

Model 7002-HD High Density Switch System

User's Manual

7002HD-900-01 Rev. A / November 2004

KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

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Model 7002-HD High Density Switch System User's Manual

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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-900-01)November 2004

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.

Table of Contents

1	General Information	
	Introduction	1-2
	Features	1-2
	Warranty information	1-2
	Manual addenda	1-2
	Safety symbols and terms	1-3
	Specifications	1-3
	Unpacking and inspection	1-3
	Inspection for damage	1-3
	Shipment contents	1-3
	Manuals	1-4
	Repacking for shipment	1-4
	Optional accessories	1-4
2	Installation	
	Introduction	2-2
	Card installation and removal	2-2
	Card installation	2-3
	Card removal	2-3
3	Getting Started	
	Introduction	3-2
	Front and rear panel configurations	3-2
	Front panel	3-2
	Rear panel	3-2
	Channel assignments	3-5
	Card 1	3-5
	Card 2	3-5
	Front panel operation summary	3-6
	Create channel list and/or scan list	3-6
	Close and Open channels	3-7
	Scan channels	3-7
	IEEE-488 operation summary	3-9
	Bus connections	3-9
	Primary address	3-9
	Abbreviated SCPI command summary	3-9
	Programming examples	3-11

4 Front Panel Operation

Introduction	4-2
Power-up procedure	4-2
Line power connections	4-2
Power switch	4-2
Power-up sequence	4-2
Front panel display	4-3
Vacuum fluorescent display (VFD)	4-3
Display messages	4-4
Annunciators	4-4
Analog backplane	4-5
Backplane connections	4-5
Typical backplane	4-5
Channel assignments	4-6
Slot designations	4-6
Channel numbers	4-6
Channel list and scan list	4-6
Entering lists	4-7
Closing and opening channels	4-9
Scanning channels	4-10
Scan process (Trigger Model)	4-10
Scan procedure	4-13
Scanning examples	4-16
Channel patterns (STORE and RECALL)	4-18
Storing channel patterns	4-18
Recalling channel patterns	4-19
Menus	4-20
Using menus	4-20
Main MENU	4-21
Card configuration menu	4-22
Scan configuration menu	4-23
Trigger Link	4-26
Trigger Link connections	4-26
Trigger Link operation	4-27

5 IEEE-488 Operation

Introduction	5-2
Remote operations	5-2
IEEE-488 bus connections	5-2
Primary address selection	5-4
Front panel IEEE-488 operation	5-5
Error and status messages	5-5
IEEE-488 status indicators	5-5
LOCAL key	5-6

Trigger model	5-6
Idle and initiate	5-8
Arm layer1	5-8
Arm layer2	5-8
Trigger layer	5-8
Common commands	5-9
SCPI commands	5-11
DISPlay subsystem	5-11
ROUte subsystem	5-12
Sense subsystems	5-13
STATus subsystem	5-14
SYSTem subsystem	5-16
Trigger subsystem	5-16

A Specifications

Specifications	A-2
----------------------	-----

B Status and Error Messages

List of Illustrations

2	Installation	
Figure 2-1	Card installation in Model 7002-HD mainframe	2-4
3	Getting Started	
Figure 3-1	Model 7002-HD front panel	3-3
Figure 3-2	Model 7002-HD rear panel	3-4
4	Front Panel Operation	
Figure 4-1	Model 7002-HD vacuum fluorescent display	4-3
Figure 4-2	Analog backplane (typical)	4-5
Figure 4-3	Trigger model (front panel scan process)	4-11
Figure 4-4	Trigger Link connectors	4-26
Figure 4-5	Trigger Link output pulse specifications	4-27
Figure 4-6	Trigger Link input pulse specifications	4-27
Figure 4-7	Semi-synchronous trigger link pulse specifications	4-29
Figure 4-8	Typical semi-synchronous mode connections	4-29
5	IEEE-488 Operation	
Figure 5-1	IEEE-488 connector	5-2
Figure 5-2	IEEE-488 connections	5-3
Figure 5-3	IEEE-488 connector location	5-4
Figure 5-4	Trigger Model (IEEE-488 bus operation)	5-7

List of Tables

3 Getting Started

Table 3-1	Abbreviated SCPI command summary	3-10
-----------	--	------

4 Front Panel Operation

Table 4-1	Main MENU structure	4-21
Table 4-2	Default conditions	4-22
Table 4-3	CARD CONFIG MENU structure	4-23
Table 4-4	TYPE assignments	4-23
Table 4-5	Scan configuration menu	4-24

5 IEEE-488 Operation

Table 5-1	IEEE-488.2 common commands and queries	5-9
Table 5-2	DISPlay command summary	5-11
Table 5-3	ROUTE command summary	5-12
Table 5-4	SENSe command summary	5-13
Table 5-5	STATus command summary	5-14
Table 5-6	SYSTem command summary	5-16
Table 5-7	Trigger command summary	5-17

B Status and Error Messages

Table B-1	Status and error messages	B-2
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1

General Information

Section 1 topics

- Introduction**, page 1-2
 - Features, page 1-2
 - Warranty information, page 1-2
 - Manual addenda, page 1-2
 - Safety symbols and terms, page 1-3
 - Specifications, page 1-3
- Unpacking and inspection**, page 1-3
 - Inspection for damage, page 1-3
 - Shipment contents, page 1-3
 - Manuals, page 1-4
 - Repacking for shipment, page 1-4
- Optional accessories**, page 1-4

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.

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 manual.

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
- Hard copy of the 7002-HD User's Manual
- PDF copies of the Model 7002-HD User's and Reference Manuals on CD-ROM
- Additional accessories as ordered

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.

Optional accessories

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

- **Model 7002-HD-MTX1 6 × 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 × 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.

2 Installation

Section 2 topics

[Card installation and removal](#), page 2-2

[Card installation](#), page 2-3

[Card removal](#), page 2-3

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.

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 card manual) 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.

