Model 7002-HD High Density Switch System

Reference Manual

7002HD-901-01 Rev. A / November 2004

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WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

Revision A (Document Number 7002HD-901-01) .....November 2004

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high transient over-voltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting ca-

bles or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol indicates a connection terminal to the equipment frame.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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1 General Information

Section 1 topics

Introduction

This section contains general information about the Model 7002-HD High Density Switch System.

Features

Key features include:

- **High Density Switching** — Up to 400 channels (or matrix crosspoints) per mainframe using only two switching cards in the CARD 1 and CARD 2 locations. (Slots 1 through 5 are mapped to CARD 1, and slots 6 through 10 are mapped to CARD 2.)
- **Analog Backplane** — Can be used to internally connect the rows or banks of a Model 7002-HD series card installed in one slot to the rows or banks of the Model 7002-HD series cards installed in the other slot.
- **Close/Open or Scan** — The Model 7002-HD can close and/or open one or more channels, or scan through a specified list of channels.
- **Memory** — Up to 500 channel patterns (pattern of open and closed channels) and 10 customized instrument setups can be saved in memory for later recall.
- **IEEE-488 Bus** — Bus operation conforms to the IEEE-488.2 and SCPI standards.
- **Trigger Link** — Trigger link provides more versatile and precise external triggering.

Warranty information

Warranty information is located on the inside front cover of this manual. Should your Model 7002-HD require warranty service, contact the Keithley representative or authorized repair facility in your area for more information. When returning the card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.

Manual addenda

Any improvements or changes concerning the manual will be explained in an addendum included with the instrument.

Return to **Section 1 topics**

Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

If a  screw is present, connect it to safety earth ground using the wire recommended in the documentation.

The  symbol on equipment indicates that you should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol indicates a connection terminal to the equipment frame.

The **WARNING** heading used in this manual explains dangers that could result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the multiplexer card. Such damage may invalidate the warranty.

Specifications

Model 7002-HD specifications are located at the end of this manual.

Unpacking and inspection

Inspection for damage

The Model 7002-HD 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 immediately. Save the original packing carton for possible future reshipment.

Shipment contents

The following items are included with every order:

- Model 7002-HD High Density Switch System
- Hardcopy of the Model 7002-HD User's Manual
- PDFs of the Model 7002-HD User's and Reference Manuals on CD-ROM
- Additional accessories as ordered

Return to **Section 1 topics**

Manuals

If additional Model 7002-HD manuals are required, order the manual package, Keithley part number 7002HD-900-00. The manual package includes manuals and any pertinent addenda.

Repacking for shipment

Should it become necessary to return the Model 7002-HD for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Advise as to the warranty status of the card.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.
- Fill out and include the service form located at the back of this manual.

Maximum channel capacity

200 channels per card slot

A single Model 7002-HD mainframe can accommodate up to two 200-channel cards. This provides up to 400 channels in a single half-rack package (89mm or 3.5 in. high). This density level provides important advantages:

- Reduces the amount of switching hardware required for a given application.
- Provides high flexibility. The high density cards can be used with special signal cards to cover all your signal needs for a large application with one mainframe.

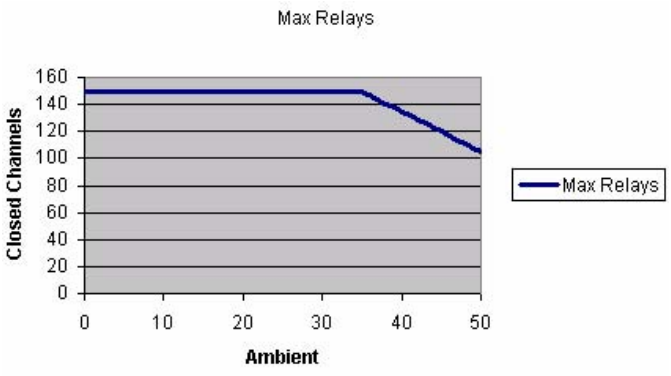
Relay drive considerations

The Model 7002-HD delivers up to 5A of relay drive for both card openings. The maximum number of channels that can be closed at one time depends on the relay drive current for each channel. For example, for the Model 7002-HD and two Model 7002-HD-MUX1 cards, a total of 150 channels can be closed at one time. The 150 channels can be closed on a single card or divided over two cards.

Return to **Section 1 topics**

The Model 7002-HD internal temperature rise must be <85°C to achieve the rated accuracy and warranty. The internal temperature rise is dependent on the number of closed channels and ambient temperature. For reliable operation of the Model 7002-HD, do not exceed the maximum number of closed channels, with respect to ambient temperature, as shown in Figure 1-1.

Figure 1-1
Closed channels and ambient temperature (°C)



Optional accessories

The following accessories are available from Keithley for use with the Model 7002-HD:

- **Model 7002-HD-MTX1 6 x 32 Differential Matrix Card** — Provides differential matrix switching configured with 6 rows by 32 columns. The card can be expanded for 6 x 64 matrix switching using a second card and is capable of 200VDC or 200Vrms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum.
- **Model 7002-HD-MUX1 Quad 1 x 40 Differential Multiplexer Card** — Provides differential quad 1 x 40 multiplexers with programmable multiplex expansion and matrix input switching. The card can be expanded for 1 x 80 and 1 x 160 configurations using built-in matrix switching (can be expanded to 1 x 320 using a second card) and is capable of 200VDC or 200Vrms (283V peak for AC waveforms), 1A switched, 60W, 125VA maximum.

Return to **Section 1 topics**

2 Installation

Section 2 topics

Introduction

WARNING **The following information is intended for qualified service personnel. Do not perform these procedures unless qualified to do so.**

To prevent electric shock that could result in serious injury or death, adhere to following safety precautions:

- **Before removing or installing a card in the Model 7002-HD mainframe, make sure the mainframe power is turned off and disconnected from line power.**
- **Before making or breaking connections, make sure power is removed from all external circuitry.**

This section includes information on installing cards in the Model 7002-HD High Density Switch System and the procedure for rack mounting the Model 7002-HD.

Return to **Section 2 topics**

Card installation and removal

The following paragraphs describe how to install and remove cards from the Model 7002-HD mainframe.

WARNING **Installation or removal of Model 7002-HD cards should be performed by qualified service personnel only. Failure to recognize and observe standard safety precautions could result in personal injury or death.**

CAUTION **To prevent performance degradation caused by contamination, handle the card only by the edges and covers.**

NOTE Make sure your external circuitry is wired to the card (as explained in the manual for the card) before installing the card in the Model 7002-HD mainframe.

Card installation

After connecting the input/output cables, perform the following steps, and refer to Figure 2-1 to install the card assembly in the Model 7002-HD mainframe in either the Card 1 or Card 2 location.

WARNING **Turn off power to all instrumentation (including the Model 7002-HD), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.**

1. Slide the card edges into the guide rails inside the mainframe.
2. Carefully push the card all the way forward to seat it fully in the connectors.
3. Make sure the captive screws are securely in place.

Return to **Section 2 topics**

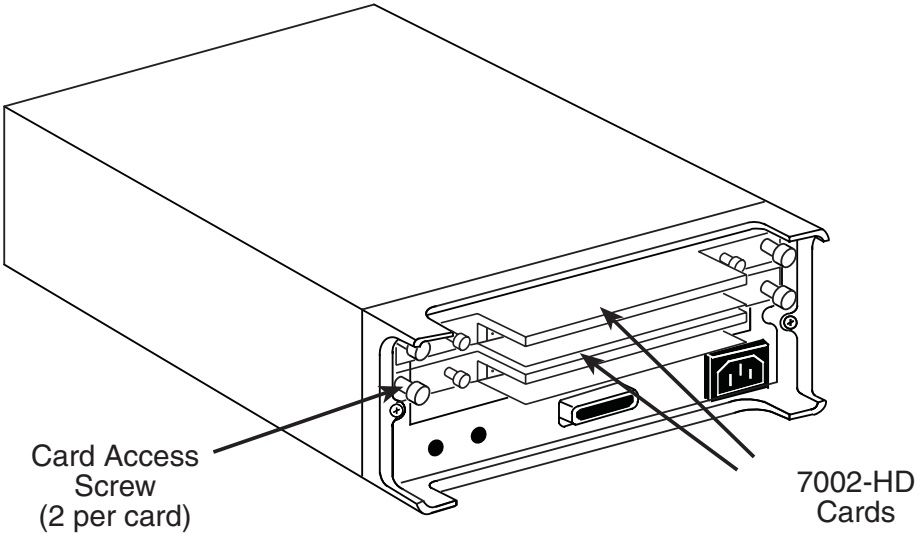
Card removal

Follow the steps below to remove the card from the mainframe.

WARNING **Turn off power to all instrumentation (including the Model 7002-HD), and disconnect all line cords. Make sure all power is removed and any stored energy in external circuitry is discharged.**

1. Loosen the captive screws that secure the card.
2. Pull out on the card until it pulls free from the internal connector.
3. Carefully slide the card out of the switching mainframe.

Figure 2-1
Card installation in Model 7002-HD mainframe



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Rack mount instructions

The Model 7002-HD mainframe can be mounted in a standard 19-inch equipment rack.

WARNING **When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.**

Rack mount hardware

Table 2-1 summarizes front support brackets. For mainframes that have one or two switching modules installed, rear support may be necessary. The Model 7002-HD includes brackets and associated hardware to provide rear support (Table 2-2).

Table 2-1
Front support bracket (Model 4288-2 dual fixed rack mounting kit parts)

Qty	Description	Keithley P/N
2	Rack Ear	4288-1-301
2	Middle Bracket	4288-2-301
4	#6-32 x 5/8 inch Slotted Headless Set Screw	6-32X5/8SLHLSET
4	#8-32 x 3/8 inch Phillips Flat Head Screw	8-32X3/8PFH
4	#8-32 x 3/8 inch Phillips Pan Head Screw	8-32X3/8PPH
4	#10-32 x 5/8 inch Phillips Truss Head Screw	10-32X5/8PHTRHD
4	Fastener	FA-148
1	Label	MC-345

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Table 2-2
Rear support bracket (Model 7002-HD dual fixed rack mounting kit parts)

Qty	Description	Keithley P/N
4	Fasteners	FA-148
4	#10-32 x 5/8 inch Phillips Truss Head Screw	10-32X5/8PHTRSH
1	Rear Support Bracket (Left)	S40-SQ00-331
1	Rear Support Bracket (Right)	S40-SQ00-332
8	#8-32 x 3/8 inch Phillips Truss Head Screw	8-32X3/8PHTRHD

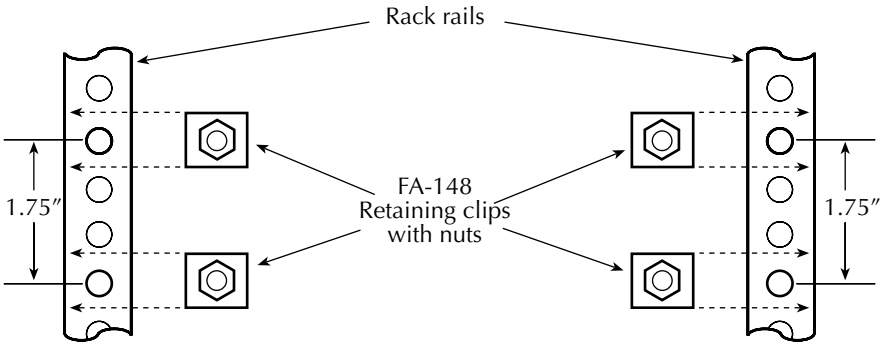
Rack mount procedure

WARNING **Make sure the Model 7002-HD is turned off, the line cord is disconnected, and it is not connected to any external circuitry.**

Front support assembly installation

1. Select a location in the rack. The mainframe takes up 3½ inches of vertical space.
2. Using Figure 2-2 as a guide, install the eight retaining clips on the front and rear rack rails. Slide each retaining clip over a mounting hole so the captive nut is positioned on the inside of the rack cabinet.

Figure 2-2
Rack preparation



3. Remove and discard the 8-32X3/8PHTRHD (2) screw from each side of the Model 7002-HD (see Figure 2-3).

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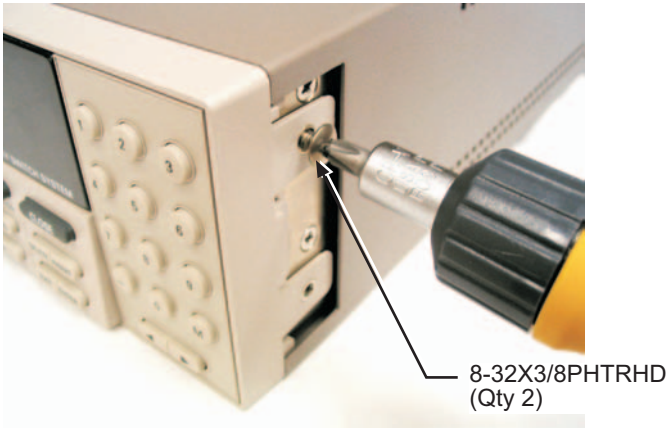
Figure 2-3
Model 7002-HD preparation for rack mounting



Rear support assembly

1. Select which side of the Model 7002-HD the S40-SQ00-33X rear rack arm will be mounted.
2. If mounting on the left side of the Model 7002-HD, use the left supporting bracket (S40-SQ00-331) and secure to the left side of one instrument using #8-32x3/8 inch Phillips **Truss** Head screws (#8-32X3/8PHTRHD). Refer to Figure 2-4 on page 2-9.
3. If mounting on the right side of the Model 7002-HD, use the right supporting bracket (S40-SQ00-332) and secure to the right side of the instrument using #8-32x3/8 inch Phillips **Truss** Head screws (#8-32X3/8PHTRHD). Refer to Figure 2-5 on page 2-10.

Front support assembly

1. Connect the instruments together:
   - Line up the front panels of both instruments.
   - Attach one-half of the middle bracket (4288-2-301) to each instrument so the brackets are between the instruments' sides.
   - Secure using the #8-32x3/8 inch Phillips **Flat** Head screws (8-32X3/8PFH).
2. Bring the two instruments together lining up the holes in the middle bracket.
3. Connect the middle bracket together with #6-32 set screws (6-32X5/8SLHLSET).

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Rack support assembly and installation

1. Attach the 4288-1-302 rack ear brackets to the Model 7002-HD using the 8-32x3/8 Phillips **Pan** Head screws (8-32X3/8PPH).
2. Position the Model 7002-HD in the rack and loosely attach the front panel to the front rack rails using four #10-32x5/8 inch Phillips **Truss** Head screws (10-32x5/8PHTRSH).
3. Loosely attach the two rear support brackets to the rear rack using the #10-32x5/8 inch Phillips **Truss** Head screws supplied in the rack kit (10-32x5/8PHTRSH).
4. Secure the mainframe to the rack by tightening the front and rear support #10-32x5/8 inch Phillips **Truss** Head screws (10-32x5/8PHTRSH).

NOTE Both right and left rear mounting brackets are included but only one is required. Disregard the unused bracket.

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Figure 2-4
Front rack support assembly and installation

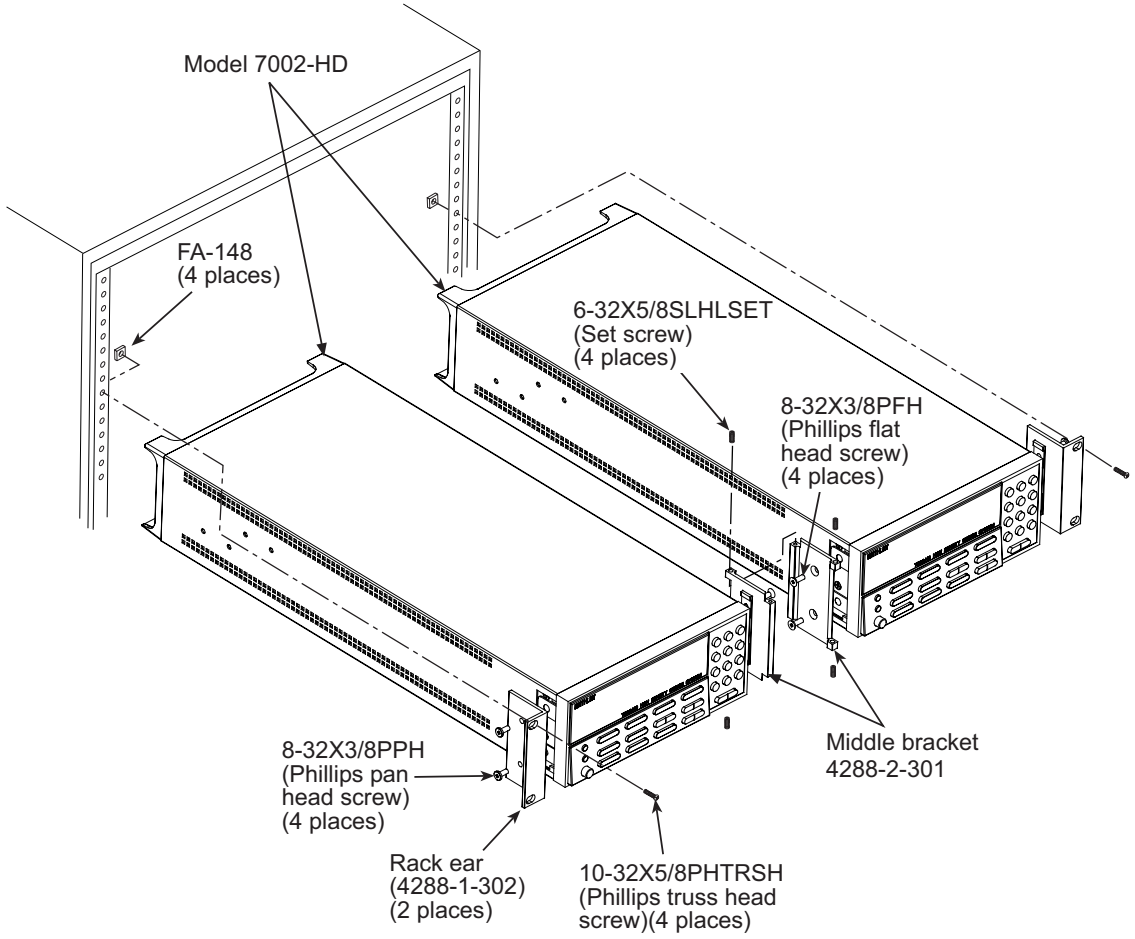

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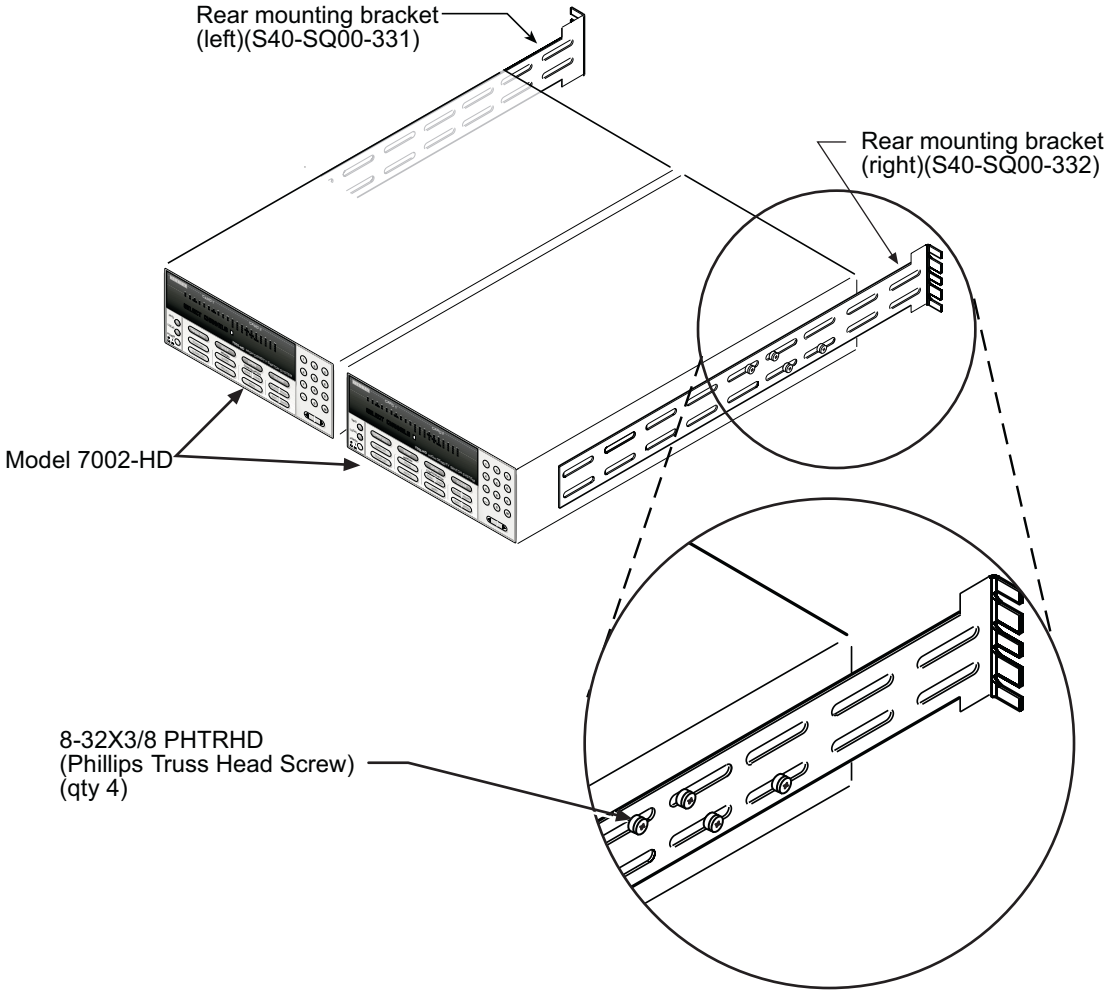
Figure 2-5
Rear mounting rack installation



Return to **Section 2 topics**

3 Getting Started

Section 3 topics

Introduction

This section contains basic information on using the Model 7002-HD including front and rear panel configurations and basic front panel and IEEE-488 bus control.

Front and rear panel configurations

Front panel

The front panel of the Model 7002-HD is shown in Figure 3-1. This figure includes important abbreviated information that should be reviewed before operating the instrument. Notice that some of the controls are dual-function, rocker-action type keys. These include SCAN/CARD CONFIGURATION, DELETE/INSERT, EXIT/ENTER, and ◁ / ▷ (cursor keys).

Rear panel

The rear panel of the Model 7002-HD is shown in Figure 3-2. This figure also includes important abbreviated information that should be reviewed before operating the instrument.

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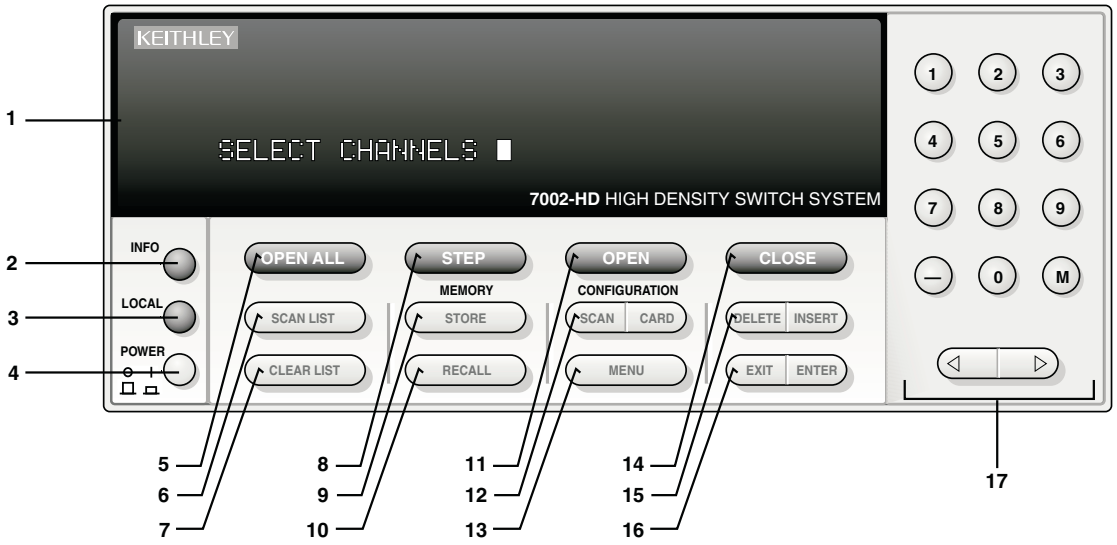
Figure 3-1
Model 7002-HD front panel



1 Vacuum Fluorescent Display (VFD)
Provides two lines of alpha-numeric information and includes annunciators.

2 INFO
Displays on-line help information. Press again (or EXIT) to cancel message.

3 LOCAL
Cancels remote, restores front panel control.

4 POWER
0 = off
1 = on

5 OPEN ALL
Opens all channels of all slots. Also, aborts a scan.

6 SCAN LIST
Toggles between Scan List and Channel List.

7 CLEAR LIST
Clears the displayed Channel List or Scan List.

8 STEP
Takes 7002-HD out of idle state and can be used to step through the Scan List.

9 STORE
Stores channel pattern or list at a specified memory location.

10 RECALL
Restores 7002-HD to a channel pattern stored at a specified memory location.

11 OPEN
Opens the specified (displayed) channels in Channel List.

12 SCAN CONFIGURATION
Enables CONFIGURE SCAN menu:
CHAN CONTROL
SCAN CONTROL
ARM CONTROL
CHAN RESTRICTIONS

CARD CONFIGURATION
Enables CARD CONFIG MENU:
TYPE
OF POLES
CARD PAIR
DELAY
READ I/O CARD

13 MENU
Enables MAIN MENU:
SAVESETUP
GPIB
DIGITAL I/O
TEST
LANGUAGE
GENERAL

14 CLOSE
Closes specified (displayed) channels in Channel List.

15 DELETE
Deletes selected entry from Channel List or Scan List.

INSERT
Inserts an entry at selected location in Channel List or Scan List.

16 EXIT
Use to back out of a menu structure. Cancels INFO message.

ENTER
Execute pending operation. Separate channels, and terminate selected list.

17 Keypad
0-9 Numeric entry
- Channel range separator (i.e., 1 ! 1-1 ! 10).
M Memory location designator (i.e., M6).
◁ Move cursor left.
▷ Move cursor right. Separate channels, and terminate selected list.

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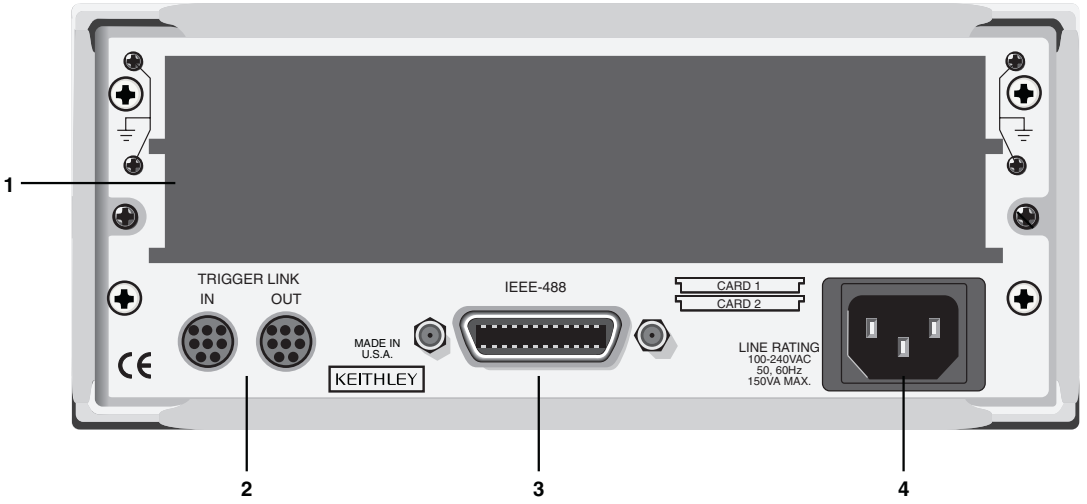
Figure 3-2
Model 7002-HD rear panel



1 CARD 1-2
CARD 1= Slots 1-5
CARD 2= Slots 6-10

2 TRIGGER LINK
Two micro 8-pin Din connectors.
Use trigger link cables.

3 IEEE-488 Connector
Use standard IEEE-488 cables.

4 Line Power Receptacle
WARNING: Connect to grounded outlet using three-wire power cord.

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Channel assignments

The Model 7002-HD uses five slot designations for control of all relays. To control the appropriate relay, the slot number must be included with the channel number when you specify a channel. The channel assignment is formatted as follows:

S!CH

where: S is the slot number
CH is the channel number

Examples:

1!1 = Slot 1, Channel 1

5!10 = Slot 5, Channel 10

NOTE The specific channel mapping will depend on the particular card being used. Consult the specific card manual for details.

Card 1

When a card is used in the Card 1 position of the Model 7002-HD, it will be controlled using slots 1 through 5.

Card 2

When a card is used in the Card 2 position of the Model 7002-HD, it will be controlled using slots 6 through 10.

Overview of scan process

The following overview is intended to acquaint you with the basic scan fundamentals without the details of enhanced capabilities. This brief overview is sufficient to support the operation examples in this section.

The simplified model for scan operation is shown in Figure 3-3. As shown, scan operation consists of three layers: the arm layer, scan layer, and channel layer.

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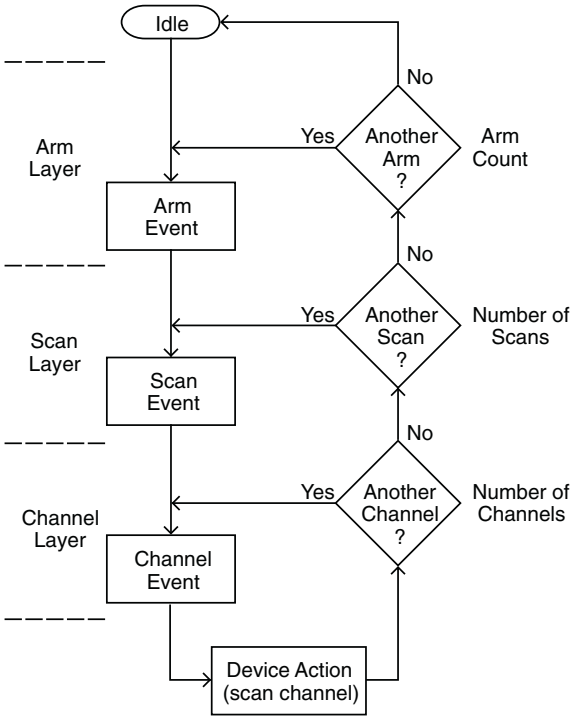
Figure 3-3
Simplified model of scan operation



Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the model. The front panel ARM indicator is off when the instrument is in the idle state.

When the Model 7002-HD is taken out of the idle state by pressing STEP (or sending the :INIT or :INIT:CONT ON command over the IEEE-488 bus), the ARM indicator turns on and operation proceeds into the arm layer.

Arm layer

In general, the instrument requires an arm event to allow operation to proceed to the scan layer. With Immediate arm spacing selected, operation immediately proceeds to the next layer when the instrument is taken out of the idle state. With one of the other arm spacing events selected, the instrument waits until the appropriate event occurs.

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With Manual arm spacing selected, the instrument waits until the front panel STEP key is pressed. With GPIB arm spacing selected, the instrument waits until a bus trigger (GET or *TRG) is received. With Trigger Link arm spacing selected, the instrument waits until an input trigger is received (via TRIGGER LINK).

After all other scanning operations are completed, the instrument can be returned to the arm layer by programming the instrument for additional arms. The arm count can be set to a finite value (1 to 9999) or to infinity.

After the instrument leaves the arm layer, operation proceeds into the scan layer.

Scan layer

In general, the instrument requires a scan event to allow operation to proceed to the channel layer. With Immediate scan spacing selected, operation immediately proceeds to the next layer. With one of the other trigger scan spacing events selected (Timer, GPIB, Manual, Trigger Link), the instrument waits until the appropriate event occurs. With Timer scan spacing selected, the first pass through the scan layer will occur immediately. For each additional scan, the instrument waits until the Timer times out. The Timer can be set for an interval from 1 millisecond to 99999.999 seconds.

The scan count (number of scans) can be set to a finite value (1 to 9999) or for an infinite number of scans. After the instrument leaves the scan layer, operation proceeds into the channel layer.

Channel layer

In general, channel events control the channel scan rate. With Immediate channel spacing selected, a channel is scanned immediately. With one of the other channel spacing events selected (Timer, GPIB, Manual or Trigger Link), the instrument waits until the appropriate event occurs before scanning a channel. With Timer channel spacing selected, the first channel is scanned immediately. Each additional channel waits for the Timer to time out before it will be scanned.

Typically, the channel count (number of channels to scan) is set to the number of channels that are contained in the Scan List (scan-list-length). However, the channel count can be set to a finite value (1 to 9999) or to infinity.

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Front panel operation summary

The following information summarizes the general procedure to open/close and scan channels. Section 4 of this manual provides the details for all aspects of operation.

WARNING **Before turning the Model 7002-HD on, make sure it is connected to a grounded power receptacle using the supplied power cord or equivalent. Failure to properly ground the unit creates a shock hazard that could result in injury or death.**

Create channel list and/or scan list

A channel list must be specified in order to close channels, and a scan list must be specified in order to scan channels.

Step 1. Select list

SELECT CHANNELS (channel list)

SCAN CHANNELS (scan list)

Press the SCAN LIST key to toggle between the channel list and the scan list. The EXIT key also selects the channel list.

Step 2. Enter channels

Pressing the CLEAR LIST key removes all channels from the selected list.

Formats: S!CH

where: S = slot

CH = channel

1. Use the number keys to enter a matrix crosspoint (slot, row, column) or a non-matrix channel (slot, channel).
2. Press ENTER or ▷ to separate entries or terminate the list.
3. Use the hyphen (- key) between the channels to specify a range of channels (i.e., 1!1-1!10 = channels 1 through 10).

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Close and Open channels

Press the CLOSE key to close the channels specified in the channel list. Pressing the OPEN key will open the channels specified in the channel list. The OPEN ALL key opens all channels, including any channels not included in the list.

NOTE A channel will remain closed until the OPEN ALL or OPENALL key is used. Channel status can be determined only via remote. See Section 5.

Scan channels

Perform the following steps to scan the channels defined in the scan list.

Step 1. Configure the Layers of the Trigger Model

Arm Layer

Factory power-on defaults set Arm Spacing to Immediate and the Arm Count to 1. For most scans, these settings do not need to be changed.

Scan Layer

Factory power-on defaults set Scan Spacing to Immediate and the scan count to Infinite. For most scans, Immediate arm spacing is appropriate and does not have to be changed. Scan count specifies how many times you want a channel scan to repeat. If you do not want the scan to continue indefinitely, change the scan count as follows:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Place the cursor on SCAN CONTROL and press ENTER to display the SCAN CONTROL menu.
3. Place the cursor on NUMBER OF SCANS and press ENTER to display the NUMBER OF SCANS menu.
4. Place the cursor on ENTER SCAN COUNT and press ENTER to display the currently selected scan count. Note that 0000 indicates that the scan count is currently set to infinite.
5. Use the keypad to key in the desired scan count and press ENTER.
6. Use EXIT to back out of the menu structure.

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Channel Layer

Factory power-on defaults set Channel Spacing to Manual and the channel count to the scan list length (number of channels in the scan list). For most scans, using the scan list length as the channel count is appropriate. With manual channel spacing selected, the STEP key is used to manually control the scan.

Available channel spacing selections are summarized as follows:

TIMER – In general, a channel is scanned each time the programmed timer interval expires.

GPIB – In general, each bus trigger (GET or *TRG) selects the next channel in the scan.

MANUAL – In general, each time the STEP key is pressed the next channel in the scan is selected.

TRIGLINK – In general, each trigger received via the Trigger Link selects the next channel in the scan.

IMMEDIATE – Channels will continue to scan immediately and not wait for any of the previous channel spacing events.

HOLD – Holds operation in the channel layer and prevents channels from being scanned.

Perform the following steps to change the channel spacing:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Place the cursor on CHAN CONTROL and press ENTER to display the CHANNEL CONTROL menu.
3. Place the cursor on CHANNEL SPACING and press ENTER to select the SELECT CHAN SPACING menu.
4. Place the cursor on the desired channel spacing selection and press ENTER. Note that selecting the TIMER will require that a time interval be entered.
5. Use EXIT to back out of the menu structure.

NOTE A typical method to control channel scanning is to use DELAY. A delay can be set for each slot. This delay is invoked after each channel of that slot is closed. By setting Channel Spacing for Immediate, the scan rate will, for the most part, be controlled by the DELAY period.

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Step 2. Starting the Scan

Assuming the instrument is in the idle state (ARM indicator on VFD off), a scan will not start until the STEP key is pressed. This takes the instrument out of the idle state (ARM indicator on). The scan will then proceed according to how it was programmed in Step 1.

A scan can be aborted at any time by pressing the OPEN ALL key.

Introduction to IEEE-488.2 and SCPI

The following paragraphs discuss fundamental information concerning operation over the IEEE-488 bus. Detailed information on operating the instrument from over the bus is contained in Section 5 of this manual.

SCPI overview

IEEE-488.2 defines a syntax for sending data to and from instruments. It also defines a set of Common Commands that are used to perform basic operations such as reading status registers, providing triggers and resetting the instrument to default conditions.

SCPI (Standard Commands for Programmable Instruments) defines a standard set of commands (and format) to control every other aspect of instrument operation. Together, IEEE-488.2 and SCPI create a command structure for all programmable instruments.

Compatibility

An instrument that uses the IEEE-488.2 standard and SCPI does not have special hardware requirements. The IEEE-488 interface that you used with the old standard will work with the new standard. Simply connect the Model 7002-HD to a computer that is equipped with an IEEE-488 interface.

Bus connections

Before using the instrument over the bus, you must connect the IEEE-488 connector on the rear panel of the instrument to the IEEE-488 connector of your controller. Use a Keithley Model 7007 or similar IEEE-488 cable for this connection.

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Primary address

The primary address of the Model 7002-HD must agree with the primary address you intend to specify in the controller's programming language. The factory setting for the primary address is 7, so if you intend to use that address, you need not change it. However, the primary address can be set to any value between 0 and 30 by using the GPIB setup menu (ADDRESS selection) available with the MENU key.

Abbreviated common command summary

Table 3-1 provides an abbreviated list of Common Commands that are defined by the IEEE-488.2 standard. These are the Common Commands that are most used for bus operation. Note that each Common Command is preceded by a star (*).

Table 3-1
Abbreviated common command summary

Mnemonic	Name	Description
*CLS	Clear status	Clears Error Queue and event registers.
*RST	Reset	Returns the 7002-HD to *RST default conditions.
*TRG	Trigger	Issues a bus trigger (same as group execute trigger command; GET).
*SAV <n>	Save	Saves the current setup configuration in memory (n = 0 to 9).
*RCL <n>	Recall	Returns the instrument to the setup configuration stored in memory (n = 0 to 9).

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Abbreviated SCPI command summary

Most instrument operations are controlled using SCPI commands. Table 3-2 provides an abbreviated list of the SCPI commands necessary to perform some basic operations.

Not shown in the table are companion query commands for the :ARM and :TRIGger Subsystem commands (:COUNt?, :DELay?, :SOURce?, and :TIMer?). For example, the :TRIGger:SOURce? query command is used to request the currently selected control source. After the query command is sent and the Model 7002-HD is addressed to talk, a message identifying the selected control source will be sent to the computer.

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Table 3-2
Abbreviated SCPI command summary

Command	Description
:SYSTem	Subsystem command path.
:PRESet	Set scan to a default configuration.
[:ROUTe]	Subsystem command path.
:CLOSe <list>	Path and command to close specified channels:
:STATe?	Request channels that are closed.
:OPEN <list>|ALL	Open specified (or all) channels.
:SCAN <list>	Path and command to specify channel list:
:POINts?	Query number of channels in scan list.
:INITiate	Initiate one trigger (scan) cycle.
:ABORt	Reset trigger system.
:ARM	Subsystem command path to configure scan:
:LAYer2	Path to program scan layer:
:COUNt <n>	Program number of scans (1 to 9999, or INFinite).
:DELay <n>	Program delay (0 to 99999.999 seconds).
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:TIMer <n>	Set timer interval (0.001 to 99999.999 seconds).
:TRIGger	Subsystem command path to program channel layer:
:COUNt <n>	Program number of channels (1 to 9999, or INFinite).
:AUTo <b>	Enable (on) or disable (off) automatic scan list count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:TIMer <n>	Set timer interval (0.001 to 99999.999 seconds).

Notes:
1. Command shortform is indicated by the uppercase characters. For example, instead of sending ":arm:layer2:source immediate", you can send ":arm:lay2:sour imm".
2. There must be at least one space between a command word and the parameter.

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Abbreviated syntax rules

Some of the basic syntax rules for programming the Model 7002-HD are covered in the following paragraphs.

Commands and parameters

The general form for SCPI commands is demonstrated in Table 3-2. They are hierarchical in nature and begin with a root command. For example, to open all channels, send the following command:

:OPEN ALL

The root command for the above example is :ROUTe. This is an optional command word (as indicated by the brackets ([]) in the table) and need not be used.

