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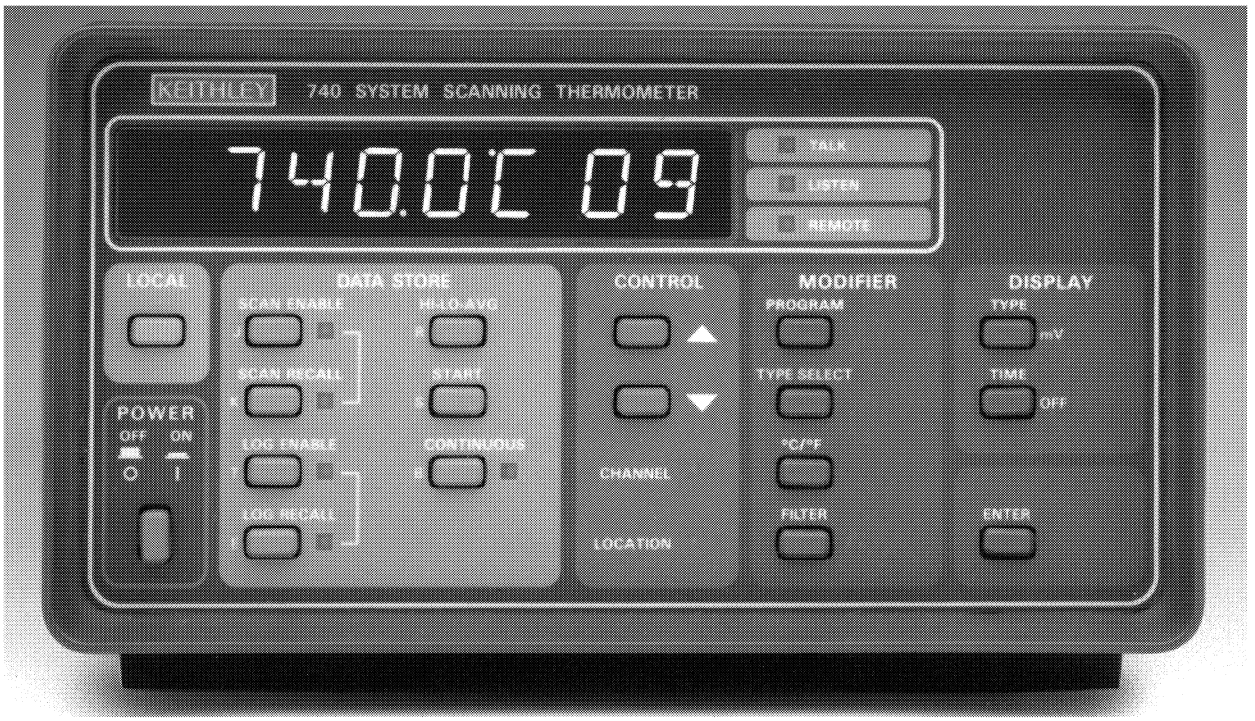
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Model 740
System Scanning Thermometer

Instruction Manual



Contains Operating and Servicing Information

KEITHLEY

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Model 740
System Scanning Thermometer
Instruction Manual

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SPECIFICATIONS
MODEL 740

ACCURACY*

Type	Range	1 Year 18°C-28°C (65°F-82°F)
mV	−99.999 to 100.000mV	±(0.02% + 3μV)
J	−100.0°C to + 760.0°C	±0.4°C
	−148.0°F to +1400.0°F	±0.8°F
K	−100.0°C to +1372.0°C	±0.5°C
	−148.0°F to +2501.0°F	±0.9°F
T	−100.0°C to + 400.0°C	±0.5°C
	−148.0°F to + 752.0°F	±0.8°F
E	−100.0°C to +1000.0°C	±0.5°C
	−148.0°F to +1832.0°F	±0.9°F
R	0°C to 1780°C	±1°C
	32°F to 3236°F	±2°F
S	0°C to 1780°C	±1°C
	32°F to 3236°F	±2°F
B	350°C to 1820°C	±1°C
	662°F to 3308°F	±2°F
EXTENDED RANGE: Types J, K, T, E,		
	−200.0°C to −100.1°C	±0.6°C
	−328.0°F to −148.0°F	±1.0°F

mV INPUT RESISTANCE: Greater than 1 GΩ.

TEMPERATURE COEFFICIENT: 0-18°C & 28-50°C
Less than 0.1 × rated accuracy/°C.

INPUT CURRENT: 800pA max. during measurement.
60μA max. during open thermocouple check.

COMMON MODE REJECTION RATIO:**
(at dc, 50 and 60Hz, 100Ω unbalance)
Less than 0.0003°C/V with filter enabled (160dB).
Less than 0.003°C/V with filter disabled (140dB).

NORMAL MODE REJECTION RATIO:**
(at 50 and 60Hz)
Less than 0.003°C/mV with filter enabled (80dB).
Less than 0.03°C/mV with filter disabled (60dB).

*Excludes thermocouple errors.
(Specifications include Model 7057A errors).

**Based on greater than 30μV/°C slope.

IEEE-488 BUS IMPLEMENTATION

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD, MLA, MTA.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, E1, C28.

PROGRAMMABLE PARAMETERS: EOI, Terminator, SRQ, Status, Trigger, Self Test, Calibration, Filter, Function, Scan Interval, Log Interval, Time & Date, Time of Day Trigger, Date Format, Alarm Limits, Output Format, Channel #, Data Buffer, Scale, Display, Channel Type.

GENERAL

MAXIMUM ALLOWABLE INPUT : 250V rms, 350 V peak (for 1 minute).

MAXIMUM COMMON MODE VOLTAGE: 200V peak to earth.

MAXIMUM THERMOCOUPLE LOOP RESISTANCE: 1kΩ.

FILTER SETTLING TIME: 100ms (typical).

SCANNING RATE: Greater than 20 channels/second, filter disabled.
Greater than 5 channels/second, filter enabled.

BENCH READING RATE: 8 readings/second, filter disabled.
4 readings/second, filter enabled.

LOGGING INTERVAL: One of 12 selectable rates from 50ms to 1 hour, or triggered.

SCANNING INTERVAL: One of 10 selectable rates from 500ms to 1 hour, or triggered.

DISPLAY: 8 0.5-inch alphanumeric LED digits with decimal point and polarity. Function, Filter, Channel, Location, Overflow, Open Thermocouple, and IEEE bus status also displayed.

INTERNAL CLOCK: Displays hour/minute/second; less than 1 minute/month error (typical).

WARMUP: 1 hour to rated accuracy.

CONNECTORS: 3 BNC; External Trigger, Serial-In, Serial-Out. (TTL compatible). Quick disconnect connectors on input card.

CHANNEL CONFIGURATION: Types J, K, T, E, R, S, B, mV or OFF for each channel.

DATA MEMORY: Battery backed up one week minimum.
Single Channel Log: 100 locations (reading, location, time taken).
Multi-Channel Scan: 90 locations (reading, channel #, time taken).
Configuration: 81 locations (channel type selected).

CAPACITY: Single channel or 10 channels (including reference junction) using one Model 7057A thermocouple scanner card. Up to 90 channels (including reference junctions) using 8 additional Model 7057A thermocouple scanner cards and one Model 706 or four Model 705 scanners.

OPERATING ENVIRONMENT: 0°-50°C; less than 80% relative humidity up to 35°C; linearly derate 3%RH/°C, 35°-50°C.

STORAGE ENVIRONMENT: −25° to +60°C

POWER: 105-125V or 210-250V (external switch selected) 20VA. 90-110V available; 50-60Hz.

DIMENSIONS, WEIGHT: 127mm high × 216mm wide × 359mm deep (5 in. × 8½ in.). Net weight 4.0kg (9 lbs.).

ACCESSORIES:

Model 1019A: Rack Mount Kit (Fixed).

Model 1019S: Rack Mount Kit (Slide).

Model 7007: IEEE-488 Cable (Shielded).

Model 7008: IEEE-488 Cable (Standard).

Model 7051-2: 2 ft. BNC to BNC Cable (RG-58C).

Model 7051-5: 5 ft. BNC to BNC Cable (RG-58C).

Model 7057A: Thermocouple Scanner Card.

Model 7401: Thermocouple Wire Kit. Contains 100 feet of type K thermocouple wire.

SCANNERS:

Model 705: 20-Channel Scanner Mainframe.

Model 706: 100-Channel System Scanner.

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SAFETY PRECAUTIONS

The following precautions apply to situations where a voltage potential may come in contact with a thermocouple. These precautions should be observed before operating the Model 740:

When using the internal channel, never connect more than one thermocouple to the input card of the instrument. Otherwise, erroneous readings and a potential safety hazard will result.

When using one or more scanner cards, never connect a thermocouple directly to the input card of the instrument. Otherwise, erroneous readings and a potential safety hazard will result.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over the manual carefully before operating this instrument.

Inspect the insulation of the thermocouple wires for possible wear, cracks or breaks. If any defects are found, replace the thermocouple assembly.

For optimum safety, do not touch the thermocouple wires while power is applied to the device under test. Turn off the power and discharge all capacitors before connecting or disconnecting the thermocouple.

Do not touch any objects which could provide a current path to the thermocouple or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage present.

Do not exceed the instrument's maximum allowable input as defined in the specifications and operation section.

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Contains an overview of the instrument including features, unpacking instructions, as well as available accessories.

SECTION 1
General Information

This section contains detailed operating information for the Model 740 System Scanning Thermometer. Use this section as a reference on all front panel operating aspects of the instrument.

SECTION 2
Bench Operation

Contains a general description of the IEEE-488 bus standard. Also included is information on connecting the Model 740 to the bus and general programming information.

SECTION 3
IEEE-488 Principles

Contains the information needed to program the Model 740 from a computer using the device-dependent commands. Also included, is information for using the Smart Print mode.

SECTION 4
Device-Dependent Command Programming

A complete description of operating principles for the instrument is located in this section. Analog, digital, microcomputer, and power supply circuits are described, as are the IEEE-488 interface.

SECTION 5
Principles of Operation

Details maintenance procedures including fuse replacement, calibration, performance verification and troubleshooting.

SECTION 6
Maintenance

Includes replacement parts information, schematic diagrams, and component location drawings for the Model 740.

SECTION 7
Replaceable Parts

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SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Model 740 is a system scanning thermometer that can make temperature measurements using seven different thermocouple types (J, K, T, E, R, S, B) or millivolt measurements. With the use of the various thermocouple types, temperature measurements in the range of -200°C to +1820°C can be made. A single internal channel is standard equipment in the Model 740. The installation of a Model 7057A scanner card into the Model 740 expands the available measurement channels to nine. The measurement system is expandable to 81 channels with the addition of four Model 705s, or one Model 706 with eight scanner cards installed.

Some important Model 740 features include:

- Automatic scanning and data storage with HI/LO, of up to 81 channels.
- 20 channels per second scanning rate.
- °C or °F temperature scale.
- mV measurement capabilities.
- 100 point single channel data logger with HI/LO/AVG.
- 24 hour clock for time day and starting a scan or log.
- Open thermocouple detection.
- IEEE "Smart Print" mode—talk to addressable as well as listen-only devices.
- Digital calibration—no internal adjustments to be made.

1.2 WARRANTY INFORMATION

Warranty information may be found on the inside front cover of this manual. Should it become necessary to exercise the warranty, contact your Keithley representative or the factory to determine the proper course of action. Keithley Instruments maintains service facilities in the United States, United Kingdom and throughout Europe. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of these locations. Check the inside front cover for addresses.

1.3 MANUAL ADDENDA

Information concerning improvements or changes to the instrument which occur after the printing of this manual will be found on an addendum sheet included with this manual. Be sure to review these changes before attempting to operate or service the instrument.

1.4 SAFETY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or found on the Model 740:

The ⚠ symbol on the instrument denotes that the user should refer to the operating instructions in this manual.

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

1.5 SPECIFICATIONS

Detailed Model 740 specifications may be found preceding the Table of Contents of this manual.

1.6 INSPECTION

The Model 740 System Scanning Thermometer was carefully inspected, both electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packing materials in case reshipment is necessary. The following items are shipped with every Model 740 order:

Model 740 System Scanning Thermometer
Model 740 Instruction Manual
Additional accessories as ordered.

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If an additional instruction manual is required, order the manual package (Keithley Part Number 740-901-00). The manual package includes an instruction manual and any applicable addenda.

1.7 USING THE MODEL 740 MANUAL

This manual contains information necessary for operating the Model 740 from the front panel and over the IEEE-488 bus. Maintenance information for calibrating and servicing the unit is also provided. The information is divided into the following sections:

- Section 1 contains general information about the Model 740 including that necessary to inspect the instrument for damage.
- Section 2 contains detailed operating information on using the front panel controls and programs.
- Section 3 contains background information on the IEEE-488 bus standard. Included is detailed information on connecting equipment to the bus, software considerations for using the HP-85 and the IBM-PC/8573 as controllers, and general bus command programming.
- Section 4 contains the device-dependent command programming information needed to operate the instrument over the IEEE-488 bus.
- Section 5 contains a description of operating theory for the Model 740. Analog, digital, power supply, and IEEE-488 interface operation is included.
- Section 6 contains information for servicing the instrument. This section includes information on fuse replacement, line voltage selection, verification, calibration and troubleshooting.
- Section 7 contains replaceable parts information.

1.8 OPTIONAL ACCESSORIES

The following accessories are available to be used with the Model 740:

Models 1019A and 1019S Rack Mounting Kits—The Model 1019A is a stationary rack mounting kit with two front panels provided to enable either single or dual side-by-side mounting of the Model 740 or other similar Keithley instrument. The Model 1019S is a similar rack mounting kit with a sliding mount configuration.

Model 7007 IEEE-488 Shielded Cables—The Model 7007 connects the Model 740 to the IEEE-488 bus using shielded cables to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter (3.3 ft.) in length and has an EMI shielded IEEE-488 connector at each end. The Model 7007-2 is identical to the Model 7007-1, but is two meters (6.5 ft.) in length.

Model 7008 IEEE-488 Cables—The Model 7008 connects the Model 740 to the IEEE-488 bus. The Model 7008-3 is 0.9m (3 ft.) in length and has a standard IEEE-488 connector at each end. The Model 7008-6 cable is identical to the Model 7008-3, but is 1.8m (6 ft.) in length.

Model 7051-2 BNC to BNC Cable—0.6 meter (2 ft.) BNC to BNC cable used to daisy chain scanners to the Model 740.

Model 7051-5 BNC to BNC Cable—1.5 meter (5 ft.) BNC to BNC cable used to daisy chain scanners to the Model 740.

Model 7057A Thermocouple Scanner Card—Enables the Model 740 to make multiple channel (up to 81) temperature measurements. Each card is field installable in the appropriate mainframe and provides nine channels and a reference junction channel that can be used for temperature measurements.

Model 7401 Type K Thermocouple Wire Kit—Contains 100 feet of Type K (Chromel-Alumel) thermocouple wire.

Model 8573 IEEE-488 Interface—The Model 8573 is an IEEE-488 standard interface designed to interface the IBM PC or XT computers to Keithley instrumentation over the IEEE-488 bus. The interface system contains two distinctive parts: an interface board containing logic to perform the necessary hardware functions and the handler software (supplied on disk) to perform the required control functions. These two important facets of the Model 8573 join together to give the IBM advanced capabilities over IEEE-488 interfaceable instrumentation.

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SECTION 2
BENCH OPERATION

2.1 INTRODUCTION

This section of the manual provides the information needed to set up and operate the instrument from the front panel. In addition to detailed operating procedures, flowcharts that summarize operation are included. Also, included are tables that list and describe the functions of front panel controls that are active during the various states of operation.

2.2 POWER UP PROCEDURE

2.2.1 Line Voltage Selection

The Model 740 may be operated from either 105-125V or 210-250V with 50 or 60Hz power sources. A special transformer may be installed for 90-110V and 195-235V operation. The instrument was shipped from the factory set for the operating voltage marked on the rear panel. To change the line voltage, proceed as follows:

1. Locate the line voltage switch on the rear panel and place the switch in the position that corresponds to the available line voltage.
2. Install a fuse that is consistent with the operating voltage as explained in paragraph 6.2.

CAUTION

The correct fuse type must be used to maintain proper instrument protection.

3. Mark the selected line voltage on the rear panel for future reference (to avoid confusion, erase the old mark).

NOTE

If the line frequency setting of the instrument needs to be checked or changed, utilize front panel Program LINE after the completion of the power-up sequence.

2.2.2 Line Power

With the instrument set to the correct line voltage (paragraph 2.2.1), connect the female end of the power cord to the AC receptacle on the rear panel of the instrument. Connect the other end of the cord to a grounded AC outlet.

WARNING

The Model 740 is equipped with a 3-wire power cord that contains a separate ground wire and is designed to be used with grounded outlets. When proper connections are made, the instrument chassis is connected to power line ground. Failure to use a grounded outlet may result in personal injury or death because of electrical shock.

CAUTION

Be sure that the power line voltage agrees with the indicated range on the rear panel of the instrument. Failure to observe this precaution may result in instrument damage.

2.2.3 Power Up Sequence

The instrument can be turned on by pressing in the front panel POWER switch. The switch will be at the innermost position when the instrument is turned on. Upon power-up, the following sequence will take place:

1. A test on non-volatile random access memory (NVRAM) will be performed. Calibration constants are stored in this memory. If NVRAM fails, the power-up sequence will stop and the instrument will display the following message:

   UN-CAL

   Corrective action, as explained in paragraph 6.6.2, should be taken if the failure occurs. With "UN-CAL" displayed, the power-up sequence can be continued by holding in any front panel momentary button until the loop setting (step 3) is displayed.
2. If the NVRAM test is successful, the date that the instrument was last calibrated will be displayed briefly. For example, if the calibration date is July 12th, one of the following messages will be displayed briefly:

   07.12 CAL (American format - factory default)
   12.07 CAL (European format)

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07.12 CAL (American format)
12.07 CAL (European format)

Note: If NVRAM failed, the calibration date will reset to 01.01.

3. A display message indicates which external scanner(s) the instrument is set to operate with (loop setting). For example, if the instrument is currently set to operate with Model 705 scanners, the following message will be displayed briefly:

705 ?

4. If the scanner is serially connected to the Model 740 and a reference junction is detected, the following message will be displayed briefly:

FOUND

If the loop setting does not match the scanner(s) serially connected to the Model 740, the instrument will lock up with the message "NO LOOP" displayed. To remedy the problem:

A. Turn off the Model 740 and the external scanner(s).
B. Power-up the Model 740 and select the alternate loop setting using front panel Program LOOP (see paragraph 2.11.5).
C. Turn off the Model 740. The alternate loop setting will be stored in battery backed-up memory.
D. Turn on the external scanner(s).
E. Lastly, turn on the Model 740. The instrument will then "find" the external channels.

Note: The loop setting and found messages are irrelevant if an external scanner(s) is not serially connected to the Model 740.

5. An internal battery is used to power memory that "remembers" various setup parameters of the instrument. If the battery is in a discharged state, the following message will be displayed briefly:

BATTFAIL

Upon receipt of instrument, the battery will probably be in a discharge condition when it is first turned on. This is not a defect. To fully charge the battery, leave the instrument powered up over night.

More information on the battery powered memory can be found in paragraph 2.2.4.

6. The instrument will then display the first available measurement channel at default conditions.

2.2.4 Default Conditions

The Model 740 contains battery powered memory that is used by the instrument to "remember" the setup conditions after power-down. Upon subsequent power-up, the instrument will return to those user defined default conditons. The following conditions are "remembered" by the Model 740:

1. Time of day.
2. Current date.
3. Channel configurations (types) - TC type, mV or OFF.
4. Readings in data store.
5. Scale - °C/°F.
6. Filter - on/off.
7. Continuous - enabled/disabled.
8. Trigger time - Program TRIG.
9. Interval

The battery charges when the instrument is on. A fully charge battery will become discharged if the battery is not charged within seven days. To charge a discharge battery, leave the instrument powered up for approximately 12 hours. If the battery discharges the instrument "forgets" the previous setup conditions and returns to the factory default conditions. The instrument will power up to the following conditions if the battery is discharged; the time of day resets to 00.00.00, the current date to 01.01, all channels are set to be OFF, all readings in the data store are lost, the scale resets to °C, filter disabled, continuous mode disabled, the trigger time will reset to 24.00 (disabled), and the interval will set to "1-SHOT".

Some other instrument parameters are saved in non-volatile random access memory (NVRAM). This type of memory retains the programmed information and does not require a power source (battery). The parameters that are saved in NVRAM include:

1. Calibration date.
2. IEEE address (set to 14 at factory).
3. Line frequency setting (set to 60Hz at factory).
4. Calibration constants.
5. Calibration serial number
6. Loop Setting - 705/706 (set to 705 at factory).
7. Date Format

2.3 FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 740 is shown in Figure 2-1, while a brief description of each front panel control is contained in Table 2-1. The following paragraphs describe the various components of the front panel in detail.

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Table 2-1. Summary of Front Panel Controls

Control	Function
POWER	Turns instrument on and off.
LOCAL	Transfers control from IEEE to front panel.
SCAN ENABLE	Toggles instrument between scan enable mode and scan disable mode. Also sets channel(s) for Type J thermocouples.
SCAN RECALL	Toggles display between stored scan readings and normal measurement readings. Also sets channel(s) for Type K thermocouples.
LOG ENABLE	Toggles instrument between log enable mode and log disable mode. Also sets channel(s) for Type T thermocouples.
LOG RECALL	Toggles between stored log readings and normal measurement readings. Also sets channel(s) to Type E thermocouples.
HI-LO-AVG	Displays the highest, lowest and average reading stored in log buffer. Displays the highest and lowest readings in the scan buffer. Also sets channel(s) to Type R thermocouples.
START	Starts scan and log processes. Also sets channel(s) for Type S thermocouples.
CONTINUOUS	Toggles scan and log modes between continuous and single. Also sets channel(s) for Type B thermocouples.
▲ and ▼	Increments and decrements channels, memory locations, and scan and log intervals. Also used with front panel programs.
PROGRAM	Selects the front panel program mode. Each subsequent press increments to next program component.
TYPE SELECT	Places instrument in the state where channels can be configured.
°C/°F	Toggles scale of display between °C and °F.
FILTER	Toggles filter between on and off.
TYPE (mV)	Displays configuration of channel. Also used to configure channel(s) for millivolt measurements.
TIME (OFF)	Displays time of day, time of scan or log, and selects Program TIME. Also used to configure channel(s) to be off.
ENTER	Enters operating and program parameters. Also returns display to previous state when TIME or TYPE is checked, and when HI-LO-AVG is displayed.

NOTE: For more information on front panel controls, see paragraph 2.3.2.

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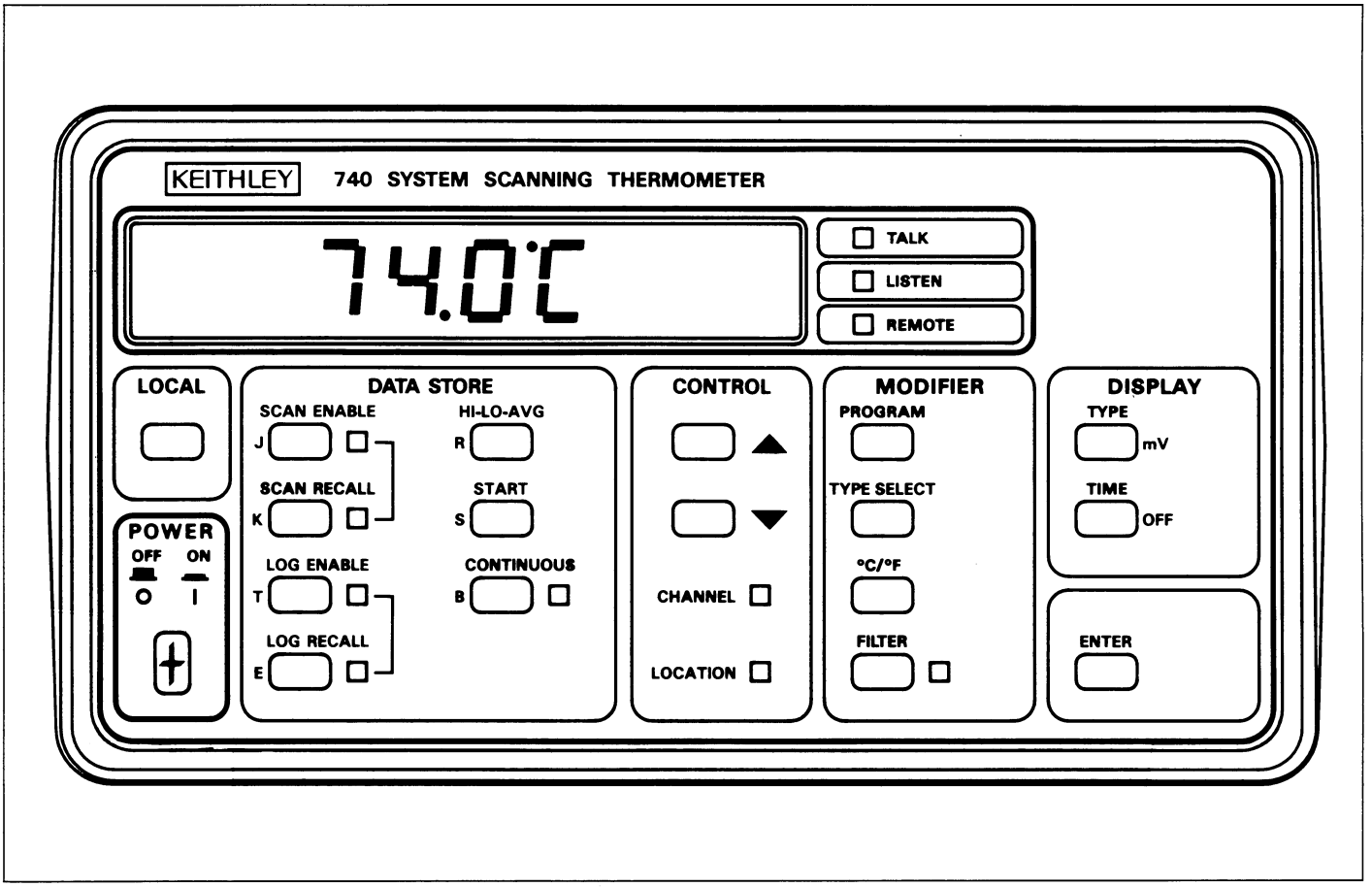


Figure 2-1. Front Panel Layout

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2.3.1 Display and Indicators

Display—The 8 character, alphanumeric, LED display is used to display temperature and millivolt measurements, channel and memory locations, and various messages associated with operation.

IEEE Status Indicators—The TALK, LISTEN and REMOTE indicators apply to instrument operation over the IEEE-488 bus. The REMOTE indicator shows when the instrument is in the IEEE-488 remote state. The TALK and LISTEN indicators show when the instrument is in the talk and listen states respectively. See Sections 3 and 4 for detailed information on operation over the bus.

Operation Status Indicators—Many of the Model 740 controls have indicators that help define the operating state of the instrument. Descriptions of these controls, along with their companion indicators, are described in paragraph 2.3.2. Descriptions of the other two indicators are as follows:

CHANNEL Indicator—When this indicator is on, the displayed information pertains to the channel. Scanner card channel numbers are displayed while the internal measurement channel number is not. The channel number is indicated by the last two display characters.

LOCATION Indicator—When this indicator is on, the displayed information pertains to the memory location that is also displayed. The memory location number is indicated by the last two display characters.

2.3.2 Controls

All front panel controls, except the POWER switch, are momentary contact switches. Many of the buttons perform more than one function. Table 2-1 summarizes the functions of the front panel control buttons.

POWER—The POWER switch controls the AC power to the instrument. Placing the switch to the "in" position turns the power on. Placing the switch to the "out" position turns the power off. The correct positions for off and on are marked on the front panel by the POWER switch.

LOCAL—When the instrument is in the IEEE-488 remote state (REMOTE indicator on), the LOCAL button will return the instrument to front panel operation. However, if local lockout (LLO) was asserted over the bus, the LOCAL button will be inoperative. See Sections 3 and 4 for information on operating the instrument over the bus.

DATA STORE Group

SCAN ENABLE (J)—This button causes the SCAN ENABLE indicator to start flashing, and places the instrument in the scanning mode of operation. When the indicator is on but not flashing, the instrument is scanning the available channels. The Model 740 can scan up to 90 channels (nine of which are reference junction channels) at one of 10 available intervals or perform a single scan. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type J thermocouples.

SCAN RECALL (K)—When the instrument is in the normal measurement state or in the scanning state, this button turns on the SCAN RECALL indicator and allows the instrument to recall scanned readings. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type K thermocouples.

LOG ENABLE (T)—This button causes the LOG ENABLE indicator to start flashing and places the instrument in the log enable mode. When the indicator is on (not flashing), the instrument is logging readings. The Model 740 can store up to 100 readings at one of 13 available storage intervals. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type T thermocouples.

LOG RECALL (E)—When the instrument is in the normal measurement state or in the logging state, this button turns on the LOG RECALL indicator and allows the instrument to recall logged readings. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type E thermocouples.

HI-LO-AVG (R)—When the instrument is in the log recall mode, this button is used to display the highest, lowest and average reading stored in the log buffer. When the instrument is in the scan recall mode, this button is used to display the highest and lowest reading stored in the scan buffer. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type R thermocouples.

START (S)—When the instrument is in the scan or log mode (SCAN ENABLE or LOG ENABLE indicator flashing), this button can be used to start the scanning or logging process. When the instrument is in type select mode, the function of this button is to configure one or all channels for Type S thermocouples.

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CONTINUOUS (B)—This button toggles the instrument between the continuous (CONTINUOUS indicator light on) and single scan/log mode. In the single scan mode, one reading of each available channel will be stored in the scan buffer. In the continuous scan mode, scans continue to occur at the selected interval. Each scan will overwrite the previous reading on each channel. In the single log mode, logging will stop after the log buffer fills (100 readings). In the continuous log mode, readings will continue to be logged after the buffer is full with the most recent reading occupying location 99. When the instrument is in the type select mode, the function of this button is to configure one or all channels for Type B thermocouples.

CONTROL Group

The ▲ and ▼ buttons are used for incrementing and decrementing channels and memory locations, selecting scanning and logging intervals, and selecting the various program parameters.

MODIFIER Group

PROGRAM—This button places the instrument in the front panel program mode. Each press of the PROGRAM button increments the instrument to the next program segment.

TYPE SELECT—This button is used to configure the channels available to the Model 740. Each channel can be configured for temperature measurements (thermocouple type selected), millivolt measurements (mV selected) of a thermocouple or set to display "OFF" (OFF selected) if the channel is not going to be used.

°C/°F—This button toggles the thermometric scale of the display between °C and °F.

FILTER—This button toggles the filter between on (FILTER indicator light on) and off. The filter cannot be enabled while the instrument is scanning, logging or recalling readings.

DISPLAY Group

TYPE (mV)—This button is used to display the configuration of the currently selected channel (thermocouple type, mV or OFF). When the instrument is in the type select mode, the function of this button is to configure the currently selected channel for millivolt (mV) measurements of the thermocouple.

TIME (OFF)—This button is used to display the current time of day and the time that a reading was scanned or logged. Time is displayed in a 24 hour clock format. For example, a time of 1:00 PM is displayed as 13:00:00. Program TIME, explained in paragraph 2.11.2, is used to set the clock to the correct time. If a trigger time is set, the "on" message will accompany the time (ie. "13:00:00 ON"). When the instrument is in the type select mode, the function of this button is to configure the channel(s) to display "OFF" if it is not going to be used.

ENTER—This button is used to enter various operating and front panel program parameters, and returns the display to the previous state when TIME or TYPE is checked.

2.4 REAR PANEL FAMILIARIZATION

The rear panel layout of the Model 740 is shown in Figure 2-2. The following information describes the various components of the rear panel:

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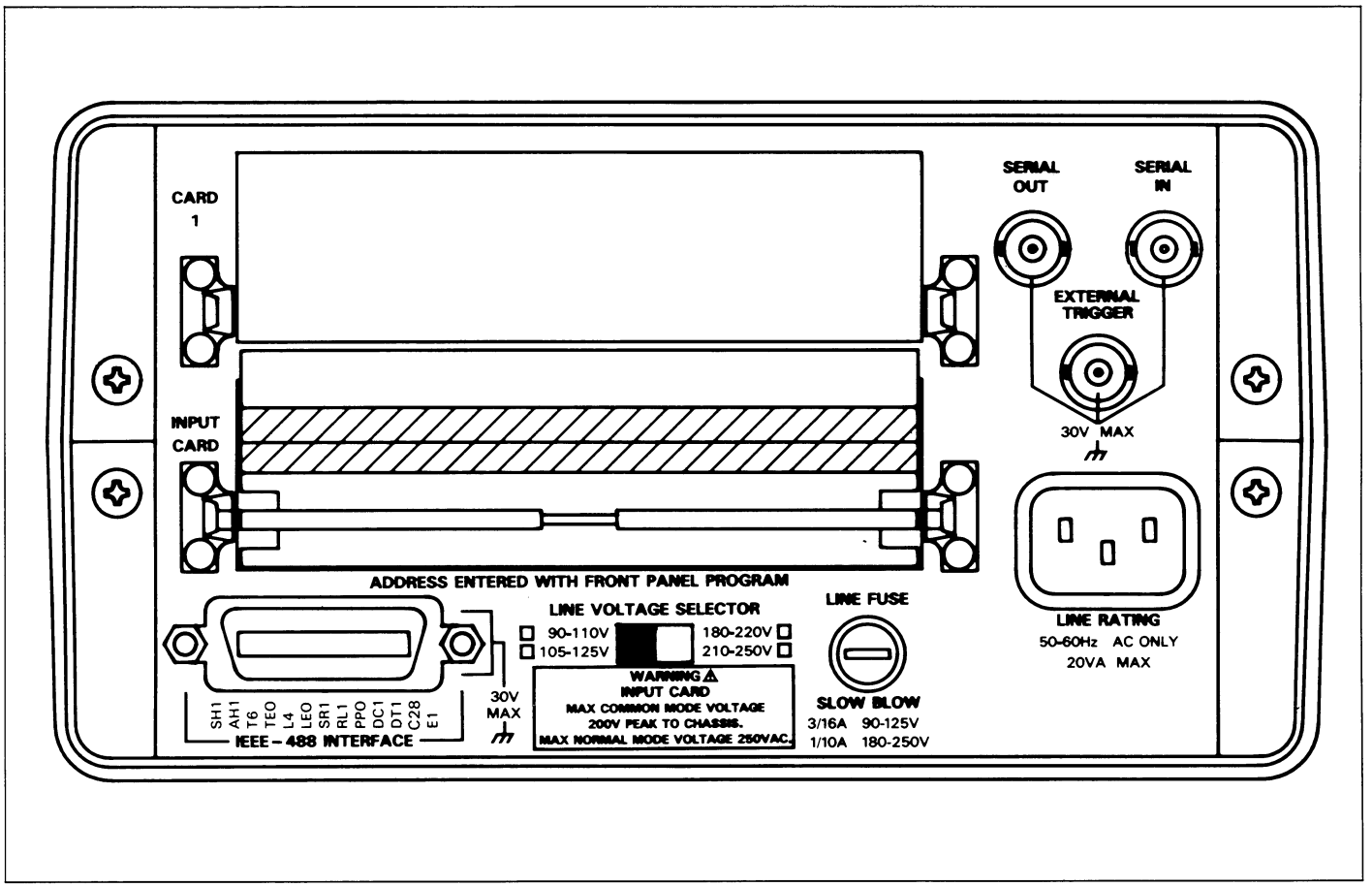


Figure 2-2. Rear Panel Layout

CARD 1 slot—This slot can accommodate one Model 7057A Thermocouple Scanner Card which makes nine channels (2 through 10) available to the Model 740. Refer to paragraph 2.6.2 for instructions on how to remove or install a scanner card.

INPUT CARD—This card is used to connect each channel of the measurement system to the input of the Model 740. When using the internal channel, a single thermocouple is connected to the terminal strip of the input card. When using one or more scanner cards, the output of each card is connected to the terminal strip.

SERIAL IN—This BNC connector provides a daisy chain configuration to a Keithley scanner that has one or more temperature scanner cards installed. SERIAL IN is connected to SERIAL OUT of the Model 705 or 706.

SERIAL OUT—This BNC connector completes the daisy chain configuration. SERIAL OUT is connected to SERIAL IN of the Model 705 or 706. Figure 2-7 and 2-8 illustrates a daisy chain configuration.

EXTERNAL TRIGGER—This BNC connector is used to connect an external pulse source to the instrument for the purpose of initiating the scan or log process. See paragraph 2.12 for complete information on external triggering.

IEEE-488 INTERFACE—The IEEE bus connector provides bus connection to the Model 740. The connector mates to the Keithley Model 7008-3 and 7008-6 cables.

LINE FUSE—This is the line power fuse and is rated as specified in Table 6-1.

LINE RECEPTACLE—The line power receptacle mates with a three wire line cord which provides connections to line voltage. For correct line voltage selection, refer to paragraph 2.2.

2.5 ERROR MESSAGES

Table 2-2 lists and explains the various error messages associated with front panel operation. Error messages associated with bus operation are covered in Section 3.

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Table 2-2. Error Messages

Message	Explanation
SCANENBL	Displayed briefly when invalid button pressed while in scan enable mode.
LOG ENBL	Displayed briefly when invalid button pressed while in log enable mode.
LOGGING	Displayed briefly if invalid button pressed while 740 is logging.
SCANNING	Displayed briefly if invalid button pressed while 740 is scanning.
OPENTC 02	TC not connected to displayed channel or TC is open.
SHORT	740 cannot log or scan at selected interval. 740 will log or scan as fast as the setup allows.
------ 00	Displayed when trying to recall the log of an "off" channel.
CARD OUT	Input card or scanner card has been removed.
RJ ERR	Reference junction outside of −10°C to +70°C range.
NO LOOP	Serial loop broken. Close loop and cycle power on 740.
TRIG OVER	Displayed when a trigger occurs while the instrument is displaying current channel measurements, or single log or single scan measurements.

Table 2-3. Thermocouple Identification

	(+) Positive Lead		(−) Negative Lead	
Thermocouple	Material	Insulation Color	Material	Insulation Color
Type J	Iron	White	Constantan	Red
Type K	Chromel	Yellow	Alumel	Red
Type T	Copper	Blue	Constantan	Red
Type E	Chromel	Purple	Constantan	Red
Type R	Pt - 13% Rh	Black	Pt	Red
Type S	Pt - 10% Rh	Black	Pt	Red
Type B	Pt - 30% Rh	Gray	Pt - 6% Rh	Red

Note: Pt = Platinum
Rh = Rhodium

2.6 SET-UP PROCEDURES

The Model 740 has one internal channel that can be used to make temperature measurements. With the addition of a Model 7057A Thermocouple Scanner Card, up to nine channels can be measured. By utilizing Model 705s or a Model 706, nine scanner cards can be used increasing the number of channels to a maximum of 81. Helpful information concerning the construction and polarity markings of the various thermocouples is located in Table 2-3.

WARNING

Never attempt to pull out the INPUT CARD that has a thermocouple in contact with an external voltage source. The shield on the card, which is exposed, is at the same possibly dangerous potential as the thermocouple.

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2.6.1 Setup Using Internal Channel

In general, setting up the instrument for using the internal channel consists of connecting the desired thermocouple (TC) to the "INT" terminals of the input card.

NOTE

The internal reference junction is located near the "INT" terminals. Failure to connect the TC to the "INT" terminals will result in measurement errors.

Perform the following procedure to set up the instrument for internal channel use:

1. Make sure the power is off, the line cord is disconnected and any connected TCs are clear of any external voltages.
2. To gain access to the input card terminal strip, unfasten the locking tabs by pulling both locks forward. Grasp the end of the card and pull it forward until it stops.
3. Remove the top section of the rubber cable clamp. The clamp is secured by two screws.
4. The TC must be connected to the pair of terminals marked "INT" (see Figure 2-3). Connect the positive wire to the HI terminal and the negative wire (red insulation) to the LO terminal.

WARNING

To prevent personal injury, or damage to the Model 740, thermocouples and external circuitry, never connect more than one thermocouple to the input card.

5. Feed the thermocouple wire over the rubber cable clamp and replace the top section of the clamp.
6. Push the input card back into the mainframe, lock the card in place as shown in Figure 2-4, and power-up the instrument.

Note: Never connect more than one thermocouple to the input card. Besides creating a safety hazard, the measurements will be erroneous.

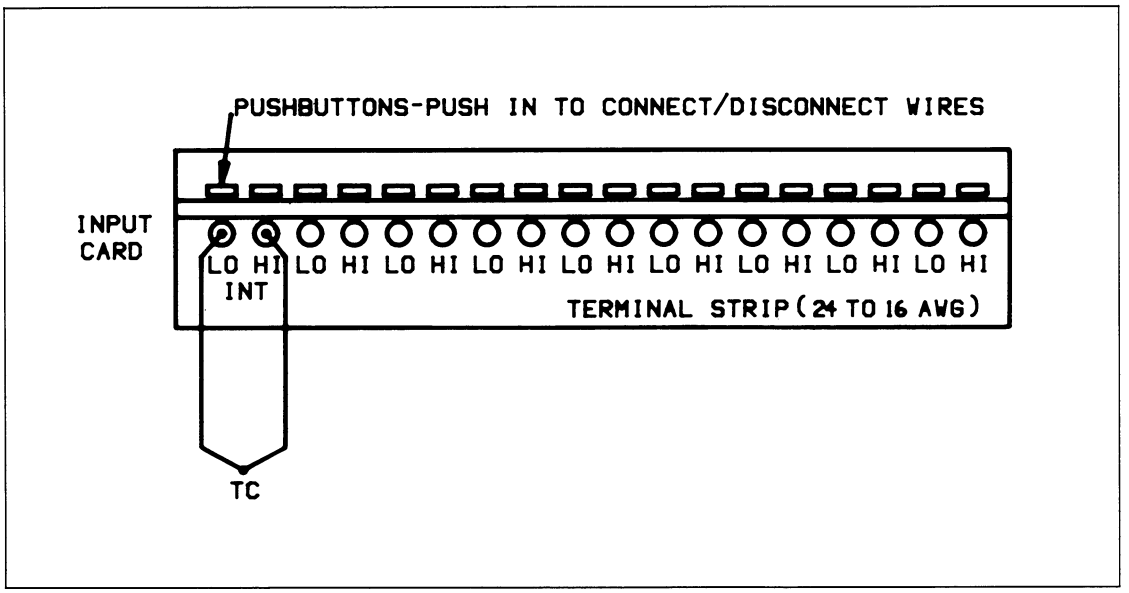


Figure 2-3. Setup Using Internal Channel

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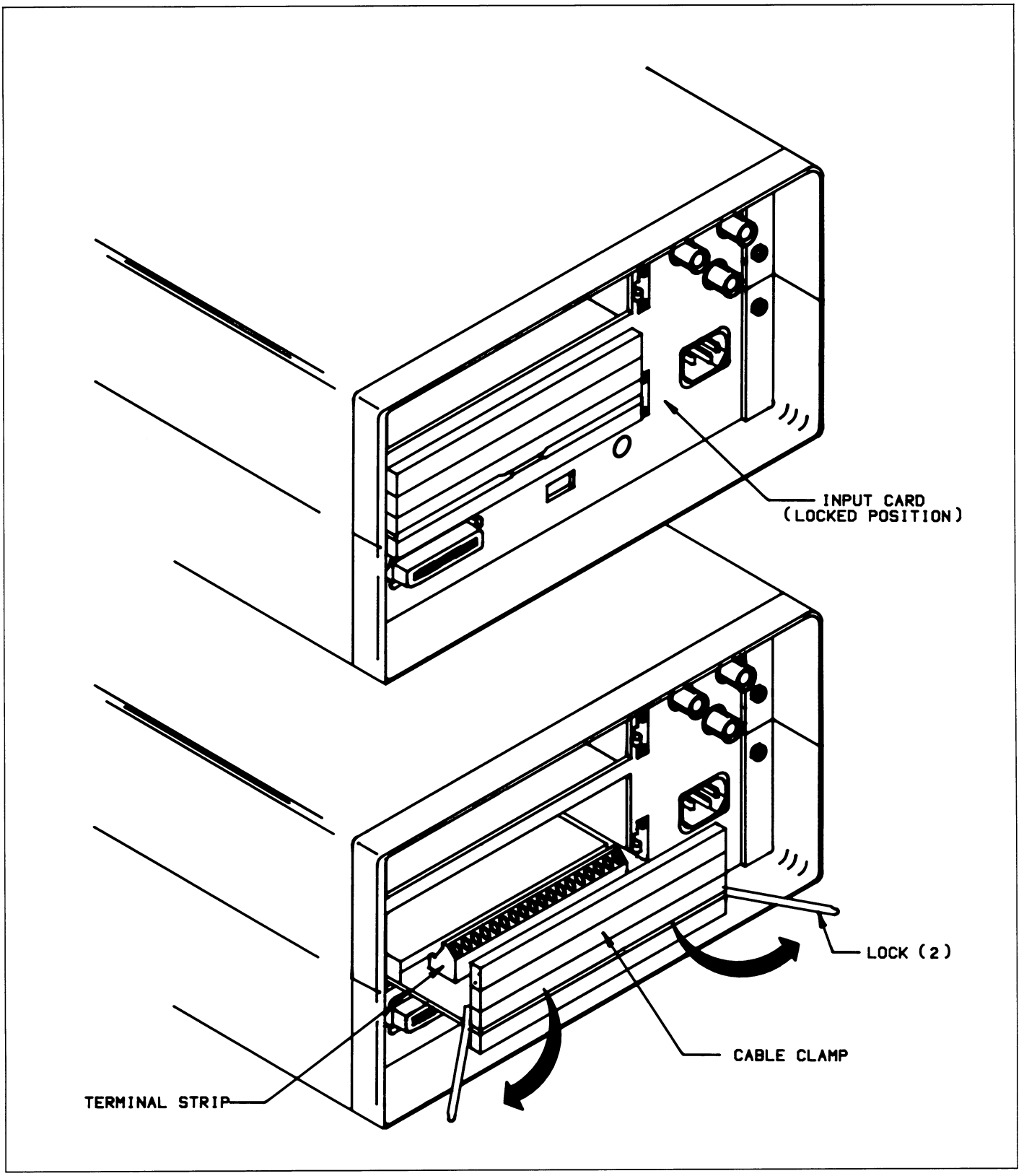


Figure 2-4. Input Card

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2.6.2 Setup Using One Scanner Card

In general, the setup to use one scanner card consists of connecting up to nine thermocouples to the scanner card, and then connecting the output of the scanner card to the input card.

