

**53A-226 THERMOCOUPLE INPUT CARD**

**OPERATING MANUAL**

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# 53A-226 THERMOCOUPLE INPUT CARD

## OPERATING MANUAL

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## 53A-226 THERMOCOUPLE INPUT CARD

### DESCRIPTION

The 53A-226 Thermocouple Card is a printed circuit board assembly for use in a CDS 53/63 Series System. The card provides 10 thermocouple input channels with isothermally-protected ice point compensation and thermocouple linearity correction for Type S, R, B, J, K, T, and E thermocouples. The Thermocouple Card makes temperature measurements at a maximum rate of fifteen readings per second (12.5 per second for 50 Hz operation).

The card provides three modes of operation:

- a "manual" mode in which a channel number is selected under program control, and then readings are taken from it.
- a scanning mode in which a scan list is programmed and readings are sequentially taken from channels as defined by that list.
- a limit check scanning mode in which high and low set points may be pre-programmed for each channel. The on-card microprocessor automatically scans and monitors each input channel for out-of-limit conditions. The Thermocouple Card may be pre-programmed to generate an interrupt when a set point trip occurs. This frees the system controller for other tasks in applications where the Thermocouple Card is needed only for temperature event detection.

Input channels may be added or deleted from the limit check scanning list, or high and low limits may be modified without interrupting the limit check scanning. An override mode allows the user to temporarily track a channel of interest without disabling the limit check operation or any resulting interrupts generated as a result of an out-of-limit occurrence. Two methods of readback are programmable for the limit check mode. Either the channel number only, or the channel number and measurement may be returned for an out-of-limit occurrence. The limit check mode also provides a programmable scanning rate to prolong relay life in low-speed scanning applications.

In all three modes, measurement readings may be programmed for return in degrees Centigrade, Fahrenheit, or Kelvin; or, the card may be programmed as a ten-channel scanning micro-voltmeter with optional limit checking. Automatic updates of amplifier drift compensation and reference junction temperature are provided. If desired, the automatic update feature may be disabled and the update performed under program control. The system controller can also read the card's reference junction temperature, thus allowing the use of the Thermocouple Card as a temperature monitor in a 53/63 card cage.

Input voltage isolation of 200 VDC is provided not only between the thermocouple inputs and the 53/63 System ground but also between any two thermocouple inputs. The Thermocouple Card provides 0.15°C or 0.27°F worst case resolution, and total instrument accuracy of 0.8°C or 1.3°F  $\pm$ 0.02% of reading.

The Thermocouple Card uses basic thermocouple principles to determine the temperature of the thermocouple connected to the card. The difference between the temperature at the

thermocouple sensor and temperature at a reference junction (the Thermocouple Card screw terminals) corresponds to a known voltage for various thermocouple types, as published by the National Bureau of Standards (now the National Institute of Science and Technology, NIST). Compensating for the reference junction is known as "ice-point compensation" because, historically, the reference junction was placed in an ice bath at 0°C rather than electronically measured. Electronic ice point compensation is accomplished on the Thermocouple Card by an on-card microprocessor measuring the temperature of two high-accuracy thermistors located in close thermal proximity to the input screw terminals. Thermocouple curve linearity compensation is provided by the microprocessor to conform to within 0.06°C of the Thermocouple Reference Tables published by NIST.

The screw terminals are completely enclosed in an isothermal chamber in order to maintain a minimum temperature difference between the input connections and the thermistor. Access to the screw terminals is provided through an easily removable rubber-seated cover plate which also provides strain relief for installed thermocouple wires. The screw terminal assembly is removable to allow easy installation of thermocouple wires, and also to allow subsequent removal of the card without disconnecting the cable-to-screw connections.

## CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-226 Card's operating environment.

### Address Select Switch

The Thermocouple Card has a miniature 10-position switch which selects the 53A-226 Card's address (0-9) in the 53/63 Series System. Open the switch's cover and use a screwdriver with a narrow, flat blade to turn the cam-action wiper to the desired position.