A space must be used to separate the command word (:OPEN) and the parameter (ALL).

The general form for Common Commands is shown in Table 3-1. Note that each common command is preceded by a star (*).

Typical parameter types used to program the instrument include:

<name> **Name parameter:** Select a parameter name from a listed group.

<list> **List of channels.** The following examples demonstrate proper format:

(@ 1!1, 1!5) Channels 1 and 5 of slot 1

(@ 1!1:1!10) Channels 1 through 10 of slot 1

<b> **Boolean:** Enable (1 or on) or disable (0 or off) a function.

<NRf> **Numeric representation format:** Number can be expressed as an integer, real number or an exponent (e.g., 2.3E6).

<n> **Numeric value:** An NRf number or one of the following name parameters:

DEFault: Uses the *RST default parameter value

MINimum: Uses the lowest allowable parameter value

MAXimum: Uses the largest allowable parameter value

Most SCPI command words and name parameters have a short-form version. The short form versions are identified in the SCPI tables by the upper case characters. Example:

:TRIGger:SOURce:TIMer? = :trig:sour:tim?

Note from the above example that command words and parameter names are not case sensitive.

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Query commands

This type of command requests (queries) information and is identified by the question mark (?). Example:

:CLOSe:STATe? Queries the channels that are closed.

Whenever a query command is sent, the Model 7002-HD must be addressed to talk in order to send the response message to the computer.

Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Note from Table 3-2 that some programming operations require several command words.

Single Command Message – This program message uses the command words required to perform a single programming operation. Example:

:TRIGger:COUNt:AUTo ON Enables auto scan list count.

Multiple Command Message – This program message contains two or more command operations. Each command string is separated by a semicolon (;). The following example uses the short-form format to reduce the size of the message:

:trig:sour imm; :trig:del 0.5

The above program message selects the Immediate control source, and then sets delay to 0.5 seconds.

Commands that are on the same command level can be executed without needing to repeat the entire command path. For example, the above multiple command message can be formatted as follows:

:trig:sour imm; del 0.5

Since :SOURce and :DELay are on the same command level (see Table 3-2), the :TRIGger command word does not need to be repeated for the second command string. Note also that the leading colon (:) for :DELay is not used.

Common commands and SCPI commands can be used in the same program message as long as they are separated by a semicolon (;). Example:

*RST; CLOSe (@ 1!1, 1!3)

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Programming examples

Closing and opening channels

The following command sequence will close channels 1, 3, 4, 5, and 6 of slot 1, and then open them:

```
*RST; open all                ' Opens any channels that are closed.
:CLOS (@ 1!1, 1!3:1!6)        ' Close channels 1, 3, 4, 5, and 6 of slot 1.
:OPEN (@ 1!1, 1!3:1!6)        ' Open channels in the channel list.
```

Manual scanning

The following command sequence will configure the Model 7002-HD to perform an infinite number of manual scans of 10 channels for slot 1:

```
:SYST:PRES                    ' Return 7002-HD to :SYSTem:PRESet default
                              ' configuration (scan count = infinite, channel
                              ' count = 10 channels, channel control source =
                              ' manual).
:SCAN (@1!1:1!10)             ' Define scan list.
:INIT                         ' Take 7002-HD out of idle to start scan.
```

When the above program is run, the scan will arm (ARM indicator on) and then wait for front panel STEP key presses to control the channel scan. After taking the Model 7002-HD out of remote (press LOCAL key), each press of the STEP key will scan the next channel in the scan list.

Bus trigger controlled scan

The manual scan example is modified so the channel scan will be controlled by bus triggers (*TRG or GET):

```
:SYST:PRES                    ' Return 7002-HD to :SYST.:PRES defaults.
:SCAN (@1!1:1!10)             ' Define scan list.
:TRIG:SOUR BUS                ' Program for bus triggers.
:INIT                         ' Take 7002-HD out of idle to start scan.
```

When the above sequence is run, the scan will arm and then wait for bus triggers to control the channel scan. Either a *TRG or GET command can be used to trigger the scan. Every time one of these commands is sent, it will cause the next channel in the scan list to be scanned.

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Timer controlled channel scan

The previous manual scan example is modified so the channel scan will be controlled by a timer:

```
:SYST:PRES                ' Return 7002-HD to :SYST:PRES default.
:SCAN (@1!1:1!10)         ' Define scan list.
:TRIG:SOUR TIM            ' Program channel control source for timer.
:TRIG:TIM  0.5            ' Set timer for 0.5 second interval.
:INIT                     ' Take 7002-HD out of idle state.
```

When the above command sequence is run, the scan will arm and scan channels continuously at a 0.5 second rate.

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4
Front Panel Operation

Section 4 topics

Introduction

This section contains detailed information on using the Model 7002-HD from the front panel.

Power-up procedure

The Model 7002-HD can be operated from line voltages from 100-240VAC at line frequencies of 50 or 60Hz.

Line power connections

Using the supplied power cord, connect the instrument to an appropriate AC power source. The female end of the cord connects to the AC receptacle on the rear panel of the instrument. The other end of the cord connects to a grounded AC outlet.

WARNING **The Model 7002-HD must be connected to a grounded outlet to maintain continued protection against possible shock hazards. Failure to use a grounded outlet may result in personal injury or death due to electric shock.**

Power switch

To turn on the power, push in the front POWER switch. Power is on when the switch is at the inner (1) position. To turn power off, press POWER a second time to release the switch.

Power-up sequence

On power-up, the Model 7002-HD will go through the following sequence:

1. The instrument will perform self-tests on its EPROM and RAM memory elements. If a failure is detected, the instrument will lock up and display the following message:

   No Comm Link

NOTE If a problem develops while the instrument is under warranty, return it to Keithley Instruments, Inc. for repair.

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2. If the instrument passes the self-tests, the firmware revision levels and currently selected IEEE-488 address will be displayed. An example of this display is shown as follows:

   Model 7002

   BXX BYY --- IEEE Addr = 07

   where:

   BXX is the firmware revision level for the main CPU.

   BYY is the firmware revision level for the VFD display.

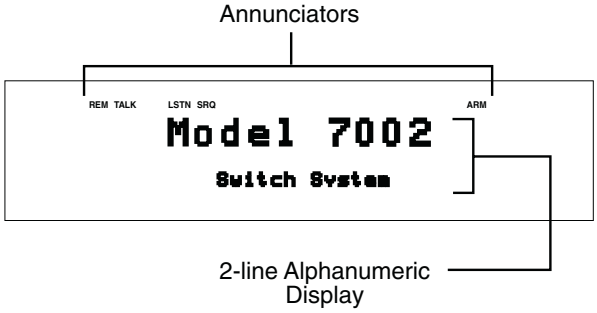
   7 is the current IEEE-488 Address. Note that the instrument is shipped from the factory with the address set to 7.

Front panel display

Vacuum fluorescent display (VFD)

The vacuum fluorescent display (VFD) is shown in Figure 4-1. It provides two lines of alphanumeric information. The first line can display up to 20 alphanumeric characters and the second line can display up to 32 alphanumeric characters. Also included are annunciators that are located along the top of the display.

Figure 4-1
Model 7002-HD vacuum fluorescent display



Display messages

Display messages include the various configuration menus, error messages, and status messages. Error and status messages for the Model 7002-HD are summarized in Table 4-1. In addition, the front panel INFO key provides context-sensitive operating information. Pressing EXIT or INFO a second time will cancel the message.

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Table 4-1
Status and error messages

Code number	Description
+551	“Incorrect software revision” (EE)
+550	“Forbidden channel error” (EE)
+530	“Slot 10 identification error” (EE)
+529	“Slot 9 identification error” (EE)
+528	“Slot 8 identification error” (EE)
+527	“Slot 7 identification error” (EE)
+526	“Slot 6 identification error” (EE)
+525	“Slot 5 identification error” (EE)
+524	“Slot 4 identification error” (EE)
+523	“Slot 3 identification error” (EE)
+522	“Slot 2 identification error” (EE)
+521	“Slot 1 identification error” (EE)
+510	“Saved state error” (EE)
+350	“Too many channels closed” (EE)
+174	“Re-entering the idle layers” (SE)
+173	“Waiting in arm layer 2” (SE)
+172	“Waiting in arm layer 1” (SE)
+171	“Waiting in trigger Layer” (SE)
+161	“Program running” (SE)
+126	“Device calculating” (SE)
+125	“Device measuring” (SE)
+124	“Device sweeping” (SE)
+123	“Device ranging” (SE)
+122	“Device settling” (SE)
+121	“Device calibrating” (SE)

EE = Error event
SE = Status event

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Table 4-1 (cont.)
Status and error messages

Code number	Description
+101	“Operation Complete” (SE)
0	“No error” (SE)
-100	“Command Error” (EE)
-101	“Invalid Character” (EE)
-102	“Syntax Error” (EE)
-103	“Invalid Separator” (EE)
-104	“Data Type Error” (EE)
-105	“GET not allowed” (EE)
-108	“Parameter not allowed” (EE)
-109	“Missing Parameter” (EE)
-110	“Command Header Error” (EE)
-111	“Command Header Separator Error” (EE)
-112	“Program mnemonic too long” (EE)
-113	“Undefined header” (EE)
-114	“Header suffix out of range” (EE)
-120	“Numeric data error” (EE)
-121	“Invalid character in number” (EE)
-123	“Exponent too large” (EE)
-124	“Too many digits in number” (EE)
-128	“Numeric data not allowed” (EE)
-140	“Character data error” (EE)
-141	“Invalid character data” (EE)
-144	“Character data too long” (EE)
-148	“Character data not allowed” (EE)
-150	“String data error” (EE)
-151	“Invalid string data” (EE)
-154	“String too long”
-158	“String data not allowed” (EE)
-160	“Block data error” (EE)
-161	“Invalid block data” (EE)

EE = Error event
SE = Status event

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Table 4-1 (cont.)
Status and error messages

Code number	Description
-168	"Block data not allowed" (EE)
-170	"Expression error" (EE)
-171	"Invalid expression" (EE)
-178	"Expression data not allowed" (EE)
-200	"Execution error" (EE)
-201	"Invalid while in local" (EE)
-202	"Settings lost due to rtl" (EE)
-210	"Trigger error" (EE)
-211	"Trigger ignored" (EE)
-212	"Arm ignored" (EE)
-213	"Init ignored" (EE)
-214	"Trigger deadlock" (EE)
-215	"Arm deadlock" (EE)
-220	"Parameter Error" (EE)
-221	"Settings conflict" (EE)
-222	"Parameter data out of range" (EE)
-223	"Too much data" (EE)
-224	"Illegal parameter value" (EE)
-241	"Hardware missing" (EE)
-260	"Expression Error" (EE)
-281	"Cannot create program" (EE)
-282	"Illegal program name" (EE)
-284	"Program currently running" (EE)
-285	"Program syntax error" (EE)
-330	"Self Test failed" (EE)
-350	"Queue overflow" (EE)
-410	"Query interrupted" (EE)
-420	"Query unterminated" (EE)
-430	"Query deadlocked" (EE)
-440	"Query unterminated after indefinite response" (EE)

EE = Error event
SE = Status event

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Annunciators

The five annunciators along the top of the display indicate the following conditions:

SRQ — Turns on when the unit requests service over the IEEE-488 bus. Programming the Service Request Enable Register allows you to control which conditions will generate an SRQ (see Section 5).

REM — Turns on to indicate that the Model 7002-HD is in remote when used over the IEEE-488 bus. The Model 7002-HD can be placed in remote by addressing it to listen with the bus REN line true.

TALK — Turns on to indicate that the Model 7002-HD is the active talker on the IEEE-488 bus. The unit can be placed in the talker active state by sending it the correct bus talk command, which is derived from the primary address.

LSTN — Turns on when the unit is an active IEEE-488 bus listener. The Model 7002-HD can be placed in the active listener state by addressing it to listen.

ARM — Turns on when the Model 7002-HD is taken out of the idle state. A scan can only be performed with the Model 7002-HD out of the idle state.

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Analog backplane

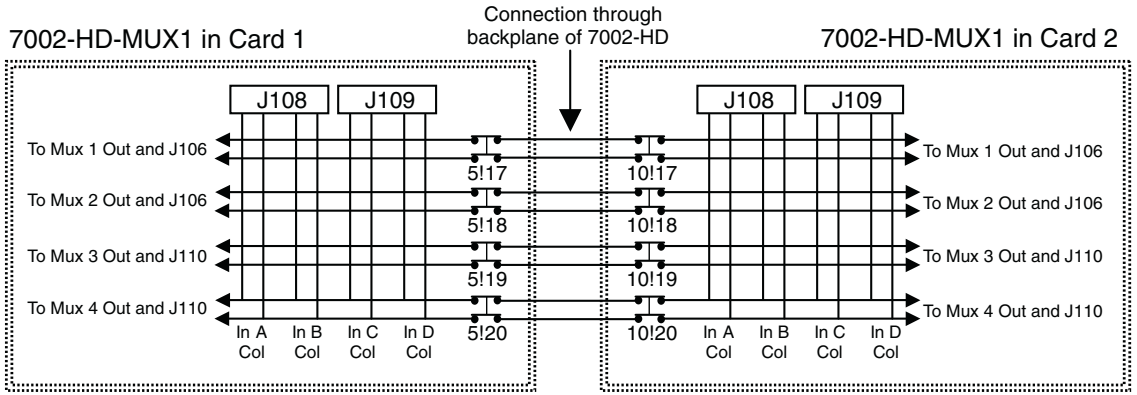
Backplane connections

The Model 7002-HD has an analog backplane that allows the rows or multiplexers of a Model 7002-HD series card installed in one card location to be connected to the rows or multiplexers of a 7002-HD series card installed in the other card location. There are a total of 32 backplane signal paths available.

Typical backplane connections

Typical backplane connections are shown in Figure 4-2. In this example, two Model 7002-HD-MUX1 cards are installed in the Model 7002-HD. Note that a relay on each card must be close to connect that signal path to the backplane.

Figure 4-2
Typical backplane connections



4 x 8 Matrix Configuration

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Channel assignments

Channel assignments used to program the mainframe are based on the switching card type, basic channel designation, and the card location in which the card is installed (Card 1 or Card 2).

Slot designations

When programming the Model 7002-HD, you must designate the slot depending on the card location:

- Card 1 location: slots 1 through 5
- Card 2 location: slots 6 through 10

Channel numbers

Combining the slot number with the card channel number provides the CHANNEL assignment for the mainframe. The slot and card channel are separated by an exclamation point (!). For the following examples, “CHANNEL” refers to the programming channel assignment for the mainframe, while “Channel” refers to the channel number of the switching card.

CHANNEL 1!1 = Slot 1, Channel 1 (Card 1)

CHANNEL 4!20 = Slot 4, Channel 20 (Card 1)

CHANNEL 9!2 = Slot 9, Channel 2 (Card 2)

CHANNEL 6!36 = Slot 6, Channel 36 (Card 2)

See the card manual for details on the particular card being used.

Channel list and scan list

The Model 7002-HD can perform two basic operations: it can close and open a list of channels, and it can scan through a list of channels. The following paragraphs explain how to enter channels for these operations. The basic operations are explained in ”Closing and opening channels” on page 4-13 and ”Scan procedure” on page 4-18.

Each operation has its own list. For basic close/open operation, channels are entered into the channel list. For scan operation, channels are entered into the scan list.

For basic close/open operation, the order of channels in the channel list is not important since all listed channels will either close or open at the same time. For scan operation, the order of channels is important. Channels will be scanned in the order that they are presented in the scan list.

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The Scan List is not lost (cleared) after the instrument is turned off. However, the Scan List is cleared if any of the following events occur:

1. A channel in the Scan List becomes unavailable.
2. A channel in the Scan List becomes restricted. A channel becomes restricted by adding it to the restricted channel list.
3. Two or more channels in the Scan List become interlocked. Channels become interlocked by specifying them in the Interlock lists.

Channel list considerations

When a scan list is modified over the IEEE-488 bus, the displayed scan list will not update until a display state change occurs (i.e., pressing the SCAN LIST key). A channel list is lost after the instrument is turned off. However, a channel pattern stored in memory can be recalled at any time. The channel list will not be reinstated, but the channel pattern will be reinstated.

A scan list can contain up to 400 channels (including repeats). An entry that causes the list to exceed 400 channels will generate the following error:

ERROR: ID CODE = -223

Too much data

When this error occurs, only the first 400 channels will be scanned. However, if the 400th channels falls in the middle of a range entry, then the entire range of channels will be ignored. For example:

SCAN CHANNELS 1!1-1!40, 2!1-2!40, 3!1-3!40, 4!1-4!40, 5!1-5!40,

5!1, 6!1-6!40, 7!1-7!40, 8!1-8!40, 9!1-9!40, 10!1-10!40,

The above scan list contains 401 channels. It includes 10 range entries of 40 channels each, and one single channel entry (5!1). The 400th channel in the list is channel 10!39. Since this channel is inside channel range 10!1-10!40, all 40 channels of that range will be ignored when the scan is performed. Channel 9!40 will be the last channel in the scan.

Entering lists

Perform the following steps to create a channel list or scan list using the front panel keys:

Step 1: Make sure appropriate list is selected.

Open/close operations use the channel list, and scan operations use the scan list. The SCAN LIST key toggles between the channel list and the scan list. If the desired list is not already displayed, press SCAN LIST. Note that pressing EXIT will also select the channel list.

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Step 2: Enter slot number and card channel.

1. **Enter slot number** — Using the keypad, enter the slot number (1 through 10). The separator between slot and channel will automatically be entered after you key in the slot number. For example, if you selected slot 2, the entered channel data will look like one of these:

   SELECT CHANNELS 2!

   SCAN CHANNELS 2!

2. **Enter card channel** — Use the keypad to enter the card channel number. For example, if you entered channel 20 (with slot 2 previously selected), the entered channel data will look like one of these:

   SELECT CHANNELS 2!20

   SCAN CHANNELS 2!20

   At this point, the entered channel can be cancelled by pressing the left cursor key.

Step 3. Enter channel separator or terminator.

Channel separators are required for multiple channel entries, and a terminator should be used after the last entered channel.

The comma (,) is used to separate channels and serves to terminate the list. After entering a channel, as explained in Step 2, press the right cursor key or ENTER to put in the comma separator. Another channel can then be keyed-in. After the last channel in the list is keyed-in, use the ENTER key or the right cursor key to terminate the list. The comma terminator prevents the last entered channel from being cancelled when the left cursor key is pressed. The following example shows proper format:

SELECT CHANNELS 1!1, 1!2, 1!3, 1!4, 1!5, 1!6, 1!7, 1!8, 1!9, 1!10, M1,

SCAN CHANNELS 1!1, 1!2, 1!3, 1!4, 1!5, 1!6, 1!7, 1!8, 1!9, 1!10, M1,

The above display indicates that channels 1!1 through 1!10, and the closed channels stored at memory location 1 (M1) are entered.

The hyphen (-) is used to designate a range of channels. After entering the first channel, as explained in Step 2, press the “-” key on the keypad to put in the hyphen, and then key-in the last channel. The following example shows proper format:

SELECT CHANNELS 1!1-1!10, M1,

SCAN CHANNELS 1!1-1!10, M1,

The above display indicates that channels 1!1 through 1!10 and the channel pattern stored at memory location 1 (M1) are entered.

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Step 4. Repeat the basic procedure in Steps 2 and 3 to enter all required channels.

Step 5. Edit the entered list as required.

Edit keys are available to make changes to a list. These keys allow you to change channels, delete channels, or insert channels anywhere in the list. When editing, a channel range (i.e., 1!1-1!6) and a memory location (i.e., M1) are treated as single channel entries.

1. **Changing a channel** — Perform the following steps to change a channel:
   a. Use the cursor keys to place the cursor at the beginning of the channel entry to be changed.
   b. Key in the new channel entry, and press the right cursor key or ENTER to add the comma.
2. **Deleting a channel** — Perform the following steps to delete a channel:
   a. Place the cursor at the beginning of the channel to be deleted.
   b. Press the DELETE key to delete the channel entry.
3. **Inserting a channel** — Perform the following steps to insert a channel anywhere in the list:
   a. Position the cursor at the desired location in the list. The channel will be inserted between the cursor and the channel entry before it.
   b. Press the INSERT key. The following message will be displayed:
      INSERTING ENTRY
   c. Key in the new channel entry, and press the right cursor key or ENTER to add the comma.
   d. Press INSERT a second time to cancel the insert edit function.
4. **Deleting all channels** — The entire list can be cleared by pressing CLEAR LIST.

Previously closed channels with SCAN

If a selected channel is closed, and the channel is defined in a scan list, the selected channel will open once the channel is cycled through the scan list.

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Closing and opening channels

One of the basic operations of the Model 7002-HD is to close (or open) one or more channels specified by the user. All the specified channels will either close or open at the same time. An exception to this is when Single Channel mode is enabled. With Single Channel mode enabled, only the lowest numbered channel in the lowest numbered slot will close.

NOTE A channel will remain closed until the OPEN ALL or OPEN key is used. Channel status can be determined only via remote. See Section 5.

Perform the following steps to close and open channels:

Step 1. Select the channel list.

The channel list must be selected in order to close channels. The SCAN LIST key toggles between the scan list and the channel list. If the channel list is not currently selected, press SCAN LIST. The following channel list prompt is displayed:

SELECT CHANNELS

Note that when the scan list is selected, pressing EXIT will also select the channel list.

Step 2. Define channel list.

Enter channels into the channel list. The following example demonstrates proper format:

SELECT CHANNELS 1!1, 4!1-4!10, M1,

The above channel list includes channel 1 of slot 1, channels 1 through 10 of slot 4, and whatever channels are contained in the channel pattern stored at memory location 1 (M1).

Step 4. Close (or open) listed channels.

Perform the appropriate close/open operation as follows:

a. Press the CLOSE key to close the listed channels.
b. Press the OPEN key to open channels that are listed in the channel list. Note that only the listed channels will open. Any closed channels that are not included in the channel list will not be opened by OPEN. To open unlisted channels, press OPEN ALL.

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Scanning channels

The Model 7002-HD can scan through a specified list of channels. The order that the channels are presented in the scan list determines the channel order for the scan.

Scan process (Trigger Model)

The following information describes front panel control of the scan process. The flowchart (Trigger Model) in Figure 4-3 summarizes scan operation from the front panel.

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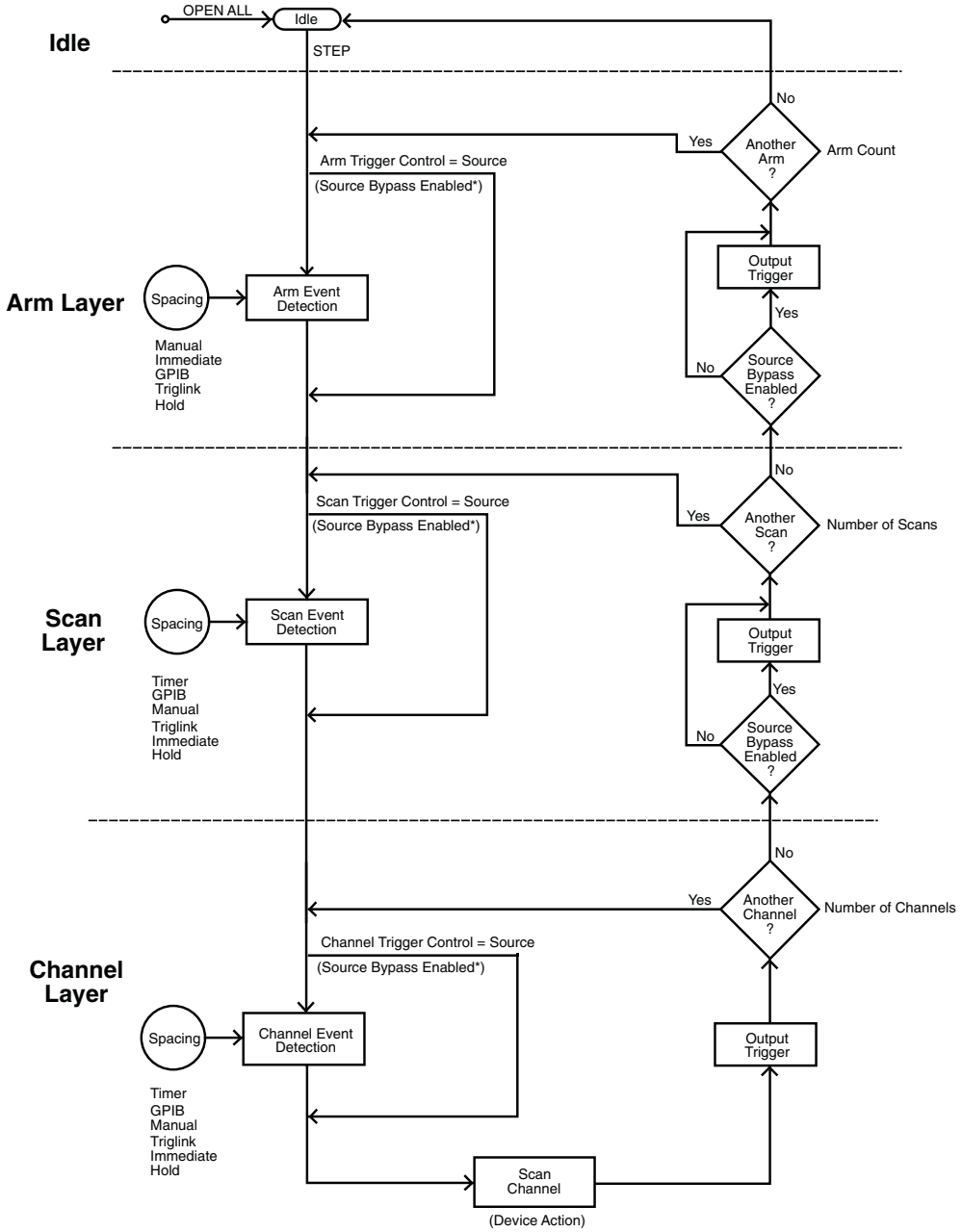
Figure 4-3
Trigger model (front panel scan process)



* Take bypass path the first time a layer is entered

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Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform a scan.

From the front panel, the Model 7002-HD is taken out of the idle state by pressing the STEP key. When not in the idle state (ARM indicator on), the scanning function is considered to be enabled.

A scan can be aborted at any time by pressing the OPEN ALL key. The Model 7002-HD will return to the idle state.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer of the Trigger Model.

Arm layer

In general, the instrument requires an arm event to allow operation to proceed to the next layer (scan layer). With Immediate arm spacing selected, operation immediately proceeds to the next layer when the instrument is taken out of the idle state. RESET and factory defaults set arm spacing to Immediate. With one of the other arm spacing events selected, the instrument waits until the appropriate event occurs.

- With Manual arm spacing selected, the instrument waits until the front panel STEP key is pressed.
- With GPIB arm spacing selected, the instrument waits for a bus trigger (GET or *TRG).
- With TrigLink arm spacing selected, the instrument waits for an input trigger via TRIGGER LINK on the rear panel.
- With Hold arm spacing selected, the instrument does not respond to any of the arm spacing events.

As can be seen in the flowchart, there is a path that allows operation to loop around the programmed spacing event. This path is called the Source Bypass. When the Source Bypass is enabled (Arm Trigger Control set to Source) and TrigLink arm spacing is selected, operation loops around the spacing event on the initial pass through the arm layer. If programmed for another arm (arm count >1), the bypass loop is not in effect even though it is enabled. The Source Bypass loop resets (back in effect) when operation goes into Idle.

Enabling the Source Bypass also enables the Output Trigger in this layer. When operation returns to the arm layer from the scan layer, an output trigger pulse occurs. If TrigLink arm spacing is selected, the output trigger pulse is available on the programmed TRIGGER LINK output line. For all other arm spacing selections, the output trigger pulse is available at the Trigger Link connector. The output trigger for this layer is disabled when the Source Bypass is disabled (Arm Trigger

Control set to Acceptor). RESET and factory defaults set Arm Trigger Control to Acceptor.

After all other trigger model operations are completed, the Model 7002-HD can be returned to the arm layer by programming the instrument for additional arms. Arm Count can be set to infinity or to a finite value (1 to 9999). RESET and factory defaults set arm count to one.

After leaving the arm layer, operation proceeds into the scan layer.

Scan layer

Operation in the scan layer is similar to operation in the arm layer, except that spacing is controlled by scan events rather than arm events. A timer is available in this layer to control scan spacing. When Timer scan spacing is selected, operation will immediately proceed into the channel layer on the initial pass through the scan layer. Each additional scan (1 to 9999 or infinite) will not occur until the programmed timer interval elapses. The timer can be set to an interval from 1 millisecond to 99999.999 seconds.

The Source Bypass and Output Trigger function in the same manner as the Source Bypass and Output Trigger in the arm layer. The Source Bypass (if enabled) will reset (back in effect) after all programmed scans are completed.

RESET and factory defaults set scan spacing to Immediate, scan count to Infinite, and Scan Trigger Control to Acceptor.

After leaving the scan layer, operation proceeds into the channel layer.

Channel layer

Operation in the channel layer is similar to operation in the scan layer, except that spacing is controlled by channel events rather than scan events and the Output Trigger is always enabled.

When Timer channel spacing is selected, the first channel will be scanned immediately. Each additional channel is then scanned at a rate determined by the programmed timer interval (1 millisecond to 99999.999 seconds). With Immediate channel spacing selected, channels will be scanned immediately. The scan rate will primarily be determined by the internally set relay settling time and any user programmed delay. The user programmed delay is in addition to the relay settling time.

The device action (scan channel) for each channel includes:

1. Open the previous channel and wait for the internal settling delay to time out.
2. Close the next channel in the scan and wait for the internal settling delay to time out.
3. Wait for the user programmed delay (0 to 99999.999 seconds) to time out.

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The Source Bypass (if enabled) will reset (be in effect) after the programmed number of channels are scanned.

The Output Trigger for the channel layer is always enabled and occurs after each channel is scanned (device action). For all channel spacing selections, except TrigLink, the TTL Output Trigger Pulse is available at the Trigger Link connector. For TrigLink channel spacing, the Output Trigger functions as follows:

1. If the asynchronous Trigger Link mode is selected, the TTL Output Trigger pulse is available on the programmed Trigger Link output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (Channel Trigger Control set for Acceptor), the Trigger Link line is released (goes high).
3. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (Channel Trigger Control set for Source), the Trigger Link line is pulled down low and then released.

RESET and factory defaults set channel spacing to Manual, channel count to the scan list length, and Channel Trigger Control to Source.

Previously closed channel patterns with SCAN

Channels will be scanned in the order that they are presented in the scan list, but a closed channel will not open until it is scanned in the list (see "Previously closed channels with SCAN" on page 4-12). Channel pattern M1 will be treated as a single channel entry (see "Channel patterns (STORE and RECALL)" on page 4-24). When the channel pattern is scanned, the closed channels in the pattern will close and remain closed for the duration of the scan. A channel pattern is useful for supplying bias voltages in a test system.

Scan procedure

Perform the following steps to scan channels:

Step 1. Press OPEN ALL.

Before configuring a scan, you should place the Model 7002-HD in the idle state by pressing OPEN ALL. This will stop any scan that is currently in process, open all channels, and place the Model 7002-HD in the idle state.

Step 2. Select the scan list.

The channel list must be selected in order to close channels. The SCAN LIST key toggles between the scan list and the channel list. If the scan list is not currently selected, press SCAN LIST. The following scan list prompt is displayed:

SCAN CHANNELS

Step 3. Define scan list.

Enter channels into the scan list. The following example demonstrates proper format:

SCAN CHANNELS 1!1, 4!1-4!10, M1,

The above scan list includes channel 1 of slot 1, channels 1 through 10 of slot 4, and the channel pattern stored at memory location 1 (M1).

At the conclusion of a scan, the last channel in the list will remain closed. If you wish to open the last channel, specify a memory location that has no closed channels as the last entry in the scan list. For example, if in the previous scan list M1 has no closed channels, Channel 4!10 will open at the conclusion of a single scan.

Step 4. Configure the Channel Layer of the scan.

The channel layer is programmed from the CHAN CONTROL menu of the CONFIGURE SCAN menu.The following procedure summarizes the steps to configure the channel layer:

1. From the CONFIGURE SCAN menu, select CHAN CONTROL.
2. From the CHANNEL CONTROL menu, select CHANNEL SPACING.
3. From the SELECT CHAN SPACING menu, select one of the following to control the process of scanning channels:
   a. **TIMER** — Use to set a time interval (1 millisecond to 99999.999 seconds) between channels.
   b. **GPIB** — With this selection, bus triggers (GET or *TRG) control channel spacing. Each bus trigger received by the Model 7002-HD will select the next channel of the scan.
   c. **MANUAL** — With this selection, the front panel STEP key is used to control channel spacing. Each press of the STEP key will select the next channel of the scan.
   d. **TRIGLINK** — With this selection, triggers received over the Trigger Link will control channel spacing. Each trigger will select the next channel in the scan.
   e. **IMMEDIATE** — With this selection, events are not used to control channel spacing. Only the time delay for relay settling and an optional DELAY programmed by the user affect channel spacing in the scan.
4. From the CHANNEL CONTROL menu, select NUMBER OF CHANS.
5. From the NUMBER OF CHANNELS menu, select one of following items to specify the number of channels to scan:
   a. **USE SCANLIST LENGTH** — With this selection, a single scan of all the channels in the scan list will occur for every programmed scan (scan count).

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b. **CHAN COUNT** — With this selection, you have the following two options for CHANNEL COUNT:
   - **INFINITE** — With this count selection, the channel scan will repeat indefinitely.
   - **ENTER CHAN COUNT** — Use this selection to define the number of channels (1 to 9999) to scan. The channel scan wraps around and continues to satisfy a channel count that exceeds the scan list length.

Step 5. Configure the Scan Layer of the scan.

The scan layer is programmed from the SCAN CONTROL menu of the CONFIGURE SCAN menu.

The following procedure summarizes the steps to configure the scan layer:

1. From the CONFIGURE SCAN menu, select SCAN CONTROL.
2. From the SCAN CONTROL menu, select SCAN SPACING.
3. From the SELECT SCAN SPACING menu, select one of the following to control scan spacing:
   a. **TIMER** — Use to set a time interval (1 millisecond to 99999.999 seconds) between scans.
   b. **GPIB** — With this selection, bus triggers (GET or *TRG) control scan spacing. A bus trigger received by the Model 7002-HD will allow operation to proceed to the channel layer.
   c. **MANUAL** — With this selection, the front panel STEP key is used to control scan spacing. Each press of the STEP key will allow operation to proceed to the channel layer.
   d. **TRIGLINK** — With this selection, triggers received over the Trigger Link will control scan spacing. A trigger will allow operation to proceed to the channel layer.
   e. **IMMEDIATE** — With this selection, events are not used to control scan spacing. Operation will proceed immediately to the channel layer.
4. From the SCAN CONTROL menu, select NUMBER OF SCANS.
5. From the NUMBER OF SCANS menu, select one of following items to specify the number of scans to be performed:
   a. **INFINITE** — With this selection, the scan will repeat indefinitely.
   b. **ENTER SCAN COUNT** — Use this selection to define the number of scans (1 to 9999) to be performed.

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Step 6. Configure the Arm Layer of the scan.

The arm layer is programmed from the ARM CONTROL menu of the CONFIGURE SCAN menu.The following procedure summarizes the steps to configure the arm layer:

1. From the CONFIGURE SCAN menu, select ARM CONTROL.
2. From the SETUP ARM CONTROL menu, select ARM SPACING.
3. From the SELECT ARM SPACING menu, select one of the following to control the interval between arms:
   a. **MANUAL** — With this selection, the front panel STEP key is used to control arm spacing. Pressing the STEP key will allow operation to proceed to the scan layer.
   b. **IMMEDIATE** — With this selection, events are not used to control arm spacing. Operation will proceed immediately to the scan layer.
   c. **GPIB** — With this selection, bus triggers (GET or *TRG) control arm spacing. A bus trigger received by the Model 7002-HD will allow operation to proceed to the scan layer.
   d. **TRIGLINK** — With this selection, triggers received over the Trigger Link will control arm spacing. A trigger will allow operation to proceed to the scan layer.
4. From the SETUP ARM CONTROL menu, select ARM COUNT.
5. From the ARM COUNT menu, select one of following items to specify the number of arms to be performed:
   a. **INFINITE** — With this selection, the number of arms is infinite.
   b. **ENTER ARM COUNT** — Use this selection to define the number of arms (1 to 9999) to be performed.

Step 7. Start the scan

Step 1 of this procedure placed the Model 7002-HD in the idle state. In this idle state, a scan cannot be performed. The Model 7002-HD is taken out of the idle state by pressing the STEP key.

Once out of the idle state, the scan is considered enabled. The scan will proceed according to how the three layers are programmed. If Immediate spacing is selected, operation will pass immediately into the next layer. If spacing is programmed for a particular event, operation will not pass into the next layer until the programmed event occurs.

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Scanning examples

The following examples assume two scans of a two-channel scan list. All events in these examples can be substituted by the STEP key.

Example 1:

ARM SPACING = IMMEDIATE

SCAN SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

CHANNEL SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002-HD in the idle state.
2. Press STEP to take the 7002-HD out of the idle state (ARM indicator turns on).
3. The first scan spacing event will pass operation into the channel layer.
4. The first channel spacing event will scan the first channel in the scan list.
5. The next channel spacing event will scan the second channel.
6. The next scan spacing event will pass operation back into the channel layer.
7. The next channel spacing event will scan the first channel.
8. The next channel spacing event will scan the second channel and disarm (idle) the scan.

Example 2:

ARM SPACING = IMMEDIATE

SCAN SPACING = IMMEDIATE

CHANNEL SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002-HD in the idle state.
2. Press STEP to take the 7002-HD out of idle state and operation into the channel layer.
3. The first channel spacing event will scan the first channel.
4. The next channel spacing event will scan the second channel.
5. Operation passes automatically back into the channel layer since IMMEDIATE scan spacing is selected.
6. The next channel spacing event will scan the first channel.
7. The next channel spacing event will scan the second channel and disarm (idle) the scan.

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Example 3:

ARM SPACING = MANUAL, GPIB, or TRIGLINK

SCAN SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

CHANNEL SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002-HD in the idle state.
2. Press STEP to take the 7002-HD out of the idle state.
3. The arm spacing event allows operation to pass into the scan layer.
4. The first scan spacing event passes operation into the channel layer.
5. The first channel spacing event will scan the first channel in the scan list.
6. The next channel spacing event will scan the second channel.
7. The next scan spacing event will pass operation back into the channel layer.
8. The next channel spacing event will scan the first channel.
9. The next channel spacing event will scan the second channel and disarm (idle) the scanner.

Example 4:

ARM SPACING = MANUAL, GPIB, or TRIGLINK

SCAN SPACING = IMMEDIATE

CHANNEL SPACING = TIMER, GPIB, MANUAL, or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002-HD in the idle state.
2. Press STEP to take the 7002-HD out of the idle state.
3. The arm spacing event allows operation to pass into the scan layer.
4. Operation passes immediately into the channel layer since IMMEDIATE scan spacing is selected.
5. The first channel spacing event will scan the first channel in the scan list.
6. The next channel spacing event will select the second channel.
7. Operation passes automatically back into the channel layer since IMMEDIATE scan spacing is selected.
8. The next channel spacing event will select the first channel.

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Channel patterns (STORE and RECALL)

A channel pattern is a pattern of open and closed channels that is stored in memory. Up to 500 channel patterns can be stored in memory.

Channel Patterns are not lost (cleared) when the instrument is turned off. However, a Channel Pattern is cleared if any of the following events occur:

1. A closed channel in the Channel Pattern becomes unavailable.
2. A closed channel in the Channel Pattern becomes restricted. A channel becomes restricted by adding it to the restricted channel list.
3. Two or more closed channels in the Channel Pattern become interlocked. Channels become interlocked by specifying them in the Interlock lists.

Note that if a Channel Pattern is included in the Scan List (i.e., M1) and the Channel Pattern is lost (as explained above), then the Scan List will also be lost.

Storing channel patterns (STORE)

There are two methods to store a channel pattern. One method is to actually close and open the desired channels and then save that pattern into memory. The other method is to define a list of channels and then save that channel list into memory. The channels defined in the list will be the closed channels of the pattern. All the unlisted channels will be open.

Perform the following steps to store a channel list in memory:

1. Decide on which storage method you wish to use:
   a. If you want to store an actual pattern of open and closed channels into memory, go ahead and open and close the desired channels.
   b. If you want to store a list of the closed channels for the channel pattern, go ahead and define the channel list.
2. Press STORE to display the following menu:
   STORE TO MEMORY
   RELAY-PATTERN CURRENT-LIST
3. Place the cursor on the appropriate selection:
   a. Place the cursor on RELAY PATTERN if storing the actual pattern of open and closed channels.
   b. Place the cursor on CURRENT-LIST if storing the defined channel list.
4. With the cursor on the appropriate selection, press ENTER. One of the following typical messages will be displayed:
   STORE CHANS AT #001 or STORE LIST AT #001

   Both messages indicate that storage will occur at memory location 1 (M1). Note that you can cancel the store operation at this time by using the EXIT key to back out of the menu structure.

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5. If you wish storage to occur at the displayed memory location proceed to Step 6. Otherwise, use the cursor keys and the numeric keypad to key in the desired memory location (001 to 500).
6. To store the channel pattern or list at the displayed memory location, press ENTER.