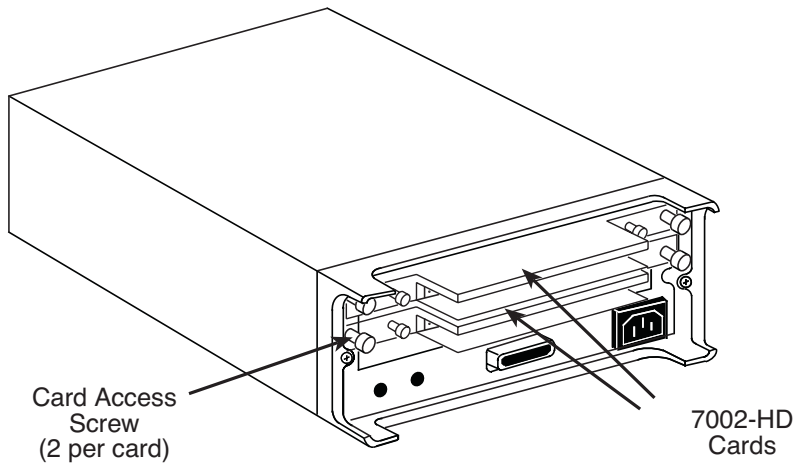
Card removal

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



3 Getting Started

Section 3 topics

Front and rear panel configurations, page 3-2

Front panel, page 3-2

Rear panel, page 3-2

Channel assignments, page 3-5

Card 1, page 3-5

Card 2, page 3-5

Front panel operation summary, page 3-6

Create channel list and/or scan list, page 3-6

Close and Open channels, page 3-7

Scan channels, page 3-7

IEEE-488 operation summary, page 3-9

Bus connections, page 3-9

Primary address, page 3-9

Abbreviated SCPI command summary, page 3-9

Programming examples, page 3-11

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

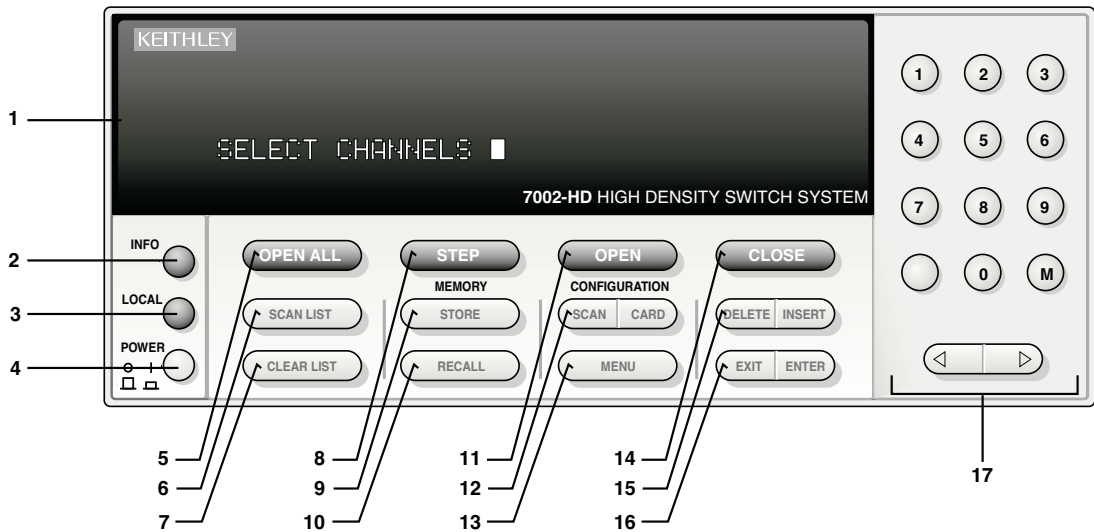
Front panel

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 $\triangleleft / \triangleright$ (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.

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

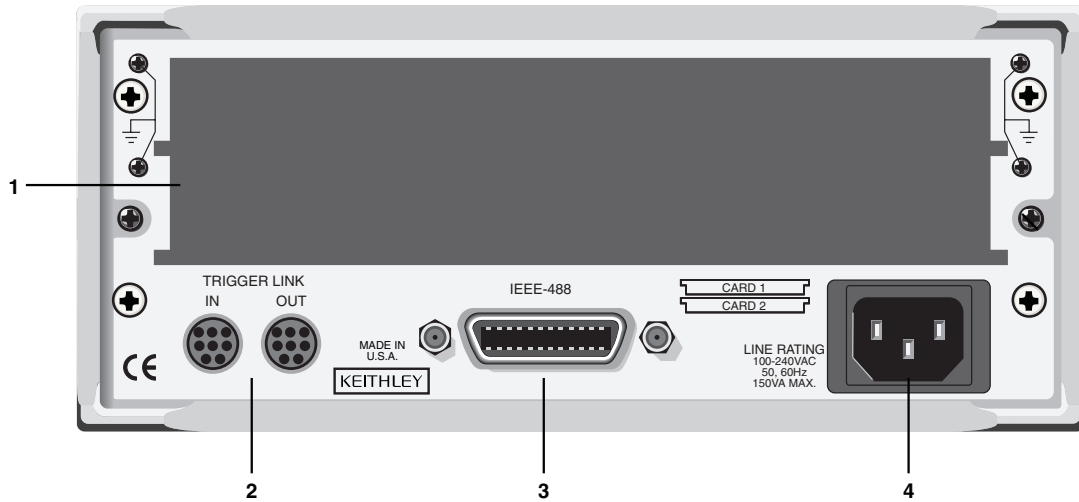
14 CLOSE
Closes specified (displayed) channels in Channel List.

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.

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.

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 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.

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 non-matrix channel (slot, channel).
2. Press ENTER or right cursor key to separate entries or terminate the list.
3. Use the hyphen (- key) between channels to specify a range of channels (i.e., !11-!110 = channels 1 through 10).

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 OPEN 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.

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.

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.

IEEE-488 operation summary

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

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.

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 SCPI command summary

Most instrument operations are controlled using SCPI commands. [Table 3-1](#) 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.

Table 3-1
Abbreviated SCPI command summary

Command	Description
:SYSTem :PRESet	Subsystem command path. Set scan to a default configuration.
[[:ROUte] :CLOSe <list> :STATe? :OPEN <list> ALL :SCAN <list> :POINts?	Subsystem command path. Path and command to close specified channels: Request channels that are closed. Open specified (or all) channels. Path and command to specify channel list: 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 	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.