### Power LED

The Power LED provides a valuable diagnostic tool by giving the system programmer a visual indication of the action which the system is currently taking. Whenever the 53A-226 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-226 Card is unaddressed, but that all required dc power 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 and Switches

### Channel LEDS (T8, T4, T2, T1)

The four channel LEDS are lit in a binary format to indicate the thermocouple channel presently selected:

<u>T8</u>	<u>T4</u>	<u>T2</u>	<u>T1</u>	<u>Selects:</u>
Off	Off	Off	Off	Channel 0
Off	Off	Off	On	Channel 1
Off	Off	On	Off	Channel 2
Off	Off	On	On	Channel 3
Off	On	Off	Off	Channel 4
Off	On	Off	On	Channel 5
Off	On	On	Off	Channel 6
Off	On	On	On	Channel 7
On	Off	Off	Off	Channel 8
On	Off	Off	On	Channel 9
On	On	On	On	Calibration Mode

### Error LED

When the Thermocouple Card is being used to take measurements, the Error LED will be lit if an improper command is sent to the card, e.g., a Mode command "M3C".

When the Thermocouple Card is in the Calibration Mode, the Error LED will light to indicate an unsuccessful calibration attempt.

### Halt Switch

This two-position slide switch is located near the card's backplane edge connector. It selects the state of the 53A-226 Card after an @XH (Halt) or STOP command is received by the 53/63 Series System.

- In the ON position, the Thermocouple Card will be reset to its initial power-up condition, and the Power LED will be lit, indicating deselection of the card.
- In the OFF position, the Thermocouple Card power LED will light, indicating deselection of the card, but the Thermocouple Card will retain its last programmed channel and function.

### 60Hz/50Hz Switch

The 60Hz/50Hz switch is a single rocker switch used to select the power line frequency for which the Thermocouple Card will provide the maximum power line rejection.

<u>Switch Position</u>	<u>Function Selected</u>
C1	Maximum 50 Hz rejection
C2	Maximum 60 Hz rejection

## SPECIFICATIONS

<u>Types of Thermocouple:</u>	J, K, E, T, R, S, B.
<u>Number of Channels:</u>	10.
<u>Data Returned as:</u>	ASCII Characters, base 10 decimal notation.
<u>Modes:</u>	Three: Manual, Scan, and Limit Check Scan.
<u>Functions:</u>	Temperature: Centigrade, Fahrenheit, or Kelvin. Voltage: -13.9 to 76.5 mV range, -0.7 to 21.2 mV range.
<u>Input Configuration:</u>	Two wires plus shield, each channel isolated.
<u>Input Protection:</u>	250 VDC or 250 VRMS across input terminals.
<u>Input Isolation:</u>	±200 VDC or peak AC between low and ground or any two channels.
<u>Input Connections:</u>	3 screws per channel, located within an isothermal chamber. Access by removal of cover plate.
<u>Reference Junction Compensation Accuracy:</u>	±0.2°C from 0°C to 50°C.
<u>Common Mode Rejection:</u>	120 dB at 50/60Hz with 1K ohm imbalance.
<u>Normal Mode Rejection:</u>	70 dB at 50/60 Hz.
<u>Reading Rate:</u>	15 readings/second or 66.7 milliseconds/reading, 60 Hz. 12.5 readings/second or 80 milliseconds/reading, 50 Hz.  Add additional 66.7 milliseconds for autorange, add additional 200.0 milliseconds for null compensation and reference junction update.
<u>Response Time:</u>	Latest reading available immediately.
<u>Ranging:</u>	Automatic between 0.57 µV resolution range and 2.4 µV resolution range.
<u>Autoranging Levels:</u>	Uprange at 100% of sensitive range. Downrange at approximately 99% of sensitive range.
<u>Calibration Cycle:</u>	12 months.
<u>Temperature Coefficient:</u>	±(25 ppm ±2 µv)/°C.
<u>Open Circuit Detection:</u>	Measurement of 99,999 is returned when open circuit condition is detected.

**Resolution:**Voltage: 0.57  $\mu\text{V}$  on -0.7 to 21.2 mV range2.4  $\mu\text{V}$  on -13.9 to 76.5 mV range

Temperature: Divide voltage resolution by the

voltage/degree gradient from the NIST

Thermocouple Tables for the desired thermocouple type and temperature.

