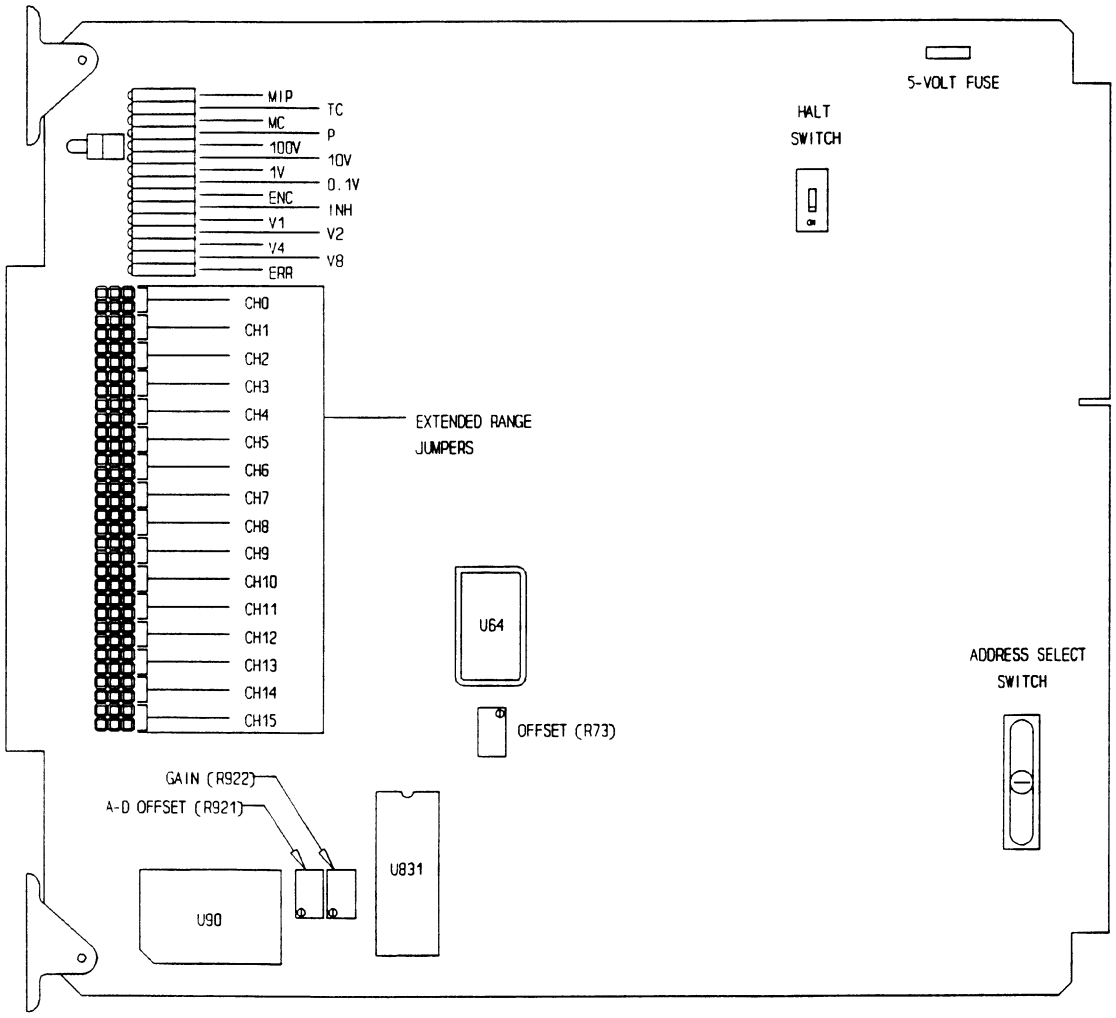


Figure 519B-1: 53A-519B Controls and Indicators

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-519B Card's operating environment.

Address Select Switch

The 53A-519B Card has a miniature 10-position switch which selects the 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.

Halt Switch

This two-position slide switch is located near the card's backplane edge connector. It selects the state of the 53A-519B 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-519B 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-519B Card becomes unaddressed, the Power LED is lit, and any programmed parameters of the card remain unchanged.

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-519B 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-519B Card is unaddressed, but that all required dc power (5 V dc) is being supplied.

Fuses

The 5-volt dc power bus has a fuse that protects the system from overloads. If the fuse has blown, the Power LED will not light.

Function LEDS

Measurement In Process LED (MIP)

The MIP LED will be lit after the DAS is instructed to initiate a measurement sequence by a Trigger command. The LED will remain lit until the measurement sequence is complete.

Trigger Complete LED (TC)

The T LED will be lit when the voltage threshold condition defined by parameter Z_4 of the Trigger command has been met or when the External Trigger signal specified by the Z_6 parameter is detected. The LED will remain lit until the DAS receives the next Trigger command.

Measurement Complete LED (MC)
The MC LED will be lit when the measurement sequence defined by the last Trigger command has been completed. The LED will remain lit until a new Trigger command is issued to the DAS.

Preprocess LED (P)
The P LED will be lit whenever the DAS is executing a Preprocessing command.

Range LEDs
The four Range LEDs indicate the voltage range being used to digitize an input voltage level.

LED	RANGE
100V	High Extended
10V	High or Middle Extended
1V	Middle or Low Extended
0.1V	Low

Encode LED (ENC)
This LED will flash each time the DAS digitizes an input channel.

Inhibit LED (INH)
The Inhibit LED will be lit when the inhibit line (Pin 1 on the 53A-519B front edge connector) is at a TTL low and the DAS is inhibited from making measurements.

Voltage Channel LEDs (V1, V2, V4, V8)
The four Voltage Channel LEDs indicate in binary format (1, 2, 4, 8) what multiplexer channel (0 - 15) is addressed.

Error LED (ERR)
The ERR LED will be lit whenever a programming error has been made.

Extended Range Jumper Blocks

A programmable jumper block is available to divide any input channel by ten, extending the highest range to ±99.95V, and removing the 0.1V low range.

Jumper block J33 should be on the two left pins of P25 (toward the front edge connector) to provide the extended range.