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
:CLOS (@ 1!1, 1!3:1!6)
:OPEN (@ 1!1, 1!3:1!6)
```

- ‘ Opens any channels that are closed.
- ‘ Close channels 1, 3, 4, 5, and 6 of slot 1.
- ‘ 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
:SCAN (@1!1:1!10)
:INIT
```

- ‘ Return 7002-HD to :SYSTEM:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
- ‘ Define scan list.
- ‘ 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 that the channel scan will be controlled by bus triggers (*TRG or GET):

```
:SYST:PRES
:SCAN (@1!1:1!10)
:TRIG:SOUR BUS
:INIT
```

- ‘ Return 7002-HD to :SYST.:PRES defaults.
- ‘ Define scan list.
- ‘ Program for bus triggers.
- ‘ 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.

Timer controlled channel scan

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

```
:SYST:PRES  
:SCAN (@1!1:1!10)  
:TRIG:SOUR TIM  
:TRIG:TIM 0.5  
:INIT
```

- ' Return 7002-HD to :SYST:PRES default.
- ' Define scan list.
- ' Program channel control source for timer.
- ' Set timer for 0.5 second interval.
- ' 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.

Front Panel Operation

Section 4 topics

Power-up procedure, page 4-2

Line power connections, page 4-2

Power switch, page 4-2

Power-up sequence, page 4-2

Front panel display, page 4-3

Vacuum fluorescent display (VFD), page 4-3

Display messages, page 4-4

Annunciators, page 4-4

Analog backplane, page 4-5

Backplane connections, page 4-5

Typical backplane, page 4-5

Channel assignments, page 4-6

Slot designations, page 4-6

Channel numbers, page 4-6

Channel list and scan list, page 4-6

Entering lists, page 4-7

Closing and opening channels, page 4-9

Channel list and scan list, page 4-6

Entering lists, page 4-7

Closing and opening channels, page 4-9

Scanning channels, page 4-10

Scan process (Trigger Model), page 4-10

Scan procedure, page 4-13

Scanning examples, page 4-16

Channel patterns (STORE and RECALL), page 4-10

Storing channel patterns, page 4-18

Recalling channel patterns, page 4-19

Menus, page 4-20

Using menus, page 4-20

Main MENU, page 4-21

Card configuration menu, page 4-22

Scan configuration menu, page 4-23

Trigger Link, page 4-26

Trigger Link connections, page 4-26

Trigger Link operation, page 4-27

NOTE This section contains basic information on front panel operation. For complete details, see Section 4 of the Model 7002-HD Reference Manual.

Introduction

This section contains basic 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

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

- 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.

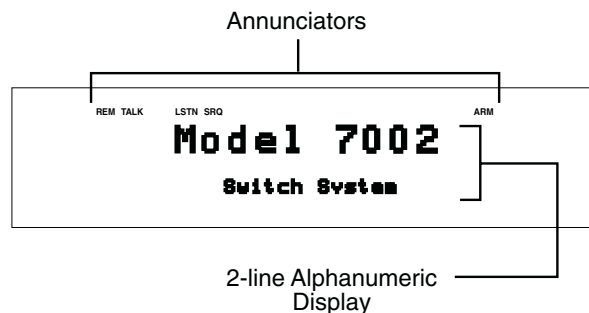
7 is the current IEEE-488 Address. Note that the instrument is shipped from the factory with the address set to 7.

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 B-1 on page B-2](#).

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 of the Model 7002-HD Reference Manual).

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.

Analog backplane

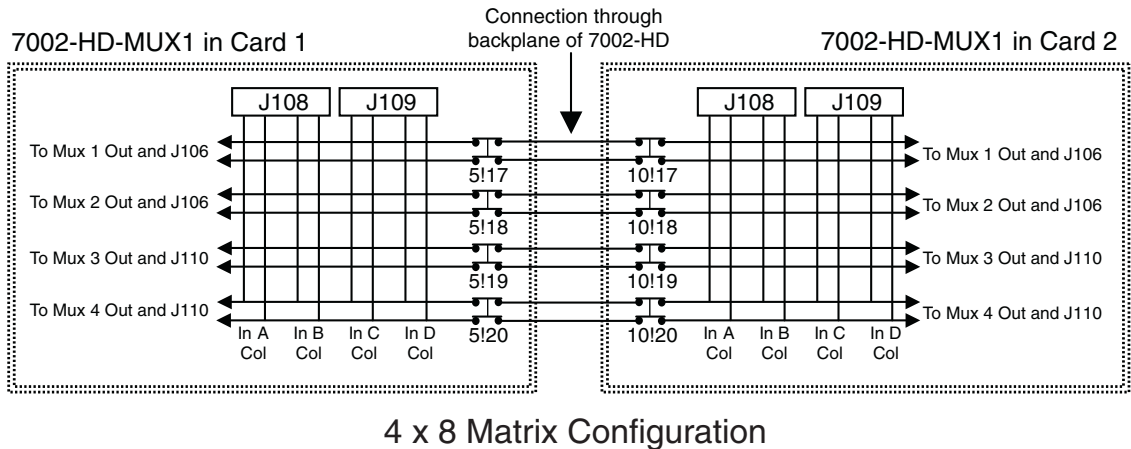
Backplane connections

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

Figure 4-2 shows a simplified drawing of the analog backplane. In general, a card is connected to the backplane by closing specific relays, but the exact nature of backplane connections will depend on the particular card. See the card manual for details.

Figure 4-2
Analog backplane (typical)



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 4-9](#) and ["Scan procedure" on page 4-13](#).

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.

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.

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.

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.
2. Key in the new channel entry, and press the right cursor key or ENTER to add the comma.
3. **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.
4. **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.
5. **Deleting all channels** — The entire list can be cleared by pressing CLEAR LIST.