**Maximum Instrument Errors** (Includes all sources of instrument measurement error):

<u>Thermocouple Type</u>	<u>Temperature Range</u>	<u>25°C <math>\pm</math> 5°C (90 days)</u>	<u>25°C <math>\pm</math> 5°C (1 year)</u>
E Nickel chromium/ constantan	-328°F to +1832°F -200°C to +1000°C	$\pm$ .02% rdg $\pm$ 1.3°F $\pm$ .02% rdg $\pm$ .8°C	$\pm$ .03% rdg $\pm$ 1.8°F $\pm$ .03% rdg $\pm$ 1.1°C
J Iron/constantan	-328°F to +1400°F -200°C to +760°C	$\pm$ .02% rdg $\pm$ 1.3°F $\pm$ .02% rdg $\pm$ .5°C	$\pm$ .03% rdg $\pm$ 1.8°F $\pm$ .03% rdg $\pm$ 1.1°C
K Nickel chromium/ Nickel aluminum	-328°F to +2498°F -200°C to +1370°C	$\pm$ .02% rdg $\pm$ 1.3°F $\pm$ .02% rdg $\pm$ .5°C	$\pm$ .03% rdg $\pm$ 1.8°F $\pm$ .03% rdg $\pm$ 1.1°C
T Copper/constantan	-328°F to +752°F -200°C to +400°C	$\pm$ .02% rdg $\pm$ 1.3°F $\pm$ .02% rdg $\pm$ .5°C	$\pm$ .03% rdg $\pm$ 1.8°F $\pm$ .03% rdg $\pm$ 1.1°C
R Platinum 13% rhodium Platinum	-58°F to +3200°F -50°C to +1760°C	$\pm$ .02% rdg $\pm$ 3.2°F $\pm$ .02% rdg $\pm$ 1.8°C	$\pm$ .03% rdg $\pm$ 4.5°F $\pm$ .03% rdg $\pm$ 2.1°C
S Platinum 10% rhodium Platinum	-58°F to +3200°F -50°C to +1760°C	$\pm$ .02% rdg $\pm$ 1.5°F $\pm$ .02% rdg $\pm$ 1.8°C	$\pm$ .03% rdg $\pm$ 4.5°F $\pm$ .03% rdg $\pm$ 2.1°C
B Platinum -30% Rhodium Platinum -6% Rhodium	+887°F to +3308°F +475°C to +1820°C	$\pm$ .02% rdg $\pm$ 3.2°F $\pm$ .02% rdg $\pm$ 1.8°C	$\pm$ .03% rdg $\pm$ 4.5°F $\pm$ .03% rdg $\pm$ 2.1°C

For E type: Add error of  $\pm$ 0.15°C between -50°C and -150°C.For J, K, and T types: Add error of  $\pm$ 0.15°C below -150°C.For R and S types: Add error of  $\pm$ 0.3°C below 35°C.For B type: Add error of  $\pm$ 0.3°C below 625°C.**Voltage Mode****Maximum Errors:** $\pm$ 0.02% rdg  $\pm$ 0.020 mV, 90 days (25°C  $\pm$  5°C) $\pm$ 0.03% rdg  $\pm$ 0.027 mV, 1 year (25°C  $\pm$  5°C)



<b><u>Power Up:</u></b>	When power is turned on, the card will go to the following known states: Unaddressed (Power LED - Lit). Channel selected (No channel LEDs lit). Manual Mode. Type J thermocouple compensation. Degrees Centigrade measurement. Interrupt disabled.
<b><u>Power Requirements:</u></b>	4.75 to 5.25 VDC Current: 0.90 amperes, maximum quiescent. 1.20 amperes, peak
<b><u>Cooling:</u></b>	Provided by the fan in the 53/63 Card Cage.
<b><u>Temperature:</u></b>	-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.
<b><u>Humidity:</u></b>	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.
<b><u>Dimensions:</u></b>	197 mm High, 220 mm Deep, 23 mm Wide (7.25" x 8.66" x 0.9")
<b><u>Dimensions, Shipping:</u></b>	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots.  When ordered alone, the shipping dimensions are: 254 mm x 254 mm x 127 mm (10" x 10" x 5")
<b><u>Weight:</u></b>	0.64 Kg. (1.4 lbs.)
<b><u>Weight, Shipping:</u></b>	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots.  When ordered alone the shipping weight is: 0.90 Kg. (2.0 lbs.)
<b><u>Mounting Position:</u></b>	Any orientation.
<b><u>Mounting Location:</u></b>	Installs in any function-card slot of the 53/63 Series Card Cage.
<b><u>Equipment Supplied:</u></b>	53A-226 Thermocouple Input Card Spare Fuse (Part #42202-52003) Operating Manual (Part #00000-12260) Service Manual (Part #00000-22260)

## OPERATION

### Overview

The 53A-226 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-226 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane.

To address a function card for the first time, the system command @XY must be issued. X is the card cage address (0-9) selected on the 53A-171 Control Card in the addressed card cage; Y is the 53A-226 Card's address (0-9) within the addressed card cage. The 53A-226 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. After the 53A-226 Card is addressed, the commands listed below may be issued until another function card is addressed.