Jumper blocks J1 through J32 are used in pairs (J1 and J2 for Channel 0, through J31 and J32 for Channel 15) to select extended range (±99.95V max) or normal range (±9.995V max) for each of the 16 input channels. For extended range, the pair of jumpers for a channel are on the left two pins, and for normal range, the jumpers are to the right.

SPECIFICATIONS

Programmed By:	ASCII Characters.
Memory Storage:	15000 twelve bit readings.
Memory Organization:	Fixed Length Sequential or Circular Buffer.
Ranges:	Normal Range: ±9.995V, ±0.9995V, ±0.09995V. Extended Range (selected by a programmable jumper block): ±99.95V, ±9.995V, ±0.9995.
Sampling Rate:	Internal Rate Generator.

Voltage Measurement Type	Maximum Sample Rate[1] (Readings per second)	Minimum Delay Between Readings (µs)
Single Channel[2]	37,037	27
Random Channel Selection-Single Input Range[2]	33,333	30
Random Channel Selection-Single Input Range[3]	31,250	32
Random Channel Selection-Multiple Input Ranges[2]	23,809	42
Random Channel Selection-Multiple Input Ranges[3]	22,727	44
Random Channel Selection-Multiple Input Ranges[4]	17,241	58

1 - The maximum rate at which measurements can be taken and placed in memory.

2 - Programmable internal voltage level triggering or external triggering not used.

3 - Programmable internal voltage level triggering not used, programmable number of measurement cycles completed after receipt of External Trigger Pulse.

4 - Programmable internal voltage level triggering used, programmable number of measurement cycles completed after threshold crossing or receipt of External Trigger Pulse.

Delay Between Readings: 0 to 32,767 μs, ms, seconds or hours.

Delay Between Measurement Cycles: 0 to 32,767 μs, ms, seconds or hours. (set of one or more channels repeatedly measured).

External Rate Generator:
Type Input: TTL, low true, 1 TTL Load.
Pulse Width: min. 50 ns; max. 24 μs.
Pulse Rate: 37037 Hz max.

Input Characteristics (each channel):

No. of Input Channels: 16.

Type Input: Differential.

Coupling: DC.

Maximum Input: ±200V between any of the 32 input connections and analog ground. ±300V analog ground to earth ground.

Input Impedance Normal Range: Selected multiplexer channel: >1 MOhm, shunted by <100pf.
Unselected multiplexer channel: >1 MOhm, shunted by <15pF.

Input Impedance Extended Range: >100 KOhms, shunted by <15pF.

Effective Common Mode Rejection: 50dB, DC to 1 KHz (1K ohm unbalance).

Maximum Common Mode Voltage: Extended Ranges (100V, 10V, 1V): ±50V dc relative to analog ground.
Normal Ranges (10V, 1V, 0.1V): ±5V dc relative to analog ground.

Cross Talk (channel to channel): DC to 10KHz <75 dB.
10KHz to 30KHz <68 dB

Dynamic System Accuracy (Voltage Measurement)*: (at 25°C ±3°C)

Input Range	Accuracy
±99.07V (extended High)	±0.2% + 121 mV
±9.907V (extended Med)	±0.2% + 12.1 mV
±0.9907V (extended Low)	±0.2% + 1.21 mV
±9.995V	±0.008% + 12.2 mV
±0.9995V	±0.008% + 1.22 mV
±0.09995V	±0.008% + 122μV

* Switching between 0V and ±full scale voltage, at maximum sampling rate.

System Accuracy Drift: High range, ±30 ppm/°C
Mid range, ±50 ppm/°C
Low range, ±200 ppm/°C
Extended ranges, ±25 ppm/°C additional drift.

Sample and Hold Aperture Time: 35ns.

Aperture Time Uncertainty: ±0.5ns.

Calibration Cycle: Every six months.

Triggering:

Internal: Measurement sequence proceeds when a Trigger command is received from the system controller.

Voltage Level: Measurement sequence proceeds when the voltage on a specified channel is < or > programmed trigger voltage.

External Trigger: Measurement sequence proceeds when the External Trigger input is low for >1ms. Input loading: 1 TTL load.

Trigger Collection Modes: Memory configured as a fixed length buffer: DAS will begin taking measurements when external trigger is received.

Memory configured as a circular buffer: DAS will complete 0 to N additional measurement cycles after trigger is received.

Post Trigger Measurement Storage (Memory configured as a circular buffer): Under program control; from 0 to N measurement cycles after the trigger event may be stored. N is equal to 15,000 divided by the number of measurements per cycle.

Inhibit Input: When low, prevents DAS from sampling. TTL, low true, 1 TTL load.

Data Output: Programmable; four decimal digits with sign and decimal point, or 12 bit binary packed into two 8 bit bytes, or blocked into records with a checksum.

Power Requirements: 5V dc power is provided by the internal Power Supply in the 53/63 Series Card Cage.

Voltage: 4.75V to 5.25V dc.

Current: 0.8 amperes, maximum quiescent.
0.9 amperes, 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, 220mm deep, 13mm wide (7.75" X 8.66 X 0.5")
Dimensions, Shipping:	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping dimensions are: 254 mm x 254 mm x 127 mm. (10 in x 10 in x 5 in).
Weight:	0.32 kg. (0.7 lb.)
Weight, Shipping:	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, the card's shipping weight is: 0.73 kg. (1.6 lb.)
Mounting Position:	Any orientation.
Mounting Location:	Installs in any function-card slot of the 53/63 Series Card Cage.
A/D Input/Output Connections:	A 48-pin printed circuit type hooded connector (53A-780) provides a connection for all A/D Input/Output connections.
Required Equipment: (not supplied)	53A-780 Hooded Connector.
Equipment Supplied:	53A-519B Data Acquisition Subsystem. 1 - spare fuse, 3 Amps. (Part # 42202-52003). Operating Manual, (Part # 00000-15190). Service Manual, (Part # 00000-25190).
Software Revision:	V1.3.

OPERATION

Overview

Each of the 16 differential input channels of the DAS is configured on an individual basis by the system controller to be used as a voltage measurement channel.

The DAS is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The DAS 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 mainframe address (0-9) selected on the 53A-171 Control Card in the addressed mainframe; Y is the 53A-519B Card's address (0-9) within the addressed card cage. The 53A-519B 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-519B Card is addressed, the commands listed below may be issued until another function card is addressed.