NOTE

Refer to the Model 7057A Instruction Manual for complete information on the thermocouple scanner card.

Perform the following procedure to use the Model 740 with a Model 7057A Thermocouple Scanner Card installed:

1. Make sure the power is off, the line cord is disconnected and any TCs are clear of external voltages.
2. If a scanner card is installed in the mainframe, it must be removed. To remove the scanner card, unfasten the locking tabs by pulling the locks outward. Grasp the end of the card and pull it out of the mainframe.

NOTE

Handle the scanner card by the edges to avoid contaminating it with dirt, body oil, etc.

3. On the scanner card, remove the top section of the rubber cable clamp. The clamp is secured by two screws.
4. Connect one to nine thermocouples (TCs) to the channels of the scanner card as shown in Figure 2-6. Connect the positive wire of each thermocouple to the HI terminal and the negative wire (red) to the LO terminal.

WARNING

When using a scanner card, never connect a thermocouple directly to the input card, as personal injury or damage to the instrument may result.

5. Connect two wires to the OUTPUT terminals of the scanner card. Note the polarity as these wires will be connected to the terminal strip of the input card.
6. Feed all the wires over the rubber cable clamp and replace the top section of the clamp.
7. Install the scanner card into the rear panel opening with the component side facing up (see Figure 2-5). Make certain the card edges are aligned with the grooves in the receptacle. With the card fully inserted, push the locks into the locked position.
8. To gain access to the input card terminal strip, unfasten the locking tabs by pulling both locks forward (see Figure 2-4). Grasp the end of the card and pull it forward until it stops.
9. Remove the top section of the rubber cable clamp. The clamp is secured by two screws.
10. Connect the scanner OUTPUT wires to any pair of terminals on the input card terminal strip (see Figure 2-6). Be sure to observe the proper polarity.
11. Feed the output wires over the rubber cable clamp and replace the top section of the clamp.
12. Push the input card back into the mainframe, lock the card in place as shown in Figure 2-4, and power up the instrument.

Notes:

1. Never connect a thermocouple to the input card of the instrument when using one or more scanner cards. Besides creating a safety hazard, the measurements will be erroneous.
2. Channel 1 is the reference junction of the card.

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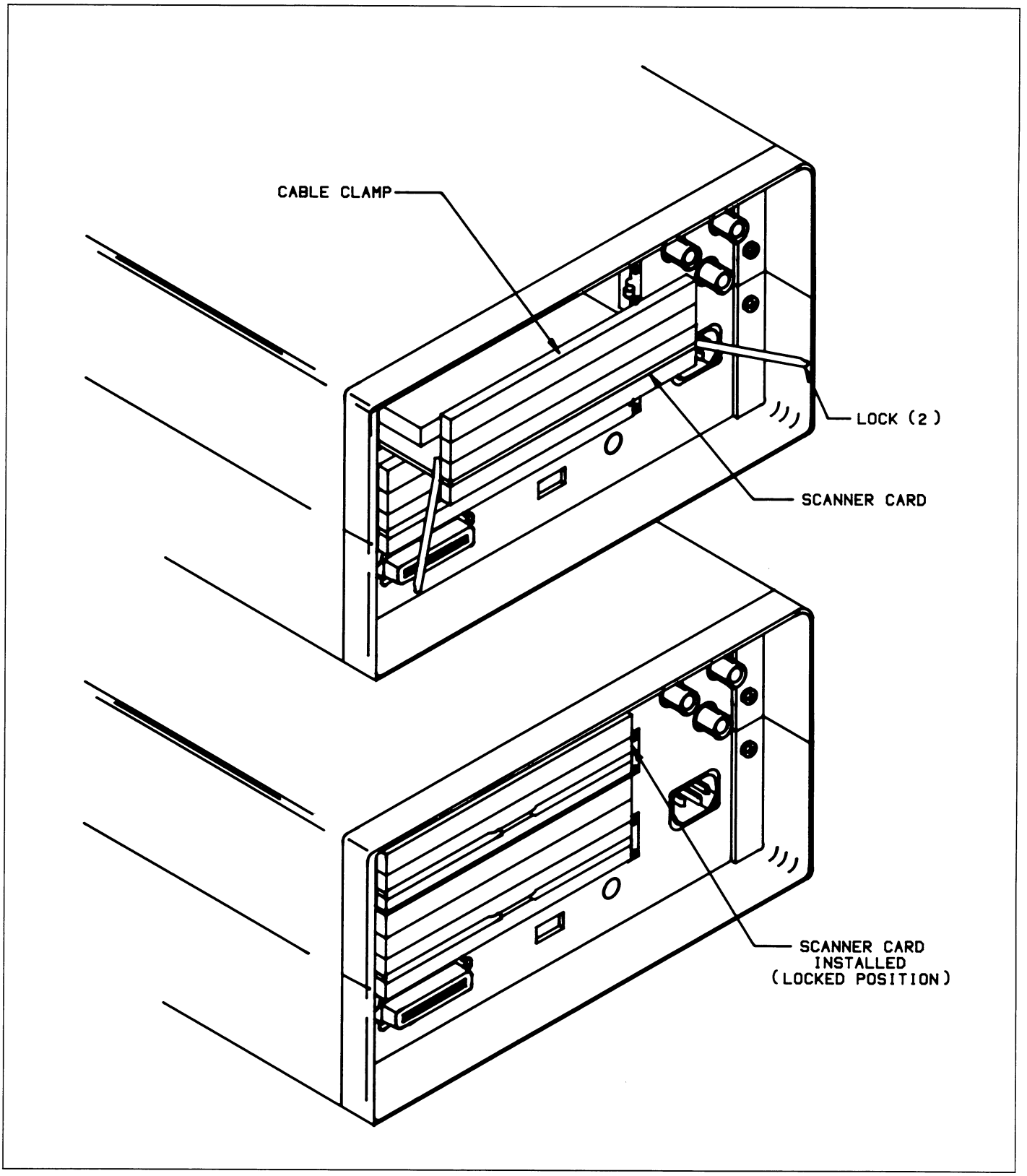


Figure 2-5. Scanner Card Installation

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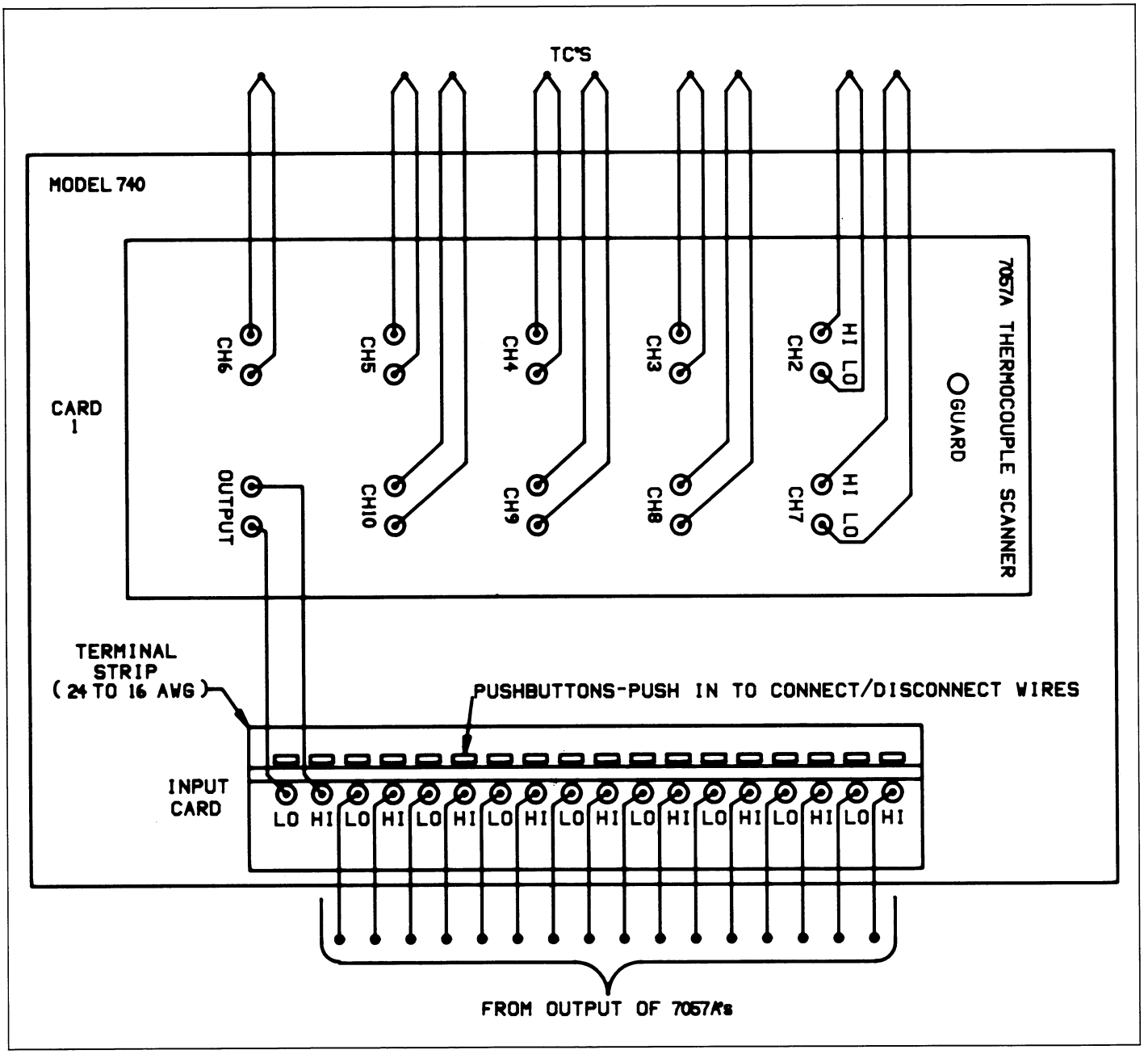


Figure 2-6. Setup Using Up to Nine Scanner Cards

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2.6.3 Setup Using Additional Scanner Cards

In general, the setup to use up to eight additional scanner cards consists of connecting the thermocouples to the scanner cards, installing the cards in the Model 705s or a Model 706, and connecting the outputs of the scanner cards to the input card of the Model 740. The equipment is then serially connected together as shown in Figure 2-7 or Figure 2-8.

NOTE

Refer to the individual instruction manuals for complete information on the Models 7057A, 705 and 706.

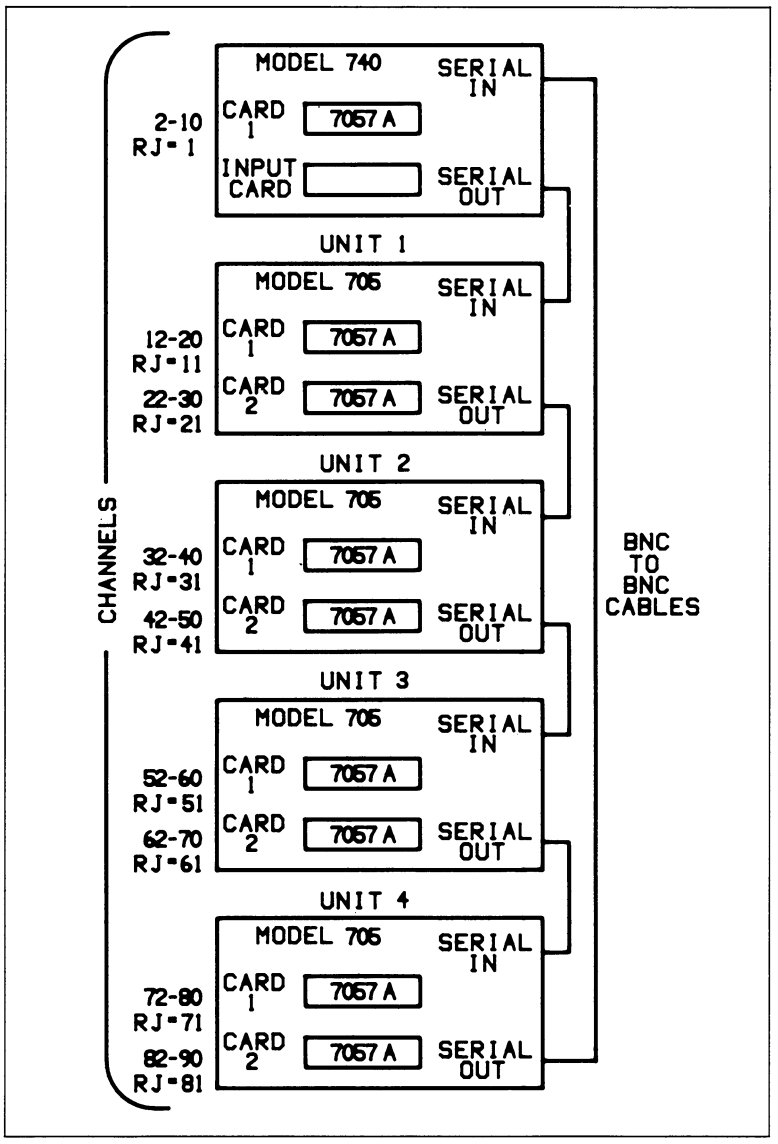


Figure 2-7. Daisy Chaining Model 705's

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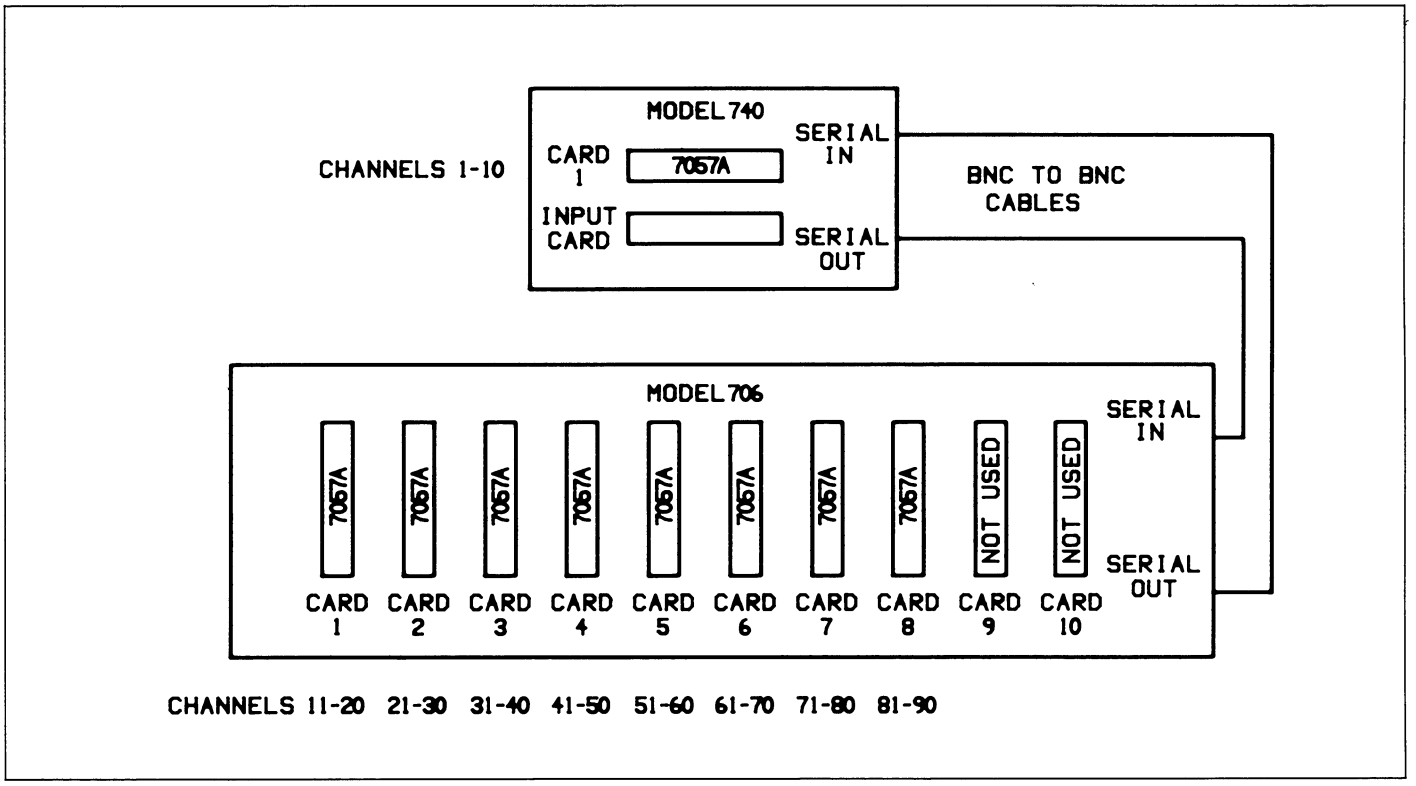


Figure 2-8. Daisy Chaining Model 706

Perform the following procedure to use the Model 740 with up to eight additional scanner cards:

1. Power up the instrument and check the display to see if the instrument is set to be operated with the desired scanner(s). The message "705 ?" or "706 ?" will be displayed briefly to indicate the setting. If necessary, use Program LOOP (paragraph 2.11.5) to change the setting.
2. Turn off the power, disconnect the line cord, and make sure that any connected TCs are clear of external voltages.
3. Set up each scanner card as explained in steps 3 through 6 of paragraph 2.6.2.
4. Install the scanner cards in either the Model 705s or a Model 706. If using a Model 706, do not install a scanner card in card slots nine and 10.
5. To gain access to the Model 740 input card terminal strip, unfasten the locking tabs by pulling both locks forward (see Figure 2-4). Grasp the end of the card and pull it forward until it stops.
6. Remove the top section of the rubber cable clamp. The clamp is secured by two screws.
7. Observing the proper polarity, connect the OUTPUT of each scanner card to any pair of terminals on the terminal strip (see Figure 2-6).
8. Feed the output wires over the rubber cable clamp and replace the top section of the clamp.
9. Push the input card back into the mainframe and lock the card in place as shown in Figure 2-4.
10. To wire the scan control circuitry, perform one of the following steps:
    A. If using a Model 706, connect the scanner to the Model 740 as shown in Figure 2-8.
    B. If using Model 705(s), connect the scanner(s) to the Model 740 using Figure 2-7, which shows four scanners, as a guide. Connect SERIAL OUT of the last scanner to SERIAL IN of the Model 740.
11. Power up the Model 706 or 705s, and program each one to be a slave by entering Program 92 on each scanner (Press the PRGM button and then the "9" and "2" buttons).
12. Lastly, power up the Model 740. During the power up sequence, verify that the scanner(s) used has been found. For example, if a Model 705 scanner is serially connected to the instrument and the 7057A output(s) is connected to the input card, the "705 ?" and "FOUND" messages will be displayed briefly.

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Notes:
1. Never connect a thermocouple to the input card when using one or more scanner cards. Besides creating a safety hazard, the measurements will be erroneous.
2. Channel number assignments are dependent on the position of the scanner cards in the system. Figures 2-7 and 2-8 show the channel assignments. If a card is not installed, those 10 channels will be unavailable to the Model 740.
3. Channels 1, 11, 21, 31, 41, 51, 61, 71 and 81 are used by the reference junctions of the scanner cards.
4. Upon power up, the Model 740 senses the channels that are available ("FOUND") in the measurement system. If the loop setting of the Model 740 does not match the scanner(s) serially connected to the Model 740, the instrument will lock up with the message "NO LOOP" displayed. To remedy the problem:
   A. Turn off the Model 740 and the external scanner(s).
   B. Power-up the Model 740 and select the alternate loop setting using front panel Program LOOP (see paragraph 2.11.5).
   C. Turn off the Model 740. The alternate loop setting will be stored in battery backed-up memory.
   D. Turn on the external scanner(s).
   E. Lastly, turn on the Model 740. The instrument will then "find" the external channels.
5. Whenever Program LOOP is used to change the scanner selection, power must be cycled to sense that scanner(s).

2.7 ENVIRONMENTAL CONDITIONS

Operation of the Model 740 should take place in an environment that has an ambient temperature within the range of 0° to 50°C with 0% to 80% relative humidity up to 35°C. Between 35°C and 50°C, derate linearly 3%RH/°C. Environmental conditions for storage are -25°C to +60°C.

2.8 BASIC MEASUREMENTS

By using the appropriate thermocouple (Type J, K, T, E, R, S or B), the Model 740 can make temperature measurements in the range of -200.0°C to +1820°C. The instrument can display the measurements in °C or °F or instead, the voltage generated (in millivolts) by the thermocouple.

The Model 740 can measure the one channel that is built in or measure up to 81 channels with the use of nine Model 7057A Thermocouple Scanner Cards. Paragraph 2.6 explains how to set up the necessary equipment.

WARNING

If temperature measurements are going to be made in an environment where voltage potentials may be present, adhere to the safety precautions found in front of Section 1 of this manual. Always assume that hazardous voltages are present if not sure.

CAUTION

To prevent damage to the instrument and possible personal injury, do not apply more than 250V RMS (for more than one minute) to the input (HI and LO), or 200V peak between input LO and the chassis.

2.8.1 Internal Channel Measurements

In general, operation consists of connecting a thermocouple to the "INT" terminals of the input card and configuring the channel for the appropriate thermocouple type or for millivolt measurements.

The procedure to make internal channel temperature measurements is summarized by the flowchart shown in Figure 2-9. Note that the step numbers used in the flowchart correspond to the steps of the following detailed procedure.

With the instrument in the measurement state (Data Store inactive), perform the following procedure to make measurements using the internal channel:

NOTE

When making measurements using the internal measurement channel, a channel number is not displayed by Model 740.

1. Connect the thermocouple to the input card as explained in paragraph 2.6.1.
2. If the channel configuration is not going to be changed, the measurement can now be taken from the display.
3. To reconfigure the channel, press the TYPE SELECT button. The current configuration of the channel will be displayed. For example, if the channel is currently configured to be off, the following message will be displayed:

OFF =

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4. To set for a TC type, press the J, K, T, E, R, S or B button. The selected TC type must match the TC type connected to the internal channel. To configure the channel to measure the voltage generated by the TC (in millivolts), press the mV button. If the channel is not going to be used, press the OFF button.

5. With the appropriate configuration displayed, press the ENTER button. The measurement of the internal channel will be displayed.

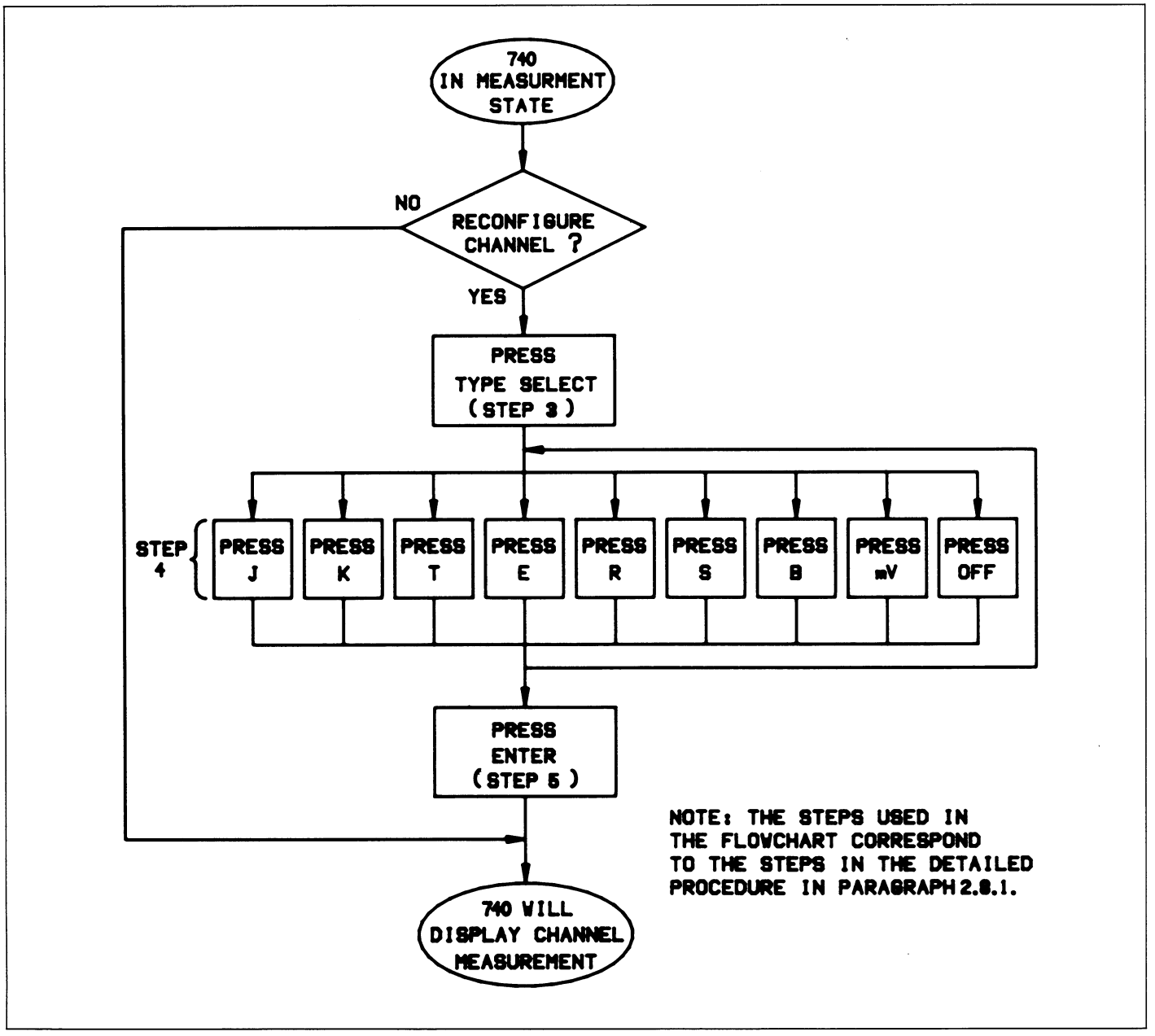


Figure 2-9. Flowchart—Internal Channel Measurements

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Notes:
1. To change the scale that temperature readings are displayed in, press the °C/°F button. This button toggles the scale between °C and °F.
2. To change the filter status, press the FILTER button. This button toggles the filter between on (FILTER indicator on) and off. Paragraph 2.9 provides detailed information on the filter.
3. The Model 740 can automatically scan the one internal channel. Each scan will store the new reading in the scan buffer. Detailed information on scanning can be found in paragraph 2.10.1.
4. The Model 740 can log and store up to 100 readings in the log buffer. See paragraph 2.10.3 for complete information on the log feature.
5. To display the temperature of the internal reference junction, refer to the procedure in paragraph 2.8.3.
6. If the input card is pulled out while power is on, the instrument will lock up with the message "CARD OUT" displayed. Power must then be cycled.
7. Table 2-4 lists the buttons that are functional when the instrument is in the measurement state and briefly describes what happens when they are pressed.

2.8.2 Multi-Channel Measurements

In general, operation using multi-channels consists of connecting one or more thermocouples (via scanner cards) to the Model 740, configuring the available channels and using the ▲ and ▼ buttons to display the reading on each channel.

The procedure to make temperature measurements is illustrated by the flowchart shown in Figure 2-10. Note that the step numbers used in the flowchart correspond to the steps of the following detailed temperature measurement procedure.

With the instrument in the normal measurement state (Data Store inactive), perform the following procedure to make multi-channel temperature measurements:

1. Connect the thermocouple(s) to the instrument as explained in paragragh 2.6.2 or 2.6.3.
2. If current channel configurations are not to be changed, proceed to step 8. To check the current configuration of one or more available channels, perform the following steps:
   A. Press the TYPE button. The configuration of the current channel will be displayed. For example, if the current channel is 2, and is configured for Type K temperature measurements, the following message will be displayed:

      TYPE K 02

   B. Use the ▲ and ▼ buttons to display the configurations of the other available channels. The ▲ and ▼ buttons increment and decrement the channels respectively. Note that on each reference junction channel (0l, 11, 21 ... 81), the temperature of the junction will be displayed.
   C. To return the display to the measurement mode, press the ENTER button.
3. Press the TYPE SELECT button to reconfigure one or more channels. The current configuration of the current channel will be displayed. For example, if channel 2 is the current channel and configured for Type K TCs, the following message will be displayed:

   K = 02

4. Each channel can be set up for a separate and unique configuration or all channels can be set up for the same configuration. Perform one of the following steps to configure the available channels of the Model 740:
   A. To configure all available channels to the same configuration, press the TYPE SELECT button again. The current configuration will be displayed. For example, if the previously displayed channel was set for Type K TCs, then the following message will be displayed:

      ALL K

      Note: The TYPE SELECT button toggles between the "configure each channel" mode and "configure all channels the same" mode.
   B. To configure an available channel, use the ▲ and ▼ buttons to display the desired channel (if not already displayed). The ▲ button increments the available channels and conversely, the ▼ button decrements the available channels. Note: Reference junction channels cannot be configured. These channels will only display the temperature of the reference junction.
5. To select a TC type, press the J, K, T, E, R, S or B button. The selected TC type must match the TC type connected to the channel(s). Pressing the mV button configures the channel(s) for millivolt measurements (of the TC) rather than temperature measurements. If the channel is not going to be used, press the OFF button. The message "OFF" will be displayed whenever this channel is selected. NOTE: An "OFF" channel is still available to the Model 740. That is, it can be displayed and scanned. A channel that is referenced to as being unavailable means that the channel is physically not in the measurement system.
6. To configure the rest of the available channels, repeat steps 4B and 5.
7. When the available channels are configured as desired, press the ENTER button. The reading (temperature, millivolts or OFF) on the last selected channel will be displayed.
8. Use the ▲ and ▼ buttons to display the readings on the other available channels.

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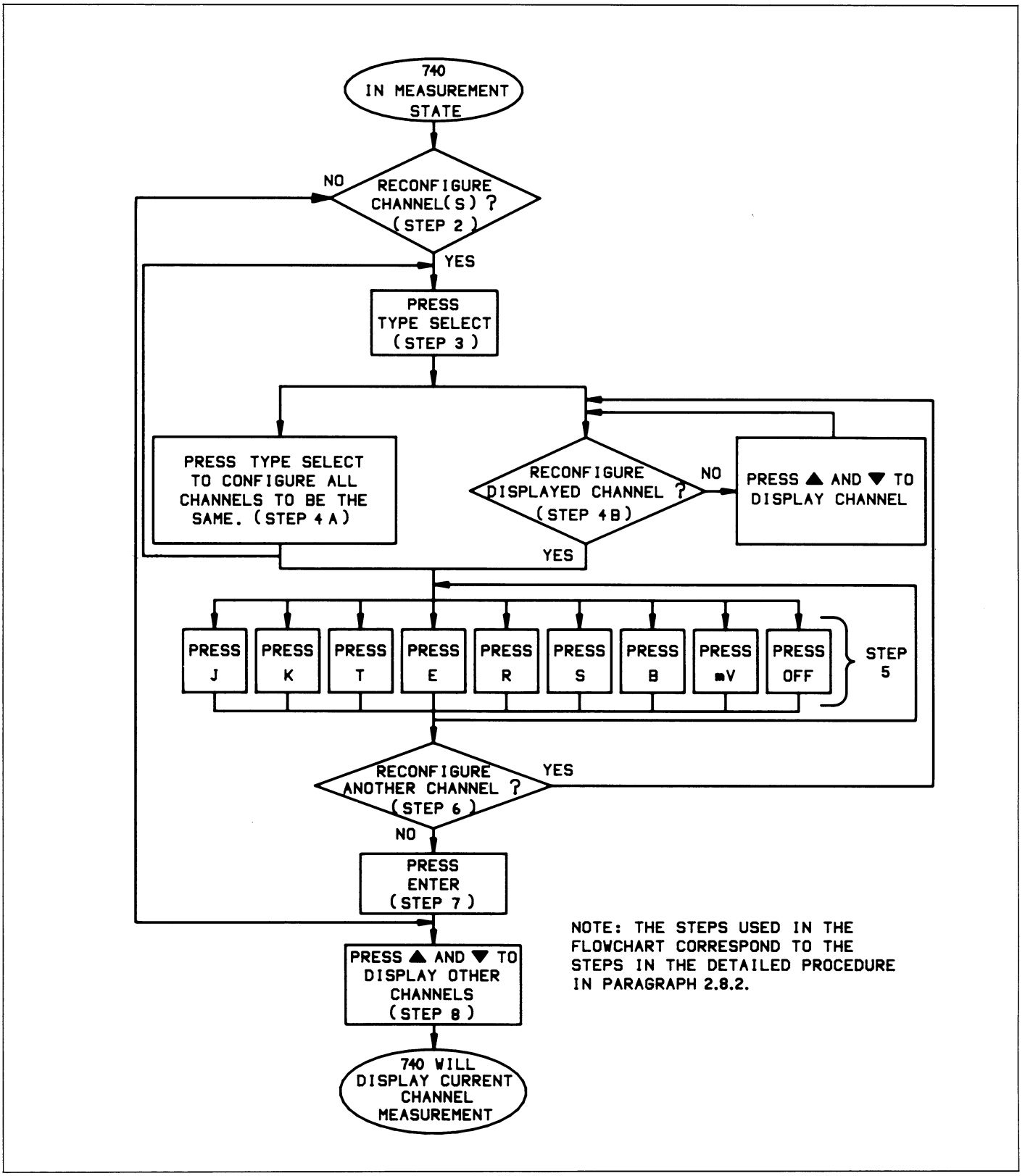


Figure 2-10. Flowchart—Multi-channel Measurements

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Table 2-4. Functional Controls—Measurement State*

Control	Function
SCAN ENABLE	Enter scan enable mode. Press again to exit scan mode.
SCAN RECALL	Enter scan recall mode and display scanned reading. Press again to exit recall mode.
LOG ENABLE	Enter log enable mode and display logging interval. Press again to exit log mode.
LOG RECALL	Enter log recall mode and display last logged reading. Press again to exit recall mode.
CONTINUOUS	Toggle continuous mode between enable and disable.
▲	Increment to next available measurement channel.
▼	Decrement to next available measurement channel.
PROGRAM	Enter program mode and display trigger hour (Program TRIG).
TYPE SELECT	Enter type select mode - display configuration of channel (see ENTER).
°C/°F	Toggle scale between °C and °F.
FILTER	Toggle filter between enable and disable.
TYPE (mV)	Display configuration of channel (see ENTER).
TIME (OFF)	Display time of day (see ENTER).
ENTER	Returns display to measurement mode if TIME or TYPE displayed.

*Data Store not in use and current channel measurement displayed.

Notes:
1. Channels that do not have a TC connected to it or have an open TC connected to it will display the "OPENTC" message.
2. To change the thermometric scale that temperature readings are displayed in, press the °C/°F button. The °C/°F button toggles the scale between °C and °F.
3. To change the analog filter status, press the FILTER button. The FILTER button toggles the filter between on (FILTER indicator light on) and off. Paragraph 2.9 provides further information on the analog filter.
4. The Model 740 can automatically scan channels and store the readings in the Data Store. The procedure for using the scan feature can be found in paragraph 2.10.1.
5. The Model 740 can log and store up to 100 readings of any one channel. The procedure for using the log feature can be found in paragraph 2.10.3.
6. If a scanner card or the input card is pulled out while power is on, the instrument will lock up with the message "CARD OUT" displayed. Power must then be cycled.
7. Table 2-4 lists the buttons that are functional when the instrument is in the normal measurement state (Data Store inactive) and briefly describes what happens when they are pressed.

2.8.3 Reference Junction Temperature Measurements

Perform the following procedure to display the temperature reading of a reference junction:

1. Press the TYPE button and then use the ▲ and ▼ buttons to display the temperature of the desired reference junction channel. Reference junction channels include the internal reference junction (RJ), or scanner card reference junctions (channels 01, 11, 21, 31, 41, 51, 61, 71 and 81). Notice that reading on the display is not being updated (decimal point not flashing).
2. Press the ENTER button. The displayed temperature readings will then update at the current conversion rate. An updating display is indicated by the flashing decimal point.

Note: The displayed reference junction temperature will be lost when another channel is selected.

2.9 FILTER

The analog filter is used to stabilize the readings of a noisy input level. Considerations of filter usage are as follows:

1. Typically, it takes 100msec to achieve a settled reading. A thermocouple loop resistance >1kΩ will increase the filter settling time.
2. The scanning rate is decreased to five channels per second.
3. Normal mode rejection (NMR) is increased by 20dB at 50 and 60Hz.

To enable the filter, press the FILTER button. The FILTER indicator light will turn on. To disable the filter, press the FILTER button a second time.

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2.10 DATA STORE

The Data Store can be used as a scanner or as a logger. As a scanner the instrument stores one reading of each available channel in the scan buffer. As a logger the instrument stores up to 100 readings of one selected channel in the log buffer. Thus, the fundamental difference between the two features is that the scanner stores one reading of every channel, while the logger stores a number of readings of one channel.

Table 2-5. Data Store Intervals

Display Message	Interval
50mS ▲▼	Logging—One reading every 50msec. Scanning—Interval not available.
100mS ▲▼	Logging—One reading every 100msec. Scanning—Interval not available.
500mS ▲▼	Logging—One reading every 500msec. Scanning—Scan channels every 500msec.
1SEC ▲▼	Logging—One reading every 1sec. Scanning—Scan channels every 1sec.
5SEC ▲▼	Logging—One reading every 5sec. Scanning—Scan channels every 5sec.
10SEC ▲▼	Logging—One reading every 10sec. Scanning—Scan channels every 10sec.
30SEC ▲▼	Logging—One reading every 30sec. Scanning—Scan channels every 30sec.
1MIN ▲▼	Logging—One reading every 1min. Scanning—Scan channels every 1min.
5MIN ▲▼	Logging—One reading every 5min. Scanning—Scan channels every 5min.
15MIN ▲▼	Logging—One reading every 15min. Scanning—Scan channels every 15min.
30MIN ▲▼	Logging—One reading every 30min. Scanning—Scan channels every 30min.
1HR ▲▼	Logging—One reading every 1hr. Scanning—Scan channels every 1hr.
1-SHOT ▲▼	Logging—One-shot mode*. Scanning—No message displayed.**

*In one-shot mode, one reading is stored everytime the START button is pressed or an external trigger pulse is received.

**One-shot mode selected when in single scan mode (continuous indicator off). One scan occurs everytime the START button is pressed or an external trigger pulse occurs.

2.10.1 Scanning Channels

The Model 740 can scan up to 81 measurement channels (plus reference junction channels). Scans can be performed manually or programmed to scan automatically at one of 10 available intervals (see Table 2-5). Parapraph 2.6 explains how to connect the desired number of channels to the instrument.

Single Scan Mode—When the instrument is in the single scan mode (CONTINUOUS indicator light off), one reading of each available channel will be stored in the scan buffer when triggered to start. The scan may be started by pressing the START button, programming a trigger time (Program TRIG, see paragraph 2.11.1), or by an external trigger pulse.

Continuous Scan Mode—In the continuous scan mode (CONTINUOUS indicator light on), a scan will be started by a programmed trigger time (Program TRIG) or when the START button is pressed. Scans will continue to occur at the selected scan interval. Each scan overwrites the data previously stored and stores the currently scanned reading of each available channel, as well as the time of day it was taken.

In general, the scan procedure consists of programming a scan start time (if desired), selecting a scan mode (continuous or single), pressing the SCAN ENABLE button, and selecting a scan interval (if in continuous mode). The scan will start at the programmed trigger time or when the START button is pressed.

The procedure to scan channels is summarized by the flowchart shown in Figure 2-11. Note that the step numbers used in the flowchart correspond to the steps of the following detailed scan procedure.

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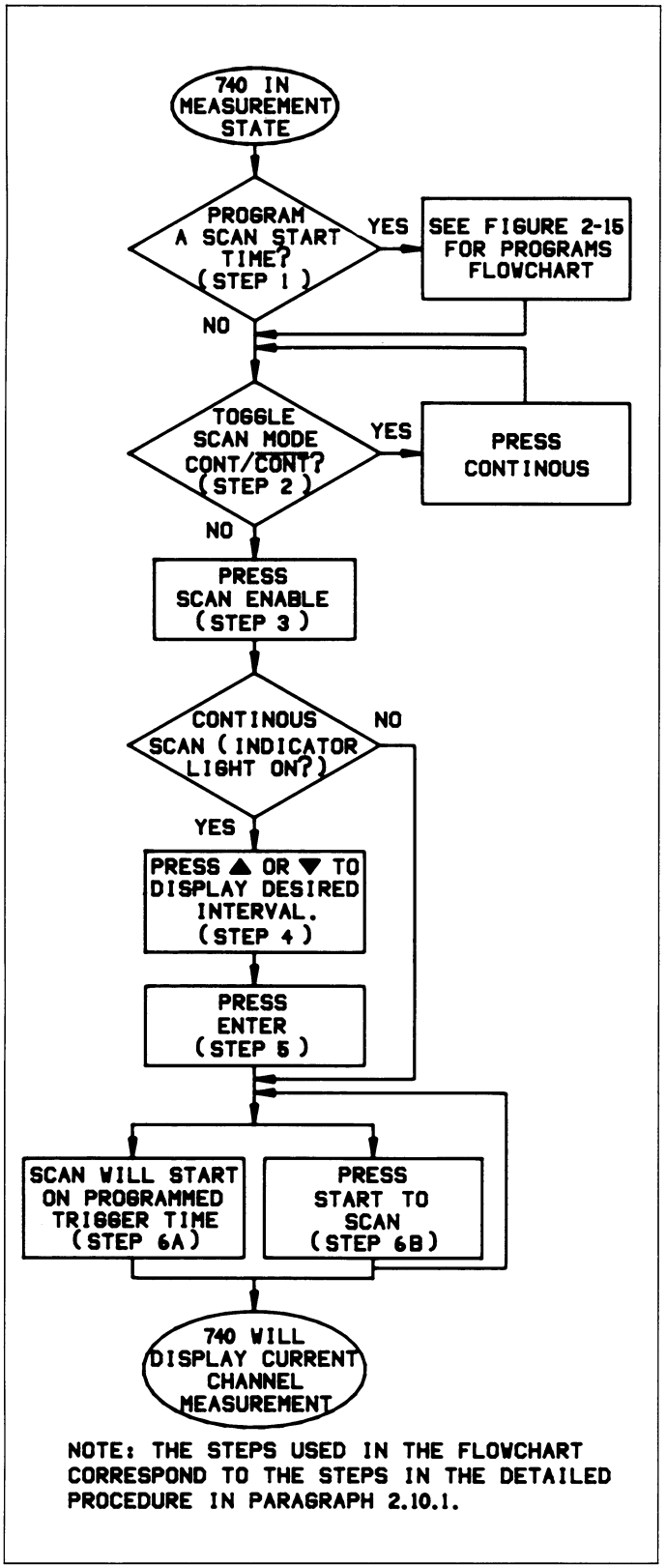


Figure 2-11. Flowchart—Scanning Channels

With the available channels configured and the instrument in the normal measurement state, perform the following procedure to scan the channels:

1. If it is desired to program a trigger time to start the scan, use Program TRIG as explained in paragraph 2.11.1.
2. If it is desired to select the alternate scan mode (continuous or single) press the CONTINUOUS button. This button toggles between continuous scan (CONTINUOUS indicator on) and single scan.
3. Press the SCAN ENABLE button. The SCAN ENABLE indicator will start flashing and, if in the continuous mode, the current scan interval will be displayed. For example, if the current scan interval is five minutes, the following message will be displayed:

   5 MIN ▲ ▼

4. If in the single scan mode, proceed to step 5. In the continuous scan mode (CONTINUOUS indicator on), select an appropriate scan interval (if not already displayed) using the ▲ and ▼ buttons and then press the ENTER button. The display will return to the current channel.
5. The scan process can be started by either a programmed trigger time, the START button or an external trigger pulse. When the scan starts, the SCAN ENABLE indicator stops flashing, but remains on. The methods for starting a scan are explained as follows:
   A. The scan process will automatically start at the time of day that has been programmed by the TRIG program (step 1).
   B. The scan process can be started by pressing the START button. Each time this button is pressed a scan will occur.
   C. The scan process may be started by an external trigger pulse. See paragraph 2.12 for details.