More than one command to the Thermocouple Card may be entered on a line by simply stringing commands together; they are scanned and acted upon in left-to-right order. Spaces, null characters, commas, periods, colons, and semi-colons may be inserted between commands or command arguments without affecting operation. Carriage returns and line feeds may be inserted between commands if desired. Commands that have optional arguments may be transmitted without the optional arguments, with the following consideration: if another command to the Thermocouple Card is not sent directly after the command, a carriage return must be sent as a command terminator.

The Thermocouple Card provides three basic modes of operation: the Manual Mode, the Scan Mode, and the Limit Check Mode. Table I, on the following page, summarizes the commands for all three modes. A detailed description of each command follows Table I. The command descriptions are divided into four major sections: the basic 53/63 System commands, commands common to all three modes, Manual Mode commands, Scan Mode commands, and Limit Check Mode commands.

TABLE I

COMMAND	DESCRIPTION
<hr/>	
<b>COMMON COMMANDS</b>	
MZ <sub>1</sub> Z <sub>2</sub>	MODE Command, Z <sub>1</sub> = 0, 1, or 2 for Manual, Scan or Limit Check Mode, Z <sub>2</sub> = C, F, K, or V for Centigrade, Fahrenheit, Kelvin, or microvolt operation.
NZ	AUTO-ZERO MODE Command, Z = 0, 1 or 2 to disable the Auto-Zero Mode, take one auto-zero measurement, or enable the Auto-Zero Mode.
V	VERIFY Command, returns a 2-digit error code on next input request.
<hr/>	
<b>MANUAL MODE COMMANDS</b>	
DZ <sub>1</sub> Z <sub>2</sub>	DEFINE Command, Z <sub>1</sub> = 0 to 9 for channel number or * for all channels, Z <sub>2</sub> = S, R, E, B, J, K, or T for thermocouple type.
G	GO Command, triggers a measurement.
IZ	INTERRUPT MODE Command, Z = 0 for disabled, 1 for enabled.
<hr/>	
<b>SCAN MODE COMMANDS</b>	
DZ <sub>1</sub> Z <sub>2</sub>	DEFINE Command, take one measurement at defined channel, then return to scan list, Z <sub>1</sub> and Z <sub>2</sub> same as in Manual Mode.
G	GO Command, start scanning scan list.
IZ	INTERRUPT MODE Command, Z = 0 for disabled, 1 for enabled.
LZ <sub>1</sub> ...Z <sub>2</sub> L	LIST Command, defines scan list of up to 100 channel numbers.
<hr/>	
<b>LIMIT CHECK MODE COMMANDS</b>	
DZ <sub>1</sub> Z <sub>2</sub>	DEFINE Command, take measurements from defined channel, Z <sub>1</sub> and Z <sub>2</sub> same as in Manual Mode
HZ	HIGH LIMIT SET Command, Z = floating point number with optional sign and decimal point, <u>no</u> exponent.
Ln	LOW LIMIT SET Command, n = floating point number with optional sign and decimal point, <u>no</u> exponent.
C	CANCEL Command, cancel limits for defined channel.
G	GO Command, start limit check scanning.
Q	QUIT Command, quit limit check scanning.
WZ	WHICH Command, Z = 0 to return out-of-limit channel number(s) only, Z = 1 to return channel number and out-of-limit value.
IZ	INTERRUPT MODE Command, Z = 0 for disabled, 1 for enabled.
PZ	PACE Command, slow scanning speed, Z = 000 to 255, Z times 66.67 milliseconds added to each measurement cycle.

## Card Commands

Following the System commands, the detailed descriptions of each card command are presented in the same order as in Table I.

### 53/63 System Commands

<u>Command</u>	<u>Description</u>
@XY	<p>The @XY (Address) command addresses a function card in the 53/63 Series System.</p> <p>@ is a delimiter used by the 53/63 Series System.</p> <p>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.</p> <p>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.</p> <p><u>Example:</u> Assume that the Thermocouple Card has address 4 and is located in a mainframe which has address 0. The command @04 addresses the Thermocouple Card and extinguishes the Power LED. The Thermocouple Card will remain addressed until another @ character is sent to the system.</p>
@XS	<p>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 @XS command allows the interrupt status of the 53A-226 Card to be read as programmed by the I (Interrupt) command. The <u>53A-171 Control Card Operating Manual</u> describes the @XS command in detail.</p>
@XH	<p>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. In all cases, an addressed function card (Power LED out) becomes unaddressed (Power LED lit).</p> <p><u>Example:</u> Assume the Thermocouple Card is located in a Mainframe which has address 0 and the Halt switch is in the ON position. The command sequence @0H would unaddress all function cards in the Mainframe</p>

with address 0 and reset the Thermocouple Card as if power had been recycled.