Recalling channel patterns (RECALL)

There are two methods for recalling a channel pattern. One method is to immediately access the channel pattern from memory using RECALL. The open/close channel pattern will be reinstated by the Model 7002-HD. The other method is to specify the memory location (i.e., M1) of the channel pattern in the channel list and/or scan list. The channel pattern will be re-installed when that memory location is closed or scanned.

Recalling a channel pattern using RECALL

Perform the following steps to use RECALL:

1. Press RECALL to display the following typical message:
   RECALL CHANS AT #001

   The above message indicates that the channel pattern will be recalled from memory location M1. You can exit from the Recall mode without recalling the channel pattern by pressing EXIT. The instrument will return to the channel list display state.
2. If you wish to recall the channel pattern from the displayed memory location, proceed to step 3. Otherwise, use the cursor keys and the number keys to key in the desired memory location (001 to 500).
3. To recall the channel pattern from the displayed memory location, press ENTER. The instrument will return to the channel status display state and display the recalled channel pattern.

CAUTION **As soon as the display updates to the selected channel pattern, the corresponding relays on the cards will also update. Thus, make sure you want to energize the card relays before recalling a channel pattern.**

Recalling a channel pattern via channel list and/or scan list

A channel pattern can be recalled by specifying the memory location in a channel list and/or scan list. For example, assume a channel pattern that has Channels 2!11 and 2!36 closed is stored at memory location M10. Also assume that M10 is included in the following channel list:

SELECT CHANNELS 1!1, 1!4, M10,

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When CLOSE is pressed with the previous channel list displayed, Channels 1!1, 1!4, 2!11, and 2!36 will close.

Now assume the M10 is included in the following scan list:

SCAN CHANNELS 1!1, 1!4, M10, 1!6,

When M10 is selected in the scan, both Channels 2!11 and 2!36 will be closed at the same time and will remain closed when channel 1!6 is scanned.

Typically, a channel pattern is used to switch in a bias supply. Once the memory location (i.e., M10) is scanned, the closed channels in the pattern will remain closed to supply power for the duration of the scan.

MENU

MENU overview

Various instrument operations to configure the Model 7002-HD are performed using the front panel MENU. The MENU structure is shown and summarized in Table 4-2.

General rules to use MENU:

1. The MAIN MENU is displayed by pressing the MENU key. The MAIN MENU selections are shown as follows:

   MAIN MENU
   SAVESETUP GPIB DIGITAL-I/O ▶
   ◀ TEST LANGUAGE GENERAL
2. Pressing the EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the MAIN MENU is displayed, pressing EXIT or MENU will disable MENU.
3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys.
4. A displayed arrow indicates that there is more information or additional menu items to select from. When the right arrow is displayed, use the right cursor key to display the additional message(s); and conversely, when the left arrow is displayed, use the left cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad.

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Table 4-2
MENU structure

Menu item	Description
SAVESETUP	Setup Menu:
SAVE	Save setup at a memory location (up to 10).
RESTORE	Return 7002 -HD to setup stored at a memory location.
PWRON	Power-on Menu:
FACTORY DEFAULT	Power-on to factory default setup conditions.
USER SETUP	Power-on to setup stored at a memory location.
RESET	Return 7002-HD to original power-on setup.
GPIB	GPIB Setup Menu:
ADDRESS	Check/change IEEE-488 address.
STATUS	Display IEEE-488 status byte.
TEST	Self-Test Menu:
BUILT-IN TESTS	Test Digital Board:
AUTO	Run all tests automatically.
MANUAL	Select tests to run.
DISPLAY TESTS	Test Display Board:
KEYS	Verify operation of front panel keys.
PATTERNS	Verify operation of VFD display.
CHAR SET	Display ASCII character set.
LANGUAGE	Choose 7002-HD Language:
ENGLISH	Display messages in English.
GERMAN	Display messages in German.
FRENCH	Display messages in French.
GENERAL	General Menu:
SERIAL #	Displays serial number, SCPI version, and software revision.
STATUS-MESSAGES	Enables/disables status message mode.
DISPLAY	Not a valid option for 7002-HD.
BREAK BEFORE MAKE	Enables/disables Break-Before-Make.

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MENU descriptions

SAVESETUP

The SAVESETUP menu is used for the following operations:

- Save setup at a memory location.
- Return to setup stored at a memory location.
- Power-on to factory default setup conditions.
- Power-on to setup stored at a memory location.
- Return 7002-HD to original power-on setup.

Perform the following steps to display the SAVESETUP menu:

1. Press MENU to display the MAIN MENU.
2. Use the cursor keys to place the cursor on SAVESETUP, and press ENTER to display the following menu:

   SETUP MENU
   SAVE RESTORE PWRON RESET

SAVE — Use this menu item to save the current setup conditions in memory at a specified memory location. To select SAVE, place the cursor on SAVE and press ENTER. The following typical message will be displayed:

SAVE SETUP #0 (0-9)

1. To save the current setup at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To save the current setup to a different memory location, key in a value (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

RESTORE — Use this menu item to return the instrument to the setup conditions that are stored in memory at a specified memory location. To select RESTORE, place the cursor on RESTORE and press ENTER. The following typical message will be displayed:

RESTORE SETUP #0

1. To restore the instrument to the setup conditions stored at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To restore the instrument to the setup conditions stored at a different memory location, key in the memory location (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

PWRON — Use this menu item to select the setup conditions that the instrument will power-on to. To select the PWRON menu item, place the cursor on PWRON and press ENTER. The following menu will be displayed:

SET POWER-ON DEFAULT
FACTORY-DEFAULT USER-SETUP

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FACTORY DEFAULT — With this selection, the instrument will return to the factory default conditions (see Table 4-3) the next time it is turned on. To select the FACTORY-DEFAULT menu item, place the cursor on FACTORY-DEFAULT and press ENTER. The instrument will return to the SETUP MENU.

USER SETUP — Using this selection, the instrument will power-on to the setup conditions saved at a specified memory location. To select USER SETUP, place the cursor on USER-SETUP and press ENTER. The following typical message will then be displayed:

PWRON DEFAULT = #0

1. To power-on to the setup conditions stored at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To power-on to setup conditions stored at a different memory location, key in the memory location (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

RESET — Use this menu item to reset the instrument to the RESET default setup conditions (see Table 4-3). To select RESET, place the cursor on RESET and press ENTER. The following message will be displayed:

RESETTING INSTRUMENT

Press ENTER to confirm or EXIT to abort. Pressing ENTER will display the following message:

RESET COMPLETE

Press ENTER to return to the SETUP MENU, or EXIT to back out of the menu structure.

Table 4-3
Default conditions

Item	Factory default	RESET
Channel status	All open	All open
Channel list	Cleared	No change
Scan list	No change	No change
GPIB address	No change	No change
Digital I/O output level	High	High
Language	No change	No change
Status messages	Off	Off
# of poles	No change	No change
Card pair	Off	Off
Delay	0 seconds	0 seconds
Channel spacing	Manual (STEP key)	Manual (STEP key)
Number of channels	Scan list length	Scan list length
Channel trigger control	Source	Source
Scan spacing	Immediate	Immediate
Number of scans	Infinite	Infinite
Scan trigger control	Acceptor	Acceptor
Arm spacing	Immediate	Immediate
Arm count	1	1
Arm trigger control	Acceptor	Acceptor
Single channel	Off	Off
Restricted channels	No change	No change
Interlock	No change	No change
Break Before Make	On	On

Note: “No change” indicates that the currently set conditions are not affected.

GPIB

The GPIB menu is used for the following operations:

- Check and/or change the address of the IEEE-488 bus.
- Display the status byte of the IEEE-488 bus.

Perform the following steps to display the GPIB menu:

1. Press MENU to display the MAIN MENU.
2. Use the cursor keys to place the cursor on GPIB, and press ENTER to display the following menu:

   GPIB SETUP MENU
   ADDRESS STATUS

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ADDRESS — Use this menu item to check and/or change the IEEE-488 address. At the factory the address is set to 7, but it can be changed to any value from 0 to 30. To select ADDRESS, place the cursor on ADDRESS and press ENTER. If the address is currently set to 7, the following message will be displayed:

ADDRESS = 07 (0-30)

1. To retain the displayed address, press ENTER or EXIT. The instrument will return to the GPIB SETUP MENU.
2. To change the address, simply key in a valid value (0 to 30) and press ENTER. The instrument will return to the GPIB SETUP MENU.

STATUS — Use this menu item to display the IEEE-488 status byte. Refer to Section 5 (IEEE-488 Reference) for information on the status byte. To select STATUS, place the cursor on STATUS and press ENTER. If for example, all bits of the status byte are reset to zero, it will be displayed as follows:

SHOW STATUS BYTE
EVA = 0 QSB = 0 MAV = 0 ESB = 0 ▶
◀ MSS = 0 OSB = 0

When finished viewing the status byte, press either ENTER or EXIT. The instrument will return to the GPIB SETUP MENU.

TEST

The TEST menu is to be used as a diagnostic tool to isolate problems with the Model 7002-HD. Refer to Section 6 for information on using these test procedures.

LANGUAGE

The LANGUAGE menu is used to change the language for display messages. Language selections include:

- Display messages in ENGLISH.
- Display messages in GERMAN.
- Display messages in FRENCH.

Perform the following steps to change the language of display messages:

1. Press MENU to display the MAIN MENU.
2. Use the cursor keys to place the cursor on LANGUAGE and press ENTER. The following language menu selections will be displayed:

   CHOOSE MENU LANGUAGE
   ENGLISH GERMAN FRENCH

   The cursor will be located on the currently selected language. Note that if a language other than English is currently selected, the menu will be displayed in the selected language.
3. To retain the currently selected language, press EXIT or ENTER. The display will return to the MAIN MENU.

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4. To select one of the other languages, place the cursor on the desired language selection and press ENTER. The instrument will return to the MAIN MENU. The selected language becomes the power-up default.
5. When finished with LANGUAGE, use EXIT to back out of the menu structure.

GENERAL

The GENERAL MENU is used for the following operations:

- Read the serial # of the Model 7002-HD.
- Read the SCPI version control number.
- Read the software revision level installed in the Model 7002-HD.
- Control the Status Message Mode.
- Disable/Enable Break Before Make.

Perform the following steps to use the GENERAL MENU:

1. Press MENU to display the MAIN MENU.
2. Use the cursor keys to place the cursor on GENERAL and press ENTER. The following menu will be displayed:

   GENERAL MENU
   SERIAL # STATUS-MSGS ▶
   ◀ BREAK BEFORE MAKE

SERIAL # — To display the serial number, SCPI version and software revision level of the instrument, place the cursor on SERIAL # and press ENTER. The following information will be displayed:

Serial #XXXXXX
SCPI Version 1996.0
software rev AXX/AYY /---

where: AXX is the software revision of the main CPU.

AYY is the software revision of the VFD display CPU.

When finished, press ENTER or EXIT to return to the GENERAL MENU.

STATUS MESSAGES — This selection is used to enable or disable the status message mode. When enabled, status messages will be displayed to identify specific operations that are performed. Place the cursor on STATUS-MESSAGES and press ENTER. The following message will be displayed:

STATUS MESSAGES
OFF ON

Place the cursor on the desired state (on or off) and press ENTER. The instrument will return to the GENERAL MENU.

BREAK-BEFORE-MAKE — This selection is used to enable or disable Break-Before-Make. When enabled, the previous channel will open before the next channel closes during a scan. This ensures that two scanned channels will not be

closed at the same time. When recalling a channel pattern from memory, all other channels will open before the channels in the pattern close.

When disabled, break-before-make is no longer ensured. During a scan, this could result in two channels closed momentarily at the same time. When recalling a channel pattern, the channels in the pattern could close before the previous channels open.

Break-Before-Make incorporates a delay to make sure that a channel(s) opens before the next channel(s) closes. If Break-Before-Make is not necessary for your test system, you can increase scanning speed by disabling it.

Place the cursor on BREAK-BEFORE-MAKE and press ENTER to display the following selections:

BREAK BEFORE MAKE
ON OFF

Cursor position indicates the current state of Break-Before-Make.

Place the cursor on the desired state and press ENTER. The instrument will return to the GENERAL MENU. When finished with the GENERAL MENU, use EXIT to back out of the menu structure.

Card configuration

Various operations to configure the slots of the mainframe are performed from the CARD CONFIG MENU.

NOTE Most 7002-HD cards do not require manual configuration.

Card configuration overview

The menu structure is shown and summarized in Table 4-4.

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Table 4-4
CARD CONFIG MENU structure

Menu item	Description
DELAY SLOT	Set Delay For: Set delay for card in specified slot.
READ-I/O-CARD	Identify I/O Cards.

General rules to use CARD CONFIG MENU:

1. The CARD CONFIG MENU is displayed by pressing the CARD CONFIGURATION key. The CARD CONFIG MENU selections are shown as follows:

   CARD CONFIG MENU
   TYPE #-OF-POLES CARD-PAIR ▶
   ◀ DELAY READ-I/O-CARD
2. The EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the CARD CONFIG MENU is displayed, pressing EXIT will disable card configuration.
3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys.
4. A displayed arrow indicates that there is more information or additional menu items to select from. When the left arrow is displayed, use the left cursor key to display the additional message(s); and conversely, when right arrow is displayed, use the right cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry.
8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.

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DELAY

The DELAY feature sets a channel delay for each of the ten cards installed in the mainframe. The delay can be set from 00000.001 seconds (1 millisecond) to 99999.999 seconds. This delay is in addition to the internally set relay settling time delay.

This user programmed delay is the time delay between channels during a scan. The first delay period occurs after the first channel(s) closes. In other words, the programmed delay does not occur at the beginning of a scan.

Perform the following steps to set a delay:

1. Press CARD CONFIGURATION to display CARD CONFIG MENU.
2. Place the cursor on DELAY and press ENTER. The following message is displayed:

   SET DELAY FOR:
   SLOT-#1 #2 #3 #4 #5 ▶
   ◀ SLOT-#6 #7 #8 #9 #10
3. Place the cursor on the slot that you wish to set a delay for and press ENTER. If, for example, you select slot 6 and it currently is set for a one second delay, the following message is displayed:

   (06) DELAY=00001.000
4. To change the delay period, use the cursor keys and the numeric keypad to key in the new value.
5. With the desired delay period displayed, press ENTER.
6. When finished, use the EXIT key to back out of the menu structure.

READ-I/O-CARD

This menu selection is used to identify if there are any I/O cards installed in the Model 7002-HD.

1. Press CARD CONFIGURATION to display the CARD CONFIG MENU.
2. Place the cursor on READ-I/O-CARD and press ENTER to display the model number of an installed I/O card.
3. Press EXIT to back out of the menu structure.

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Scan configuration

Various operations to configure a scan are performed from the CONFIGURE SCAN menu.

Scan configuration overview

The menu structure is shown and summarized in Table 4-5.

General rules to use CONFIGURE SCAN:

1. The CONFIGURE SCAN menu is displayed by pressing the SCAN CONFIGURATION key. The CONFIGURE SCAN menu selections are shown as follows:

   CONFIGURE SCAN
   CHAN-CONTROL SCAN-CONTROL ▶
   ◀ ARM-CONTROL CHAN-RESTRICTIONS
2. The EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the CONFIGURE SCAN menu is displayed, pressing EXIT will disable SCAN CONFIGURATION.
3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys.
4. A displayed arrow indicates that there is more information or additional menu items to select from. When the left arrow is displayed, use the left cursor key to display the additional message(s), and conversely, when the right arrow is displayed, use the right cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry.
8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.

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Table 4-5
CONFIGURE SCAN menu structure

Menu item	Description

CHAN-CONTROL
  CHANNEL-SPACING
  TIMER
  EXTERNAL
  GPIB
  MANUAL
  TRIGLINK
  ASYNCHRONOUS
  SEMI-SYNCHRONOUS
  IMMEDIATE
  HOLD
  NUMBER-OF-CHANS
  USE-SCANLIST-LENGTH
  CHAN-COUNT
  INFINITE
  ENTER-CHAN-COUNT
  CONTROL
  SOURCE
  ACCEPTOR
	Configure Channel Layer:
	  Select channel spacing:
	  Use a timer to select each channel in the scan.
	  Will be accepted, but no valid hardware exists.
	  Use a bus trigger to select each channel.
	  Use STEP key to select each channel.
	  Use a Trigger Link trigger to select each channel.
	  Use separate lines for In/Out triggers.
	  Use same line for In/Out triggers.
	  Use to scan channels immediately.
	  Use to hold up the scan in the channel layer.
	  Define number of channels to scan:
	  Count = number of channel entries in scan list.
	  User defined count:
	  Repeat channel scanning indefinitely.
	  Count = user defined value (1 to 9999)
	  Select trigger control mode:
	  Enable the Source Bypass.
	  Disable the Source Bypass.

SCAN-CONTROL
  SCAN-SPACING
  TIMER
  EXTERNAL
  GPIB
  MANUAL
  TRIGLINK
  IMMEDIATE
  HOLD
  NUMBER-OF-SCANS
  INFINITE
  ENTER-SCAN-COUNT
  CONTROL
  SOURCE
  ACCEPTOR
	Configure Scan Layer:
	  Select scan spacing:
	  Use the timer to control scan spacing.
	  Will be accepted, but no valid hardware exists.
	  Use bus triggers to control scan spacing.
	  Use STEP key to control scan spacing.
	  Use Trigger Link triggers to control scan spacing.
	  Use to pass operation immediately into the channel layer.
	  Use to hold up the scan in the scan layer.
	  Define number of scans to be performed:
	  Repeat scan indefinitely.
	  Count = user defined value (1 to 9999).
	  Select trigger control mode:
	  Enable Source Bypass.
	  Disable Source Bypass.

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Table 4-5 (cont.)
CONFIGURE SCAN menu structure

Menu item	Description
ARM-CONTROL ARM SPACING MANUAL IMMEDIATE GPIB EXTERNAL TRIGLINK HOLD ARM-COUNT INFINITE ENTER-ARM-COUNT TRIGGER-CONTROL SOURCE ACCEPTOR	Configure Arm Layer: Select arm spacing control: Use STEP key to arm scanner. Use to arm scanner immediately. Use a bus trigger to arm scanner. Will be accepted, but no valid hardware exists. Use a Trigger Link trigger to arm scanner. Use to hold up the scan in the arm layer. Define number of times to arm scanner: Continuously re-arm scanner. User defined count value (1 to 9999). Select trigger control mode: Enable Source Bypass. Disable Source Bypass.
CHAN-RESTRICTIONS SINGLE-CHAN RESTRICTED-CHANNELS INTERLOCK	Define channel restrictions: Enable/disable Single Channel Mode. Designate channels that cannot be closed. Specify up to five sets of interlocked channels.

Scan configuration description

CHAN-CONTROL

Channel control is used for the following operations:

- To select the event that controls the time period (CHANNEL SPACING) between channel closures of a scan.
- Designate the NUMBER OF CHANS (channels) in the scan.
- Enable or disable the Source Bypass.

Perform the following steps to configure the channel layer:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Use the cursor keys to place the cursor on CHAN-CONTROL and press ENTER to access the following menu:

   CHANNEL CONTROL
   CHANNEL-SPACING NUMBER-OF-CHANS ▶
   ◀ CONTROL

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CHANNEL-SPACING

Use this menu item to select the event that controls the time period between channel closures of the scan. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on CHANNEL-SPACING and pressing ENTER. The following menu will be displayed:

SELECT CHAN SPACING
TIMER EXTERNAL GPIB MANUAL ▶
◀ TRIGLINK IMMEDIATE HOLD

Timer — Use the timer to control channel spacing. The timer is used to set a time interval between channel closures of the scan. The timer can be set for an interval from zero to 99999.999 seconds with 0.001 second (1 millisecond) resolution. The first interval begins after the first channel of the scan closes. Perform the following steps to use the timer:

1. With the SELECT CHAN SPACING menu displayed, place the cursor on TIMER and press ENTER. A message indicating the currently set time interval (in seconds) will be displayed. If, for example, the timer is set to 1 millisecond, the following message will be displayed:

   INTERVAL = 00000.001

2. To retain the displayed timer interval, press EXIT or ENTER. The instrument will return to the CHANNEL CONTROL menu.
3. To set a different time interval, use the keypad to key in the value (in seconds) and press ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key (see MANUAL) is active with the timer selected. Each press of the STEP key will select the next channel of the scan. This can be used to quickly step through a scan that has a relatively long timer interval.

External — Will be accepted, but no valid hardware exists.

GPIB — With this selection, bus triggers are used to control channel spacing for the scan. Each trigger sent over the bus (GET or *TRG) will open the current channel and close the next channel of the scan. See Section 5 for detailed information on bus triggers.

Select bus triggering from the SELECT CHAN SPACING menu by placing the cursor on GPIB and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Each press of the STEP key will select the next channel of the scan.

Manual — With this selection, the front panel STEP key is used to control channel spacing. Each time the STEP key is pressed, the current channel of the scan will open and the next channel will close.

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Select manual triggering from the CHANNEL SPACING menu by placing the cursor on MANUAL and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key is active when TIMER, GPIB or TRIGGER LINK is selected.

Triglink — With this selection, channel spacing of the scan is controlled by the Trigger Link of the Model 7002-HD. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Each trigger stimulus applied to the Model 7002-HD will open the current channel and close the next channel of the scan.

Note: The front panel STEP key (see MANUAL) is active with Trigger Link selected. Each press of the STEP key will select the next channel of the scan.

Select the Trigger Link from the SELECT CHAN SPACING menu by placing the cursor on TRIGLINK and pressing ENTER. The following menu will be displayed:

SET TRIGGERLINK MODE
ASYNCHRONOUS SEMI-SYNCHRONOUS

ASYNCHRONOUS — The asynchronous trigger link mode is used for trigger configurations that require input and output triggers to be routed on separate lines. Perform the following steps to select the asynchronous mode, and to select the input and output trigger lines for the Model 7002-HD:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on ASYNCHRONOUS and press ENTER. The following message will be displayed:

   SELECT INPUT LINE
   #1 #2 #3 #4 #5 #6

2. To select a trigger input line for the Model 7002-HD, place the cursor on the desired line number and press ENTER. The following message will be displayed:

   SELECT OUTPUT LINE
   #1 #2 #3 #4 #5 #6

3. To select a trigger output line for the Model 7002-HD, place the cursor on a different line number and press ENTER. The instrument will return to the SELECT CHAN SPACING menu. Note that you cannot use the same trigger line for both input and output.

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SEMI-SYNCHRONOUS — In this mode, the input and output triggers for the Model 7002-HD are assigned to the same line. Perform the following steps to select the semi-synchronous mode, and to select the trigger line:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on SEMI-SYNCHRONOUS and press ENTER. The following message will be displayed:

   SET SEMI-SYNC LINE
   #1 #2 #3 #4 #5 #6

2. To select a trigger line for the Model 7002, place the cursor on the desired line number and press ENTER. The instrument will return to the SELECT CHAN SPACING menu.

Immediate — With this selection, events (such as the TIMER triggers) do not control channel spacing. Once the scan starts, the Model 7002-HD will step through it as fast as the internal settling time and user programmed delay will allow.

Select immediate triggering from the SELECT CHAN SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Hold — When HOLD is selected, channel spacing is suppressed. As a result, the scan is stopped and will not continue until HOLD is cancelled by selecting another channel spacing selection. Select trigger hold from the SELECT CHAN SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

NUMBER-OF-CHANS

Use this menu item to define the number of channels to be scanned. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on NUMBER-OF-CHANS and pressing ENTER. The following menu will be displayed:

NUMBER OF CHANNELS
USE-SCANLIST-LENGTH CHAN-COUNT

Use-scanlist-length — With this selection, the number of channels in the scan is determined by the number of channels defined in the scan list. For example, if the scan list is made up of channels 1!1, 1!2, 1!3, and 1!4, the number of channels to be scanned is four. Select scan list length count from the NUMBER OF CHANNELS menu by placing the cursor on USE-SCANLIST-LENGTH and pressing ENTER. The display will return to the CHANNEL CONTROL menu.

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Chan-count — With this selection, the user determines the number (count) of channels to scan. The user programmed count can be smaller, equal to, or larger than the number of channels in the scan list. For example, if the scan list is made up of four channels (1!1, 1!2, 1!3, and 1!4), the user can program a count of 12. With this count value, the instrument will repeat the channel scan three times. An advantage of repeating channels (rather than scans) is that delays in the scan layer of operation (SCAN CONTROL) are avoided. The channel spacing delays between all 12 channels are the same.

Select CHAN-COUNT from the NUMBER OF CHANNELS menu by placing the cursor on CHAN-COUNT and pressing ENTER. The following menu will be displayed:

CHANNEL COUNT
INFINITE ENTER-CHAN-COUNT

INFINITE — Use this selection to continuously repeat the scan. With the CHANNEL COUNT menu displayed, select this menu item by placing the cursor on INFINITE and pressing ENTER. The display will return to the CHANNEL CONTROL menu.

ENTER-CHAN-COUNT — Use this selection to define the number of channels in the scan. Perform the following steps to define a finite count:

1. With the CHANNEL COUNT menu displayed, place the cursor on ENTER-CHAN-COUNT and press ENTER. A message indicating the current count will be displayed.

   CHANNEL COUNT = 0010

   The above message indicates that the current count is set to 10.
2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the CHANNEL CONTROL menu.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the channel spacing event on the first pass through the channel layer. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu will be displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

Cursor position indicates the current selection.

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Source — With this selection, the source bypass is enabled. The channel spacing event will be bypassed on the first pass through the channel layer if TRIG LINK channel spacing is selected. This will allow the first channel in the scan to close without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

Place the cursor on the desired selection and press ENTER. When finished with the channel layer, use EXIT to back out of the MENU structure.

SCAN-CONTROL

Scan control is used for the following operations:

- To select the event that controls scan spacing.
- Designate the NUMBER-OF-SCANS to be performed.
- Enable or disable the Source Bypass.

Perform the following steps to configure the scan layer:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Use the cursor keys to place the cursor on SCAN-CONTROL and press ENTER to access the following menu:

   SCAN CONTROL
   SCAN-SPACING NUMBER-OF-SCANS ▶
   ◀ CONTROL

SCAN-SPACING

Use this menu item to select the event that controls the time period between scans. With the SCAN CONTROL menu displayed, select this menu item by placing the cursor on SCAN-SPACING and press ENTER. The following menu will be displayed:

SELECT SCAN SPACING
TIMER EXTERNAL GPIB MANUAL ▶
◀ TRIGLINK IMMEDIATE HOLD

Timer — Use the timer feature to control scan spacing. The timer is used to set a time interval between scans. The timer can be set for an interval from zero to 99999.999 seconds with 0.001 second (1 millisecond) resolution. After a scan is triggered to start, the next scan will start at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single scan, the next scan will not start until the previous scan is completed.

Note: The front panel STEP key (see MANUAL) is active with the timer selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7002-HD is programmed for another scan; see NUMBER OF SCANS).

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Perform the following steps to use the timer:

1. With the SELECT SCAN SPACING menu displayed, place the cursor on TIMER and press ENTER. A message indicating the currently set time interval (in seconds) will be displayed:

   INTERVAL = 00000.001

2. To retain the displayed timer interval, press EXIT or ENTER. The instrument will return to the SCAN CONTROL menu.
3. To set a different time interval, use the keypad to key in the value (in seconds) and press ENTER. The instrument will return to the SCAN CONTROL menu.

External — Will be accepted, but no valid hardware exists.

GPIB — With this selection, bus triggers are used to control scan spacing. Operation will pass into the channel layer when a bus trigger (GET or *TRG) is received by the Model 7002-HD. See Section 5 for detailed information on bus triggers.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7002-HD is programmed for another scan; see NUMBER OF SCANS).

Select bus triggering from the SELECT SCAN SPACING menu by placing the cursor on GPIB and pressing ENTER. The display will return to the SCAN CONTROL menu.

Manual — With this selection, the front panel STEP key is used to control scan spacing. Operation will pass into the channel layer when STEP is pressed.

Note: The front panel STEP key is active when TIMER, GPIB or TRIGGER LINK is selected.

Select manual triggering from the SELECT SCAN SPACING menu by placing the cursor on MANUAL and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

Triglink — With this selection, scan spacing is controlled by the Trigger Link of the Model 7002-HD. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the channel layer when the Model 7002-HD receives a trigger over the Trigger Link.

Note: The front panel STEP key (see MANUAL) is active with the Trigger Link selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7002-HD is programmed for another scan; see NUMBER OF SCANS).

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Select the Trigger Link from the SELECT SCAN SPACING menu by placing the cursor on TRIGLINK and pressing ENTER. The following menu will be displayed:

SELECT INPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the currently selected input line.

To select a trigger input line for the Model 7002-HD, place the cursor on the desired line number and press ENTER. The following message will be displayed:

SELECT OUTPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the currently selected output line.

To select a trigger output line for the Model 7002-HD, place the cursor on a different line number and press ENTER. Note that you cannot use the same trigger line for both input and output.

Immediate — With IMMEDIATE selected, operation passes immediately into the channel layer. Select immediate scanning from the SELECT SCAN SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

Hold — When HOLD is selected, scan spacing is suppressed. As a result, operation will not continue until HOLD is cancelled by selecting one of the other scan spacing selections. Select HOLD from the SELECT SCAN SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

NUMBER-OF-SCANS

Use this menu item to define the number of scans to be performed by the Model 7002-HD. With the SCAN CONTROL menu displayed, select this menu item by placing the cursor on NUMBER-OF-SCANS and press ENTER. The following menu will be displayed:

NUMBER OF SCANS
INFINITE ENTER-SCAN-COUNT

Infinite — Use this selection to continuously repeat the scan. Select continuous scanning from the NUMBER OF SCANS menu by placing the cursor on INFINITE and pressing ENTER. The display will return to the SCAN CONTROL menu.

Enter-Scan-Count — With this selection, the user determines the number of scans to perform. You can program the Model 7002-HD to perform from 1 to 9999 scans. For example, if you enter a scan count of 10, the programmed scan will be performed 10 times. Perform the following steps to enter the scan count:

1. With the NUMBER OF SCANS menu displayed, place the cursor on ENTER-SCAN-COUNT and press ENTER. A message indicating the current scan count will be displayed.

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SCAN COUNT = 0001

The above scan count indicates that the Model 7002-HD will perform one scan. A value of “0000” indicates that the scan count is set to infinite.

2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the SCAN CONTROL menu.

CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the scan spacing event on the first pass through the scan. With the SCAN CONTROL menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu will be displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

Source — With this selection, the source bypass is enabled. The scan spacing event will be bypassed on the first pass through the scan layer if or TRIG LINK scan spacing is selected. This will allow operation to proceed on into the channel layer without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

Place the cursor on the desired selection and press ENTER. When finished with the scan layer, use EXIT to back out of the menu structure.

ARM CONTROL

Arm control is used for the following operations:

- To select the arming event (ARM SPACING) for the scanner.
- Designate the number of times the scanner is to be armed (ARM COUNT).
- Enable or disable the Source Bypass.

Perform the following steps to configure the arm layer:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Use the cursor keys to place the cursor on ARM CONTROL and press ENTER to access the following menu:

   SETUP ARM CONTROL ▶
   ARM-SPACING ARM-COUNT
   ◀ TRIGGER-CONTROL

ARM-SPACING

This menu item is used to select the event that controls the arm spacing. To select this menu item, place the cursor on ARM-SPACING and press ENTER. The following menu will be displayed:

ARM SPACING
MANUAL IMMEDIATE GPIB ▶
◀ EXTERNAL TRIGLINK HOLD

Manual — With this selection, the front panel STEP key is used to control arm spacing. Operation will pass into the scan layer when the STEP key is pressed.

Note: The front panel STEP key is active when TIMER, GPIB, or TRIGGER LINK is selected.

To select manual triggering (STEP key) from the SELECT ARM SPACING menu, place the cursor on MANUAL and press ENTER. The instrument will return to the SETUP ARM CONTROL menu.

Immediate — With this selection, operation will pass immediately into the scan layer.

Select immediate triggering from the SELECT ARM SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the SETUP ARM CONTROL menu.

GPIB — With this selection, bus triggers are used to control arm spacing. Operation will pass immediately into the scan layer when a bus trigger (GET or *TRG) is received by the Model 7002-HD. See Section 5 for detailed information on bus triggers.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Pressing the STEP key will pass operation into the scan layer.

To select bus triggering from the SELECT ARM SPACING menu, place the cursor on GPIB and press ENTER. The display will return to the SETUP ARM CONTROL menu.

External — Will be accepted, but no valid hardware exists.

Triglink — With this selection, arm spacing is controlled by the Trigger Link of the Model 7002-HD. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the scan layer when the Model 7002-HD receives a trigger over the Trigger Link. Note: The front panel STEP key (see MANUAL) is active with the Trigger Link selected. Pressing the STEP key will pass operation into the scan layer.

To select the Trigger Link from the SELECT ARM SPACING menu, place the cursor on TRIGLINK and press ENTER. The following menu will be displayed:

SELECT INPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the currently selected input line.

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To select a trigger input line for the Model 7002-HD, place the cursor on the desired line number and press ENTER. The following message will be displayed:

SELECT OUTPUT LINE
#1 #2 #3 #4 #5 #6

The position of the cursor indicates the currently selected output line.

To select a trigger output line for the Model 7002-HD, place the cursor on a different line number and press ENTER. Note that you cannot use the same trigger line for both input and output.

Hold — When HOLD is selected, arm spacing is suppressed. As a result, operation will not pass into the scan layer until HOLD is cancelled by selecting one of the other arm spacing selections. Select HOLD from the SELECT ARM SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the SETUP ARM CONTROL menu.

ARM-COUNT

This menu item is used to define the number of times operation will return to the arm layer. With the SETUP ARM CONTROL menu displayed, select this menu item by placing the cursor on ARM-COUNT and press ENTER. The following menu will be displayed:

ARM COUNT
INFINITE ENTER-ARM-COUNT

Infinite — Use this selection to continuously return operation to the arm layer. Select continuous arming from the ARM COUNT menu by placing the cursor on INFINITE and pressing ENTER. The display will return to the SETUP ARM CONTROL menu.

Enter-Arm-Count — With this selection, the user determines the number of times operation returns to the arm layer. You can program the Model 7002-HD to arm up to 9999 times. Perform the following steps to enter the arm count:

With the ARM COUNT menu displayed, place the cursor on ENTER-ARM-COUNT and press ENTER. A message indicating the current arm count will be displayed.

ARM COUNT = 0001

The above arm count indicates that the scanner will arm one time. An arm count of “0000” indicates that infinite is selected.

To program for a different count (1 to 9999), use the keypad to enter the count value.

With the desired count value displayed, press ENTER. The display will return to the SETUP ARM CONTROL menu.

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TRIGGER-CONTROL

Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the arm spacing event on the first pass through the scan. With the SETUP ARM CONTROL menu displayed, select this menu item by placing the cursor on TRIGGER-CONTROL and pressing ENTER. The following menu will be displayed:

TRIGGER CONTROL
SOURCE ACCEPTOR

Source — With this selection, the source bypass is enabled. The arm spacing event will be bypassed on the first pass through the arm layer if TRIG LINK arm spacing is selected. This will allow operation to proceed on into the scan layer without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

Place the cursor on the desired selection and press ENTER. When finished with the arm layer, use EXIT to back out of the menu structure.

CHAN-RESTRICTIONS

The Model 7002-HD can be programmed for the following channel restrictions:

- Enabling SINGLE CHAN (Single Channel) prevents more than one channel from being closed at one time.
- You can define a list of restricted channels (RESTRICTED CHANS). Channels in this list cannot be closed.
- INTERLOCK prevents interlocked channels from being closed.

Perform the following steps to set up channel restrictions:

1. Press SCAN CONFIGURATION to display the CONFIGURE SCAN menu.
2. Place the cursor on CHAN RESTRICTIONS and press ENTER to display the following menu:

   CHANNEL RESTRICTIONS
   SINGLE-CHAN RESTRICTED-CHANS ▶
   ◀ INTERLOCK

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SINGLE-CHAN

Use this selection to enable or disable Single Channel. With Single Channel enabled (ON), only one channel can be closed. Two or more channels cannot be closed at the same time.

Perform the following steps to check or change the state of Single Channel:

1. With the CHANNEL RESTRICTIONS menu displayed, place the cursor on SINGLE CHAN and press ENTER. The following message is displayed:

   SINGLE CHANNEL MODE
   OFF ON

   Cursor position indicates the current state of Single Channel.

2. Place the cursor on the desired state (OFF or ON) and press ENTER. The display returns to the CHANNEL RESTRICTIONS menu.

Operating notes:

1. With Single Channel enabled and more than one channel assigned to the channel list, only the lowest numbered channel in the lowest numbered slot will close when the CLOSE operation is performed. For example, assume the following channel list is defined:

   SELECT CHANNELS 2!1, 5!6, 1!1,

   When the CLOSE operation is performed, only channel 1!1 will close.

2. When Single Channel is enabled, all previously stored channel patterns are cleared from memory.
3. A channel pattern that consists of one closed channel can be saved in memory while Single Channel is enabled. If a channel pattern is saved from a list that contains more than one channel, then only the lowest numbered channel in the lowest numbered slot will close when recalled.
4. Single Channel cannot be enabled if two or more channels are already closed (Settings Conflict error).

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RESTRICTED-CHANS

Use to specify channels that cannot be closed from either the front panel or over the IEEE-488 bus. This is primarily a safety feature to prevent the inadvertent closing of a channel that could cause damage to instrumentation or DUT (i.e., shorting a power supply to ground in a matrix test system).

Perform the following steps to specify restricted channels:

1. With the CHANNEL RESTRICTIONS menu displayed, place the cursor on RESTRICTED-CHANS and press ENTER. The following prompt for channels will be displayed:

   RESTRICTED CHANNELS
   SELECT CHANNELS

2. Enter the channel list from the keypad, and then press EXIT. The display returns to the CHANNEL RESTRICTIONS menu.

Operating notes:

1. If you try to perform a CLOSE operation with a restricted channel in the channel list, none of the channels in the list will close and the following error message will occur:

   ERROR:ID CODE = 550
   Forbidden channel error

2. Whenever you enter a restricted channel into a scan list, the “Forbidden channel error” will occur. The restricted channel will go into the list, but the channel will be skipped when the scan is performed.
3. If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, a saved state error (+510) occurs and the entire Scan List and/or Channel Pattern is cleared (lost).

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INTERLOCK

The Model 7002-HD has five channel interlocks. An interlock is a safety feature that prevents interlocked channels from being closed. Each interlock is made up of two user-defined lists of channels. Each channel in one list is interlocked to each channel in the other list. In general, channels that are interlocked cannot be closed at the same time.

For example, assume Interlock #1 is configured as follows:

Interlock #1:List A = 1!1, 1!2, 1!3

List B = 1!4, 1!5, 1!6

Now assume that the following channel list is defined:

SELECT CHANNELS 1!1, 1!4, 1!9, 1!10,

If you try to close the channels in the above channel list, a “Forbidden channel error” will occur since you are trying to close two channels that are interlocked (channels 1!1 and 1!4). None of the channels in the channel list will close.

Also, if a channel in List A is already closed, then you will not be able to close any of the channels in List B. Conversely, if a channel in List B is already closed, then you will not be able to close any of the channels in List A.

Perform the following steps to specify interlocked channels:

1. With the CHANNEL RESTRICTIONS menu displayed, place the cursor on INTERLOCK and press ENTER to display the following menu:

   SELECT INTERLOCK

   #1 #2 #3 #4 #5
2. Place the cursor on the desired interlock and press ENTER. If for example you select Interlock #1, the following message is displayed:

   INTERLOCK #1

   LIST-A LIST-B
3. Place the cursor on LIST-A and press ENTER to display the list.

   INTERLOCK #1 LIST-A

   SELECT CHANNELS

   The above message shows an empty list. Unwanted channels can be cleared by pressing CLEAR LIST.
4. Using the keypad, enter the interlocked channel or channels for List A.
5. With the desired channel or channels entered into the list, press EXIT to return to the INTERLOCK #1 menu.
6. Place the cursor on LIST-B and press ENTER to display that list.
7. Enter the interlocked channel or channels into List B.
8. Press EXIT to display the INTERLOCK #1 menu. Pressing EXIT one more time will back up the display to the SELECT INTERLOCK menu where you can configure another interlock if you like.
9. When finished, use EXIT to back out of the menu structure.

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Operating notes:

1. An interlock is disabled if one or both of its lists are empty (no channels).
2. Any CLOSE operation that would result in having interlocked channels closed at the same time will be aborted and will display the following error message:

   ERROR:ID CODE = 550
   Forbidden channel error
3. Interlocked channels can be scanned as long as only one channel is closed at a time. However, if a scan is performed while a channel is left closed, any channels in the scan list that are interlocked to the closed channel will be skipped when the scan is performed.
4. If a channel is closed, you can enter a channel that is interlocked to it into the scan list but the “Forbidden channel error” message will occur to indicate that it will not be scanned (see note 3 above).
5. If you specify channels to be interlocked, and they are already included in the Scan List and/or a Channel Pattern (interlock violation), a saved state error (+510) occurs and the entire Scan List and/or Channel Pattern is cleared (lost). For example, if the Scan List includes channels 1!1 and 1!2, and you specify those two channels to be interlocked (1!1 in List A and 1!2 in List B), then the Scan List is cleared.

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Trigger Link

The Model 7002-HD has enhanced external triggering capabilities using the Trigger Link. The Trigger Link has six lines allowing up to six instruments to be controlled over this trigger bus.