Before initiating a measurement sequence with a Trigger command, the DAS is programmed (using the Format and Sequence commands) for the type of measurement to be made. A complete measurement cycle is the one-time execution of all scan sequences in the sequence command stack. By placing multiple scan sequences (format number, beginning channel number, ending channel number) in the sequence command stack, the DAS can be programmed to scan channels in any order desired.

Following completion of a measurement sequence, an Accept command is issued to the DAS to instruct it to return the measurement results to the system controller. Data reduction may be performed on the raw measurement data before it is returned to the system controller by using one of the DAS Preprocess commands before issuing an Accept command.

Summary

An overview of the commands, in the order they typically would be programmed is as follows:

Command	Function
FORMAT	Defines up to 32 possible measurement formats (Range, Voltage, etc.).
ENCODE	Specifies whether sample rate generation is under control of the DAS or an externally supplied signal.
INTERRUPT	Enables interrupts from the DAS.
SEQUENCE	Defines the order in which channels are to be sampled and the measurement format to be used on each channel.
TRIGGER	Initiates a measurement sequence as defined by previously issued Format and Sequence commands.

QUERY	Polls the DAS to determine its current status.
ACCEPT	Instructs the DAS to return the results of a measurement sequence to the system controller.
PREPROCESS	Selects preprocessing functions to be done on the raw data stored in the DAS memory prior to returning the measurement results to the system controller.
RESET	Resets the sequence stack and the format table to their initial power-up condition and clears the Error LED.
DISPLAY ERROR	Returns an error code.
KILL	Stops all measurement collection or preprocessing and restores the DAS to its power-up condition.
HALT	Halts all system cards within a card cage.
STOP	When a STOP command is initiated by the system controller, individual system cards will react as though they had received a Halt command.

Card Commands

Detailed descriptions of the 53A-519B Card's commands, in alphabetical order, are given on the following pages.

The format and syntax for the card commands is as follows:

- Each command is limited to 40 characters.
- A command sequence must begin with "@XY" (as defined above).
- A command must end with a carriage return character <CR>. A line feed <LF> is optional.
- Omitted optional parameters must be specified in the command with commas as field delimiters.

Command	Description

A ACCEPT

Syntax: @XYAZ$_1$,Z$_2$<CR>

The Accept command instructs the DAS that the system controller is ready to input the measurements stored in the DAS memory. The Accept command also instructs the DAS as to the format in which the measurement results are to be returned.

Z_1 Z_1 is a letter followed by a number [n] from 1 to 15,000. The letter specifies the format in which the data will be returned, and the number indicates now many measurement values are to be transferred. Data returned will end with the most recent measurement collected. After the number of measurements requested has been returned, a special "terminator" will be sent. Valid selections for Z_1 are A, B, or R:

A[n] Return all measurement data in ASCII base 10 decimal notation. The format of the returned data is a plus or minus sign followed by four or five digits with a correctly positioned decimal point and <CR><LF>.

Terminator: ±9.999

B[n] Return the data in packed binary form. For each measurement, two binary bytes will be returned. The first byte returned will contain the high order six bits of a twelve bit measurement in the low order six bits of the data byte. The second byte returned will contain the low order six bits of a twelve bit measurement in the low order six bits of the byte. The most significant two bits of each byte returned are chosen so that no binary byte returned can represent control characters such as <CR> or <LF>.

Terminator: two bytes, each containing hex AF (the ASCII "/" character).

R[n] The R format is the same as the B format above, except that multiple measurements are blocked into a single record to reduce transfer time. The number of measurements blocked into a record is defined by Z_2. The record format consists of Z_2 binary measurements (two bytes per measurement) followed by a two byte checksum and <CR><LF>. the two checksum bytes are formatted exactly like the two measurement bytes. The two checksum bytes are formed by taking the exclusive-OR of the twelve bits of each measurement contained in the record.

Terminator: two bytes, each containing hex AF (the ASCII "/" character).

NOTE: If the number of measurements plus the terminator do not completely fill the last record returned, the unused portion of the last record returned will be filled with terminator characters.

Z_2 Z_2 is a number from 1 to 15000 which specifies the number of measurements to be blocked into a record when the R format parameter is used. Z_2 is only allowed when the Z_1 parameter is an R. When the R format is used and the Z_2 is unspecified, Z_2 will default to 33.

After the Accept command is issued, the DAS will begin returning measurement data as soon as the system controller requests input from the DAS. Since the system controller may not know in advance the total number of measurements stored in the DAS memory, the DAS must indicate to the system controller when the last measurement has been returned. The DAS does this by sending the special terminator indicated for each format type.

If the system controller requests more measurements than are available in the DAS memory, the DAS will first return all available measurements, then it will return terminator characters for all subsequent system controller input requests.

When data is returned in binary format, the returned data can be converted to the actual measurement result as follows:

1. Convert the 12 bits to their equivalent decimal value.

2. Subtract 2,048 from the value obtained in step 1.

3. For normal ranges, multiply the result by 4.8828125. For extended ranges, multiply by 48.397289.

4. If the measurement was made on the high range, divide the result obtained in step 3 by 1000; if it was taken on the mid range, divide by 10,000; if on the low range, divide by 100,000.

If the Accept command is issued to the DAS before a measurement sequence is complete, the DAS will halt the measurement sequence at the end of the next measurement cycle and prepare to return the data taken up to that point to the system controller. Before sending an Accept command, use the Query command to make sure the measurement cycle is complete.

Examples:

@01AR400,25	would return 400 measurements blocked into 16 records of 25 measurements each.
@01AA10000	would return the last 10000 measurements taken. If, for example, the DAS had been programmed to take 2000 measurements after a trigger condition, the DAS would return 8000 pre-trigger measurements followed by 2000 post-trigger measurements.

Command	Description

DE or DG DISPLAY ERROR

Syntax: @XYDE<CR> or @XYDG<CR>

The Error command is used to return the error code and to extinguish the ERR LED. When the Error command is followed by an input request, a two digit error code will be returned. The ERR LED will remain lit after an error until it is read by the Error command or reset by the Reset or Kill command.