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 the 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:

1. Press the CLOSE key to close the listed channels.
2. 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.

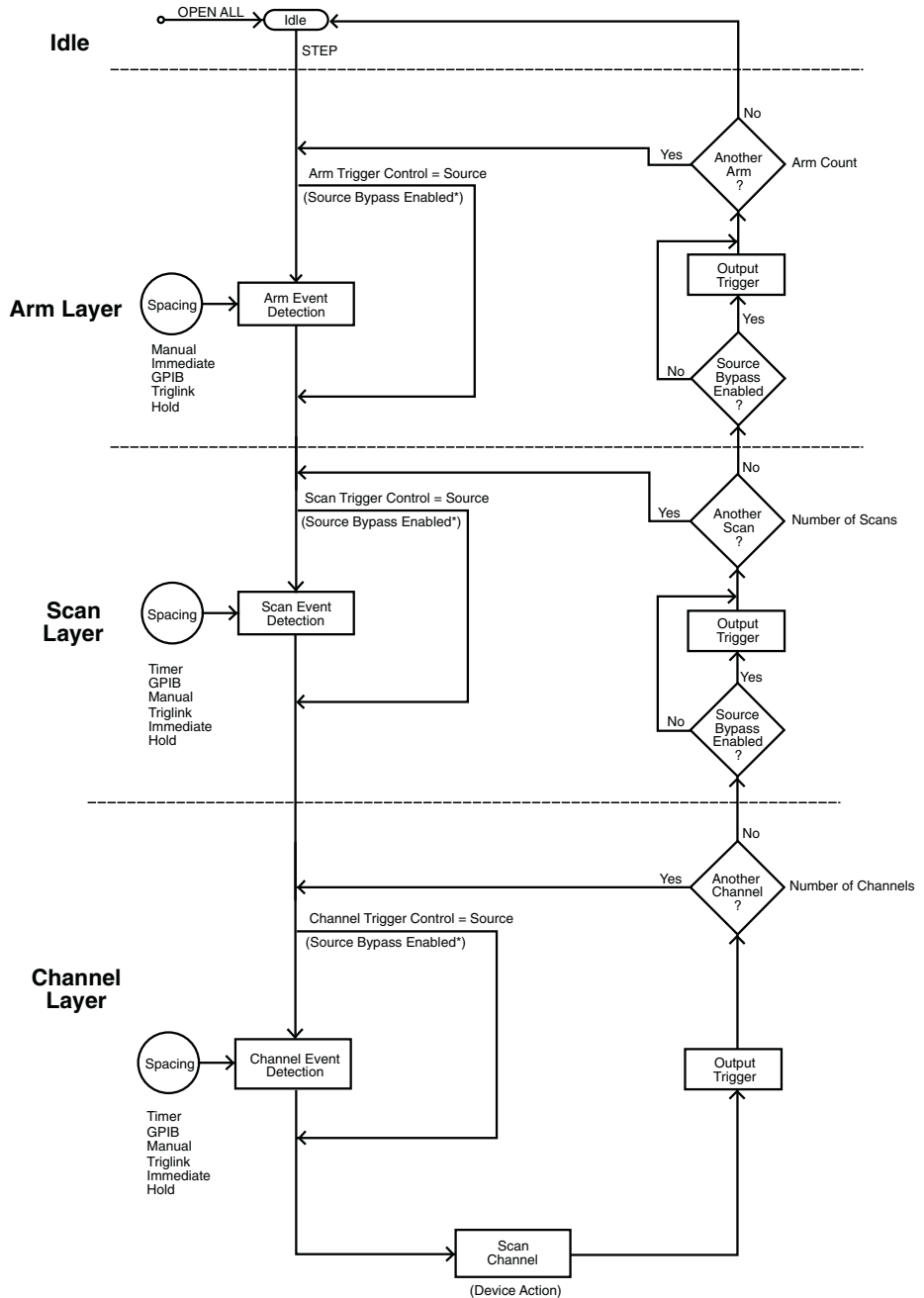
Scanning channels

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.

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



* Take bypass path the first time a layer is entered

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.

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.

Scan procedure

Perform the following steps to scan channels:

Step 1. Press OPEN ALL.

Before configuring a scan, 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).

Channels will be scanned in the order they are presented in the scan list. Channel pattern M1 will be treated as a single channel entry. 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.

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 above 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.

Return to [Section 4 topics](#)

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).
 - 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.

NOTE The menus also include an EXTERNAL trigger selection, but the Model 7002-HD has no BNC connectors to support this function, so it should not be used.

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.

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.

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.

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.

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.

Storing channel patterns

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

1. Decide on the 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.
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

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.