Trigger Link connections

The 8-pin micro DIN sockets used for the Trigger Link are shown in Figure 4-4.The two rear panel Trigger Link connectors are actually connected in parallel to each other.

The output trigger signal a TTL-compatible output pulse that can be used to trigger other instrumentation. The specifications for this trigger pulse are shown in Figure 4-5. The Trigger Link input requires a falling-edge, TTL-compatible pulse with the specifications shown in Figure 4-6.

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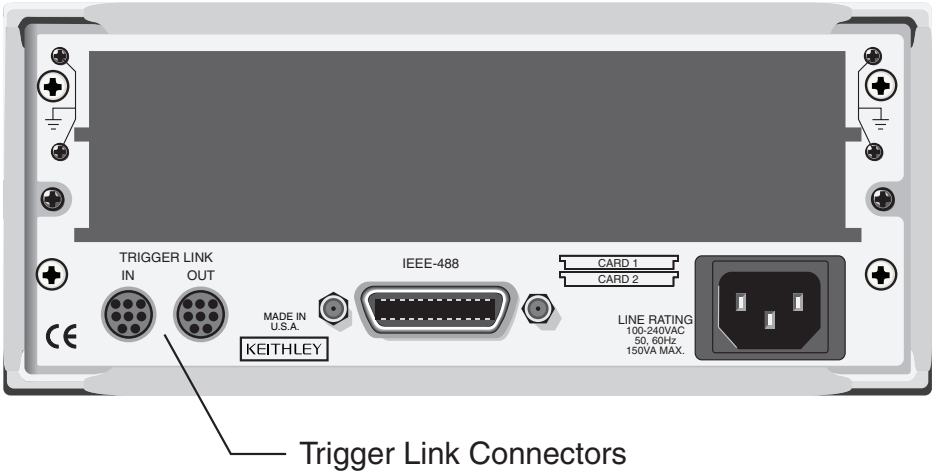
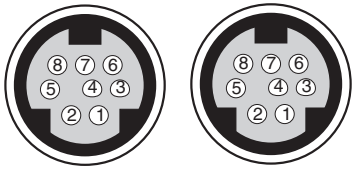
Figure 4-4
Trigger Link connectors



TRIGGER LINK

IN OUT



Pin Number	Trigger Link Line
1	Line #1
2	Line #2
3	Line #3
4	Line #4
5	Line #5
6	Line #6
7	Digital Common
8	Digital Common

Figure 4-5
Trigger Link output pulse specifications

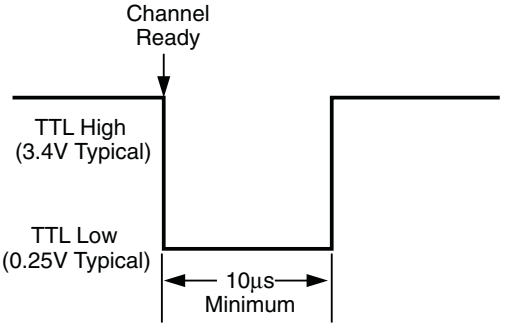


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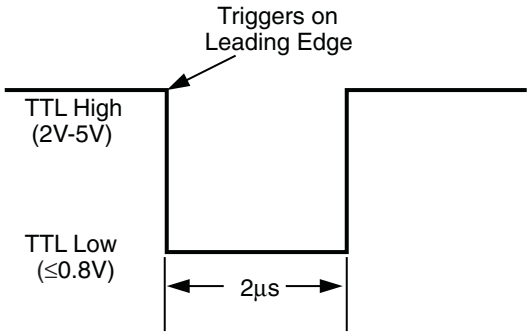
Figure 4-6
Trigger Link input pulse specifications



Trigger Link operation

In general, Trigger Link input triggers to the Model 7002-HD are used to control scan operation. In order for the Model 7002-HD to respond to Trigger Link compatible triggers, the appropriate layers of the scan must be properly programmed. For example, if you want Trigger Link input triggers to control the channel scan process, you must program Channel Spacing for TRIGLINK trigger events. Typically, a Trigger Link output trigger from the Model 7002-HD would be used to trigger another instrument to measure the currently selected channel.

There are two modes of operation for Trigger Link: asynchronous and semi-synchronous. In the asynchronous mode, separate lines are used for input and output triggers, and in semi-synchronous mode, the same line is used for both input and output triggers.

In general, external triggers can be used as events to control scan operation. In order for the Model 7002-HD to respond to external triggers, the appropriate layers of scan operation must be properly configured. ”Scan configuration” on page 4-36 explains how to program the three layers of the scan.

Channel ready

Typically, you would want the Model 7002-HD to output a trigger after each channel closes and settles (settling time includes the internally set relay settle time and the user programmed DELAY period).

The Model 7002-HD can also output a trigger while in the scan and/or arm layers of operation. Figure 4-3 on page 4-15 shows where these triggers occur in the trigger model. An output trigger will occur on each return path through the scan layer if the scan layer Source Bypass is enabled (Control = Source). An output trigger will occur on each return path through the arm layer if the arm layer Source Bypass is enabled (Control = Source). See "Scan configuration" on page 4-36 for programming the scan and arm layer.

Asynchronous operation

The asynchronous mode uses separate lines for input and output triggers. For typical asynchronous Trigger Link operation, the channel layer of the scan is configured with Channel Spacing set to TRIGLINK and Triggerlink Mode set to Asynchronous. You must also select input and output lines for the channel layer. Input and output triggers can be set to any of the six lines, but they cannot use the same line. For example, if you select line #1 for input triggers, then output triggers must use one of the other five lines (#2 through #6). During operation in the channel layer, each Trigger Link input trigger will close a channel in the scan. After the relay settles and the user programmed DELAY times out, the Model 7002-HD will output a Trigger Link trigger (typically to a DMM to make a measurement). The channel layer is configured using the CONFIGURE SCAN menu (see "Scan configuration" on page 4-36).

The scan layer and/or arm layer can also be programmed for TRIGGER LINK: SCAN SPACING is set to TRIGLINK, and ARM SPACING is set to TRIGLINK. When using Trigger Link in these layers, you must also select input and output lines as you did in the channel layer. Keep in mind that you can use the same lines in the scan and arm layers that you selected in the channel layer.

Trigger hold-off

A re-trigger hold-off time of 500μsec is required before another external trigger will be acknowledged. Re-triggering <500μsec will result in ignored or lost triggers.

Asynchronous Trigger Link example

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a meter.

The Trigger Link connections for this test system are shown in Figure 4-7. Trigger Link of the Model 7002-HD is connected to Trigger Link of the meter. Notice that only one Trigger Link cable is needed.

For this example, the Model 7002-HD and the meter are configured as follows:

Model 7002-HD:

Scan List = 1!1-1!10,

- Arm Layer:
- Arm Spacing = Immediate*
- Arm Count = 1*

Arm Trigger Control = Acceptor*

Scan Layer:

- Scan Spacing = Immediate*
- Number of Scans = 1
- Scan Trigger Control = Acceptor*

Channel Layer:

- Channel Spacing = TrigLink
- Trigger Link Mode = Asynchronous
- Input Line = #2
- Output Line = #1
- Channel Trigger Control = Source*
- Number of Channels = Use Scanlist Length*

* Indicates that the setting is the RESET (and factory) default condition.

2001 Multimeter:

Arm Layer:

- Arm Source = Immediate
- Arm Count = 1
- Arm Trigger Control = Acceptor

Scan Layer:

- Scan Source = Immediate
- Scan Count = 1
- Scan Trigger Control = Acceptor

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Measure Layer:

Measure Source = TrigLink

Trigger Link Mode = Asynchronous

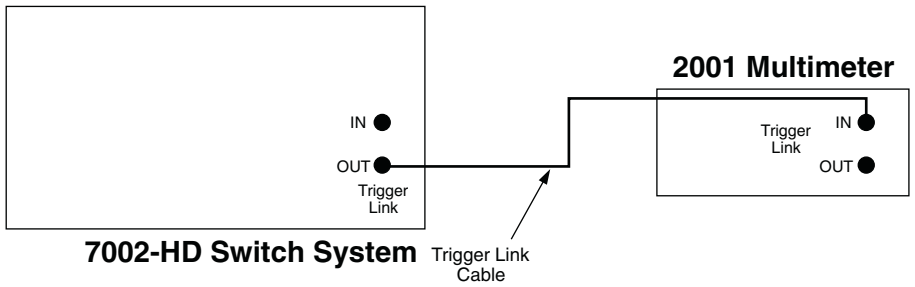
Input Line = #1

Output Line = #2

Measure Trigger Control = Acceptor

Measure Count = 10

Figure 4-7
Trigger Link asynchronous example test connections



Notice that Channel Trigger Control of the Model 7002-HD is set for Source. With this selection, scan operation will initially bypass the need for a Trigger Link trigger to close the first channel. Since arm spacing and scan spacing are set for Immediate, the scan will start immediately as soon as the scanner is taken out of the idle state by pressing the STEP key (assuming the 2001 is also out of the idle state).

To run the test, press STEP on the Model 7002-HD. The following explanation on operation is referenced to the operation model shown in Figure 4-8.

A: Typically, the Model 2001 is used in the continuous initiation state which means it will be in the not idle state. Since both the arm layer and scan layer are programmed for Immediate Source, operation drops down to the measure layer at point A where it waits for a Trigger Link trigger.

B: Pressing STEP takes the Model 7002-HD out of the idle state. Since both the arm and scan layers are programmed for Immediate Spacing, operation drops down to the channel layer at point B.

C: Since Channel Trigger Control is set for Source, the scan will not wait at point B for a trigger. Instead it will bypass “Wait for Trigger Link Trigger” and close the first channel (point C). Note that the Bypass is only in effect on the first pass through the model.

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D: After the relay settles, the Model 7002-HD will output a Trigger Link trigger pulse (point D). Since the instrument is programmed to scan 10 channels, operation will loop back up to point B where it will wait for an input trigger. Note that Bypass is no longer in effect.

E & F: Remember that 2001 operation is at point A waiting for a trigger. The output trigger from the Model 7002-HD triggers the 2001 to measure DUT #1 (point E). After the measurement has completed, the 2001 will output a trigger pulse (point F) and then loop back to point A where it will wait for another input trigger.

The trigger applied to the Model 7002-HD from the 2001 closes the next channel in the scan which in turn triggers the meter to measure the next DUT. This process continues until all 10 channels are scanned and measured.

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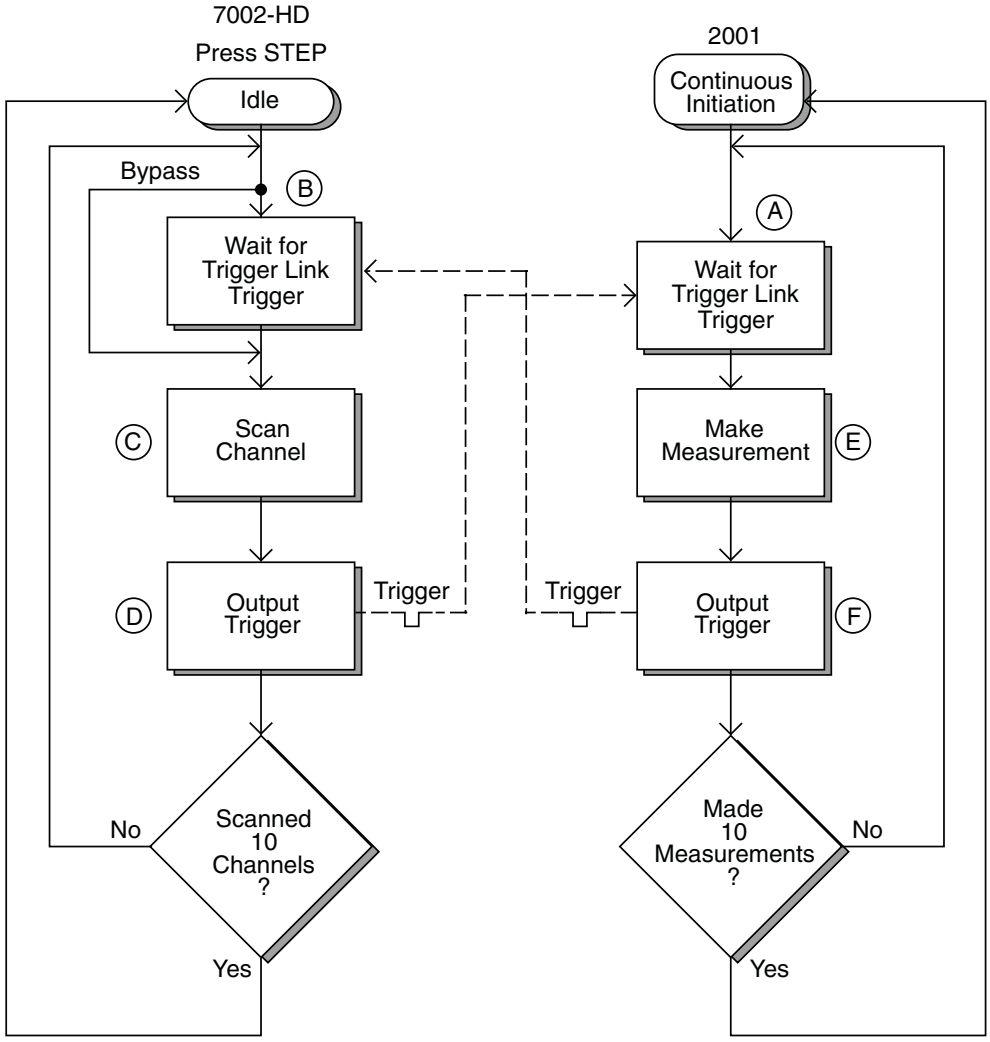
Figure 4-8
Operation model for asynchronous Trigger Link example



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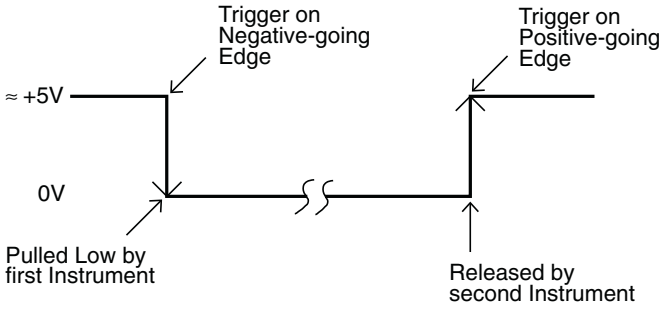
Semi-synchronous operation

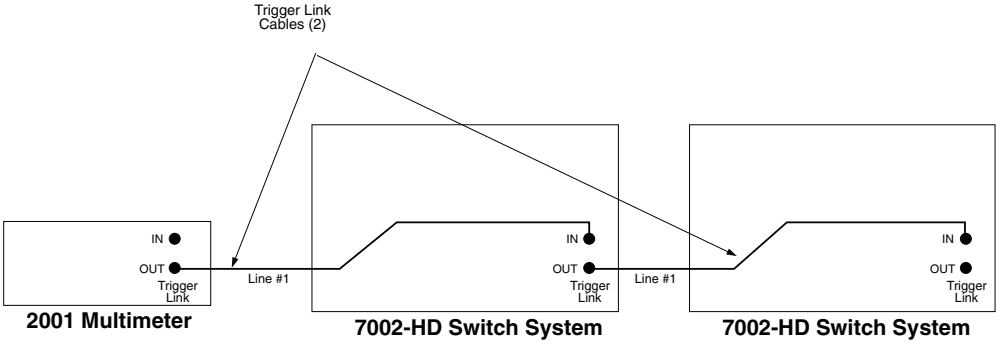
In the semi-synchronous Trigger Link mode all triggering (input and output) in the test system is controlled by a single line. When the normally high (+5V) trigger line is pulled low (0V), a trigger occurs on the negative-going edge. When the trigger line is released, a trigger occurs on the positive-going edge (see Figure 4-9). The advantage of this single line trigger is that as long as one of the instruments in the system holds the line low, the trigger is suppressed. In other words, the trigger will not occur until all instruments in the system are ready.

Figure 4-9
Semi-synchronous trigger link pulse specifications



For example, assume that a Model 2001 Multimeter is connected to two Model 7002-HDs for semi-synchronous operation as shown in Figure 4-10. All three instruments are programmed to use trigger line #1. The two Model 7002-HDs have relay settling times of 10 milliseconds and 50 milliseconds respectively.

Figure 4-10
Typical semi-synchronous mode connections



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Assume that the 2001 initially performs a measurement. After the reading is done, the meter will drive the trigger line low. The negative-going edge will trigger both Model 7002-HDs to close a channel. While the Model 7002-HDs are in the process of closing a channel, they will hold the trigger line low. Ten milliseconds after switch closure, the first Model 7002-HD will release the trigger line. However, the second Model 7002-HD will continue to hold the line low since it is not finished. Fifty milliseconds after switch closure, the second Model 7002-HD will release the trigger line. The positive-going edge will trigger the meter to perform a measurement and subsequently pull the trigger line back down to close the next channels. This process continues until all channels are scanned and measured.

Semi-synchronous trigger link example

This example uses the same test system that was used for the asynchronous Trigger Link example #1. However, triggering will be done using the semi-synchronous mode. Trigger Link connections are shown in Figure 4-11 on page 4-64.

The two instruments are configured as follows:

Model 7002-HD:

Scan List = 1!1-1!10,

Arm Layer:

- Arm Spacing = Immediate*
- Arm Count = 1*
- Arm Trigger Control = Acceptor*

Scan Layer:

- Scan Spacing = Immediate*
- Number of Scans = 1
- Scan Trigger Control = Acceptor*

Channel Layer:

- Channel Spacing = TrigLink
- Trigger Link Mode = Semi-Synchronous
- Semi-Sync Line = #1
- Trigger Control = Source*
- Number of Channels = Use Scanlist Length*

* Indicates that the setting is the RESET (and factory) default condition

Model 2001:

Arm Layer:

- Arm Source = Immediate
- Arm Count = 1
- Arm Trigger Control = Acceptor

Scan Layer:

Scan Source = Immediate

Scan Count = 1

Scan Trigger Control = Acceptor

Measure Layer:

Measure Source = TrigLink

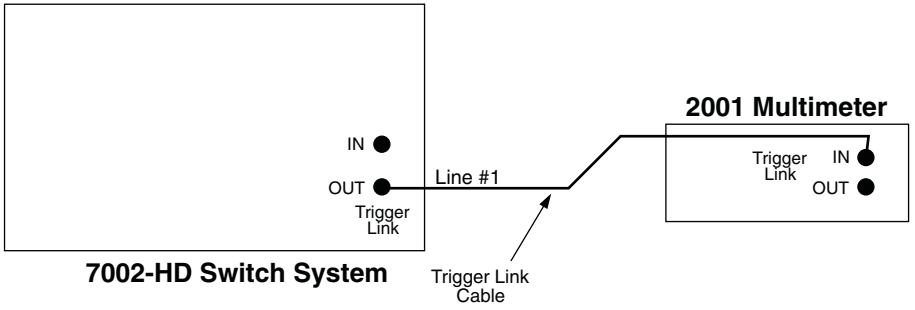
Trigger Link Mode = Semi-Synchronous

Semi-Sync Line = #1

Trigger Control = Acceptor

Measure Count = 10

Figure 4-11
Trigger Link connections (semi-synchronous example)



To run the test, press STEP on the Model 7002-HD. The following explanation on operation is referenced to the operation model shown in Figure 4-12.

A: Typically, the Model 2001 is used in the continuous initiation state which means it will be in the not idle state. Since both the arm layer and scan layer are programmed for Immediate Source, operation drops down to the measure layer at point A where it waits for a Trigger Link trigger.

B: Pressing STEP takes the Model 7002-HD out of the idle state. Since both the arm and scan layers are programmed for Immediate Spacing operation drops down to the channel layer at point B.

C: Since Channel Trigger Control is set for Source, the scan will not wait at point B for a trigger. Instead it will bypass “Wait for Trigger Link Trigger” and close the first channel (point C). Note that the Bypass is only in effect on the first pass through the model.

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D: After the relay settles, the Model 7002-HD will pull down the Trigger Link trigger line (point D). Since the instrument is programmed to scan 10 channels, operation will loop back up to point B where it will wait for an input trigger. Note that Bypass is no longer in effect.

E & F: Remember that 2001 operation is at point A waiting for a trigger. When the trigger line was pulled low by the Model 7002-HD, the leading negative-going edge triggers the meter to measure DUT #1 (point E). Note that the 2001 holds the trigger line low. After the measurement has completed, the 2001 will release the trigger line (point F) and then loop back to point A where it will wait for another input trigger.

When the 2001 releases the trigger line, the leading positive-going edge triggers the Model 7002-HD to close the next channel in the scan, which in turn pulls the trigger line low triggering the meter to measure the next DUT. This process continues until all 10 channels are scanned and measured.

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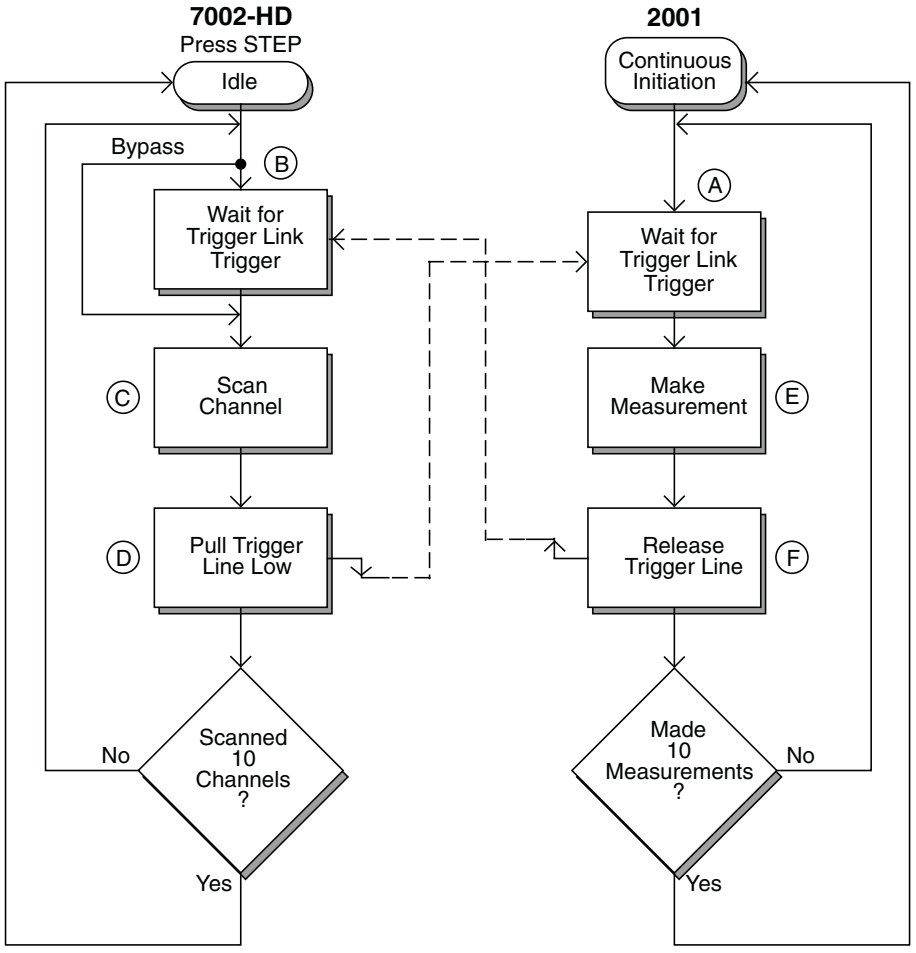
Figure 4-12
Operation model for semi-synchronous Trigger Link example



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5 IEEE-488 Operation

Section 5 topics

Introduction

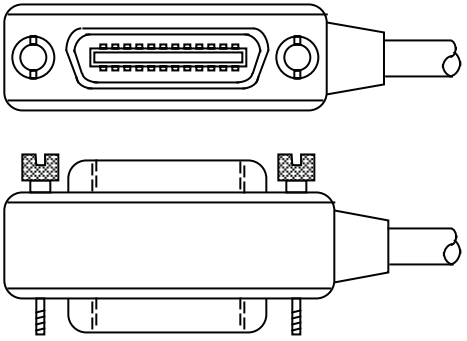
This section contains detailed information on using the Model 7002-HD over the IEEE-488 bus.

Remote operations

IEEE-488 bus connections

The Model 7002-HD can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors as shown in Figure 5-1. The connector can be stacked to allow a number of parallel connections to one instrument. Two screws are located on each connector to ensure that connections remain secure.

Figure 5-1
IEEE-488 connector



A typical connecting scheme for a multi-unit test system is shown in Figure 5-2. Although any number of connectors could theoretically be stacked on one instrument, it is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage. In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Model 7007 shielded IEEE-488 cables are available from Keithley.

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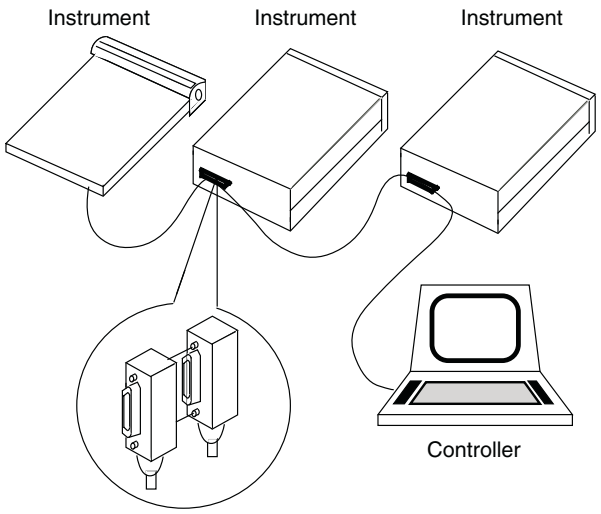
Figure 5-2
IEEE-488 connections



Connect the Model 7002-HD to the IEEE-488 bus as follows:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so it will fit only one way. Figure 5-3 shows the location of the IEEE-488 connector on the instrument.
2. Tighten the screws securely but do not overtighten them.
3. Add additional connectors from other instruments, as required.
4. Make certain that the other end of the cable is properly connected to the controller.

Note that the IEEE-488 bus is limited to a maximum of 15 devices, including the controller. The maximum cable length is 20 meters, or two meters times the number of devices, whichever is less. Failure to observe these limits may result in erratic bus operation.

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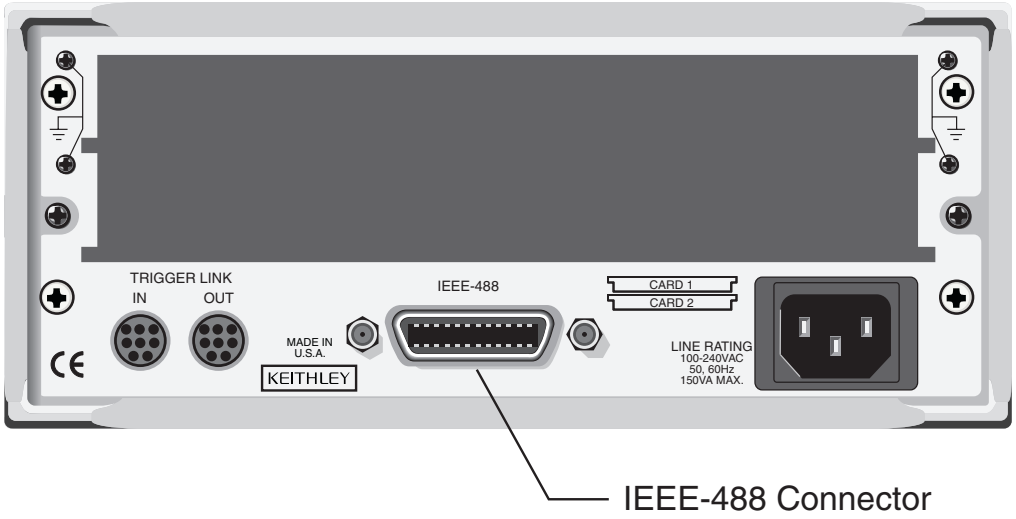
Figure 5-3
IEEE-488 connector location



Primary address selection

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 do not use that address either. Most frequently, controller addresses are 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, perform the following procedure:

1. Display the MAIN MENU by pressing the MENU key.
2. Use the cursor keys to place the cursor on GPIB and press ENTER. The GPIB SETUP MENU will then be displayed.
3. Use the cursor keys to place the cursor on ADDRESS and press ENTER. The current primary address of the instrument will be displayed. For example, if the instrument is set to primary address 7, the following message will be displayed:

   ADDRESS = 07 (0-30)
4. To retain the displayed address, press EXIT three times to return the instrument to the channel status display state.

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5. To change the primary address, use the keypad to display the new address value (0 to 30) and press ENTER. Press EXIT two times to return to the channel status display state.

Front panel IEEE-488 operation

The following paragraphs discuss aspects of the front panel that are part of IEEE-488 operation, including messages, status indicators, and the LOCAL key.

Error and status messages

Table 4-1 on page 4-4 summarizes the error and status messages associated with Model 7002-HD operation. Note that the instrument may be programmed to generate an SRQ, and command queries can be performed to check for specific error conditions.

IEEE-488 status indicators

The REM (remote), TALK (talk), LSTN (listen), and SRQ (service request) annunciators show the present IEEE-488 status of the instrument. Each of these indicators is briefly described below.

REM — As the name implies, this indicator shows when the instrument is in the remote state. Note that REM does not necessarily indicate the state of the REM line, as the instrument must be addressed to listen with REM true before the REM indicator turns on. When the instrument is in remote, all front panel keys except for the LOCAL key are locked out. When REM is turned off, the instrument is in the local state, and front panel operation is restored.

TALK — This indicator is on when the instrument is in the talker active state. The unit is placed in this state by addressing it to talk with the correct MTA (My Talk Address) command. TALK is off when the unit is in the talker idle state. The instrument is placed in the talker idle state by sending it an UNT (Untalk) command, addressing it to listen, or with the IFC (Interface Clear) command.

LSTN — This indicator is on when the Model 7002-HD is in the listener active state, which is activated by addressing the instrument to listen with the correct MLA (My Listen Address) command. Listen is off when the unit is in the listener idle state. The unit can be placed in the listener idle state by sending UNL (Unlisten), addressing it to talk, or by sending IFC (Interface Clear) over the bus.

SRQ — The instrument can be programmed to generate a service request (SRQ) when one or more errors or conditions occur. When this indicator is on, a service request has been generated. This indicator will stay on until the serial poll byte is read.

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LOCAL key

The LOCAL key cancels the remote state and restores local operation of the instrument.

Since all front panel keys except LOCAL are locked out when the instrument is in remote, this key provides a convenient method of restoring front panel operation. Pressing LOCAL also turns off the REM indicator, and returns the display to normal if a user defined message was displayed.

Note that the LOCAL key is also inoperative if the LLO (Local Lockout) command is in effect.

Status structure

The status register structure of the Model 7002-HD is shown in Figure 5-4. The following information will explain the various registers and queues that make up this structure.

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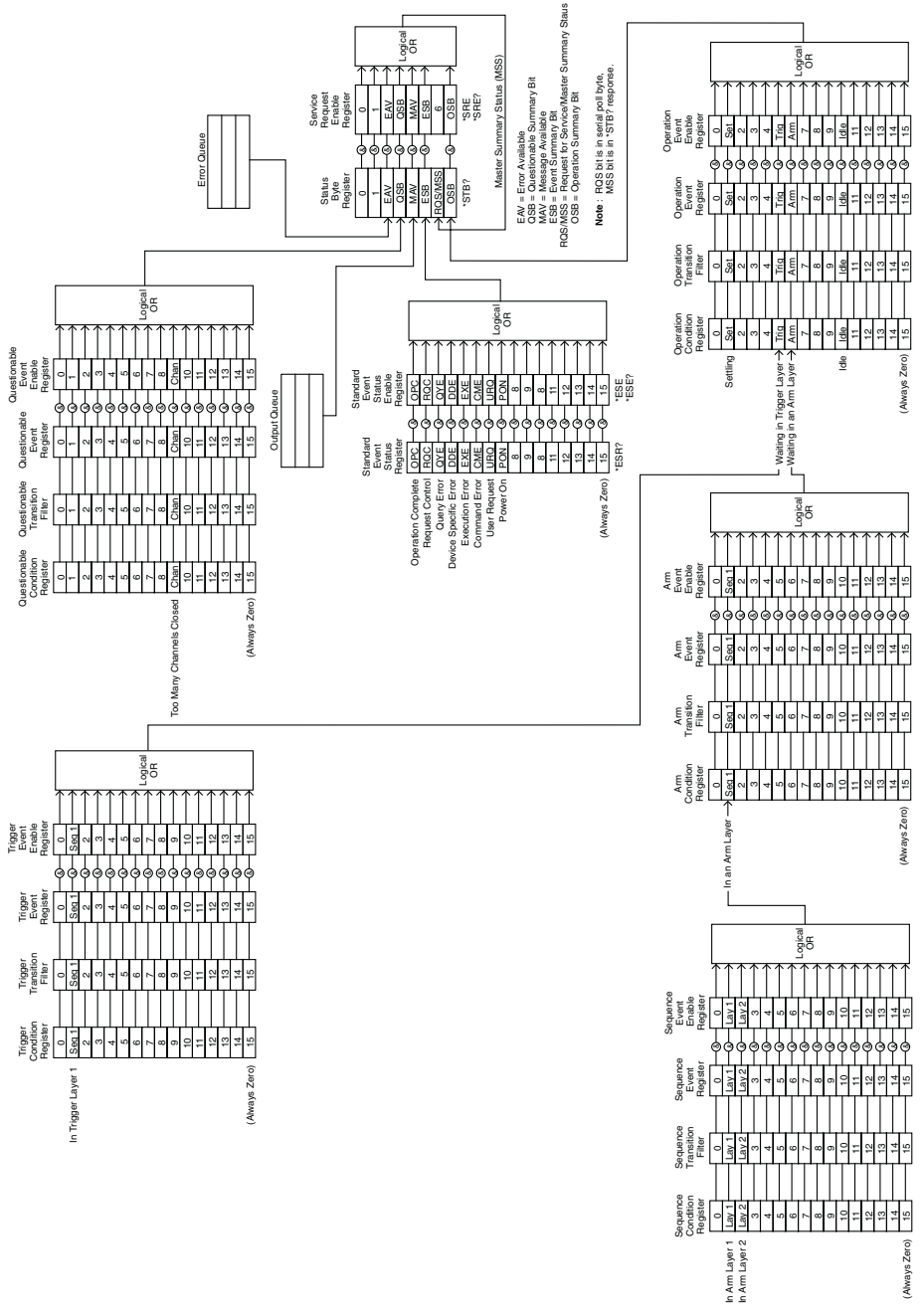
Figure 5-4
Status register structure



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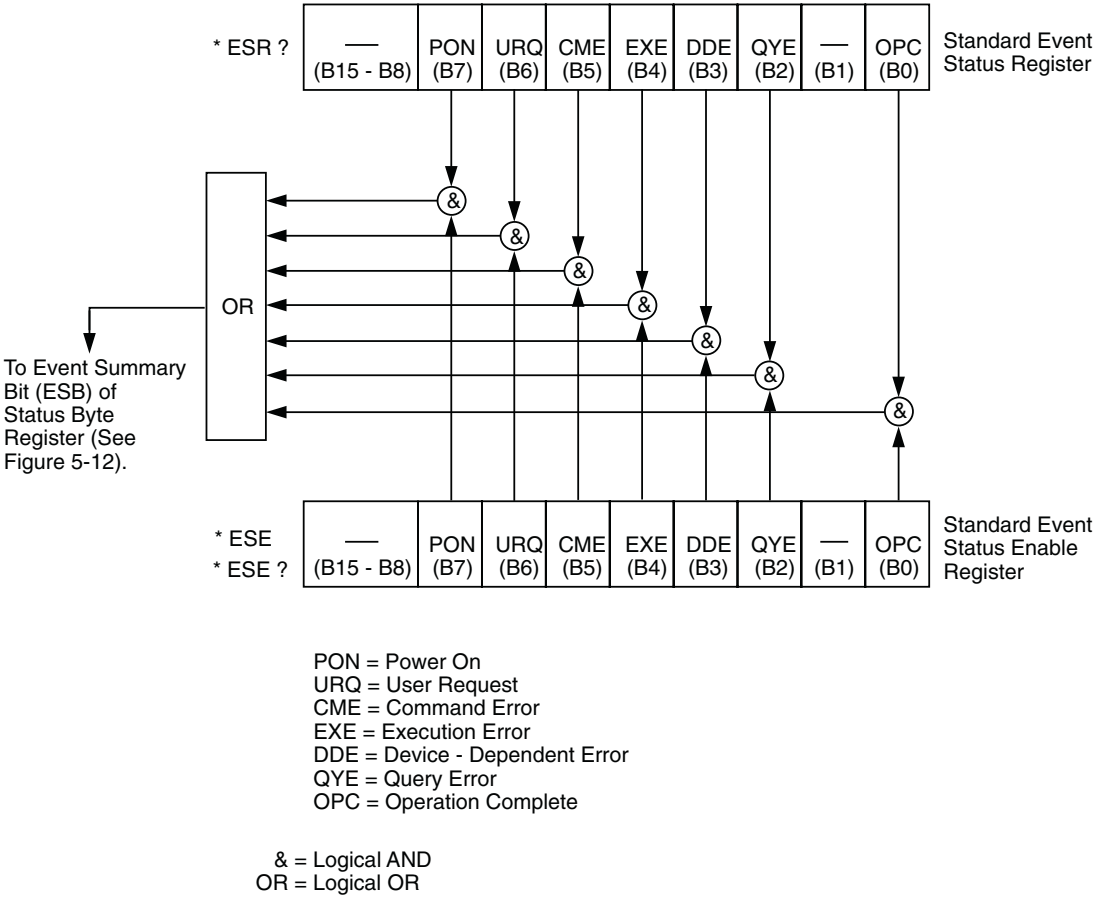
Standard event status

The reporting of standard events is controlled by two 16-bit registers: the Standard Event Status Register and the Standard Event Status Enable Register. Figure 5-5 shows how these registers are structured.

In general, the occurrence of a standard event sets the appropriate bit in the Standard Event Status Register. This register can be read at any time to determine which, if any, standard events have occurred. Also, with the proper use of the Standard Event Status Enable Register, a standard event can set the Event Summary Bit (ESB) of the Status Byte Register. This allows the programmer to take advantage of the service request (SRQ) feature.

Figure 5-5
Standard event status



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Standard Event Status Register

This is a latched read only register that is used to record the occurrence of standard events. Each used bit in the register represents a standard event.

When a standard event occurs, the appropriate bit in the Standard Event Status Register sets. For example, if you attempt to read data from an empty Output Queue, a Query Error (QYE) will occur and set bit B2 of the status register. A set bit in this register will remain set until an appropriate operation is performed to clear the register. The Standard Event Status Register can be read at any time by using the following common query command:

*ESR?

Reading this register using the *ESR? command also clears the register. The following list summarizes all operations that clear the Standard Event Status Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the *ESR? common command.

Standard Event Status Enable Register

This register is programmed by the user and serves as a mask for standard events. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked, the occurrence of that event will set the ESB bit.

A bit in the Standard Event Status Register is masked when the corresponding bit in the Standard Event Status Enable Register is cleared (0). When the masked bit of the Standard Event Status Register sets, it is ANDed with the corresponding cleared bit in the Standard Event Status Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and will therefore not set the ESB bit in the Status Byte Register.

A bit in the Standard Event Status Register is unmasked when the corresponding bit in the Standard Event Status Enable Register is set (1). When the unmasked bit of the Standard Event Status Register sets, it is ANDed with the corresponding set bit in the Standard Event Status Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and therefore sets the ESB bit in the Status Byte Register.

The individual bits of the Standard Event Status Enable Register can be set or cleared by using the following common command:

*ESE <NRf>

The Standard Event Status Enable register can be read at any time by using the following common query command:

*ESE?

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Reading this register using the *ESE? command does not clear the register. The following list summarizes all operations that will clear the Standard Event Status Enable Register:

1. Cycling power.
2. *ESE 0

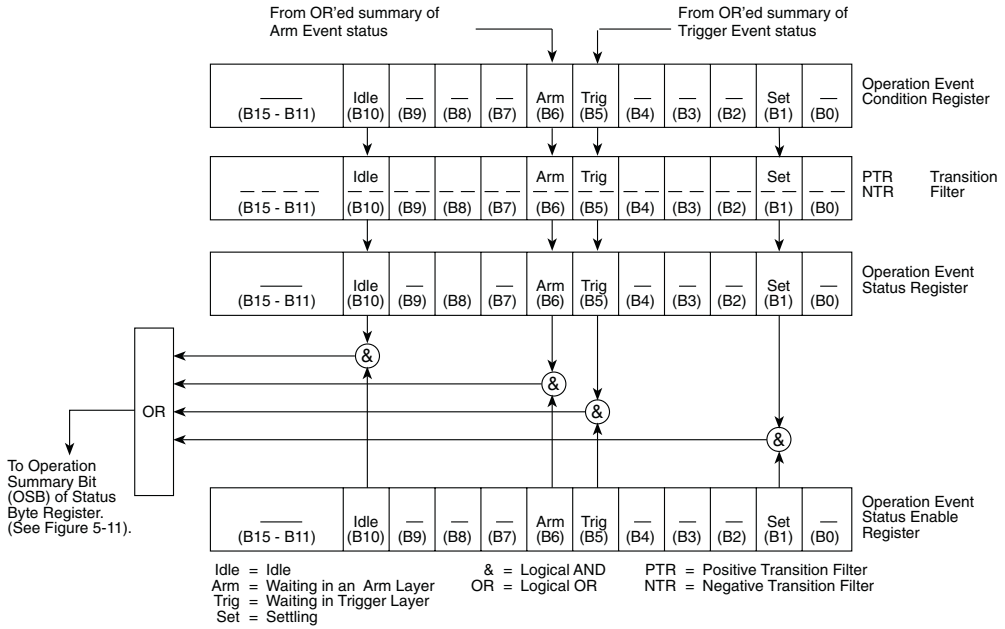
Operation event status

The reporting of operation events is controlled by a set of 16-bit registers: Operation Condition Register, Transition Filter, Operation Event Register, and Operation Event Enable Register. Figure 5-6 shows how these registers are structured.