Notes:
1. A flashing SCAN ENABLE indicator specifies that the instrument is in the SCAN ENABLE mode and is waiting for a trigger to start the scan process. When the scan starts, the indicator stops flashing but remains on.
2. In the single scan mode, the SCAN ENABLE indicator will start flashing again when the scan stops.
3. In the single scan mode, the display will refresh (decimal point flashes) at the conversion rate. In the continuous scan mode, the display will refresh upon each scan.
4. The display message "SHORT" indicates that the insrument cannot scan as fast as the selected interval. The scans will occur as fast as the hardware will allow. Instrument speed is affected by filter, number of channels and configuration types. For example: trying to scan 10 channels (eight OFF, two configured for TCs) with the filter enabled at a 500msec interval or less, will result in the "SHORT" message.

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5. To take the instrument out of the scan mode, press the SCAN ENABLE button. The SCAN ENABLE indicator light will turn off.
6. The procedure for recalling scanned readings is contained in paragraph 2.10.2.
7. Table 2-6 lists the buttons that are functional when the instrument is in the scanning state and briefly describes what happens when they are pressed.
8. Pressing the LOG ENABLE or LOG RECALL buttons while in the scan enable mode will briefly display the "SCANENBL" message.
9. Pressing the ▲ or ▼ button after the scanning process has started, will display the other available channels.

Table 2-6. Functional Controls—Scanning State*

Control	Function
SCAN ENABLE	Exit scanning state - display channel measurement.
SCAN RECALL	Enter scan recall mode - display scanned reading.
CONTINUOUS	Places 740 in alternate scan mode. Intervals displayed when in continuous mode.
▲	Increment to next available channel and display readings.
▼	Decrement to next available channel and display readings.
°C/°F	Toggle scan between °C and °F.
TYPE (mV)	Display configuration of channel (see ENTER).
TIME (OFF)	Display time of day (see ENTER).
ENTER	Returns display to measurement mode if TIME or TYPE displayed.

*SCAN ENABLE indicator on and scanning process started. Current channel measurements displayed.

2.10.2 Recalling Scanned Channels

Readings stored in the scan buffer can be recalled with the instrument in the normal measurement state (Data Store inactive) or while the instrument is in the scanning state.

In general, recalling a scan consists of pressing the SCAN RECALL button, and using the ▲ and ▼ buttons to display the reading stored for each available channel. The TIME button permits the scan time of each channel to be checked.

The procedure to recall scanned readings is summarized by the flowchart shown in Figure 2-12. Note that the step numbers used in the flowchart correspond to the steps of the following detailed scan recall procedure.

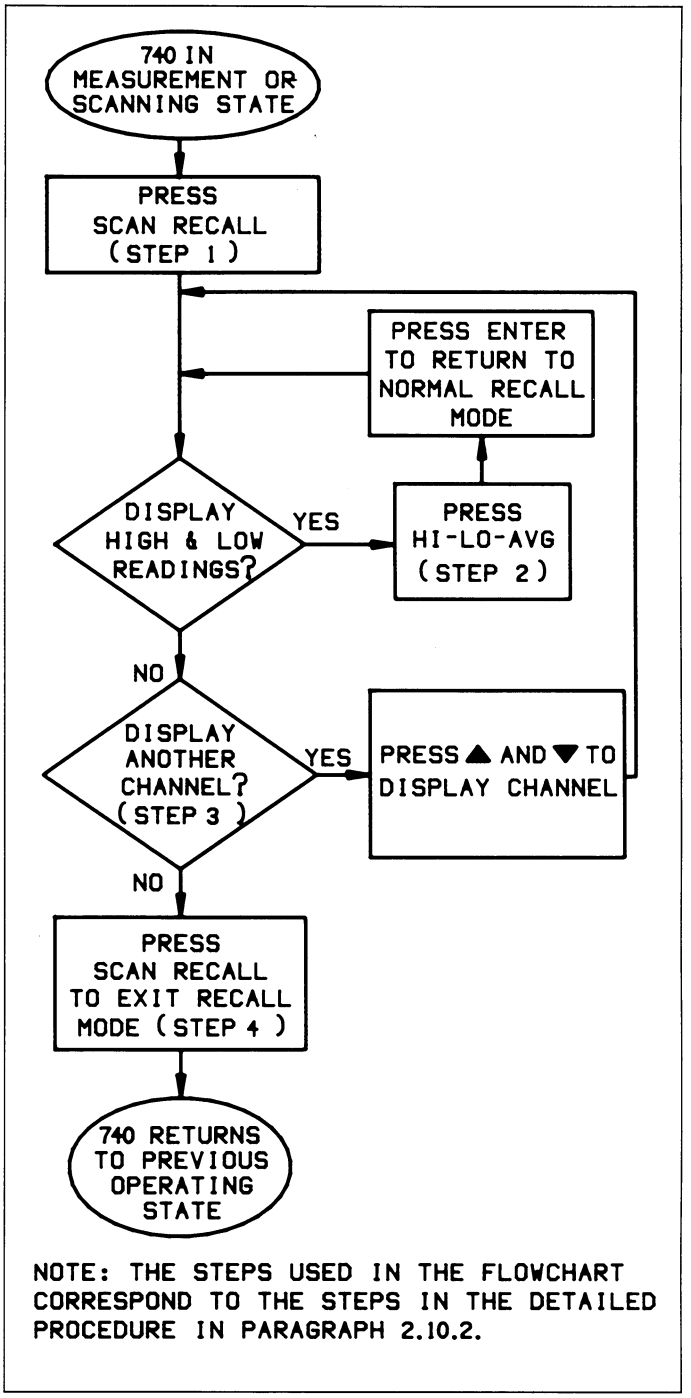


Figure 2-12. Flowchart—Recalling Scan

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With the Model 740 in the normal measurement state (Data Store inactive) or in the scan mode, perform the following procedure to recall scanned readings:

1. Press the SCAN RECALL button. The SCAN RECALL indicator turns on and the following message will be displayed briefly:

   RECALL

   The stored temperature for the first available reference junction channel will then be displayed. For example, if the stored temperature reading for channel 1 is 72.3°F, the following message will be displayed:

   72.3°F 01

2. Perform the following procedure to display the highest and lowest reading stored in the scan buffer:
   A. Press the HI-LO-AVG button. The following message will be displayed briefly:

      HI

      The highest reading in the scan buffer along with the channel will be displayed. For example, if the highest reading in the scan buffer is 23.9°C at channel 8, the following message will be displayed:

      23.9°C 08

   B. To display the lowest reading in the scan buffer, again press the HI-LO-AVG button. The following message will be displayed briefly:

      LO

      The reading along with the channel number will be displayed. For example, if the lowest reading is 10.0°C at channel 3, the following message will be displayed:

      10.0°C 03

   C. To exit from HI/LO recall, press the ENTER button. The instrument will then be in the normal recall state.
3. With a stored reading displayed, pressing the ▲ and ▼ buttons will display the stored reading for each of the other available channels. Each press of the ▲ button increments the display to the next available channel and the ▼ button decrements the display to the next available channel.
4. To exit from the recall mode, press the SCAN RECALL button. The instrument will return to the previous operating state.

Notes:
1. A channel number will not be displayed if the internal channel of the instrument is being used. The internal reference junction channel is displayed as "RJ".
2. A displayed scan reading will update immediately every time a scan occurs.
3. If it is desired to check the time that a displayed reading was stored, press the TIME button with the desired channel displayed. Pressing the ENTER button will return the display to the stored reading.
4. To check channel types (configurations) after a scan, first exit the recall mode, display the channel, and then press the TYPE button. The ENTER button returns the display to the current channel measurement.
5. HI and LO readings can be displayed at any time while the instrument is in the SCAN RECALL mode.
6. Reference junction channels, and channels that are configured for mV measurements and OFF are ignored by HI-LO recall. If there are not any valid temperature readings to be recalled in HI-LO recall, the message "------" will be displayed.
7. If the "SHORT" message is displayed while the instrument is scanning, the SCAN RECALL state cannot be entered. To recall scanned readings, exit the scanning state.
8. Table 2-7 lists which buttons are functional when the instrument is in the scan recall state and briefly describes what happens when they are pressed.

Table 2-7. Functional Controls—Scan Recall State*

Control	Function
SCAN RECALL	Enter scan recall mode and display channel current measurement.
HI-LO-AVG	Displays high and low reading in scan buffer.
▲	Increment to next available channel and display stored reading.
▼	Decrement to next available channel and display stored reading.
°C/°F	Toggle scale between °C and °F.
TIME (OFF)	Display time of scan (see ENTER).
ENTER	Returns display to stored reading mode if TIME of scan or high/low reading is displayed.

*SCAN RECALL indicator on.

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2.10.3 Logging Readings

The Model 740 can log up to 100 readings of one channel at a selectable storage rate ranging from one reading every 50msec to one reading every one hour. Also available is a one-shot mode where each reading is stored by the press of the START button.

Single Log Mode—When the instrument is in the single log mode (CONTINUOUS indicator light off), the instrument will stop logging after the buffer fills.

Continuous Log Mode—In the continuous log mode (CONTINUOUS indicator light on), the instrument will continue to log readings after the buffer fills. After the buffer fills (memory location 99 contains the 100th reading), the 101st reading will be stored in memory location 99 and the other stored readings will decrement one memory location. The first stored reading that was in memory location 00 will be lost. The process of placing the most recent reading in memory location 99 and decrementing the memory location of the other stored readings continues as long as the instrument is in the continuous logging state. As an example, Table 2-8 shows the contents of the buffer after continuously logging 250 readings.

Table 2-8. Memory Locations of Continuously Logged Readings

Memory	Readings				
	1st 100	101	102	103	250*
00	1st	2nd	3rd	4th	151th
01	2nd	3rd	4th	5th	152th
02	3rd	4th	5th	6th	153rd
03	4th	5th	6th	7th	154th
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
97	98th	99th	100th	101st	248th
98	99th	100th	101st	102nd	249th
99	100th	101st	102nd	103rd	250th
Rdgs Lost	None	1st	1st & 2nd	1st - 3rd	1st - 150th

*Example only—No limit to the number of readings that can be logged in the continuous mode.

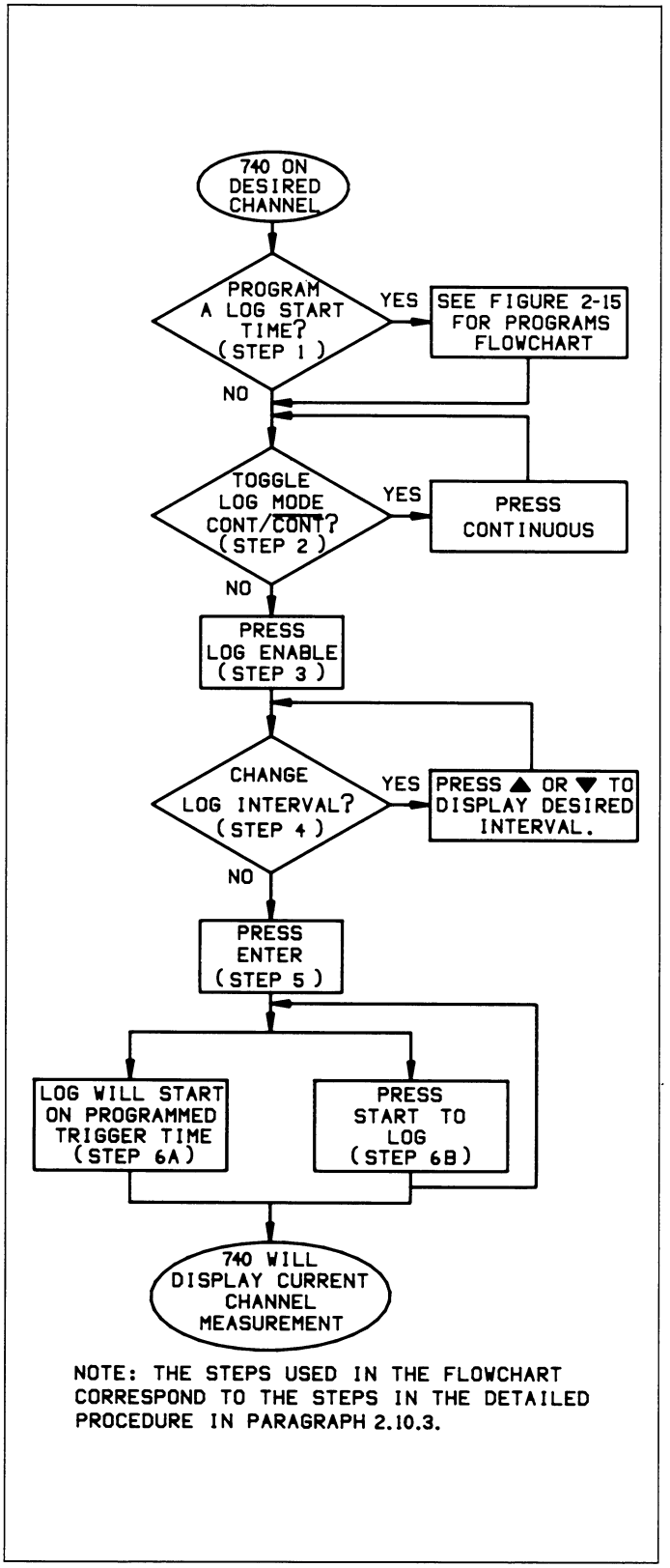


Figure 2-13. Flowchart—Logging Readings

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In general, the log procedure consists of programming a start time (if desired), selecting a log mode (continuous or single), selecting a log interval and pressing the ENTER button. Logging will start at the programmed trigger time or when the START button is pressed.

The procedure to log readings is illustrated by the flowchart shown in Figure 2-13. Note that the step numbers used in the flowchart correspond to the steps of the following detailed log procedure.

With the desired channel displayed, perform the following procedure to log readings in the Data Store:

1. If it is desired to program a trigger time to start the logging process, use Program TRIG as explained in paragraph 2.11.1.
2. If it is desired to select the alternate log mode (continuous or single), press the CONTINUOUS button. This button toggles between continuous log (CONTINUOUS indicator on) and single log.
3. Press the LOG ENABLE button. The LOG ENABLE indicator will start flashing and the current log interval will be displayed. For example, if the current log interval is one hour, the following message will be displayed:

   1 HR ▼▲

4. If a different log interval is desired, use the ▲ and ▼ buttons to display it. The available log intervals are listed in Table 2-5.
5. With the desired log interval displayed, press the ENTER button. The display will return to the current channel.
6. The log process can be started by either a programmed trigger time, the START button or by an external trigger. When the log starts, The LOG ENABLE indicator stops flashing, but remains on. The methods for starting a log are explained as follows:
   A. The log process will automatically start at the time of day that has been programmed by the TRIG program (step 1).
   B. The log process can be started by pressing the START button.
   C. The log process, may be started by an external trigger pulse. See paragraph 2.12 for details.

Notes:
1. A flashing LOG ENABLE indicator specifies that the instrument is in the LOG ENABLE mode and is waiting for a trigger to start the log process. When the log process starts, the indicator stops flashing but remains on.
2. The display message "SHORT" indicates that the instrument cannot log at the selected interval. The actual logging rate will only be as fast as the instrument can run. Factors affecting instrument speed include filter and type of configuration. For example: trying to log a channel configured for a TC type at a 100msec interval or less will result in the "SHORT" message.
3. In the single log mode, the LOG ENABLE indicator will start flashing again when the log buffer fills.
4. To take the instrument out of the log mode, press the LOG ENABLE button. The LOG ENABLE indicator will turn off.
5. The procedure to recall logged readings can be found in the next paragraph.
6. The display will continuously update at the conversion rate while in the log enable mode and at 10 rdgs/sec while logging.
7. If the SCAN ENABLE button or the SCAN RECALL button is pressed while in the log enable mode (LOG ENABLE indicator flashing), the message "LOG EN BL" will be displayed briefly.
8. If an invalid button is pressed while the instrument is logging, the message "LOGGING" will be displayed briefly.
9. Readings cannot be logged on an "OFF" channel. Trying to log on an "OFF" channel will clear the buffer.
10. With the "1-SHORT" interval selected, one reading will be stored every time the START button is pressed or an external trigger pulse is applied.
11. Table 2-9 lists the buttons that are functional when the instrument is in the logging state and briefly describes what happens when they are pressed.
12. In most instances, the high speed logging interval (50msec) is intended to be used in the single log mode. To achieve this speed, the Model 740 only measures the reference junction temperature once at the start of the log. The instrument can be used to make accurate temperature measurements in the continuous log mode (at 50msec) as long as the reference junction temperature remains constant.

Table 2-9. Functional Controls—Logging State*

Control	Function
LOG ENABLE	Exit logging mode.
LOG RECALL	Enter log recall mode - display last logged reading and memory location.
CONTINUOUS	Toggle continuous mode between enable and disable.
°C/°F	Toggle scale between °C and °F.
TYPE (mV)	Display configuration of channel (see ENTER).
TIME (OFF)	Display time of day (see ENTER).
ENTER	Return to measurement mode if TIME or TYPE displayed.

*LOG ENABLE indicator on and logging process started. Current channel measurements displayed.

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2.10.4 Recalling Logged Readings

Readings stored in the log buffer can be recalled with the instrument in the normal measurement state (Data Store inactive) or while the instrument is in the logging state.

In general, recalling logged readings consists of pressing the LOG RECALL button, and using the ▲ and ▼ buttons to display the stored readings. The HI-LO-AVG button displays the highest, lowest and average reading stored in the buffer. The TIME button can be used to check the time that a reading was logged.

The procedure to recall logged readings is illustrated by the flowchart shown in Figure 2-14. Note that the step numbers used in the flowchart correspond to the steps of the following detailed log recall procedure.

With the Model 740 in the normal measurement state (Data Store inactive) or in the logging state, perform the following procedure to recall logged readings:

1. Press the LOG RECALL button. The LOG RECALL indicator will turn on and a message indicating the channel will be displayed. For example if readings were logged on channel 2, the following message will be displayed briefly:

   RECALL 02

   The last stored reading and the memory location will then be displayed. For example, if the buffer filled and the reading at the last memory location (99) is 236°F, the following message will be displayed:

   236.0°F 99

2. Perform the following procedure to display the highest, lowest and average reading in the log buffer:
   A. Press the HI-LO-AVG button. The following message will be displayed briefly:

      HI

      The highest reading in the log buffer along with the memory location will be displayed. For example, if the highest reading in the buffer is 99.9°C at memory location 36, the following message will be displayed:

      99.9°C 36

   B. To display the lowest reading in the log buffer, again press the HI-LO-AVG button. The following message will be displayed briefly:

      LO

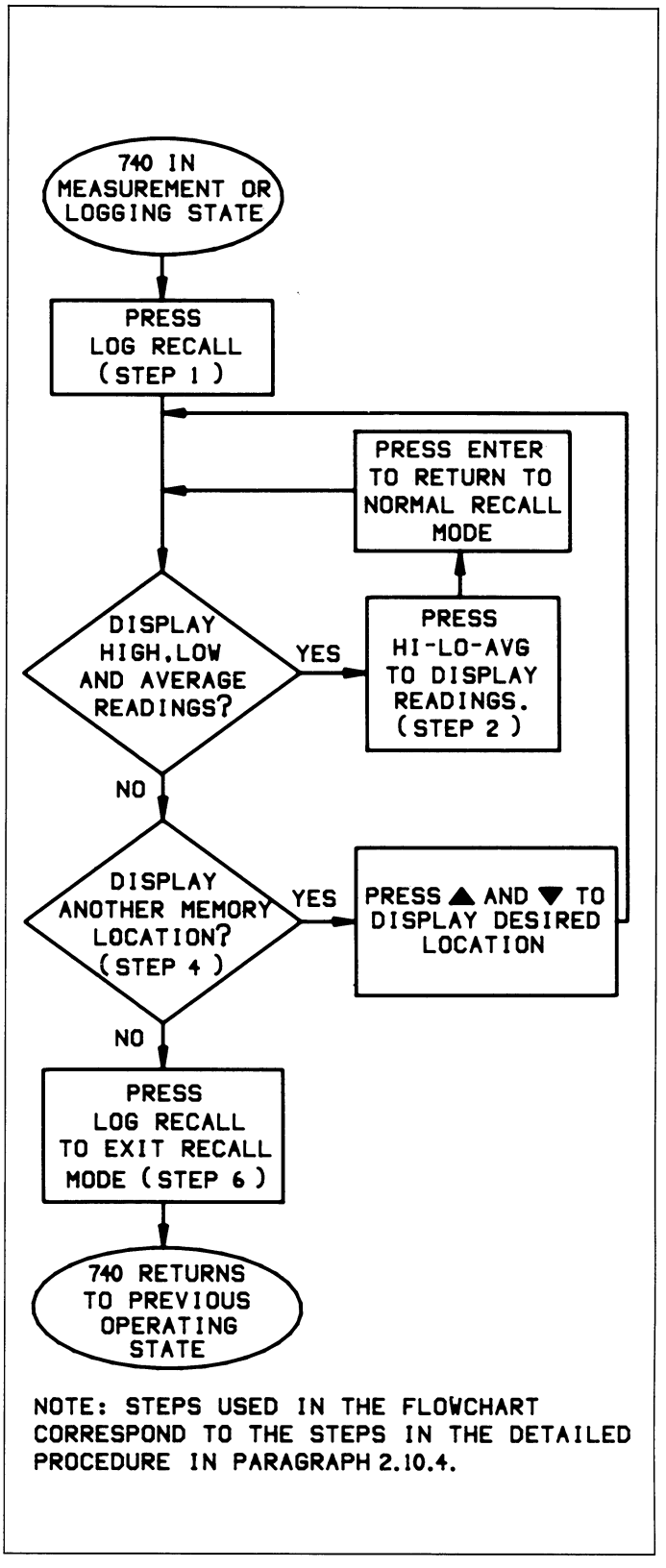


Figure 2-14. Flowchart—Recalling Log

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The reading along with the memory location will be displayed. For example, if the lowest reading is 12.7°C at location 22, the following message will be displayed:

12.7°C 22

C. To display the average reading in the log buffer, again press the HI-LO-AVG button. The brief message will include the number of readings used to compute the average reading. For example, if 99 readings were used to compute the average, the following message will be displayed briefly:

AVG 99

The average reading will then be displayed.

D. To exit from HI-LO-AVG recall, press the ENTER button. The instrument will then return to the normal recall state.

3. With a stored reading displayed, pressing the ▲ and ▼ buttons will display the stored reading for each of the other available memory locations.
4. To exit from the recall mode, press the LOG RECALL button. The instrument will return to the previous operating state.

Notes:

1. A channel number will not be displayed if the internal channel of the instrument is being used.
2. If the instrument is logging readings, a displayed log recall reading will update immediately if the reading at that buffer location changes.
3. If it is desired to check the time of day that the displayed reading was stored, press the TIME button. The time of log and the memory location number will be displayed. Press the ENTER button to return the display to the logged reading.
4. To check the channel type (configuration) after logging, first exit the log recall mode and then with the logged channel displayed, press the TYPE button. The ENTER button returns the display to the current channel measurement.
5. HI-LO-AVG readings can be displayed at any time while the instrument is in the LOG RECALL mode. Overranged readings or open TC's are not used to calculate the average.
6. Trying to recall readings that were logged on an OFF channel will result in the "------ 00" message being displayed.
7. Recalling readings from a channel that had an open input will result with "OPENTC" being displayed at all filled memory locations.
8. Table 2-10 lists the buttons that are functional when the instrument is in the log recall state and briefly describes what happens when they are pressed.

Table 2-10. Functional Controls—Log Recall State*

Control	Function
LOG RECALL	Exit log recall mode and display channel measurement.
HI/LO/AVG	Display high, low and average reading in buffer.
▲	Increment to next available memory location.
▼	Decrement to next available memory location.
°C/°F	Toggle scale between °C and °F.
TIME (OFF)	Display time of log (see ENTER).
ENTER	Returns display to stored reading mode if TIME of log or high/low/avg is displayed.

*LOG RECALL indicator on.

2.11 FRONT PANEL PROGRAMS

Five programs are available from the front panel. Table 2-11 lists and briefly describes each program. The following paragraphs describe and explain the operation of each program.

Table 2-11. Front Panel Programs

Program	Description	Paragraph
TRIG	Set a trigger time to start a scan or log.	2.11.2
TIME	Set the time of the clock.	2.11.3
IEEE	Set the IEEE address or Smart Print mode.	2.11.4
LINE	Select the line frequency setting (50Hz or 60Hz).	2.11.5
LOOP	Used to check or change the loop setting (705 or 706).	

Using a front panel program is a simple matter because only four buttons control every aspect of operation. The functions of these four control buttons are summarized in Table 2-12, while more detail is provided in paragraph 2.3.2.

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Table 2-12. Functional Controls—Front Panel Program State

Control	Function
PROGRAM	Press once to place instrument in program mode. Subsequent presses scrolls through programs.
▲ and ▼	Changes program parameters.
ENTER	Enters current program parameters and exits program mode.

In general, program selection is accomplished by pressing the PROGRAM button until the desired program parameter is displayed. The ▲ and ▼ buttons modify the displayed parameter, and the ENTER button enters the current program parameters and exits the program mode.

The procedure to use the front panel programs is summarized by the flowchart shown in Figure 2-15 while detailed procedures are provided in the following paragraphs.

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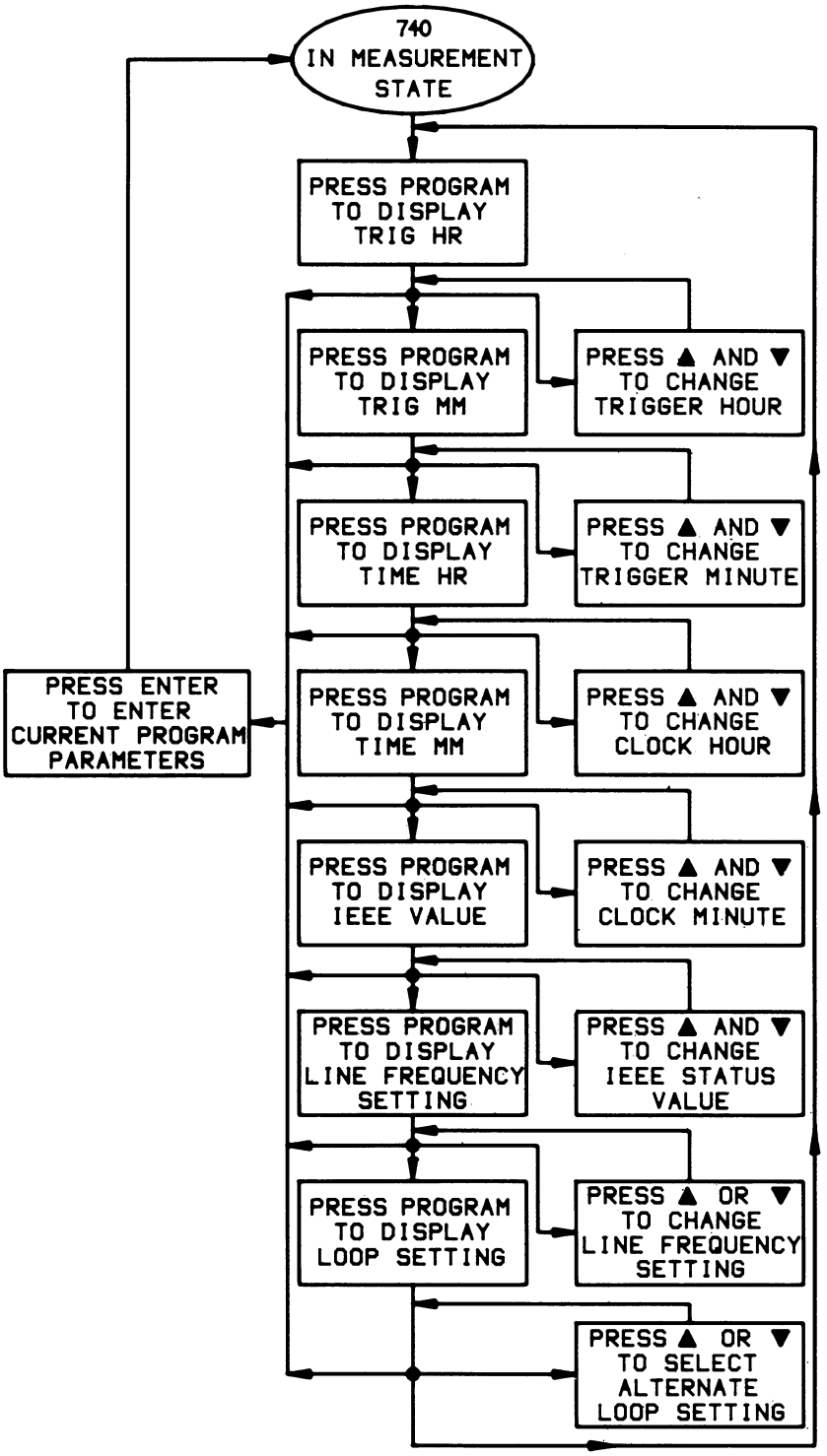


Figure 2-15. Flowchart—Front Panel Programs

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2.11.1 Program TRIG

Scanning and logging can be programmed to start automatically at any time of the day by setting a trigger time using this two component program. The first component sets the trigger hour and the second component sets the trigger minute.

This program consists of setting the trigger hour and then the trigger minute. The trigger time is entered when the ENTER button is pressed.

Perform the following procedure to set a trigger time:

1. Press the PROGRAM button until the current trigger hour is displayed. For example, if the trigger hour is set to 24 (trigger disabled), the following message will be displayed:

   TRIGHR 24

2. To change the trigger hour, use the ▲ and ▼ buttons. The ▲ and ▼ buttons increment and decrement the displayed hour.
3. To display the current trigger minute, press the PROGRAM button. For example, if the current trigger minute is 00, the following message will be displayed:

   TRIGMM 00

4. To change the trigger minute, use the ▲ and ▼ buttons to display the desired minute.
5. Perform one of the following procedures:
   A. To enter all current program parameters and exit the program mode, press the ENTER button. The scan or log process will start at the programmed time if scan or log is enabled.
   B. If it is desired to use another front panel program refer to the procedure for that program.

Notes:
1. Keyed in program parameters are not entered until the ENTER button is pressed.
2. Programming a trigger hour of 24 disables the trigger feature. The trigger minute is irrelevent in this case.
3. To indicate that a trigger time is set, the message "ON" is included with the normal time of day message.
4. After a time of day trigger passes, the trigger hour resets to 24 (disabled).

2.11.2 Program TIME

This program is used to set the clock for the correct time. Time is displayed in a 24 hour clock format with the hour, minute and second displayed. For example, a time of 2:36:54 PM is displayed as "14.36.54". With this two component program, the hour and minute can be set. The second is automatically set to 00 when the clock resets.

This program consists of setting the clock hour and then the clock minute. The clock starts keeping time when the ENTER button is pressed.

Perform the following steps to set the time of the program clock:

1. Press the PROGRAM button until the clock hour is displayed. For example, if the clock hour is currently 12, the following message will be displayed:

   TIMEHR 12

2. To change the clock hour, use the ▲ and ▼ buttons. These buttons increment and decrement the hour.
3. Press the PROGRAM button to display the current clock minute. For example, if the current clock minute is 30, the following message will be displayed.

   TIMEMM 30

4. Use the ▲ and ▼ buttons to change the clock minute.

Note: The clock does not reset to a new time until the ENTER button is pressed.

2.11.3. Program IEEE

This program is used to check or change the IEEE primary address of the instrument or select a Smart Print mode. The factory default power-up address of the instrument is 14, however the IEEE interface can be set to any address from 0 to 30. A value of 40 places the instrument in the Smart Print with prefix and suffix mode; 41 places the instrument in the Smart Print without suffix mode; and 42 selects Smart Print without prefix or suffix. Detailed information on the IEEE-488 bus is provided in Sections 3 and 4.

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This program simply consists of checking or changing the IEEE value that corresponds to a primary address or Smart Print mode.

Perform the following procedure to check or change the IEEE address or to select a Smart Print mode:

1. Press the PROGRAM button until the current IEEE value is displayed. For example, if the current IEEE address of the instrument is 14, the following message will be displayed:

   IEEE 14

2. If it is desired to change the IEEE value, use the ▲ and ▼ buttons to display one of the following values:
   A. Values 0 through 30 to set an IEEE address.
   B. Value 40 to place the instrument in the Smart Print with prefix and suffix mode.
   C. Value 41 to place the instrument in the talk-only without suffix mode.
   D. Value 42 to place the instrument in the Smart Print mode without prefix and suffix.
3. Perform one of the following steps:
   A. To enter a modified address value and exit the program mode, press the ENTER button.
   B. If it is desired to use another front panel program, refer to the procedure for that program.

Note: Keyed in program parameters are not entered until the ENTER button is pressed.

2.11.4 Program LINE

The Model 740 does not automatically detect the power line frequency on power-up. This program allows the user to check the frequency setting of the instrument and to select the alternate frequency. The instrument can be set to either 50Hz or 60Hz. The instrument is set ot 60Hz at the factory.

Perform the following procedure to check and change the frequency setting of the instrument:

1. Press the PROGRAM button until the current line frequency setting is displayed. For example, if the instrument is currently set for 60Hz, the following message will be displayed:

   LINE 60

2. If the alternate frequency setting is needed, press the ▲ or ▼ button. The display will toggle to the alternate frequency.
3. Perform one of the following steps:
   A. To enter a modified line frequency setting and exit the program mode, press the ENTER button.
   B. If it is desired to use another front panel program, refer to the procedure for that program.

Note: A modified line frequency setting is not entered until the ENTER button is pressed.

2.11.5 Program LOOP

This program is used to set the Model 740 to match the external scanner(s) that are going to be used in the measurement system. This setting is only relevant for measurement systems utilizing Model 705 scanners or a Model 706 scanner. The instrument is set to be used with Model 705 scanners at the factory. Perform the following procedure to check or change the loop status:

1. Press the PROGRAM button until the current loop status is displayed. For example, if the instrument is currently compatible to be used with one or more Model 705 scanners, the following message will be displayed:

   LOOP 705

2. If it is desired to select the alternate setting, press the ▲ or ▼ button. These buttons toggle the display between the two settings.
3. Perform one of the following steps.
   A. To enter a modified setting and exit the program mode, press the ENTER button.
   B. If it is desired to use another front panel program, refer to the procedure for that program.

2.12 EXTERNAL TRIGGERING

The EXTERNAL TRIGGER input allows the instrument to be triggered by other devices. Depending on how the instrument is set, an external trigger pulse can be used to trigger a reading(s), or start the scan or log process. The external trigger serves the same function as the front panel START button as it is used in the data store mode (see paragraph 2.10). Each external trigger pulse is the equivalent of pressing the START button once.

On power-up, the instrument is in the continuous trigger mode with the conversion rate determined by the internal time base. In this mode, an external trigger pulse can be used to start the log or scan process.

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The one-shot trigger mode is used with the logging feature. In the one-shot mode, a single trigger pulse will cause one reading to be stored in the log buffer. To use the one-shot mode for logging, press the LOG ENABLE button, and then select the one-shot interval using the ▲ and ▼ buttons.

The EXTERNAL TRIGGER input requires a falling edge pulse at TTL logic levels, as shown in Figure 2-16. Connections to the rear panel EXTERNAL TRIGGER input jack should be made with a standard BNC connector. The Model 740 is triggered when the negative-going edge of the external trigger pulse occurs.

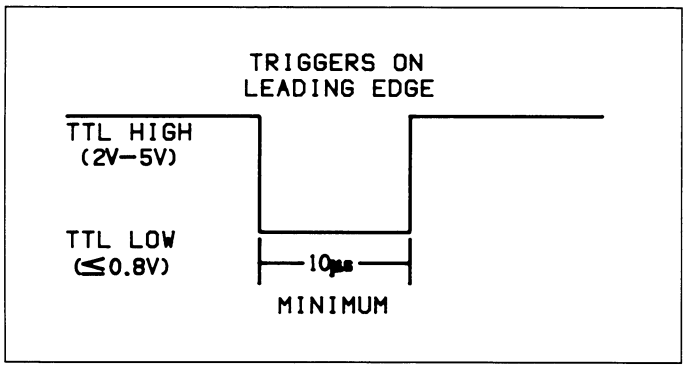


Figure 2-16. External Trigger Pulse Specifications

To use external triggering, proceed as follows:

1. Connect the external trigger source to the rear panel BNC EXTERNAL TRIGGER input connector. The shield (outer) part of the connector is connected to digital common. Since an internal pull-up resistor is used, a mechanical switch may be used. Note, however, that debouncing circuitry will probably be required to avoid improper triggering.

CAUTION
Do not exceed 30V between digital common and chassis ground, or instrument damage may occur.

2. With the instrument in the desired trigger mode (continuous or one-shot), apply a pulse to the EXTERNAL TRIGGER input. The pulse will cause the instrument to perform according to the way it is set up.

Notes:

1. If the instrument is triggered while processing a reading from a previous trigger, a trigger overrun error will result ("TRIGOVER" message) and the trigger will be ignored.
2. The instrument must be in the appropriate trigger mode to respond to external triggering (the unit will be in this mode upon power-up). See paragraph 4.7.5 for using external triggering over the IEEE bus.

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SECTION 3
IEEE-488 BUS PRINCIPLES

3.1 INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. In 1978, standards were upgraded into the IEEE-488-1978 standards. The Model 740 conforms to these standards.

The following information is presented in this section:

1. A description of the IEEE-488 bus standard is located in paragraphs 3.1.1 through 3.6.
2. Information necessary to connect the Model 740 to the IEEE-488 bus is contained in paragraphs 3.7 and 3.8.
3. General bus command programming is covered in paragraph 3.9.

NOTE

Device-dependent command programming is described in Section 4. These are the most important commands associated with the Model 740, as they control most of the instrument functions. Also included in Section 4 is information on using the instrument in the Smart Print mode.

3.1.1 Overview of Bus

Basically, the IEEE-488 bus is simply a communcication system between two or more electronic devices. A device can be either an instrument or a computer. When a computer is used on the bus, it serves to supervise the communication exchange between all the devices and is known as the controller. Supervision by the controller consists of determining which device will talk and which devices will listen. As a talker, a device will output information and as a listener, a device will receive information. To simplify the task of keeping track of the devices, a unique address number is assigned to each one.

On the bus, only one device can talk at a time and is addressed to talk by the controller. The device that is talking is known as the active talker. The devices that need to listen to the talker are addressed to listen by the controller. Each listener is then referred to as an active listener. Devices that do not need to listen are instructed to unlisten. The reason for the unlisten instruction is to optimize the speed of bus information transfer. The speed of the information transfer is determined by the speed of the slowest listener.

Through the use of control lines, a handshake sequence takes place in the transfer process of information from a talker to a listener. This handshake sequence helps ensure the credibility of the information transfer. The basic handshake sequence between an active controller (talker) and a listener is as follows:

1. The listener indicates that it is ready to listen.
2. The talker places the byte of data on the bus and indicates that the data is available to the listener.
3. The listener, aware that the data is available, accepts the data and then indicates that the data has been accepted.
4. The talker, aware that the data has been accepted, stops sending data and indicates that data is not being sent.
5. The listener, aware that there is no data on the bus, indicates that it is ready for the next byte of data.

The handshake (control) lines are discussed in more technical detail in paragraph 3.3.3.

3.2 BUS DESCRIPTION

The IEEE-488 bus, which is also frequently referred to as the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and with most commands. Five bus management lines and three handshake lines round out the complement of bus signal lines.

A typical set up for controlled operation is shown in Figure 3-1. Generally, a system will contain one controller and a number of other instruments to which the commands are given. Device operation is categorized into three operators: controller, talker and listener. The controller does what its name implies; it controls the instruments on the bus. The talker sends data while a listener receives data. Depending on the type of instrument, any particular device can be a talker only, a listener only or both a talker and a listener.

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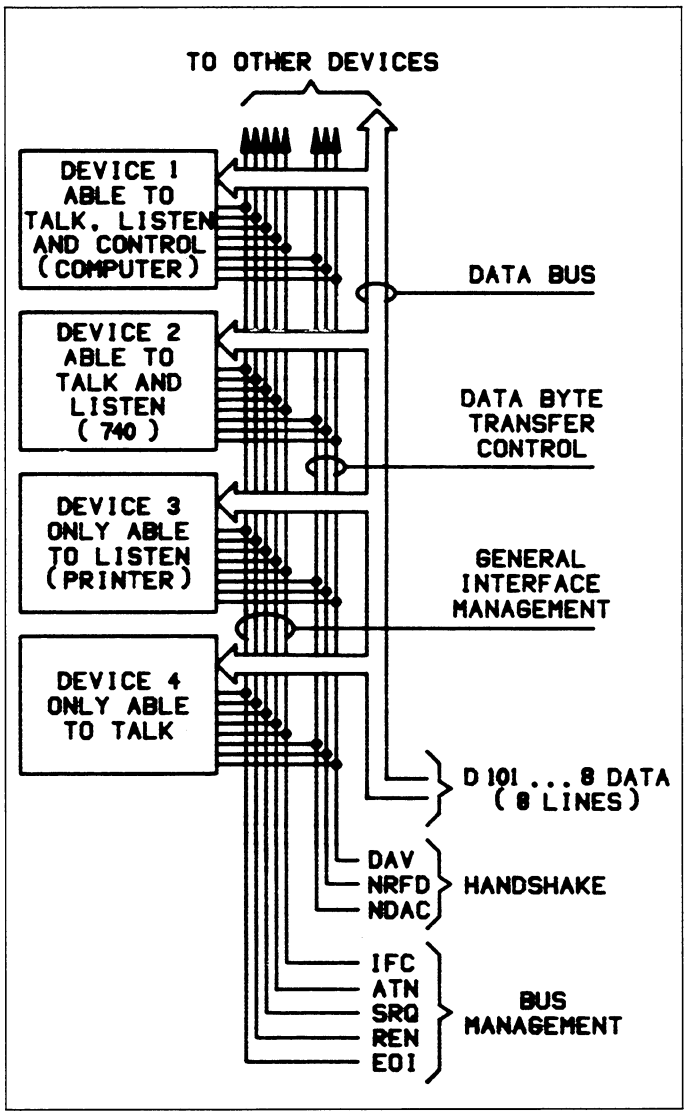


Figure 3-1. IEEE-488 Bus Configuration

There are two catagories of controllers: system controller, and active controller. Both are able to control other instruments, but only the system controller has the absolute authority in the system. In a system with more than one controller, only one controller may be active at any given time. Certain protocol is used to pass control from one controller to another.

The IEEE-488 bus is limited to 15 devices, including the controller. Thus, any number of talkers and listeners up to that limit may be present on the bus at one time. Although several devices may be commanded to listen simultaneously, the bus can have only one active talker, or communications would be scrambled.

A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary address. The primary address may have any value between 0 and 30, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by ORing the primary address with $20. For example, if the primary address is 14 ($0E), the actual listen address is $2E ($2E = $0E + $20). In a similar manner, the talk address is obtained by ORing the primary address with $40. With the present example, the talk address derived from a primary address of 14 decimal would be $4E ($4E = $0E + $40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of $60-$7F. Note, however that many devices do not use secondary addressing.

Once a device is addressed to talk or listen, the appropriate bus transactions take place. For example: if the instrument is addressed to talk, it places its data string on the bus one byte at a time. The controller reads the information and the appropriate software can be used to direct the information to the desired location.

3.3 IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three different categories: data lines, management lines and handshake lines. The data lines handle bus data and commands, while the management and handshake lines ensure that proper data transfer and operation takes place. Each bus line is active low, with approximately zero volts representing a logic 1 (true). The following paragraphs describe the purpose of these lines, which are shown in Figure 3-1.