Using 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!4, M10,
```

When CLOSE is pressed with the above 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.

Menus

Using menus

Various instrument operations to configure the Model 7002-HD are performed using these menus:

- Press the MENU key to access the main menu.
- Press the CARD CONFIGURATION key to configure cards.
- Press the SCAN CONFIGURATION key to configure scanning.

General rules for using menus:

1. Press the appropriate key to access the desired menu.
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 menu is displayed, pressing EXIT will disable the 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.

Main MENU

The main menu can be accessed by pressing the MENU key. [Table 4-1](#) summarizes these menu selections.

Table 4-1

Main MENU structure

Menu item	Description
SAVESETUP SAVE RESTORE PWRON FACTORY DEFAULT USER SETUP RESET	Setup Menu: Save setup at a memory location (up to 10). Return 7002-HD to setup stored at a memory location. Power-on Menu: Power-on to factory default setup conditions (Table 4-2). Power-on to setup stored at a memory location. Return 7002-HD to original power-on setup.
GPIB ADDRESS STATUS	GPIB Setup Menu: Check/change IEEE-488 address. Display IEEE-488 status byte.
TEST BUILT-IN TESTS AUTO MANUAL DISPLAY TESTS KEYS PATTERNS CHAR SET	Self-Test Menu: Test Digital Board: Run all tests automatically. Select tests to run. Test Display Board: Verify operation of front panel keys. Verify operation of VFD display. Display ASCII character set.
LANGUAGE ENGLISH GERMAN FRENCH	Choose 7002-HD Language: Display messages in English. Display messages in German. Display messages in French.
GENERAL SERIAL # STATUS-MESSAGES DISPLAY BREAK BEFORE MAKE	General Menu: Displays serial number, SCPI version, and software revision. Enables/disables status message mode. Not a valid option for 7002-HD. Enables/disables Break-Before-Make.

Table 4-2
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.

Card configuration menu

Cards can be configured by pressing the CARD CONFIGURATION key. The menu structure is shown and summarized in [Table 4-3](#). [Table 4-4](#) summarizes card types.

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

Table 4-3
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.

Table 4-4
TYPE assignments

Assignment message	Interpretation*
SLOT CARD:7002-HD**	7002-HD series card installed in specified slot. Card 1 slots = 1-5; Card 2 slots = 6-10. For example, 7002-HD-MTX1 will read as "MTX1" card type.
SLOT CARD:NONE	No card installed in slot, or specified slot is not assigned.

* Assumes that power is cycled whenever a card is installed or removed from the mainframe.

** Model 7002-HD series card.

Scan configuration menu

Various operations to configure a scan are performed from the CONFIGURE SCAN menu. The menu structure is shown and summarized in [Table 4-5](#).

Table 4-5
Scan configuration menu

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.

Table 4-5 (cont.)

Scan configuration menu

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.

Trigger Link

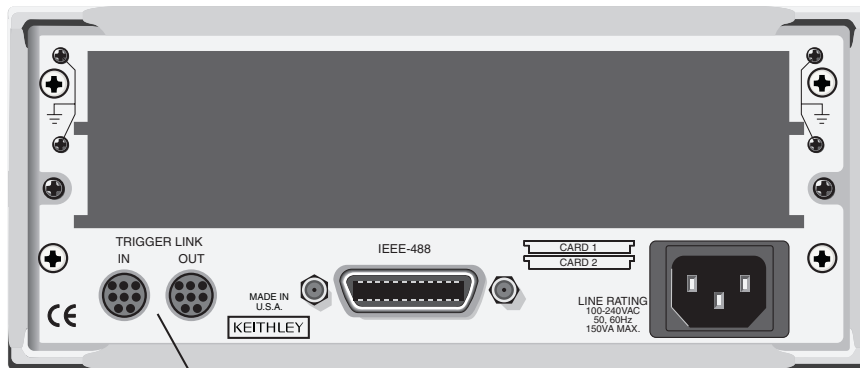
The Model 7002-HD has enhanced external triggering capabilities using the Trigger Link. The Trigger Link has six lines allowing up to six instruments to be controlled over this trigger bus.

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 signals 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](#).

Figure 4-4
Trigger Link connectors



Trigger Link Connectors

Figure 4-5
Trigger Link output pulse specifications

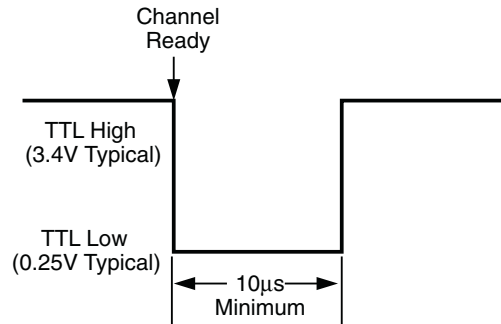
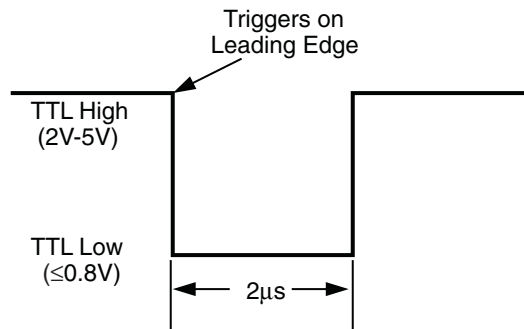


Figure 4-6
Trigger Link input pulse specifications



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 procedure" on page 4-13](#) explains how to program the three layers of the scan.

Asynchronous operation

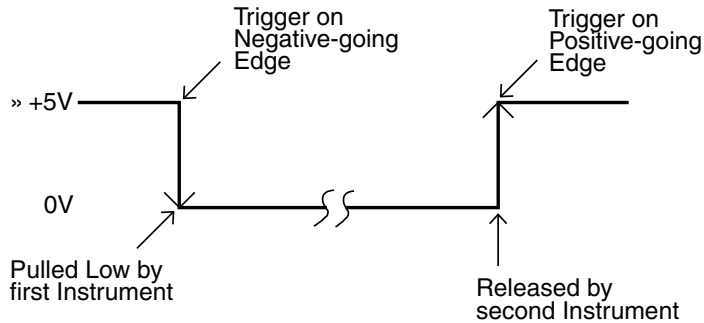
The asynchronous mode uses separate lines for input and output triggers. For typical asynchronous Trigger Link operation, the channel layer of the scan is configured with Channel Spacing set to TRIGLINK and Triggerlink Mode set to Asynchronous. You must also select input and output lines for the channel 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 procedure" on page 4-13](#)).

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.

Semi-synchronous operation

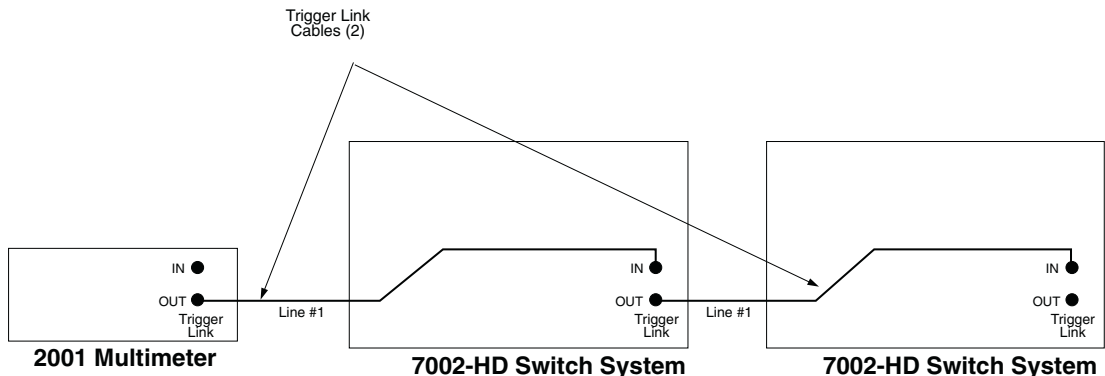