If the Thermocouple Card's Halt switch is in the OFF position, the @0H command would unaddress all system cards in the Mainframe with the address 0 and would have no other effect on the Thermocouple Card.

## 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-226 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.

## Input Request

An Input Request is not a string of ASCII characters. An input request is generated by the system controller when data is requested from the 53/63 System. When input is requested, a string of ASCII characters will be returned from the addressed function card. The returned ASCII character string will be terminated by Carriage-Return and Line-Feed characters.

The Thermocouple Card continuously takes measurements at 15 readings/second (for 60 Hz operation). A reading is immediately available whenever an input request is made, unless requests are made closer than 66.67 milliseconds apart. If input requests are made closer than 66.67 milliseconds apart, the card will hold off returning a new measurement until one is available, automatically spacing readings 66.67 milliseconds apart. A reading may take longer than a single 66.67 millisecond period if automatic auto-zero or internal auto-ranging have been selected.

Optional input modes for the Thermocouple Card allow information other than a measurement to be returned (see V and W Commands).

## Commands Common To All Modes

### Command

### Description

M

The Mode (M) command is used at any time to reset the Card and to specify the operating mode and units of measurement.

Syntax: MZ<sub>1</sub>Z<sub>2</sub>

Z<sub>1</sub> is a single digit integer (0, 1, or 2) which specifies the mode:

<u>Z<sub>1</sub></u>	<u>Mode</u>
0	Manual Mode
1	Scan Mode
2	Limit Mode

Z<sub>2</sub> is a single character letter (C, F, K, or V) that specifies the measurement units and the measurement format to be returned:

<u>Z<sub>2</sub></u>	<u>Measurement Units</u>	<u>Format*</u>
C	Degrees Centigrade	±dddd.dd
F	Degrees Fahrenheit	±dddd.dd
K	Degrees Kelvin	±dddd.dd
V	Microvolts DC	±dddddd.dd

\* Leading 0 digits and the + sign are dropped from the returned character string.

The M command must include both command arguments or an error will be generated.

The M command does not change the thermocouple types specified for the 10 channels. It does cancel any active scan lists or active limit check settings.

N

The Auto-zero (N) command is used to enable and disable automatic Auto-zero cycles, as well as to request a single measurement of the reference temperature and null offset drift comparison voltage. An Auto-zero cycle takes three measurements, and thus requires three measurement cycles (200 milliseconds at 60 Hz).

Syntax: NZ

Z is a single-digit integer (0, 1, or 2):

## Z    Selects

- 0    the Auto-zero Mode is turned off.
- 1    a single Auto-zero cycle is performed and either the reference temperature within the isothermal chamber is returned (degrees C, F or K Mode selected), or the offset drift voltage is returned (Voltage Mode selected), if the system controller subsequently requests input.
- 2    the Auto-zero Mode is turned on to perform an Auto-zero every 5 seconds for the first minute after power-on, every 20 seconds up to 10 minutes after power-on, and every 2 minutes thereafter.

## V

The Verify (V) command is used to clear the ERR LED and return a 2-digit error code in response to an input request directly following the command:

### Error Codes

- 00    No errors
- 01    Command input exceeds 125 characters
- 04    Numeric argument too large
- 12    Calibration command not preceded and followed by "CALIB" character string
- 13    Calibration command not formatted properly
- 14    Calibration command value not within one of the required ranges
- 15    Calibration input level not reasonably close to input level specified in "CALIB" command.
- 30    Illegal argument for M (Mode) command
- 31    Incorrect argument for D (Define) command
- 32    Incorrect argument for L (List) command
- 33    Incorrect argument for H (High Limit) command
- 34    Incorrect argument for L (Low Limit) command
- 35    Incorrect argument for I (Interrupt) command
- 36    Incorrect argument for P (Pace) command
- 37    Incorrect argument for N (Auto-zero) command
- 38    Incorrect argument for W (Which) command
- 40    Illegal command characters in Manual Mode
- 41    Illegal command characters in Scan Mode
- 42    Illegal command characters in Limit Check Mode

## Manual Mode Commands (Mode 0)

### Command

### Description

**D** The Define (D) command defines the active channel and specifies the thermocouple type for each channel.

In the Manual Mode all input requests return data from the channel specified by the most recent D command.