Error Code	Explanation
00	No error
01	Input line too long
02	Not a valid command
03	Illegal input request
04	Too large a number or too many digits
05	Not a valid number
06	Invalid format number
07	Invalid range specification
09	Invalid measurement extension
10	Too many parameters
11	Invalid measurement type
12	Invalid delay interval specification
13	Sequence stack overflow
14	Invalid channel number
15	Faulty format table
17	Invalid threshold
18	Invalid buffering technique
19	Data not available
20	Invalid Preprocess command
21	Invalid Display command
22	Invalid Reset command
23	Invalid Interrupt command
25	Invalid Query command
26	Query command not followed by input request
27	Invalid Accept command
28	Invalid buffer length
30	Invalid external trigger specification
31	Invalid Encode command
33	Invalid measurement type
35	Invalid threshold channel store flag

Command	Description
E	ENCODE

Syntax: @XYEZ<CR>

Z is either 0 or 1:

0 the internal encode generator of the DAS is used.

1 an external encode source is required (Pin 24 on the front edge of the 53A-519B Card).

The Encode capability may be used with single or multiple channels, single or multiple ranges and with internal, external, or threshold triggering. The external encode input is separate from the external trigger input allowing operation where the external trigger starts the measurement cycle and the external encode faces the individual readings.

The Encode command allows the measurement rate of the DAS to be paced from an external source. A single external encode pulse must be issued to the DAS for each measurement made.

When External Encode is used, the delay between readings (Trigger command, Z_2 parameter) and the delay between measurement cycles (Trigger command, Z_3 parameter) are both inactive even though they may have been programmed to a value. If the Autoselect mode of triggering has been programmed (Trigger command Z_2 is an A), measurement readings are paced by controller input requests, and if External Encode is used, a pulse on the external encode line triggers the reading before each controller input request.

On power-up, the internal encode generator of the DAS is selected. If a delay between measurements hasn't been programmed with the Trigger command, the DAS supplies internal encode pulses, it will always choose the maximum possible sampling rate compatible with the options selected.

When supplying external encode pulses, it is necessary to insure that the pulse rate never exceeds the maximum throughput rate for the particular combination of options selected.

The DAS provides tailored, high-speed internal software sampling logic for the six special option cases described below. If external encode is used, it is recommended that one of the following sets of options be used to take advantage of the greater operating speed provided by the internal software for these options. Use of options other than these may slow sampling down by more than an order of magnitude. Use of autoranging, in particular, slows sampling capability significantly.

Option 1

Maximum external sampling rate:	37,037 Hz (1/27 μs).
Measurement cycle:	Single channel, single range, no external triggering.
Trigger command parameter:	Z_3, Z_4, Z_5 and Z_6 are not used.

Format command parameter:	Z_2 does not specify autoranging and is the same for all channels. Parameters Z_3 and Z_4 are not used.

Sampling is halted when the specified number of samples have been taken, an External Trigger pulse or an A command is received by the DAS.

Option 2

Maximum external sampling rate:	33,333 Hz (1/30 μs).
Measurement cycle:	Multiple channels, single range, no external triggering.
Format command parameter:	Z_2 does not specify autoranging and is the same for all channels. Parameters Z_3 and Z_4 are not used.
Trigger command parameter:	Z_3, Z_4, Z_5 and Z_6 are not used.

Sampling is halted when the specified number of samples have been taken, an External Trigger pulse or an A command is received by the DAS.

Option 3

Maximum external sampling rate:	31,250 Hz (1/32 μs).
Measurement cycle:	Multiple channels, single range, external triggering.
Trigger command parameter:	Z_3, Z_4 and Z_5 are not used. Z_6 is "1".
Format command parameter:	Z_1 does not specify autoranging and is the same for all channels. Z_3 and Z_4 are not used.

An External Trigger pulse is used to indicate the trigger required by the Trigger command parameter Z_1.

Option 4

Maximum external sampling rate:	23,809 Hz (1/42 μs).
Measurement cycle:	Multiple channels, multiple ranges, no external triggering.
Trigger command parameter:	Z_3, Z_4, Z_5 and Z_6 are not used.
Format command parameter:	Z_2 does not specify autoranging. Z_3 and Z_4 are not used.

Sampling is halted when the specified number of samples have been taken, or an External Trigger pulse or an A command is received by the DAS.

Option 5

Maximum external sampling rate:	22,727 Hz (1/44 μs).
Measurement cycle:	Multiple channels, multiple ranges, external triggering.
Trigger command:	Z_3, Z_4 and Z_5 are not used. Z_6 is "1".
Format command:	Z_2 does not specify autoranging. Z_3 and Z_4 are not used.

An External Trigger pulse is used to indicate the trigger required by the Trigger command parameter Z_1.

Option 6

Maximum external sampling rate:	17,241 Hz (1/58 μs).
Measurement cycle:	Multiple channels, multiple ranges, threshold triggering.
Trigger command:	Z_3 is not used.
Format command:	Z_2 does not specify autoranging. Z_3 and Z_4 are not used.

An External Trigger pulse or a threshold crossing on the specified trigger channel indicate the trigger required by the Trigger command parameter Z_1.

	Option Number					
Options	1	2	3	4	5	6
SC = Single channel only MC = Multiple channels	SC	MC	MC	MC	MC	MC
SR = Single range only MR = Multiple ranges, no autorange	SR	SR	SR	MR	MR	MR
CT = Count cycles after trigger ST = Stop one cycle after trigger	ST	ST	CT	ST	CT	CT
NT = No threshold trigger TH = Threshold trigger used	NT	NT	NT	NT	NT	TH
Minimum Interval between samples (μs)	27	30	32	42	44	58

To determine the maximum external encode rate for a set of options not specified above, first program the DAS for the set of options required, with Z_2 and Z_3 of the Trigger command not specified. Connect an oscilloscope to pin AA of the 53A-519B Card and issue the Trigger command to be used. While the DAS is taking measurements, measure the maximum period of the pulse train on pin AA. The reciprocal of the period so measured is the maximum external sampling rate that can be used with the options selected.

If an oscilloscope is unavailable, program the Trigger command with the desired encode rate for Z_2. An error 12 will be generated if the selected rate is too fast. Try larger Z_2 values until no error is detected.

Examples:

To use an external encode source with single channel measurements, make sure that all of the requirements of Option 1 are met, including the minimum interval between samples of 27 μs, and then send the command E1.