In the semi-synchronous Trigger Link mode, all triggering (input and output) in the test system is controlled by a single line. When the normally high (+5V) trigger line is pulled low (0V), a trigger occurs on the negative-going edge. When the trigger line is released, a trigger occurs on the positive-going edge (see [Figure 4-7](#)). 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 4-7
Semi-synchronous trigger link pulse specifications



For example, assume that a Model 2001 Multimeter is connected to two Model 7002-HD units for semi-synchronous operation as shown in Figure 4-8. All three instruments are programmed to use trigger line #1. The two Model 7002-HD mainframes have relay settling times of 10 milliseconds and 50 milliseconds, respectively.

Figure 4-8
Typical semi-synchronous mode connections



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-HD switch systems to close a channel. While the Model 7002-HD units 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.

5

IEEE-488 Operation

Section 5 topics

Remote operations, page 5-2

[IEEE-488 bus connections](#), page 5-2

[Primary address selection](#), page 5-4

Front panel IEEE-488 operation, page 5-5

[Error and status messages](#), page 5-5

[IEEE-488 status indicators](#), page 5-5

[LOCAL key](#), page 5-6

Trigger model, page 5-6

[Idle and initiate](#), page 5-8

[Arm layer1](#), page 5-8

[Arm layer2](#), page 5-8

[Trigger layer](#), page 5-8

Common commands, page 5-9

SCPI commands, page 5-11

[DISPlay subsystem](#), page 5-11

[ROUte subsystem](#), page 5-12

[Sense subsystems](#), page 5-13

[STATus subsystem](#), page 5-14

[SYSTem subsystem](#), page 5-16

[Trigger subsystem](#), page 5-16

NOTE This section contains only basic information on IEEE-488 operation. For complete details, see Section 5 of the Model 7002-HD Reference Manual.

Introduction

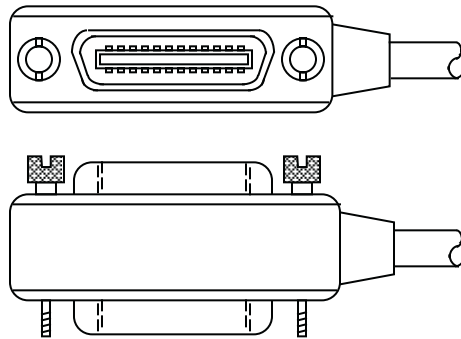
This section contains basic information on using the Model 7002-HD over the IEEE-488 bus.

Remote operations

IEEE-488 bus connections

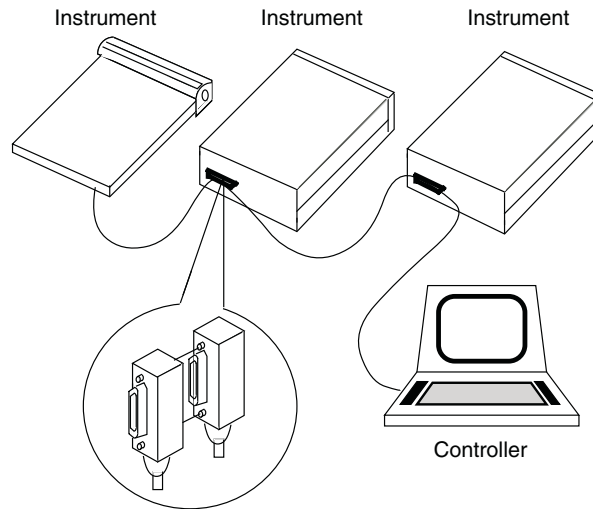
The Model 7002-HD can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example is shown in [Figure 5-1](#). The connector can be stacked to allow a number of parallel connections to one instrument. Two screws are located on each connector to ensure that 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.

Figure 5-2
IEEE-488 connections

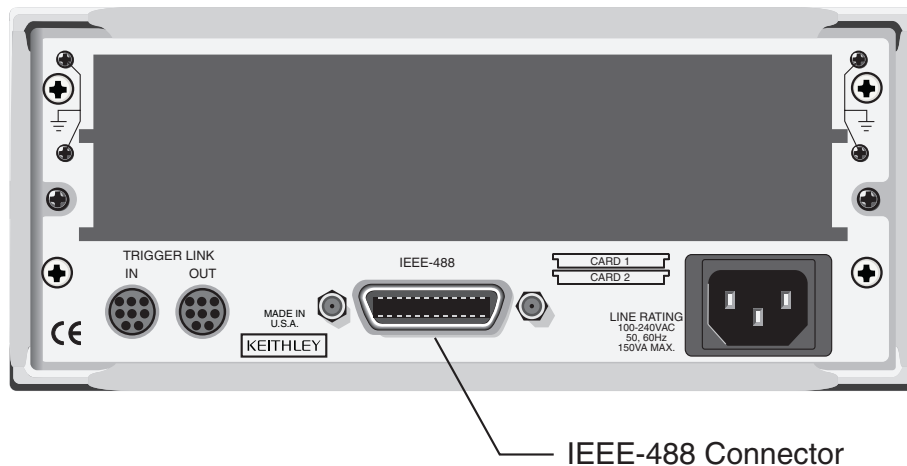


Connect the Model 7002-HD to the IEEE-488 bus as follows:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so that 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.

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.
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 B-1 on page B-2](#) 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 (see Section 5 of the Model 7002-HD Reference Manual).

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.

LOCAL key

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

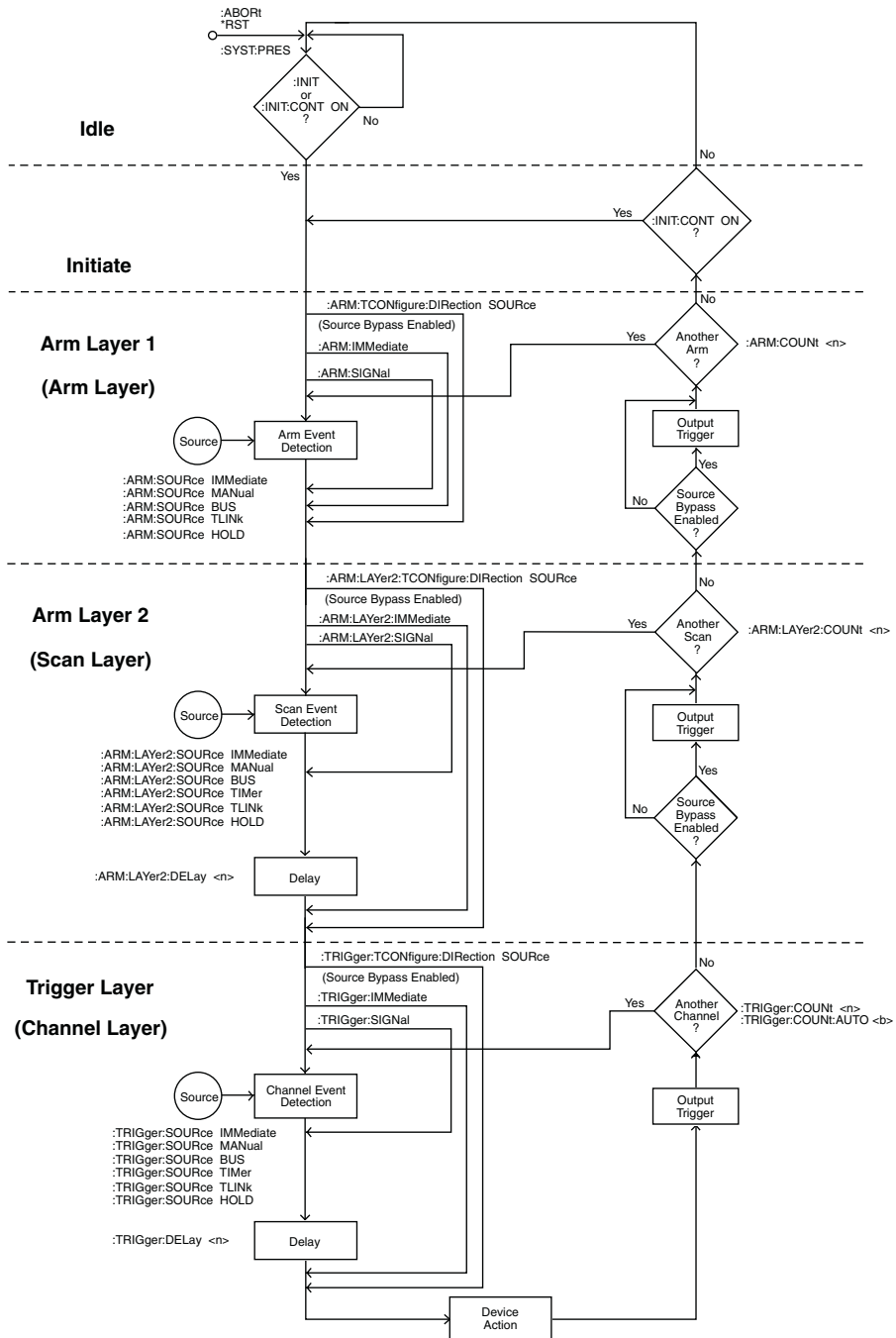
Since all front panel keys except LOCAL are locked out when the instrument is in remote, this key provides a convenient method of restoring front panel operation. Pressing LOCAL also turns off the REM indicator, and returns the display to normal if a user defined message was displayed.

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

Trigger model

The following information describes the operation process of the Model 7002-HD over the IEEE-488 bus. The flowchart in [Figure 5-4](#), 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.

Figure 5-4
Trigger Model (IEEE-488 bus operation)



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.

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.

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.

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.

Common commands

[Table 5-1](#) summarizes the common commands used by the Model 7002-HD and are presented in alphabetical order.

Table 5-1

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.

Table 5-1 (cont.)

IEEE-488.2 common commands and queries

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 that 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.

SCPI commands

DISPlay subsystem

The display subsystem controls the display circuitry of the Model 7002-HD and is summarized in [Table 5-2](#).

Table 5-2

DISPlay command summary

Command	Description