3.3.1 Data Lines

The IEEE-488 bus uses eight data lines that transfer data one byte at a time. DIO1 (Data Input/Output) through DIO8 are the eight data lines used to transmit both data and multiline commands and are bidirectional. The data lines operate with low true logic.

3.3.2 Bus Management Lines

The five bus management lines help to ensure proper interface control and management. These lines are used to

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send the uniline commands that are described in paragraph 3.4.1.

ATN (Attention)—The ATN line is one of the more important management lines in that the state of this line determines how information on the data bus is to be interpreted.

IFC (Interface Clear)—As the name implies, the IFC line controls clearing of instruments from the bus.

REN (Remote Enable)—The REN line is used to place the instrument on the bus in the remote mode.

EOI (End or Identify)—The EOI line is usually used to mark the end of a multi-byte data transfer sequence.

SRQ (Service Request)—This line is used by devices when they require service from the controller.

3.3.3 Handshake Lines

The bus uses handshake lines that operate in an interlocked sequence. This method ensures reliable data transmission regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the three handshake lines is controlled by the source (the talker sending information), while the remaining two lines are controlled by accepting devices (the listener or listeners receiving the information). The three handshake lines are:

DAV (Data Valid)—The source controls the state of the DAV line to indicate to any listening devices whether or not data bus information is valid.

NRFD (Not Ready For Data)—The acceptor controls the state of NRFD. It is used to signal to the transmitting device to hold off the byte transfer sequence.

NDCA (Not Data Accepted)—NDCA is also controlled by the accepting device.

The complete handshake sequence for one data byte is shown in Figure 3-2. Once the source checks to see that NRFD is high, indicating that all active devices are ready data is placed on the data lines. At the same time, NDAC should be low from the previous byte transfer. If these conditions are not met, the source must wait until NDAC and NRFD have the correct status. If the source is a controller, NRFD and NDAC must by stable for at least 100nsec after ATN is set true.

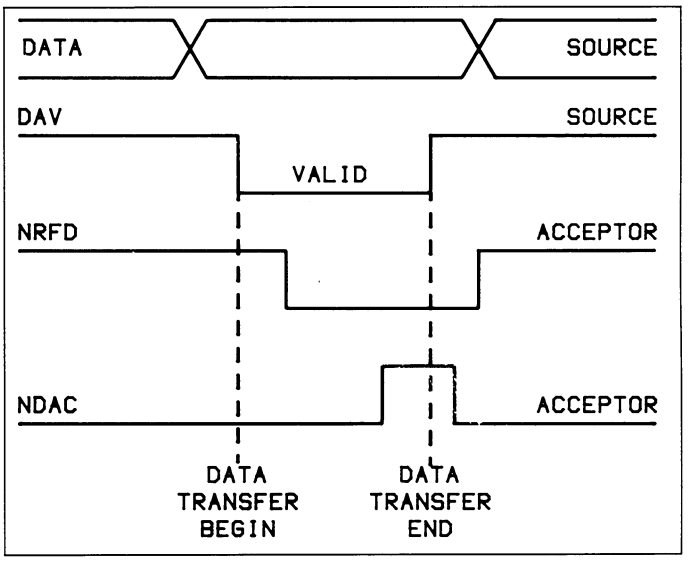


Figure 3-2. IEEE-488 Handshake Sequence

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating to accepting devices that the byte on the data lines is now valid. NRFD will then go low, and NDAC will go high once all devices have accepted the data. Each device will release NDAC at its own rate, but NDAC will not be released to go high until all devices have accepted the data byte.

The sequence just described is used to transfer both data, talk and listen addresses, as well as multiline commands. The state of the ATN line determines whether the data bus contains data, addresses or commands as described in the following paragraph.

3.4 BUS COMMANDS

The instrument may be given a number of special bus commands through the IEEE-488 interface. This section briefly describes the purpose of the bus commands which are grouped into the following three categories:

1. Uniline Commands—Sent by setting the associated bus lines true (low).
2. Multiline Commands—General bus commands which are sent over the data lines with the ATN line true (low).
3. Device-Dependent Commands—Special commands whose meanings depend on device configurations; sent with ATN high (false).

These bus commands and their general purposes are summarized in Table 3-1.

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Table 3-1. IEEE-488 Bus Command Summary

Command Type	Command	State of ATN Line*	Comments
Uniline	REN (Remote Enable)	X	Set up for remote operation.
	EOI	X	Marks end of transmission.
	IFC (Interface Clear)	X	Clears Interface
	ATN (Attention)	Low	Defines data bus contents.
	SRQ	X	Controlled by external device.
Multiline			
Universal	LLO (Local Lockout)	Low	Locks out front panel controls.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Poll Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Send go to local.
	GET (Group Execute Trigger)	Low	Triggers device for reading.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from bus.
	UNT (Untalk)	Low	Removes any talkers from bus.
Device-dependent		High	Programs Model 740 for various modes.

*Don't Care.

3.4.1 Uniline Commands

ATN, IFC and REN are asserted only by the controller. SRQ is asserted by an external device. EOI may be asserted either by the controller or other devices depending on the direction of data transfer. The following is a description of each command. Each command is sent by setting the corresponding bus line true.

REN (Remote Enable)—REN is sent to set up instruments on the bus for remote operation. Generally, REN should be sent before attempting to program instruments over the bus.

EOI (End Or Identify)—EOI is used to positively identify the last byte in a multi-byte transfer sequence, thus allowing data words of various lengths to be transmitted easily.

IFC (Interface Clear)—IFC is used to clear the interface and return all devices to the talker and listener idle states.

ATN (Attention)—The controller sends ATN while transmitting addresses or multiline commands.

SRQ (Service Request)—SRQ is asserted by a device when it requires service from a controller.

3.4.2 Universal Commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the command is transmitted. As with all multiline commands, these commands are transmitted with ATN true.

LLO (Local Lockout)—LLO is sent to the instrument to lock out their front panel controls.

DCL (Device Clear)—DCL is used to return instruments to some default state. Usually, instruments return to their power-up conditions.

SPE (Serial Poll Enable)—SPE is the first step in the serial polling sequence, which is used to determine which device has requested service.

SPD (Serial Poll Disable) - SPD is used by the controller to remove all devices on the bus from the serial poll mode and is generally the last command in the serial polling sequence.

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3.4.3 Addressed Commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands:

SDC (Selective Device Clear)—The SDC command performs essentially the same function as the DCL command except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the SDC command.

GTL (Go To Local)—The GTL command is used to remove instruments from the remote mode. With some instruments, GTL also unlocks front panel controls if they were previously locked out with the LLO command.

GET (Group Execute Trigger)—The GET command is used to trigger devices to perform a specific action that depends on device configuration (for example, take a reading). Although GET is an addressed command, many devices respond to GET without addressing.

3.4.4 Unaddress Commands

The two unaddress commands are used by the controller to remove any talkers or listeners from the bus. ATN is true when these commands are asserted.

UNL (Unlisten)—Listeners are placed in the listener idle state by the UNL command.

UNT (Untalk)—Any previously commanded talkers will be placed in the talker idle state by the UNT command.

3.4.5 Device-Dependent Commands

The meaning of the device-dependent commands will depend on the configuration of the instrument. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, the command sequence F1X is used to place the instrument in the log enable mode. The IEEE-488 bus actually treats these commands as data in that ATN is false when the commands are transmitted. Complete information on device-dependent command programming is found in Section 4.

3.5 COMMAND CODES

Each multiline command is given a unique code that is transmitted over the bus as 7 bit ASCII data. This section briefly explains the code groups, which are summarized in Figure 3-3.

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D_7 D_6 D_5 D_4					X 0 0 0		X 0 0 1		X 0 1 0	PRIMARY ADDRESS	X 0 1 1	PRIMARY ADDRESS	X 1 0 0	PRIMARY ADDRESS	X 1 0 1	PRIMARY ADDRESS	X 1 1 0		X 1 1 1	
BITS D_3 ↓	D_2 ↓	D_1 ↓	D_0 ↓	COLUMN→ ROW↓	0(A)	0(B)	1(A)	1(B)	2(A)	2(B)	3(A)	3(B)	4(A)	4(B)	5(A)	5(B)	6(A)	6(B)	7(A)	7(B)
0	0	0	0	0	NUL		DLE		SP	0	0	16	@	O	P	16			p	
0	0	0	1	1	SOH	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a		q	
0	0	1	0	2	STX		DC2		"	2	2	18	B	2	R	18	b		r	
0	0	1	1	3	ETX		DC3		#	3	3	19	C		S	19	c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d		t	
0	1	0	0	5	ENQ	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e		u	
0	1	1	0	6	ACK		SYN		&	6	6	22	F	6	V	22	f		v	
0	1	1	1	7	BEL		ETB		'	7	7	23	G	7	W	23	g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(	8	8	24	H	8	X	24	h		x	
1	0	0	1	9	HT	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i		y	
1	0	1	0	10	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
1	0	1	1	11	VT		ESC		+	11	;	27	K	11	[	27	k		{	
1	1	0	0	12	FF		FS		,	12	<	28	L	12	\	28	l		:	
1	1	0	1	13	CR		GS		-	13	=	29	M	13	]	29	m		}	
1	1	1	0	14	SO		RS		.	14	>	30	N	14	∩	30	n		~	
1	1	1	1	15	SI		US		/	15	?	UNL	O	15	—	UNT	o		DEL	

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP (SDC)

*PPC (PARALLEL POLL CONFIGURE), PPU (PARALLEL POLL UNCONFIGURE), AND TCT (TAKE CONTROL) NOT IMPLEMENTED BY MODEL 740.

NOTE: D_0 = DIO1 ... D_7 = DIO8
X = DON'T CARE

Figure 3-3. Command Groups

Addressed Command Group (ACG)—Addressed commands and corresponding ASCII codes are listed in columns 0(A) and 0(B).

Universal Command Group (UCG)—Universal commands and values are listed in columns 1(A) and 1(B).

Listen Address Group (LAG)—Columns 2(A) through 3(B) list codes for commands in this address group. For example, if the primary address of the instrument is 14, the LAG byte will be an ASCII period (.).

Talk Address Group (TAG)—TAG primary address values and corresponding ASCII characters are listed in columns 4(A) through 5(B).

The preceding address groups are combined together to form the Primary Command Group (PCG). The bus also has another group of commands, called the Secondary Command Group (SCG). These are listed in Figure 3-3 for informational purposes only; the Model 740 does not have secondary addressing capabilities.

Note that these commands are normally transmitted with the 7 bit code listed in Figure 3-3. For many devices, the condition of DIO8 is unimportant. However, many devices may require that DIO8 has a value of logic 0 (high) to properly send commands.

Hexadecimal and decimal values for each of the commands or command groups are listed in Table 3-2. Each value assumes that DIO8 has a value of 0.

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Table 3-2. Hexadecimal and Decimal Command Codes

Command	Hex Value	Decimal Value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
UNL	3F	63
UNT	5F	95

3.6 COMMAND SEQUENCES

The proper command sequence must be sent to the instrument before it will respond as intended. Universal commands, such as LLO and DCL, require only that ATN be set low when sending the command. Other commands require that the instrument be properly addressed to listen first. This section briefly describes the bus sequence for several types of commands.

3.6.1 Addressed Command Sequence

Before a device will respond to one of these commands, it must receive a LAG command derived from its primary address. Table 3-3 shows a typical sequence for the SDC command; the example assumes that a primary address of 14 is being used.

Table 3-3. Typical Addressed Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	.	2E	46
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 14.

Note that an UNL command is generally sent before the LAG, SDC sequence. This is usually done to remove all other listeners from the bus so that the desired device responds to the command.

3.6.2 Universal Command Sequence

Universal commands are sent by setting ATN low and then placing the command byte on the data bus. ATN would then remain low during the period the command is transmitted. For example, if the LLO command were to be sent, both ATN and LLO would be asserted simultaneously.

3.6.3 Device-Dependent Command Sequence

Device-dependent commands are transmitted with ATN false. However, a device must be addressed to listen before these commands are transmitted. Table 3-4 shows the byte sequence for a typical Model 740 command (F1X), which sets the instrument for the log enable mode of operation.

Table 3-4. Typical Device-Dependent Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	.	2E	46
3	Data	Set High	F	46	70
4	Data	Stays High	0	30	48
5	Data	Stays High	X	58	88

*Assumes primary address = 14.

3.7 HARDWARE CONSIDERATIONS

Before the Model 740 can be operated over the IEEE-488 bus, it must be connected to the bus with a suitable cable. Also, the primary address must be programmed the correct value, as described in the following paragraphs.

3.7.1 Typical Controlled Systems

System configurations are many and varied and will depend on the application. To obtain as much versatility as possible, the IEEE-488 bus was designed so that additional instrumentation could be easily added. Because of this versatility, system complexity can range from the very simple to extremely complex.

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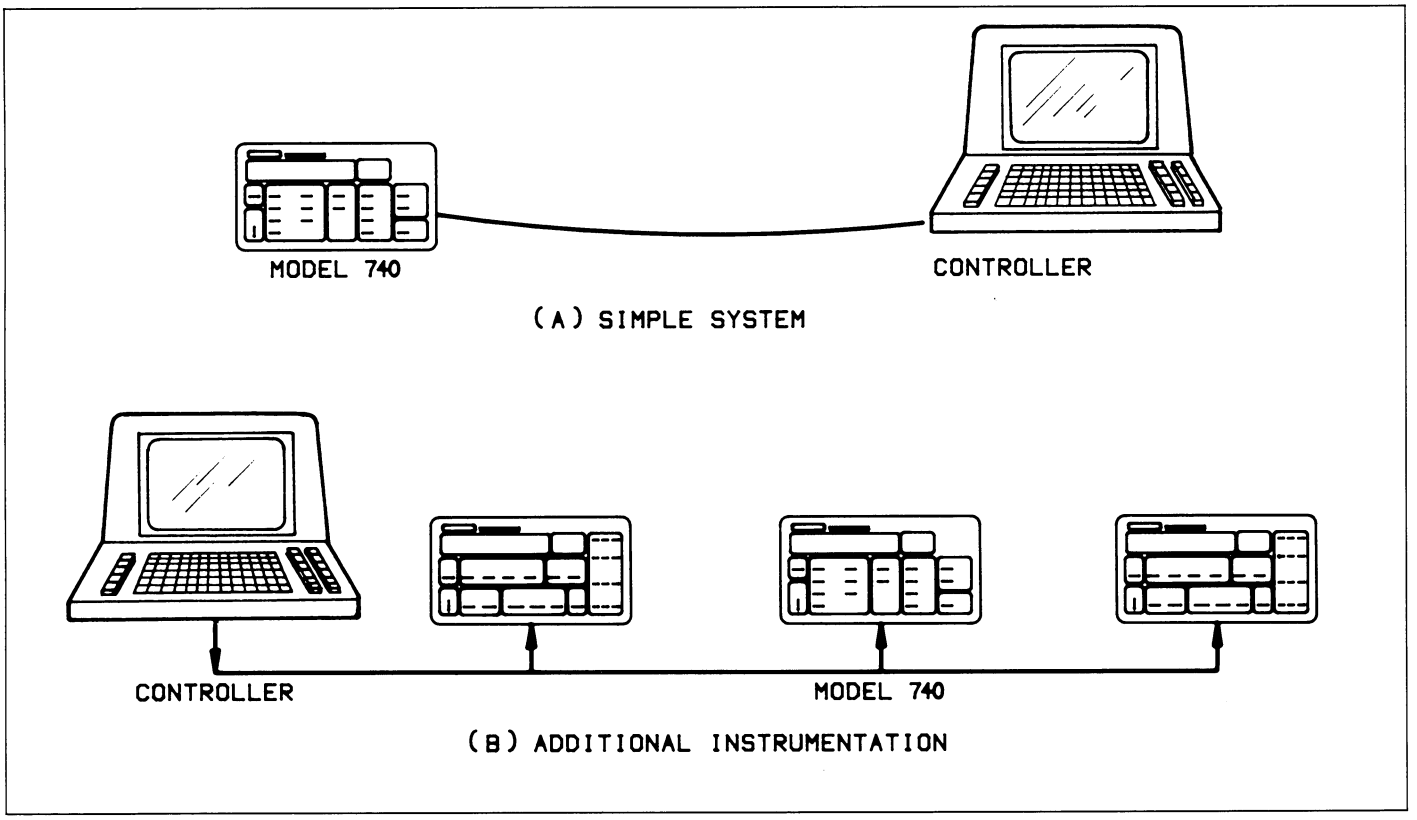


Figure 3-4. System Types

Figure 3-4 shows two possible system configurations. Figure 3-4(A) shows the simplest possible controlled system. The controller is used to send commands to the instrument, which sends data back to the controller.

The system in Figure 3-4(B) is somewhat more complex in that additional instruments are used. Depending on programming, all data may be routed through the controller, or it may be sent directly from one instrument to another.

In very complex applications, a larger computer could be used. Tape drives or disks could be used to store any data generated by the instruments.

3.7.2 Bus Connections

The Model 740 is to be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example of which is shown in Figure 3-5. The connector is designed to be stacked to allow a number of parallel connections. Two screws are located on each connector to ensure that connections remain secure. Current standards call for metric threads, as identified by dark colored screws. Earlier versions had different screws, which are silver colored. Do not attempt to use these types of connectors with the Model 740 which is designed for metric threads.

NOTE

When using Model 705s or a Model 706 in the temperature measurement system, do not connect them to the IEEE bus. These scanners are set to operate as slaves to the Model 740 and are controlled by the serial loop circuitry.

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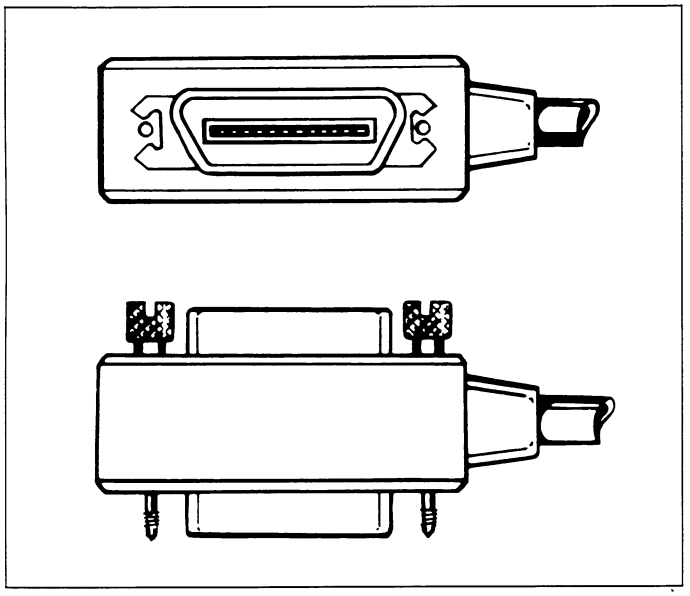


Figure 3-5. Typical Bus Connections

A typical connecting scheme for the bus is shown in Figure 3-6. Each cable normally has the standard connector on each end. These connectors are designed to be stacked to allow a number of parallel connections on one instrument.

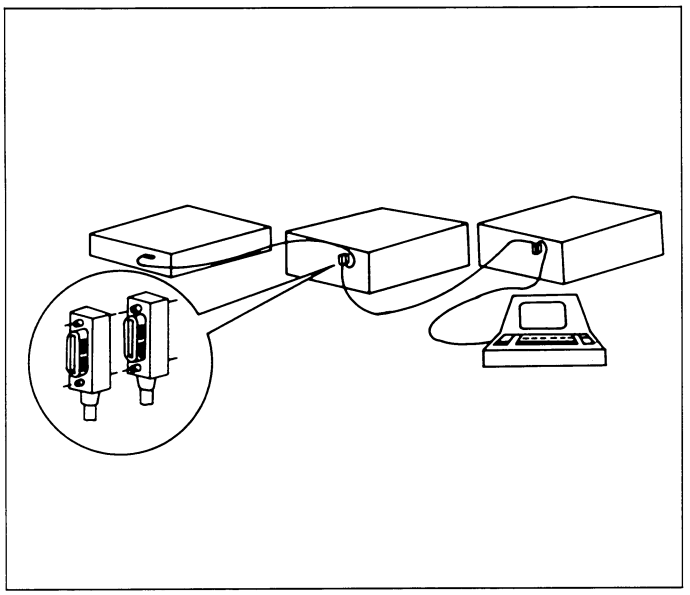


Figure 3-6. IEEE-488 Connections

NOTE

To avoid possible damage, it is recommended that you stack no more than three connectors on any one instrument.

Connect the Model 740 to the cable as follows:

1. Line up the connector on the cable with the connector on the rear panel of the instrument. See Figure 3-7 for connector location.
2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments as required.
4. Make sure the other end of the cable is properly connected to the controller. Some controllers have an IEEE-488 type connector, while others do not. Consult the instruction manual for your controller for the proper connecting method.

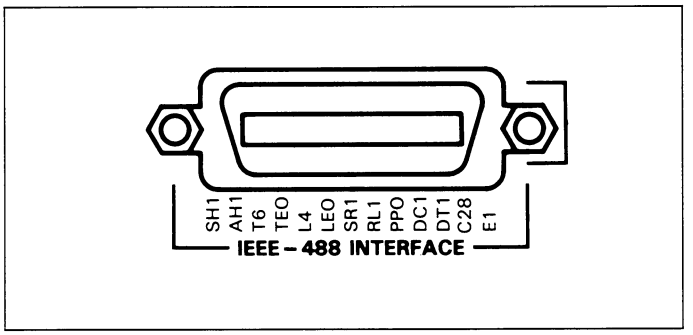


Figure 3-7. Model 740 IEEE-488

NOTE

The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is limited to 20 meters, or 2 meters times the number of devices, which ever is less. Failure to heed these limits may result in erratic bus operation.

Custom cables may be constructed by using the information in Table 3-5 and Figure 3-8. Table 3-5 lists the contact assignments for the various bus lines, while Figure 3-8 shows contact assignments.

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Table 3-5. IEEE Contact Designation

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

*Number in parenthesis refer to signal ground return of reference contact number. EOI and REN signal lines return on contact 24.

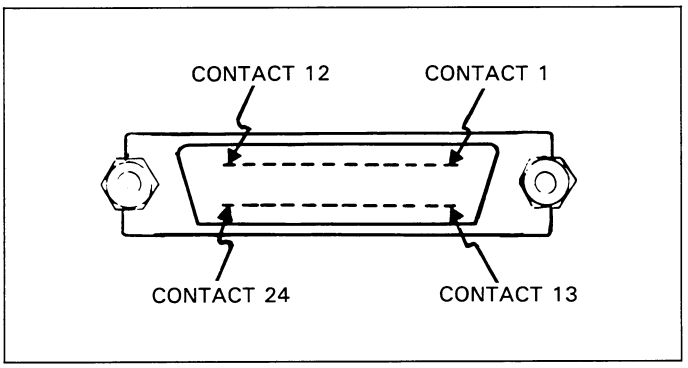


Figure 3-8. Contact Assignments

CAUTION
The voltage between IEEE-488 common and chassis ground must not exceed 30V or instrument damage may occur.

3.7.3 Primary Address Programming

The Model 740 must receive a listen command before it will respond to addressed commands. Similarly, the unit must receive a talk command before it will transmit its data. The Model 740 is shipped from the factory with a programmed primary address of 14. Until you become more familiar with your instrument, it is recommended that you leave the address at this value because the programming examples included in this manual assume that address.

The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that controllers are also given a primary address, so you must be careful not to use that address either. Most frequently, controller addresses are set to 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one, use front panel Program IEEE. See paragraph 2.11.3 for information on using this program.

Notes:
1. Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.
2. The Model 740 may be placed into the Smart Print mode and be used with a printer. When in this mode, the instrument will ignore commands given over the bus and merely output data to the printer. Paragraph 4.11 provides the complete procedure for using the instrument in the Smart Print mode.

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3.8 SOFTWARE CONSIDERATIONS

There are a number of IEEE-488 controllers available, each of which has its own programming language. Also, different instruments have differing capabilities. In this section, we will discuss programming languages for two typical controllers: the HP-85, and the IBM-PC interfaced to the bus through a Keithley Model 8573 IEEE-488 interface. In addition, interface function codes that define Model 740 capabilities will be discussed.

3.8.1 Controller Handler Software

Before a specific controller can be used over the IEEE-488 bus, it must have IEEE-488 handler software installed. With some controllers, the software is located in ROM, and no software initialization is required on the part of the user. With other controllers, software must be loaded from disk or tape and be properly initialized. With the HP-85, for example, an additional I/O ROM that handles interface functions must be installed. With the Keithley Model 8573 interface for the IBM-PC, software must be installed and configured from a diskette.

Other small computers that can be used as IEEE-488 controllers may have limited capabilities. With some, interface programming functions may depend on the interface being used. Often little software "tricks" are required to obtain the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the interface. Often, the user may incorrectly suspect that the hardware is causing a problem when it was the software all along.

3.8.2 Interface BASIC Programming Statements

Many of the programming instructions covered in this section use examples written with Hewlett Packard Model 85 BASIC and Model 8573 Interface statements. These computers and interfaces were chosen for these examples because of their versatility in controlling the IEEE-488 bus. This section covers those HP-85 and Model 8573 statements that are essential to Model 740 operation.

A partial list of HP-85 and Model 8573 statements is presented in Table 3-6. HP-85 statements have a one or three digit argument that must be specified as part of the statement. The first digit is the interface select code, which is set to 7 at the factory. The last two digits of those statements, requiring a 3-digit argument, specify the primary address.

Table 3-6. BASIC Statements Necessary to Send Bus Commands

Action	HP-85 Statement	Model 8573 Statement
Transmit string to device 14.	OUTPUT 714;A$	CALL IBWRT (M740%, CMD$)
Obtain string from device 14.	ENTER 714; A$	CALL IBRD (M740%, RD$)
Send GTL to device 14.	LOCAL 714	CALL IBLOC (M740%)
Send SDC to device 14.	CLEAR 714	CALL IBCLR (M740%)
Send DCL to all devices.	CLEAR 7	CMD$=CHR$ (&H14): CALL IBCMD (BRD0%, CMD$)
Send remote enable.	REMOTE 7	V%=1: CALL IBSRE (BRD0%, V%)
Cancel remote enable.	LOCAL 7	V%=0: CALL IBSRE (BRD0%, V%)
Serial poll device 14.	SPOLL (714)	CMD$=CNR$ (&H11): CALL IBCMD (BRD0%, CMD$)
Send Local Lockout.	LOCAL LOCKOUT	CALL IBRSP (M740%, SB%)
Send GET to device.	TRIGGER 714	CALL IBTRG (M740%)
Send IFC.	ABORTIO 7	CALL IBSIC (BRD0%)

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Those statements with a 3-digit argument listed in the table show a primary address of 14 (the factory default primary address of the Model 740). For a different address, you would, of course, change the last two digits to the required value. For example, to send a GTL command to a device using a primary address of 22, the following statement would be used: LOCAL 722.

Some of the statements have two forms; the exact configuration depends on the command to be sent over the bus. For example, CLEAR 7 sends a DCL command, while CLEAR 714 sends the SDC command to a device with a primary address of 14.

The Model 8573 statements, which are also listed in Table 3-6, take on a somewhat different form. Each of these statements uses the IBM BASIC CALL statement, with various variables passed as shown in the table. The command words, such as IBCLR (Interface Bus Clear) and IBSRE (Interface Bus Send Remote Enable), are, in fact, BASIC variables themselves, which must be initialized at the start of each BASIC program. In addition, you must remember not to use these keywords for any other purpose in your BASIC program.

Before using the Model 8573 examples throughout this section, you must configure the software by using the procedure below. Note that the binary handler file called GPIB.COM and the system configuration file called CONFIG.SYS must be present on the DOS boot disk, as described in the Model 8573 Instruction Manual.

1. Boot up your system in the usual manner and enter BASICA.
2. Place the Model 8573 software disk into the default drive and load the program called "DECL.BAS". Modify the program by changing the XXXXX values in lines 1 and 2 to 16000.
3. Add the following lines to the declaration file:
```
7 NA$="GPIB0":CALL IBFIND(NA$,BRD0%)
8 NA$="DEV0":CALL IBFIND(NA$,M740%)
9 V%=14:CALL IBPAD(M740%,V%)
```
4. Now save the modified declaration file for future use. Remember that you must load and run this short program before using the Model 8573 programming examples throughout this section. Also, do not use the BASIC CLEAR or NEW commands after running this program.

3.8.3 Interface Function Codes

The interface function codes, which are part of the IEEE-488-1978 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Model 740 are listed in Table 3-7. These codes are also listed for convenience on the rear panel adjacent to the IEEE-488 connector. The codes define Model 740 capabilities as follows:

Table 3-7. Model 740 Interface Function Codes

Code	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T6	Talker (Basic Talker, Serial Poll, Unaddressed To Talk On LAG)
L4	Listener (Basic Listener, Unaddressed To Listen On TAG)
SR1	Service Request Capability
RL1	Remote/Local Capability
PP0	No Parallel Poll Capability
DC1	Device Clear Capability
DT1	Device Trigger Capability
C28	Some Controller Capability
E1	Open Collector Bus Drivers
TE0	No Extended Talker Capabilities
LE0	No Extended Listener Capabilities

SH (Source Handshake Function)—SH1 defines the ability of the instrument to initiate the transfer of message/data over the data bus.

AH (Acceptor Handshake Function)—AH1 defines the ability of the instrument to guarantee proper reception of message/data transmitted over the data bus.

T (Talker Function)—The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities exist only after the instrument has been addressed to talk, or when it has been placed in the talk-only mode.

L (Listener Function)—The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities of the instrument exist only after it has been addressed to listen.

SR (Service Request Function)—The SR function defines the ability of the instrument to request service from the controller.

RL (Remote-Local Function)—The RL function defines the ability of the instrument to be placed in the remote or local modes.

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PP (Parallel Poll Function)—The instrument does not have parallel polling capabilities.

DC (Device Clear Function)—The DC function defines the ability of the instrument to be cleared (initialized).

DT (Device Trigger Function)—The ability for the instrument to have its readings triggered is provided by the DT function.

C (Controller Function)—The instrument does have controller capabilities.

TE (Extended Talker Function)—The instrument does not have extended talker capabilities.

LE (Extended Listener Function)—The instrument does not have extended listener capabilities.

E (Bus Driver Type)—The instrument has open-collector bus drivers.

3.8.4 IEEE Command Groups

Command groups supported by the Model 740 are listed in Table 3-8. Device-dependent commands, which are covered in Section 4 are not included in this list.

Table 3-8. IEEE Command Groups

HANDSHAKE COMMAND GROUP	
	DAC=DATA ACCEPTED
	RFD=READY FOR DATA
	DAV=DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN=ATTENTION
	DCL=DEVICE CLEAR
	IFC=INTERFACE CLEAR
	LLO=LOCAL LOCKOUT
	REN=REMOTE ENABLE
	SPD=SERIAL POLL DISABLE
	SPE=SERIAL POLL ENABLE
ADDRESS COMMAND GROUP	
LISTEN:	LAG=LISTEN ADDRESS GROUP
	MLA=MY LISTEN ADDRESS
	UNL=UNLISTEN
TALK:	TAG=TALK ADDRESS GROUP
	MTA=MY TALK ADDRESS
	UNT=UNTALK
	OTA=OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP	
	ACG=ADDRESSED COMMAND GROUP
	GET=GROUP EXECUTE TRIGGER
	GTL=GO TO LOCAL
	SDC=SELECTIVE DEVICE CLEAR
STATUS COMMAND GROUP	
	RQS=REQUEST SERVICE
	SRQ=SERIAL POLL REQUEST
	STB=STATUS BYTE
	EOI=END

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3.9 GENERAL BUS COMMAND PROGRAMMING

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument type. Commands supported by the Model 740 are listed in Table 3-9, which also lists both HP-85 and Model 8573 statements necessary to send each command. Note that commands requiring that a primary address be specified assume that the Model 740 primary address is set to 14 (its default address). If you are using Model 8573 programming examples, remember that the modified declaration file must be loaded and run first, as described in paragraph 3.8.2.

3.9.1 REN (Remote Enable)

The remote enable command is sent to the Model 740 by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN true will not actually place the instrument in the remote mode. Instead the instrument must be addressed after setting REN true before it will go into remote.

To place the Model 740 in the remote mode, the controller must perform the following sequence:

1. Set the REN line true.
2. Address the instrument to listen.

HP-85 Programming Example—This sequence is automatically performed by the HP-85 when the following is typed into the keyboard.

```
REMOTE 714
```

After the END LINE key is pressed, the instrument will be in the remote mode, as indicated by the REMOTE light. If not, check to see that the instrument is set to the proper primary address (14), and check to see that the bus connections are properly made.

Model 8573 Programming Example—To place the instrument into the remote mode, type the following lines into the computer.

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="X":CALL IBWRT(M740%,CMD$)
```

The instrument will go into the remote mode when the return key is pressed the second time.

3.9.2 IFC (Interface Clear)

The IFC command is sent by the controller to place the Model 740 in the local, talker and listener idle states. The unit will respond to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those modes.

Table 3-9. General Bus Commands and Associated BASIC Statements

Command	HP-85 Statement	Model 8573 Statement	Affect On Model 740
REN	REMOTE 7	V%=1: CALL IBSRE(BRD0%,V%)	Goes into remote when next addressed.
IFC	ABORTIO 7	CALL IBSIC(BRD0%)	Goes into talker and listener idle states.
LLO	LOCAL LOCKOUT 7	CMD$=CHR$ (&H11): CALL IBCMD M740%, CMD$)	Front panel controls locked out.
GTL	LOCAL 714	CALL IBLOC (M740%)	Cancel remote.
DCL	CLEAR 7	CMD$=CHR$ (&H14): CALL IBCMD (M740%, CMD$)	Returns to default conditions.
SDC	CLEAR 714	CALL IBCLR (M740%)	Returns to default conditions.
GET	TRIGGER 714	CALL IBTRG (740)	Triggers reading in T2 and T3 modes.
	LOCAL 7	V%=0: CALL IBSRE (BRD0%,V%)	Cancel LLO

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To send the IFC command, the controller need only set the IFC line true for a minimum of 100μsec.

HP-85 Programming Example—Before demonstrating the IFC command, turn on the TALK indicator with the following statements:

```
REMOTE 714
ENTER 714;A$
```

At this point, the REMOTE and TALK lights should be on. The IFC command can be sent by typing in the following statement into the HP-85:

```
ABORTIO 7
```

After the END LINE key is pressed, the REMOTE and TALK lights will turn off, indicating that the instrument has gone into the talker idle state.

Model 8573 Programming Example—Place the instrument in the remote and talker active states with the following statements:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=CHR$(&H5B):CALL IBCMD(BRD0%,CMD$)
```

After the return key is pressed the second time, the instrument should be in the remote and talker active states, as indicated by the respective indicators.

To send IFC, enter the following statement into the IBM-PC:

```
CALL IBSIC(BRD0%)
```

After the return key is pressed, the instrument will return to the local and talker idle states.

3.9.3 (Local Lockout)

The LLO command is used to remove the instrument from the local operating mode. After the unit receives LLO, all its front panel controls except POWER will be inoperative. REN must be true for the instrument to respond to LLO. REN must be set false to cancel LLO.

To send the LLO command, the controller must perform the following steps:

1. Set ATN true.
2. Place the LLO command on the data bus.

HP-85 Programming Example—The LLO command is sent by using the following HP-85 statement:

```
REMOTE 7
LOCAL LOCKOUT 7
```

After the second statement is entered, the instrument's front panel controls will be locked out.

Model 8573 Programming Example—To send the LLO command from the IBM-PC, type in the following statements:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=CHR$(&H11):CALL IBCMD$(BRD0%,CMD$)
```

After the return key is pressed, the instrument front panel controls will be locked out.

3.9.4 GTL (Go To Local) and Local

The GTL command is used to take the instrument out of the remote mode. With some instruments, GTL may also cancel LLO. With the Model 740, however, REN must first be placed false before LLO will be cancelled.

To send GTL, the controller must perform the following sequence:

1. Set ATN true.
2. Address the instrument to listen.
3. Place the GTL command on the bus.

HP-85 Programming Example—Place the instrument in the remote mode with the following statement:

```
REMOTE 714
```

Now send GTL with the following statement:

```
LOCAL 714
```


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when the END LINE key is pressed, the front panel REMOTE indicator goes off, and the instrument goes into the local mode. To cancel LLO, send the following:

```
LOCAL 7
```

Model 8573 Programming Example—Place the instrument in the remote mode with the following statements:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="X":CALL IBWRT(M740%,CMD$)
```

Now send GTL with the following statement:

```
CALL IBLOC(M740%)
```

After return is pressed, the REMOTE indicator turns off, and the instrument goes into the local mode. To cancel LLO, send the following:

```
V%=0:CALL IBSRE(M740%,V%)
```

3.9.5 DCL (Device Clear)

The DCL command may be used to clear the Model 740 and return it to its power-up default conditions. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously. When the Model 740 receives a DCL command, it will return to the power-up default conditions.

To send the DCL command, the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command byte on the data bus.

HP-85 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the HP-85 keyboard:

```
CLEAR 7
```

When the END LINE key is pressed, the instrument returns to the power-up default conditions.

Model 8573 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the IBM computer:

```
CMD$=CHR$(&H14):CALL IBCMD(BRD0%,CMD$)
```

When the return key is pressed, the instrument returns to the power-up default conditions.

3.9.6 SDC (Selective Device Clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only a single, selected instrument instead of clearing all instruments simultaneously, as is the case with DCL. When the Model 740 receives the SDC command, it will return to the power-up default conditions.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 740 to listen.
3. Place the SDC command on the data bus.

HP-85 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the HP-85 keyboard:

```
CLEAR 740
```

After END LINE is pressed, the instrument returns to the power-up default conditions.

Model 8573 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the IBM computer:

```
CALL IBCLR(M740%)
```

After the return key is pressed, the instrument returns to the power-up default conditions.

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3.9.7 GET (Group Execute Trigger)

GET may be used to trigger the Model 740 to take readings if the instrument is placed in the appropriate trigger mode (more information on trigger modes may be found in paragraph 4.7.5.

To send GET, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 740 to listen.
3. Place the GET command byte on the data bus.

HP-85 Programming Example—Type in the following statements into the HP-85 keyboard to place the instrument in remote and enable the correct trigger mode for this demonstration:

```
REMOTE 714
OUTPUT 714;''T3X''
```

Now send the GET command with the following statement:

```
TRIGGER 714
```

When the END LINE key is pressed, the instrument will process a single reading.