Notice in Figure 5-4 that bits B5 (Waiting in Trigger Layer) and B6 (Waiting in An Arm Layer) of the Operation Condition Register are controlled by the arm register set, trigger set, and trigger register set. Each of the bits that is used in these registers represents an operation event.

The operation status registers are controlled by the :STATus:OPERation commands in the :STATus subsystem.

Figure 5-6
Operation event status



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Operation Condition Register

This is a real-time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 7002-HD. For example, when the instrument is in idle, bit B10 (Idle) of this register will be set. When the instrument leaves the idle state, bit B10 will clear.

The following SCPI query command can be used to read the Operation Condition Register:

:STATus:OPERation:CONDition?

The Operation Condition Register and the Transition Filter are used to set the bits of the Operation Event Register. The Transition Filter is discussed next.

Operation Transition Filter

The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Operation Condition Register will set the corresponding bit in the Operation Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR), or both. When an event bit is programmed for a positive transition, the event bit in the Operation Event Register will set when the corresponding bit in the Operation Event Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:OPERation:PTR <NRf>

:STATus:OPERation:NTR <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:OPERATION:PTR?

:STATus:OPERation:NTR?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:PTR 65535 and :STATus:OPERation:NTR 0 commands.

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Operation Event Register

This is a latched, read-only register whose bits are set by the Operation Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Operation Event Enable Register and applied to an OR gate. The output of the OR gate is the Operation Summary Bit (OSB) that is applied to the Status Byte Register. The following SCPI query command can be used to read the Operation Event Register:

:STATus:OPERation?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:EVENt? query command.

Operation Event Enable Register

This register is programmed by the user and serves as a mask for the Operation Event Register. When masked, a set bit in the Operation Event Register will not set the Operation Summary Bit (OSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Operation Event Register will set the OSB bit.

A bit in the Operation Event Register is masked when the corresponding bit in the Operation Event Enable Register is cleared (0). When the masked bit of the Operation Event Register sets, it is ANDed with the corresponding cleared bit in the Operation Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and thus, will not set the OSB bit in the Status Byte Register.

A bit in the Operation Event Register is unmasked when the corresponding bit in the Operation Event Enable Register is set (1). When the unmasked bit of the Operation Event Register sets, it is ANDed with the corresponding set bit in the Operation Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and, will therefore set the OSB bit in the Status Byte Register.

The individual bits of the Operation Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:ENABle <NRf>

The following SCPI query command can be used to read the Operation Event Enable Register:

:STATus:OPERation:ENABle?

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Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Operation Event Enable Register:

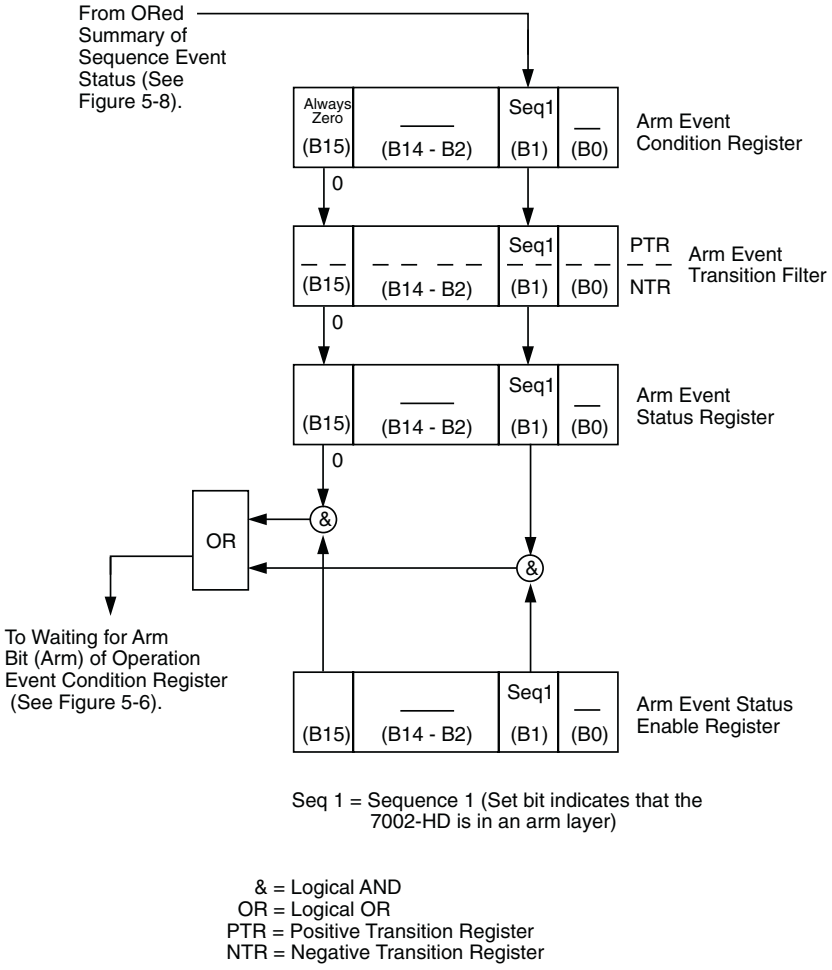
1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ENABle 0 command.

Arm event status

The reporting of the arm event is controlled by a set of 16-bit registers: Arm Condition Register, Transition Filter, Arm Event Register, and Arm Event Enable Register. Figure 5-7 shows how these registers are structured. Notice in Figure 5-4 that bit B1 (In An Arm Layer) of the Arm Condition Register is controlled by the sequence event register set. In general, bit B1 sets when the instrument is in the arm layer (Arm Layer 1) or scan layer (Arm Layer 2) of operation.

The various registers used for arm event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM commands of the :STATus subsystem.

Figure 5-7
Arm event status



Arm Condition Register

This is a real-time 16-bit read-only register that constantly updates to reflect the OR'ed summary of the sequence event register set. In general, if bit B1 is set, the instrument is in an arm layer. The following SCPI query command can be used to read the Arm Condition Register:

:STATus:OPERation:ARM:CONDition?

The Arm Condition Register and the Transition Filter are used to set the bits of the Arm Event Register. The transition filter is discussed next.

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Arm Transition Filter

The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Arm Condition Register will set bit B1 in the Arm Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR), or both. When an event bit is programmed for a positive transition, the event bit in the Arm Event Register will set when the corresponding bit in the Arm Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0. The transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:OPERation:ARM:PTR <NRf>

:STATus:OPERation:ARM:NTR <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:OPERation:ARM:PTR?

:STATus:OPERation:ARM:NTR?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:PTR 65535 and :STATus:OPERation:ARM:NTR 0 commands.

Arm Event Register

This is a latched, read-only register whose bits are set by the Arm Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Arm Event Enable Register and applied to an OR gate. The output of the OR gate is the Arm Summary Bit that is applied to the Operation Condition Register. The following SCPI query command can be used to read the Arm Event Register:

:STATus:OPERation:ARM:EVENt?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM? query command.

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Arm Event Enable Register

This register is programmed by the user and serves as a mask for the Arm Event Register. When masked, a set bit (B1) in the Arm Event Register will not set the Waiting for Arm bit in the Operation Condition Register. Conversely, when unmasked, a set bit (b1) in the Arm Event Register will set the Waiting for Arm bit.

Bit B1 in the Arm Event Register is masked when the corresponding bit (B1) in the Arm Event Enable Register is cleared (0). When the masked bit of the Arm Event Register sets, it is ANDed with the corresponding cleared bit in the Arm Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and will therefore not set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 in the Arm Event Register is unmasked when the corresponding bit (B1) in the Arm Event Enable Register is set (1). When the unmasked bit of the Arm Event Register sets, it is ANDed with the corresponding set bit in the Arm Event Enable Register. The logic “1” output of the AND gate is applied to the input or the OR gate and will therefore set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 of the Arm Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:ARM:ENABle <NRf>

The following SCPI query command can be used to read the Arm Event Enable Register:

:STATus:OPERation:ARM:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Arm Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:ARM:ENABle 0 command.

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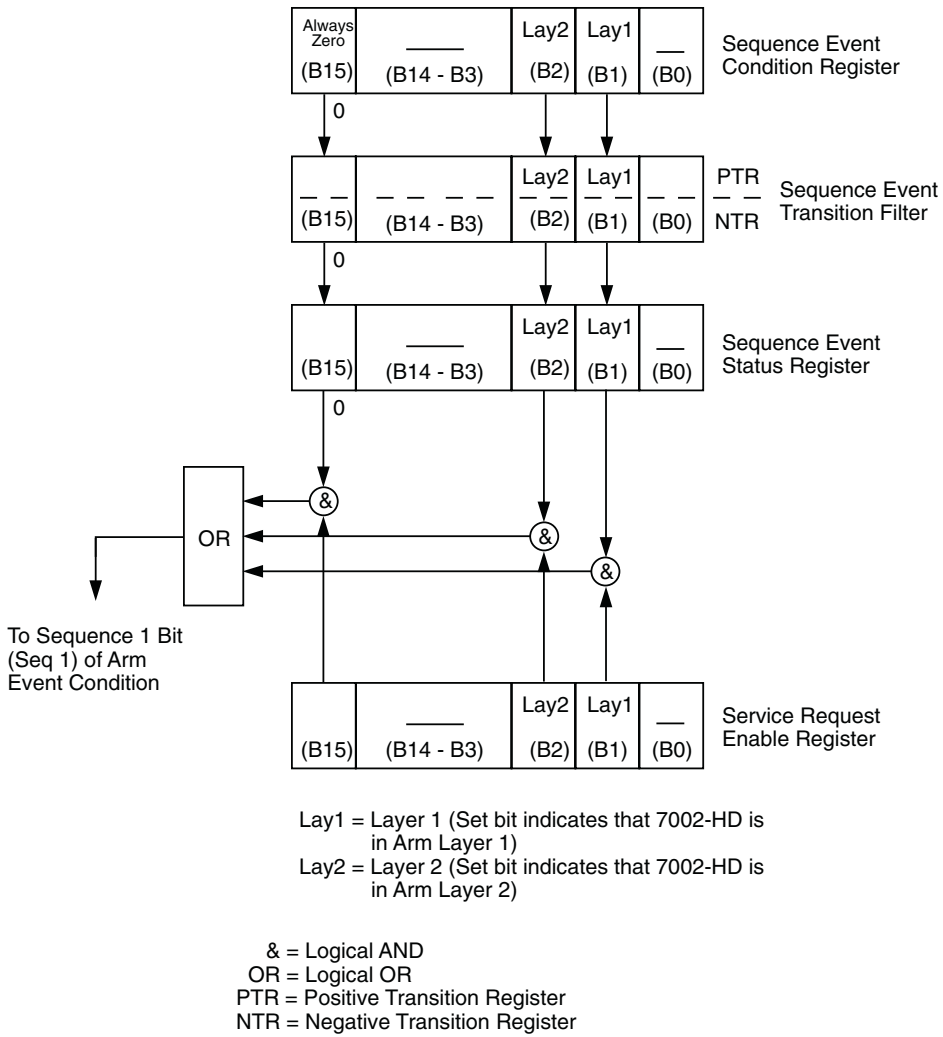
Sequence event status

The reporting of sequence events is controlled by a set of 16-bit registers: Sequence Condition Register, Transition Filter, Sequence Event Register, and Sequence Event Enable Register. Figure 5-8 shows how these registers are structured.

Figure 5-8
Sequence event status



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Two bits of this register set are used by the Model 7002-HD to report sequence events. Bit B1 (In Arm Layer 1) is set when instrument is in (or exited) the arm layer (Arm Layer 1) of operation. Bit B2 (In Arm Layer 2) is set when the instrument is in (or exited) the scan layer (Arm Layer 2).

The various registers used for sequence event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM:SEQuence commands of the :STATus subsystem.

Sequence Condition Register

This is a real-time 16-bit read-only register that constantly updates to reflect the current arm layer status of the instrument. For example, if the Model 7002-HD is currently in the scan layer of operation, bit B2 (In Arm Layer 2) of this register will be set.

The following SCPI query command can be used to read the Sequence Condition Register:

:STATus:OPERation:ARM:SEQuence:CONDition?

The Sequence Condition Register and the Transition Filter are used to set the bits of the Sequence Event Register. The Transition Filter is discussed next.

Sequence Transition Filter

The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Sequence Condition Register will set the corresponding bit in the Sequence Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR), or both. When an event bit is programmed for a positive transition, the event bit in the Sequence Event Register will set when the corresponding bit in the Sequence Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>

:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:OPERation:ARM:SEQuence:PTRansition?

:STATus:OPERation:ARM:SEQuence:NTRansition?

Reading a transition filter register using the above query commands does not affect the contents of the register.

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The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:SEQuence: PTR 65535 and :STATus:OPERation:ARM: SEQuence:NTR 0 commands.

Sequence Event Register

This is a latched, read-only register whose bits are set by the Sequence Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing sequence. The bits of this register are logically ANDed with the bits of the Sequence Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B1 of the Arm Condition Register. The following SCPI query command can be used to read the Sequence Event Register:

:STATus:OPERation:ARM:SEQuence?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Sequence Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM:SEQuence? query command.

Sequence Event Enable Register

This register is programmed by the user and serves as a mask for the Sequence Event Register. When masked, a set bit in the Sequence Event Register will not set bit B1 of the Arm Condition Register. Conversely, when unmasked, a set bit in the Sequence Event Register will set the bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is masked when the corresponding bit in the Sequence Event Enable Register is cleared (0). When the masked bit of the Sequence Event Register sets, it is ANDed with the corresponding cleared bit in the Sequence Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and will therefore not set bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is unmasked when the corresponding bit in the Sequence Event Enable Register is set (1). When the unmasked bit of the Sequence Event Register sets, it is ANDed with the corresponding set bit in the Sequence Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and thus, will set bit B1 of the Arm Condition Register.

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The individual bits of the Sequence Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:ARM:SEQuence:ENABle <NRf>

The following SCPI query command can be used to read the Sequence Event Enable Register:

:STATus:OPERation:ARM:SEQuence:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Sequence Event Enable Register:

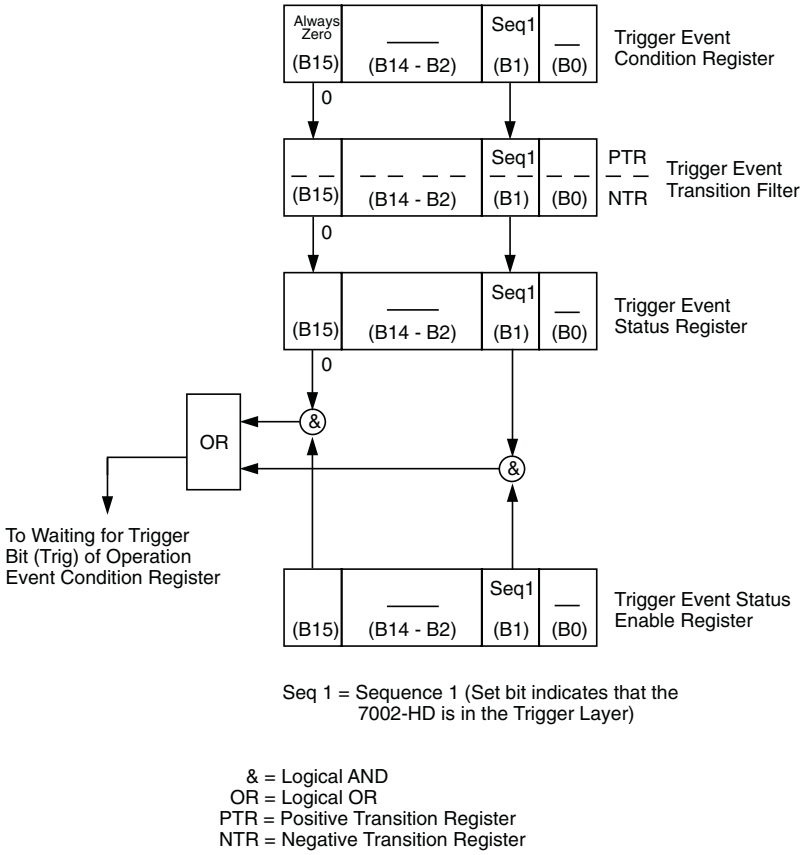
1. Cycling power.
2. Sending the :STATus:OPERation:ARM:SEQuence:ENABle 0 command.

Trigger event status

The reporting of the trigger event is controlled by a set of 16-bit registers: Trigger Condition Register, Transition Filter, Trigger Event Register, and Trigger Event Enable Register. Figure 5-9 shows how these registers are structured.

Bit B1 (Seq1) of the register set is used for the trigger event (In Trigger Layer). In general, Bit B1 sets when the instrument is in (or has exited) the measure layer of operation.The various registers used for trigger event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:TRIGger commands of the :STATus subsystem.

Figure 5-9
Trigger event status



Trigger Condition Register

This is a real-time 16-bit read-only register that constantly updates to reflect the trigger layer status of the instrument. If bit B1 is set, the instrument is in the trigger layer (measure layer) of operation.

The following SCPI query command can be used to read the Trigger Condition Register:

:STATus:OPERation:TRIGger:CONDition?

The Trigger Condition Register and Transition Filter are used to set bit B1 of the Trigger Event Register. The Transition Filter is discussed next.

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Trigger Event Transition Filter

The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Trigger Condition Register will set bit B1 in the Trigger Event register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR), or both. When an event bit is programmed for a positive transition, the event bit in the Trigger Event Register will set when the corresponding bit in the Trigger Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:OPERation:TRIGger:PTRansition <NRf>

:STATus:OPERation:TRIGger:NTRanstion <NRf>

The transition filter register can be read at any time by using the following SCPI query commands:

:STATus:OPERation:TRIGger:PTRansition?

:STATus:OPERation:TRIGger:NTRansition?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:TRIGger:NTR 0 commands.

Trigger Event Register

This is a latched, read-only register whose bits are set by the Trigger Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Trigger Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B5 (Waiting for Trigger) of the Operation Condition Register.

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The following SCPI query command can be used to read the Trigger Event Register:

:STATus:OPERation:TRIGger:EVENt?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Trigger Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:TRIGger? query command.

Trigger Event Enable Register

This register is programmed by the user and serves as a mask for the Trigger Event Register. When masked, a set bit (B1) in the Trigger Event Register cannot set bit B5 (Waiting for Trigger) of the Operation Condition Register. Conversely, when unmasked, a set bit (B1) in the Trigger Event Register will set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Enable Register is masked when the corresponding bit (B1) in the Trigger Event Enable Register is cleared (0). When the masked bit of the Trigger Event Register sets, it is ANDed with the corresponding cleared bit in the Trigger Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and therefore cannot set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Register is unmasked when the corresponding bit (B1) in the Trigger Event Enable Register is set (1). When the unmasked bit of the Trigger Event Register sets, it is ANDed with the corresponding set bit in the Trigger Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and thus, will set bit B5 of the Operation Condition Register.

Bit B1 of the Trigger Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:TRIGger:ENABle <NRf>

The following SCPI query command can be used to read the Trigger Event Enable Register:

:STATus:OPERation:TRIGger:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Trigger Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:TRIGger:ENABle 0 command.

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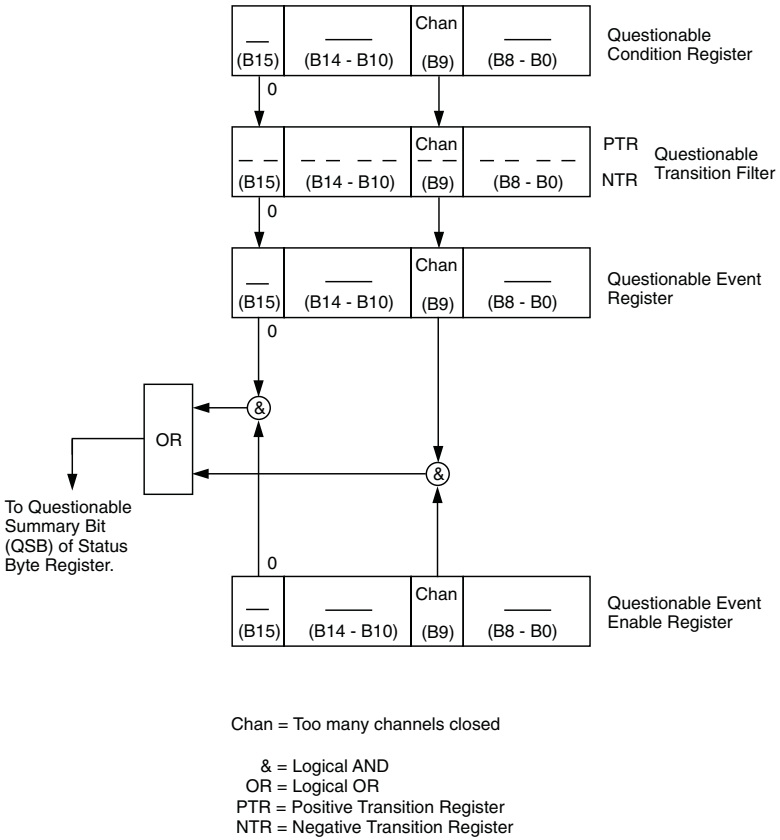
Questionable event status

The reporting of questionable events is controlled by a set of 16-bit registers: Questionable Condition Register, Transition Filter, Questionable Event Register, and Questionable Event Enable Register. Figure 5-10 shows how the registers are structured. Each of the bits that is used in these registers represent a questionable event.

Figure 5-10
Questionable event status



The questionable status registers are controlled by the :STATus:QUEStionable commands in the :STATus subsystem.

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Questionable Condition Register

This is a real time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 7002-HD. For example, when too many channels are closed, bit B9 (Chan) will set. After the channels open, bit B9 will clear.

The following SCPI query command can be used to read the Questionable Condition Register:

:STATus:QUEStionable:CONDition?

The Questionable Condition Register and Transition Filter are used to set the bits of the Questionable Event Register. The Transition Filter is discussed next.

Questionable Transition Filter

The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Questionable Condition Register will set the corresponding bit in the Questionable Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR), or both. When an event bit is programmed for a positive transition, the event bit in the Questionable Event Register will set when the corresponding bit in the Questionable Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

:STATus:QUEStionable:PTR <NRf>

:STATus:QUEStionable:NTR <NRf>

The transition filter registers can be read at any time by using the following SCPI query commands:

:STATus:QUEStionable:PTR?

:STATus:QUEStionable:NTR?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:QUEStionable:PTR 65535 and :STATus:QUEStionable:NTR 0 commands.

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Questionable Event Register

This is a latched, read-only register whose bits are set by the Questionable Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Questionable Event Register and applied to an OR gate. The output of the OR gate is the Questionable Summary Bit (QSB) of the Status Byte Register. The following SCPI query command can be used to read the Questionable Event Register:

:STATus:QUEStionable:EVENt?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Questionable Event Registers:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:QUEStionable? query command.

Questionable Event Enable Register

This register is programmed by the user and serves as a mask for the Questionable Event Register. When masked, a set bit in the Questionable Event Register will not set the Questionable Summary Bit (QSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Questionable Event Register will set the QSB bit.

A bit in the Questionable Event Register is masked when the corresponding bit in the Questionable Event Enable Register is cleared (0). When the masked bit of the Questionable Event Register sets, it is ANDed with the corresponding cleared bit in the Questionable Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and will therefore not set the QSB bit in the Status Byte Register.

A bit in the Questionable Event Register is unmasked when the corresponding bit in the Questionable Event Enable Register is set (1). When the unmasked bit of the Questionable Event Register sets, it is ANDed with the corresponding set bit in the Questionable Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and will therefore set the QSB bit in the Status Byte Register.

The individual bits of the Questionable Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:QUEStionable:ENABle <NRf>

The following SCPI query command can be used to read the Questionable Event Enable Register:

:STATus:QUEStionable:ENABle?

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Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Questionable Event Enable Register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:QUEStionable:ENABle 0 command.

Queues

The Model 7002-HD uses two queues: Output Queue and Error/Status Queue. The queues are first-in first-out (FIFO) registers. They are used to hold data messages and error/status messages, respectively. The Model 7002-HD Status Model (Figure 5-4 on page 5-7) shows how the two queues are structured with the other registers.

Output Queue

The Output Queue is used to hold all data that pertains to the normal operation of the instrument. For example, when a query command is sent, the data message that pertains to that query is placed in the Output Queue.

When a data message is placed in the Output Queue, the Message Available (MAV) bit in the Status Byte Register becomes set. A data message is cleared from the Output Queue when it is read. The Output Queue is considered cleared when it is empty. An empty Output Queue clears the MAV bit in the Status Byte Register.

Error Queue

The Error Queue is used to hold error messages and status messages. When an error or status event occurs, a message that defines the error/status is placed in the Error Queue. This queue will hold up to 10 messages.

When a message is placed in the Error Queue, the Error Available (EAV) bit in the Status Byte Register is set. An error message is cleared from the Error Queue when it is read. The Error Queue is considered cleared when it is empty. An empty Error Queue clears the EAV bit in the Status Byte Register.

An error message from the Error Queue is read by sending either of the following SCPI query commands and then addressing the Model 7002-HD to talk:

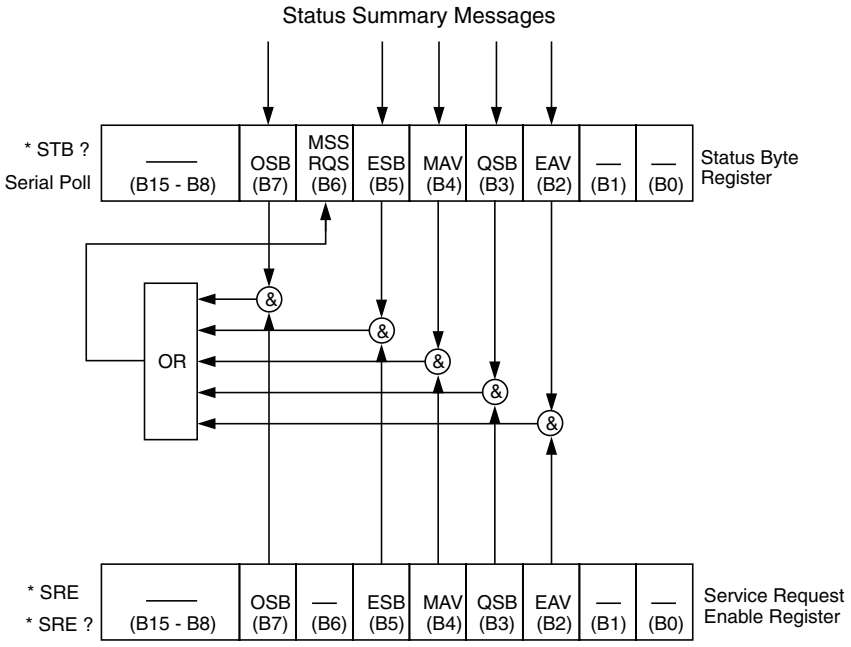
:SYSTem:ERRor?

:STATus:QUEue?

Status byte and service request

Service request is controlled by two 8-bit registers: Status Byte Register and Service Request Enable Register. The structure of these registers is shown in Figure 5-11.

Figure 5-11
Status byte and service request (SRQ)



OSB = Operation Summary Bit
MSS = Master Summary Status (IEEE-488.2)
RQS = Request for Service (IEEE-488.1)
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

& = Logical AND
OR = Logical OR

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Status Byte Register

The summary messages from the status registers and queues are used to set or clear the appropriate bits (B2, B3, B4, B5, and B7) of the Status Byte Register. These bits do not latch and their states (0 or 1) are solely dependent on the summary messages (0 or 1). For example, if the Standard Event Status Register is read, its register will clear. As a result, its summary message will reset to 0, which in turn will clear the ESB bit in the Status Byte Register.

Bit B6 in the Status Byte Register is either:

- The Master Summary Status (MSB) bit, sent in response to the *STB? command, indicates the status of any set bits with corresponding enable bits set.
- The Request for Service (RQS) bit, sent in response to a serial poll, indicates which device was requesting service by pulling on the SRQ line.
- The IEEE-488.2 standard uses the following common query command that reads the Status Byte Register contents:
  *STB?

When reading the Status Byte Register using the *STB? command, bit B6 is called the MSB bit. None of the bits in the Status Byte Register are cleared when using the *STB? command to read it.

The IEEE-488.1 standard has a serial poll sequence that will also read the Status Byte Register and is better suited to detect a service request (SRQ). When using the serial poll, bit B6 is called the RQS bit. Serial polling causes bit B6 (RQS) to reset. Serial polling is discussed in more detail later in this section (see “Serial poll and SRQ”).

The following operations clears all bits of the Status Byte Register:

1. Cycling power.
2. Sending the *CLS common command.

Note that MAV bit may or may not be cleared.

Service Request Enable Register

This register is programmed by the user and serves as a mask for the Status Summary Message bits (B2, B3, B4, B5, and B7) of the Status Byte Register. When masked, a set summary bit in the Status Byte Register will not set bit B6 (MSS/RQS) of the Status Byte Register. Conversely, when unmasked, a set summary bit in the Status Byte Register will set bit B6.

A Status Summary Message bit in the Status Byte Register is masked when the corresponding bit in the Service Request Enable Register is cleared (0). When the masked summary bit in the Status Byte Register sets, it is ANDed with the corresponding cleared bit in the Service Request Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and will therefore not set the MSS/RQS bit in the Status Byte Register.

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A Status Summary Message bit in the Status Byte Register is unmasked when the corresponding bit in the Service Request Enable Register is set (1). When the unmasked summary bit in the Status Byte Register sets, it is ANDed with the corresponding set bit in the Service Request Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and will therefore set the MSS/RQS bit in the Status Byte Register.

The individual bits of the Service Request Enable Register can be set or cleared by using the following common command:

*SRE <NRf>

The Service Request Enable Register can be read using the following common query command:

*SRE?

The Service Request Enable Register is not cleared when it is read using the *SRE? query command. The Service Request Enable Register will clear when power is cycled or a parameter (n) value of zero is sent with the *SRE command (*SRE 0).

Serial poll and SRQ

Any enabled event summary bit that goes from 0 to 1 will set RQS and generate a service request (SRQ). The user's test program can periodically read the Status Byte Register to check to see if a service request (SRQ) has occurred and what caused it. In the event of an SRQ, the program can, for example, branch to an appropriate subroutine that will service the request. Typically, service requests (SRQs) are managed by the serial poll sequence of the Model 7002-HD. If an SRQ does not occur, bit B6 (RQS) of the Status Byte Register will remain cleared, and the program will proceed normally after the serial poll is performed. If an SRQ does occur, bit B6 of the Status Byte Register will set, and the program can branch to a service subroutine when the SRQ is detected by the serial poll.

The serial poll will automatically reset RQS of the Status Byte Register. This will allow subsequent serial polls to monitor Bit 6 for an SRQ occurrence generated by other event types. After a serial poll, the same event can cause another SRQ, even if the event register that caused the first SRQ has not been cleared.

A serial poll clears RQS but does not clear MSS. The MSS bit will stay set until all Status Byte event summary bits are cleared or until the corresponding bits in the service request enable registers are cleared.

Trigger model

The following information describes the operation process of the Model 7002-HD over the IEEE-488 bus. The flowchart in Figure 5-12, which summarizes operation over the bus, is called the Trigger Model. It is called the Trigger Model because operation is controlled by SCPI commands from the Trigger subsystem. Notice that key SCPI commands are included in the Trigger Model.

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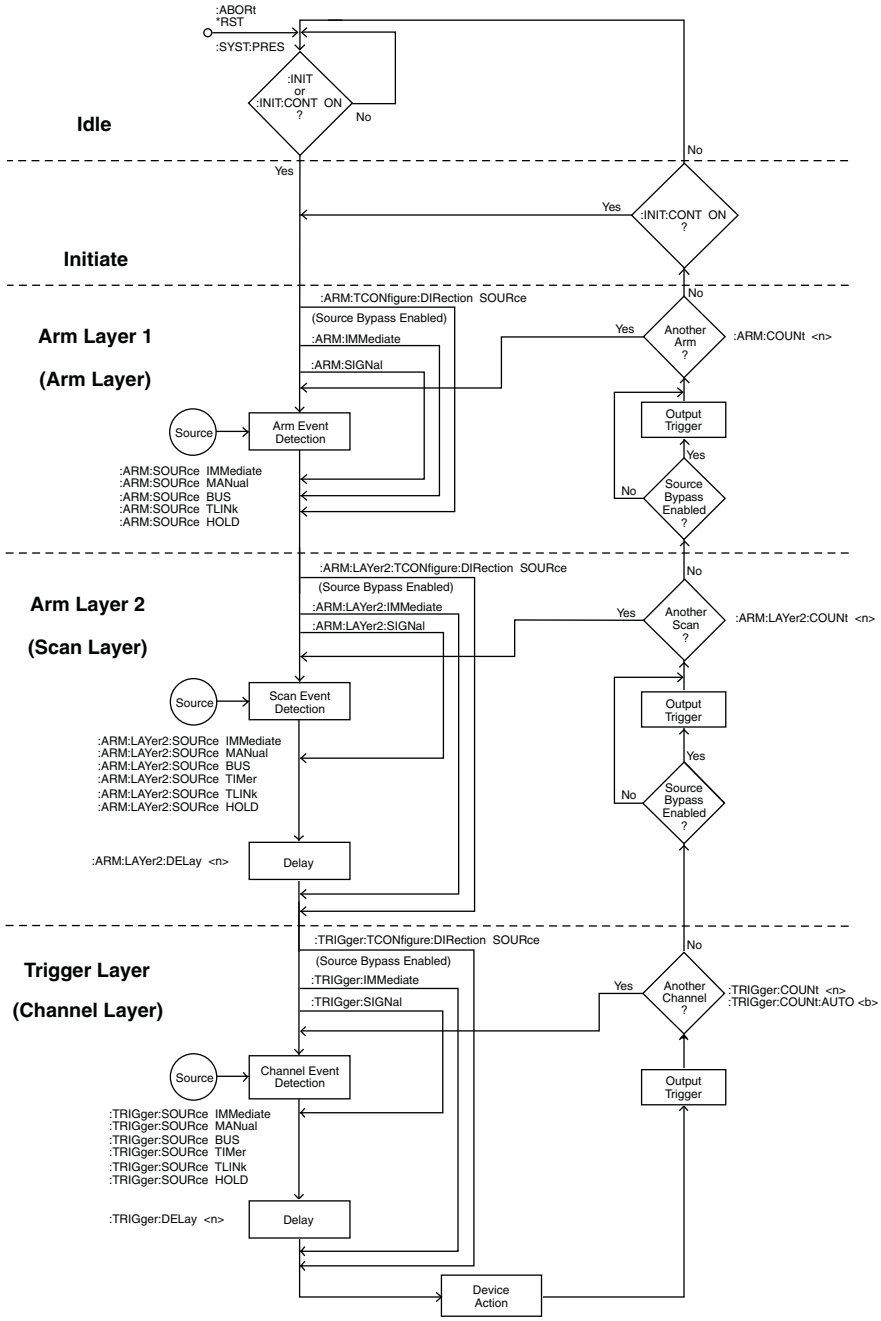
Figure 5-12
Trigger Model (IEEE-488 bus operation)



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Idle and initiate

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any scan functions. Over the bus, there are two SCPI commands that can be used to take the instrument out of the idle state: :INITiate or :INITiate:CONTinuous ON.

Notice that with continuous initiation enabled (:INIT:CONT ON), the instrument will not remain in the idle state after all programmed operations are completed. However, the instrument can be returned to the idle state at any time by sending the *RST command, or the :SYST:PRES command.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer (Arm Layer 1) of the Trigger Model.

Arm layer1

NOTE For front panel operation, this layer is called the arm layer.

In general, the instrument requires an arm event to allow operation to proceed to the next layer (Arm Layer 2). With the Immediate control source selected (:ARM:SOURce IMMediate), operation immediately proceeds to the next layer when the instrument is taken out of the idle state. The *RST and :SYSTem:PRESet commands also set the arm control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Manual control source selected (:ARM :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002-HD must be taken out of remote (press LOCAL key or send GTL over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:SOURce BUS), the instrument will wait until a bus trigger (GET or *TRG) is received. With the Trigger Link control source selected (:ARM:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:SOURce HOLD), the instrument will not respond to any of the control source events.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the Trigger Link control source is selected, operation will loop around the control source on the initial pass through Arm Layer 1. If programmed for another arm (arm count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes into Idle.

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Enabling the Source Bypass also enables the Output Trigger. When operation returns to Arm Layer 1 from Arm Layer 2, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM :TCONfigure:DIRection ACCeptor).

2. Each time the :ARM:IMMediate command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).
3. Each time the :ARM:SIGNal command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).

After all other instrument operations have been completed, the instrument can be returned to Arm Layer 1 by programming the instrument for additional arms. The :ARM:COUNt <n> command can be used to set the arm count to a finite value (where <n> = 1 to 9999) or for an infinite (<n> = INF) number of arms. The *RST and :SYSTem:PRESet commands set the arm count to 1.

After the instrument leaves Arm Layer 1, operation proceeds into the scan layer (Arm Layer 2).

Arm layer2

NOTE For front panel operation, this layer is called the scan layer.

In general, the instrument requires a scan event to allow operation to proceed to the next layer (trigger layer). With the Immediate control source selected (:ARM:LAYer2:SOURce IMMediate), operation immediately proceeds to the next layer. The *RST and :SYSTem:PRESet commands also set the scan control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:ARM:LAYer2-SOURce TIMer), operation will immediately proceed into the channel layer on the initial pass through Arm Layer 2. Each additional scan will not occur until the programmed timer interval elapses. The timer can be set to an interval from 1 millisecond to 999999.999 seconds.

With the Manual control source selected (:ARM:LAYer2:-SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002-HD must be taken out of remote (press LOCAL key or send GTL over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:LAYer2:SOURce BUS), the instrument will wait until a bus trigger is

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received (GET or *TRG). With the Trigger Link control source selected (:ARM:LAYer2:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:LAYer2:SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed scan event is detected, the instrument will wait for the programmed Delay to time out. The :ARM:LAYer2:DELay <n> command is used to set the Delay (where n = 0 to 999999.999 seconds). The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the Trigger Link control source is selected, operation will loop around the control source on the initial pass through arm layer 2. If programmed for another scan (scan count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back into arm layer 1.

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to arm layer 2 from the trigger layer, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM:TCONfigure:DIRection ACCeptor).

2. Each time the :ARM:LAYer2:IMMediate command is sent, operation will loop around the scan control source and the Delay. It is used when you do not wish to wait for a programmed scan event to occur (or when the Hold control source is selected).

3. Each time the :ARM:LAYer2:SIGNal command is sent, operation will loop around the scan control source. This path functions the same as :ARM:LAYer2:IMMediate except that it does not loop around the Delay.

After all other operations in the next layer have been completed, the instrument can be returned to Arm Layer 2 by programming the instrument for additional scans. The :ARM:LAYer2:COUNt <n> command can be used to set the scan count to a finite value (where <n> = 1 to 9999) or for an infinite (<n> = INF) number of scans. The *RST command sets the scan count to one and the :SYSTem:PRESet command sets the scan count to infinite.

After the instrument leaves arm layer 2, operation proceeds to the Channel Layer (Trigger Layer).

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Trigger layer

NOTE For front panel operation, this layer is called the channel layer.

In general, measure events control the channel scan rate. With the Immediate control source selected (:TRIGger:SOURce IMMediate), operation immediately proceeds to the Delay. The *RST command also sets the measure control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:TRIGger :SOURce TIMer), the first channel will be scanned immediately. Each additional will be scanned at a rate determined by the programmed timer interval (1 millisecond to 999999.999 seconds).

With the Manual control source selected (:TRIGger :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002-HD must be taken out of remote (press LOCAL key or send GTL over bus) before it will respond to the STEP key. The :SYSTem:PRESet command also selects the Immediate control source.

With the Bus control source selected (:TRIGger :SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the Trigger Link control source selected (:TRIGger:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:TRIGger :SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed channel event is detected, the instrument will wait for the programmed Delay to time out. The :TRIGger:DELay <n> command is used to set the Delay (where n = 0 to 999999.999 seconds).

The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM :TCONfigure:DIRection SOURce) and the Trigger Link control source is selected, operation will loop around the control source on the initial pass through the Trigger Layer. If programmed to scan another channel (channel count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back to Arm Layer 2.
2. Each time the :TRIGger:IMMediate command is sent, operation will loop around the control source and the Delay. It is used when you do not wish to wait for a programmed channel event to occur (or when the Hold control source is selected).