:DISPlay [:WINDow[1]] :TEXT :DATA <a> :DATA? :STATe :STATe?	Path to locate message to top display. Path to control user text messages. Define ASCII message "a" using up to 20 characters. Query text message. Enable (1 or ON) or disable (0 or OFF) message mode. Query text message mode (0 or 1).
:WINDow2 :TEXT :DATA <a> :DATA? :STATe :STATe?	Path to locate message to bottom display. Path to control user text messages. Define ASCII message "a" using up to 32 characters. Query text message. Enable (1 or ON) or disable (0 or OFF) message mode. Query text message mode (0 or 1).
:SMESsage :SMESsage? :ENABle :ENABle?	Enable (1 or ON) or disable (0 or OFF) status message mode. Query status message mode (0 or 1). Turn on (1 or ON) or turn off (0 or OFF) the front panel display. 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.

ROUTe subsystem

The ROUTe subsystem is used to control signal routing through the switch system and is summarized in [Table 5-3](#).

Table 5-3

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 	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel 	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.

Table 5-3 (cont.)

ROUTE command summary

Command	Description
:MEMory :SAVE [:RELays] M<num> :LIST <list>, M<num> :RECall M<num>	Path to program memory: Path to save channel patterns: Save current channel pattern at specified memory location (1 to 500). Save defined channel pattern at specified memory location (1 to 500). 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 one space is required between a command word and the parameters.

Sense subsystems

The sense subsystems are used to read the inputs of digital cards installed in slots 1 through 10, respectively. [Table 5-4](#) lists commands

Table 5-4

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.

STATus subsystem

The status subsystem is used to control the status registers of the Model 7002-HD. The commands in this subsystem are summarized in [Table 5-5](#).

Table 5-5
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 5-5 (cont.)
STATus command summary

Command	Description
:STATus :TRIGger [:EVENT]? :ENABle <NRf> :ENABle? :PTRansition <NRf> :PTRansition? :NTRansition <NRf> :NTRansition? :CONDition? :QUESTionable [:EVENT]? :ENABle <NRf> :ENABle? :PTRansition <NRf> :PTRansition? :NTRansition <NRf> :NTRansition? :CONDition? :PRESet :QUEue [:NEXT]? :ENABle <list> :ENABle? :DISable <list> :DISable?	Path to control trigger event registers: Query event register. Program the enable register. Query enable register. Program the positive transition register. Query positive transition register. Program the negative transition register. Query negative transition register. Query condition register. 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.

SYSTem subsystem

The system subsystem contains miscellaneous commands and are summarized in [Table 5-6](#).

Table 5-6
SYSTem command summary

Command	Description
:SYSTem :PRESet :POSetup <name> :POSetup? :VERSIon? :ERRor?	Return to :SYST:PRES defaults. Select power-on setup: RST, PRESet, SAV0-SAV9. Query power-on setup. Query revision level of SCPI standard. 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.

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 5-4 on page 5-7](#)). These commands and subsystems are summarized in [Table 5-7](#).

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 Name; Front Layer Name; IEEE-488	
Layer	Panel Operation	Bus Operation
First layer	Arm Layer	Arm Layer 1
Second layer	Scan Layer	Arm Layer 2
Third layer	Channel Layer	Trigger Layer

Table 5-7
Trigger command summary

Command	Description
<pre> :INITiate [:IMMEDIATE] :CONTinuous :CONTinuous? :ABORT :ARM[:SEquence[1]] [:LAYer[1]] :IMMEDIATE :COUNT <n> :COUNT? :SOURce <name> :SOURce? :SIGNal :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :LAYer2 :IMMEDIATE :COUNT <n> :COUNT? :DELay <n> :DELay? :SOURce <name> :SOURce? :TIMer <n> :TIMer? :SIGNal </pre>	<pre> Subsystem command path: Initiate one trigger cycle. Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system. Query continuous initiation. Reset trigger system. Subsystem command path to configure arm layers: Path to program arm layer 1: Immediately go to Layer2. Program arm count (1 to 9999, or INF). Query arm count. Select control source: HOLD, IMMEDIATE, MANUal, BUS, TLINK. Query control source. Loop around 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. Path to program arm layer 2: Immediately go to Trigger Layer. Program scan count (1 to 9999 or INF). Query scan count. Program delay (0 to 99999.999 seconds). Query delay. Select control source: HOLD, IMMEDIATE, TIMer, MANUal, BUS, TLINK. Query control source. Set timer interval (0 to 99999.999 seconds). Query timer. Loop around control source. </pre>