Command	Description

F FORMAT

Syntax: @XYFZ$_1$,Z$_2$,Z$_3$<CR>

The Format command specifies the Measurement Format (Range, Voltage, etc.) that will be used by the DAS when making measurements.

Up to 32 separate Format commands can be stored by the DAS.

Z_1 Z_1 is the Format command number, 1 through 32. This number may be output either with or without leading zeroes. The Format number is an identifier that distinguishes one format from another.

Z_2 Z_2 is one or two letters that specify the DAS input voltage range:

A Autorange. When autoranging the A/D will first try range "M" and then switch to range "L" or "H" if required.

AE Autorange Extended. The same as autorange with extended range.

Normal Ranges: (The jumper blocks for the channel are connected to the pins farthest from the front edge connector.)

H High Range (±9.995V)
M Mid Range (±.9995V)
L Low Range (±.09995V)

Extended Ranges: (The jumper blocks for the channel are connected to the pins closest to the front edge connector.)

HE High Range Extended (±99.95V)
ME Mid Range Extended (±9.995V)
LE Low Range Extended (±0.9995V)

The default is Autorange if Z_2 is omitted.

Z_3 The normal mode for most A/D converters is to measure a voltage and store that reading into memory. The DAS system has extensions which allow complex measurements to be made with the results stored as a single reading.

Z_3 is a letter followed by a number (1 through 32,767). The letter specifies the measurement extension to be used, and the number specifies the total number of measurements over which the extension is performed. The available measurement extensions are:

M Mean of the samples.
P Peak or maximum of the samples.
V Valley or minimum of the samples.
T True RMS value of the samples.

The default is no measurement extension.

On power-up, Format command F1 will be set to Autorange and no measurement extension. Format commands F2 through F32 will be undefined.

Examples:

@01F6	would define configuration format six to be: Mid Range, digitize one voltage measurement.
@01F7,L,M500	would define configuration format seven to be: Low Range, take 500 measurements and store the mean value.

Command	Description
H	HALT

Syntax: @XH

The Halt command halts all system cards within a card cage. Individual types of system cards will react differently to the Halt command. However, all system cards if addressed (Power LED - out) will become unaddressed (Power LED - lit) after a Halt command.

The Halt command affects only the system cards in the card cage defined by X. (See Halt switch description).

Example:

Assume the Halt switch is in the OFF position. The command @0H would unaddress all system cards in the card cage with address 0 and would have no effect on the DAS.

If the Halt switch was in the ON position, the effect of the Halt command would have been the same as turning the power off and back on (the power-up condition).

Command	Description
I	INTERRUPT

Syntax: @XYIZ$_1$Z$_2$Z$_3$<CR>

This command enables interrupts from the DAS. Detection and handling of vectored priority interrupts are described in the 53A-171 Control Card manual.

A given interrupt will be armed when the appropriate I command is issued to the DAS. Once an interrupt condition occurs, the DAS will continue to signal an interrupt condition to the 53A-171 Control Card until the interrupt condition is cleared with an @XS command to the 53A-171 Control Card, or when the controller communicates with the DAS.

Z_1 is either 0 or 1:

- 0 this interrupt is turned off.
- 1 the DAS will interrupt when the measurement sequence specified by the last issued Trigger command is complete.

Z_2 is either 0 or 1:

- 0 this interrupt is turned off.
- 1 the DAS will interrupt when the trigger conditions specified by Z_4 or Z_6 in the Trigger command have been met.

Z_3 is either 0 or 1:

- 0 this interrupt is turned off.
- 1 the DAS will interrupt the system controller when the DAS has finished a P command.

If not specified, Z_1, Z_2, and Z_3 default to 0.

Note that there are no comma separators between Z_1, Z_2, and Z_3 (see Example 2 below).

Examples:

1. The command @01I would turn off all interrupts.

2. The command sequence @01I010 would turn on interrupt Z_2 and turn off all others.

Command	Description
K	KILL

Syntax: @XYK

The Kill command immediately resets the entire DAS to the power-up state.

Command	Description

P PREPROCESS

Syntax: @XYPZ<CR>

The Preprocess command specifies the type of data reduction to be done on all measurement data taken during each measurement cycle resulting from the last issued Trigger command and stored in the DAS memory, prior to the data being read by the system controller.

Z is one or more of the following characters:

A[n] For each DAS channel, take the average of every [n] measurements and store the result in the DAS memory. [n] is a number from 1 to 999. When the average function is executed, the original raw data stored in memory is destroyed.

S For each DAS channel, compute the standard deviation of all measurement data stored in the DAS memory.

M For each DAS channel, compute the Mean of all measurement data stored in the DAS memory.

P For each DAS channel, determine the Peak (maximum) reading stored in the DAS memory.

V For each DAS channel, determine the Valley (minimum) measurement value stored in the DAS memory.

R For each DAS channel, compute the RMS value of the AC component of all measurement values stored in the DAS memory.

T For each DAS channel, compute the True RMS value of all measurement values stored in the DAS memory.

If a particular channel is sampled more than once during a measurement cycle, then each occurrence of the given channel in the measurement cycle will be included in the preprocessing as an independent channel.

Execution of preprocessing functions S, M, P, V, R, or T will result in one measurement result being stored in the DAS memory for each channel used in the last measurement cycle.

When a sequence of Preprocess and Accept commands are used together, it is necessary to use the concept of a "Working Array" in order to correctly interpret the results. The memory of the DAS is divided into two areas called arrays. The primary array is a large area where raw measurements are stored as they are digitized; this array can hold up to 15,000 measurements. The auxiliary array is a smaller area of memory where the results of a Preprocess command (other than A) are stored.

When a Preprocess command puts measurement values into the auxiliary array, it in no way modifies or erases the data contained in the primary array. It does, however, change a pointer so that subsequent Accept commands will refer to the preprocessed data in the auxiliary array. If another Preprocess command is issued, it will again preprocess the original data in the primary array, and replace the data in the secondary array with the new preprocessed data.

The A command is an exception to this. When an A Preprocess command is executed, the DAS modifies the data in the primary array as it executes, and then sets the Accept command pointer to the primary array.

Any Preprocess command (other than A) will set the Accept command pointer to the auxiliary array. If it is necessary to restore the pointer to the primary array without modifying the raw data, this may be done by issuing the command @XYPA1.