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3. Each time the :TRIGger:SIGNal command is sent, operation will loop around the channel control source. This path functions the same as :TRIGger:IMMediate except that it does not loop around the Delay.

At this point the first (or next) channel in the Scan List will be scanned (Device Action). When scanning channels, the previous channel will open and the next channel will close (break-before-make). Also included in the Device Action is the internal settling time delay for the relay and any additional programmed settling time delay using the :STIMe command of the :ROUTe Subsystem.

After a channel is scanned, an Output Trigger will occur. If the Trigger Link control source is selected, Output Trigger action will occur as follows:

1. If the asynchronous Trigger Link mode is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (:trig :tcon:dir acc), the Trigger Link line will be released (goes high).
3. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (:trig :tcon:dir sour), the Trigger Link line will be pulled down low and then released.

See ”Trigger Link” on page 4-54 for details on using the Trigger Link.

After a channel is scanned and an output trigger occurs, the instrument will (if programmed to do so) return to the beginning of the trigger layer to scan another channel. The :TRIGger:COUNt <n> command is used to set the channel count to a finite value (where <n> = 1 to 9999) or for a continuous scan of the Scan List (<n> = INF). The :TRIGger:COUNt :AUTo ON command is used to automatically set the channel count to the length of the Scan List. The *RST command sets the channel count to one and the :SYSTem:PRESet command enables the automatic channel count.

General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. Commands supported by the Model 7002-HD are listed in Table 5-1.

Table 5-1
General bus commands

Command	Effect on Model 7002-HD
REN	Goes into effect when next addressed to listen.
IFC	Goes into talker and listener idle states.
LLO	LOCAL key locked out.
GTL	Cancel remote, restore front panel operation.
DCL	Returns 7002-HD to known conditions.
SDC	Returns all devices to known conditions.
GET	Initiates a trigger.
SPE, SPD	Serial Polls the Model 7002-HD.

REN (remote enable)

The remote enable command is sent to the Model 7002-HD 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 does not actually place the instrument in the remote state. Instead the instrument must be addressed to listen after setting REN true before it goes into remote. Note that the instrument need not be in remote to be a talker.

IFC (interface clear)

The IFC command is sent by the controller to place the Model 7002-HD in the local, talker, and listener idle states. The unit responds to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those states.

Note that this command does not affect the status of the instrument; settings, data, and event registers are not changed.

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

LLO (local lockout)

The LLO command is used to prevent local operation of the instrument. After the unit receives LLO, all its front panel controls except POWER are inoperative. In this state, pressing LOCAL will not restore control to the front panel.

GTL (go to local) and local

The GTL command is used to take the instrument out of the remote state. Operation of the front panel keys is restored. If LLO is in effect, the front panel LOCAL key will be disabled when the Model 7002-HD is put into remote. To cancel LLO, you must set REN false.

DCL (device clear)

The DCL command may be used to clear the Model 7002-HD and return it to a known state. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously.

When the Model 7002-HD receives a DCL command, it will clear the Input Buffer and Output Queue, cancel deferred commands, and clear any command that prevents the processing of any other device command. A DCL will not affect instrument settings, stored data, the channel list, or scan list.

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 selected instruments instead of clearing all instruments simultaneously, as is the case with DCL.

GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan, and/or channel event to control the scanning process. The Model 7002-HD will react to this trigger if it is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem).

SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 7002-HD serial poll byte. The serial poll byte contains important information about internal functions, as described in ”Status byte and service request” on page 5-28. 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 7002-HD.

Programming syntax

The following programming syntax information covers both common commands and SCPI commands. For information not covered here, refer to the documentation for the IEEE-488.2 standard and SCPI.

Command words

One or more command words make up the program message that is sent to the computer to perform one or more operations.

Commands and command parameters

Both common commands and SCPI commands may or may not use a parameter. Examples:

*SAV 0	Parameter (0) required.
*RST	No parameter used with this command.
:INITiate:CONTinuous <b>	Parameter (<b>) required.
:SYSTem:PRESet	No parameter used with this command.

Note that there must be at least one space between the command word and the parameter.

Brackets [ ]

Throughout this manual, you will find command words that are enclosed in brackets ([]). These brackets are used to denote an optional command word that does not need to be included in the program message. For example:

:INITiate[:IMMediate]

The brackets indicate that :IMMediate is implied (optional) and does not have to be used. Thus, the above command can be sent in one of two ways:

:INITiate or :INITiate:IMMediate

Notice that the optional command is used without the brackets. **Do not include the brackets when using an optional command word.**

Parameter types

Some of the more common parameter types used in this manual are explained as follows:

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<b> **Boolean:** Used to enable or disable an instrument operation. In general, 0 or OFF disables the operation, and 1 or ON enables the operation. Specifically, a Boolean parameter is processed as follows:

- While ignoring the sign (+ or -), the parameter value is rounded to an integer.
- A zero result is interpreted as OFF, and a non-zero result is interpreted as ON.

Example:

:INITiate:CONTinuous ONEnable continuous initiation

<name> **Name parameter:** Select a parameter name from a listed group. Example:

<name>=RST

:SYSTem:POSetup RST

<NRf> **Numeric representation format:** This parameter is a number that can be expressed as an integer (e.g., 8), a real number (e.g., 23.6), or an exponent (2.3E6). When necessary, the Model 7002-HD will round real and exponential parameter values to an integer. Example:

:SAV 36 Save setup in memory location 36.

<n> **Numeric value:** A numeric value parameter can consist of an NRf number or one of the following name parameters; DEFault, MINimum or MAXimum. When the DEFault parameter is used, the instrument will be programmed to the *RST default value. When the MINimum parameter is used, the instrument will be programmed to the lowest allowable value. When the MAXimum parameter is used, the instrument will be programmed to the largest allowable value. Examples:

:TRIGger:TIMer	0.1	Sets timer to 100 milliseconds.
:TRIGger:TIMer	DEFault	Sets timer to 1 millisecond.
:TRIGger:TIMer	MINimum	Sets timer to 1 millisecond.
:TRIGger:TIMer	MAXimum	Sets timer to 999999.999 second.

<list> **List:** This parameter type is used to indicate that a list of channels is required with the command word. The following example demonstrates the proper format for specifying a list:

:CLOSe (@ 1!1, 1!3)Close channels 1 and 3 of Slot 1.

Angle brackets < >: In this manual, angle brackets (<>) are used to denote parameter type. **Do not** include the brackets in the program message. For example:

:INITiate:CONTinuous <b>

The <b> indicates that a Boolean type parameter is required. Thus, to set digital input line #2 true, you must send the command with the ON or 1 parameter as follows:

:INITiate:CONTinuous ON or :INITiate:CONTinuous 1

Query commands

This type of command requests (queries) the currently programmed status. It is identified by the question mark (?) at the end of the fundamental form of the command. Most commands have a query form. Examples:

*OPT?	Common query command.
:TRIGger:TIMer?	SCPI query command.

All commands that require a numeric parameter (<n>) can also use the DEFault, MINimum, and MAXimum parameters for the query form. These query forms are used to determine the *RST default value, and the upper and lower limits for the fundamental command. Examples:

:TRIGger:TIMer?	DEFault	Queries the *RST default value.
:TRIGger:TIMer?	MINimum	Queries the lowest allowable value.
:TRIGger:TIMer?	MAXimum	Queries the largest allowable value.

Case sensitivity

Common commands and SCPI commands are not case sensitive. You can use upper or lower case, and any case combination. Examples:

*RST =*rst

:SCAN? =:scan?

:SYSTem:PRESet=:system:preset

Long-form and short-form versions

A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in this section provide the commands in the long-form version. However, the short-form version is indicated by upper case characters. Examples:

:SYSTem:PRESet	Long-form
:SYST:PRES	Short-form
:SYSTem:PRES	Long and short-form combination

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Note that each command word must be in long-form or short-form, and not something in between. For example, :SYSTe:PRESe is illegal and will generate an error. The command will not be executed.

There are no short-form versions for common commands.

Short-form rules

The following rules can be used to determine the short-form version of any SCPI command:

1. If the length of the command word is four letters or less, there is no short-form version. Examples:

   :open=:open

   :line=:line

2. The following rules apply to command words that exceed four letters:
   a. If the fourth letter of the command word is a vowel, delete it and all the letters after it. Examples:

      :immediate=:imm

      :timer=:tim

   b. If the fourth letter of the command word is a consonant, retain it but drop all the letters after it. Examples:

      :output=:outp

      :asynchronous=:asyn

3. If there is a question mark (?; query) or a non-optional number included in the command word, it must be included in the short-form version. Examples:

   :delay?=:del?

   :layer2=:lay2

4. As previously explained, command words or characters that are enclosed in brackets ([]) are optional and need not be included in the program message. Example:

   :STATus:OPERation[:EVENt]?

   The brackets ([]) indicate that :EVENt is optional. Thus, either of the following two command program messages are valid:

   :STATus:OPERation:EVENt?=:STATus:OPERation?

   Notice that when using the optional word or character, the brackets ([]) are not included in the program message.

   The complete short-form version of the above command is as follows:

   :stat:oper?

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Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Each common command is simply a three letter acronym preceded by an asterisk (*). SCPI commands are categorized into subsystems and are structured as command paths. The following command paths are contained in the :STATus subsystem and are used to help explain how command words are structured to formulate program messages.

:STATus		Path (Root)
:OPERation		Path
:PTRansition	<NRf>	Command and parameter
:NTRansition	<NRf>	Command and parameter
:ENABle	<NRf>	Command and parameter
:PRESet		Command

Single command messages

There are three levels to the above command structure. The first level is made up of the root command (:STATus) and serves as a path. The second level is made up of another path (:OPERation) and a command (:PRESet). The third path is made up of three commands for the :OPERation path. The four commands in this structure can be executed by sending four separate program messages as follows:

:stat:oper:ptr <NRf>

:stat:oper:ntr <NRf>

:stat:oper:enab <NRf>

:stat:pres

In each of the above program messages, the path pointer starts at the root command (:stat) and moves down the command levels until the command is executed.

Multiple command messages

Multiple commands can be sent in the same program message as long as they are separated by semicolons (;). Example showing two commands in one program message:

:stat:pres; :stat:oper:enab <NRf>

When the above message is sent, the first command word is recognized as the root command (:stat). When the next colon is detected, the path pointer moves down to the next command level and executes the command. When the path pointer sees the colon after the semicolon (;), it resets back to the root level and starts over.

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Commands that are on the same command level can be executed without having to retype the entire command path. Example:

:stat:oper:enab <NRf>; ptr <NRf>; ntr <NRf>

After the first command (:enab) is executed, the path point is at the third command level in the structure. Since :ptr and :ntr are also on the third level, they can be typed in without repeating the entire path name. Notice that the leading colon for :ptr and :ntr are not included in the program message. If a colon were included, the path pointer would reset to the root level and expect a root command. Since neither :ptr nor :ntr are root commands, an error would occur.

Command path rules

1. Each new program message must begin with the root command, unless it is optional (e.g., [:SENSe]). If the root is optional, treat a command word on the next level as the root.
2. The colon (:) at the beginning of a program message is optional and need not be used. Example:

   :stat:pres=stat:pres
3. When the path pointer detects a colon (:) it will move down to the next command level. An exception is when the path pointer detects a semicolon (;), which is used to separate commands within the program message (see next rule).
4. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.
5. The path pointer can only move down. It cannot be moved up a level. Executing a command at a higher level requires that you start over at the root command.

Using common commands and SCPI commands in same message

Both common commands and SCPI commands can be used in the same message as long as they are separated by semicolons (;). A common command can be executed at any command level and will not affect the path pointer. Example:

:stat:oper:enab <NRf>; ptr <NRf>; *ESE <NRf>; ntr <NRf>

Program Message Terminator (PMT)

Each program message must be terminated with an LF (line feed), EOI (end or identify), or an LF + EOI. The bus will hang if your computer does not provide this termination. The following example shows how a multiple command program message must be terminated:

:rout:open all; scan (@1:5) <PMT>

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Command execution rules

1. Commands are executed in the order that they are presented in the program message.
2. An invalid command will generate an error and, of course, not be executed.
3. Valid commands that precede an invalid command in a multiple command program message will be executed.
4. Valid commands that follow an invalid command in a multiple command program message will be ignored. Example:

   :rout:open all; harve; scan?

   :open all will execute. Harve is an invalid command and will generate an error. The scan query will be ignored.

Response messages

A response message is the message sent by the instrument to the computer in response to a query command program message.

Sending a response message

After sending a query command, the response message is placed in the Output Queue. When the Model 7002-HD is then addressed to talk, the response message is sent from the Output Queue to the computer.

There are two special query commands that are used to read the Error Queue. As error and status messages occur they are stored in the Error Queue. This queue is a first-in first-out (FIFO) register. Either of the following two SCPI commands can be used to read the Error Queue:

:STATus:QUEue?

:SYSTem:ERRor?

After sending either of the above commands, the oldest message in the Error Queue will be moved to the Output Queue. When the Model 7002-HD is then addressed to talk (as explained above), the response message will be sent to the computer.

Multiple response messages

If you send more than one query command in the same program message (see ”Multiple command messages” on page 5-43), the multiple response message for all the queries will be sent to the computer when the Model 7002-HD is addressed to talk. The responses are sent in the order that the query commands were sent and will be separated by semicolons (;). Items within the same query are separated by commas (,). The following example shows the response message for a program message that contains four single item query commands:

0; 1; 1; 0

Response Message Terminator (RMT)

Each response message is terminated with an LF (line feed) and EOI (end or identify). The following example shows how a multiple response message is terminated:

0; 1; 1; 0 <RMT>

Message exchange protocol

The message exchange protocol can be summarized by the two following rules:

Rule 1. You must always tell the Model 7002-HD what to send to the computer.

The following two steps must always be performed, in this order, to send information from the instrument to the computer:

1. Send the appropriate query command(s) in a program message.
2. Address the Model 7002-HD to talk.

Rule 2. The complete response message (including the RMT) must be received by the computer before another program message can be sent to the Model 7002-HD.

Common commands

Common commands are device commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Command command summary

Table 5-2 summarizes the common commands used by the Model 7002-HD and are presented in alphabetical order.

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Table 5-2
IEEE-488.2 common commands and queries

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event status enable command	Sets the contents of the Standard Event Status Enable Register.
*ESE?	Event status enable query	Request the programmed value of the Standard Event Status Enable Register.
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII “1” into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Request the assigned model number for all slots.
*RCL <NRf>	Recall command	Returns the Model 7002-HD to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the Model 7002-HD to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.
*SRE?	Service request enable query	The Model 7002-HD returns the value of the Service Request Enable Register.

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Table 5-2 (cont.)
IEEE-488.2 common commands and queries

Mnemonic	Name	Description
*STB?	Read status byte query	Returns the value of the Status Byte Register.
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.
*TST?	Self-test query	When this query is sent, the Model 7002-HD will perform a checksum test on ROM and return the results.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

Note: At least one space is required between the command and the parameter.

Common command descriptions

*CLS — clear status

Purpose To clear status registers and error queue.

Format *CLS

Description The *CLS command is used to clear (reset to 0) the bits of the following registers in the Model 7002-HD:

- Standard Event Status Register
- Operation Event Register
- Questionable Event Register
- Error Queue
- Trigger Event Register
- Sequence Event Register
- Arm Event Register

This command also forces the instrument into the operation complete command idle state and operation complete query idle state.

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*ESE — event status enable

Purpose To set the contents of the Standard Event Status Enable Register.

Format *ESE <NRf>

Parameters

<NRf>	= 0	Clear (reset) register
	= 1	Set OPC (B0) of enable register
	= 4	Set QYE (B2) of enable register
	= 8	Set DDE (B3) of enable register
	= 16	Set EXE (B4) of enable register
	= 32	Set CME (B5) of enable register
	= 64	Set URQ (B6) of enable register
	= 128	Set PON (B7) of enable register

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description The *ESE command is used to set the contents of the Standard Event Status Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of the bits in the register.

This register is used as a mask for the Standard Event Status Register. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked (enabled), the occurrence of that event will set the ESB bit

A cleared bit (bit set to “0”) in the enable register will prevent (mask) the ESB bit in the Status Byte Register from setting when the corresponding standard event occurs. A set bit (bit set to “1”) in the enable register will allow (enable) the ESB bit to set when the corresponding standard event occurs.

The Standard Event Status Enable Register is shown in Figure 5-13. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to be set is the value that is sent with the *ESE command. For example, to set the CME and QYE bits of the Standard Event Status Enable Register, send the following command:

*ESE 36

where:

CME (bit B5) = Decimal32

QYE (bit B2) = Decimal 4

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parameter = 36

If a command error (CME) occurs, bit B5 of the Standard Event Status Register will set. If a query error (QYE) occurs, bit B2 of the Standard Event Status Register will set. Since both of these events are unmasked (enabled), the occurrence of any one of them will cause the ESB bit in the Status Byte Register to set.

The contents of the Standard Event Status Event Register can be read by using the *ESE? query command.

Figure 5-13
Standard Event Status Enable Register

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	–	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	–	0/1

Value: 1 = Enable Standard Event
0 = Disable (Mask) Standard Event

Events: PON = Power On
URQ = User Request
CME = Command Error
DDE = Device-dependent Error
EXE = Execution Error
QYE = Query Error
OPC = Operation Complete

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*ESE? — event status enable query

Purpose To read the contents of the Standard Event Status Enable Register.

Format *ESE?

Description This command is used to acquire the value (in decimal) of the Standard Event Status Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *ESE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002-HD is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, bits B4 and B5 of the Standard Event Status Enable Register are set.

The *ESE? query command does not clear the Standard Event Status Enable Register.

*ESR? — event status register query

Purpose To read the contents of the Standard Event Status Register and clear it.

Format *ESR?

Defaults

Power-up	Clears register
*CLS	Clears register
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description This command is used to acquire the value (in decimal) of the Standard Event Status Register (see Figure 5-5 on page 5-8). The binary equivalent of the returned decimal value determines which bits in the register are set. When the *ESR? command is sent, the decimal value is placed in the Output Queue and the Standard Event Status Register is cleared. When the Model 7002-HD is addressed to talk, the value in the Output Queue is sent to the computer.

A set bit in this register indicates that a particular event has occurred. For example, for an acquired decimal value of 48, the binary equivalent is 0011 0000. For this binary value, bits B4 and B5 of the Standard Event Status Register are set. These set bits indicate that a device-dependent error and command error have occurred.

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The bits of the Standard Event Status Register are described as follows:

Bit B0, Operation Complete (OPC) — Set bit indicates that all pending selected device operations are completed and the Model 7002-HD is ready to accept new commands. This bit will only set in response to the *OPC? query command.

Bit B1 — Not Used

Bit B2, Query Error (QYE) — Set bit indicates that you attempted to read data from an empty Output Queue.

Bit B3, Device-Dependent Error (DDE) — Set bit indicates that an instrument operation did not execute properly due to some internal condition.

Bit B4, Execution Error (EXE) — Set bit indicates that the Model 7002-HD detected an error while trying to execute a command.

Bit B5, Command Error (CME) — Set bit indicates that a command error has occurred. Command errors include:

1. **IEEE-488.2 syntax error:** Model 7002-HD received a message that does not follow the defined syntax of the IEEE-488.2 standard.
2. **Semantic error:** Model 7002-HD received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
3. The instrument received a Group Execute Trigger (GET) inside a program message.

Bit B6, User Request (URQ) — Set bit indicates that the LOCAL key on the Model 7002-HD front panel was pressed.

Bit B7, Power On (PON) — Set bit indicates that the Model 7002-HD has been turned off and turned back on since the last time this register has been read.

*IDN? — identification query

Purpose To read the identification code of the Model 7002-HD.

Format *IDN?

Description The *IDN? query command places the identification code of the Model 7002-HD in the Output Queue. When the Model 7002-HD is addressed to talk, the identification code will be sent to the computer.

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The identification code includes the manufacturer, model number, serial number, and firmware revision levels, and is sent in the following format:

KEITHLEY INSTRUMENTS INC., MODEL 7002, wwwwwww, xxxxx,/yyyyy/------

where:

wwwwwww is the serial number

xxxxx is the firmware revision level of the digital board

yyyyy is the firmware revision level of the VFD display

*OPC — operation complete

Purpose To set the Operation Complete bit in the Standard Event Status Register after all overlapped commands are complete.

Format *OPC

Description On power-up, or when *CLS or *RST is executed, the Model 7002-HD goes into the Operation Complete Command Idle State (OCIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 7002-HD:

:INITiate

:INITiate:CONTinuous ON

*TRG

When the *OPC command is sent, the Model 7002-HD exits from OCIS and enters the Operation Complete Command Active State (OCAS). In OCAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is complete (No-Operation-Pending flag set to true), the Operation Complete (OPC) bit in the Standard Event Status Register sets, and the instrument goes back into OCIS.

Note that the instrument always goes into OCAS when *OPC is executed. If there are no pending command operations (e.g., trigger model in idle state), the Model 7002-HD immediately sets the OPC bit and returns to OCIS.

When used with the :INITiate or :INITiate:CONTinuous ON command, the OPC bit of the Standard Event Status Register will not set until the Model 7002-HD goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

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When used with the *TRG command, the OPC bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event.

In order to use *OPC exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, the OPC bit will set when the *TRG command is finished.

See *OPC?, *TRG and *WAI for more information.

*OPC? — operation complete query

Purpose Place a “1” in the Output Queue after all overlapped commands are completed.

Format *OPC?

Description On power-up, or when *CLS or *RST is executed, the Model 7002-HD goes into the Operation Complete Command Query Idle State (OQIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 7002-HD:

:INITiate

:INITiate:CONTinuous ON

*TRG

When the *OPC? command is sent, the Model 7002-HD exits from OQIS and enters the Operation Complete Command Active State (OQAS). In OQAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is completed (No-Operation-Pending flag set to true), an ASCII character “1” is placed into the Output Queue, the Message Available (MAV) bit in the Status Byte sets, and the instrument goes back into OQIS. Addressing the Model 7002-HD to talk will send the ASCII “1” to the computer.

Note that the instrument always goes into OQAS when *OPC? is executed. If there are no pending command operations (e.g. trigger model in idle state), the Model 7002-HD immediately places an ASCII “1” in the Output Queue, sets the MAV bit and returns to OQIS.

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When used with the :INITiate or :INITiate:CONTinuous ON command, an ASCII “1” will not be sent to the Output Queue and the MAV bit will not set until the Model 7002-HD goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

When used with the *TRG command, an ASCII “1” will not be placed into the Output Queue and the MAV bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event.

In order to use *OPC? exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, an ASCII “1” will be place in the Output Queue and the MAV bit will set when the *TRG command is finished.

After *OPC? is executed, additional commands cannot be sent to the Model 7002-HD until the pending overlapped commands have finished. For example, :INITiate:CONTinuous ON followed by *OPC? will lock up the instrument and will require a device clear (DCL or SDC) before it will accept any more commands.

See *OPC, *TRG and *WAI for more information.

*OPT? — option identification query

Purpose To read the identification code of optional switch cards installed in the Model 7002-HD.

Format *OPT?

Description The *OPT? query command places the option identification code in the Output Queue. When the Model 7002-HD is addressed to talk, the code is sent from the Output Queue to the computer.

The option identification code indicates the assigned model number for each slot of the mainframe.

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*RCL — recall

Purpose To return the Model 7002-HD to a setup configuration previously stored in memory.

Format *RCL <n>

Parameters <NRf> = 0 to 9 Memory location

Description The Model 7002-HD can store up to 10 setup configurations in memory locations 0 to 9. Over the bus, the *SAV command is used to save setup configurations.

The *RCL command is used to return the Model 7002-HD to a setup configuration stored at one of the memory locations. For example, if a setup configuration was previously stored at memory location 9, the Model 7002-HD can be returned to those setup conditions by sending the following command:

*RCL 9

Note: The Model 7002-HD is shipped from the factory with :SYSTem:PRESet defaults stored in all ten memory locations (see Table 5-3 on page 5-58).

*RST — reset

Purpose To reset the Model 7002-HD.

Format *RST

Description When the *RST command is sent, the Model 7002-HD performs the following operations:

1. Returns the Model 7002-HD to the *RST default conditions (see Table 5-3).
2. Cancels all pending commands.
3. Cancels response to any previously received *OPC and *OPC? commands.

The following instrument states are not affected by this command:

IEEE-488 address

Standard Event Status Register

Status Byte Register

*SAV — save

Purpose To save the current setup configuration in memory.

Format *SAV <NRf>

Parameters <NRf> = 0 to 9 Memory location

Description The Model 7002-HD can store up to 10 setup configurations at memory locations 0 to 9 by using the *SAV command. For example, to store the current setup configuration at memory location 6, send the following command:

*SAV 6

Table 5-3 lists the setup items (along with the bus commands to program them), that can be saved by the *SAV command. The *RCL command is used to return the instrument to a saved setup.

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Table 5-3
Default conditions

Command name	*RST value	:SYSTem:PRESet value
:INITiate		
:CONTinuous	OFF	OFF
:ARM		
:SEQuence[1]		
:LAYer[1]		
:COUNt	1	1
:SOURce	IMMediate	IMMediate
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:LAYer2		
:COUNt	1	INFinite
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.001	0.001
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:TRIGger		
:SEQuence1		
:COUNt	1	Scan list length
:AUTO	OFF	ON
:DELay	0	0
:SOURce	IMMediate	MANual
:TIMer	0.001	0.001
:TCONfigure		
:PROTocol	ASYNchronous	ASYNchronous
:DIRection	ACCeptor	SOURce
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:SSYNchronous		
:LINE	1	1

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Table 5-3 (cont.)
Default conditions

Command name	*RST value	:SYSTem:PRESet value
[:ROUTe]		
:CONFigure		
:BBMake	ON	ON
:SLOTX where X=1 to 10		
:STIMe	0	0
:SCHannel	OFF	OFF
:DISPlay		
:SMESsage	OFF	OFF

*SRE — service request enable

Purpose To set the contents of the Service Request Enable Register.

Format *SRE <NRf>

Parameters

<NRf>	= 0	Clears enable register
	= 4	Set EAV bit (Bit 2)
	= 8	Set QSB bit (Bit 3)
	= 16	Set MAV bit (Bit 4)
	= 32	Set ESB bit (Bit 5)
	= 128	Set OSB bit (Bit 7)

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description The *SRE command is used to set the contents of the Service Request Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the register.

This enable register is used along with the Status Byte Register to generate service requests (SRQ). With a bit in the Service Request Enable Register set, an SRQ will occur when the corresponding bit in the Status Byte Register is set by an appropriate event.

The Service Request Enable Register is shown in Figure 5-11 on page 5-28. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that

you wish to set is the value that is sent with the *SRE command. For example, to set the ESB and MAV bits of the Service Request Enable Register, send the following command:

*SRE 34

where:

ESB (bit B5) = Decimal32

MAV (bit B4) = Decimal16

<NRf> =48

The contents of the Service Request Enable Register can be read using the *SRE? query command (see next paragraph).

*SRE? — service request enable query

Purpose To read the contents of the Service Request Enable Register.

Format *SRE?

Description The *SRE? command is used to acquire the value (in decimal) of the Service Request Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *SRE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002-HD is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 17, the binary equivalent is 0001 0001. This binary value indicates that Bits 4 and 0 of the Service Request Enable Register are set (see previous paragraph).

*STB? — status byte query

Purpose To read the contents of the Status Byte Register.

Format *STB?

Description The *STB? query command is used to acquire the value (in decimal) of the Status Byte Register. The Status Byte Register is shown in Figure 5-11 on page 5-28. The binary equivalent of the decimal value determines which bits in the register are set. The set bits in this register define the operating status of the Model 7002-HD.

When the *STB? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002-HD is addressed to talk, the value is sent from the Output Queue to the computer.

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All bits, except Bit 6, in this register are set by other event registers and queues. Bit 6 sets when one or more enabled conditions occur.

The *STB? query command does not clear the status byte register. This register can only be cleared by clearing the related registers and queues.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. This binary value indicates that Bits 4 and 5 of the Status Byte Register are set.

The bits of the Status Byte Register are described as follows:

Bit 0 — Not used.

Bit 1 — Not used.

Bit 2, Error Available (EAV) — Set bit indicates that an error message is present in the Error Queue. The error message can be read using one of the following SCPI commands:

:SYSTem:ERRor?

:STATus:QUEue?

Bit 3,Questionable Summary Bit (QSB) — Set bit indicates that too many channels have closed.

Bit 4, Message Available (MAV) — Set bit indicates that a message is present in the Output Queue. The message is sent to the computer when the Model 7002-HD is addressed to talk.

Bit 5, Event Summary Bit (ESB) — Set bit indicates that an enabled standard event has occurred. The event can be identified by reading the Standard Event Status Register using the *ESE? query command.

Bit 6, Master Summary Status (MSS) / Request Service (RQS) — Set bit indicates that one or more enabled conditions have occurred to generate a service request (SRQ). Note that the IEEE-488.1 standard designates Bit 6 as the RQS bit and is read by performing a Serial Poll.

Bit 7, Operation Summary Bit (OSB) — Set bit indicates that an enabled operation event has occurred. The event can be identified by reading the Operation Event Status Register using the following SCPI command structure:

:STATus:OPERation?

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*TRG — trigger

Purpose To issue a GPIB trigger to the Model 7002-HD.

Format *TRG

Description The *TRG command is used to issue a GPIB trigger to the Model 7002-HD. It has the same effect as a group execute trigger (GET). The *TRG command is an overlapped command, while GET is not. See *OPC, *OPC?, and *WAI for more information.

The *TRG command is used as an arm, scan, and/or channel event to control the scan cycle. The Model 7002-HD will react to this trigger if GPIB is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem.

*TST? — self-test query

Purpose To run the self-tests and acquire the results.

Format *TST?

Description The *TST? query command is used to perform a checksum test on ROM and place the coded result (0 or 1) in the Output Queue. When the Model 7002-HD is addressed to talk, the coded result is sent from the Output Queue to the computer.

A returned value of zero (0) indicates that the test passed, and a value of one (1) indicates that the test has failed.

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*WAI — wait-to-continue

Purpose To prevent the execution of further commands until all previous overlapped commands are completed.

Format *WAI

Description There are two types of device commands: sequential commands and overlapped commands. A sequential command is a command whose operations are allowed to finish before the next command is executed. An overlapped command is a command that allows the execution of subsequent commands while device operations of the overlapped command are still in progress. The *WAI command is used to hold off the execution of subsequent commands until the device operations of all previous overlapped command are finished. The *WAI command is not needed for Sequential commands.

See *OPC, *OPC?, and *TRG for more information.

The :INIT command takes the Model 7002-HD out of the idle state to enable the scan function. The device operations of the :INIT command are not considered complete until the Model 7002-HD goes back into the idle state. Typically, this occurs when all programmed scan operations are completed. By sending the *WAI command after the :INIT command, all subsequent commands will not execute until the Model 7002-HD goes back into the idle state.

The *TRG command issues a bus trigger that could be used to provide the arm, scan, and channel events for the Trigger Model. By sending the *WAI command after the *TRG command, subsequent commands will not be executed until the pointer for the Trigger Model has finished moving in response to *TRG and has settled at its next state.

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SCPI commands

DISPlay subsystem

The display subsystem controls the display circuitry of the Model 7002-HD and is summarized in Table 5-4.

Table 5-4
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display.
:ENABle?	Query state of the display (0 or 1).

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

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:TEXT commands

:DATA <a>

:DISPlay[:WINDow[1]]:TEXT:DATA <a> Define message for top display
:DISPlay:WINDow2:TEXT:DATA <a> Define message for bottom display

Parameters <a> = ASCII characters for message.

Defaults

Power-up	Null string
*RST	No effect
:SYSTem:PRESet	No effect

Query :DATA? Query the defined text message

Description These commands define the text messages that you wish to display. The message can be as long as 20 characters for the top display, and up to 32 characters for the bottom display. A space is counted as a character. Excess message characters (over 20 and 32, respectively) will cause error.

A string message must be enclosed in single quotes or double quotes. Both of the following sting messages are valid:

'Keithley Model 7002-HD' or "Keithley Model 7002-HD"

An indefinite block message must be the only command in the program message or the last command in the program message. If you include a command after an indefinite block message (on the same line), it will be treated as part of the message and will be displayed instead of executed.

Example DISP:TEXT:DATA "Hello" Display "Hello" in top display

:STATe <b>

:DISPlay[:WINDow[1]]:TEXT:STATe <b> Control message; top display
:DISPlay:WINDow2:TEXT:STATe <b> Control message; bottom display

Parameters

<b>	= 0 or OFF	Disable text message for specified display
	= 1 or ON	Enable text message for specified display

Defaults

Power-up	OFF
*RST	No effect
:SYSTem:PRESet	No effect

Query :STATe? Query state of message mode for specified display

Response 1 (on) or 0 (off)

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Description These commands enable and disable the text message modes. When enabled, a defined message (see previous command) will be shown on the top or bottom portion of the display. When disabled, the message will be removed from the display, and the Model 7002-HD will resume normal operation.

A user defined text message remains displayed only as long as the instrument is in remote. Taking the instrument out of remote (by pressing the LOCAL key or sending GTL), cancels the message and disables the text message mode.

Example DISP:TEXT:STAT 1 Turn on top display

:SMESsage <b>

:DISPlay:SMESsage <b> Control status messages

Parameters	<b>	= 0 or OFF	Disable status messages
		= 1 or ON	Enable status messages
Defaults	Power-up		Saved power-on setup
	*RST		OFF
	:SYSTem:PRESet		OFF

Query :SMESsage? Query state of status message mode

Description This command is used to enable/disable the status message mode for the Model 7002-HD. The status message mode is a diagnostic tool that provides real-time messages that relate to the current operating state of the instrument. When the status message mode is disabled, only the error events (EE) in Table 4-1 on page 4-4 will be reported to the display.

Example DISP:SMES ON Turn on status messages

:ENABle <b>

:DISPlay:ENABle <b> Control display circuitry

Parameters	<b>	= 0 or OFF	Disable display circuitry
		= 1 or ON	Enable display circuitry
Defaults	Power-up		ON
	*RST		No effect
	:SYSTem:PRESet		No effect

Query :ENABle? Query state of display

Response 1 (on) or 0 (off)

Description This command is used to enable and disable the front panel display circuitry. Disabling the display circuitry allows the instrument to operate at a higher speed. While disabled, the display will be frozen with the following message:

FRONT PANEL DISABLED

Press LOCAL to resume.

As reported by the message, all front panel controls (except LOCAL) will be disabled. Normal display operation can be resumed by using the :ENABle command to enable the display or by putting the Model 7002-HD into local.

Example :DISP:ENAB OFF Disable display

ROUTe subsystem

The ROUTe subsystem is used to control signal routing through the switch system and is summarized in Table 5-5. The brackets indicate that :ROUTe is optional and need not be included in the command message.

Table 5-5
ROUTe command summary

Command	Description
[:ROUTe]	
:CLOSe <list>	Close specified channels.
:STATe?	Query list of closed channels.
:CLOSe? <list>	Query state of specified channels (1 = closed, 0 = open).
:OPEN <list>|ALL	Open specified (or all) channels.
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).
:SCAN <list>	Define scan list.
:POINts?	Query number of channels in scan list.
:SCAN?	Query scan list.
:FCHannels <list>	Specify channels that cannot be closed.
:FCHannels?	Query channels that cannot be closed.
:INTerlockX	Specify interlock (X = [1] to 5).
:LIST1	Define List 1 for specified interlock.
:LIST1?	Query List 1 for specified interlock.
:LIST2	Define List 2 for specified interlock.
:LIST2?	Query List 2 for specified interlock.
:CONFigure	Configuration command path:
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel <b>	ENable (1 or ON) or Disable (0 or OFF) Single Channel.
:SCHannel?	Query Single Channel.
:SLOTX	Configure SLOT X, where X = [1] to 10.
:STIMe <n>	Specify delay (0 to 99999.999 seconds) for specified slot.
:STIMe?	Query delay for specified slot.
:MEMory	Path to program memory:
:SAVE	Path to save channel patterns:
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).
:RECall M<num>	Recall channel pattern from memory (1 to 500).

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least on space is required between a command word and the parameters.

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:CLOSe commands

:CLOSe <list>

[:ROUTe]:CLOSe <list> Close specified channels

Parameters	<list> = (@ chanlist)	where: chanlist is the specified list of channels (channel list) to be closed.
Defaults	Power-up	All channels open
	*RST	No effect
	:SYSTem:PRESet	No effect
Query	:CLOSe? <list>	Query state of specified channels.

Description The :CLOSe command is used to close the channel(s) specified by the channel list (chanlist) in the <list> parameter.

The :CLOSe? <list> query command is used to determine the state (closed or not closed) of each specified channel. After sending this command and addressing the Model 7002-HD to talk, the values for the specified channels will be sent to the computer. A value of “1” indicates that the channel is closed, and a “0” indicates that the channel is not closed (open).

Example CLOS (@1!5) Close slot 1, channel 5

:STATe?

[:ROUTe]:CLOSe:STATe? Query closed channels

Description This query command is used to request the channels that are currently closed.

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:OPEN <list>|ALL

[:ROUTe]:OPEN <list>|ALL — Open specified (or all) channels

Parameters
<list> = (@ chanlist) Open listed channels
ALL Open all channels

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query :OPEN? <list> Query state of specified channels.

Response
1 = specified channel(s) open.
0 = specified channel(s) not open.

Description
The :OPEN command is used to open one or more channels. The <list> parameter is used to define a channel list (chanlist) the specifies which channels to open. The ALL parameter is used to open all channels.

The :OPEN? <list> query command is used to determine the state (open or not open) of each specified channel. After sending this command and addressing the Model 7002-HD to talk, the values for the specified channels will be sent to the computer. A value of "1" indicates that the channel is open, and a "0" indicates that the channel is not open (closed).

Example :OPEN (@1,5) Open slot 1, channel 5

:SCAN <list>

[:ROUTe]:SCAN <list> — Define scan list

Parameters
<list> = (@ scanlist)
scanlist = list of channels to be scanned.

Defaults

Power-up	Last defined scan list
*RST	No effect
:SYSTem:PRESet	No effect

Query :SCAN? Query scan list

Response Currently defined scan list

Description
The :SCAN command is used to define a scan list. The list of channels to be scanned (scanlist) are included in the <list> parameter.

The Scan List is not lost (cleared) after the instrument is turned off. However, the Scan List is cleared if a channel in the Scan List becomes unavailable, restricted, or interlocked to another channel in the list.

Example :SCAN (@1!30:1!40, 2!1:2!10) Scan 1!30-1!40,2!1-2!10)

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:POINts?

[:ROUTe]:SCAN:POINts? Query scan list length

Description This query command is used to request the number of channels in the scan list. A channel pattern (i.e., M1) in the scan list is counted as one channel. For example, assume the following scan list:

(@ 1!1:1!5, 1!10, M2)

After the POINt? command is sent and the Model 7002-HD is addressed to talk, the following message will be sent to the computer:

7

The "7" indicates that the scan list length is seven channels.

:FCHannels <list>

[:ROUTe]:FCHannels <list> Define "forbidden" channel list

Parameters <list> = (@ forblist)
forblist = list of "forbidden" channels that cannot be closed.

Defaults

Power-up	Last defined "forbidden" channel list
*RST	No effect
:SYSTem:PRESet	No effect

Query :FCHannels? Query "forbidden" channel list

Description The :FCHannels <list> command is used to define a list of channels that cannot be closed.

A "forbidden" channel list can be cancelled by sending an empty forblist as follows:

:fch (@)

If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared (lost).

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:INTerlock:LIST Commands

:LIST[1] <list>

:LIST2 <list>

:[ROUTe]:INTerlock[1]:LIST[1] <list>	Define List 1 for Interlock #1
:[ROUTe]:INTerlock[1]:LIST2 <list>	Define List 2 for Interlock #1
:[ROUTe]:INTerlock2:LIST[1] <list>	Define List 1 for Interlock #2
:[ROUTe]:INTerlock2:LIST2 <list>	Define List 2 for Interlock #2
:[ROUTe]:INTerlock3:LIST[1] <list>	Define List 1 for Interlock #3
:[ROUTe]:INTerlock3:LIST2 <list>	Define List 2 for Interlock #3
:[ROUTe]:INTerlock4:LIST[1] <list>	Define List 1 for Interlock #4
:[ROUTe]:INTerlock4:LIST2 <list>	Define List 2 for Interlock #4
:[ROUTe]:INTerlock5:LIST[1] <list>	Define List 1 for Interlock #5
:[ROUTe]:INTerlock5:LIST2 <list>	Define List 2 for Interlock #5

Parameters <list> = (@ locklist)
where: locklist is the list of channels to be interlocked to channels in the
second list.

Defaults

Power-up	Last defined interlock lists
*RST	No effect
:SYSTem:PRESet	No effect

Response List of channels

Description These commands are used to define the lists for the interlocks. The Model 7002-HD has five channel interlocks. Each interlock is made up of two user-defined lists of channels. Each channel in one list is interlocked to each channel in the other list. In general, channels that are interlocked cannot be closed at the same time. More detailed information on the interlocks can be found in Section 4 of this manual.

An interlock can be disabled by emptying one or both of its lists. For example, the following program message disables Interlock #1:

:int:list (@)

If you specify channels to be interlocked and they are already included in the Scan List and/or a Channel Pattern (interlock violation), then the entire Scan List and/or Channel Pattern is cleared (lost).