Model 8573 Programming Example—Type in the following statements to make sure the instrument is in the remote and correct trigger modes for purposes of this demonstration:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''T3X'':CALL IBWRT(M740%,CMD$)
```

Now send GET to the instrument with the following statement:

```
CALL IBTRG(M740%)
```

When the return key is pressed, the instrument will process a single reading.

3.9.8 Serial Polling (SPE,SPD)

The serial polling sequence is used to obtain the Model 740 status byte. The status byte contains important information about internal functions, as described in paragraph 4.9.1. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 740.

The serial polling sequence is conducted as follows:

1. The controller sets ATN true.
2. The controller then places the SPE (Serial Poll Enable) command byte on the data bus. At this point, all active devices are in the serial poll mode and waiting to be addressed.
3. The Model 740 is then addressed to talk.
4. The controller sets ATN false.
5. The instrument then places its status byte on the data bus, at which point it is read by the controller.
6. The controller then sets ATN true and places the SPD (Serial Poll Disable) command byte on the data bus to end the serial polling sequence.

Once instruments are in the serial poll mode, steps 3 through 5 above can be repeated by sending the correct talk address for each instrument. ATN must be true when the address is transmitted and false when the status byte is read.

HP-85 Programming Example—The HP-85 SPOLL statement automatically performs the sequence just described. To demonstrate serial polling, type in the following statements into the HP-85:

```
REMOTE 714
S=SPOLL (714)
DISP S
```

When the END LINE key is pressed the second time, the computer conducts the serial polling sequence. The decimal value of the status byte is then displayed on the computer CRT when the END LINE key is pressed the third time. More information on the status byte may be found in paragraph 4.9.1.

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Model 8573 Programming Example—Use the following sequence to serial poll the instrument and display the decimal value of the status byte on the computer CRT:

```
V%=1:CALL IBSRE(BRD0%,V%)
  CALL IBRSP(M740%,SB%)
       PRINT SB%
```

When the return key is pressed the second time, the serial polling sequence is conducted. The status byte value is displayed when the return key is pressed the third time.

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SECTION 4
DEVICE-DEPENDENT COMMAND PROGRAMMING

4.1 INTRODUCTION

This section contains all the information needed to control the Model 740 over the IEEE-488 bus using the device-dependent commands. Background information on the bus, as well as general bus command programming and programming information for using the IBM-PC and HP-85 computers are covered in Section 3 of this manual. Also included in this section is information on the Smart Print mode and miscellaneous information on bus operation, that includes bus errors and data transmission times.

The device-dependent command information in this section is presented in the order that the instrument will most likely be used.

4.2 BUS CONNECTIONS

Instrumentation that is to be controlled over the IEEE-488 bus is connected using cables that are terminated with standard IEEE-488 connectors. The connector is designed to be stacked to allow for parallel connection. Paragraph 3.7.2 contains complete information on bus connections.

NOTE

When Keithley Model 705s or 706 scanners are being used as slave instruments in the temperature measurement system, do not connect them to the IEEE bus. The thermocouple cards in these scanners are controlled by the serial link circuitry of the Model 740.

4.3 PROGRAMMING OVERVIEW

IEEE-488 device-dependent commands (summarized in Table 4-1) are used with the Model 740 to control various operating modes such as function, trigger and data format. Each command is made up of a single ASCII letter followed by a number representing an option of that command. For example, a command to control the measuring function is programmed by sending an ASCII "F" followed by a number representing the function option. The IEEE-488 bus actually treats these commands as data in that ATN is false when the commands are transmitted.

A number of commands may be grouped together in one string. A command string is usually terminated with an ASCII "X" character, which tells the instrument to execute the command string. Commands sent without the execute character will not be executed at that time, but they will be retained within an internal command buffer for execution at the time the X character is received. If any errors occur, the instrument will display appropriate front panel error messages and generate an SRQ if programmed to do so. None of the commands contained in the error string will be executed.

Commands that affect instrument operation will trigger a reading when the command is executed. These bus commands affect the Model 740 much like the front panel controls. Note that commands are not necessarily executed in the order received. Thus to force a particular command sequence, you would follow each command with the execute character (X), as in the example string, P0XF0X, which will turn off the filter and set the instrument to measure the current channel.

Device-dependent commands can be sent either one at a time, or in groups of several commands within a single string. Some examples of valid command strings include:

F0X—Single command string.
F0K1P0X—Multiple command string.
T6 X—Spaces are ignored.

Typical invalid command strings include:

E1X—Invalid command, as E is not one of the instrument commands.
F3X—Invalid command option because 3 is not an option of the F command.

If an illegal command (IDDC), illegal command option (IDDCO), is sent, or if a command string is sent with REN false, the string will be ignored.

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Table 4-1. Device-Dependent Command Summary

Mode	Command	Description	Paragraph
Execute	X	Execute other device-dependent commands.	4.3.1
Type	N0	Set current channel OFF	4.4.1
	N1	Set current channel for Type J	
	N2	Set current channel for Type K	
	N3	Set current channel for Type E	
	N4	Set current channel for Type T	
	N5	Set current channel for Type R	
	N6	Set current channel for Type S	
	N7	Set current channel for Type B	
	N8	Set current channel for Millivolts	
	N9	Same as N0	
	N10	Set all channels OFF	
	N11	Set all channels for Type J	
	N12	Set all channels for Type K	
	N13	Set all channels for Type E	
	N14	Set all channels for Type T	
	N15	Set all channels for Type R	
	N16	Set all channels for Type S	
	N17	Set all channels for Type B	
	N18	Set all channels for Millivolts	
Initialize	I0	Set for 705(s)	4.5.1
	I1	Set for 706	
Channel	Cnn	Close channel nn	4.5.2
	C91	Close internal reference channel	
	C92	Close internal measurement channel	
Scale	O0	Degrees celsius	4.6.1
	O1	Degrees fahrenheit	
Filter	P0	Filter off	4.6.2
	P1	Filter on	
Hi-Limit	H±n	Set Hi-Limit to ±nnnn.n °C or °F	4.6.3
Lo-Limit	L±n	Set Lo-Limit to ±nnnn.n °C Cor °F	4.6.4
Display	D0	Temperature or millivolts	4.7.1
	D1	Time	
Time	Shh.mm	Set time, where hh=hour, mm=minute	4.7.2
Interval	W0	One-Shot	4.7.3
	W1	0.05 second	
	W2	0.1 second	
	W3	0.5 second	
	W4	1 second	
	W5	5 seconds	
	W6	10 seconds	
	W7	30 seconds	
	W8	1 minute	
	W9	5 minutes	
	W10	15 minutes	
	W11	30 minutes	
	W12	1 hour	

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Table 4-1. Device-Dependent Command Summary (Cont.)

Mode	Command	Description	Paragraph
Trigger Time	Qhh.mm	Set time to trigger on clock, where hh=hour, mm=min.	4.7.4
Triggers	T0 T1 T2 T3 T4 T5 T6 T7	Continuous on talk One-shot on talk Continuous on GET One-shot on GET Continuous on X One-shot on X Continuous on External Trigger or Clock One-shot on External Trigger or Clock	4.7.5
Function	F0 F1 F2	Current channel Log enabled Scan enabled	4.7.6
Read Mode	B0 B1 B2	Current channel Log buffer Scan buffer	4.8.1
Recall	Rnn	Recall from buffer channel/location nn	4.8.2
Data Format	G0 G1 G2 G3 G4 G5	Single output w/prefix and w/suffix Single output w/prefix and w/suffix Single output wo/prefix and w/suffix Complete output w/prefix and w/suffix Complete output w/prefix and w/suffix Complete output wo/prefix and w/suffix	4.8.3
SRQ	M0 M1 M2 M4 M8 M16 M32	Clear SRQ mask Reading overflow or open TC Log buffer full or scan complete Temperature reading out of limits Reading done Ready Error	4.9.1
Status	U0 U1 U2 U3 U4 U5 U6 U7 U8 U9 U10 U11 U12 U13 U14 U15 U16 U17 U18 U19 U20 U21	Send machine status word Send error status word Send data status word Send calibration date Send high-limit Send lo-limit Send high reading in log buffer Sedn low reading in log buffer Send average reading in log buffer Send high reading in scan buffer Send low reading in scan buffer Send card 1 status Send card 2 status Send card 3 status Send card 4 status Send card 5 status Send card 6 status Send card 7 status Send card 8 status Send card 9 status Send time and date Send trigger time	4.9.2

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Table 4-1. Device-Dependent Command Summary (Cont.)

Mode	Command	Description	Paragraph
EOI and Bus Hold-off	K0 K1 K2 K3	Enable EOI and bus hold-off on X Disable EOI, enable bus hold-off on X Enable EOI, disable bus hold-off on X Disable both EOI and bus hold-off on X	4.9.3
Terminator	Y0 Y1 Y2 Y3 Y4	CR LF LF CR CR LF None	4.9.4
Self-Test	J0 J1	Clear J byte in U0 status word Perform self-test	4.10.1
Calibration	Vn	First V command calibrates ZERO (n=−0.099 to 0.101) Second V command calibrates GAIN (n=−0.099 to 0.101) Third V command calibrates Reference Junction (n=−10°C/14°F to 70°C/158°F)	4.10.2
Date	Amn.dd Add.mn	American format (mn=month, date=day) European format (dd=day, mn=month)	4.10.3
Date Format	Z0 Z1	American date format (mn.dd) European date format (dd.mn)	4.10.4

Device-dependent commands that control the Model 740 are listed in Table 4-1 These commands are covered in detail in the following paragraphs. The associated programming examples show how to send the commands with both the HP-85 and the IBM-PC/8573.

NOTE

Programming examples assume that the Model 740 is at its factory default IEEE address of 14.

In order to send a device-dependent command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 740 to listen.
3. Set ATN false.
4. Send the command string over the bus one byte at a time.

NOTE

REN must be true when sending device-dependent commands to the instrument, or it will ignore the command and display a bus error message.

General HP-85 Programming Example—Device-dependent commands may be sent from the HP-85 with the following statement:

```
OUTPUT 714;A$
```

A$ in this case contains the ASCII characters representing the command string.

General Model 8573 Programming Example—Use the following general syntax to send device-dependent commands from the IBM-PC:

```
CALL IBWRT(M740%,CMD$)
```

Again, CMD$ contains the command letters to program the instrument. Remember that the modified declaration file (paragragh 3.8.2) must be loaded and run before using any of the programming examples.

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4.3.1 Execute (X)

The execute command (X) will be explained first since X must be used to execute all other device-dependent commands.

The execute command is implemented by sending an ASCII "X" over the bus. Its purpose is to direct the Model 740 to execute other device-dependent commands such as F (function) or N (type). Usually, the execute character is the last byte in the command string (a number of commands may be grouped together into one string); however, there may be certain circumstances where it is desirable to send a command string at one time, and then send the execute character later on. Command strings sent without the execute character will be stored within an internal command buffer for later execution. When the X character is finally transmitted, the stored commands will be executed, assuming that all commands in the previous strings were valid.

HP-85 Programming Example—Enter the following statements into the HP-85 keyboard:

```
REMOTE 714
OUTPUT 714;"X"
```

When the END LINE key is pressed the second time, the X character will be transmitted to the instrument. No mode changes will occur with this example because no other commands were sent. Note that the instrument remains in the listener active state (LISTEN LED on) after the command is transmitted.

Model 8573 Programming Example—Enter the following statements into the IBM computer:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="X":CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the X character is transmitted to the instrument, although no mode changes occur because no other commands are transmitted. Note that the instrument remains in the listener idle state (LISTEN LED off) after the command is transmitted because IBWRT automatically sends UNT (Untalk) and UNL (Unlisten) at the end of the transmission sequence.

4.4 SINGLE (INTERNAL) CHANNEL MEASUREMENTS

The single internal channel is selected whenever there are not any scanner cards connected to the input card of the Model 740. Using the single internal channel to make temperature measurements consists of powering up the instrument and configuring the channel for the desired TC type.

The instrument will power up to display the internal channel. If the internal channel has not been previously set, the "OFF" message will be displayed. The following command is used to configure and measure the internal channel.

4.4.1 Type (N)

NOTE

The following discussion on the Type command (N) includes information for configuring multiple channels. This information will be useful in paragraph 4.5 which explains multiple channel measurements.

Use the N command to configure the current channel, or use to set up all available channels to the same configuration. The commands for configuring available channels are listed as follows:

N0 = Sets current channel to OFF.
N1 = Sets current channel to TYPE J.
N2 = Sets current channel to TYPE K.
N3 = Sets current channel to TYPE E.
N4 = Sets current channel to TYPE T.
N5 = Sets current channel to TYPE R.
N6 = Sets current channel to TYPE S.
N7 = Sets current channel to TYPE B.
N8 = Sets current channel to mV (millivolts).
N9 = Same as N0.
N10 = Sets all channels to OFF.
N11 = Sets all channels to TYPE J.
N12 = Sets all channels to TYPE K.
N13 = Sets all channels to TYPE E.
N14 = Sets all channels to TYPE T.
N15 = Sets all channels to TYPE R.
N16 = Sets all channels to TYPE S.
N17 = Sets all channels to TYPE B.
N18 = Sets all channels to mV (millivolts).

Channel configurations are saved in battery backed-up memory and are changed as soon as an N command is executed. In the event of a "BATTFAIL" (i.e. discharged battery), channel configurations default to OFF.

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Note: If it is desired to make measurements in millivolts (mV) rather than in temperature, send N8 or N18 over the bus.

4.4.2 Programming Examples—Single (Internal) Channel Measurements

The following programming examples show how to configure the internal channel of the instrument and to display the subsequent reading.

Programming Examples—Connect a Type K thermocouple to the internal channel of the Model 740. Make sure that there are not any scanner cards connected to the instrument. To configure the internal channel for Type K thermocouples, enter the following statements into the computer:

HP-85:

```
REMOTE 714
OUTPUT 714;''N2X''
```

When the END LINE key is pressed the second time, the internal channel will be configured for a Type K thermocouple and the temperature reading will be displayed.

Model 8573:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''N2X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the internal channel will be configured for a Type K thermocouple and the temperature measurement will be displayed.

4.5 MULTIPLE CHANNEL MEASUREMENTS

Multiple channel temperature measurements consists of connecting one or more scanner cards to the Model 740 and configuring the desired channels for a TC type. Also, if an external Keithley scanner is to be used in the measurement system, the Model 740 must first be initialized for that type of scanner.

4.5.1 Initialize (I)

The I command is used when thermocouple scanner cards are being used in external Keithley scanners. When this command is sent, the Model 740 will look for the appropriate scanner(s), and recognize and remember the channels that are available to the measurment system. This initialization process also occurs on power-up. The I commands are as follows:

I0 = Initialize the Model 740 to be used with Keithley Model 705 scanners.

I1 = Initialize the Model 740 to be used with a Keithley Model 706 scanner.

Notes:

1. This setting is stored in NVRAM and will not reset upon power-up or when a DCL or SDC command is sent.
2. The I command is similar to front panel Program LOOP with the exception that power does not have to be cycled after sending the command to initialize the instrument.
3. Sending the wrong I command while a scanner is serially connected to the Model 740 will result in the error message "NO LOOP" to be displayed. To remedy the problem, send the appropriate I command. For example, if I1 is sent while a Model 705 is serially connected to the Model 740, the no loop message will be displayed. To correct the problem, send I0 over the bus.

HP-85 Programming Example—Enter the following statements to initialize the Model 740 for use with Keithley Model 705 scanners:

```
REMOTE 714
OUTPUT 714;''I0X''
```

When the END LINE key is pressed the second time, the Model 740 will initialize itself to be used with Model 705 scanners and will then search for the scanner and remember the channels that are available.

Model 8573A Programming Example—Enter the following statements to initialize the Model 740 for use with Keithley Model 705 scanners:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''I0X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the Model 740 will initialize itself to be used with Model 705 scanners and will then search for the scanner and remember the channels that are available.

4.5.2 Channel (C)

Use the channel (C) command to close and display an available channel. Any available measurement channel can be closed to make a measurement (temperature or millivolts) or to change the configuration (as explained in

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the previous paragraph). Any reference channel (91, 11, 21, 31, 41, 51, 61, 71 and 81) can be closed to measure the temperature of the reference junction. The channel commands are as follows:

Cnn = Close channel nn
C91 = Internal reference channel
C92 = Internal measurement channel

Upon power-up, or after the instrument has recieved a DCL or SDC command, the first available channel will be displayed.

Notes:

1. Channel changes over the bus cannot be accomplished while the instrument is in the logging or scanning states and will result with the "CONFLICT" error message being displayed briefly and a STATE ERROR being flagged in the ERROR STATUS WORD (see paragraph 4.9.2).
2. Over the bus, channels that are not part of Model 740 measurement system can be closed. For example, a Model 7058 Low Current Scanner Card may be in a slot position occupying channels 41 through 50 with its output not connected to the Model 740. To close a channel used by the Model 7058, first configure the channel for mV (N8) and then use the appropriate C command. Example command string; send "N8C45" to close channel 45. The channel will close even if the Model 740 displays irrelevant data.

4.5.3 Programming Example—Multiple Channel Measurements

The following programming examples show how to configure two channels of a scanner card and display the subsequent readings on the Model 740. Note that the Type command (N) used in these programs was previously explained in paragraph 4.4.1.

Programming Examples—Install a Model 7057A scanner card into the mainframe of the Model 740. This card makes channels 2 through 10 available for measurements. To configure channel 2 for Type J thermocouples and channel 6 for Type K thermocouples, enter the following statements into the computer:

HP-85:

```
REMOTE 714
OUTPUT 714;''C2N1X''
OUTPUT 714;''C6N2X''
```

When the END LINE key is pressed the second time, the first available channel, which is 2, will be configured for a Type J thermocouple and display the reading at that channel. When the END LINE key is pressed the third time, channel 6 will be selected, configured for a Type K thermocouple and the reading at that channel will be displayed.

Model 8573:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''C2N1X'':CALL IBWRT(M740%,CMD$)
CMD$=''C6N2X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the first available channel, which is 2, will be configured for a Type J thermocouple and display the reading at that channel. When the return key is pressed the third time, channel 6 will be configured for a Type K thermocouple and the reading at that channel will be displayed.

4.6 ADDITIONAL MEASUREMENT COMMANDS

Commands are available to select the alternate thermometric scale (°C or °F), control the filter (on/off), and set high and low limits for temperature readings. These commands are explained in the following paragraphs. (Example programs using these commands can be found in paragraph 4.6.5).

4.6.1 Scale (O)

The scale (O) command is used to select the alternate scale (°C or °F) that temperature measurements are made on. This command affects the display and readings sent over the bus. The scale commands are as follows:

O0 = Celsius
O1 = Fahrenheit

Temperature scale is battery backed-up. Thus, on power-up or after the instrument has recieved a DCL or SDC, the temperature scale will not reset.

HP-85 Programming Example—From the front panel, set the instrument to the °C scale and enter the following statements into the computer to select the °F scale:

```
REMOTE 714
OUTPUT 714;''O1X''
```


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When the END LINE key is pressed the second time, the °F scale will be selected.

Model 8573 Programming Example—From the front panel, set the instrument to the °C scale and enter the following statements into the computer to select the °F thermometric scale:

```
U%=1:CALL IBSRE(BRD0%,U%)
CMD$=''O1X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the °F scale will be selected.

4.6.2 Filter (P)

The filter (P) command is used to enable or disable the filter. The filter commands are as follows:

P0 = Filter disabled
P1 = Filter enabled

Filter status is battery backed-up. Thus, on power-up or after the instrument has recieved a DCL or SDC, the filter status will not reset.

HP-85 Programming Example—From the front panel, disable the filter and enter the following statements into the computer to turn on the filter:

```
REMOTE 714
OUTPUT 714;''P1X''
```

When the END LINE key is pressed the second time, the front panel FILTER indicator light will turn on.

Model 8573 Programming Example—From the front panel, disable the filter and enter the following statements into the computer to enable the filter:

```
U%=1:CALL IBSRE(BRD0%,U%)
CMD$=''P1X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the front panel FILTER indicator light will turn on.

4.6.3 HI-Limit (H)

The HI-limit (H) command is used to flag a temperature reading that has reached or exceeded a programmed value. If the HI-limit is reached or surpassed, the OVER LIMIT flag in the U2 Data Status Word (see paragraph 4.9.2) will be set. An over limit will also cause the instrument to generate a SRQ if it was programmed to do so. See paragraph 4.9.1 for complete information on SRQ. The HI-limit command is in the following form:

H±n=Set HI-limit

where ±nnnn.n is the value in °C or °F as determined by the O command.

Leading zeroes of the value need not be sent. Also if the value is a whole number then the decimal point and zero need not be sent. For example, +50° can be sent as H+50 rather than as H+0050.0.

On power-up or after the instrument has recieved a DCL or SDC, the HI-limit will reset to 2000°C.

Notes:

1. Sending the H command resets the OVER LIMIT flag in the U2 Data Status Word.
2. Channels configured to make millivolt measurements will not be affected by the H command.
3. Sending an H value that is outside the range of ±2000°C (±4000°F), will cause an IDDCO bus error. Paragraph 4.11.1 provides information on bus errors.

HP-85 Programming Example—With the °C scale selected, enter the following statements into the computer to set a HI-limit of +300.5°C:

```
REMOTE 714
OUTPUT 714;''H+300.5X''
```

When the END LINE key is pressed the second time, a HI-limit of +300.5°C will be established.

Model 8573 Programming Example—With the °C scale selected, enter the following statements into the computer to set a HI-limit of +300.5°C:

```
U%=1:CALL IBSRE(BRD0%,U%)
CMD$=''H+300.5X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, a HI-limit of +300.5°C will be established.

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4.6.4 LO-Limit (L)

The LO-limit (L) command is used to flag a temperature reading that has equaled or fallen below a programmed value. If the LO-limit is reached or surpassed, the UNDER LIMIT flag in the U2 Data Status Word will be set (see paragraph 4.9.2). An under limit will also cause the instrument to generate a SRQ if it was programmed to do so. See paragraph 4.9.1 for information on SRQ. The LO-limit command is in the following form:

L±n = Set LO-limit

where ±nnnn.n is the value in °C or °F

Leading zeroes of the value need not be sent. Also, if the value is a whole number, then the decimal point and zero need not be sent. For example, +50° can be sent as L+50 rather than as L+0050.0.

On power-up or after the instrument has recieved a DCL or SDC, the LO-limit will reset to −2000°C.

Notes:

1. Sending the L command resets the UNDER LIMIT flag in the U2 Data Status word.
2. Channels configured to make millivolt measurements will not be affected by the L command.
3. Sending a L value that is outside the range of ±2000°C (±4000°F), will cause an IDDCO bus error. Paragraph 4.11.1 provides information on bus errors.

HP-85 Programming Example—With the °C scale selected, enter the following statements into the computer to set a LO-limit of +4°C:

```
REMOTE 714
OUTPUT 714;''L+4X''
```

When the END LINE key is pressed the second time, a LO-limit of +4°C will be established.

Model 8573 Programming Example—With the °C scale selected, enter the following statements into the computer:

```
U%=1:CALL IBSRE(BRD0%,U%)
CMD$=''L+4X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, a LO-limit of +4°C will be established.

4.6.5 Programming Examples—Additional Measurement Commands

The following programs use the output (O), filter (P) and limit (H and L) commands for demonstration purposes.

Programming Examples—To select the °F scale, turn the filter on, set the HI-limit to +500°F and set the LO-limit to +50°F, enter the following statements into the computer:

HP-85:

```
REMOTE 714
OUTPUT 714;''O1P1X''
OUTPUT 714;''H+500L+50X''
```

When the END LINE key is pressed the second time, the ±F scale will be selected and the filter will enable. When the END LINE is pressed the third time, the high and low limits are set to +500°F and +50°F respectively.

Model 8573:

```
U%=1:CALL IBSRE(BRD0%,U%)
CMD$=''O1P1X'':CALL IBWRT(M740%,CMD$)
CMD$=''H+500L+50X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the °F scale will be selected and the filter will enable. When the return key is pressed the third time, the high and low limits are set to +500°F and +50°F respectively.

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4.7 LOGGING AND SCANNING

The device-dependent commands explained in this section are associated with the logging and scanning capabilities of the Model 740. Also include in this section are example programs that log readings and scan channels. The basic procedure to log readings or scan available channels is as follows:

1. Select an appropriate interval (W).
2. Set a trigger time (Q) if it is desired to start the log or scan process at a particular time of day.
3. Select the appropriate trigger (T).
4. Place the instrument in the Log Enable (F1) or Scan Enable (F2).

The log or scan will start when a valid trigger occurs. It is important to note that recalling buffer readings must be done over the bus, as explained in paragraph 4-8. When in remote, recalled readings are not displayed by the instrument.

NOTE

The Display (D) and Time (S) commands are discussed first, since the internal clock must be set to the correct time in order to set a trigger time to start a log or scan.

4.7.1 Display (D)

The display (D) command is used to control what the instrument is displaying. The Model 740 can either display measurements (temperature or millivolts) or the time of day. Checking for the correct time of day is especially important if a scan or log is to be triggered by the clock (see paragraph 4.7.2). The display commands are as follows:

D0 = Display temperature or millivolt reading of current channel.
D1 = Display time of day in 24 hour clock format.

When in the D0, the type of reading (temperature or millivolts) depends on the configuration (Type) of the current channel. See paragragh 4.4.1 for information on the N (Type) command.

The 24 hour clock (D1) is battery backed-up, but will only last about a week if the instrument is not powered back-up to recharge the battery.

Upon power-up or after the instrument receives a DCL or SDC command, the display will be in measurement (D0).

HP-85 Programming Example—Enter the following statements into the computer to display the 24 hour clock:

```
REMOTE 714
OUTPUT 714;''D1X''
```

At this point the current time on the 24 hour clock will be displayed. Enter the following statement to return the display to the measurement mode:

```
OUTPUT 714;''D0X''
```

When the END LINE key is pressed, the display will return to the previous measurement mode.

Model 8573 Programming Example—Enter the following statements into the computer to display the 24 hour clock:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''D1X'':CALL IBWRT(M740%,CMD$)
```

At this point the current time of the 24 hour clock will be displayed. Enter the following statement to return the display to the measurement mode:

```
CMD$=''D0X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed, the display will return to the previous measurement mode.

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4.7.2 Time (S)

The time (S) command is used to set the 24 hour clock to the correct time. Correct time is essential if logging and scanning processes are to be started by clock trigger. The time command is in the following form:

Shh.mm = Set 24 hour clock
hh = hour (0-23), mm = minute (0-59)

Notes:

1. The 24 hour clock will continue to maintain the correct time after the instrument is turned off. The battery back-up will last approximately one week while the instrument is off and will recharge when the instrument is turned back on.
2. Sending the S command while the instrument is in the logging or scanning process will cause the "CONFLICT" error message to be displayed briefly and the STATE ERROR flag in the ERROR STATUS WORD to be set (see paragraph 4.9.2).

HP-85 programming Example—Enter the following statements into the computer to set the clock for the correct time:

```
REMOTE 714
OUTPUT 714;''D1X''
OUTPUT 714;''Shh.mmX''
```

When the END LINE key is pressed the second time, the current clock will be displayed. The thrid statement will set the clock to the correct time.

Model 8573 Programming Example—Enter the following statements into the computer to set the clock for the correct time:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''D1X'':CALL IBWRT(M740%,CMD$)
CMD$=''Shh.mmX'':CALL IBWRT(M740%,CMD$)
```

When the END LINE key is pressed the second time, the current clock time will be displayed. The third statement will set the clock to the correct time.

4.7.3 Interval (W)

The interval (W) command is used to control the rate that readings are logged into the log buffer or to control the rate that scans occur. The interval commands are as follows:

W0 = One-shot
W1 = 0.05 second
W2 = 0.1 second
W3 = 0.5 second
W4 = 1 second
W5 = 5 seconds
W6 = 10 seconds
W7 = 30 seconds
W8 = 1 minute
W9 = 5 minutes
W10 = 15 minutes
W11 = 30 minutes
W12 = 1 hour

When logging with W0 (one-shot) asserted, one reading will be logged each time a trigger occurs. When scanning with W0, a single scan will occur each time a trigger occurs. W0 need not be asserted if scanning is to be done with the instrument in a one-shot trigger mode (T1, T3, T5 or T7).

Notes:

1. Sending the W command while the instrument is in the logging or scanning process will cause the "CONFLICT" error message to be displayed briefly and the STATE ERROR flag in the ERROR STATUS WORD to be set (see paragraph 4.9.2).
2. If the scanning interval is set faster than the hardware, then the scanning rate will only be as fast as the hardware. For example, it takes one second to scan 20 channels with the filter off. Thus, the scan rate will be one second even with W1, W2 or W3 asserted.

Interval is battery backed-up. Thus, upon power-up or after the instrument recieves a DCL or SDC, the interval will not reset.

HP-85 Programming Example—Enter the following statements into the computer to set an interval rate of one minute:

```
REMOTE 714
OUTPUT 714;''W8X''
```


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When the END LINE key is pressed the second time, the instrument will be set to an interval rate of one minute.

Model 8573 Programming Example—Enter the following statements into the computer to set an interval rate of one minute:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="W8X":CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the interval rate will be set to one minute.

4.7.4 Trigger Time (Q)

The trigger time (Q) command is used to program the time of day that a trigger occurs. This trigger can be used to start the scanning or logging process, or trigger a reading while the instrument is in the normal measurement mode (Data Store inactive). The instrument must be in trigger T6 or T7 in order to produce the trigger (see paragraph 4.7.5). The trigger time command is in the following form:

Qhh:mm = Set trigger time
hh = hour (0 - 24), mm = minute (0 - 59)

Notes:

1. Programming a trigger hour of 24 disables the trigger time feature. The trigger time minute is irrelevent in this case.
2. After a trigger time passes, the trigger time resets to 24:00 (disabled).
3. Sending a trigger time exceeding 24:59 will result in a IDDCO bus error (see paragraph 4.11.1).

Upon power-up or after the instrument recieves a DCL or SDC, the trigger time will be set to 24:00 (disabled).

HP-85 Programming Example—Enter the following statements into the computer to set a trigger time of 1:15 PM:

```
REMOTE 714
OUTPUT 714;"Q13.15X"
```

When the END LINE key is pressed the second time, a trigger time of 1:15 PM will be set.

Model 8573 Programming Example—Enter the following statements into the computer to set a trigger time of 1:15 PM:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="Q13.15X":CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, a trigger time of 1:15 PM will be set.

4.7.5 Triggers (T)

When the instrument is in the current channel measurement (F0), triggering provides a stimulus to begin a reading conversion within the instrument. When the instrument is in log (F1) or scan (F2) a trigger will start the logging or scanning process. Triggering may be done in two basic ways:

1. In continuous mode, a single trigger command is used to start a continuous series of readings. When in log, a trigger will start the logging process at the programmed interval (W). Readings will continue to be logged, by overwriting, after the 100 point buffer fills. When in scan, a trigger will start the scanning process and the instrument will perform a scan at each programmed interval.
2. In a one-shot trigger, a separate trigger stimulus is required to start each conversion. When in log, a trigger will start the logging process at the programmed interval (W). The logging process will stop when the 100 point buffer fills. When in scan, a trigger will start the scanning process and stop after the one scan is completed. The programmed interval is irrelevent in this case.

The Model 740 has eight trigger commands as follows:

T0 = Continuous on Talk
T1 = One-shot on Talk
T2 = Continuous on GET
T3 = One-shot on GET
T4 = Continuous on X
T5 = One-shot on X
T6 = Continuous on External Trigger or Clock
T7 = One-shot on External Trigger or Clock

The trigger modes are paired according to the type of stimulus that is used to trigger the instrument. In T0 and T1, triggering is performed by addressing the Model 740 to talk. In T2 and T3, the IEEE-488 multiline GET command performs the trigger function. The instrument execute (X) character provides the trigger stimulus in T4 and T5. In T6 and T7, the trigger stimulus is performed by an external trigger (see paragraph 2.12) or by a programmed trigger time (see paragraph 4.7.4).

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Upon power-up or after the instrument receives a DCL or SDC command, the Model 740 will return to T6 trigger.

NOTE

The following example programs entail triggering readings with the instrument in the current channel measurement state (F0). Programs that trigger the log and scan processes can be found in paragraphs 4.7.7 and 4.7.8.

HP-85 Programming Example—Place the instrument in the one-shot on X trigger mode with the following statements:

```
REMOTE 714
OUTPUT 714;''T5X''
```

When the END LINE key is pressed the second time, the X in the command string will trigger one reading.

Model 8573 Programming Example—Place the instrument in the one-shot on X trigger mode with the following statements:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''T5X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the X in the command string will trigger one reading.

4.7.6 Function (F)

The function (F) command is used to select the operating mode of the instrument. The three functions are as follows:

F0 = Current channel measurements
F1 = Log enabled
F2 = Scan enabled

In F0, the instrument measures the current channel that the instrument is on.

In F1, the instrument is placed in log enable. The logging process will not start until a valid trigger is received. In the pre-trigger state, the instrument will make continuous readings on the current channel.

In F2, the instrument is placed in scan enable. The scan process will not start until a valid trigger is received. In the pre-trigger state, the instrument will make continuous readings on the current channel.

Note:

Executing the function command (F) stops the current operation of the instrument and places it in a pre-triggered state for that function. For example, sending F0 while the instrument is in log (F1), will place the instrument in the F0 function (current channel), but measurements will not commence until another valid trigger is received.

Upon power-up or after the instrument receives a DCL or SDC, F0 will be selected.

HP-85 Programming Example—To place the instrument in log enabled, enter the following statements into the computer:

```
REMOTE 714
OUTPUT 714;''F1X''
```

When the END LINE key is pressed the second time, log enable will be selected.

Model 8573 Programming Example—To place the instrument in log enable, enter the following statements into the computer:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''F1X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, log enable will be selected.

4.7.7 Programming Examples—Logging Readings

The following programs will do a single log of a selected channel. The logging process will be triggered by X (T5).

Programming Examples—Select the channel that is to be logged and enter the following statements to perform a single log at an interval of 0.1 second:

HP-85:

```
REMOTE 714
OUTPUT 714;''W2T5F1X''
```


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When the END LINE key is pressed the second time, the 0.1 second interval and log enable will be selected. The logging process will start after the X command is executed. The logging process will stop when the buffer fills.

Model 8573:

```
V%=:CALL IBSRE(BRD0%,V%)
CMD$="W2T5F1X":CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the 0.1 second interval and log enabled, will be selected. The logging process will start after the X command is executed. The logging process will stop when the buffer fills.

4.7.8 Programming Examples—Scanning Channels

The following programs will do a single scan of the available channels. The scanning process will be triggered by X (T5).

Programming Examples—Enter the following statements into the computer to perform a single scan:

HP-85:

```
REMOTE 714
OUTPUT 714;"T5F2X"
```

When the END LINE key is pressed the second time, a single scan of all available channels will be triggered by X at the end of the command string. Note that an interval (W) did not have to be selected since a one-shot trigger mode was used.

Model 8573:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="T5F2X":CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, a single scan of all available channels will be triggered by X at the end of the command string. Note that an interval (W) did not have to be selected since a one-shot trigger mode was used.

4.8 SENDING READINGS OVER BUS

The basic procedure to send readings over the bus is as follows:

1. Select the source of the data to be sent over the bus using the B command.
2. If desired, select a starting buffer location or channel using R command.
3. Select the format that data is to be sent using the G command.
4. Address the Model 740 to talk.

NOTE

The instrument cannot talk (send readings) when on an "OFF" channel. Trying to do so will lock up the bus. In this event, cycle power on the Model 740.

The following paragraphs explain the device-dependent commands that are associated with sending current channel measurements, and readings from the log or scan buffer over the IEEE-488 bus. Also included are programming examples that send buffer readings over the bus.

4.8.1 Read (B)

The read (B) command parameters allow the selection of the source of data that is transmitted over the IEEE-488 bus. Through this command, the user has a choice of data from the current channel, log buffer or scan buffer. The read commands are as follows:

B0 = Readings from current channel
B1 = Readings from log buffer
B2 = Readings from scan buffer

When in B0, readings sent over the bus will reflect the current channel. When B1 is sent, the buffer pointer will initialize to log buffer location 00. After the logged reading is sent, the buffer pointer will increment to the next location. Each reading will increment the buffer pointer until the last location (99) is reached, after which the buffer pointer will remain at 99. When B2 is sent, the buffer pointer will initialize to the lowest available channel. Reference channels are available, but channels configured to be OFF are not. After the reading from the scan buffer is sent, the buffer pointer will increment to the next available channel. Each reading will increment the buffer pointer until the highest available channel is reached, after which the buffer pointer will again point to the lowest available channel.

Notes:

1. The buffer pointer is always reset to the beginning of the respective buffer when a B1 or B2 command is sent.

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2. Further manipulation of the buffer pointer is accomplished with the R command which is explained in paragragh 4.8.2.

Upon power-up or after the instrument receives a DCL or SDC command, current channel read (B0) will be selected.

HP-85 Programming Example—Enter the following statements into the computer to place the instrument in the current channel read mode and send a reading over the bus.

```
REMOTE 714
DIM A$[40]
OUTPUT 714;"B0X"
ENTER 714;A$
DISP A$
```

After the END LINE key is pressed the third time, the instrument will be placed in the current channel read mode. When END LINE is pressed the fourth time, the Model 740 will be addressed to talk and will send one reading over the bus. The last program line will display the reading on the computer CRT.

Model 8573 Programming Example—Enter the following statements into the computer to place the instrument in the current channel read mode and send one reading over the bus:

```
V%=:CALL IBSRE(BRD0%,V%)
CMD$="B0X":CALL IBWRT(M740%,CMD$)
RD$=SPACE$(40):CALL IBRD(M740%,RD$)
PRINT RD$
```

After the return key is pressed the second time, the instrument will be placed in the current channel read mode. When return is pressed the third time, the Model 740 will be addressed to talk and will send one reading over the bus. The last program line will display the reading on the computer CRT.

4.8.2 Recall (R)

The recall (R) command is used to point to a starting location or channel in the buffers and is only valid when used with the B1 and B2 read commands. After the reading at that location or channel is sent, the buffer pointer increments to the next location or channel. After the reading in the last location (99) or channel is sent, the buffer pointer will point to location 99 or the lowest buffer channel. The recall command is in the following form:

Rnn = Channel number or memory location number

Note: The R command is not required when used with the G3, G4 or G5 commands (see paragraph 4.8.3).

Upon power-up or after the instrument receives a DCL or SDC command, R will be set to location 00 or the lowest available channel.

HP-85 Programming Example—From the front panel or over the bus, fill up the log buffer. Enter the following statements into the computer to send the reading from memory location 36 over the bus:

```
REMOTE 714
DIM A$[40]
OUTPUT 714;"B1R36X"
ENTER 714;A$
DISP A$
```

When the END LINE key is pressed the third time the log buffer read mode will be selected and the buffer pointer will point at memory location 36. When END LINE is pressed the fourth time, the Model 740 will be addressed to talk and send the reading from memory location 36 over the bus. The last line will display the reading on the computer CRT.