If the Preprocess command is issued to the DAS before a measurement sequence is complete, the DAS will halt the measurement sequence and perform the indicated Preprocess function on the data stored in the DAS memory up to that point. Use the Query command to determine whether the measurement is complete.

Examples:

@01PS<CR> This command would cause the DAS to calculate the standard deviation of all the data. If this command is followed by @01AA1<CR> and then an input request, the standard deviation will be returned.

Command	Description
Q	QUERY

Syntax: @XYQ<CR>

The Query command tests the condition of the DAS system.

On receiving the Q command, the DAS sends a single ASCII character followed by <CR><LF> back to the system controller on its next input request.

The DAS will return a 1 if a measurement sequence is in process or if a Preprocess function is being performed. Otherwise, the DAS will return a 0.

Command	Description

R RESET

Syntax: @XYRZ<CR>

The Reset command is used to clear the error LEDs and initialize the Sequence List and the Format command table to their power-up conditions.

Z Z is a single character indicating the reset function to be performed and is defined as follows:

E - Clear the ERR LED.

F - Set the Format Table to its power-up condition:
F1 = Autorange, no delay, no measurement extension; F2 through F32 undefined.

S - Set the Sequence Stack to its power-up condition:
S1 = 1,0 (channel 0 only using Format 1); S2 through S32 undefined.

A - All of the above.

If Z is not specified, an error occurs.

Examples:

RE clears the ERR LED (if lit).

RF sets the Format Table to its power-up condition.

RS sets the Sequence Table to its power-up condition.

RA clears the ERR LED (if lit), sets the Format Table to its power-up condition, and sets the Sequence Table to its power-up condition.

Command	Description
S	SEQUENCE

Syntax: @XYSZ$_1$,Z$_2$,Z$_3$;.....;Z$_1$,Z$_2$,Z$_3$<CR>

The Sequence command defines groups of scan sequences to be measured, and specifies the measurement format (as defined by the Format command) to be used on each scan sequence. A scan sequence consists of a sequential listing of one or more DAS input channels (format number, beginning channel number, ending channel number). Up to 32 different scan sequences can be stored by the DAS in its sequence command stack. The scan sequences are performed in the order specified by this command. The full set of scan sequences is referred to as a 'measurement cycle' in this manual.

Multiple scan sequences may be defined in a single command using the semicolon separator, or individually defined in separate commands.

Each scan sequence issued to the DAS is appended to the end of a sequence command stack. If more than 32 scan sequences are issued to the DAS before clearing the sequence command stack, the 33rd and succeeding scan sequences will be ignored by the DAS and an error will be indicated by the error LED. The sequence command stack is cleared by using the R (Reset) command.

Z_1 specifies the Format command to be used for this scan sequence.

Z_2 the beginning channel number of a scan sequence (0 through 15).

Z_3 the ending channel number of a scan sequence (0 through 15). Z_3 is optional and if omitted, only the single channel specified by Z_2 will be digitized.

; the delimiter used between scan sequences when multiple scan sequences are combined in a single Sequence command string.

Example:

Assume that Format command numbers F1 and F2 have both been previously defined.

The command sequence @01S2,1,3;1,8;1,5,6 would define the DAS measurement cycle to be: Measure channels 1 through 3 using Measurement Format 2. Next measure channel 8 using Measurement Format 1. Then measure channels 5 and 6 using Measurement Format 1.

On power-up, the Sequence Stack will be set to:

S1 = Format 1 (default settings)
Beginning channel 0.
Ending channel 0.
S2 through S32 will be undefined.

Command	Description
T	TRIGGER

Syntax: @XYTZ$_1$,Z$_2$,Z$_3$,Z$_4$,Z$_5$,Z$_6$<CR>

The Trigger command initiates one or more measurement cycles, as defined by previously issued Format and Sequence commands.

Three different trigger sources are allowed:

1) an immediate software trigger following processing of the Trigger command,

2) a positive or negative threshold trigger on a specified channel, or

3) a front connector TTL External Trigger input.

The Trigger command also specifies the buffering method as either a field length buffer or a circular buffer. Triggering can either start a measurement cycle or be used to stop the measurement cycle with a specified number of measurements following the trigger.

The Trigger command is also used to specify the time delay between measurement and an independent time delay between measurement cycles (when internal sampling is specified with the Encode command). These delay times are specified in microseconds, milliseconds, seconds, or hours. The sampling rate can also be specified to be the maximum sampling rate available, or the sampling rate can be based on the rate of controller input requests.

Sampling may be stopped at any time by sending a command (other than the Q command) to the DAS. Sampling will stop at the end of the current measurement cycle.

Z_1 Z_1 defines the storage mode and the number of measurement cycles the DAS will complete and store in memory. The actual number of measurements stored in memory on each measurement cycle will depend on the number of DAS channels included in each measurement cycle (Sequence command).

Z_1 may be either of the following values:

F[n] (Fill Memory)
Instructs the DAS to complete and store [n] measurement cycles in the DAS memory, where [n] is a number from 1 to N_{Max}. N_{Max} = M/S, where M is equal to the maximum number of measurements that can be stored in the DAS memory (15,000), and S is the number of measurements in one complete measurement cycle. M is determined by the number of scan sequences and the number of channels in each scan sequence as programmed by the Sequence command.

If the value chosen for [n] exceeds M/S, the DAS will halt when memory is full.

If [n] is omitted, the DAS will start continuously taking measurement cycles and storing the results in memory until memory is full. This is the same as F[n] when [n] is equal to N_{Max}. If the Z_1 parameter is omitted entirely, the default specification will be F1.

C[n] (Circular Memory)
Instructs the DAS to begin taking measurement cycles and to reconfigure its memory in a circular manner - i.e., after reaching the end of memory, the DAS will start loading measurements at the beginning of memory again, writing new data over old data.

The DAS will continue to complete measurement cycles, loading data into its memory in a circular fashion until any one of the trigger conditions is satisfied. When the trigger condition specified by Z_4 or by $Z_6 = 1$ is met, the DAS will complete the additional number of measurement cycles specified by [n], where [n] is a number from 1 to N_{Max} as defined above. The circular memory will then contain the results of measurements completed before and after the trigger condition occurred. If [n] is omitted, no additional measurement cycles will be completed after the trigger condition is met.