Syntax: DZ<sub>1</sub>Z<sub>2</sub>

Z<sub>1</sub> is a single digit channel number (0-9) or an \* character to indicate all channels. The \* is used when setting all thermocouple channels to the same type.

Z<sub>2</sub> is a single character letter (S, R, E, B, J, K, or T) specifying the thermocouple type that is connected to the specified channel(s). Only another D command or cycling power to the card will change the thermocouple type. All thermocouple types are assumed to be Type J on power-up.

**G**

The Go (G) command is used in the Manual Mode to trigger a new measurement cycle. Without a G command being issued, the Thermocouple Card continually takes measurements on the channel specified by the most recent D command; therefore, the G command is only necessary if the measurement must be made after some external event, such as a relay closure, has occurred. The measurement caused by the G command will take as long as 66.7 milliseconds for the completion of the present A/D conversion cycle, plus 66.7 milliseconds for the desired measurement, plus about 30 milliseconds for computations.

**I**

The Interrupt Mode (I) command is used to enable or disable interrupts.

Syntax: IZ

Z is a single digit integer (0 or 1) and specifies the following:

<u>Z</u>	<u>Action</u>
0	Disable Interrupts
1	Enable Interrupts

If the Interrupt Mode is enabled, a single interrupt is generated when a measurement is available after a Go command. The interrupt is cleared when the system controller requests input or sends another command to the Thermocouple Card. See the 53A-171 Control Card Operating Manual for more details on 53/63 System handling of interrupts.



## Scan Mode Commands (Mode 1)

### Command

### Description

D

The Define (D) command defines the active channel and specifies the thermocouple type for each channel.

Syntax: DZ<sub>1</sub>Z<sub>2</sub>

In the Scan Mode the D command will cause the active channel to change from the channel specified by the present position in the scan list for the next input request only. The card will then return to where it left off in the scan list for additional input requests.

Z<sub>1</sub> is the single digit channel number (0-9) or an \* character to indicate all channels. The \* is used when setting all thermocouple channels to the same type.

Z<sub>2</sub> is a single character letter (S, R, E, B, J, K, or T) specifying the thermocouple type that is connected to the specified channel(s). Only another D command or cycling power to the card will change the thermocouple type. All thermocouple types are assumed to be Type J on power-up.

G

The Go (G) command is used in the Manual Mode to trigger a new measurement cycle. Without a G command being issued, the Thermocouple Card continually takes measurements on the channel specified by the last-issued D command; therefore, the G command is only necessary if the measurement must be made after some external event, such as a relay closure, has occurred. The measurement caused by the G command will take as long as 66.7 milliseconds for the completion of the present A/D conversion cycle, plus 66.7 milliseconds for the desired measurement, plus about 30 milliseconds for computations.

I

The Interrupt Mode (I) command is used to enable or disable interrupts.

Syntax: IZ

Z is a single digit integer (0 or 1) and specifies the following:

<u>Z</u>	<u>Action</u>
0	Disable Interrupts
1	Enable Interrupts

If the Interrupt Mode is enabled, a single interrupt is generated when a measurement is available after a Go command. The interrupt is cleared when the system controller requests input or sends another command to the Thermocouple Card. See the 53A-171 Control Card

Operating Manual for more details on 53/63 System handling of interrupts.

L

The List (L) command is used to alter or reset the scan list.

Syntax: LZ<sub>1</sub>...Z<sub>n</sub>L

The Z<sub>1</sub> through Z<sub>n</sub> characters are decimal digits (0-9) that specify the order in which channels will be scanned. Up to 100 channel numbers may be specified in any desired sequence. If the list is broken up into more than one statement, carriage returns and line feeds within the command must be suppressed. An L command issued with no Z arguments resets scanning to the beginning of the scan list. At power-up, the scan list contains ten values, the values 0 through 9.

The final L character is a terminator to specify the end of the command string.