Table 5-7
Trigger command summary

Command	Description
<pre> :ARM[:SEquence[1]] :LAYer2 :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :TRIGger[:SEquence[1]] :IMMediate :COUNt <n> :AUTO :AUTO? :COUNt? :DELay <n> :DELay? :SOURce <name> :SOURce? :TIMer <n> :TIMer? :SIGNAL :TCONfigure :PROTOcol <name> :PROTOcol? :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :SSYNchronous :LINE <NRf> :LINE? </pre>	<p>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.</p> <p>Path to program trigger layer: Immediately perform a scan step. Program measure count (1 to 9999, or INF). Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length). Query auto-count. Query measure count. Program delay (0 to 99999.999 seconds). Query delay. Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINK. Query control source. Set timer interval (0 to 99999.999 seconds). Request the programmed timer interval. Loop around control source.</p> <p>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.</p> <p>Path to configure semi-synchronous Trigger Link: Select trigger line (1 to 6). Query trigger line.</p>

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.

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 SCANLIST¹:

7002-HD Cards	Individual Channels		Channel Patterns		
	External Trigger Rate	External Trigger Speed ²	External Trigger Rate	External Trigger Speed ²	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 ENVIRONMENT³

7002-HD Cards	Maximum Closed Channels ⁴	Temperature	Humidity
	MTX1		
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

Status and Error Messages

Table B-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)
+101	"Operation Complete" (SE)
0	"No error" (SE)
-100	"Command Error" (EE)
-101	"Invalid Character" (EE)
-102	"Syntax Error" (EE)

EE = Error event

SE = Status event

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

Code number	Description
-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)
-168	"Block data not allowed" (EE)
-170	"Expression error" (EE)
-171	"Invalid expression" (EE)
-178	"Expression data not allowed" (EE)
-200	"Execution error" (EE)

EE = Error event

SE = Status event

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

Code number	Description
-201	"Invalid while in local" (EE)
-202	"Settings lost due to rti" (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

Index

A

- accessories 1-4
- Analog backplane 4-5
- Arm Layer 3-7, 4-12, 4-15, 5-8
- Arm layer1 5-8
- Arm layer2 5-8
- Asynchronous trigger link 4-28

B

- Bus 3-11
- Bus connections 3-9

C

- Card 2-2, 2-3, 3-5
- Channel 3-5, 3-6
- Channel assignments 4-6
- Channel Layer 3-7, 4-12, 4-13, 5-8
- Channel list 4-6, 4-9
- Channel patterns 4-18
- Channel ready 4-28
- Close and Open channels 3-7
- Closing and opening channels 3-11
- Closing channels 4-9
- Create channel list 3-6
- Create scan list 3-6

D

- DISPlay subsystem 5-11

F

- Front and rear panel configuration 3-2
- Front panel operation 3-6

I

- Idle 4-12, 5-8
- IEEE 3-9
- IEEE-488 status indicators 5-5
- initiate 5-8
- Inspection 1-3

L

- Line power connections 4-2
- LOCAL key 5-6

M

- Manual scanning 3-11
- Manuals 1-4
- MENU 4-20

O

- Open 3-7
- Opening channels 4-9
- Optional 1-4
- Output connectors 1-1

P

- Power-up sequence 4-2
- Primary address 3-9
- Primary address selection 5-4
- Programming examples 3-11

R

- Rear panel 3-2
- RECALL 4-19
- Repacking 1-4
- ROUTE 5-12

S

- Safety 1-3
- Scan channels 3-7
- Scan Layer 3-7, 4-14, 5-8
- Scan list 4-6, 4-13
- Scan operation 5-6
- Scan procedure 4-13
- Scan process 4-10
- Scanning channels 4-10
- SCPI 3-9
- Semi-synchronous trigger link 4-28
- Sense 5-13
- Shipment 1-3
- Slot 4-6
- Specifications A-1
- STATus 5-14
- SYSTEM Subsystem 5-16

T

- Timer 3-12
- Trigger layer 5-8
- Trigger Link 4-26
- Trigger Model 4-10, 5-6
- Trigger subsystem 5-16

U

- Unpacking 1-3

V

- Vacuum fluorescent display (VFD) 4-3

W

- Warranty 1-2



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.

Specifications are subject to change without notice.

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KEITHLEY

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