Z_2 Z_2 is the letter A (Autoselect), or a number between 1 and 32767, which is preceded by U (microseconds), M (milliseconds), S (seconds) or H (hours) to define the amount of time between successive samples taken by the DAS. If Z_2 is omitted, the DAS will select and digitize a channel at the maximum rate possible, based on the Format and Sequence commands programmed.

If Z_2 is specified, the time selected must be greater than or equal to the minimum sampling interval required by the various Format and Sequence options selected. See the Encode command description for a discussion on how to calculate the minimum sampling interval.

NOTE: If auto-ranging or extended (mean, max, min, or TRMS) measurements have been selected with the Format command, the wait will only precede the first digitization of the measurement process. The subsequent digitization required for multiple measurements or auto-ranging will occur at the maximum rate of the A/D. The time specified by Z2 is from the start of one autorange or extended measurement to the start of the next one.

Setting Z_2 to the letter A indicates that samples are to be digitized at a rate determined by the system controller. In this case, the system controller must input the value of each sample before the next sample will be digitized.

Measurement values will be formatted in ASCII as described for the A option of the Z_1 parameter of the Accept command. When using this option, the sample values will be passed directly to the system controller and stored into DAS memory.

NOTE: A Trigger command does not need to be re-issued in order to return measurement values to the system controller multiple times. Data may be read multiple times, or preprocessing performed before or after reading raw measurements without destroying the original data. (The Preprocess Average command is an exception; the raw data is destroyed.)

Z_3 Z_3 specifies a delay between the completion of one measurement cycle and the start of another, if multiple measurement cycles have been specified by the Z_1 parameter. For example, the DAS could complete a measurement cycle once every 30 minutes until the number of measurement cycles specified by Z_1 had been completed.

Z_3 is a number between 0 and 32767, which is preceded by a range character U (microseconds), M (milliseconds), S (seconds), or H (hours).

Z_4 Z_4 defines a voltage level threshold. The function of the threshold depends on the Z_1 parameter used (see Z_1). When Z_1 specifies a fixed number of measurement cycles, the threshold must be crossed before the DAS will begin to store measurement cycle data in memory. When Z_1 is a C (Circular memory), the DAS will complete the number of measurement cycles specified, after the threshold has been crossed.

If more than one DAS input channel is specified in a measurement cycle by the Sequence command, the threshold determination will be made using the first channel specified for the measurement cycle.

If the trigger channel is sampled more than once in a measurement cycle, the threshold condition will be evaluated each time the channel is sampled.

Z_4 is a < or > sign, followed by a number from -99 to +99, where the number represents the two most significant digits of the threshold voltage. If a > sign is used, the threshold requirement will be met when a threshold measurement exceeds the Z_4 number. If a < sign is used, the threshold requirement will be met when a threshold measurement is taken that is less than the Z_4 number. The trigger voltage specified is converted to an eight bit number by the DAS and compared to the most significant eight bits of measurement data from the threshold channel.

Z_5 Z_5 is only active if Z_4 has been used. Once the storage in memory of measurement cycle data has begun, if Z_5 is a 1 or not specified, the data from the channel used for threshold determination will be stored in memory on each measurement cycle. If Z_5 is a 0, the data from the channel used for threshold determination will not be stored in memory. This feature allows dedicating a DAS channel to external trigger

control without having to consume DAS memory storing trigger level data.

Z_6 Z_6 determines the function assigned to the External Trigger line. If Z_6 is a 0, the external trigger signal will cause measurement collection to cease at the end of the current measurement cycle.

If Z_6 is a 1, then the external trigger signal will have the same effect as would the crossing of the threshold value for a trigger channel.

The external trigger signal will be recognized by the DAS within five measurements or less for the two cases using external trigger described in the Special Options Table of the Encode command. For other cases, the external trigger is examined only once after each reading is stored in memory. If slow encode rates or large values of Z_3 for the Format command are used, recognition may be delayed accordingly. The external trigger signal is not internally latched and it must, therefore, be maintained until it is recognized.

Once recognized, an internal counter is incremented each time a measurement cycle is completed. When the counter reaches the value specified by [n], measurement sampling will cease. The measurement cycle during which the external trigger occurred is included in the count.

The External Trigger Input may be used to terminate measurement sequences initiated with either of the Z_1 values. It is normally used, though, in conjunction with the Z_1 value C[n], to allow the DAS to capture and store measurements before and after the occurrence of an external event.

Examples:

@01TF500 instructs the DAS to immediately make 500 measurement cycles and store the result in memory.

@01TF500,,M560 perform the same measurement, but delay 560 milliseconds between each of the 500 measurement cycles.

@01TC300,,,>+51 use this command string if the DAS input voltage range for the first channel in a measurement cycle was programmed to the High Range, and you want to capture 300 measurement cycles after the voltage on the first channel in the measurement cycle exceeded 5.1 volts.

In this example, the DAS memory is configured as a circular buffer, with the measurement data from the trigger channel being stored in memory. If there were 10 DAS voltage channels in the measurement cycle, there could be up to 1200 measurement cycles stored

in the DAS memory before the voltage threshold was detected. There would be exactly 300 measurement cycles stored in the DAS memory after the voltage threshold was detected [(1200 · 10) + (300 · 10) = 15,000 total measurements].

When the internal sampling rate generator of the DAS is used, samples will be digitized in a time-coherent manner when any one of the six cases described in the Special Options Table are selected. When any one of these cases is selected, the time interval between successive samples will be accurate to within ±0.5 microseconds of the time specified by the Z_2 parameter of the Trigger command.