Model 8573 Programming Example—From the front panel or over the bus, fill the log buffer. Enter the following statements into the computer to send the reading from memory location 36 over the bus:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="B1R36X":CALL IBWRT(M740%,CMD$)
RD$=SPACE$(40):CALL IBRD(M740%,RD$)
PRINT RD$
```

When the return key is pressed the second time, the log buffer read mode will be selected and the buffer pointer will point to memory location 36. When return is pressed the third time, the Model 740 will be addressed to talk and will send the reading from location 36 over the bus. The last line will display the reading on the computer CRT.

4.8.3 Data Format (G)

Through the use of the G command, the format of the data the instrument sends over the bus may be controlled as follows:

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G0 = Send single reading with prefix and with suffix.

Examples:
DEGC01000.0E+0,CH02,23:59:59 (Current channel reading - B0)
DEGC01000.0E+0,BL00,23:59:59 (Log buffer reading - B1)
DEGC01000.0E+0,BC01,23:59:59 (Channel buffer reading - B2)

G1 = Send single reading with prefix and without suffix.

Example:
DEGC01000.0E+0 (B0, B1 and B2)

G2 = Send single reading without prefix and without suffix.

Example:
01000.0E+0 (B0, B1 and B2)

G3 = Send complete readings with prefix and with suffix.

Examples:
DEGC01000.0E+0,CH02,23:59:59 (B0)
DEGC01000.0E+0,BL00,23:59:50,DEGC01200.0E+0,BL01, 23:59:51, ... (B1)
DEGC01000.0E+0,BC01,23:59:59, DEGC01200.0E+0,BC02, 23:59:59, ... (B2)

G4 = Send complete readings with prefix and without suffix.

Example:
DEGC01000.0E+0 (B0)
DEGC01000.0E+0, DEGC01200.0E+0, ... (B1 and B2)

G5 = Send complete readings without prefix and without suffix.

Examples:
01000.0E+0 (B0)
01000.0E+0, 01200.0E+0, ... (B1 and B2)

Figure 4-1 further clarifies the general data format. Note that the prefix defines the reading type (temperature or millivolts), and the suffix identifies the source of the reading and lists the time that the reading was taken. Also, note that only one reading is sent in G3, G4 and G5 when readings are from the current channel (B0).

Upon power-up or after the instrument receives a DCL or SDC command, the G0 format will be selected.

4.8.4 Programming Examples—Sending Current Channel Readings Over Bus

The following programs will send three current channel readings (B0) over the bus in the three available data formats.

HP-85 Programming Example—Place the instrument in the current channel measurement mode and enter the following program into the computer to send three readings over the bus:

PROGRAM	COMMENTS
`10 DIM A$[40]`	
`20 REMOTE 714`	Send remote enable.
`30 OUTPUT 714;"B0G0X"`	Send B0 and G0 command.
`40 ENTER 714;A$`	Obtain reading from 740.
`50 DISP A$`	Display current channel reading.
`60 OUTPUT 714;"G1X"`	Send G1 command.
`70 ENTER 714;A$`	Obtain reading from 740.
`80 DISP A$`	Display reading.
`90 OUTPUT 714;"G2X"`	Send G2 command.
`100 ENTER 714;A$`	Obtain reading from 740.
`110 DISP A$`	Display reading.
`120 END`	

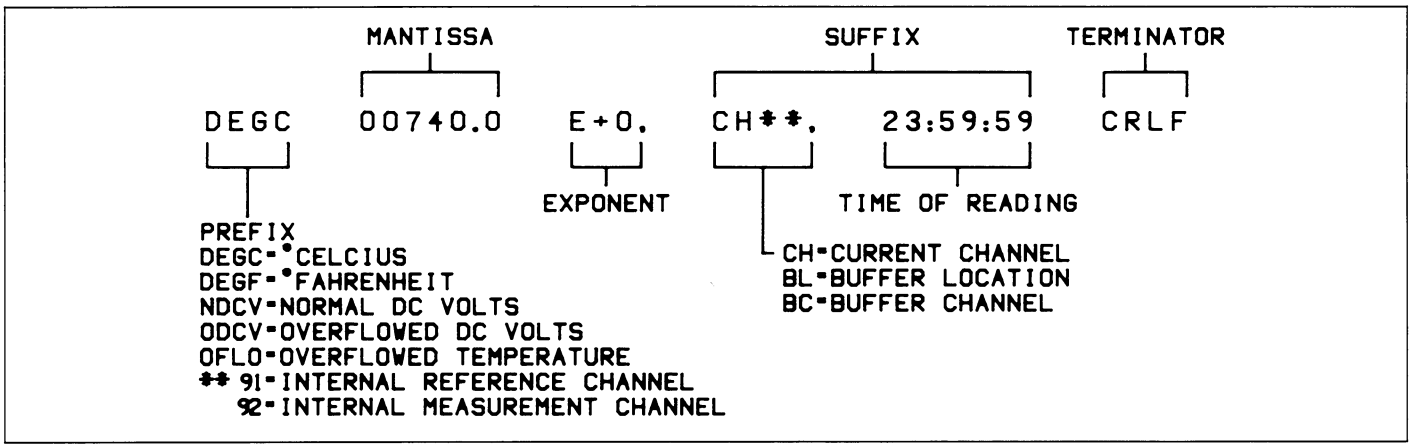


Figure 4-1. General Data Format

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After entering the program, run it by pressing the RUN key. The program will place the unit in remote (line 20), send the B0 and G0 commands (line 30), and then obtain and display the current channel reading (lines 40 and 50). The G1 command is then sent (line 60) and the reading is then obtained and displayed (lines 70 and 80). Lastly, the G2 command is sent (line 90), and the reading is obtained and displayed on the computer CRT (lines 100 and 110).

Model 8573 Programming Example—To send three current channel readings over the bus: load the modified DECL.BAS file from disk (see the Model 8573 Instruction Manual) and add the lines from the program below:

PROGRAM	COMMENTS
`10 NA$="GPIB0":CALL IBFIND (NA$,BRD0%)`	Find the board descriptor.
`20 NA$="DEV1":CALL IBFIND (NA$,M740%)`	Find the instrument descriptor.
`30 V%=14:CALL IBPAD(M740%,V%)`	Set primary address to 14.
`40 V%=1:CALL IBSRE(BRD0%,V%)`	Send remote enable.
`50 CMD$="B0G0X":CALL IBWRT (M740%,CMD$)`	Send B0 and G0 command
`60 RD$=SPACE$(40):CALL IBRD (M740%,RD$)`	Get current channel reading from 740.
`70 PRINT RD$`	Display reading on CRT.
`80 CMD$="G1X":CALL IBWRT (M740%,CMD$)`	Send G1 command.
`90 RD$=SPACE$(40):CALL IBRD (M740%,RD$)`	Get current reading from 740.
`100 PRINT RD$`	Display reading on CRT.
`110 CMD$="G2X":CALL IBWRT (M740%,CMD$)`	Send G2 command.
`120 RD$=SPACE$(40):CALL IBRD (M740%,RD$)`	Get reading from 740.
`130 PRINT RD$`	Display reading on CRT.
`140 V%=0:CALL IBONL (BRD0%,V%)`	Close the board file.
`150 CALL IBONL (M740%,V%)`	Close the instrument file.

Press the F2 key to run the program. Line 40 will place the instrument in remote. Lines 50, 60 and 70 send the B0 and G0 commands, obtain the first reading and display it on the computer CRT. Lines 80, 90 and 100 send the G1 command, obtain the second reading and display it on CRT. Lines 110, 120 and 130 send the G2 command, obtain the third reading and display it on the CRT.

4.8.5 Programming Examples—Sending Readings From Log Buffer Over Bus

The following programs demonstrate sending readings from the log buffer over the bus to the computer.

HP-85 Programming Example—Enter the following program in the computer to first display the last logged reading in the buffer and then display all 100 log buffer readings:

PROGRAM	COMMENTS
`10 DIM A$[4000]`	
`20 REMOTE 714`	Send remote enable.
`25 CLEAR 714`	
`30 OUTPUT 714;"W1T3F1X"`	Set LOG ENABLE.
`35 TRIGGER 714`	Start log.
`40 S=SPOLL(714)`	Serial poll the 740.
`50 IF NOT BIT(S,1) THEN 40`	If buffer not full, wait.
`60 OUTPUT 714; "B1R99G0X"`	Send B1, R99 and G0 commands.
`70 ENTER 714;A$`	Get reading from location 99.
`80 DISP A$`	Display reading from buffer.
`90 OUTPUT 714;"G3X"`	Send G3 command.
`100 ENTER 714;A$`	Get all readings from buffer.
`110 DISP A$`	Display all readings from buffer.
`120 END`	

Run the program by pressing the RUN key. Line 20 will place the instrument in remote. Lines 30 and 35 will place the instrument in the log enable function, select the 0.1 second interval and start the logging process. Lines 40 and 50 will keep serial polling the instrument until the buffer fills. Lines 60, 70 and 80 will obtain the last logged reading in the buffer and display it on the computer CRT. Lines 90, 100 and 110 will obtain all 100 readings from the buffer and display them on the CRT.

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Model 8573 Programming Example—The following program will send and display the last stored reading in the log buffer and then display all 100 log buffer readings. Load the modified DECL.BAS file from disk (see the Model 8573 Instruction Manual) and add the lines from the program below:

PROGRAM	COMMENTS
`10 NA$=''GPIB0'':CALL IBFIND (NA$,BRD0%)`	Find the board descriptor.
`20 NA$=''DEV1'':CALL IBFIND (NA$,M740%)`	Find the instrument descriptor.
`30 V%=14:CALL IBPAD (M740%,V%)`	Set primary address to 14.
`40 V%=1:CALL IBSRE(BRD0%,V%)`	Send remote enable.
`45 CALL IBCLR(M740%)`	
`50 CMD$=''W1T3F1X'':CALL IBWRT (M740%,CMD$)`	Set LOG ENABLE.
`55 CALL IBTRG(M740%)`	Start log.
`60 CALL IBRSP(M740%,SB%)`	Serial poll the 740.
`70 IF (SB% AND 2) = 0 THEN 60`	If buffer not full wait.
`80 CMD$=''B1G0X'':CALL IBWRT (M740%,CMD$)`	Send B1, and G0 commands.
`90 FOR I = 1 TO 100`	Loop 100 times.
`100 RD$=SPACE$(40):CALL IBRD (M740%,RD$)`	Get a buffer reading.
`110 PRINT RD$`	Display reading.
`120 NEXT I`	Go back and get another reading.
`130 V%=0:CALL IBONL(BRD0%,V%)`	Close the board file.
`140 CALL IBONL(M740%,V%)`	Close the instrument file.

Press the F2 key to run the program. Lines 50 and 55 will place the instrument in the log enable mode, select the 0.1 second interval and start the log process. Lines 60 and 70 will keep serial polling the instrument until the buffer fills. Lines 80 through 120 will then request and display all 100 readings from the buffer. The first reading displayed will be from memory location 99, which is the last stored reading. The rest of the readings will start with location 00 and increment to location 98.

4.8.6 Programming Examples—Sending Readings From Scan Buffer Over Bus

The following programs demonstrate how to send readings from the scan buffer over the bus to the computer.

HP-85 Programming Example—Connect a Model 7057A Thermocouple Scanner Card to the Model 740 so that there are 10 channels available. Enter the following program into the computer to send the 10 scanned channel readings from the scan buffer to the computer:

PROGRAM	COMMENTS
`10 DIM A$[400]`	
`20 REMOTE 714`	Send remote enable.
`25 CLEAR 714`	
`30 OUTPUT 714;''T3F2X''`	Set SCAN ENABLE
`35 TRIGGER 714`	Perform single scan.
`40 S=SPOLL (714)`	Serial poll the 740.
`50 IF NOT BIT(S,1) THEN 40`	If buffer not full, wait.
`60 OUTPUT 714;''B2G3X''`	Send B2 and G3 commands.
`70 ENTER 714;A$`	Obtain readings from buffer.
`80 DISP A$`	Display readings.
`90 END`	

Run the program by pressing the RUN key. Lines 30 and 35 will select scan enable and perform a single scan of the 10 available channels. Lines 40 and 50 will keep serial polling the instrument until the scan buffer fills. Lines 60, 70 and 80 will obtain all ten readings from the scan buffer and display them on the CRT.

Model 8573 Programming Example—Connect a Model 7057A Thermocouple Scanner Card to the Model 740 so that there are 10 channels available. The following program will send the 10 scanned channel readings from the scan buffer to the computer. Load the modified DECL.BAS file from disk (see the Model 8573 Instruction Manual) and add the lines from the program below:

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PROGRAM	COMMENTS
`10 NA$="GPIB0":CALL IBFIND (NA$,BRD0%)`	Find the board descriptor.
`20 NA$="DEV1":CALL IBFIND (NA$,M740%)`	Find the instrument descriptor.
`30 V%=14:CALL IBPAD (M740%,V%)`	Set primary address to 14.
`40 V%=1:CALL IBSRE(BRD0%,V%)`	Send remote enable.
`45 CALL IBCLR(M740%)`	
`50 CMD$="T3F2X":CALL IBWRT (M740%,CMD$)`	Set SCAN ENABLE.
`55 CALL IBTRG(M740%)`	Perform single scan.
`60 CALL IBRSP(M740%,SB%)`	Serial poll the 740.
`70 IF (SB% AND 2) = 0 THEN 60`	If buffer not full, wait.
`80 CMD$="B2G5X":CALL IBWRT (M740%,CMD$)`	Send B2 and G5 commands.
`90 RD$=SPACE$(200):CALL IBRD (M740%,RD$)`	Obtain readings from buffer.
`100 PRINT RD$`	Display readings.
`110 V%=0:CALL IBONL(BRD0%,V%)`	
`120 CALL IBONL(M740%,V%)`	

Press the F2 key to run the program. Lines 50 and 55 will select scan enable and perform a single scan of the 10 available channels. Lines 60 and 70 will keep serial polling the instrument until the scan buffer fills. Lines 80, 90 and 100 will obtain all ten readings from the scan buffer and display them on the computer CRT.

4.9 MISCELLANEOUS BUS COMMANDS

The following paragraphs explain the miscellaneous device-dependent commands that are used to operate the instrument over the bus. The commands include: SRQ (M), Status (U), EOI and Bus Hold-Off (K) and Terminator (Y).

4.9.1 SRQ Mask (M) and Serial Poll Byte Format

The SRQ command controls which of a number of conditions within the Model 740 will cause the instrument to request service from the conroller by asserting SRQ. Once a SRQ is generated, the serial poll byte can be checked to determine if the Model 740 was the instrument that asserted SRQ, and if so, what conditions can be checked by using the U1 and U2 commands, as described in paragraph 4.9.2.

The Model 740 can be programmed to generate SRQ under one or more of the following conditions:

1. If a reading overflow or open TC occurs.
2. When the log buffer is full or a scan is complete.
3. When a temperature reading is out of limits.
4. When a reading is done.
5. When the instrument is ready to accept bus commands.
6. When an error condition occurs.

Upon power-up or after a DCL or SDC command is received, SRQ is disabled.

SRQ Mask—The Model 740 uses an internal mask to determine which conditions will cause SRQ to be generated. Figure 4-2 shows the general format of this mask, which is made up of eight bits. The SRQ has the same general format as the status byte (described below) except that bits 6 and 7 are not used in the SRQ mask.

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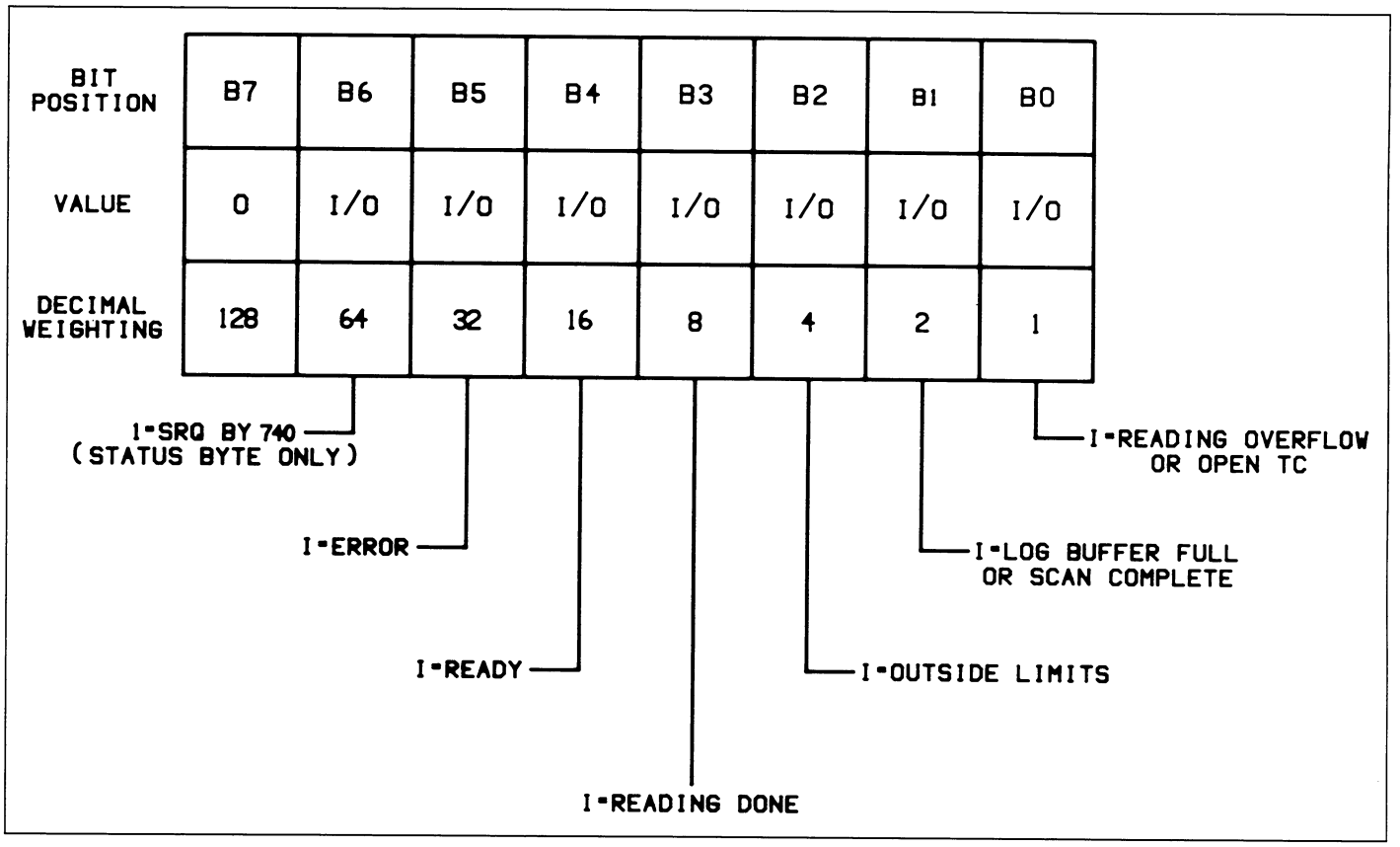


Figure 4-2. SRQ Mask and Status Byte Format

SRQ can be programmed by sending the ASCII letter "M" followed by a decimal number to set the appropriate bit in the SRQ mask. Decimal values for the various bits are summarized as follows:

M0 = Clear SRQ mask
M1 = Reading overflow or open TC
M2 = Log buffer full or scan complete
M4 = Temperature out of limits
M8 = Reading done
M16 = Ready
M32 = Error

Note that the instrument may be programmed for more than one set of conditions simultaneously. To do so, simply add up the decimal bit values for the required SRQ conditions. For example, to enable SRQ under reading overflow and buffer full conditions, send M3X. To disable SRQ, send M0X.

This command will clear all bits in the SRQ mask.

Serial Poll Byte Format—The serial poll byte contains information relating to data and error conditions within the instrument. The general format of the status byte (which is obtained by using the serial polling sequence, as described in paragraph 3.9.8) is shown in Figure 4-2. Note that the various bits correspond to the bits in the SRQ mask as described above.

The bits in the serial poll byte have the following meanings:

Bit 0 (Reading Overflow or Open TC)—Set when an input is beyond the limit (overflow) of the thermocouple or the thermocouple is not connected or is physically open. Also set when a mV reading is outside of the allowable limits.

Bit 1 (Buffer Full or Scan Complete)—Set when the log buffer is full or a scan is complete. A scan complete is the same as a full scan buffer. The buffer in question is determined by the current function (F).

Bit 2 (Outside Limits)—Set when a reading is outside the limits defined by the HI-limit (H) and LO-limit (L) commands. The limit exceeded can be determined by reading the U2 Data Status Word.

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Bit 3 (Reading Done)—Set when the instrument has completed the present reading conversion.

Bit 4 (Ready)—Set when the insrument has processed all previously received commands and is ready to accept additional commands or a trigger.

Bit 5 (Error)—Set when one of the following errors have occurred:

1. An illegal device dependent command (IDDC) or an illegal device dependent command option (IDDCO) was transmitted.
2. The instrument was programmed when not in remote.
3. A trigger overrun has occurred.
4. A broken loop error has occurred.
5. A state error has occurred.

The nature of the error can be determined with the U1 command. The U1 command explanation and more information on the associated errors are covered in paragraph 4.9.2.

Bit 6 (SRQ)—Provides a means to determine if SRQ was asserted by the Model 740. If this bit is set, service was requested by the instrument.

Bit 7—Not used and always set to zero.

Note that the status byte should be read to clear the SRQ line once the instrument has generated a SRQ. The bit that corresponds to the condition that caused the SRQ, and the SRQ bit, will be latched when the SRQ is generated. Bit 6 (SRQ) will be cleared when the serial poll byte is read.

Even with SRQ disabled, the serial poll byte can be read to determine appropriate instrument conditions. All set bits (0 through 5) will remain latched until M0 is asserted, power is cycled, or a DCL or SDC is sent. However, bit 2 can be cleared by reading the U1 error status word (see paragraph 4.9.2).

HP-85 Programming Example—Enter the following program to generate a SRQ on an IDDC bus error:

PROGRAM	COMMENTS
`10 REMOTE 714`	Send remote enable.
`20 CLEAR 714`	Clear 740 (SDC).
`30 OUTPUT 714;''M32X''`	Program for SRQ on IDDC.
`40 OUTPUT 714;''E2X''`	Attempt to program illegal command.
`50 S=SPOLL(714)`	Serial poll the instrument.
`60 DISP ''B7 B6 B5 B4 B3 B2 B1 B0''`	Identify the bits.
`70 FOR I=7 TO 0 STEP -1`	Loop eight times.
`80 DISP BIT(S,1);`	Display each bit position.
`90 NEXT I`	
`100 DISP`	
`110 END`	

Once the program is entered and checked for errors, press the HP-85 RUN key. Line 20 sets the instrument to the power-up default conditions. Line 30 programs the SRQ mode of the instrument. Line 40 then attempts to program an illegal command, at which point the instrument generates a SRQ and sets the bus error bit in its serial poll byte. The computer then serial polls the instrument (line 50), and then displays the status byte bits in proper order on the CRT. In this example, the SRQ (B6) and error (B5) bits are set because of the attempt to program an illegal command (I2). Other bits may also be set depending on instrument status.

Model 8573 Programming Example—Load the modified DECL.BAS file into the IBM computer (see the Model 8573 Instruction Manual) and add the following lines to generate an SRQ on an IDDC bus error.

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PROGRAM	COMMENTS
10 NA$=''GPIB0'':CALL IBFIND (NA$,BRD0%)	Find the board descriptor.
20 NA$=''DEV1'':CALL IBFIND (NA$,M740%)	Find the instrument descriptor.
30 V%=14:CALL IBPAD (M740%,V%)	Set primary address to 14.
40 V%=1:CALL IBSRE(BRD0%,V%)	Send remote enable.
45 CALL IBCLR(M740%)	Clear instrument.
50 CMD$=''M32X'':CALL IBWRT (M740%,CMD$)	Program for SRQ on IDDC.
60 CMD$=''E2X'':CALL IBWRT (M740%,CMD$)	Attempt to program illegal command.
70 PRINT''B7 B6 B5 B4 B3 B2 B1 B0''	Identify the bits.
80 MASK%=128	Define bit mask.
90 CALL IBRSP(M740%,SB%)	Serial poll the instrument.
100 FOR I=1 TO 8	Loop eight times.
110 IF (SB% AND MASK%)=0 THEN PRINT ''0 ''; ELSE PRINT ''1 '';	Mask off the bits and display them.
120 MASK%=MASK%/2	
130 NEXT I	
140 PRINT	
150 V%=0:CALL IBONL(BRD0%,V%)	Close the board file.
160 CALL IBONL(M740%,V%)	Close the instrument file.

To run the program press the F2 function key. After placing the instrument in remote (line 40), the program then sets the SRQ (line 50). An attempt is made to program an illegal command (line 60), at which point the instrument generates a SRQ and sets the error and SRQ bits in its serial poll byte. Other bits may also be set depending on instrument status. Lines 70-90 display the bit positions, set the mask value to the most significant bit, and serial poll the instrument. Since the serial poll byte is in decimal form, lines 100-130 are used to generate the binary equivalent of the serial poll byte value.

4.9.2 Status (U)

The status command allows access to information concerning various operating modes and conditions of the Model 740. Status commands include:

U0 = Send Machine Status Word
U1 = Send Error Status Word
U2 = Send Data Status Word
U3 = Send Calibration Date
U4 = Send Hi-Limit
U5 = Send Lo-Limit
U6 = Send highest reading in log buffer
U7 = Send lowest reading in log buffer
U8 = Send average reading in log buffer
U9 = Send highest reading in scan buffer
U10 = Send lowest reading in scan buffer
U11 = Send card 1 status
U12 = Send card 2 status
U13 = Send card 3 status
U14 = Send card 4 status
U15 = Send card 5 status
U16 = Send card 6 status
U17 = Send card 7 status
U18 = Send card 8 status
U19 = Send card 9 status
U20 = Send time and date
U21 = Send trigger time

Status words are sent with prefixes if the current G mode includes the prefix, and are sent without prefixes if the current G mode excludes the prefix. Status words are sent with suffixes if the current G mode includes the suffix, and are sent without suffixes if the current G mode excludes the suffix.

When the command sequence U0X is transmitted, the instrument will transmit the machine status word instead of its normal data string the next time it is addressed to talk. The status word will be transmiited only once each time the U0 command is given. To make sure that correct status is transmitted, the status word should be requested as soon as possible after the command is transmitted.

The format of U0 status is shown in Figure 4-3. Note that the letters correspond to modes programmed by the respective device-dependent commands. The default values in the status word are also shown in Figure 4-3.

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```
740B0C**D0F0G0I*J0K0M00N*O*P*R00T6W**Y0Z*
```

*VALUE DETERMINED BY SETUP.

MODEL NUMBER PREFIX (740)

READING MODE (B)
0 = Current channel
1 = Log buffer
2 = Scan, buffer

CHANNEL (C)
nn = Channel nn closed
91 = Internal reference channel
92 = Internal measurement channel

DISPLAY (D)
0 = Temperature or Volts
1 = Time
2 = Message mode

FUNCTION (F)
0 = Current channel measurement
1 = Log enabled
2 = Message mode

DATA FORMAT (G)
0 = Single output with prefix and with suffix
1 = Single output with prefix and without suffix
2 = Single output without prefix and without suffix
3 = Complete output with prefix and with suffix
4 = Complete output with prefix and without suffix
5 = Complete output without prefix and without suffix

INITIALIZE (I)
0 = Set for 705s
1 = Set for 706

SELF TEST (J)
0 = Cleared
1 = Self test failed
2 = Self test passed

EOI (K)
0 = EOI and Hold-off
1 = No EOI and Hold-off
2 = EOI and no Hold-off
3 = No EOI and no Hold-off

SRQ (M)
00 = Mask cleared
01 = Reading overflow or TC open
02 = Log buffer full or scan complete
04 = Temperature out of limits
08 = Reading done
16 = Ready
32 = Error

TYPE (N)
0 = OFF
1 = Type J
2 = Type K
3 = Type E
4 = Type T
5 = Type R
6 = Type S
7 = Type B
8 = Millivolts

SCALE (O)
0 = °C
1 = °F

FILTER (P)
0 = Enabled
1 = Disabled

RECALL (R)
nn = Recall from buffer channel/location nn

TRIGGER (T)
0 = Continuous on talk
1 = On-shot on talk
2 = Continuous on GET
3 = One-shot on GET
4 = Continuous on X
5 = One-shot on X
6 = Continuous on external trigger or clock
7 = One-shot on external trigger or clock

INTERVAL (W)
00 = One-shot
01 = 0.05 second
02 = 0.1 second
03 = 0.5 second
04 = 1 second
05 = 5 seconds
06 = 10 seconds
07 = 30 seconds
08 = 1 minute
09 = 5 minutes
10 = 15 minutes
11 = 30 minutes
12 = 1 hour

TERMINATOR (Y)
0 = CR LF
1 = LF CR
2 = CR
3 = LF
4 = None

DATE FORMAT (Z)
0 = American date format - mn.dd
1 = European date format - dd.mn

Figure 4-3. U0 Machine Status Word (Default Conditions Shown)

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Note that all returned values correspond to the programmed numeric values. For example, if the instrument is presently in the F1 function, the F byte in the status word will correspond to an ASCII 1.

The U1 command allows access to Model 740 error conditions in a similar manner. Once the sequence U1X is sent, the instrument will transmit the error status with the format shown in Figure 4-4 the next time it is addressed to talk in the normal manner. The error condition word will be sent only once each time the U1 command is transmitted. Note that the error status word is actually a string of ASCII characters representing binary bit positions. An error condition is also flagged in the serial poll byte, and the instrument can be programmed to generate a SRQ when an error condition occurs, Note that all bits in the error condition word and the serial poll byte error bit will be cleared when the word is read. In addition, SRQ operation will be restored after an error condition by reading U1.

The various bits in the U1 Error Status words are described as follows:

IDDC—Set when an illegal device-dependent command (IDDC) such as E1X is received ("E" is illegal).

IDDCO—Set when an illegal device-dependent command option (IDDCO) such as T9X is received ("9" is illegal).

No Remote—Set when a programming command is received when REN is false.

Self-Test—Set when the Self-Test has failed.

Trigger Overrun—Set when the instrument receives a trigger while it is still processing a reading from a previous trigger.

State Error—Set if a command was received that cannot be executed while the Model 740 is currently in a logging or scanning state.

Broken Loop—Set if the serial link between the Model 740 and any external Model 705s (or a Model 706) was broken.

Card Out—Set if the input card or a scanner card is pulled out of the Model 740.

Notes:

1. The complete command string will be ignored if an IDDC, IDDCO or no remote error occurs.
2. Reading the U1 Error Status Word will reset the error bits.

In a similar manner, the U2X sequence allows access to instrument data conditions. When this command is transmitted, the instrument will transmit the data status word shown in Figure 4-5 the next time it is addressed to talk. This information will be transmitted only once each time the command is received. As with the U1 error word, the U2 word is made up of ASCII characters representing binary values. Unlike the U1 error word, however, the U2 data condition word will not be cleared when read; thus, instrument status in the U2 word is always current.

MODEL NO.	IDDC	IDDCO	NO REMOTE	SELF TEST	TRIGGER OVERRUN	STATE ERROR	BROKEN LOOP	CARD OUT
740	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0

Figure 4-4. U1 Error Status Word

MODEL NO.	BUFFER FULL					OVER LIMIT	UNDER LIMIT	TRIGGER TIME
740	1/0	0	0	0	0	1/0	1/0	1/0

Figure 4-5. U2 Data Status Word

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The various bits in the U2 Data Status include:

Buffer Full—Set when the log buffer is full (100 readings) or a scan of all available channels has occurred. Used with the buffer full bit in the status byte.

Over-Limit—Set to indicate a reading was taken that was greater or equal to the limit set by the H command. Used with the limit bit in the status byte.

Under-Limit—Set to indicate a reading was taken that was less than or equal to the limit set by the L command. Used with the limit bit in the status byte.

Trigger Time—Set when the trigger time is pending. This bit will reset after the trigger time passes.

The U3 command allows access to the date that the instrument was last calibrated. The formats for the calibration date are shown in Figure 4-6. The format that is transmitted over the bus depends on the Z command (Date Format) status. Note that the year is not included since calibration is to be done yearly. The calibration date can only be changed by the A command (Date).

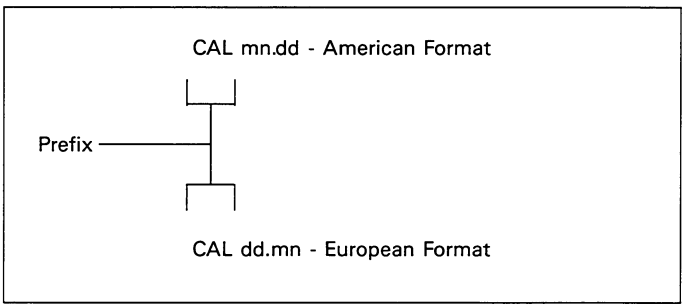


Figure 4-6. U3 Calibration Data

The U4 command allows access to the current setting of the HI-limit value. The format for the HI-limit value that is sent over the bus is shown in Figure 4-7. The value will be either in °C or °F depending on the current O (Output) mode. The HI-limit value can only be changed by the HI-limit command (H).

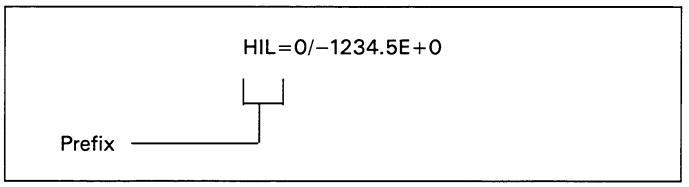


Figure 4-7. U4 High Limit

The U5 command allows access to the current setting of the LO-limit value. The format for the LO-limit value that is sent over the bus is shown in Figure 4-8. The value will be either in °C or °F depending on the current O (Output) mode. The LO-limit value can only be changed by the LO-limit command (L).

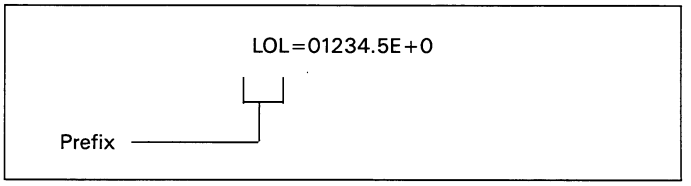


Figure 4-8. U5 Low Limit

The U6 command allows access to the highest (most positive) reading in the log buffer along with the memory location of that reading. The format for the reading that is sent is shown in Figure 4-9. The value will be in either °C or °F depending on the current O (Output) mode. This command can be sent while the instrument is logging and will always send the most current high reading.

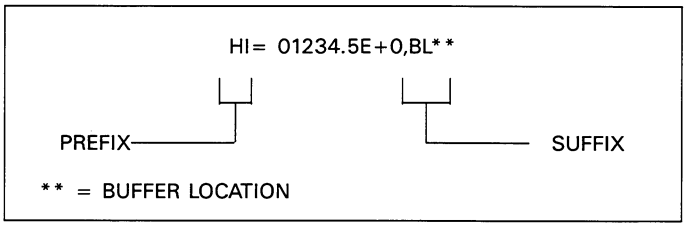


Figure 4-9. U6 Highest Reading in Log Buffer

The U7 command allows access to the lowest (most negative) reading in the log buffer along with the memory location of that reading. The format for the reading that is sent is shown in Figure 4-10. The value will be in either °C or °F depending on the current O (Output) mode. This command can be sent while the instrument is logging and will always send the most current low reading.

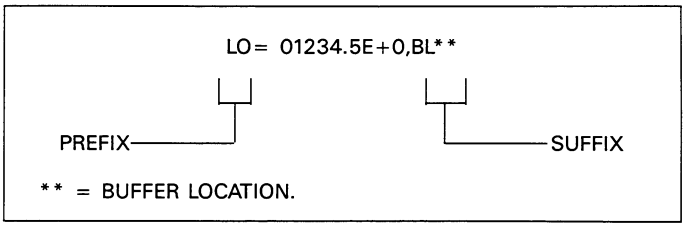


Figure 4-10. U7 Lowest Reading in Log Buffer

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The U8 command allows access to the average reading in the log buffer along with the number of readings that were averaged. The format for the reading that is sent is shown in Figure 4-11. The value will be sent in either °C or °F depending on the current O (Output) mode. This command can be sent while the instrument is logging and will always send the most current average reading.

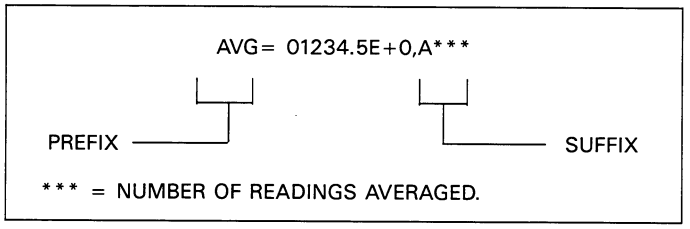


Figure 4-11. U8 Average Reading in Log Buffer

The U9 command allows access to the highest (most positive) reading in the scan buffer along with the buffer channel number. The format for the reading that is sent is shown in Figure 4-12. The value will be sent in either °C or °F depending on the current O (Output) mode. This command can be sent while the instrument is scanning and will always send the most current high reading.

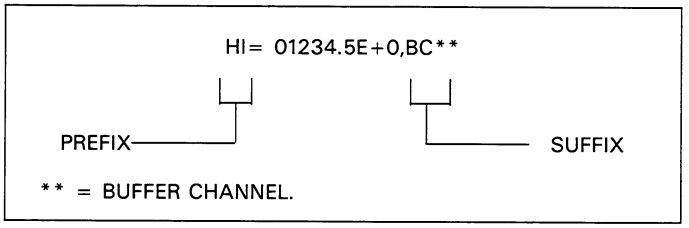


Figure 4-12. U9 High Reading in Scan Buffer

The U10 command allows access to the lowest (most negative) reading in the scan buffer along with the buffer channel number. The format for the reading that is sent is shown in Figure 4-13. The value will be sent in either °C or °F depending on the current O (Output) mode. This command can be sent while the instrument is scanning and will always send the most current low reading.

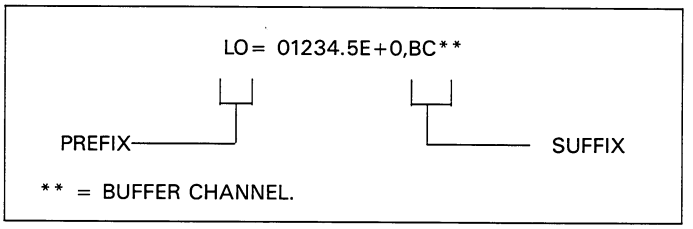


Figure 4-13. U10 Low Reading in Scan Buffer

The U11 through U19 commands allows access to the channel type of each channel on that scanner card. The format for the channel types that are sent is shown in Figure 4-14. The "n" value for a channel corresponds to the Type (N) command value. "n" values of nine for the channels of a scanner card indicate that the scanner card, along with its channels, are physically unavailable.

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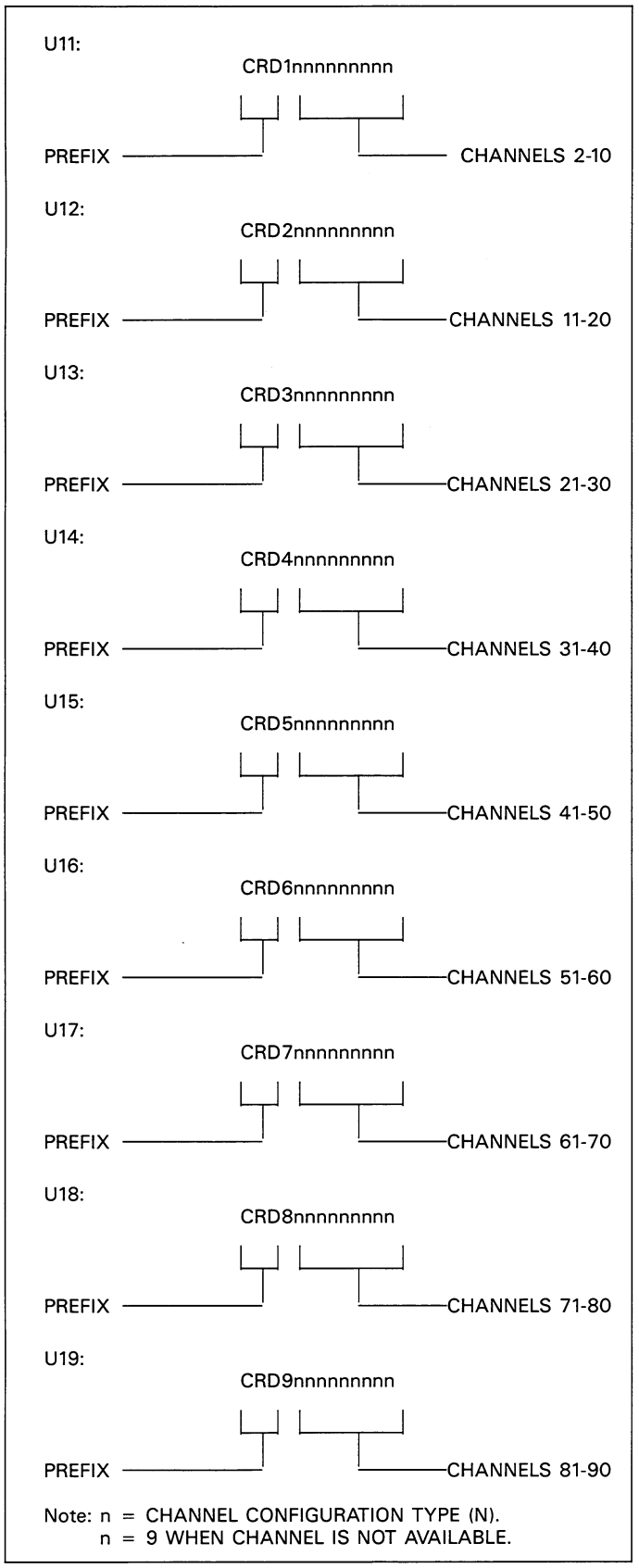


Figure 4-14. U11-U19 Channel Types

The U20 command allows access to the real-time clock which provides the current time and date. The time and date are sent in one of the formats shown in Figure 4-15. The date format is dependent on the selected Z command.

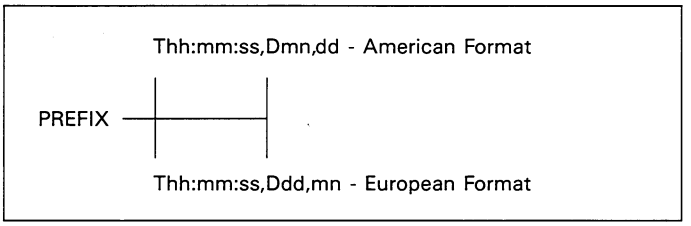


Figure 4-15. U20 Time and Date

The U21 command allows access to the time that the clock is programmed to provide a trigger pulse used to start the logging or scanning process. After a trigger time passes, the trigger time will reset to 24:00 which disables the clock trigger. The trigger time format is shown in Figure 4-16.

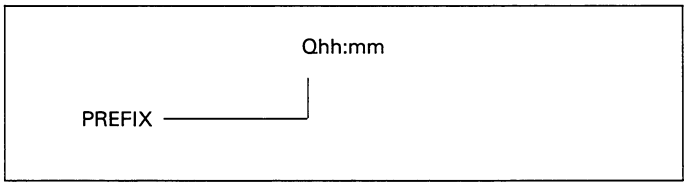


Figure 4-16. U21 Trigger Time

HP-85 Progamming Example—Enter the following statements into the computer to obtain and display the U0 machine status word of the Model 740.

PROGRAM	COMMENTS
`10 REMOTE 714`	Send remote enable.
`20 DIM A$[50]`	
`30 OUTPUT 714;"U0X"`	Send U0 command.
`40 ENTER 714;A$`	Obtain U0 status from instrument.
`50 DISP A$`	Display U0 status word.
`60 END`	

After entering the program, run it by pressing the HP-85 RUN key. Line 30 will send the U0 command, and then the U0 status word will be obtained and displayed on the CRT of the computer (lines 40 and 50).

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Model 8573 Programming Example—Obtain and display the U0 machine status word of the Model 740 as follows: Load the modified DECL.BAS file from disk (see the Model 8573 Instruction Manual) and add the lines from the program below:

PROGRAM	COMMENTS
`10 NA$="GPIB0":CALL IBFIND (NA$,BRD0%)`	Find the board descriptor.
`20 NA$="DEV1":CALL IBFIND (NA$,M740%)`	Find the instrument descriptor.
`30 V%=14:CALL IBPAD(M740%,V%)`	Set primary address to 14.
`40 V%=1:CALL IBSRE(BRD0%,V%)`	Send remote enable.
`50 CMD$="U0X":CALL IBWRT (M740%,CMD$)`	Send U0 command.
`60 RD$=SPACE$(50):CALL IBRD (M740%,RD$)`	Get status word from instrument.
`70 PRINT RD$`	Display status word.
`80 V%=0:CALL IBONL(BRD0%,V%)`	Close the board file.
`90 CALL IBONL(M740%,V%)`	Close the instrument file.

Press the computer F2 key to run the program. The U0 command will be sent (Line 50), and then the status word will be obtained and displayed on the CRT of the computer.

4.9.3 EOI and Bus Hold-off Modes (K)

The K command allows control over whether or not the instrument sends the EOI command at the end of its data string, and whether or not bus activity is held off (through the NRFD line) until all commands sent to the instrument are internally processed once the instrument receives the X character. K command options include:

K0 = Send EOI with last byte; hold-off bus until commands processed on X.
K1 = Do not send EOI with last byte; hold-off bus until commands processed on X.
K2 = Send EOI with last byte; do not hold-off bus on X.
K3 = Send no EOI with last byte; do not hold-off bus on X.

Upon power-up, or after the instrument receives a DCL or SDC command, the instrument will return to K0.

The EOI line on the IEEE-488 bus provides a method to positively identify the last byte in a multi-byte transfer sequence. Keep in mind that some controllers rely on EOI to terminate their input sequences. In this case, suppressing EOI with the K command may cause the controller input sequence to hang unless other terminator sequences are used.

The bus hold-off mode allows the instrument to temporarily hold up bus operation when it receives the X character until it processes all commands sent in the command string. The purpose of the hold off is to ensure that the front end FETs and relays are properly configured before taking a reading. Keep in mind that all bus operation will cease--not just activity associated with the Model 740. The advantage of this mode is that no bus commands will be missed while the instrument is processing commands previously received.

The hold-off period depends on the commands being processed. Table 4-2 lists hold-off times for a number of different commands. Since a NRFD hold off is employed, the handshake sequence for the X character is completed.

Table 4-2. Bus Hold-Off Times

Commands	Bus held off on X for: (all times are typical)
Self Test (J)	900ms
Time (S)	80ms
Most other commands	30ms to 60 ms

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HP-85 Programming Example—To program the instrument for K2, enter the following statements into the HP-85:

```
REMOTE 714
OUTPUT 714;"K2X"
```

When the second statement is executed, the instrument will be placed in K2. In this mode, EOI will still be transmitted at the end of the data string, but bus hold-off will be disabled.

Model 8573 Programming Example—To place the instrument in K2, enter the following statements into the IBM computer:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="K2X":CALL IBWRT(M740%,CMD$)
```

The Model 740 will be placed in K2 when the second statement is executed. The EOI mode will be enabled, but the bus hold-off will be disabled.

4.9.4 Terminator (Y)

The terminator sequence that marks the end of the instrument's data string or status word can be programmed by sending the Y command followed by an appropriate character. The default terminator sequence is the commonly used carriage return, line feed (CR LF) sequence (Y0). The terminator will assume this default value upon power-up, or after the instrument receives a DCL or SDC command. Programmable terminators include:

Y0 = CR LF
Y1 = LF CR
Y2 = CR
Y3 = LF
Y4 = No terminator

HP-85 Programming Example—To reserve the default (CR LF) terminator sequence, type the following lines into the computer:

```
REMOTE 714
OUTPUT 714;"Y0X"
```

When the second statement is executed, the normal terminator sequence will be reserved; the instrument will terminate each data string or status word with a (LF CR) sequence.

Model 8573 Programming Example—Use the following statements to reserve the default terminator sequence:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="Y0X":CALL IBWRT(M740%,CMD$)
```

The terminator sequence will be reversed when the second statement is executed.

4.10 MAINTENANCE COMMANDS

The following device-dependent commands are associated with memory testing and calibration of the instrument.

4.10.1 Self-Test (J)

The J command is used by the instrument to perform tests on its memory elements. When the self-test is run, the Model 740 performs the following tests:

1. ROM Test
2. RAM Test
3. NVRAM Test

J command parameters include:

J0 = Clear J byte in U0 status word
J1 = Perform self-test

If the self-test is successful, the J byte in the U0 status word will be set to 2. Otherwise this byte will be set to 1.

HP-85 Programming Example—Enter the following statements into the computer to perform the Model 740 self-test:

```
REMOTE 714
OUTPUT 714;"J1X"
```

When the END LINE key is pressed the second time, the instrument performs the self-test. If successful, the self-test byte (J) in the U0 status word will be set to 2. This byte may be cleared with the following statement:

```
OUTPUT 14;"J0X"
```


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Model 8573 Programming Example—Enter the following statements into the computer to run the self-test:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''J1X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the instrument performs the self-test. If successful, the self-test byte (J) in the U0 status word will be set to 2. This byte may be cleared with the following statement:

```
CMD$=''J0X'':CALL IBWRT(M740%,CMD$)
```

4.10.2 Digital Calibration (V)

An advanced feature of the Model 740 is its digital calibration capability. Instead of the more difficult method of adjusting a number of potentiometers, the user need only apply an appropriate calibration signal and send the calibration value over the bus.

In general, calibration consists of sending the appropriate V command three times. The first V command calibrates ZERO of the A/D converter, the second V command calibrates GAIN of the A/D converter, and the third V command calibrates the internal reference junction.

A/D Converter Calibration—The V command is used to calibrate the A/D of the Model 740 by sending values over the bus that correspond to the calibration levels applied to the input. The recommended calibration points are 0mV (short) for zero calibration and 100mV for gain calibration. Different calibration points may be used, however to ensure an accurate calibration, the cal points should be as close as possible to 0mV and 100mV.

Reference Junction Calibration—The V command is also used to calibrate the reference junction of the Model 740 for a particular thermocouple. The recommended calibration point is 0°C since this temperature is relatively easy to attain in an ice bath. It is also recommended that Type J, K, T and E thermocouples be used, as their output is higher than the other types and will ensure a much more stable reference junction temperature. When calibrating the reference junction, the instrument must be configured for the type of TC used. If you are not sure about the current configuration, send the appropriate N command along with the V command. Also, the V value sent must correspond to the currently selected temperature scale. If you are not sure about the scale, send the appropriate O command along with the V command.

The V commands are used in the following sequence and form to calibrate the Model 740:

Vn - Calibrate ZERO; where n should be a value equal to or approximate to 0mV.

Vn - Calibrate GAIN; where n should be a value equal to or approximate to 100mV.

Vn - Calibrate RJ; where n should be a value equal to or approximate to 0.0°C (32.0°F).

Thus to calibrate the Model 740 using a Type K TC and calibration values of 0mV, 100mV and 0.0°C, send the following command strings:

V0X
V0.1X
N2O0V0.0X

Note that only as many significant digits as necessary need be sent over the bus. For example, a 100mV cal point may be sent as V.1X.

CAUTION

Precision calibration signals must be connected to instrument before attempting calibration, otherwise, instrument accuracy will be affected. See Section 6 of this manual for complete details on calibrating the instrument either from the front panel or over the bus.

4.10.3 Date (A)

The date command is used to set the internal clock to the correct date. When the instrument is calibrated, the current date is recorded as the calibration date. Thus, to ensure a correct calibration date, check the current date which is displayed when the calibration mode is selected, and change the date if necessary. Use one of the following commands to set the current date:

Amn.dd = American format, where mn=month, dd=day
Add.mm = European format, where dd=day, mn=month

To determine the current date format, read the U0 machine status word as explained in paragraph 4.9.2. To change the date format, see paragraph 4.10.4.

Notes:

1. The current date is battery backed-up. In the event of a "BATTFAIL" the date will reset to Month 01 and Day 01.

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2. Trying to change the date while the instrument is logging or scanning will cause the STATE ERROR bit in the U1 Error Status Word to be set.

HP-85 Programming Example—Enter the following statements to set the date using the American format:

```
REMOTE 714
OUTPUT 714;''Amn.ddX''
```

When the END LINE key is pressed the second time, the date will be entered.

Model 8573 Programming Example—Enter the following statements to set the date using the American format:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''Amn.ddX'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the date will be entered.

4.10.4 Date Format (Z)

The date format command is used to set the format that the calibration date and date is displayed or sent over the bus. The commands to select the date format are as follows:

Z0 = American date format (mn.dd)
Z1 = European date format (dd.mn)

Notes:

1. The date format is stored in NVRAM when the Z command is executed and will not be lost when the instrument is powered down.
2. Trying to change the date format over the bus while the instrument is scanning or logging will cause the STATE ERROR bit in the U1 Error Status Word to be set.

HP-85 Programming Example—With the instrument in the American date format, enter the following programming statements to select the European date format:

```
REMOTE 714
OUTPUT 714;''Z1X''
```

When the END LINE key is pressed the second time, the date and calibration date will be in the European format.

Model 8573 Programming Example—With the instrument in the American date format, enter the following program statements into the computer to select the European date format:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''Z1X'':CALL IBWRT(M740%,CMD$)
```

When the return key is pressed the second time, the date and calibration date will be in the European format.

4.11 SMART PRINT MODE

The Model 740 may be placed in the Smart Print mode and be used with an addressable or listen-only printer. In this mode, the instrument will ignore commands given over the bus and merely output data as requested by the printer. When using an addressable printer, the Model 740 will automatically determine the address of the device and send the data to it. When the instrument is in the Smart Print mode, the front panel TALK LED will turn on.

Placing the instrument in the Smart Print mode consists of selecting the appropriate parameter (40, 41 or 42) in the front panel IEEE program. Data is released over the bus when readings are logged, or channels are automatically scanned.

Perfom the following procedure to place the instrument in the Smart Print mode and output stored readings over the bus:

1. Connect an IEEE addressable or listen-only printer to the Model 740 via the IEEE connector. The printer must be the only device on the bus.
2. Using front panel Program IEEE, select one of the following Smart Print values:

   40 - Smart Print; readings with prefix and suffix.

   Example: DEGC 38.2E+0,BL00,13:45:26

   41 - Smart Print; readings with prefix and without suffix.

   Example: DEGC 38.2E+0

   42 - Smart Print; readings without prefix and without suffix.

   Example: 38.2E+2

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3. Set the Model 740 to scan or log. When the scan or log starts, the printer will start printing the readings from the respective buffer.

Notes:

1. Single Log—While logging, the message "PRINTING" will be displayed if the log buffer fills up faster than all the readings can be printed. After all the stored readings have been sent to the printer the "PRINTING" message will disappear.
2. Continuous Log—If the log buffer fills up with 100 readings faster than the readings can be printed, the Model 740 will temporarily stop logging and wait for the printer to catch up. While waiting for the printer to catch up, the message "PRINTING" will be displayed. After the printer has recieved the first 100 readings, the Model 740 will again start logging at an interval determined by the printing rate. The "PRINTING" message will be displayed each time a reading is sent to the printer. Keep in mind that after the first 100 readings are logged, the most current reading will always be in the memory location 99.
3. Single Scan—While scanning, the message "PRINTING" will be displayed until all the scanned readings are recieved by the printer.
4. Continuous Scan—The scanning interval of the Model 740 cannot be faster than speed of the printer. A scan will not occur until all previously scanned readings have been sent to the printer. While the Model 740 is waiting for the printer to catch up, the message "PRINTING" will be displayed.

4.12 DISPLAYED ERROR MESSAGES

The Model 740 has a number of front panel messages associated with IEEE-488 programming. These messages are intended to inform you of certain conditions that occur when sending device-dependent commands to the instrument.

The following paragraphs describe the front panel error messages associated with IEEE-488 programming.

4.12.1 Bus Errors

A bus error will occur if the instrument receives a device dependent command when it is not in remote, or if an illegal device-dependent command (IDDC) or illegal device-dependent command option (IDDCO) is sent to the instrument. Under these conditions, the complete command string will be rejected and one of the following messages will be displayed:

NO REM
IDDC
IDDCO
CONFLICT

In addition, the error bit and pertinent bits in the U1 word will be set (paragraph 4.9.2) and the instrument can be programmed to generate SRQ under these conditions.

A no remote error can occur when a command is sent to the instrument when the REN line is false. Note that the state of REN is only tested when the X character is received. An IDDC error can occur when an invalid command such as E1X is transmitted (this command is invalid because the instrument has no command associated with that letter). Similarly, an IDDCO error occurs when an invalid option is sent with a valid command. For example, the command T9X has an invalid option because the instrument has no such trigger mode. A conflict error occurs when a command is in conflict with the current operating state of the instrument. For example, a conflict error occurs when the interval command (W) is sent while the instrument is logging or scanning.

HP-85 Programming Example—To demonstrate a bus error, send an IDDC with the following statements:

```
REMOTE 714
OUTPUT 714;"E1X"
```

When the second statement is executed, the bus error message appears on the display for about one second.

Model 8573 Programming Example—Type in the following statements to demonstrate a bus error by sending an IDDC:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$="E1X":CALL IBWRT(M740%,CMD$)
```

The bus error message will be displayed for about one second when the second statement in executed.