## Limit Check Mode Commands (Mode 2)

<u>Command</u>	<u>Description</u>
D	<p>The Define (D) command defines the active channel and specifies the thermocouple type for each channel.</p> <p>Syntax: DZ<sub>1</sub>Z<sub>2</sub></p> <p>Z<sub>1</sub> is a single digit channel number (0-9) or an * character to indicate all channels.</p> <p>Z<sub>2</sub> is a single character letter specifying the thermocouple type (S, R, E, B, J, K, or T) that is connected to the specified channel(s). Only another D command or cycling power to the card will change the thermocouple type. All thermocouple types are assumed to be Type J on power-up.</p> <p>In the Limit Check Mode, the D command specifies the active channel for subsequent H, L, or C commands. The D command also specifies a channel for returning measurements. Measurements will be returned from the channel specified by the D command until a Which command is issued. At that time, measurement return will be as specified by the Which command. Another D command can be issued anytime and will specify measurement return until another Which command is issued.</p>
H or L	<p>The High Limit (HZ) or Low Limit (LZ) command is used to set a High or Low test limit for the channel specified by the last Define command. The H or L command places the channel in the Limit check scan list if not already there. The H or L command can be used to add a channel to the limit check scan list or to change a limit value either before or after the Go command and the indicated change will become effective on the next measurement taken.</p>
C	<p>The Cancel (C) command is used to cancel High or Low Limits or an out-of-limit conditions for the channel specified by the last Define command. The command also removes the channel specified by the last Define command from the limit check scan list. The C command can be issued before or after the GO command and will be effective on the next measurement taken.</p>
G	<p>The Go (G) command starts the card limit check scanning all channels sequentially for which a high or low limit is active.</p>
Q	<p>The Quit (Q) command terminates limit check scanning. Another Go command may be issued to resume scanning.</p>

W

The Which (W) command is used to define the response of the Thermocouple Card to input requests.

Syntax: WZ

If a W command has not been issued since the last Define command, the card will simply return measurements from the channel specified by the Define command. When a W command is issued, the card will instead return out-of-limit information as specified by the W command. Either a channel number for an out-of-limit condition or a channel number and measurement will be returned depending upon the value of Z:

**Z    Value returned**

- 0    returns in sequential order (with each successive input request) all channel numbers (as a single digit plus CR-LF) with an out-of-limit condition. After all out-of-limit channels have been read once, colon characters are returned.
  
- 1    returns 2 parameters for each channel, one parameter per input request. The first value returned is the channel number, as above, and the second value returned is the first measurement which caused the out-of-limit condition for the channel. When all out-of-limit channels have been read once, the colon character and a limit value of 99999 are returned alternately for additional input requests.

When a channel has been read in the W0 Mode or the channel and value have been read in the W1 Mode, the out-of-limit condition for the channel is cleared. The next scan of the channel which exceeds the limit places a new value in the out-of-limit register. The new limit condition can be read, however, only after issuing a new W command.

Although a D command can be issued during limit check scanning without affecting limit checking or interrupt generation, a W command must be issued to read back the out-of-limit information.

I

The Interrupt Mode (I) command enables or disables interrupts.

Syntax: IZ

Z is the single digit integer 0 or 1:

- Z    Action**
- 0    Disable Interrupts
  - 1    Enable Interrupts

If the Interrupt Mode is enabled, an interrupt is generated each time an out-of-limits condition has occurred. The interrupt is cleared when the system controller requests input from the Thermocouple Card. However, if a second channel still has an out-of-limit condition, the

interrupt will set again immediately. The interrupt will continue to set after each input request as long as scanning continues and any channel is out of limits. See the 53A-171 Control Card Operating Manual for more details on 53/63 System handling of interrupts.

P

The Pace (P) command is used to slow the input scanning in order to extend relay life in slow-speed scanning applications.

Syntax: PZ

Z is a three-digit number from 000 to 255 which specifies how many times the measurement of each channel will be repeated before scanning to the next channel. The P command adds an additional 66.67 times Z milliseconds to each measurement cycle time. Leading zeros may be omitted from Z in the P command if Z is followed by a carriage return and line feed.

## INSTALLATION

The 53A-226 Card is a function card; therefore, it may be installed in any blue card slot. Setting the Address Select switch defines the card's programming address. To avoid confusion, it is recommended that the slot number and the programming address be the same.

### **CAUTION:**

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

- a. Match the keyed slot on the card to the key in the backplane connector. The component side should be to the right for a 53 Series Chassis and to the top for a 63 Series Chassis.
- b. There are two ejectors on the card. Make sure the ejector marked "53A-226" is at the top for a 53 Series Chassis and to the left for a 63 Series Chassis.

### **CAUTION:**

The 53A-226 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.