INSTALLATION

The 53A-519B 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:

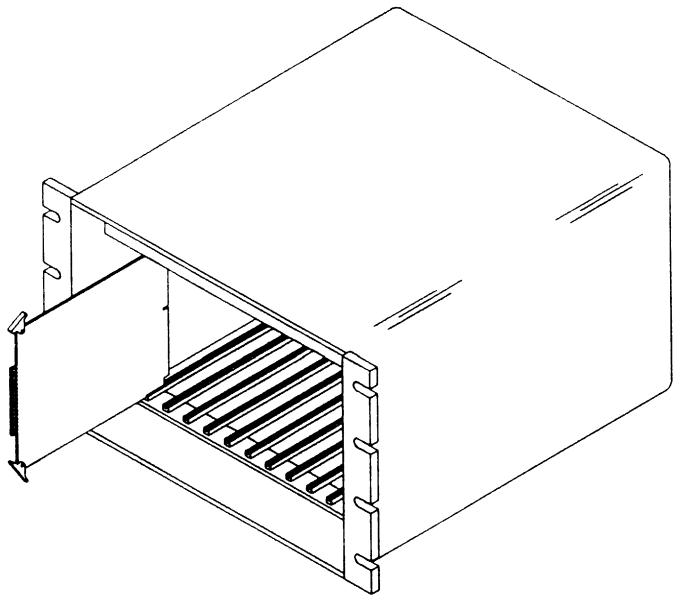
a. Match the keyed slot on the card to the key in the backplane connector. The component side should be to the right for a 53 Series Chassis and to the top for a 63 Series Chassis.

b. There are two ejectors on the card. Make sure the ejector marked "53A-519B" is at the top for a 53 Series Chassis and to the left for a 63 Series Chassis.

CAUTION:

The 53A-519B 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.

NOTE: Isolated Analog Ground (Pin 23) should be connected to the analog common of the device being measured. To avoid damage to the multiplexer section of the 53A-519B Card, the voltage between any of the 32 input connections and analog ground must not exceed ±200V. The voltage between analog ground and earth ground must not exceed 300V.



CALIBRATION

The 53A-519B Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibrate the 53A-519B 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.

Six adjustments are required to calibrate the DAS, offset and full scale gain for each range.

Equipment Required:

- 53A-850 Extender Card
- precision voltage source capable of outputting ±9.751V ±0.001V, ±0.9751V ±0.0001V and ±0.09751V ±25μV.
- 53A-780 Hooded Connector

Many DC calibrators have ripple or noise output specifications that are high enough so that the DAS with its high speed sample and hold is able to measure them. In the calibration procedure that follows, the DAS will be programmed to take a number of measurements, and then display the average of these readings in order to integrate out possible calibrator noise.

SET OFFSET AND FULL SCALE GAIN

Connections:

1. The 53A-519B must be placed on a 53A-850 Extender Card to access the front edge connector inputs and adjustment potentiometers on the 53A-519B.
2. Connect the calibrator high and low outputs to the high and low inputs, Channel 0, of the DAS.
3. Connect the guard output of the calibrator to the isolated analog ground of the DAS (Pin 23).

Procedure:

1. Program the DAS with the following commands to continuously take 200 readings on Channel 0, and then display the average of these readings:

   @XYF1,A,M200<CR>
   @XYTC,A<CR>

2. Adjust the calibrator to output zero volts.

3. Adjust the OFFSET potentiometer R73 until the displayed reading is 0.000V. R73 is just under the metal DIP U64 (AD365) near the center of the card.

4. Adjust the calibrator to output -9.751V.

5. Adjust the GAIN potentiometer R922 until the displayed reading is -9.751V. R922 is next to U831 (AD674).

6. Adjust the calibrator to output +9.751V (±5mV).

7. Adjust the OFFSET potentiometer R921 until the displayed reading is +9.751V (±5mV). R921 is next to U90 (DP23).

8. Repeat steps 2 through 7 until the correct readings are displayed with either 0.000V or 9.751V input to the DAS.

MULTIPLEXER OFFSET CHECK

1. Program the DAS to continuously take 200 readings on input Channel 0, High Range, and display their average value.

2. Short together the high and low inputs of Channel 0.

3. Observe the displayed reading to be 0.000V, ±0.006V.

4. Repeat the above procedure for Channels 2 through 15. If any input channel fails the above test, the multiplexer associated with that channel must be replaced.

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 interrupt is cleared if the Status command is sent to the 53A-171 Card or if the 53A-519B is written to or read. The @XS command allows the interrupt status of the 53A-519B Card to be read as programmed by the Interrupt command (see the Card Commands subsection in the Operation section of this manual).
@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-519B Card the position of the Halt switch causes the @XH command to have the following effects: If the Halt switch is ON, the 53A-519B Card is reset to power-up conditions. If the Halt switch is OFF, the 53A-519B is unaddressed but otherwise unaffected. 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-519B 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

Analog input signals are connected to the DAS via the front edge connector of the 53A-519B Card.

Component Platforms

Located next to the front edge connector are 32 rows of 3-pin headers with 32 jumper blocks installed. The jumper blocks are used in pairs to select extended range or normal range for each channel. CH0 is the top pin, CH15 is the lowest.

To select extended range, connect a jumper block from the center pin to the pin nearest the front card edge on each of the two rows associated with the channel.

To select normal range, connect a jumper block from the center pin to the pin farthest from the card edge on each of the two rows associated with the channel.

53A-519B Pin Assignments

Pin	
A	External Trigger - TTL, Low True
B	Channel 0, high input.
C	Channel 1, high input.
D	Channel 2, high input.
E	Channel 3, high input.
F	Channel 4, high input.
H	Channel 5, high input.
J	Channel 6, high input.
K	Channel 7, high input.
L	Channel 8, high input.
M	Channel 9, high input.
N	Channel 10, high input.
P	Channel 11, high input.
R	Channel 12, high input.
S	Channel 13, high input.
T	Channel 14, high input.
U	Channel 15, high input.
AA	Encode Output, pulsed to a TTL Low each time the DAS digitizes an input channel.
BB	53A system ground.

53A-519B Pin Assignments

Pin

1 Inhibit input, TTL. Typically pulled low by an external device to halt the continuous loading of data into memory.
2 Channel 0, low input.
3 Channel 1, low input.
4 Channel 2, low input.
5 Channel 3, low input.
6 Channel 4, low input.
7 Channel 5, low input.
8 Channel 6, low input.
9 Channel 7, low input.
10 Channel 8, low input.
11 Channel 9, low input.
12 Channel 10, low input.
13 Channel 11, low input.
14 Channel 12, low input.
15 Channel 13, low input.
16 Channel 14, low input.
17 Channel 15, low input.
23 Isolated Analog Ground.

24 External Encode Input, TTL, Low True. See External Encode command.