4.12.2 Trigger Overrun Error

A trigger overrun occurs when the instrument receives a trigger while it is still processing a reading from a previous trigger. Note that only the overrun triggers are ignored and will have no effect on the instrument except to generate the message below. When a trigger overrun occurs, the following front panel message will be displayed for approximately one second:

TRIGOVER

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HP-85 Programming Example—To demonstrate a trigger overrun error, enter the following statements into the HP-85 keyboard:

```
REMOTE 714
OUTPUT 714;''T3X''
TRIGGER 714 @ TRIGGER 714
```

Note that the trigger overrun message is displayed when the third line above is executed.

Model 8573 Programming Example—Enter the following statements into the computer to demonstrate the trigger overrun message:

```
V%=1:CALL IBSRE(BRD0%,V%)
CMD$=''T3X'':CALL IBWRT(M740%,CMD$)
CALL IBTRG(M740%):CALL IBTRG(M740%)
```

The trigger overrun error message will be displayed when the third line above is executed.

4.13 BUS DATA TRANSMISSION TIMES

A primary consideration is the length of time it takes to obtain a reading once the instrument is triggered to make a conversion. The length of time will vary somewhat depending on the selected function and trigger mode. Table 4-3 gives typical times.

Table 4-3. Trigger to Reading Ready Times

Configuration*	Time (Typical)
Thermocouple measurement filter off (N1P0)	114ms
Thermocouple measurement filter on (N1P1)	230ms
Millivolt measurement filter off (N8P0)	98ms
Millivolt measurement filter on (N8P1)	216ms

*All times are measured using T1 (one-shot on talk) Trigger.

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SECTION 5
PRINCIPLES OF OPERATION

5.1 INTRODUCTION

The purpose of this section is to provide a general functional description of the Model 740 without going into excessive detail. This information, along with the maintenance information in Section 6, is primarily intended to assist a qualified electronic technician in troubleshooting the instrument.

5.2 OVERALL FUNCTIONAL DESCRIPTION

A simplified block diagram of the Model 740 is shown in Figure 5-1. The instrument may be divided into two sections: analog and digital circuitry. The analog and digital sections are electrically isolated from each other by the use of pulse transformers for control and communications. Separate power supplies for the analog and digital sections ensure proper isolation.

The analog section consists of the input, multiplexer, input amplifier, A/D converter and control circuitry. The heart of the digital section is the 68B09 microprocessor that supervises the entire operation of the instrument. Additional digital circuitry includes the display and the IEEE-488 interface.

5.3 ANALOG CIRCUITRY

Detailed illustration of the Model 740 analog circuitry is located on schematic diagram number 740-126.

5.3.1 Input Section

The input section of the Model 740 is that of a one range (100mV) DC voltmeter. The input is applied directly to the multiplexer through R301. L302 is a choke that acts as a filter for common mode noise seen at the input. R301 along with U302 and associated components, make up the Gaussian three pole analog filter. Protection of the analog circuitry from high normal mode voltage is provided by Q301 and Q302. Protection of Q309 (see next paragraph) is provided by Q315 which routes overload currents to U324C.

5.3.2 Multiplexer

The multiplexer circuitry selects from amongst the various signals that are part of the Model 740 measurement cycle and connects them the input amplifier. Figure 5-2 shows a simplified schematic of the multiplexer circuitry. Figure 5-3 shows the general switching phases for the various signals. During each phase, an integration is performed by the A/D converter, and the resultant data is used by the microprocessor to calculate the final reading.

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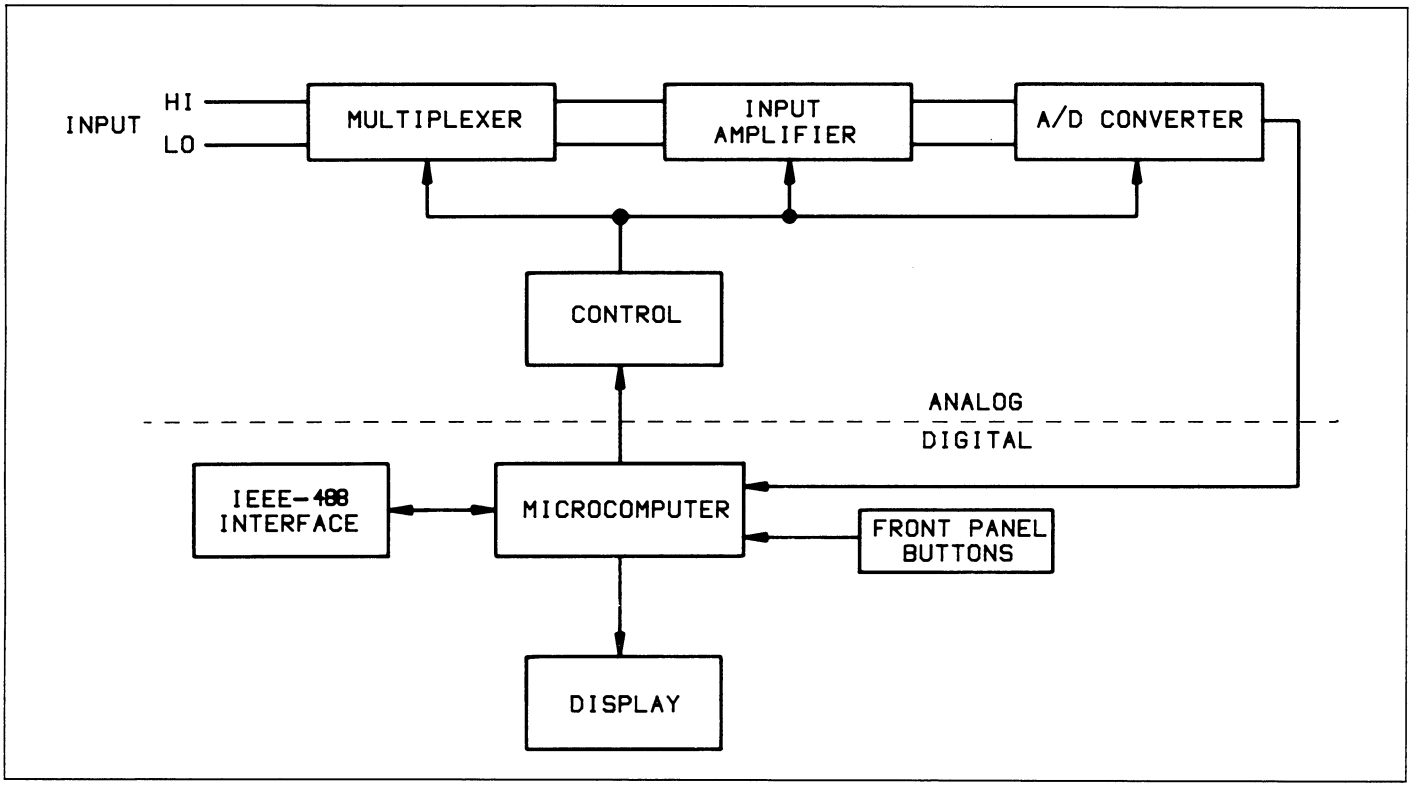


Figure 5-1. Overall Block Diagram

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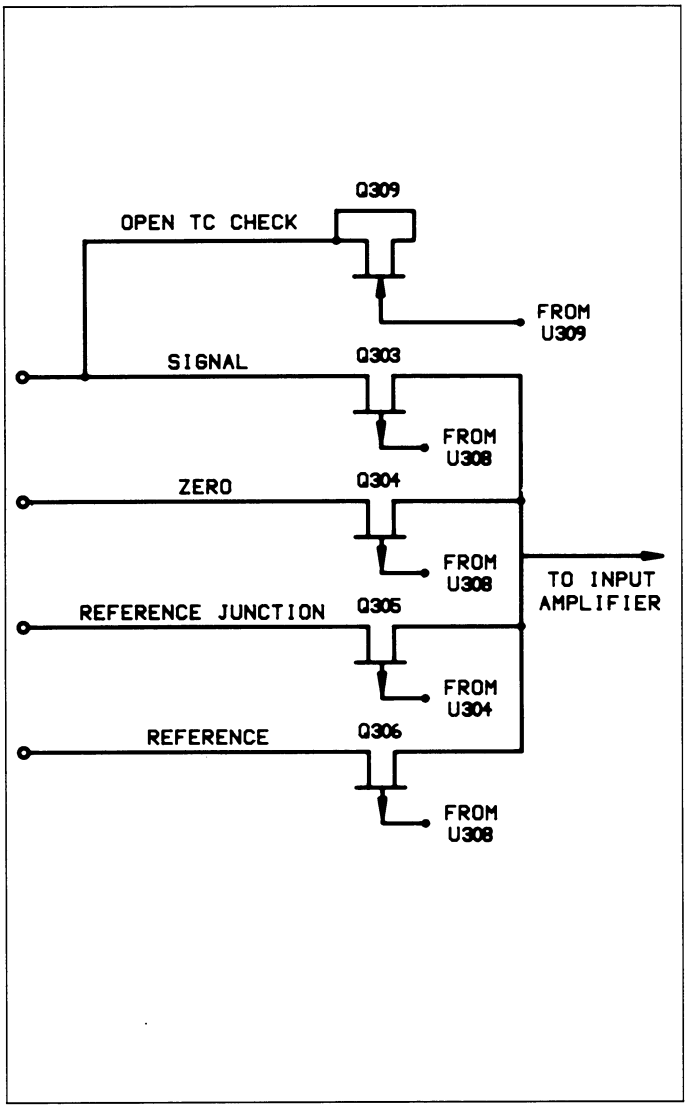


Figure 5-2. Multiplexer

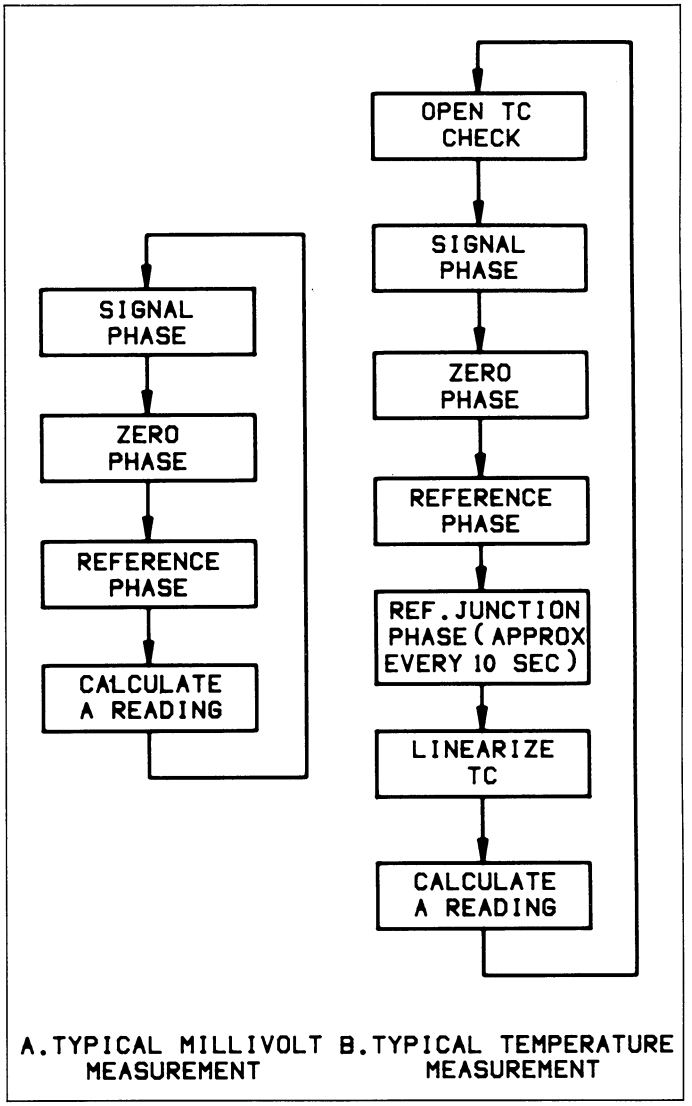


Figure 5-3. Multiplexer Phase

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Millivolt Measurements—During the signal phase, signal high is selected through Q303. During the zero phase, signal common is selected through Q304. During the reference phase, the multiplexer selects the +0.1V reference through Q306.

Temperature Measurements—At the start of each measurement cycle, a check for an open thermocouple is made. +5V is momentarily applied to Q309. If the TC is functional (less than an equivalent circuit of 77mV and 1kΩ), the input voltage will remain at a low enough level that will not saturate the A/D converter, and the microprocessor will interpret this as a closed TC. If the TC is open, the input voltage will be high, turning on Q301 and saturating the A/D converter. The microprocessor will interpret this as an open TC and display the open TC message. During the reference junction phase, the output of U304 is selected through Q305. During the signal phase, the signal high is selected through Q303. During the zero phase, the signal common is selected through Q304 and during the reference phase, the +0.1V reference is selected through Q306.

5.3.3 +0.1V Reference Source

Voltage measurements are based on comparing the unknown signal with an internal +0.1V reference voltage source. During each measurement cycle, the unknown signal is sampled and then compared with the signal common and the +0.1V reference values.

CR301 provides a stable +6.4V reference, while U303 and R311 through R313 provide a constant current to minimize zener voltage variations. R314 divides down the +6.4V value to the final +0.1V reference voltage.

5.3.4 Internal Reference Junction

To make temperature measurements, the input signal also needs to be compared to a reference junction. The heart of the reference junction is U304 which is a temperature transducer. The output voltage of the transducer is dependent on the temperature of the input connector pair noted by "INT". Thus, when using the internal channel, thermocouples should be connected to these inputs only.

5.3.5 Input Buffer Amplifier

The input buffer amplifier (U301) is configured for non-inverting X20 gain to provide the A/D converter with usable levels. The amplifier also provides isolation between the input signal and the A/D converter.

5.4 A/D CONVERTER

The Model 740 uses a constant frequency, variable pulse width, analog-to-digital converter. A simplified schematic of the A/D used in the Model 740 is shown in Figure 5-4.

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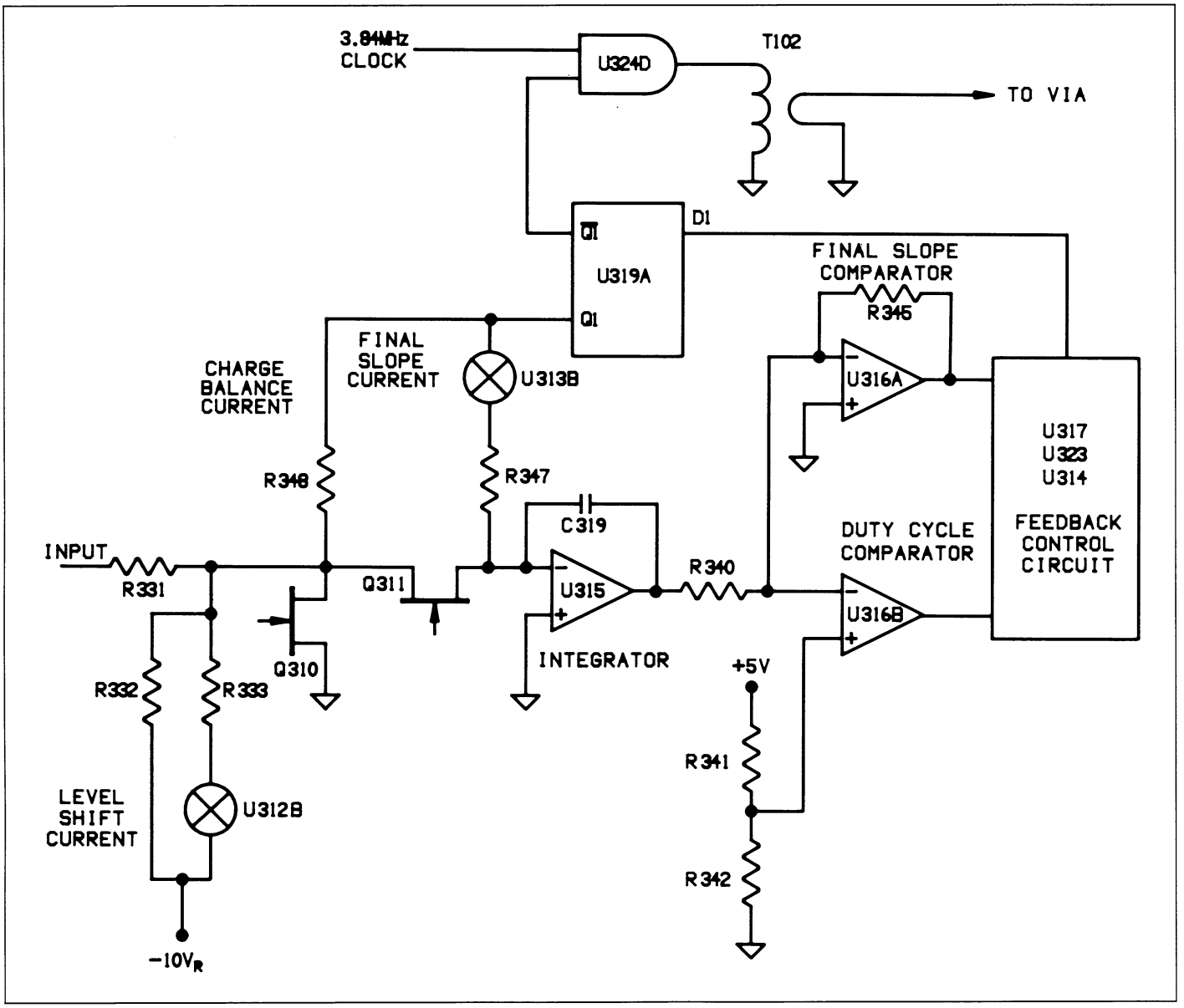


Figure 5-4. A/D Converter Simplified Schematic

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The charge balance phase begins when the INT line is set high. This occurs at the end of a software-generated delay period that allows the signal to settle after the appropriate multiplexer FET is turned on. Once the INT is enabled, the signal from the buffer amplifier is added to the level shift current applied through R333 and R332. In this manner, the ±1.99V bipolar signal from the buffer amplifier is converted to a unipolar signal that can be integrated.

The integrator is made up of Q312, U315 and C318. When the input to the integrator is applied, the integrator output ramps up until its voltage is slightly higher than the voltage applied to the non-inverting input of the duty cycle comparator (U316B). The charge balance current is added to the integrator input through R348 and Q311. Since the charge balance current is much larger than the sum of the input and level shift currents, the integrator output now ramps in the negative direction until Q1 of U319A goes low. The process keeps repeating until the integration is complete (16.67ms for 60Hz and 20ms for 50Hz). For all integrations, charge balancing occurs the same number of times; thus the term "constant frequency" is used. The VIA then counts the total number of pulses that occur during the charge balance phase.

At the end of the charge balance phase, the output of the integrator is resting at some positive voltage. Since the integrator output is connected to the non-inverting input of the final-slope comparator (U316A), the final-slope comparator output remains high until the integrator output ramps in the negative direction. During final-slope, Q311 is turned off and the final slope current is fed through U313B to the integrator input. The final-slope comparator output is then gated with the 3.84MHz clock and counted. Once the comparator output goes low, the VIA stops counting and the reading can be computed.

5.5 CONTROL CIRCUITRY

The signals for the circuitry that provides control of the various FETs are supplied by the shift store registers U308 and U309. CLOCK, DATA and STROBE signals are sent from the VIA (U109) across pulse transformers T103, T104 and T105. The pulse transformers provide 200V isolation between the analog and digital sections of the instrument. DATA is serially loaded into the shift store registers and a STROBE pulse causes the registers to simultaneously output the appropriate logic levels to the FETs.

5.6 DIGITAL CIRCUITRY

The Model 740 is controlled by an internal microcomputer. This section briefly describes the operation of the microcomputer and associated digital circuitry. Refer to schematic diagram number 740-106 for circuit details.

5.6.1 Microcomputer

The microcomputer centers around the 8-bit 68B09 microprocessor. The MPU has direct control over the display, front panel switches, A/D converter, IEEE-488 bus, EXTERNAL TRIGGER input and the SERIAL IN and SERIAL OUT ports. Timing for the microprocessor is accomplished by the use of Y101; an 8MHz crystal. Internally, this frequency is divided down by four to obtain a bus operating frequency of 2MHz.

Instrument operation software is stored in EPROMS U105 and U106. Calibration constants are stored in NVRAM (U310). U107 is the RAM and has battery back-up. Partial address decoding is used in this system. The device selected is determined by the state of A9 through A15 address lines. These address lines determine which device is selected by the decoder (U103). Only one device (EPROM, RAM, VIA, etc) will have access to the data bus at any one time.

The battery back-up circuitry turns on when power is turned off. The battery is connected to the RAM and clock circuitry. This retains the data in the buffer locations when the power is shut down. When power is lost, transistors Q101 and Q102 turn off and the battery voltage is routed through to the RAM and clock circuitry.

Detection of a 7057A card installed in the Model 740 is performed by PA3 of the VIA (U109). When a 7057A card is installed in the Model 740, PA3 goes to a low logic level and makes channels 1 through 10 available to the measurement system. Control of the relay switching of the installed 7057A card is accomplished by the parallel data on the data bus (D0-D7). The data is loaded into latches U116 and U117. When the appropriate clock pulse occurs the latches release its data to the current drivers (U117 and U119) which in turn drives the appropriate relay on the scanner card.

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Detection and control of external 7057A scanner cards is accomplished by the ACIA (U108) via the SERIAL OUT and SERIAL IN ports. R110, R111 and CR107 comprise a protection network for these two ports. SERIAL OUT data is transmitted via R110 and pin 6 of the ACIA. SERIAL IN data is received via R111 and pin 2 of the ACIA. The EXTERNAL TRIGGER input is controlled by the VIA. U109 and CR108 comprise a protection circuit for the external trigger line. The EXTERNAL TRIGGER input is routed into the circuitry via R113 and pin 40 of the VIA.

5.6.2 Display Circuitry

The display information is sent through display latches U110 and U111. Upon each display update, new segment information is presented to the display latches and a clock pulse is sent on PA0. The clock pulse to U203 shifts a digit enable bit to the next digit to be enabled. Every nine times the display is updated, a digit enable bit is generated at PA1 and goes to the data input of the shift register. Q201 through Q204 are the drivers for the LED segments of the display digits.

5.7 POWER SUPPLIES

The main power supplies of the Model 740 are located on sheet 1 of 3 of schematic drawing number 740-106. Fuse F101 is the line fuse which is accessible from the rear panel. S102 is the POWER OFF switch and S101 selects 115V or 230V operation by placing the transformer primary windings in parallel or series. The power transformer, T101, has three secondary windings; one for the +5V digital supply, one for the +5 analog supply, and one for the ±15V supply. CR101, CR102 and CR103 provide fullwave rectification for the three supplies, while VR101, VR102, VR103 and VR104 provide the regulation.

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SECTION 6
MAINTENANCE

6.1 INTRODUCTION

This section contains information necessary to maintain, calibrate, verify performance and troubleshoot the Model 740. The line fuse replacement procedure is also included.

WARNING

The procedures included in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps in this section may expose you to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

6.2 LINE FUSE REPLACEMENT

The line fuse protects the line power input of the instrument. The fuse can be replaced by using the following procedure.

WARNING

Disconnect the instrument from the power line and from other equipment before replacing fuses.

1. Turn off the power and disconnect the line cord and all other test cables from the instrument.
2. Place the end of a flat-blade screwdriver into the slot in the line fuse holder on the rear panel. Push in and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse and the carrier out of the holder.
3. Remove the fuse and replace it with the proper type using Table 6-1 as a guide.

CAUTION

Do not use a fuse with a rating higher than specified or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse.

4. Install the new fuse and the carrier into the holder by reversing the above procedure.

6.3 CALIBRATION

Calibration should be performed every 12 months, or if the performance verification procedures in paragraph 6.4 show that the Model 740 is out of specification. If any of the calibration procedures in this section cannot be performed properly, refer to the troubleshooting information in this section. If the problem persists, contact your Keithley representative or the factory for further information.

Table 6-1. Line Fuse Selection

Size	Line Voltage	Rating	Keithley Part No.
American (3AG)	105V-125V 210V-250V	$^{3}/_{16}$ A, 250V, Slo-Blo $^{1}/_{10}$ A, 250V, Slo-Blo	FU-17 FU-20
European (5mm)	105V-125V 210V-250V	0.16A, 250V, Slo-Blo 0.10A, 250V, Slo-Blo	FU-75 FU-76

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The entire calibration procedure may be performed from the front panel or over the IEEE-488 bus without having to make any internal adjustments. The calibration procedure consists of setting the calibration date, calibrating the A/D converter, and then calibrating the reference junction temperature.

6.3.1 Recommended Calibration Equipment

Table 6-2 lists recommended calibration equipment. Alternate equipment may be used as long as equipment accuracy is at least as good as the specifications listed in the table.

6.3.2 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient temperature of 23°C ± 1°C and a relative humidity of less than 70%.

6.3.3 Instrument Preparation

The instrument must be thoroughly warmed up for at least 2 hours before calibration can be performed. Also, once warmed up, the internal temperature must be maintained throughout the entire procedure. In order to maintain a constant internal temperature, power must not be interrupted or the input card pulled out. Perform the following procedure to prepare the Model 740 for calibration:

1. Turn the Model 740 off, disconnect the line cord, disconnect all other instrumentation, and physically remove all test leads from the INPUT CARD. Paragraph 2.6.1 explains how to pull out the INPUT CARD.
2. Using Figure 6-1 as a guide, connect an appropriate female TC connector to the INT terminals of the INPUT CARD. A thermocouple will later be mated to the connector for the purpose of calibrating the internal reference juction. Connect a pair of copper test leads to any other pair of terminals on the INPUT CARD. These leads will be used to short the input for zero calibration and to input 100mV to calibrate gain.
3. With the INPUT CARD reinstalled in the Model 740, turn on the instrument and allow it to warm up for at least two hours before beginning the calibration procedure. If the instrument has been subjected to extremes of temperature or humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure.

Table 6-2. Recommended Calibration Equipment

Mfg	Model	Description	Specifications
Fluke	5440A	DC Voltage Calibration	200mV ±50ppm
—	—	Pure distilled water ice bath (Dewer's flask or thermos)	±0.1°C
—	—	Male-to-male BNC cable	Short for loop test

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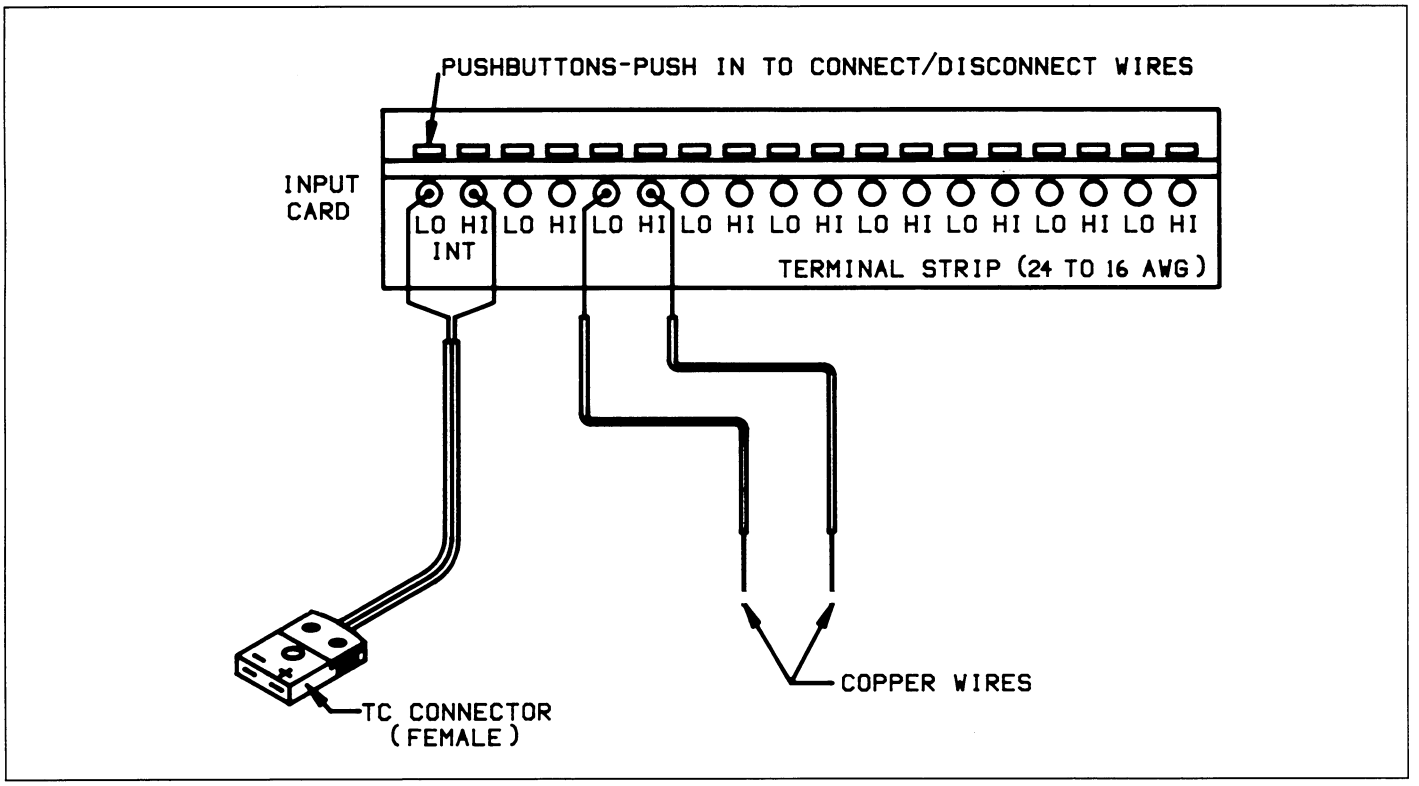


Figure 6-1. Calibration Preparation Setup

6.3.4 Ice Bath Preparation

One of the calibration steps requires that a thermocouple be placed in an ice bath to achieve 0°C. Prepare the pure water ice bath as follows:

1. Drill a hole in the cap of a Dewer flask or thermos to accomodate the thermocouple.
2. Firmly pack the flask with pea-size ice cubes made from distilled water, and then fill the flask with distilled water.
3. Replace the melted ice with more ice while removing the excess water.
4. Place the cap on the flask. Immerse the thermocouple into the flask and allow 20 minutes for temperature stabilization.

6.3.5 Front Panel Calibration

The following information provides the complete procedure for calibrating the instrument from the front panel:

1. Turn the Model 740 off and while holding in the PROGRAM button, turn the Model 740 back on. Continue to hold in the PROGRAM button until the calibration serial number is displayed. This number is incremented by one every time the A/D converter is calibrated. For example, if the current calibration serial number is 100, then the following message will be displayed briefly:

   No. 100

   The current month should then be displayed. For example, if the current month is September, the following message should be displayed:

   MONTH 09

2. If the wrong month is displayed, select the correct month using the ▲ and ▼ buttons.
3. With the current month displayed, press the ENTER button. The current day of the month should now be displayed. For example, if the current date is September 30th, the following message should be displayed:

   DAY 30

4. If the wrong day is displayed, select the correct day using the ▲ and ▼ buttons.
5. With the current day of the month displayed, press the ENTER button. The current date format will be displayed. For example, if the date is currently set to

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the American format the following messages will be displayed:

FORMAT
MM.DD ? ▼▲

where MM = month, DD = day

6. If the alternate date format is desired, press the ▲ or ▼ button to toggle the display. For example if the American format is presently displayed, pressing the ▲ button will toggle the display to the European format as shown:

DD.MM ? ▼▲

Note: If it is desired to exit the calibration mode at this time, press the ENTER button. The previous calibration date will not be changed. Otherwise, continue on to the next step to calibrate the A/D converter.

7. Short the two copper wires from the INPUT CARD together as shown in Figure 6-2.

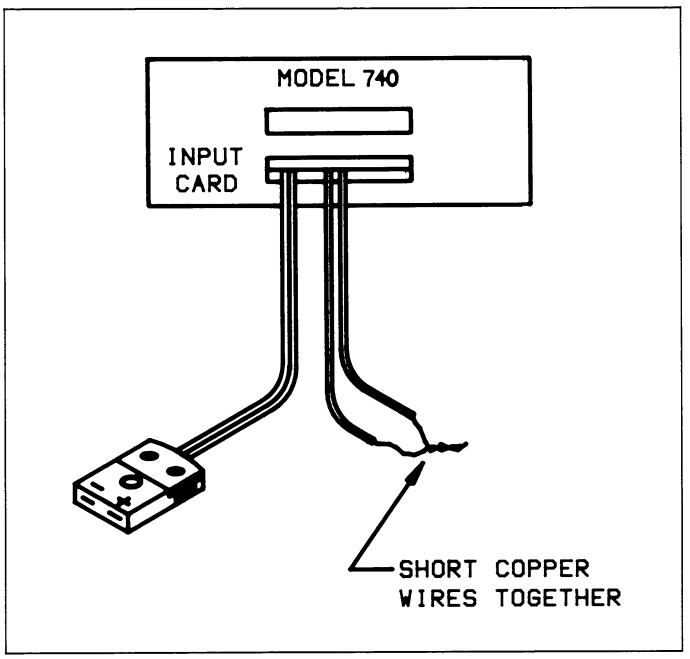


Figure 6-2. A/D Converter—Zero Calibration

8. Press the PROGRAM button until the following message is displayed briefly:

ZERO CAL

The default zero calibration point will now be displayed in millivolts as follows:

0.000 ▼▲

9. The zero calibration point can be adjusted to match the actual input level with the use of the ▲ and ▼ buttons. This adjustment is helpful in compensating for known offsets. To insure a good calibration, the input level should be as close to 0.000mV as possible.
10. After waiting a sufficient amount of time for the input signal to settle, press the ENTER button. The following messages will be displayed briefly to indicate that the instrument is calibrating and that gain is to be calibrated next:

WAIT
GAIN

The following gain calibration point (in millivolts) will now be displayed as follows:

100.000 ▼▲

11. The gain calibration point can be adjusted to match the actual input level to be used with the use of the ▲ and ▼ buttons. To ensure a good calibration, the input level should be as close to 100.000mV as possible.
12. Disconnect the short and connect the DC calibrator to the two copper wires as shown in Figure 6-3. Be sure to observe the proper polarity.

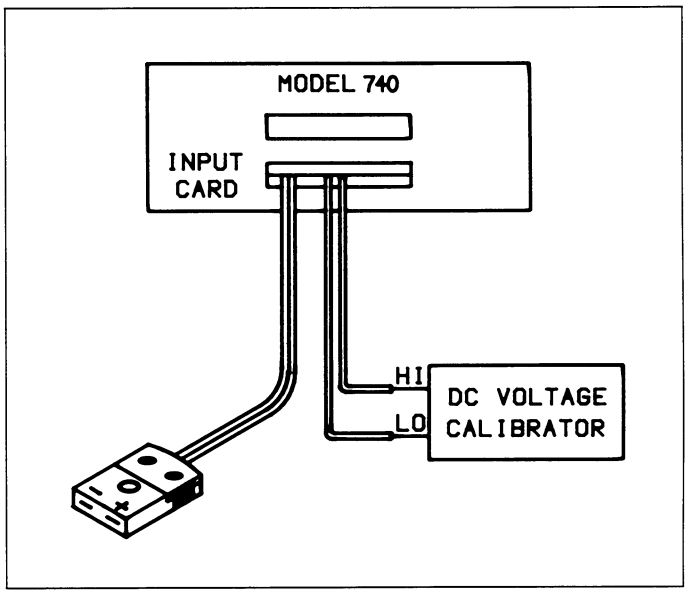


Figure 6-3. A/D Converter—Gain Calibration

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13. Set the DC calibrator to output the displayed millivolt level.
14. After allowing a sufficient time for the calibrator to settle, press the ENTER button. The following message will be displayed to indicate that the instrument is calibrating:

    WAIT

    The following message will then be displayed to indicate that calibration of the A/D converter is completed:

    COMPLETE

    Note: If it is desired to exit the calibration mode at this time, press the ENTER button. The calibration constants, the calibration date and the serial number will be stored in NVRAM. Otherwise, proceed on to the next step to calibrate the temperature reference junction.
15. Press the PROGRAM button until the following message is displayed briefly:

    RJ CAL

    The following message will then be displayed to indicate that the instrument is configured to calibrate the reference junction for a Type K TC (thermocouple).

    TYPE K

16. To calibrate the reference junction for a different thermocouple type, press the front panel button (J, T, E, R, S, B) that corresponds to the thermocouple type that is to be used. The selected TC will then be displayed.
17. With the desired TC type displayed, press the ENTER button. The following message will be displayed briefly:

    ICE PT

    The temperature calibration point of 0°C or 32°F for the ice bath will be displayed. For example, if the instrument is currently on the °C scale, the following message will be displayed:

    0.0°C

    Note: The calibration point can be displayed in the alternate thermometric scale by pressing the °C/°F button.
18. If the TC is going to be at a temperature other than 0.0°C (32.0°F), use the ▲ and ▼ buttons to display that temperature reading. The ▲ and ▼ buttons may also be used to compensate for any known TC errors. (°F will yield the best resolution).
19. Remove the DC calibrator from the input and connect the TC that is in the ice bath to the female TC connector as shown in Figure 6-4. Make sure that the two copper wires do not short together.

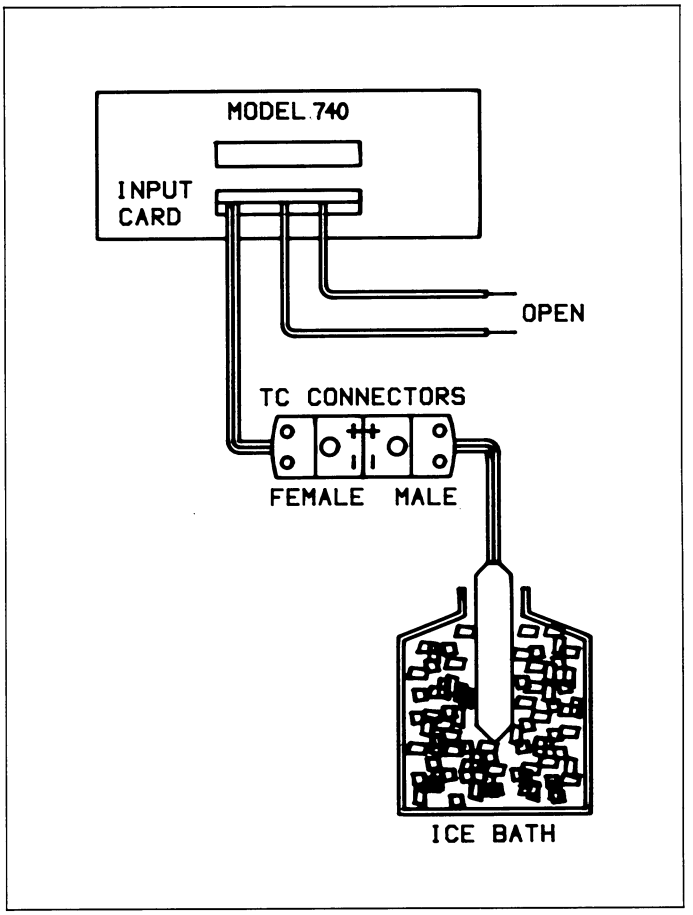


Figure 6-4. Reference Junction Calibration

20. Allow the TC junction to reach 0°C. As the ice melts, replace the water with more ice chips.
21. After allowing a sufficient amount of time for the TC junction to reach 0°C (32°F), press the ENTER button. The following message will be displayed while calibration occurs:

    WAIT

22. The following message will then be displayed briefly to indicate that calibration of the reference junction is completed.

    COMPLETE

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23. Press the ENTER button to exit the calibration mode. All calibrtion constants, serial number, and the calibration date will be stored in NVRAM.

Notes:
1. A calibration error ("CALERR") will occur if a calibration point is entered under the following circumstances:
   A. An open input.
   B. A/D calibration—An applied voltage that is not within 10mV of the displayed calibration point.
   C. RJ calibration—Temperature not within −10.0°C to 70.0°C. In the event of a CALERR, repeat the calibration step.
2. Calibration can be aborted at any time without changing the previous calibration parameters by cycling power on the Model 740.
3. To calibrate only the A/D converter, enter the calibration mode as explained in step 1 and press the PROGRAM button until "ZERO CAL" is is displayed. Perform steps 8 through 14 of the calibration procedure.
4. Since each thermocouple has a unique offset, it is recommended that the internal reference junction of the Model 740 be calibrated with the TC that is going to be used. To calibrate only the reference junction, enter the calibration mode as explained in step 1 and perform steps 15 through 23 of the above calibration procedure.
5. Another way to exit calibration and save any modified calibration parameters is to press the PROGRAM button until the message "EXIT?" is displayed, and then press the ENTER button.
6. The adjustment range for the A/D calibration points is from -99.999mV to 101.000mV. The adjustment range for the reference junction calibration point is from -10.0°C (14.0°F) to 70.0°C (158.0°F).

6.3.6 IEEE-488 Bus Calibration

Calibration of the Model 740 over the bus is similar in procedure to front panel calibration with the difference being that calibration constants are entered over the bus, rather than with the front panel controls.

In general, calibration consists of sending the appropriate V command three times. The first V command calibrates ZERO of the A/D converter, the second V command calibrates GAIN of the A/D converter, and the third V command calibrates the reference junction.

Perform the following procedure to calibrates the Model 740 over the IEEE-488 bus:

1. Prepare the Model 740 for calibration as explained in paragraph 6.6.3.
2. Place the Model 740 in the calibration mode by powering up the instrument while holding in the PROGRAM button until the calibration serial number is displayed.
3. Over the bus, the calibration date automatically sets to the current date stored by the Model 740. If the instrument is not set to the current date or desired date format, perform the following steps:
   A. To change the date format, use the Z command. For example, to select the American date format, send "Z0X" over the bus.
   B. To set the instrument to the current date, use the A command. For example, to set the date to November 9 in the American format, send "A11.09X".
4. Short the two copper wires together as shown in Figure 6-2.
5. After waiting a sufficient time for the reading to settle, perform zero calibration by sending the appropriate V command. With the shorted input, send V0X.
6. Disconnect the short and connect the DC calibrator to the two copper wires as shown in Figure 6-3. Be sure to observe the proper polarity.
7. Set the DC calibrator to output +100.000mV.
8. After allowing the calibrator to settle, perform gain calibration by sending the appropriate V command. With +100.000mV on the input, send "V0.1X".
9. Remove the DC calibrator from the input and connect the thermocouple that is in the ice bath to the female TC connector as shown in Figure 6-4. Make sure that the two copper wires do not short together.
10. Allow the junction to reach 0°C.
11. The instrument must be configured for the type of TC that is going to be used to calibrate the reference junction. If not sure about the current configuration, use the appropriate N command along with the V command to calibrate the reference junction. The value sent with the V command is dependent on the current temperature scale of the unit. If not sure which scale is currently selected, use the O command to select the desired scale. For example, to calibrate the reference junction for a Type K TC on the °C scale, send "N2O0V0X".
12. To store the calibration constants and calibration date in NVRAM, send the "F" or "T" command. The instrument will exit calibration.

Notes:
1. A "CALERR" will be displayed if a V command is sent with an open input or an input that exceeds the range of the instrument. In this event, calibration will be void and the next V command will calibrate ZERO.
2. To calibrate only the A/D converter, perform steps 2 through 8 of the above procedure and then send the "F" or "T" command over the bus. The cal date will also be stored in NVRAM.
3. To exit calibration without saving calibration parameters, send a DCL or SDC over the bus, or cycle power on the Model 740.

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HP-85 Programming Example—The following program calibrates the instrument over the IEEE bus for a Type K TC. Prepare the instrument for calibration as explained in paragraph 6.3.3, and from the front panel, place the Model 740 in the calibration mode. The program assumes that the instrument's primary address is at 14.