Example INT5:LIST2 (@3!1:3!10, 5!2)

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:CONFigure Commands

:BBMake <b>

[:ROUTe]:CONFigure:BBMake <b> Control Break-Before-Make switching

Parameters

<b>	= 0 or OFF	Disable Break-Before-Make switching
	= 1 or ON	Enable Break-Before-Make switching

Defaults

Power-up	Saved power-on setup
*RST	On
:SYSTem:PRESet	On

Description When scanning, recalling saved channel patterns or, in the Single Channel mode, enabling Break-Before-Make will assure that the currently closed channel will open before the next channel closes.

When Break-Before-Make is disabled, the assurance that the current channel will open before the next channel closes is lost. In other words, two channels could momentarily be closed at the same time. An advantage to disabling Break-Before-Make is an increase in speed.

Example :CONF:BBM ON Turn on Break-Before-Make

:SCHannel <b>

[:ROUTe]:CONFigure:SCHannel <b> Control Single Channel mode

Parameters

<b>	= 0 or OFF	Disable Single Channel mode.
	= 1 or ON	Enable Single Channel mode.

Defaults

Power-up	Saved power-on setup
*RST	Off
:SYSTem:PRESet	Off

Description The Single Channel mode (when enabled) is used to prevent more than one channel from closing at a time. When a single channel is closed, the previous closed channel will open. This ensures that even with random channel closures, only one channel can be closed at a time. Toggling the Single Channel mode from off to on causes all channels to open. For complete details on Single Channel, see Section 4.

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:STIMe <n>

[:ROUTe]:CONFigure:SLOT[1]:STIMe <n>	Set delay for Slot 1
[:ROUTe]:CONFigure:SLOT2:STIMe <n>	Set delay for Slot 2
[:ROUTe]:CONFigure:SLOT3:STIMe <n>	Set delay for Slot 3
[:ROUTe]:CONFigure:SLOT4:STIMe <n>	Set delay for Slot 4
[:ROUTe]:CONFigure:SLOT5:STIMe <n>	Set delay for Slot 5
[:ROUTe]:CONFigure:SLOT6:STIMe <n>	Set delay for Slot 6
[:ROUTe]:CONFigure:SLOT7:STIMe <n>	Set delay for Slot 7
[:ROUTe]:CONFigure:SLOT8:STIMe <n>	Set delay for Slot 8
[:ROUTe]:CONFigure:SLOT9:STIMe <n>	Set delay for Slot 9
[:ROUTe]:CONFigure:SLOT10:STIMe <n>	Set delay for Slot 10

Parameters

<n>	= 0 to 99999.999	Settling time in seconds
	= DEFault	0 seconds
	= MINimum	0 seconds
	= MAXimum	99999.999 seconds

Defaults

Power-up	0 seconds
*RST	0 seconds
:SYSTem:PRESet	0 seconds

Query

:STIMe?	Query programmed delay for specified slot
:STIMe? DEFault	Query *RST default delay
:STIMe? MINimum	Query minimum delay
:STIME? MAXimum	Query maximum delay

Response

0 to 99999.999

Description

An internally set relay settling time is provided to allow for switch bounce when it closes. At power-up, a settling time is automatically set based on the acquired identification information from the card. The :STIMe command allows you to increase the delay for each slot.

The delay value can be entered using the exponent form. For example, instead of sending a parameter value of 2000 (seconds), you can instead send 2E3. To cancel this delay, send this command using a parameter value of 0.

For complete information on this delay, see DELAY in Section 4.

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:MEMory commands

:SAVE[:RELays] M<num>

[:ROUTe]:MEMory:SAVE[:RELays] M<num> — Save current channel pattern at specified memory location

Parameters	<num> = 1 to 500	Specify memory location
Defaults	Power-up	No effect
	*RST	No effect
	:SYSTem PRESet	No effect

Description

This command is used to save (store) the current channel pattern at a memory location. For example, if channels 1!1, 1!6, 1!8, and 2!5 are currently closed, you can save that channel pattern to memory location 236. When M236 is later recalled or scanned, the four channels of that channel pattern will close, and all other channels will open.

Up to 500 channel patterns can be saved in memory locations 1 to 500. A channel pattern can be recalled from memory using the :RECall command. Note: An alternate method to save a channel pattern is to use the :SAVE:LIST command. This allows you to define the channel pattern without having to close or open channels.

A Channel Pattern is not lost (cleared) after the instrument is turned off. However, a Channel Pattern is cleared if a closed channel in the pattern becomes unavailable, restricted or interlocked to another channel in the pattern.

Example	:CLOS (@1!1:1!10)	Close ch 1-10, slot 1
	:MEM:SAVE M36	Save pattern to

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:SAVE:LIST <list>, M <num>

[:ROUTe]:MEMory:SAVE:LIST <list>, M <num> Save specified channel pattern at a specified memory location

Parameters <num> = a whole number from1 to 500 Specify memory location
<list> = (@ chanlist) Specify channel pattern
chanlist = list of closed channels

Defaults

Power-up	No effect
*RST	No effect
:SYSTem PRESet	No effect

Description This command is used to define and save (store) a channel pattern at a memory location. The <NRf> parameter specifies the memory location for the channel pattern. The <list> parameter defines the channel pattern. When the channel pattern is recalled or scanned, the channels listed in the chanlist will close. The following examples demonstrate various forms for expressing channel entries for a chanlist.

Up to 500 channel patterns can be saved in memory locations 1 to 500. A channel pattern can be recalled from memory using the :RECall command.

Note: An alternate method to save a channel pattern is to use the :SAVE:[RELays] command. With this method, you close the desired channels and then save that channel pattern at a memory location.

A Channel Pattern is not lost (cleared) after the instrument is turned off. However, a Channel Pattern is cleared if a closed channel in the pattern becomes unavailable, restricted, or interlocked to another channel in the pattern.

Example :MEM:SAVE:LIST (@1!1:1!10), M24 Save ch 1-10 to M24

:RECall M<NRf>

[:ROUTe]:MEMory:RECall M<NRf> Recall channel pattern from memory

Parameters <NRf> = 1 to 500 Specify memory location

Description This command is used to recall a channel pattern stored at a memory location. Channel patterns can be recalled from memory locations 1 to 500. As soon as the channel pattern is recalled, channels will immediately close and/or open as dictated by the channel pattern. The front panel channel status display will also update to reflect the channel pattern.

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The Model 7002-HD is shipped from the factory with blank channel patterns stored in all 500 memory locations. A blank channel pattern has no closed channels. All channels for all slots will open.

Channel patterns can be stored in memory using the :SAVe[:RECall] or :SAVE:LIST command.

Example :MEM:REC M24 Recall location 24

Sense subsystems

The sense subsystems are used to read the inputs of digital cards installed in slots 1 through 10, respectively. Table 5-6 lists the commands.

Table 5-6
SENSe command summary

Command	Description
:SENSeX :DATA? <list>	Specify slot; X=2 (slot 1) through 11 (slot 10). Read specified input channels for the specified slot.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

:DATA? <list>

:SENSe2:DATA? <list>	Read specified inputs of slot 1
:SENSe3:DATA? <list>	Read specified inputs of slot 2
:SENSe4:DATA? <list>	Read specified inputs of slot 3
:SENSe5:DATA? <list>	Read specified inputs of slot 4
:SENSe6:DATA? <list>	Read specified inputs of slot 5
:SENSe7:DATA? <list>	Read specified inputs of slot 6
:SENSe8:DATA? <list>	Read specified inputs of slot 7
:SENSe9:DATA? <list>	Read specified inputs of slot 8
:SENSe10:DATA? <list>	Read specified inputs of slot 9
:SENSe11:DATA? <list>	Read specified inputs of slot 10

Parameters <list> = (@ chanlist)
where: chanlist is the specified list of input channels to be read.

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Description These commands are used to read the specified inputs of digital I/O cards installed in the slots of the mainframe. After sending one of these commands and addressing the Model 7002-HD to talk, a value indicating the status of each specified input channel is sent to the computer. A value of "1" indicates that the input channel is high (on) and a value of "0" indicates that the input channel is low (off).

The conventional form for the <list> parameter includes the slot and input channel number. However, for these commands, you do not need to include the slot number. For example, you can send either of the following two commands to read input channel 23 of slot 6:

:SENSe7:DATA? (@6!23) or :SENSe7:DATA? (@23)

After the mainframe is addressed to talk, the response message will indicate the state of input channel 23 of slot 6. In another example, you can send either of the following two commands to read all 40 input channels of an I/O card in slot 8.

:SENSe9:DATA? (@8!1:8!40) or :SENSe9:DATA? (@ 1:40)

The response message will include a "0" (off) or "1" (on) for each of the 40 input channels (i.e. "0, 0, 0, 1, 0 ... 1"). You can send up to two of the query commands in the same program message. For example, the following program message is valid:

:sens2:data? <list>; :sens3:data? <list>

Sending three or more of these queries in the same program message will cause the Model 7002-HD to lock up and will require that you send an IFC and then a DCL to restore operation.

Sending one of these query commands for a slot that does not have an I/O card installed will result in the following error message:

ERROR: ID CODE = -241

Hardware missing

STATus subsystem

The status subsystem is used to control the status registers of the Model 7002-HD. These registers and the overall status structure are explained in "Status structure" on page 5-6. The commands in this subsystem are summarized in Table 5-7.

NOTE The various status register drawings are covered in detail in "Status structure" on page 5-6.

Table 5-7
STATus command summary

Command	Description
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.

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Table 5-7 (cont.)
STATus command summary

Command	Description
:STATus :QUEStionable [:EVENt]? :ENABle <NRf> :ENABle? :PTRansition <NRf> :PTRansition? :NTRansition <NRf> :NTRansition? :CONDition? :PRESet :QUEue [:NEXT]? :ENABle <list> :ENABle? :DISable <list> :DISable?	Path to control questionable event registers: Query the event register. Program the enable register. Query the enable register. Program the positive transition register. Query the positive transition register. Program the negative transition register. Query the negative transition register. Query the condition register. Return status registers to default states. Path to access error queue: Query most recent error message. Specify error and status messages for queue. Query enabled messages. Specify messages not to be placed in queue. Query disabled messages.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

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[:EVENt]?

:STATus:OPERation[:EVENt]?	Query Operation Event Register
:STATus:OPERation:TRIGger[:EVENt]?	Query Trigger Event Register
:STATus:OPERation:ARM[:EVENt]?	Query Arm Event Register
:STATus:OPERation:ARM:SEQUENCE[:EVENt]?	Query Sequence Event Register
:STATus:QUEStionable[:EVENt]?	Query Questionable Event Register

Defaults

Power-up	Clears (0) all bits
*CLS	Clears (0) all bits
:STATus:PRESet	No effect

Description

These query commands are used to query the event registers. After sending one of these commands and addressing the Model 7002-HD to talk, a decimal value is sent to the computer. The binary equivalent of this value determines which bits in the appropriate register are set. The event registers are shown in Figure 5-6 on page 5-10 through Figure 5-10 on page 5-24. Note that querying an event register clears the bits in that register.

For example, assume that querying the Operation Event Register results in an acquired decimal value of 34. The binary equivalent is 0000 0000 0010 0010. For this binary value, bits B5 and B1 of the Operation Event Register are set.

The significance of a set bit in these registers depend on how the transition filter is programmed (see :PTRansition and :NTRansition commands). If an event is programmed for a positive transition (PTR), the corresponding bit in this register will set when the event occurs (0 to 1 transition). If the event is instead programmed for a negative transition (NTR), the bit will set when the event becomes not true (1 to 0 transition).

Operation event register:

Bit B0 — Not used.

Bit B1, Settling (Set) — Set bit indicates that the scan is currently in the settling period for a relay (PTR) or the settling period has expired (NTR).

Bits B2, B3 and B4 — Not used.

Bit B5, Waiting for Trigger (Trig) — Set bit indicates that the instrument is waiting in the Trigger Layer of the trigger model (PTR) or that it has left the Trigger Layer (NTR).

Bit B6, Waiting for Arm (Arm) — Set bit indicates that the instrument is waiting in an Arm Layer of the trigger model (PTR) or operation has passed from the arm layers into the trigger layer (NTR).

Bits B7, B8 and B9 — Not used.

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Bit B10, Idle — Set bit indicates that the instrument is in the idle state (PTR) or has left the idle state to perform a scan (NTR).

Bits B11 through B15 — Not used.

Trigger Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in the Trigger Layer (PTR), or that the instrument has exited from the Trigger Layer (NTR).

Bits B2 through B15 — Not used.

Arm Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in an arm layer (PTR), or that the instrument has exited from the arm layers (NTR).

Bits B2 through B15 — Not used.

Sequence Event Register:

Bit B0 — Not used.

Bit B1, Layer 1 (Lay1) — Set bit indicates that instrument operation is in Arm Layer 1 (PTR), or that operation has exited from Arm Layer 1 (NTR).

Bit B2, Layer 2 (Lay2) — Set bit indicates that instrument operation is in Arm Layer 2 (PTR), or that operation has exited from Arm Layer 2 (NTR).

Bits B3 through B15 — Not used.

Questionable Event Register:

Bit B0 through B8 — Not used.

Bit B9, Too Many Channels Closed (Chan) — Set bit indicates that too many channels have closed (PTR), or that those channels have subsequently opened (NTR). This error occurs when the required relay drive current exceeds the current capability of the +6V supply.

Bit B10 through B15 — Not used.

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:ENABle <NRf>

:STATus:OPERation:ENABle <NRf>	Operation Event Enable Register
:STATus:OPERation:TRIGger:ENABle <NRf>	Trigger Event Enable Register
:STATus:OPERation:ARM:ENABle <NRf>	Arm Event Enable Register
:STATus:OPERation:ARM:SEQUENCE:ENABle <NRf>	Sequence Event Enable Register
:STATus:QUEStionable:ENABle <NRf>	Questionable Event Enable Register

Parameters

<NRf>	= 0	Clear enable register
	= 2	Set bit B1 of enable register
	= 4	Set bit B2 of enable register
	= 32	Set bit B5 of enable register
	= 64	Set bit B6 of enable register
	= 512	Set bit B9 of enable register
	= 1024	Set bit B10 of enable register

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query :ENABle? Query enable register

Response Decimal value (below)

Description These commands are used to set the contents of the event enable registers (see Figure 5-5 on page 5-8 through Figure 5-10 on page 5-24). An :ENABle command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the appropriate register.

The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B5 and B6 are set.

Each event enable register is used as a mask for events (see [:EVENt] for descriptions of events). When a bit in an event enable register is cleared (0), the corresponding bit in the event register is masked and thus, cannot set the corresponding summary bit of the next register set in the status structure. Conversely, when a bit in an event enable register is set (1), the corresponding bit in the event register is unmasked. When the unmasked bit in the event register sets, the summary bit of the next register set in the status structure will set.

The sum of the decimal weights of the bits that you wish to set is sent as the parameter (<NRf>) for the appropriate :ENABle command. For example, to set the Idle and Set bits of the Operation Event Enable Register, send the following command:

```
:stat:oper:enab  1026
```

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where:

Idle (bit B10)=1024

Set (bit B1)=2

<NRf>=1026

:PTRansition <NRf>

:STATus:OPERation:PTRansition <NRf>	Operation Transition Filter
:STATus:OPERation:TRIGger:PTRansition <NRf>	Trigger Transition Filter
:STATus:OPERation:ARM:PTRansition <NRf>	Arm Transition Filter
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>	Sequence Transition Filter
:STATus:QUEStionable:PTRansition <NRf>	Questionable Transition Filter

Parameters

<NRf>	= 0	Clear PTR register
	= 2	Set bit B1 of PTR register
	= 4	Set bit B2 of PTR register
	= 32	Set bit B5 of PTR register
	= 64	Set bit B6 of PTR register
	= 512	Set Bit B9 of PTR register
	= 1024	Set bit B10 of PTR register

Defaults

Power-up	Sets (1) all bits
*CLS	No effect
:STATus:PRESet	Sets (1) all bits

Query :PTRansition? Query PTR register

Response Decimal value (see below)

Description These commands are used to program the positive transition (PTR) registers. A positive transition is defined as a 0 to 1 state change in the condition register. Thus, when a an event is programmed for a positive transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 0 to 1. For example, if bit B1 of the Positive Transition Register of the Operation Transition Filter is set, then the relay settling event is programmed for a positive transition. The Set bit (B1) in the Operation Event Register will set at the start of the relay settling period. For details on register structure, "Status structure" on page 5-6.

The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0010 0110 0000. For this binary value, bits B6 and B5 are set.

The PTR registers are shown in Figure 5-7 on page 5-14 through Figure 5-10 on page 5-24. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) operation events for positive transitions, send the following command:

:stat:oper:ptr 96

where:

Arm (bit B6)=64

Trig (bit B5)=32

<NRf>=96

Effects of positive transitions on the Operation Event Register:

Operation Event	Positive Transition Effect On Operation Event Register
Settling	Sets B1 at the start of the settling period.
Trigger Layer	Sets B5 when waiting in the Trigger Layer.
Arm Layer	Sets B6 when waiting in an Arm Layer.
Idle	Sets B10 when entering the idle state.

Effects of positive transitions on the Trigger Event Register:

Trigger Event	Positive Transition Effect On Trigger Event Register
Sequence 1	Sets B1 when waiting in Trigger Layer.

Effects of positive transitions on the Arm Event Register:

Arm Event	Positive Transition Effect On Arm Event Register
Sequence 1	Sets B1 when in an Arm Layer.

Effects of positive transitions on the Sequence Event Register:

Sequence Event	Positive Transition Effect On Sequence Event Register
Layer 1	Sets B1 when in Arm Layer 1.
Layer 2	Sets B2 when in Arm Layer 2.

Effects of positive transitions on the Questionable Event Register:

Questionable Event	Positive Transition Effect On Questionable Event Register
Chan	Sets B9 when too many channels have closed.

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:NTRansition <NRf>

:STATus:OPERation:NTRansition <NRf>	Operation Transition Filter
:STATus:OPERation:TRIGger:NTRansition <NRf>	Trigger Transition Filter
:STATus:OPERation:ARM:NTRansition <NRf>	Arm Transition Filter
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>	Sequence Transition Filter
:STATus:QUEStionable:NTR <NRf>	Questionable Transition Filter

Parameters

<NRf>	= 0	Clear NTR register
	= 2	Set bit B1 of NTR register
	= 4	Set bit B2 of NTR register
	= 32	Set bit B5 of NTR register
	= 64	Set bit B6 of NTR register
	= 512	Set bit B9 of NTR register
	= 1024	Set bit B10 of NTR register

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query :NTRansition? Query NTR register

Response Decimal value (below)

Description These commands are used to program the negative transition (NTR) registers. A negative transition is defined as a 1 to 0 state change in the condition register. Thus, when an event is programmed for a negative transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 1 to 0. For example, if bit B1 of the Negative Transition Register of the Operation Transition Filter is set, then the operation event is programmed for a negative transition. The Set bit (B1) in the Operation Event Register will set at the end of the relay settling period. For details on register structure, see "Status structure" on page 5-6.

The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B6 and B5 are set.

The NTR registers are shown in Figure 5-7 on page 5-14 through Figure 5-10 on page 5-24. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) events for negative transitions, send the following command:

:stat:oper:ntr 96

where:

Arm (bit B6)=64

Trig (bit B5)=32

<NRf>=96

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Effects of negative transitions on the Operation Event Register:

Operation Event	Negative Transition Effect On Operation Event Register
Settling	Sets B1 at the end of the settling period.
Trigger Layer	Sets B5 when leaving the Trigger Layer.
Arm Layer	Sets B6 when leaving an Arm Layer.
Idle	Sets B10 when leaving the idle state.

Effects of negative transitions on the Trigger Event Register:

Trigger Event	Negative Transition Effect On Trigger Event Register
Sequence 1	Sets B1 when leaving the Trigger Layer.

Effects of negative transitions on the Arm Event Register:

Arm Event	Negative Transition Effect On Arm Event Register
Sequence 1	Sets B1 when leaving an Arm Layer.

Effects of negative transitions on the Sequence Event Register:

Sequence Event	Negative Transition Effect On Sequence Event Register
Layer 1	Sets B1 when leaving Arm Layer 1.
Layer 2	Sets B2 when leaving Arm Layer 2.

Effects of negative transitions on the Questionable Event Register:

Questionable Event	Negative Transition Effect On Questionable Event Register
Chan	Sets B9 when the channels open after the occurrence of the “too many channels closed” error.

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:CONDition?

:STATus:OPERation:CONDition?	Query Operation Condition Register
:STATus:OPERation:TRIGger:CONDition?	Query Trigger Condition Register
:STATus:OPERation:ARM:CONDition?	Query Arm Condition Register
:STATus:OPERation:ARM:SEQuence:CONDition?	Query Sequence Condition Register
:STATus:QUEStionable:CONDition?	Query Questionable Condition Register

Description These query commands are used to query the contents of the condition registers. Each set of event registers (except the Standard Event register set) has a condition register. A condition register is similar to its corresponding event register, except that it is a real-time register that constantly updates to reflect the current operating status of the instrument.

See [:EVENt] for register bit descriptions. Note from the status structure that the condition registers precede the transition filters. Thus, only the PTR descriptions apply to the condition registers.

After sending one of these commands and addressing the Model 7002-HD to talk, a decimal value is sent to the computer. The binary equivalent of this decimal value indicates which bits in the register are set.

For example, if sending :stat:oper:cond? returns a decimal value of 1024 (binary 0000 0100 0000 0000), bit B10 of the Operation Condition Register is set indicating that the instrument is in the idle state.

:PREset

:STATus:PREset	Return 7002-HD to default conditions

Description When this command is sent, the SCPI event registers are affected as follows:

1. All bits of the positive transition filter registers are set to one (1).
2. All bits of the negative transition filter registers are cleared to zero (0).
3. All bits of the following registers are cleared to zero (0): Operation Event Enable Register and Questionable Event Enable Register.
4. All bits of the following registers are set to one (1):Trigger Event Enable Register, Arm Event Enable Register, and Sequence Event Enable Register.

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Example :STAT:PRES Return registers to defaults

:QUEue commands

[:NEXT]?

:STATus:QUEue[:NEXT]? Query Error Queue

Defaults

Power-Up	Clears Error Queue
*CLS	Clears Error Queue
:STATus:PRESet	No effect

Description As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages.

The Error Queue is a first-in, first-out (FIFO) register. Every time you query the queue, the “oldest” message is read and that message is then removed from the queue. The queue will hold up to 10 messages. If the queue becomes full, the message “350, ‘Queue Overflow’” will occupy the last memory location in the register. On power-up, the Error Queue is empty. When the Error Queue is empty, the message “0, ‘No error’” is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. The messages are listed in Table 4-1 on page 4-4.

After this command is sent and the Model 7002-HD is addressed to talk, the “oldest” message in the queue is sent to the computer.

Note: The :STATus:QUEue[:NEXT]? query command performs the same function as the :SYSTem:ERRor? query command (see System Subsystem).

:ENABle <list>

:STATus:QUEue:ENABle <list> Enable messages for Error Queue

Parameters list = (numlist)
numlist is a specified list of messages for the Error Queue.

Defaults

Power-up	Enable error events, disable status events
*CLS	No effect
:STATus:PRESet	Enable error events, disable status events

Query :ENABle? Query list of enabled messages

Description On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want enabled. Messages not specified will be disabled and prevented from entering the queue.

When this command is sent, all messages will first be disabled, then the messages specified in the list will be enabled. Thus, the returned list (:ENABle?) will contain all the enabled messages.

Messages are specified by numbers (see Table 4-1 on page 4-4). The following examples show various forms for expressing a message numlist:

Numlist = -110	Single message.
= -110, -140, -222	Messages separated by commas.
= -110:-222	Range of messages (-100 through -222).
= -110:-222, -230	Range entry and single entry separated by a comma.

Note: To disable all messages from entering the Error Queue, send the following command:

:stat:que:enab ()

To enable all Model 7002-HD messages, send the following command: :stat:que:enab (-150: +550)

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:DISable <list>

:STATus:QUEue:DISable <list> Disable messages for Error Queue

Parameters <list> = (numlist)
numlist is a specified list of messages for the Error Queue.

Defaults

Power-up	Disable status events, enable error events
*CLS	No effect
:STATus:PRESet	Disable status events, enable error events

Query :DISable? Query list of disabled messages

Description On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want disabled. Disabled messages are prevented from going into the Error Queue.

Messages are specified by numbers (see Table 4-1 on page 4-4). The following examples show various forms for expressing a message numlist:

Numlist	=-110	Single message.
	=-110, -140, -222	Messages separated by commas.
	=-110:-222	Range of messages (-100 through -222).
	=-110:-222, -230	Range entry and single entry separated by a comma.

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SYSTem subsystem

The system subsystem contains miscellaneous commands and is summarized in Table 5-8.

Table 5-8
SYSTem command summary

Command	Description
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.
:VERSion?	Query revision level of SCPI standard.
:ERRor?	Query Error Queue.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

:PRESet

:SYSTem:PRESet — Return to :SYSTem:PRESet defaults

Description This command returns the instrument to states optimized for front panel operation. Table 5-3 on page 5-58 defines the default conditions for this command.

Example :SYST:PRES — Return 7002-HD to defaults

:POSetup <name>

:SYSTem:POSetup <name> — Program power-on defaults

Parameters

<name>=	RST	Select *RST defaults on power up
	= PRESet	Select :SYSTem:PRESet defaults on power up
	= SAVX	Select saved defaults on power up where: X = 0 to 9

Query :POSetup? — Query power-on setup

Response RST, PRES or SAV0-SAV9

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Description This command is used to program the power-on defaults. With RST selected, the instrument will power up to the *RST default conditions. With PRES selected, the instrument will power up to the :SYStem:PRESet default conditions. Table 5-3 on page 5-58 defines the default conditions for these commands.

With one of the SAV parameters selected, the instrument will power on to the setup that is saved in the specified memory location using the *SAV command.

:VERSion?

:SYSTem:VERSion? Read SCPI version

Description This query command is used to read the version of the SCPI standard being used by the Model 7002-HD. After sending this command and addressing the Model 7002-HD to talk, the version code will be sent to the computer. Example code:

1996.0

The above response message indicates the version of the SCPI standard.

:ERRor?

:SYSTem:ERRor? Read Error Queue

Defaults

Power-up	Clears Error Queue
*RST	No effect
*CLS	Clears Error Queue
DCL, SDC	No effect
:SYSTem:PRESet	No effect
:STATus:PRESet	No effect

Description As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages. The Error Queue is a first-in, first-out (FIFO) register. Every time you read the queue, the “oldest” message is read and that message is then removed from the queue.

If the queue becomes full, the message “350, ‘Queue Overflow’” will occupy the last memory location in the register. On power-up, the queue is empty. When the Error Queue is empty, the message “0, ‘No error’” is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. Table 4-1 on page 4-4 lists the messages.

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After this command is sent and the Model 7002-HD is addressed to talk, the “oldest” message in the queue is sent to the computer.

Note: The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command (see ”Status structure” on page 5-6).

Trigger subsystem

The Trigger Subsystem is made up of a series of commands and subsystems to configure the three layers of the Trigger Model (see Figure 5-12 on page 5-31). These commands and subsystems are summarized in Table 5-9.

Front panel operation and IEEE-488 operation use different nomenclature for the three layers of the Trigger Model and is summarized as follows:

Trigger Model Layer Nomenclature:

Layer	Layer Name; Front Panel Operation	Layer Name; IEEE-488 Bus Operation
First layer	Arm Layer	Arm Layer 1
Second layer	Scan Layer	Arm Layer 2
Third layer	Channel Layer	Trigger Layer

Table 5-9
Trigger command summary

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Immediately go to Layer2.
:COUNt <n>	Program arm count (1 to 9999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass:
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:LAYer2	Path to program arm layer 2:
:IMMediate	Immediately go to Trigger Layer.
:COUNt <n>	Program scan count (1 to 9999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Query timer.
:SIGNal	Loop around control source.

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Table 5-9 (cont.)
Trigger command summary

Command	Description
:ARM[:SEQuence[1]]	
:LAYer2	
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Immediately perform a scan step.
:COUNt <n>	Program measure count (1 to 9999, or INF).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).
:AUTO?	Query auto-count.
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.

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Table 5-9 (cont.)
Trigger command summary

Command	Description
:TCONfigure :PROTocol <name> :PROTocol? :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :SSYNchronous :LINE <NRf> :LINE?	Path to configure Triggers: Select protocol: ASYNchronous, SSYNchronous. Query protocol. Enable (SOURce) or disable (ACCeptor) Bypass. Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line. Path to configure semi-synchronous Trigger Link: Select trigger line (1 to 6). Query trigger line.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

:INITiate commands

[:IMMediate]

:INITiate[:IMMediate] Take 7002-HD out of idle

Description This command takes the Model 7002-HD out of the idle state. After the completion of a scan, the instrument will return to the idle state (if continuous initiation is disabled; see next command). This is an overlapped command (see *OPC, *OPC?, *TRG, and *WAI).

Example :INIT Remove 7002-HD from idle

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:CONTinuous <b>

:INITiate:CONTinuous <b> Control continuous initiation

Parameters

<b>	= 0 or OFF	Disable continuous initiation
	= 1 or ON	Enable continuous initiation

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

Query :CONTinuous? Query continuous initiation

Response 1 (on) or 0 (off)

Description When continuous initiation is selected (ON), the instrument is taken out of the idle state. At the conclusion of all programmed operations, the instrument will return to Arm Layer 1. This is an overlapped command (see *OPC, *OPC?, *TRG and *WAI).

In the event of a “Too many channels closed” error, all channels will open, the instrument will go into idle, and continuous initiation will disable (:INITiate:CONTinuous OFF).

Example :INIT:CONT ON Select continuous inititiation

:ABORt

:ABORt Abort operation

Description When this action command is sent, the Model 7002-HD will abort its current operations and return to the top of the Trigger Model (idle state). If the *OPC command has been sent, the OPC bit in the Standard Event Status Register will set. If continuous initiation is disabled, the instrument will go into the idle state. If continuous initiation is enabled, operation will continue on into Arm Layer 1.

The abort command will reset the Source Bypasses of the Trigger Model and reset the scan pointer back to the first channel in the scan list.

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:IMMediate

:ARM[:SEQuence[1]][:LAYer[1]]:IMMediate	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:IMMediate	Bypass scan control source and delay
:TRIGger:[:SEQuence[1]]:IMMediate	Bypass channel control source and delay

Description These action commands are used to bypass the specified layer of the Trigger Model. They are used when you do not wish to wait for the programmed event. Note from the Trigger Model (Figure 5-12 on page 5-31) that :arm:lay2:imm and :trig:imm also bypass the Delay.

The instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and the command will be ignored. When the command is sent, the bypass will occur and operation will continue on.

Note that :IMMediate is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the specified trigger model layer.

Example :ARM:IMM Bypass control source

:COUNt <n>

:ARM[:SEQuence[1]][:LAYer[1]]:COUNt <n>	Set Arm Layer 1 count
:ARM[:SEQuence[1]]:LAYer2:COUNt <n>	Set Arm Layer 2 count
:TRIGger[:SEQuence[1]]:COUNt <n>	Set Trigger Layer count

Parameters

<n>	= 1 to 99999	Specify count
	= INF	Sets count to infinite
	= DEFault	Sets count to 1
	= MINimum	Sets count to 1
	= MAXimum	Sets count to 9999

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (Arm Layer 1)
	INF (Arm Layer 2)
	Scan-list-length (Trigger Layer)

Query

:COUNt?	Query programmed count
:COUNt? DEFault	Query *RST default count
:COUNt? MINimum	Query lowest allowable count
:COUNt? MAXimum	Query largest allowable count

Response 1 to 9999 (for finite count)
+9.9e37 (for infinite count)

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Description These commands are used to specify how many times operation will loop around in the specified layer of operation. For example, if the channel count (:trig:coun) is set to 10, operation will continue to loop around in the Trigger Layer until 10 channels are scanned. After the 10th channel, operation will proceed back up to Arm Layer 2.

If you select a finite channel count (:trig:coun) that is greater than the scan-list-length, the first scan will end after the programmed number of channels are scanned. If programmed for another scan, the scan process will continue from the last scanned channel.

If you select an infinite channel count (:trig:coun), the scan will loop back to the beginning of the scan list after all channels in the list have been scanned. This process will continue indefinitely.

Note that this command is coupled to :TRIGger:COUNt:AUTO (auto-count). When auto-count is enabled, the channel count is set to the scan-list-length. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Example :TRIG:COUN 10 Set trigger count to 10

:AUTO <b>

:TRIGger[:SEQuence[1]]:COUNt:AUTO <b> Control auto-count for Trigger Layer

Parameters

<b>	= 1 or ON	Enable auto-count (scan-list-length)
	= 0 or OFF	Disable auto-count

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

Query :AUTO? Query auto-count

Response 1 (on) or 0 (off)

Description With auto-count enabled, the channel count is automatically set to the scan-list-length. For example, if there are currently 36 channels in the scan list, then enabling auto-count will set the channel count to 36. While auto-count is enabled, changing the scan list count will change the trigger count.

If the scan list is empty, enabling auto-count will set the channel count to 1.

This command is coupled to :TRIGger:COUNt which is used to manually set the channel count. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Example :TRIG:COUN:AUTO ON Trig count = scan list

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:DELay <n>

:ARM[:SEQuence[1]]:LAYer2:DELay <n>	Set Arm Layer 2 delay
:TRIGger[:SEQuence[1]]:DELay <n>	Set Trigger Layer delay

Parameters

<n>	= 0 to 99999.999	Specify delay in seconds
	= DEFault	0 second delay
	= MINimum	0 second delay
	= MAXimum	99999.999 second delay

Defaults

Power-up	Saved power-on setup
*RST	0 sec
:SYSTem:PRESet	0 sec

Query

:DELay?	Query the programmed delay
:DELay? DEFault	Query the *RST default delay
:DELay? MINimum	Query the lowest allowable delay
:DELay? MAXimum	Query the largest allowable delay

Response 0 to 99999.999 (seconds)

Description These delay periods are used to delay operation in the specified layer (Arm Layer 2 and/or Trigger Layer). After the programmed event occurs, the instrument will wait until the delay period expires before proceeding on in the Trigger Model.

Note that Arm Layer 1 does not use a Delay.

Example :TRIG:DEL 1 Trigger delay = 1 second

:SOURce <name>

:ARM[:SEQuence[1]][:LAYer[1]]:SOURce <name>	Specify arm event control source
:ARM[:SEQuence[1]]:LAYer2:SOURce <name>	Specify scan event control source
:TRIGger[:SEQuence[1]]:SOURce <name>	Specify channel event control source

Parameters

<name>	= HOLD	Hold operation in specified layer
	= IMMediate	Pass operation through specified layer
	= MANual	Select manual event
	= BUS	Select GPIB trigger as event
	= TLINk	Select Trigger Link as event
	= TIMer	Select timer as event Note: TIMer not available for Arm Layer 1

Defaults

Power-up	Saved power-on setup
*RST	IMMediate (all layers)
:SYSTem:PRESet	IMMediate (Arm Layer 1 and Arm Layer 2), MANual (TRIGger Layer)

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Query :SOURce? Query programmed control source.

Response HOLD, MAN, IMM, BUS, TLIN, EXT or TIM

Description These commands are used to select the event control source for the specified layer. With HOLD selected, operation will stop and wait indefinitely in the specified layer. While in HOLD, operation can be continued by sending the :IMMediate command or the :SIGNal command. Keep in mind however, that if the layer count >1, HOLD will again be enforced when operation loops back around.

With IMMediate selected (do not confuse :SOURce IMMediate with :IMMediate), operation will immediately pass through the specified layer.

A specific event can be used to control operation through a layer. With BUS selected, operation will continue when a GPIB trigger (GET or *TRG) is sent. With TLINk selected, operation will continue when an input trigger via the Trigger Link is received.

A TIMer event is available for Arm Layer 2 and the Trigger Layer. With TIMer selected for the specified layer, the event occurs at the beginning of the timer interval, and every time the timer times out. For example, if the Trigger Layer timer is programmed for a 30 second interval, the first pass through the Trigger Layer control source will occur immediately. Subsequent trigger events will then occur every 30 seconds. The interval for the timer is set using the :TIMer command. This timer interval is independent of the :DELay setting.

Example :TRIG:SOUR IMM Source = immediate

:TIMer <n>

:ARM:SEQuence[1]]:LAYer2:TIMer <n> Set interval for Arm Layer 2 timer
:TRIGger:SEQuence[1]]:TIMer <n> Set interval for Trigger Layer timer

Parameters

<n>	= 0.001 to 99999.999	Specify timer interval in seconds
	= DEFault	0.1 second (Trigger Layer counter) 1 second (Arm Layer 2 counter)
	= MINimum	0.001 second
	= MAXimum	99999.999 seconds

Defaults

Power-up	Saved power-on setup
*RST	0.001 second interval
:SYSTem:PRESet	0.001 second interval

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Query

:TIMer?		Query programmed timer interval
:TIMer?	DEFault	Query *RST default timer interval
:TIMer?	MINimum	Query lowest allowable timer interval
:TIMer?	MAXimum	Query largest allowable timer interval

Response 0.001 to 99999.999

Description These commands are used to set the interval for the Arm Layer 2 and Trigger Layer timers. Note that the timer is in effect only if the timer is the selected control source. Also, note that Arm Layer 1 does not use a timer.

Example :TRIG:TIM 0.25 Trigger timer = 0.25s

:SIGNal

:ARM[:SEQuence[1]][:LAYer[1]]:SIGNal	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:SIGNal	Bypass scan control source
:TRIGger[:SEQuence[1]]:SIGNal	Bypass channel control source

Description These action commands are used to bypass the specified control source and are used when you do not wish to wait for the programmed event. Keep in mind that the instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and this command will be ignored.

When this command is sent, the specified control source will be bypassed. This will allow operation to continue. Only the layer's source event between is bypassed; any :DELay time will be observed.

Note that :SIGNal is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the control source.

Example :TRIG:SIGN Bypass channel control source

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TCONfigure commands

:PROTocol <name>

:TRIGger[:SEQuence[1]]:TCONfigure:PROTocol <name> Specify Trigger Link protocol

Parameters <name>= ASYNchronous Asynchronous Trigger Link mode
= SSYNchronous Semi-synchronous Trigger Link mode

Defaults

Power-up	Saved power-on setup
*RST	ASYNchronous
:SYSTem:PRESet	ASYNchronous

Query :PROTocol? Query programmed Trigger Link protocol

Response ASYN or SSYN

Description This command is used to select the protocol for the Trigger Layer Trigger Link. With ASYNchronous selected, separate trigger lines are used for input and output triggers. With SSYNchronous selected, a single trigger line is used for both input and output triggers.

Note that Arm Layer 1 and Arm Layer 2 only use the asynchronous Trigger Link mode and therefore, the protocol does not have to be selected.

Example :TRIG:TCON:PROT SSYN Semi-sync operation

:DIRection <name>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:DIRection <name>
Control arm Source Bypass
ARM[:SEQuence[1]]:LAYer2:TCONfigure:DIRection <name>
Control scan Source Bypass
:TRIGger[:SEQuence[1]]:TCONfigure:DIRection <name>
Control channel Source Bypass

Parameters <name>= SOURce Enable Source Bypass
= ACCeptor Disable Source Bypass

Defaults

Power-up	Saved power-on setup
*RST	ACCeptor (all layers)
:SYSTem:PRESet	ACCeptor (Arm Layer 1 and Arm Layer 2) SOURce (Trigger Layer)

Query :DIRection? Query Source Bypass state

Response SOUR or ACC

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Description When a Source Bypass is enabled and the Trigger Link arm control source is selected, operation will loop around the appropriate control source on the initial pass through that layer. Note that the Source Bypass for Arm Layer 2 and the Trigger Layer also loops around the Delay.

If programmed for another pass through the specified layer (count >1), the bypass loop will not be in effect even though it will still be enabled. The bypass loop will be in effect if operation first goes back into the previous layer (or idle).

Enabling the Source Bypass for Arm Layer 1 and Arm Layer 2 also enables their Output Triggers. When operation leaves Arm Layer 1 or Arm Layer 2, the appropriate output trigger pulse will occur. If the Trigger Link (TLINk) control source is selected, the output trigger will be available on the programmed Trigger Link output line. For all other control source selections, the output trigger pulse will be available at the Trigger Link connector. The Output Trigger in these two layers is disabled when the Source Bypass is disabled.

The Output Trigger in the Trigger Layer is always enabled and occurs after the Device Action.

With ACCeptor selected, the bypass is disabled. Operation will not proceed through the specified layer until the appropriate event occurs.

Example :TRIG:TCON:DIR SOUR Set arm source bypass

:ASYNchronous:ILINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:ILINe <NRf>
Select input trigger line; Arm Layer 1

:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:ILINe <NRf>
Select input trigger line; Arm Layer 2

:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:ILINe <NRf>
Select input trigger line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (all layers)

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Query :ILINe? Query programmed input line #

Response 1 to 6

Description These commands are used to select an input line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output (see :OLINe) cannot share the same line. If you assign the input to a line that is already being used for the output, an error will occur and the command will be ignored.

:ASYNchronous:OLINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:OLINe <NRf>
Select output trig line; Arm Layer 1

:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:OLINe <NRf>
Select output trig line; Arm Layer 2

:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:OLINe <NRf>
Select output trig line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Defaults

Power-up	Saved power-on setup
*RST	2 (all layers)
:SYSTem:PRESet	2 (all layers)

Query :OLINe? Query programmed output line #

Response 1 to 6

Description These commands are used to select an output line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output cannot share the same line. If you assign the output to a line that is already being used for the input, an error will occur and the command will be ignored.