### Thermocouple Connection Installation

The Thermocouple Input Card has 10 input channels for connection of thermocouples. Each of the 10 channels is electrically isolated from the others and from the 53/63 System power supplies. The thermocouple type for each of the input channels can be individually specified, or they can all be set to the same type, using the D command (Manual Mode).

Three connections are provided for each thermocouple input channel: HI, LO, and SH for high, low and shield connections, respectively. Removable terminal blocks are used for convenience in making thermocouple connections.

Make thermocouple connections as follows:

- a. Turn off power to the card cage and remove the 53A-226 Thermocouple Card.
- b. Remove the metal cover from the isothermal chamber by removing the 4 flathead screws.
- c. Two rubber gaskets are placed around the chamber. Remove the top gasket. The thermocouple connection wires will be routed between the two gaskets.
- d. Remove the appropriate terminal strip by sliding it up, off its connecting pins. Attach the thermocouple leads or thermocouple extension leads and tighten the screw terminals.
- e. Shield connection is optional.
- f. Replace the terminal strip after making sure that all thermocouple connections are secure and that all polarities are correct.
- g. Re-install the top gasket and replace the isothermal chamber cover and screws.

- h. Re-install the card as detailed above and turn power back on.**
- i. Define the installed thermocouple type (R, S, B, E, J, K, or T) for each channel using the D (Define) command.**

## APPENDIX A

### CALIBRATION PROCEDURE

The Thermocouple Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibrations should be carried out in an environment where the temperature is between 21 °C 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.

Calibration of the Thermocouple Card is somewhat different from that of most measurement instruments in that no manual adjustments are made by the operator during calibration. Instead, during calibration the microprocessor on the Thermocouple Card updates a non-volatile memory which contains error terms for the difference between a voltage input to the Thermocouple Card and the actual voltage measured by the card. These "Error Terms" are later used by the microprocessor correct measurement values taken by the Thermocouple Card integrating A/D before measurements are returned to the user.

#### Test Equipment Required

A precision voltage source capable of putting out the following voltages:

1. A known positive DC voltage between 63000 and 73000 microvolts to an accuracy of  $\pm 5$  microvolts.
2. A known positive DC voltage between 19000 and 20900 microvolts to an accuracy of  $\pm 2$  microvolts.
3. A known negative DC voltage between -9000 and -9900 microvolts to an accuracy of  $\pm 5$  microvolts.
4. A known negative DC voltage between -500 and -600 microvolts to an accuracy of  $\pm 2$  microvolts.

#### Setup

Observe the following precautions when calibrating the Thermocouple Card:

- Send the commands M0V and D9J to the Thermocouple Card. The known calibration voltage must be applied to the thermocouple Channel 9 input terminals for a period of 1 second prior to sending the Calibration command to the Thermocouple Card. This precaution ensures that settling time errors caused by stray capacitance in the cabling between the Thermocouple Card and calibration source will not affect the calibration.
- The ERR LED must be extinguished before a Calibration command is sent to the Thermocouple Card.



## Calibration Procedure

To calibrate a given function and range, proceed as follows:

1. Input a known calibration voltage between 63000 and 73000 microvolts to the channel 9 screw terminals.
2. Issue the Calibration command. The format of the Calibration command is "CALIBnCALIB", where n is a decimal number with optional sign and decimal point, but no exponent. If using a calibration voltage of 73374 microvolts, a correct Calibration command would be "CALIB73374CALIB".
3. Check to see that the ERR LED is out. If it is on, use the Verify command to determine the reason for the unsuccessful calibration.
4. Repeat Steps 1 through 3 three more times using a calibration voltage in the range of 19000 to 20900 microvolts, -9000 to -9900 and -500 to -600 microvolts respectively.

## APPENDIX B

### SCREW TERMINAL ASSIGNMENTS

(front edge)

<u>Screw Terminal Number</u>	<u>Signal</u>
1 through 3	High, Low and Shield connection respectively for Channel 0.
4 through 6	High, Low and Shield connection respectively for Channel 1.
7 through 9	High, Low and Shield connection respectively for Channel 2.
10 through 12	High, Low and Shield connection respectively for Channel 3.
13 through 15	High, Low and Shield connection respectively for Channel 4.
16 through 18	High, Low and Shield connection respectively for Channel 5.
19 through 21	High, Low and Shield connection respectively for Channel 6.
22 through 24	High, Low and Shield connection respectively for Channel 7.
25 through 27	High, Low and Shield connection respectively for Channel 8.
28 through 30	High, Low and Shield connection respectively for Channel 9.