PROGRAM	COMMENTS
`10 REMOTE 714`	Send remote enable.
`20 DISP ''SHORT INPUT''`	
`30 DISP ''PRESS CONT TO CONTINUE''`	
`40 PAUSE`	
`50 WAIT 5000`	
`60 OUTPUT 714;''V0X''`	Send cal command to 740.
`70 ENTER 714;A$`	Get a reading.
`80 DISP A$`	Display the reading.
`90 DISP ''REMOVE SHORT''`	
`100 DISP ''INPUT 100.000mV''`	
`110 DISP ''PRESS CONT TO CONTINUE''`	
`120 PAUSE`	
`130 WAIT 5000`	
`140 OUTPUT 714;''V0.1X''`	Send cal command to 740.
`150 ENTER 714;A$`	Get a reading.
`160 DISP A$`	Display the reading.
`170 DISP''REMOVE CAL SIGNAL''`	
`180 DISP ''CONNECT TC, PLACE IN ICE BATH''`	
`190 DISP ''WAIT UNTIL TC = 0.0°C''`	
`200 DISP ''PRESS CONT TO CONTINUE''`	
`210 PAUSE`	
`220 OUTPUT 714; ''N200V0.00X''`	Send cal command string to 740.
`230 ENTER 714;A$`	Get a reading.
`240 DISP A$`	Display the reading.
`250 OUTPUT 714;''F0X''`	Return to current channel and verify reading.
`260 DISP ''CALIBRATION COMPLETED''`	
`270 END`	

Press the RUN key to start the program and follow the instructions of the prompts to calibrate the Model 740. NOTE: If a "CALERR" occurs, start calibration from the beginning by pressing the RUN key.

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Model 8573 Programming Example—The following program calibrates the instrument over the IEEE bus for a Type K TC. Prepare the instrument for calibration as explained in paragraph 6.3.3 and from the front panel place the instrument in the calibration mode. The lines below are to be added to the DECL.BAS program, as described in the Model 8573 Instruction Manual. The program assumes that the instrument is set for a primary address of 14.

PROGRAM	COMMENTS
`10 NA$=''GPIB0'':CALL IBFIND (NA$,BRD0%)`	Find board descriptor.
`20 NA$=''DEV1'':CALL IBFIND (NA$,M740%)`	Find instrument descriptor.
`30 V%=1:CALL IBSRE (BRD0%,V%)`	Send remote enable.
`40 V%=14:CALL IBPAD (M740%,V%)`	Set primary address to 14.
`50 PRINT ''SHORT INPUT''`	
`60 PRINT ''PRESS ANY IBM KEY TO CONTINUE''`	
`70 A$=INKEY$:IF A$='' '' THEN 70`	
`80 FOR I=1 TO 5000:NEXT I`	
`90 CMD$=''V0X'':CALL IBWRT (M740%,CMD$)`	Send cal command to 740.
`100 RD$=SPACE$(25):CALL IBRD (M740%,RD$)`	Get a reading.
`110 PRINT RD$`	Display reading.
`120 PRINT ''REMOVE SHORT''`	
`130 PRINT ''INPUT 100.000MV''`	
`140 PRINT ''PRESS ANY IBM KEY TO CONTINUE''`	
`150 A$=INKEY$:IF A$='' '' THEN 150`	
`160 FOR I=1 TO 5000:NEXT I`	
`170 CMD$=''V0.1X'':CALL IBWRT (M740%,CMD$)`	Send cal command to 740.
`180 RD$=SPACE$(25):CALL IBRD (M740%,RD$)`	Get a reading.
`190 PRINT RD$`	Display reading.
`200 PRINT ''REMOVE CAL SIGNAL''`	
`210 PRINT ''CONNECT TC IN ICE BATH''`	
`220 PRINT ''WAIT UNTIL TC = 0.0°C''`	
`230 PRINT ''PRESS ANY IBM KEY TO CONTINUE''`	
`240 A$=INKEY$:IF A$='' '' THEN 240`	
`250 CMD$=''N200V0.00X'':CALL IBWRT (M740%,CMD$)`	Send cal commmand string to 740.
`260 RD$=SPACE(25):CALL IBRD (M740%,RD$)`	Get a reading.
`270 PRINT RD$`	Display reading.
`280 CMD$=''F0X'':CALL IBWRT (M740%,CMD$)`	Return to current and verify reading.
`290 PRINT ''CALIBRATION COMPLETED''`	
`300 V%=0:CALL IBONL (BRD0%,V%)`	
`310 CALL IBONL(M740%,V%)`	

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Run the program by pressing the F2 function key on the computer. Follow the instructions of the prompts to calibrate the Model 740. NOTE: If a "CALERR" occurs, start calibration from the beginning by pressing the F2 key.

6.4 PERFORMANCE VERIFICATION

The procedures outlined in the following paragraphs may be used to verify that the instrument is operating within the limits stated in the specifications at the front of this manual. Performance verification may be performed when the instrument is first received to ensure that no damage has occurred during shipment. Verification may also be performed whenever there is a question of instrument accuracy, or following calibration.

NOTE

If the instrument is still under warranty (less than one year from the date of shipment), and its performance falls outside the specified range, contact your Keithley representative or the factory to determine the correct course of action.

6.4.1 Environment Conditions

All measurements should be made at 18-28°C (65-82°F) and at less than 80% relative humidity.

6.4.2 Recommended Test Equipment

Performance verification uses the same equipment that the calibration procedure uses and is listed in Table 6-2. Alternate equipment may be used as long as the equipment substituted has specifications at least as good as those listed in the table.

NOTE

The verification limits in this section do not include tolerances of test equipment or TCs used.

6.4.3 Instrument Preparation

To avoid shutting off the instrument while verifying performance, prepare the Model 740 as explained in paragraph 6.3.3. When performing step 2 of that procedure, connect a Type K female TC connector to the internal channel.

6.4.4 Performance Verification Procedure

Performance verification consists of checking the accuracy of the A/D converter by applying voltage levels to the input, and checking the accuracy of the internal reference junction that has a Type K thermocouple connected to the internal channel.

Perform the following procedure to verify the accuracy of the Model 740:

1. Configure the internal channel of the instrument to make millivolt measurements as explained in paragraph 2.8.1.
2. Short the two copper input leads together as shown in Figure 6-2.
3. After a sufficient amount of settling time, verify that the reading is 0.000 ±3 counts (Table 6-3 lists the allowable readings).
4. Remove the short and connect the DC voltage calibrator to the two copper wires as shown in Figure 6-3. Make sure to observe the proper polarity.
5. Set the calibrator to output +90.000mV.
6. After allowing sufficient time for the reading to settle, verify that the reading is 90.000 ±21 counts.
7. Set the calibrator to output -90.000mV.
8. After allowing sufficient time for the reading to settle, verify that the reading is -90.000 ±21 counts.
9. Disconnect the calibrator from the INPUT CARD and connect the Type K TC to the female TC connector as shown in Figure 6-4. Make sure that the two copper wires do not short together.
10. Place the TC junction in an ice bath. The ice bath should be filled with pea sized ice chips (made from distilled water) and distilled water. As the ice melts, replace the water with more ice.
11. Configure the Model 740 for the type of thermocouple that is connected to the input.
12. After allowing sufficient time for the TC junction to reach 0.0°C, verify that the reading is 0.0°C ±0.5°C.

Table 6-3. Limits for Performance Verification

740 Configuration	Applied to Input	Allowable Readings (18°C-28°C)
mV	Short	−0.003 to 0.003
mV	+90.000mV	89.979 to 90.021
mV	−90.000mV	−90.021 to −89.979

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6.5 DISASSEMBLY INSTRUCTIONS

If it is necessary to remove or replace a component, use the following procedure and refer to Figure 6-5, to disassemble the Model 740. Note that each step of the procedure is dependent on performing the step before it. For example, in order to remove the card cage (step 4), the input card must be removed first (step 3).

WARNING
To prevent a shock hazard, always turn the instrument off and disconnect the line cord and all other instrumentation from the unit before removing the top cover or a scanner card.

1. Remove the top cover as follows:
   A. Remove the top two retaining screws located at the rear of the instrument.
   B. Grasping the top cover at the rear, carefully lift it off of the instrument.
   C. When installing the top cover, make sure that the three tabs located at the front of the cover engage in the front panel assembly. Also, make sure the ground clips at the rear of the instrument are making contact to the top cover shield.
2. If a scanner card is installed, remove it by pulling the locks forward (see Figure 2-5) and sliding the card out of the mainframe.
3. Remove the input card as follows:
   A. At the rear of the card case assembly, there is a plastic card stopper installed through the left side (when viewed from the rear) of the cage. This stopper prevents the input card from being removed from the mainframe. Remove the stopper by inserting a thin blade knife between the plastic head of the stopper and the metal cage, and prying the stopper out.
   B. Unfasten the locking tabs of the input card by pulling the locks forward (see Figure 2-3) and slide the card out of the mainframe.
   C. When reinstalling the input card make sure to use the upper pair of slots for the card edges and remember to replace the plastic stopper after the card is installed in the mainframe.
4. Remove the card cage assembly as follows:
   A. Remove the four screws that secure the card cage assemeby to the mother board.
   B. Lift the card cage assembly out of the instrument.
   C. When reinstalling the card cage assembly, make sure that the interconnect board at the front of the assembly mates properly to the connector on the mother board.
5. Remove the mother board as follows:
   A. Remove the remaining four screws that secure the mother board to the bottom cover.
   B. Remove the two screws at the rear panel that secure the rear panel to the bottom cover.
   C. Disconnect the ribbon cable that connects the display board to the mother board.
   D. Grasp the rear panel and the mother board, and gently lift the mother board toward the rear of the instrument. Now lift the mother board and the rear panel out of the bottom cover.
   E. When reinstalling the mother board, make sure the ground clips on the rear panel are making contact to the bottom shield, and the display ribbon cable is properly mated to mother board connector.
6. Remove the display board from the front panel as follows:
   A. Remove the two screws that secure the front panel assembly to the bottom case. These screws are located under the bottom edge of the display PC board.
   B. Slide the front panel assembly up and out of the bottom case.
   C. Remove the two screws that secure the display board to the front panel. These two screws are located near the top of the display board.
   D. Separate the display board from the front panel.
   E. When reinstalling the display board and front panel, make sure the ground clips located at the bottom of the display board make contact with the display board shield and the bottom cover shield.
7. To reassemble the Model 740, reverse the above procedure steps.

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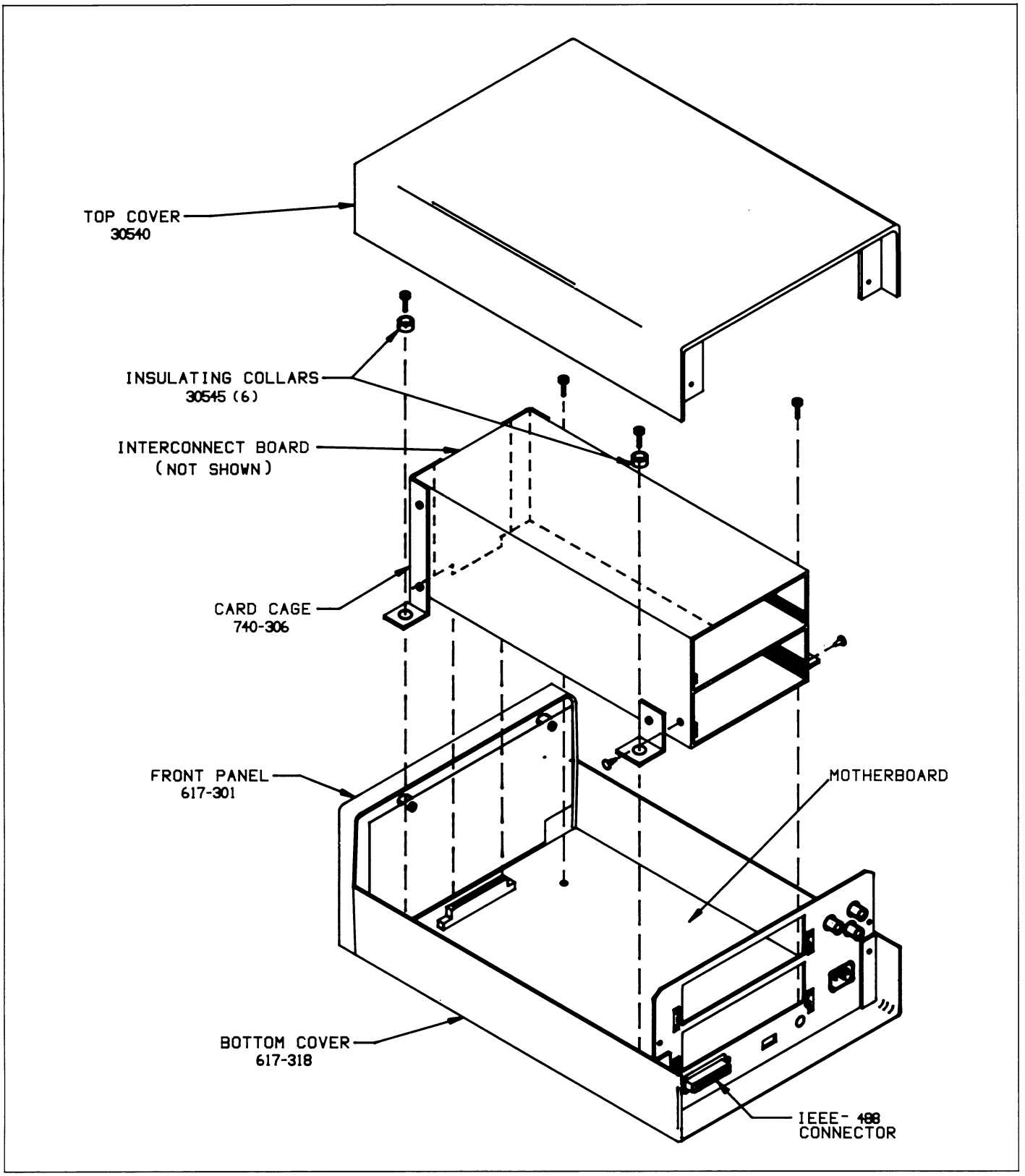


Figure 6-5. Model 740 Exploded View

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6.6 TROUBLESHOOTING

The troubleshooting information contained in this section is intended for use by qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section. Isolation of the specific component is left to the technician. Note that schematic diagrams and component location drawings, which are an essential aid in troubleshooting, are located at the end of Section 7.

6.6.1 Recommended Test Equipment

Success in troublshooting complex equipment like the Model 740 depends not only on the skill of the technician, but relies on the use of accurate, reliable test equipment. Table 6-4 lists the equipment recommended for troubleshooting the Model 740. Other equipment such as logic analyzers and capacitance meters could also be helpful especially in difficult situations.

Table 6-4. Recommended Troubleshooting Equipment

Equipment	Use
Five function DMM with 0.1% basic DCV accuracy, 10M input impedance.	Power supply and DC voltage checks; analog signal tracing, continuity, logic levels.
Dual-trace, triggered sweep oscilloscope, DC to 50MHz.	Digital and analog waveform checks.
Digital Frequency Counter	Checking clock frequencies.

6.6.2 Power-Up Self Test

During the power-up sequence (see paragraph 2.2.3), the instrument performs a self test on NVRAM. Calibration and other instrument parameters are stored in this memory. If the test fails, the power-up sequence will stop and the "UN-CAL" message will be displayed. Perform the following steps to remedy the problem:

1. Perform a complete calibration on the Model 740 as explained in paragraph 6-3.
2. Retest the NVRAM circuitry by performing the NVRAM test in the Self Diagnostic Program as explained in paragraph 6.6.3, steps 1 through 3A.
3. If NVRAM still fails, replace the NVRAM chip (U310) and again recalibrate the instrument.
4. With NVRAM functioning properly, check the following instrument parameters that are stored in this memory and change as necessary:
   A. IEEE status value.
   B. Line frequency setting.
   C. Loop setting.

6.6.3 Self Diagnostic Program

This front panel diagnostic program allows the user to run the memory tests (RAM, ROM and NVRAM), display test, loop test, and to place the instrument in two troubleshooting test modes. Troubleshooting test mode one locks the instrument in the various measurement phases with the A/D converter running. Test mode two locks the instrument in the selected measurement phases with the A/D converter off. These test modes serve to aid the servicing technician in troubleshooting the instrument. While test one checks the overall functional status of the instrument, test two limits testing to the analog circuitry. Perform the following procedure to use the self diagnostic program:

1. With the instrument off and the line cord disconnected, connect the DC voltage calibrator to the input of the Model 740. Make sure that the calibrator is in the standby mode at this time.
2. While holding in the ENTER button, power up the instrument. Continue to hold the ENTER button in until the software revision level is displayed. For example, if the software revision level is A.7, the following message will be displayed briefly:

   REV A.7

   The following message will then be displayed:

   SELFTEST

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3. Perform any or all of the following tests. The keys used to select the tests are shown in Figure 6-6.
   A. To test the display segments and the indicator lights, press the FILTER button. All the display segments and indicator lights should turn on for a short period of time.
   B. To test NVRAM circuitry where calibration constants and other instrument parameters are stored, press the ▼ button. Depending on the success of the test, one of the following messages will be displayed briefly before returning to the "SELFTEST" message.

      NVRAM OK
      NVRAMBAD

      If the test failed, try to remedy the problem by following the procedure given in paragraph 6.6.2.
   C. To perform a digital test on the ROM circuitry, press the ▲ button. Depending on the success of the test, one of the following messages will be displayed briefly before returning to the "SELF TEST" message.

      ROM OK
      ROM BAD

      If the test failed, replacing U105 or U106 may resolve the problem.
   D. A loop test is available to check the circuitry used to control external scanner cards. To perform the loop test, connect a male-to-male BNC cable from the SERIAL OUT connector to the SERIAL IN connector and press the °C/°F button. Depending on the outcome of the test, one of the following messages will be displayed briefly:

      LOOP OK
      LOOP BAD

      NOTE: Do not perform the loop test with the Model 740 connected to the Model 705 or Model 706 scanner(s) as it will cause the scanner(s) to lock up.

4. To place the instrument in troubleshooting test mode one, perform the following procedure:
   A. Press the PROGRAM button until the following messages is displayed:

      A/DTEST1

      The instrument will now operate with just the signal multiplexer FET on as indicated by the "SI" suffix on the display.
   B. Set the DC calibrator to output +50mV. The following approximate reading will then be displayed:

      50.000 SI
   C. The various measurement phases and corresponding readings are selected with the ▲ and ▼ buttons. Table 6-5 summarizes circuit conditions and expected readings for each measurement phase.
5. To place the instrument in troubleshooting test mode two, perform the following procedure:
   A. Press the PROGRAM button until the following message is displayed:

      A/DTEST2

      The multiplexer will then lock up with just the signal FET on. The A/D converter is not running in this test mode.
   B. Set the calibrator to output a voltage in the measurement range of the instrument (−99.999mV to 100.000mV).
   C. The various measurement phases can be selected with the ▲ and ▼ buttons allowing the measurement levels to be easily traced to the output of the input buffer amplifier. Table 6-5 summarizes circuit conditions for the various measurement phases.
6. To exit the diagnostic program, press the ENTER button.

Notes:
1. Any of the alternate tests can be selected at any time by pressing the PROGRAM button.
2. The front panel filter is operational in the A/D tests.
3. The diagnostic program can be exited at any time by pressing the ENTER button.

6.6.4 Power Supply Checks

Table 6-6 shows the various checks tat can be made to the power supplies of the Model 740. In addition to the normal voltage checks, it is a good idea to check the various supplies with an oscilloscope for signs of noise or oscillation.

6.6.5 Digital and Display Circuitry Checks

The digital and display circuitry can be checked out by using the troubleshooting data found in Tables 6-7 and 6-8.

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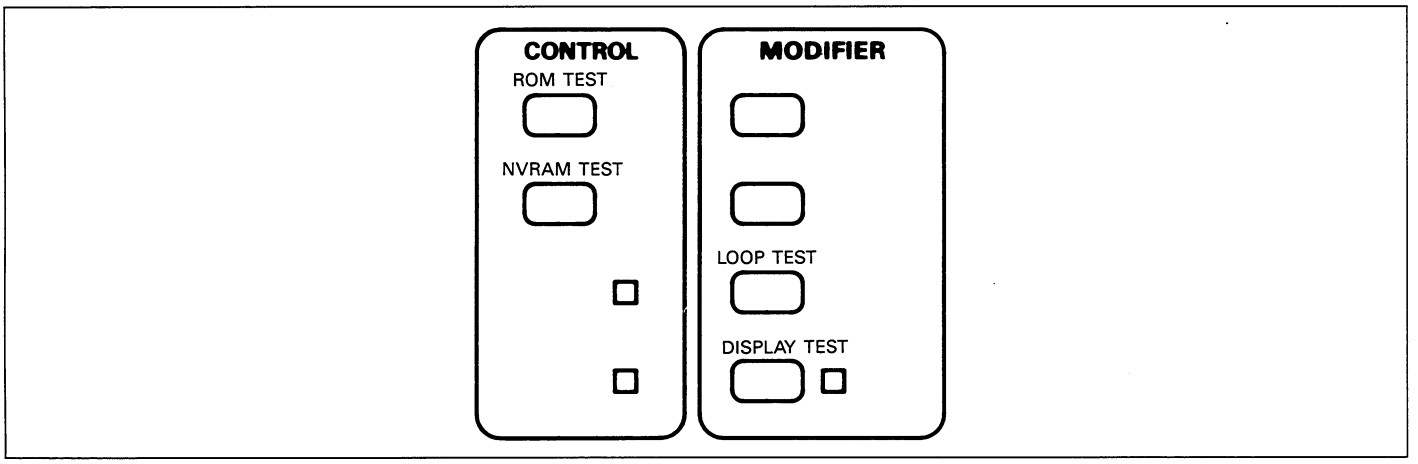


Figure 6-6. Self Test Key Identification

Table 6-5. Troubleshooting Test Modes

Measurement Phase	Multiplexing FET on	Buffer Amp Gain (U301)	Test 1 Typical Display Readings*	Test 2 Display Messages
Signal	Q303	x20	50.000 SI**	SIGNAL
Zero	Q304	x20	0.000 ZE	ZERO
Reference	Q306	x20	100.000 RE	100mVREF
Reference Junction	Q305	x20	60.000 RJ	REFJUNCT
Open TC	Q309	x20	—	OPENTC

*These are approximate readings intended only to indicate if the associated circuitry is operational.

**Approximate reading with +50mV on the input.

Table 6-6. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
1	S101 Line Switch	Set to 115 or 230V as required.	Line voltage selection.
2	F101 Line Fuse	Check for continuity.	Remove fuse to check.
3	Line Power	Plugged into live receptacle; power on.	
4	+5V Digital Supply VR101, pin 2	+5V, ±5%	Referenced to digital common.
5	+5V Analog Supply VR102, pin 2	+5V, ±5%	Referenced to analog common.
6	±15V Analog Supplies VR103 pin 2; VR104, pin 2	+15V, −15V, ±5V	Referenced to analog common.

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Table 6-7. Digital Circuitry Checks

Step	Item/Component	Required Condition	Remarks
1	U107, U105, U310	Pass RAM, PROM and NVRAM self-test on power-up.	Display will lock if failure occurs.
2	U109, pin 2 (PA0)	TTL level pulses every 1msec.	VIA clock
3	U109, pin 3 (PA1)	TTL level pulses every 15msec	Data
4	U109, pin 6 (PA4)	Switch data (+5V or 0V)	Data input to VIA
5	U109, pin 7 (PA5)	Switch data (+5V or 0V)	Data input to VIA
6	U109, pin 8 (PA6)	Switch data (+5V or 0V)	Data input to VIA
7	U109, pin 9 (PA7)	Switch data (+5V or 0V)	Data input to VIA
8	U109, pin 19	Variable pulse train (0V to +5V)	VIA Data Line
9	U120, pin 6	Variable pulse train (0V to +5V)	Data Output
10	U324, pin 13	Variable pulse train (0V to +5V)	Output of A/D Converter
11	U109, pins 12 through 16	Variable pulse train (0V to +5V)	Analog data to VIA
12	U104, pin 3	1kHz pulses	IRQ line
13	U104, pin 37	+5V, ±5%	Reset line
14	U104, pin 9	+5V signal pulsed 0V to +5V every 1msec.	INT line
15	U112, pin 19	+5V (Logic "1")	RESET line
16	U112, pin 18	2MHz square wave at 0V to +5V	clock
17	U112, pin 28	Should go false (+5V) when command is sent.	ATN line
18	U112, pins 28 (ATN), 24 (NDAC), 25 (NRFD), 26 (DAV), and the data lines.	Refer to Figure 3-2 for required conditions.	Handshake Sequence

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Table 6-8. Display Circuitry Checks

Step	Item/Component	Required Condition	Remarks
1	U204, pin 2	+5V, ±5%	+5V supply
2	Q201, pins 1, 7, 8 and 14	Variable pulses	Segment drivers
3	Q202, pins 1, 7 and 14	Variable pulses	Segment drivers
4	Q203, pins 1, 7, 8 and 14	Variable pulses	Segment drivers
5	Q204, pins 1, 7, 8 and 14	Variable pulses	Segment drivers
6	U201, pins 11, 13, 15 and 16	Variable pulses	Digital drivers
	U202, pins 10, 13, 14 and 15	Variable pulses	Digital drivers
7	U203, pins 3, 4, 5, 6, 10 and 11	1msec negative going pulse every 10msec.	
8	U204, pins 3 and 4	1msec negative going pulse every 10msec.	
9	P1008, pin 7	Depress SW201, SW218, SW212, SW202 or SW207.	Pulse present when button pressed.
10	P1008, pin 5	Depress SW219, SW215, SW205 or SW210.	Pulse present when button pressed.
11	P1008, pin 3	Depress SW216, SW211, SW204 or SW209.	Pulse present when button pressed.
12	P1008, pin 6	Depress SW206, SW213, SW203 or SW208.	Pulse present when button pressed.

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6.7 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

CMOS devices operate at very high impedance levels for low power consumption. As a result, any static charge that builds up on your person or clothing may be sufficient to destroy these devices, if they are not handled properly. Table 6-9 lists static-sensitive devices used in the Model 740. When handling these devices, use the following precautions to avoid damaging them.

1. The devices listed in the table should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in anti-static containers of plastic or foam. Keep these devices in their original containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist strap.
3. Handle the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only anti-static type solder suckers.
6. Use only grounded tip solder irons.
7. Once the device is installed on the PC board, it is normally adequately protected and normal handling can resume.

Table 6-9. Static Sensitive Devices

Circuit Designation	Keithley Part No.
Q102	TG-84
U102	IC-399
U105	740-800**
U106	740-801**
U107	LSI-66
U108	LSI-72
U109	LSI-45
U110, U111, U116, U118	IC-397
U120	IC-351
U121	IC-103
U122	IC-330
Q301, Q302, Q309, Q310, Q315	TG-128
Q312	TG-175
U303, U325, U326	IC-413
U308, U309	IC-251
U311, U323	IC-351
U312, U314	IC-283
U313	31847-1
U315	IC-414
U316	IC-343
U317, U318, U319	IC-337
U320	IC-417
U321, U322	IC-416
U324	IC-412

**Software Revision Level.

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SECTION 7
REPLACEABLE PARTS

7.1 INTRODUCTION

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 740 System Scanning Thermometer.

7.2 ELECTRICAL PARTS LISTS

Electrical parts for the various circuit boards are listed in Tables 7-1 through 7-4. Parts in each table are listed alphabetically in order of circuit designation. The parts lists are integrated with the component layout drawings and schematic diagrams for the respective circuit boards.

7.3 MECHANICAL PARTS

Miscellaneous mechanical parts are listed in Table 7-5.

7.4 ORDERING INFORMATION

Keithley Instruments, Inc maintains a complete inventory of all normal replacement parts. To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory.

When ordering parts, include the following information.

1. Instrument model number
2. Instrument serial number
3. Part description
4. Circuit designation, including schematic diagram and component layout numbers (if applicable)
5. Keithley part number

7.5 FACTORY SERVICE

If the instrument is to be returned to the factory for service, carefully pack the unit and include the following:

1. Complete the service form which follows this section and return it with the instrument.
2. Advise as to the warranty status of the instrument (see the inside front cover for warranty information).
3. Write the following on the shipping label: ATTENTION REPAIR DEPARTMENT.

7.6 COMPONENT LOCATION DRAWINGS AND SCHEMATIC DIAGRAMS

Component location drawings and schematic diagrams for the various circuit boards can be found on the following pages in the following order:

1. Analog board.
2. Mother board.
3. Display board.
4. Connectors parts list.

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Table 7-1. Analog Board, Parts List

Circuit Desig.	Description	Schematic Location Page/Zone	Keithley Part No.
C301	Capacitor, 0.0039μF, 50V, Metalized Polypropylene	1/B2	C-269-.0039
C302	Capacitor, 0.1μF, 50V	1/D1	C-365-.1
C303	Capacitor, 0.1μF, 50V	1/D2	C-365-.1
C304	Capacitor, 0.0039μF, 50V, Metalized Polypropylene	1/D3	C-269-1.0
C305	Capacitor, 0.0039μF, 50V, Metalized Polypropylene	1/D3	C-269-.68
C306	Capacitor, 0.68μF, 50V, Metalized Polyester	1/D4	C-344-.68
C307	Not Used		
C308	Capacitor, 0.1μF, 50V	1/D3	C-365-.1
C309	Capacitor, 0.1μF, 50V	1/E3	C-365-.1
C310	Capacitor, 1μF, 50V, Ceramic Film	1/F2	C-237-1
C311	Not Used		
C312	Capacitor, 1μF, 50V, Ceramic Film	1/F1	C-237-1
C313	Capacitor, 1μF, 50V, Ceramic Film	1/F4	C-237-1
C314	Not Used		
C315	Capacitor, 0.1μF, 50V	1/A6	C-365-.1
C316	Not Used		
C317	Capacitor, 0.1μF, 50V	2/F1	C-365-.1
C318	Capacitor, 0.0047μF, 100V, Metalized Polypropylene	2/E1	C-306-.0047
C319	Capacitor, 15pF, 1000V, Ceramic Disc	2/E1	C-64-15p
C320	Capacitor, 82pF, 1000V, Ceramic Disc	2/E2	C-64-82p
C321	Capacitor, 0.1μF, 50V	2/D1	C-365-.1
C322	Capacitor, 0.1μF, 50V	2/D2	C-365-.1
C323	Capacitor, 1000pF, 1000V, Ceramic Disc	2/B1	C-64-1000p
C324	Capacitor, 0.1μF, 50V	2/B2	C-365-.1
C325	Capacitor, 10μF, 25V, Aluminum Electrolytic	2/C3	C-314-10
C326	Capacitor, 0.1μF, 50V	2/D3	C-365-.1
C327	Capacitor, 0.1μF, 50V	2/F3	C-365-.1
C328	Capacitor, 0.1μF, 50V	2/A4	C-365-.1
C329	Capacitor, 150pF, 1000V, Ceramic Disc	2/A4	C-64-150p
C330	Capacitor, 150pF, 1000V, Ceramic Disc	2/B5	C-64-100p
C331	Capacitor, 0.1μF, 50V	2/B4	C-365-.1
C332	Capacitor, 1μF, 50V, Ceramic Film	2/F4	C-237-1
C333	Capacitor, 0.1μF, 50V	2/F4	C-365-.1
C334	Capacitor, 0.1μF, 50V	2/G4	C-365-.1
C335	Capacitor, 0.1μF, 50V	2/G4	C-365-.1
C336	Capacitor, 1μF, 50V, Ceramic Film	2/F5	C-237-1
C337	Capacitor, 1μF, 50V, Ceramic Film	2/F5	C-237-1
C338	Capacitor, 0.1μF, 50V	2/D1	C-365-.1
C339	Capacitor, 0.1μF, 50V	2/C2	C-365-.1
C340	Capacitor, 0.1μF, 50V	2/H3	C-365-.1
C341	Capacitor, 0.1μF, 50V	2/C5	C-365-.1
C342	Capacitor, 0.1μF, 50V	2/C4	C-365-.1
C343	Capacitor, 0.1μF, 50V	2/E5	C-365-.1
C344	Capacitor, 0.1μF, 50V	1/B3	C-365-.1
C345	Capacitor, 0.1μF, 50V	1/C5	C-365-.1
C346	Capacitor, 0.1μF, 50V	1/C6	C-365-.1
C347	Capacitor, 0.1μF, 50V	1/B6	C-365-.1
C348	Capacitor, 330pF, 1000V, Ceramic Disc	2/F3	C-64-330p
C349	Capacitor, 150pF, 1000V, Ceramic Disc	1/D3	C-64-150p
C350	Not Used		

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Table 7-1. Analog Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location Page/Zone	Keithley Part No.
C351	Capacitor, 47pF, 1000V, Ceramic Disc	2/A5	C-64-47p
C352	Capacitor, 330pF, 1000V, Ceramic Disc	1/A6	C-64-330p
C353	Capacitor, 330pF, 1000V, Ceramic Disc	2/B4	C-64-330p
C354	Capacitor, 0.1μF, 50V	1/F5	C-365-.1
C355	Capacitor, 0.1μF, 50V	1/F6	C-365-.1
C356	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F5	C-314-10
C357	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F6	C-314-10
CR301	Zener Diode, 1N4579	1/F2	DZ-73
L301	100μH	2/B4	CH-14
L302	Choke	1/A2	CH-30
Q301	Transistor, N-Channel JFET, 2N4392	1/B3	TG-128
Q302	Transistor, N-Channel JFET, 2N4392	1/B2	TG-128
Q303	Transistor, P-Channel JFET, J270	1/B1	TG-166
Q304	Transistor, P-Channel JFET, J270	1/B2	TG-166
Q305	Transistor, P-Channel JFET, J270	1/B2	TG-166
Q306	Transistor, P-Channel JFET, J270	1/B3	TG-166
Q307	Transistor, P-Channel JFET, J270	1/C2	TG-166
Q308	Transistor, P-Channel JFET, J270	1/C2	TG-166
Q309	Transistor, N-Channel JFET, 2N4392	1/B1	TG-128
Q310	Transistor, N-Channel JFET, 2N4392	2/F2	TG-128
Q311	Transistor, N-Channel JFET, 2N5434	2/F2	TG-174
Q312	Transistor, JFET, MP842	2/E2	TG-175
Q313	Transistor, N-Channel JFET, J210	2/B5	TG-167
Q314	Transistor, NPN, Silicon, 2N3904	2/G4	TG-47
Q315	Transistor, N-Channel JFET, 2N4392	1/B1	TG-128
R301	Resistor, 10kΩ, 5%, 6.5W, Wirewound	1/A1	R-336-10k
R302	Resistor, 10kΩ, 1%, 1/8W, Metal Film	1/B2	R-88-10k
R303	Resistor, 9.76kΩ, 1%, 1/8W, Metal Film	1/B2	R-88-9.76k
R304	Resistor, 9.09kΩ, 1%, 1/8W, Metal Film	1/B3	R-88-9.09k
R305	Resistor, 10kΩ, 5%, ¼W, Composition	1/C2	R-76-10k
R306	Resistor, 91kΩ, 10%, 1W, Composition	1/A1	R-2-91k
R307	Resistor, 9.53kΩ, 1%, 1/8W, Metal Film	1/D2	R-88-9.53k
R308	Resistor, 511Ω, 1%, 1/8, Metal Film	1/D2	R-88-511
R309	Resistor, 5.23kΩ, 1%, 1/8, Metal Film	1/D3	R-88-5.23k
R310	Resistor, 10.5kΩ, 1%, 1/8, Metal Film	1/D3	R-88-10.5k
R311	Resistor, 9.97kΩ, 0.1%, 1/8, Metal Film	1/E1	R-176-9.97k
R312	Resistor, 4.99kΩ, 0.1%, 1/8, Metal Film	1/F1	R-176-4.99k
R313	Resistor, 991Ω, 0.1%, 1/8, Metal Film	1/F2	R-176-991
R314	Resistor Set, 63.1kΩ, 1kΩ, 0.1%, Precision Wirewound	1/E2	R-335
R315	Resistor, 205Ω, 0.1%, 1/10W, Metal Film	1/F5	R-263-205
R316	Not Used		
R317	Not Used		
R318	Not Used		
R319	Not Used		
R320	Not Used		
R321	Not Used		

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Table 7-1. Analog Board, Parts List (Cont.)

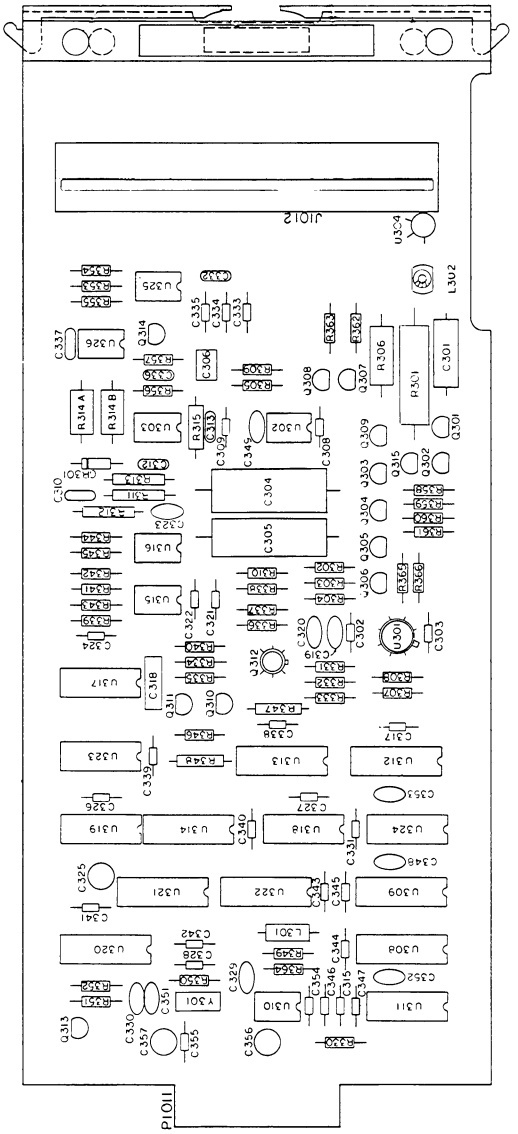
Circuit Desig.	Description	Schematic Location Page/Zone	Keithley Part No.
R322	Not Used		
R323	Not Used		
R324	Not Used		
R325	Not Used		
R326	Not Used		
R327	Not Used		
R328	Not Used		
R329	Not Used		
R330	Resistor, 82Ω, 5%, ¼W, Composition	1/A6	R-76-82
R331	Resistor, 11.5kΩ, 1%, 1/8W, Metal Film	2/G1	R-88-11.5k
R332	Resistor, 60.4kΩ, 1%, 1/8W, Metal Film	2/G2	R-88-60.4k
R333	Resistor, 48.7kΩ, 1%, 1/8W, Metal Film	2/G2	R-88-48.7k
R334	Resistor, 10kΩ, 5%, ¼W, Composition	2/F2	R-76-10k
R335	Resistor, 10kΩ, 5%, ¼W, Composition	2/F2	R-76-10k
R336	Resistor, 20kΩ, 1%, 1/8W, Metal Film	2/E1	R-88-20k
R337	Resistor, 20kΩ, 1%, 1/8W, Metal Film	2/E1	R-88-20k
R338	Resistor, 60.4kΩ, 1%, 1/8W, Metal Film	2/E2	R-88-60.4k
R339	Resistor, 10kΩ, 5%, ¼W, Composition	2/D1	R-76-10k
R340	Resistor, 3.9kΩ, 5%, ¼W, Composition	2/D1	R-76-3.9k
R341	Resistor, 3kΩ, 5%, ¼W, Composition	2/C2	R-76-3k
R342	Resistor, 3kΩ, 5%, ¼W, Composition	2/C2	R-76-3k
R343	Resistor, 10kΩ, 5%, ¼W, Composition	2/C2	R-76-10k
R344	Resistor, 10kΩ, 5%, ¼W, Composition	2/A1	R-76-10k
R345	Resistor, 220kΩ, 5%, ¼W, Composition	2/A1	R-76-220k
R346	Resistor, 7.87kΩ, 1%, 1/8W, Metal Film	2/C3	R-88-7.87k
R347	Resistor, 1MΩ, 0.1%, 1/8W, Metal Film		R-176-1M
R348	Resistor, 7.78kΩ, 0.1%, 1/8W, Metal Film	2/F3	R-176-7.78k
R349	Resistor, 22Ω, 5%, ¼W, Composition	2/A4	R-76-22
R350	Resistor, 10MΩ, 5%, ¼W, Composition	2/A5	R-76-10M
R351	Resistor, 4.7kΩ, 5%, ¼W, Composition	2/B4	R-76-4.7k
R352	Resistor, 4.7kΩ, 5%, ¼W, Composition	2/B5	R-76-4.7k
R353	Resistor, 2.15kΩ, 1%, 1/8W, Metal Film	2/F4	R-88-2.15k
R354	Resistor, 7.87kΩ, 1%, 1/8W, Metal Film	2/F4	R-88-7.87k
R355	Resistor, 1kΩ, 5%, ¼W, Composition	2/G4	R-76-1k
R356	Resistor, 10kΩ, 1%, 1/8W, Metal Film	2/F5	R-88-10k
R357	Resistor, 15.4kΩ, 1%, 1/8W, Metal Film	2/G5	R-88-15.4k
R358	Resistor, 1MΩ, 5%, ¼W, Composition	1/B2	R-76-1M
R359	Resistor, 1MΩ, 5%, ¼W, Composition	1/B2	R-76-1M
R360	Resistor, 1MΩ, 5%, ¼W, Composition	1/B2	R-76-1M
R361	Resistor, 1MΩ, 5%, ¼W, Composition	1/B3	R-76-1M
R362	Resistor, 1MΩ, 5%, ¼W, Composition	1/C2	R-76-1M
R363	Resistor, 1M,Ω, 5%, ¼W, Composition	1/C2	R-76-1M
R364	Resistor, 100kΩ, 5%, ¼W, Composition	1/B6	R-76-100k
R365	Resistor, 10kΩ, 5%, ¼W, Composition	1/C1	R-76-10k
R366	Resistor, 10kΩ, 5%, ¼W, Composition	1/D2	R-76-10k
U301	Low Noise Op Amp, LT1012	1/D1	IC-457
U302	Selected Operational Amplifier, LF351	1/D3	IC-203
U303	General Purpose Operational Amplifier, 5502DP	1/F1	IC-413
U304	Temperature Transducer, 590kH	1/F4	IC-447

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Table 7-1. Analog Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location Page/Zone	Keithley Part No.
U305	Not Used		
U306	Not Used		
U307	Not Used		
U308	8 Stage Shift/Store Register, 14094BCP	1/C3	IC-251
U309	8 Stage Shift/Store Register, 14094BCP	1/C4	IC-251
U310	16 × 16 Bit Serial Nonvolative Static RAM, 2443P	1/C6	IC-353
U311	Quad 2-Input NAND Gate, 74HC00	1/B6	IC-351
U312	Triple 2-Channel Analog Multiplexer, CD4053	2/F1	IC-283
U313	Selected IC-283	2/E3	31847-1
U314	Triple 2-Channel Analog Multiplexer, CD4053	2/A2	IC-283
U315	Inverting High Speed Operational Amplifier, 5501CP	2/D1	IC-414
U316	Dual Voltage Comparator, LM393	2/B1	IC-343
U317	Dual D Flip-Flop, 74HC74	2/B2	IC-337
U318	Dual D Flip-Flop, 74HC74	2/B2	IC-337
U319	Dual D Flip-Flop, 74HC74	2/D3	IC-337
U320	Synchronous Decade Up/Down Counter, 74HC192	2/C5	IC-417
U321	Synchronous Binary Up/Down Counter, 74HC193	2/D5	IC-416
U322	Synchronous Binary Up/Down Counter, 74HC193	2/E5	IC-416
U323	Quad 2-Input NAND Gate, 74HC00	2/B2	IC-351
U324	Integrated Circuit, 74HC02	2/D4	IC-412
U325	General Purpose Operational Amplifier, 5502DP	2/G4	IC-413
U326	General Purpose Operational Amplifier, 5502DP	2/G5	IC-413
Y301	Crystal, 3.84MHz	2/A4	CR-13

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ZONE	LTR	ECO NO	REVISION	ENG	DATE
	A	10669	RELEASED	HS	5/2/85
	B	10782	DELETED C320 (0.1uF, 100V, 10%) FROM PWB ASSY. ADDED C320 (0.1uF, 100V, 10%) WITH JUMPER	JB	7/25/85
	C	10910	ITEM #132 WAS CH-250 SET FOR	JB	9/27/85
	D	10905	CHG'D ITEMS 116-119 FROM R-28-11 TO R-28-26 AT (A6538-A361) ADDED ITEM 155	JB	10-28-85
	E	12487	CHG'D U-32 X VL PDN STND TO L-32 X 9/16 PDN STND	JB	12-7-87

Figure 7-1. Analog Board, Component Location Drawing, Dwg. No. 740-120

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