Example :TRIG:TCON:ASYN:OLIN 4 Trig layer output line =4

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:SSYNchronous:LINE <NRf>

:TRIGger[:SEQuence[1]]:TCONfigure:SSYNchronous

Specify semi-synchronous Trigger Link line for the Trigger Layer

Parameters	<NRf>	= 1	Line #1
		= 2	Line #2
		= 3	Line #3
		= 4	Line #4
		= 5	Line #5
		= 6	Line #6
Defaults	Power-up		Saved power-on setup
	*RST		1 (Trigger Layer)
	:SYSTem:PRESet		1 (Trigger Layer)
Query	:LINE?		Query programmed output line #
Response	1 to 6		

Description This command is used to select one of the six trigger lines for the semi-synchronous Trigger Link.

Example :TRIG:TCON:SSYN:LINE 6 Trig layer line = 6

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6
Servicing

Section 6 topics

Introduction

This section of the manual will assist you in servicing the Model 7002-HD.

WARNING **The information in this section is intended for qualified service personnel. Some of these procedures may expose you to hazardous voltages. Do not perform these procedures unless you are qualified to do so.**

Handling and cleaning of backplane boards

Row signal paths for Model 7002-HD series switching cards are extended onto the backplane boards of the mainframe. Thus, a contaminated backplane will degrade card isolation specifications. If an isolation problem is due to a contaminated backplane, then the two backplane boards will need to be removed and cleaned.

Handling backplane boards

Observe the following precautions when handling backplane boards:

- Handle the boards only by the edges.
- When servicing the boards, wear clean cotton gloves.
- Do not touch any board traces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off the boards.

Solder repairs and cleaning

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean foam-tipped swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab the repaired area (or contaminated area) with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, the board should be allowed to dry in a 50°C low-humidity environment for several hours.

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Static-sensitive devices

CMOS devices are designed to operate at high impedance levels for lower 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. Use the precautions below when handling static-sensitive devices:

CAUTION **Many CMOS devices are installed in the Model 7002-HD. Generally, all ICs and transistors should be handled as static-sensitive devices.**

1. Transport such devices only in containers designed to prevent static build-up. Typically, these parts will be received in anti-static containers of plastic or foam. Always leave the devices in question 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 or terminals.
4. Any printed circuit board into which the device is to be inserted must also be properly grounded to the bench or table.
5. Use only anti-static type de-soldering tools.
6. Use only soldering irons with properly grounded tips.

CAUTION **Once the device is installed on the PC board, it is usually adequately protected, and normal handling can resume.**

Basic servicing

In the event the Model 7002-HD malfunctions, such as a non-luminated VFD display, non-responding digital interface (IEEE or Trigger Link), inaudible fan, or non-responding plug-in card, inspect the power supplies. The Model 7002-HD has two internal power supplies, each with a PC board mount fuse. Refer to the following section for information on how to remove, inspect, and replace the fuses.

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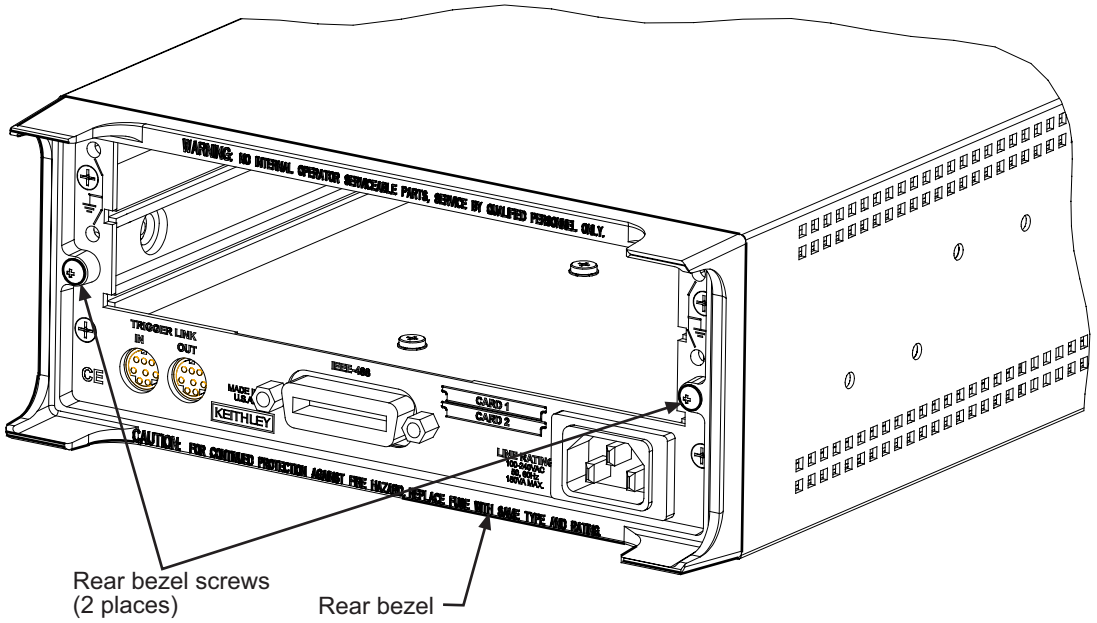
Fuse replacement

WARNING These instructions are for qualified service personnel only. These procedures may expose you to hazardous voltages. Do not perform these procedures unless you are qualified to do so.

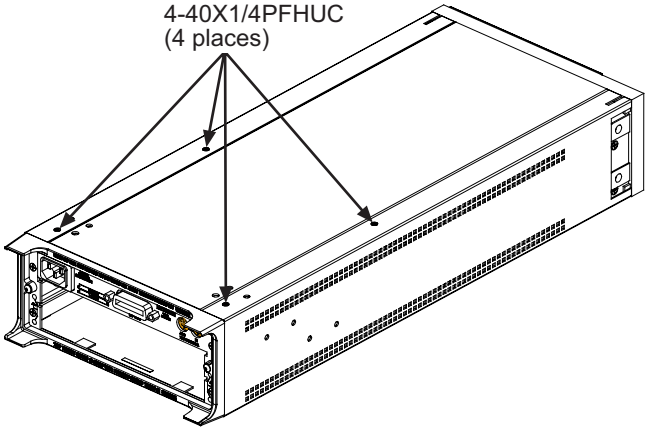
1. Remove and discharge all power from the Model 7002-HD.
2. Remove the rear bezel secured with two screws (Figure 6-1).

Figure 6-1
Rear bezel hardware



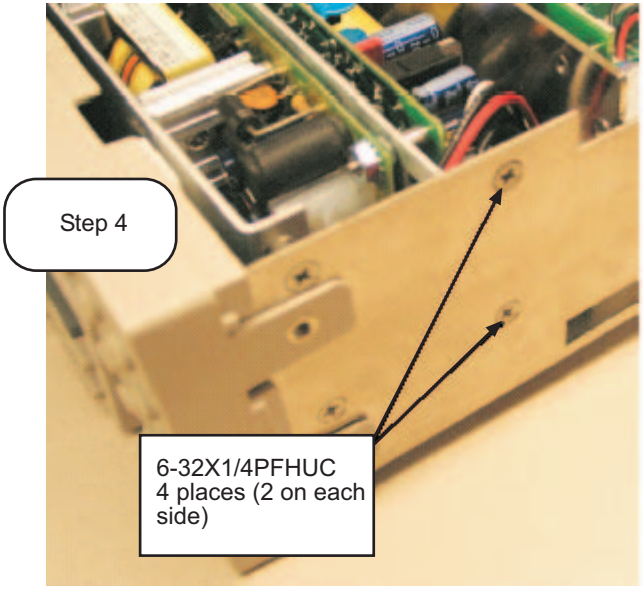
3. Remove chassis cover (4 screws) (Figure 6-2).

Figure 6-2
Chassis cover removal (bottom view)



4. Remove the power supplies mounting screws (4 screws). Shown are the right side screws (2) (Figure 6-3).

Figure 6-3
Power supply mounting hardware



5. Remove power supply assembly (assembly shown in Figure 6-4) secured by 4 screws (2 per side).

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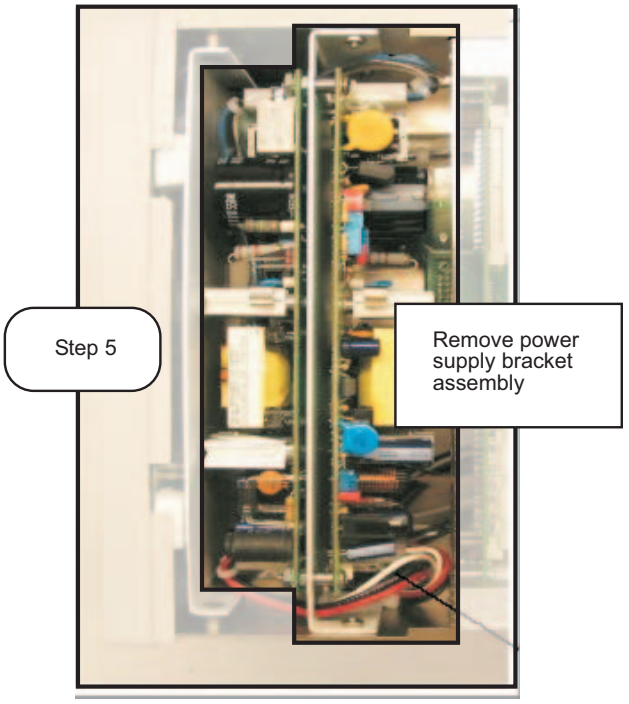
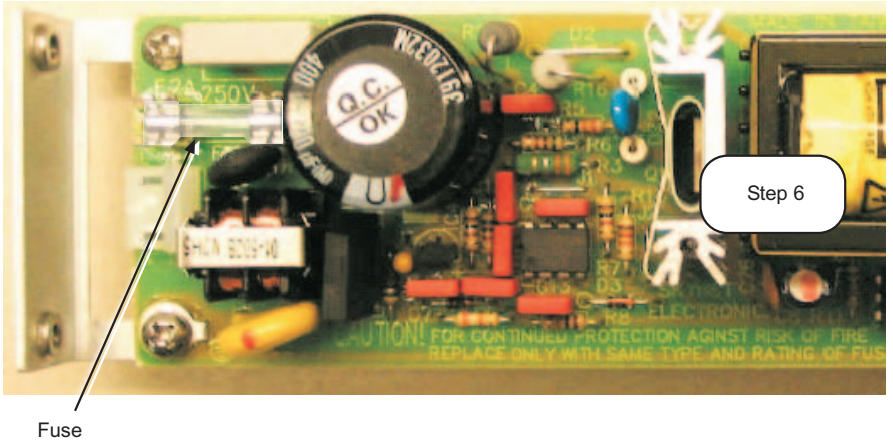
Figure 6-4
Power supply assembly removal



6. Remove fuse (1 per power supply assembly) and verify fuse functionality (Figure 6-5).

Figure 6-5
Fuse location



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7. Replace with equivalent rated fuse, if needed (Table 6-1).
8. Re-assemble 7002-HD in reverse order of steps 1–5.

Table 6-1
Fuse rating and part number

Type	Vendor	Part no.
5x20mm, 2A, 250V, Fast Blow	Littelfuse	235002

Battery replacement

WARNING Disconnect the instrument from the power line and all other equipment before changing the battery.

The volatile memories in the Model 7002-HD are protected by a replaceable battery when power is off. Typical life for the battery is approximately ten years. This battery should be suspected if the instrument no longer retains scan lists or other user-programmed operating parameters. If the battery is absent or totally exhausted, the display will show the message “No Comm Link” shortly after the Model 7002-HD is switched on.

The battery is a 3V wafer-type lithium cell, Keithley part number BA-44, which is located on the digital board. Proper operation of RAM requires that a battery (even one that is discharged) be installed. Do not remove the old battery unless you have a new one to put in its place.

WARNING The precautions below must be followed to avoid possible personal injury.

- **Wear safety glasses or goggles when working with lithium batteries.**
- **Do not short the battery terminals together.**
- **Keep lithium batteries away from all liquids.**
- **Do not attempt to recharge lithium batteries.**
- **Observe proper polarity when inserting the battery into its holder.**
- **Do not incinerate or otherwise expose the battery to excessive heat (>60°C).**
- **Bulk quantities of lithium batteries should be disposed of as a hazardous waste.**

Return to **Section 6 topics**

To replace the battery:

1. Remove the case cover. (See ”Fuse replacement” on page 6-4 for the disassembly procedure.)
2. Remove the lower insulator beneath the card slots (six screws). Once this insulator is removed, the battery is readily accessible on the 7002-102 board. On the board, it is identified with the designator of BT100.
3. Use a small non-metallic tool to lift the battery so it can be slid out from under the retainer spring clip.
4. The new battery should be reinstalled with the “+” terminal facing up. Lift up on the retaining clip, and place the edge of the battery under the clip. Slide the battery fully into the holder.
5. Re-install the insulator and case cover.
6. Recheck previously stored settings and re-enter the configuration as necessary.

Diagnostics

The Model 7002-HD includes a series of on-board diagnostic tests that may be invoked through the front panel and performed without any disassembly of the instrument. These diagnostics will help verify functionality of the Model 7002-HD, and will assist you in isolating problems to the board level.

Preparations for running the diagnostics

Before running the diagnostic tests:

1. Power down the Model 7002-HD.
2. Disconnect the IEEE-488 cable and any trigger cables from the rear panel.
3. Remove any cards that may be plugged into the backplane. (Note that card removal is not necessary for the non-volatile memory test.)

Initial power-up test

Install a line cord and apply power. The Model 7002-HD should sequence through ROM revision levels and IEEE-488 address.

Non-volatile memory test

1. Press CARD CONFIGURATION.
2. Under the CARD CONFIG MENU, select TYPE and press ENTER.
3. Under the SET CARD TYPE menu, select SLOT-#1 and press ENTER.
4. Press the cursor keys until the display shows:
   SLOT1 CARD: 9990

   then press ENTER.

   This programs the setup memory for a generic 40-channel scanner card (9990).
5. Use the EXIT key to back out of the menu structure.
6. Press the SCAN LIST key.
7. Press the CLEAR LIST key.
8. Press “1”, “1”, ENTER. The display should show:
   SCAN CHANNELS 1!1,

   This programs a scan list that should be retained in battery backed up RAM. After programming setups, the Model 7002-HD must retain these assignments when power is switched off or until reprogrammed.
9. Turn off power and wait a few minutes.
10. Turn on power.
11. Repeat Steps 1, 2, and 3 to verify that slot 1 is still set for type 9990. Use EXIT to back out of the menu structure.
12. Press SCAN LIST. Verify:
    SCAN CHANNELS 1!1,

    If the Model 7002-HD does not retain the settings, one of the following problems may exist:

    - Failure to retain the card number 9990 indicates a fault with EEPROM.
    - Failure to retain the SCAN LIST indicates a fault with battery backed up RAM.

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Display tests

Keys

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF-TEST MENU, select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY TESTS, select KEYS and press ENTER. The display will show “No keys pressed”.
5. Press each key (except POWER) in turn and verify that the corresponding key name is displayed.
6. Verify that the display returns to “No keys pressed” when each key is released (i.e., no sticking keys).
7. When you are done with the key test, press EXIT twice to exit.

Patterns

The display PATTERNS test is a visual check of the vacuum fluorescent display (VFD) module.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY TESTS select PATTERNS and press ENTER.
5. There are five test patterns in the test:

Pattern screen 1

A checkerboard pattern of 18 dots appears for all 20 characters in the top row and 32 characters in the bottom row.

Pattern screen 2

The alternate checkerboard pattern of 17 dots appears for all 20 characters in top row and 32 characters in the bottom row. The annunciators disappear and are replaced by the numbers:

1 2345678910

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Pattern screen 3

A horizontal bar moves through the seven rows of the first 5 × 7 character position. One and only one bar must be visible at a time. Movement will continue until any key is pressed.

Pattern screen 4

A vertical bar moves through the five columns of the first 5 × 7 character position. Only one bar must be visible at a time. Movement will continue until any key is pressed.

Pattern screen 5

All 35 dots of each 5 × 7 character block will turn on one character at a time. The upper row blocks include a number and (except for positions 5, 9, 13, and 16) an annunciator. Verify that only one block illuminates fully for each character position.

The first test pattern automatically appears when the display test commences. Press any key except EXIT to move to each successive pattern.

Verify all five patterns, then press EXIT to return to the SELF-TEST MENU.

Char set

This test is used to display the ASCII character set.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU, select the DISPLAY TESTS option.
4. Under DISPLAY TESTS, select CHAR-SET and press ENTER to display the ASCII character set.
5. Press any key (except EXIT) to scroll through the character set.
6. When finished, use the EXIT key to back out of the menu structure.

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A
Specifications

7002-HD High Density Switch System

SYSTEM

EXPANSION: Two plug-in cards per mainframe.

CARD COMPATIBILITY: Compatible with 7002-HD-MTX1 and 7002-HD-MUX1 cards.

MEMORY: Battery backed-up storage for 500 channel patterns.

SWITCH SETTLING TIME: Automatically selected by the mainframe. Additional time from 0 to 99999.999 seconds can be added in 1ms increments.

INPUT TRIGGER SOURCES:
IEEE-488 bus (GET, *TRG).
Trigger Link (external trigger).
Manual (front panel).
Internal Timer, programmable from 1ms to 99999.999 seconds in 1ms increments.

CHANNEL READY OUTPUT: Trigger Link.

SWITCHING SEQUENCE: Break-before-make [On (Default) / Off].

ANALOG BACKPLANE

SIGNALS: 32 single pole paths. These signals provide matrix and multiplexer expansion between cards within one mainframe.

THROUGHPUT

EXECUTION SPEED OF SCANLIST[1]:

	Individual Channels		Channel Patterns		
7002-HD Cards	External Trigger Rate	External Trigger Speed[5]	External Trigger Rate	External Trigger Speed[5]	Re-Trigger Hold-off[2]
MTX1	<128/s	>7.9ms	<100/s	>10.0ms	>0.5ms
MUX1	<128/s	>7.9ms	<100/s	>10.0ms	>0.5ms

General

DISPLAY: Dual-line vacuum fluorescent.
1st line: 20-character alphanumeric.
2nd line: 32-character alphanumeric.

REAR PANNEL CONNECTORS:
IEEE-488.
8-pin micro DIN connector for Trigger Link.
8-pin micro DIN connector for Trigger Link expansion.

Power:
100V to 240Vrms, 50/60Hz.
50VA maximum (mainframe only).
150VA maximum (mainframe with two cards at maximum closed channels).

WARRANTY: 1 year.

EMC: Complies with European Union Directive 89/336/EEC, EN61326-1.

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1.

OPERATING ENVIRONMENT[3]

7002-HD Cards	Maximum Closed Channels[4]	Temperature	Humidity
MTX1	150	0°C to 50°C	50% RH at 35°C
MUX1	150	0°C to 50°C	50% RH at 35°C

STORAGE ENVIRONMENT: -25°C to 65°C.

ALTITUDE: Maximum 2000m above sea level.

RACK MOUNT DIMENSIONS:

Configuration	Height	Width	Depth
7002-HD	89mm (3.5 in.)	213mm (8.375 in.)	537mm (21.125 in.)
Installed MTX1	89mm (3.5 in.)	213mm (8.375 in.)	562mm (22.125 in.)
Installed MUX1	89mm (3.5 in.)	213mm (8.375 in.)	562mm (22.125 in.)

WEIGHT: <5.7 kg (12.6 lb).

ACCESSORIES SUPPLIED:
Front rack-mount kit, rear rack-mount kit, line cord, and instruction manual.

ACCESSORIES AVAILABLE:

Card	Description
7002-HD-MTX1	6x32 Differential Matrix (MTX1)
7002-HD-MUX1	Quad 1x40 Differential Multiplexer (MUX1)

7002-HD Notes
[1] Display off.
[2] Time from the output of a Channel Ready pulse until a new External Trigger will be accepted on the 8-pin micro DIN connector.
[3] For indoor use only.
[4] Refer to card users guide for measurement considerations.
[5] External Trigger speed includes the time to output a Channel Ready pulse and the re-trigger hold-off time.

B
ASCII Character Codes

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
0	00	NUL	
1	01	SOH	GTL
2	02	STX	
3	03	ETX	
4	04	EOT	SDC
5	05	ENQ	PPC
6	06	ACK	
7	07	BEL	
8	08	BS	GET
9	09	HT	TCT
10	0A	LF	
11	0B	VT	
12	0C	FF	
13	0D	CR	
14	0E	SO	
15	0F	SI	
16	10	DLE	
17	11	DC1	LLO
18	12	DC2	
19	13	DC3	
20	14	DC4	DCL
21	15	NAK	PPU
22	16	SYN	
23	17	ETB	
24	18	CAN	SPE
25	19	EM	SPD
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	

* Message sent or received with ATN true.

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	”	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	’	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	’	MLA 12
45	2D	-	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	«	MTA 30
95	5F	-	UNL

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
96	60	«	MSA 0, PPE
97	61	a	MSA 1, PPE
98	62	b	MSA 2, PPE
99	63	c	MSA 3, PPE
100	64	d	MSA 4, PPE
101	65	e	MSA 5, PPE
102	66	f	MSA6, PPE
103	67	g	MSA 7, PPE
104	68	h	MSA 8, PPE
105	69	i	MSA 9, PPE
106	6A	j	MSA 10, PPE
107	6B	k	MSA 11, PPE
108	6C	l	MSA 12, PPE
109	6D	m	MSA 13, PPE
110	6E	n	MSA 14, PPE
111	6F	o	MSA 15, PPE
112	70	p	MSA 16, PPD
113	71	q	MSA 17, PPD
114	72	r	MSA 18, PPD
115	73	s	MSA 19, PPD
116	74	t	MSA 20, PPD
117	75	u	MSA 21, PPD
118	76	v	MSA 22, PPD
119	77	w	MSA 23, PPD
120	78	x	MSA 24, PPD
121	79	y	MSA 25, PPD
122	7A	z	MSA 26, PPD
123	7B	{	MSA 27, PPD
124	7C	|	MSA 28, PPD
125	7D	}	MSA 29, PPD
126	7E	~	MSA 30, PPD
127	7F	DEL	

* Message sent or received with ATN true. Numbers represent secondary address resulting in MSA (My Secondary Address).

C
IEEE-488 Bus Overview

Introduction

Basically, the IEEE-488 bus is simply a communication 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 device 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 since the task of listening takes up bus time.

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.

Bus description

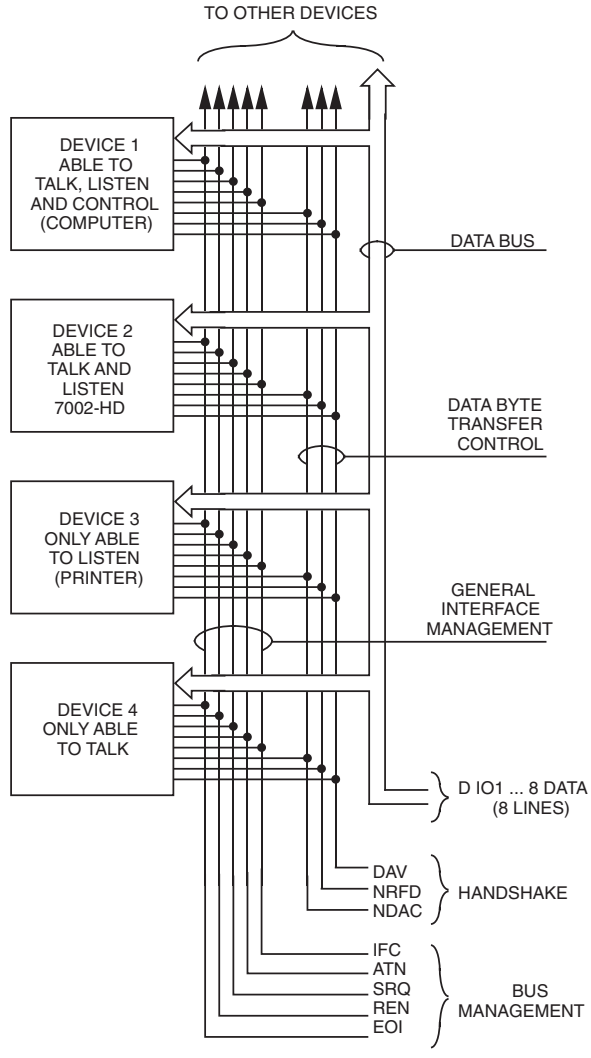
The IEEE-488 bus, which is also frequently referred to as the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both 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 C-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 listener.

Figure C-1
IEEE-488 bus configuration

.



There are two categories of controllers: system controller and basic 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 31, and is generally set 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 27 decimal ($07), the actual listen address is $27 ($27 = $07 + $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 7 decimal would be $47 ($47 = $07 + $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, including the Model 7002-HD, 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.

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 operation of these lines.

Data lines

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

Bus management lines

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

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 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.

Handshake lines

The bus handshake lines 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:

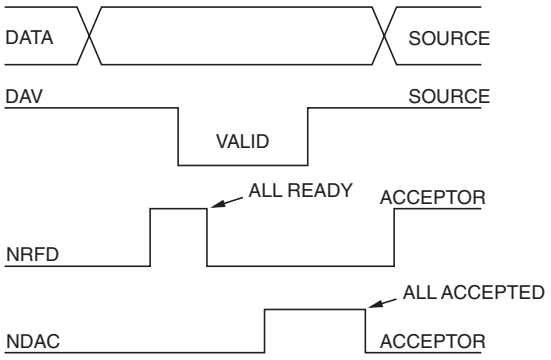
DAV (DATA VALID) — The source controls the state of the DAV line to indicate to any listening devices whether or not data bus information is valid.

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 until the accepting device is ready.

NDAC (Not Data Accepted) — NDAC is also controlled by the accepting device. The state of NDAC tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in Figure C-2. Once data is placed on the data lines, the source checks to see that NRFD is high, indicating that all active devices are ready. 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 be stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

Figure C-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 paragraphs.

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. For example, to assert REN (Remote Enable), the REN line would be set low (true).
2. **Multiline Commands** — General bus commands which are sent over the data lines with the ATN line true (low).
3. **Common Commands** — Commands that are common to all devices on the bus; sent with ATN high (false).
4. **SCPI Commands** — Commands that are particular to each device on the bus; sent with ATN (false).

These bus commands and their general purpose are summarized in Table C-1.

Table C-1
IEEE-488 bus command summary

Command type	Command	State of ATN line	Comments
Uniline	REN (Remote Enable) EOI IFC (Interface Clear) ATN (Attention) SRQ	X X X Low X	Set up devices for remote operation. Marks end of transmission. Clears interface. Defines data bus contents. Controlled by external device.
Multiline Universal	LLO (Local Lockout) DCL (Device Clear) SPE (Serial Enable) SPD (Serial Poll Disable)	Low Low Low Low	Locks our local operation. Returns device to default conditions. Enables serial polling. Disables serial polling.
Addressed	SDC (Selective Device Clear) GTL (Go To Local)	Low Low	Returns unit to default conditions. Returns device to local.
Unaddressed	UNL (Unlisten) UNT (Untalk)	Low Low	Removes all listeners from the bus. Removes any talkers from the bus.
Common	—	High	Programs IEEE-488.2 compatible instruments for common operations.
SCPI	—	High	Programs SCPI compatible instruments for particular operations.

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. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the LOCAL button (if the device is so equipped) may be locked out when REN is true. 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.

Universal multiline commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the commands are 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 the LOCAL key and thus all 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.

Addressed multiline 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. Both the commands and the address preceding it are sent with ATN true.

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.

Address commands

Addressed commands include two primary command groups and a secondary address group. ATN is true when these commands are asserted. The commands include:

LAG (Listen Address Group) — These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with $20.

TAG (Talk Address Group) — The talk commands are derived from the primary address by ORing the address with $40. Talk commands are used to address devices to talk.

SCG (Secondary Command Group) — Commands in this group provide additional addressing capabilities. Many devices (including the Model 7002-HD) do not use these commands.

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.

Common commands

Common commands are commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a common operation, such as reset. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

SCPI commands

SCPI commands are commands that are particular to each device on the bus. These commands are designated by the instrument manufacturer, and are based on the instrument model defined by the Standard Commands for Programmable Instruments (SCPI) Consortium's SCPI standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a particular operation, such as setting a range or closing a relay. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

Command codes

Command codes for the various commands that use the data lines are summarized in Figure C-3. Hexadecimal and the decimal values for the various commands are listed in Table C-2.

Table C-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
SCG	60-7F	96-127
UNL	3F	63
UNT	5F	95

Figure C-3
Command codes

D_7 D_6 D_5 D_4						X 0 0 0	Command	X 0 0 1	Command	X 0 1 0	Primary Address	X 0 1 1	Primary Address	X 0 1 1	Primary Address	X 0 1 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	@	0	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	3	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) — columns 0 (A), 0 (B)
UNIVERSAL COMMAND GROUP (UCG) — columns 1 (A), 1 (B)
LISTEN ADDRESS GROUP (LAG) — columns 2 (A) to 3(B)
TALK ADDRESS GROUP (TAG) — columns 4 (A) to 5 (B)
PRIMARY COMMAND GROUP (PCG) — columns 0 (A) to 5 (B)
SECONDARY COMMAND GROUP (SDC) — columns 6 (A) to 7 (B)

*PPC (PARALLEL POLL CONFIGURE) PPU (PARALLEL POLL UNCONFIGURE), and TCT (TAKE CONTROL) not implemented by Model 7002-HD.
Note: D_0 = DIO1 ... D_7 = DIO8; X = Don’t Care.

Typical command sequences

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. Table C-3 lists a typical bus sequence for sending the addressed multiline commands. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself.

Table C-4 gives a typical common command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the common command string.

Table C-3
Typical addressed command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1 2 3 4	UNL LAG* SDC	Set low Stays low Stays low Returns high	? ’ EOT	3F 27 04	63 39 4

*Assumes primary address = 7.

IEEE command groups

Command groups supported by the Model 7002-HD are listed in Table C-5. Common commands and SCPI commands are not included in this list.

Table C-4
Typical common command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	’	27	39
3	Data	Set high	*	2A	42
4	Data	Stays high	R	52	82
5	Data	Stays high	S	53	83
6	Data	Stays high	T	54	84

Assumes primary address = 7.

Table C-5
IEEE command groups

HANDSHAKE COMMAND GROUP	
	NDAC = NOT DATA ACCEPTED NRFD = NOT READY FOR DATA DAV = DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN = ATTENTION DCL = DEVICE CLEAR IFC = INTERFACE CLEAR 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

Table C-5 (cont.)
IEEE command groups

ADDRESSED COMMAND GROUP	
	ACG = ADDRESSED COMMAND GROUP GTL = GO TO LOCAL SDC = SELECTIVE DEVICE CLEAR
STATUS COMMAND GROUP	
	RQS = REQUEST SERVICE SRQ = SERIAL POLL REQUEST STB = STATUS BYTE EOI = END

D
IEEE-488 Conformance

Information

The IEEE-488.2 standard requires specific information about how the Model 7002-HD implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. Table D-1 provides a summary of the requirements, and provides the information or references the manual for that information.

Table D-1
IEEE-488 documentation requirements

	Requirement	Description or Reference
(1)	IEEE-488 Interface Function Codes.	See Appendix B.
(2)	Behavior of 7002-HD when the address is set outside the range 0-30.	Error message occurs. Previous address is retained.
(3)	Behavior of 7002-HD when valid address is entered.	No error message. Display returns to GPIB SETUP MENU.
(4)	Power-On Setup Conditions.	*RST; see page 5-56.
(5)	Message Exchange Options:	
(a)	Input buffer size.	256 bytes.
(b)	Queries that return more than one response message.	None.
(c)	Queries that generate a response when parsed.	All queries (Common Commands and SCPI).
(d)	Queries that generate a response when read.	None.
(e)	Coupled commands.	:TRIG:COUNT is coupled to :TRIG:COUNT:AUTO. Enabling Auto sets count to the scan list length.
(6)	Functional elements required for SCPI commands.	Contained in SCPI command subsystems tables.

Table D-1 (cont.)
IEEE-488 documentation requirements

	Requirement	Description or Reference
(7)	Buffer size limitations for block data.	Up to 20 characters for block display messages.
(8)	Syntax restrictions.	Contained in Section 5 (SCPI commands).
(9)	Response syntax for every query command.	Contained in Section 5.
(10)	Device-to-device message transfer that does not follow rules of the standard.	None.
(11)	Block data response size.	None.
(12)	Common Commands implemented by 7002-HD.	See Table 5-2 on page 5-47.
(13)	Calibration query information.	Not applicable.
(14)	Trigger macro for *DDT.	Not applicable.
(15)	Macro information.	Not applicable.
(16)	Response to *IDN (identification).	See page 5-52.
(17)	Storage area for *PUD and *PUD?	Not applicable.
(18)	Resource description for *RDT and *RDT?	Not applicable.
(19)	Effects of *RST, *RCL and *SAV.	See Table 5-3 on page 5-58.
(20)	*TST information.	See page 5-62.
(21)	Status register structure.	See ”Status structure” on page 5-6.

Table D-1 (cont.)
IEEE-488 documentation requirements

	Requirement	Description or Reference
(22)	Sequential or overlapped commands.	All are sequential except :INIT, :INIT:CONT ON, and *TRG which are overlapped.
(23)	Operation complete messages.	See page 5-53.

E
SCPI Conformance

Introduction

The Model 7002-HD complies with SCPI version 1996.0. Table E-1 lists the SCPI confirmed commands and Table E-2 lists the non-SCPI commands.

Table E-1
Syntax of SCPI confirmed commands implemented by Model 7002-HD

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).
[:ROUTe]	
:CLOSe <list>	Close specified channels.
:STATe?	Query list of closed channels.
:CLOSe? <list>	Query state of specified channels (1 = closed, 0 = open).
:OPEN <list>|ALL	Open specified (or all) channels.
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).
:SCAN <list>	Define scan list.
:POINts?	Query number of channels in scan list.

Table E-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 7002-HD

Command	Description
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:OPERation	
:ARM	
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.

Table E-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 7002-HD

Command	Description
:STATus	
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Query the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query the negative transition register.
:CONDition?	Query the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Query most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Query enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Query disabled messages.
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:VERSion?	Query revision level of SCPI standard.
:ERRor?	Query Error Queue.

Table E-1 (cont.)
Syntax of SCPI confirmed commands implemented by Model 7002-HD

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Immediatey go to Layer2.
:COUNt <n>	Program arm count (1 to 9999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:LAYer2	Path to program arm layer 2:
:IMMediate	Immediately go to Trigger Layer.
:COUNt <n>	Program scan count (1 to 9999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Query timer.
:SIGNal	Loop around control source.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Immediately perform a scan step.
:COUNt <n>	Program measure count (1 to 9999, or INF).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).
:AUTO?	Query auto-count.
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.

Table E-2
Syntax of non-SCPI commands implemented by Model 7002-HD

Command	Description
:DISPlay	
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:SCAN?	Query scan list.
:FCHannels <list>	Specify channels that cannot be closed.
:FCHannels?	Query channels that cannot be closed.
:INTerlockX	Specify interlock (X = [1] to 5).
:LIST[1]	Define List 1 for specified interlock.
:LIST[1]?	Query List 1 for specified interlock.
:LIST2	Define List 2 for specified interlock.
:LIST2?	Query List 2 for specified interlock.
:CONFigure	Configuration command path:
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel <b>	Enable (1 or ON) or Disable (0 or OFF) Single Channel.
:SCHannel?	Query Single Channel.
:SLOTX	Path to configure SLOT X (X = [1] to 10):
:STIMe <n>	Specify delay (0 to 99999.999 seconds) for specified slot.
:STIMe?	Query delay for specified slot.
:MEMory	Path to program memory:
:SAVE	Path to save channel patterns:
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).
:RECall M<num>	Recall channel pattern from memory (1 to 500).
:SENSe[1]	
:TTL1	Command path to read internal input line.
:DATA?	Read internal digital input line.
:SENSeX	Specify slot; X=2 (slot 1) through 11 (slot 10).
:DATA?	Read digital input for the specified slot.
:SYSTem	
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.

Table E-2 (cont.)
Syntax of non-SCPI commands implemented by Model 7002-HD

Command	Description
:ARM[:SEQuence[1]] [:LAYer[1]] :SOURce TLINK :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :SOURce TLINK :LAYer2 :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe?	Subsystem command path to configure arm layers: Path to program arm layer 1: Select control source. Path to configure Triggers: Enable (SOURce) or disable (ACCeptor) Bypass: Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line. Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk. Path to program arm layer 2: Path to configure Triggers: Enable (SOURce) or disable (ACCeptor) Bypass. Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line.
:TRIGger[:SEQuence[1]] :SOURce TLINK :TCONfigure :PROTocol <name> :PROTocol? :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :SSYNchronous :LINE <NRf> :LINE?	Path to program trigger layer: Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk. Path to configure Triggers: Select protocol: ASYNchronous, SSYNchronous. Query protocol. Enable (SOURce) or disable (ACCeptor) Bypass. Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line. Path to configure semi-synchronous Trigger Link: Select trigger line (1 to 6). Query trigger line.

F
Common Commands

Table F-1
Common commands

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event status enable command	Sets the contents of the Standard Event Status Enable Register.
*ESE?	Event status enable query	Request the programmed value of the Standard Event Status Enable Register.
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII “1” into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Request the assigned model number for all slots.
*RCL <NRf>	Recall command	Returns the Model 7002-HD to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the Model 7002-HD to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.

Note: At least one space is required between the command and the parameter.

Table F-1 (cont.)
Common commands

Mnemonic	Name	Description
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.
*SRE?	Service request enable query	The Model 7002-HD returns the value of the Service Request Enable Register.
*STB?	Read status byte query	Returns the value of the Status Byte Register.
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.
*TST?	Self-test query	When this query is sent, the Model 7002-HD will perform a checksum test on ROM and return the results.
*WAI	Wait-to-continue command	Wait until all previous commands are executed.

Note: At least one space is required between the command and the parameter.

G
SCPI Command Subsystems

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

Table G-1
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).

Table G-2
ROUTe command summary

Command	Description
[:ROUTe]	
:CLOSe <list>	Close specified channels.
:STATe?	Query list of closed channels.
:CLOSe? <list>	Query state of specified channels (1 = closed, 0 = open).
:OPEN <list>|ALL	Open specified (or all) channels.
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).
:SCAN <list>	Define scan list.
:POINts?	Query number of channels in scan list.
:SCAN?	Query scan list.
:FCHannels <list>	Specify channels that cannot be closed.
:FCHannels?	Query channels that cannot be closed.
:INTerlockX	Specify interlock (X = [1] to 5).
:LIST[1]	Define List 1 for specified interlock.
:LIST[1]?	Query List 1 for specified interlock.
:LIST2	Define List 2 for specified interlock.
:LIST2?	Query List 2 for specified interlock.
:CONFigure	Configuration command path:
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel <b>	ENable (1 or ON) or Disable (0 or OFF) Single Channel.
:SCHannel?	Query Single Channel.
:SLOTX	Path to configure SLOT X (X = [1] to 10):
:STIMe <n>	Specify delay (0 to 99999.999 seconds) for specified slot.
:STIMe?	Query delay for specified slot.
:MEMory	Path to program memory:
:SAVE	Path to save channel patterns:
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).
:RECall M<num>	Recall channel pattern from memory (1 to 500).

Table G-3
SENSe command summary

Command	Description
:SENSeX :DATA? <list>	Specify slot; X=2 (slot 1) through 11 (slot 10). Read specified input channels for the specified slot.

Table G-4
STATus command summary

Command	Description
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.

Table G-4 (cont.)
STATus command summary

Command	Description
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Query the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query the enable register.
:STATus	
:QUEStionable	
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query the negative transition register.
:CONDition?	Query the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Query most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Query enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Query disabled messages.

Table G-5
SYSTem command summary

Command	Description
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.
:POSetup?	Query power-on setup.
:VERSion?	Query revision level of SCPI standard.
:ERRor?	Query Error Queue.

Table G-6
Trigger command summary

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Immediatey go to Layer2.
:COUNt <n>	Program arm count (1 to 9999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass:
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.

Table G-6 (cont.)
Trigger command summary

Command	Description
:ARM[:SEQuence[1]]	
:LAYer2	Path to program arm layer 2:
:IMMediate	Immediately go to Trigger Layer.
:COUNt <n>	Program scan count (1 to 9999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Query timer.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Immediately perform a scan step.
:COUNt <n>	Program measure count (1 to 9999, or INF).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).
:AUTO?	Query auto-count.
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 99999.999 seconds).
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 seconds).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.

Table G-6 (cont.)
Trigger command summary

Command	Description
:TRIGger[:SEQuence[1]]	
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.

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Service Form

Model No. _____ **Serial No.** _____ **Date**_____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent ❑ Analog output follows display ❑ Particular range or function bad; specify

_____

❑ IEEE failure ❑ Obvious problem on power-up ❑ Batteries and fuses are OK

❑ Front panel operational ❑ All ranges or functions are bad ❑ Checked all cables

Display or output (check one)

❑ Drifts ❑ Unable to zero ❑ Unstable

❑ Overload ❑ Will not read applied input

❑ Calibration only ❑ Certificate of calibration required ❑ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

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