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KEITHLEY

Model 7002 Switch System

Instruction Manual

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

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

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

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Keithley Instruments, Inc. 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • Fax: 440-248-6168
1-888-KEITHLEY (534-8453) • www.keithley.com

Sales Offices:	BELGIUM:	Bergensesteenweg 709 • B-1600 Sint-Pieters-Leeuw • 02-363 00 40 • Fax: 02/363 00 64
	CHINA:	Yuan Chen Xin Building, Room 705 • 12 Yumin Road, Dewai, Madian • Beijing 100029 • 8610-6202-2886 • Fax: 8610-6202-2892
	FINLAND:	Tietäjäntie 2 • 02130 Espoo • Phone: 09-54 75 08 10 • Fax: 09-25 10 51 00
	FRANCE:	3, allée des Garays • 91127 Palaiseau Cédex • 01-64 53 20 20 • Fax: 01-60 11 77 26
	GERMANY:	Landsberger Strasse 65 • 82110 Germering • 089/84 93 07-40 • Fax: 089/84 93 07-34
	GREAT BRITAIN:	Unit 2 Commerce Park, Brunel Road • Theale • Berkshire RG7 4AB • 0118 929 7500 • Fax: 0118 929 7519
	INDIA:	Flat 2B, Willocrissa • 14, Rest House Crescent • Bangalore 560 001 • 91-80-509-1320/21 • Fax: 91-80-509-1322
	ITALY:	Viale San Gimignano, 38 • 20146 Milano • 02-48 39 16 01 • Fax: 02-48 30 22 74
	KOREA:	FL., URI Building • 2-14 Yangjae-Dong • Seocho-Gu, Seoul 137-130 • 82-2-574-7778 • Fax: 82-2-574-7838
	NETHERLANDS:	Postbus 559 • 4200 AN Gorinchem • 0183-635333 • Fax: 0183-630821
	SWEDEN:	c/o Regus Business Centre • Frosundaviks Allé 15, 4tr • 169 70 Solna • 08-509 04 679 • Fax: 08-655 26 10
	SWITZERLAND:	Kriesbachstrasse 4 • 8600 Dübendorf • 01-821 94 44 • Fax: 01-820 30 81
	TAIWAN:	1FL., 85 Po Ai Street • Hsinchu, Taiwan, R.O.C. • 886-3-572-9077• Fax: 886-3-572-9031

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Safety Precautions

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

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

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

The types of product users are:

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

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

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

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

Keithley products are designed for use with electrical signals that are rated Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation 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.**

For rack mount equipment in which the power cord is not accessible, in the event of fire or other catastrophic failure, the user must provide a separate power disconnect switch.

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 cables 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.

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

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

Instrumentation and accessories shall not be connected to humans.

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

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

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

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7002 High Density Switch System Specifications

SYSTEM

CAPACITY: 10 plug-in cards per mainframe.

MEMORY: Battery backed-up storage for 500 switch patterns.

SWITCH SETTLING TIME: Automatically selected by the mainframe. For different switchcards, 7002 will be set to the slowest relay settling time. Additional time from 0 to 99999.999 seconds can be added in 1ms increments.

TRIGGER SOURCES:

External Trigger (TTL-compatible, 600ns minimum pulse, rear panel BNC).
IEEE-488 bus (GET, *TRG)
Trigger Link
Manual (front panel)
Internal Timer, programmable from 1.0ms to 99999.999 seconds in 1.0ms increments.

STATUS OUTPUT: Channel Ready (TTL-compatible signal, rear panel BNC). Low going pulse (10µs typical) issued after relay settling time.

SWITCHING SEQUENCE: Break-before-make (programmable).

MAINFRAME DIGITAL I/O: 4 open collector outputs (30V maximum, 100mA maximum sink current, 10Ω output impedance), 1 TTL compatible input, 1 common, 1+5V.

RELAY DRIVE: 3.5A maximum for all 10 card slots.

CARD SIZE: 32mm high × 114mm wide × 272mm long (1¼ in × 4½ in × 10¾ in).

CARD COMPATIBILITY: Fully compatible with all 7001 cards.

ANALOG BACKPLANE

SIGNALS: Four 3-pole rows (Hi, Lo, Guard). These signals provide matrix and multiplexer expansion between cards within one mainframe.

MAXIMUM VOLTAGE: 250V DC, 250V RMS, 350V AC peak, signal path to signal path or signal path to chassis.

MAXIMUM CURRENT: 1A peak.

PATH ISOLATION:

$>10^{10}\Omega$, <50pF path to path (any Hi, Lo, Guard to another Hi, Lo, Guard)
$>10^{10}\Omega$, <50pF differential (Hi to Lo or Hi, Lo to Guard).
$>10^{9}\Omega$, <75pF path to chassis.

CHANNEL CROSSTALK: <–65dB @ 1MHz (50Ω load).

BANDWIDTH: <3dB loss at 30MHz (50Ω load).

THROUGHPUT

EXECUTION SPEED OF SCAN LIST (channels or memory locations per second):

	CHANNELS	MEMORIES
Break-Before-Make	OFF 300	243
	ON 270	189

TRIGGER EXECUTION TIME (maximum time from activation of Trigger Source to start of switch open or close[2]):

SOURCE	LATENCY	JITTER
GET[1]	200 µs	<15 µs
*TRG[2,3]	3.0 ms	
Trigger Link	200 µs	<10 µs
External	200 µs	<10 µs
Timer		<25 µs

[1] Excluding switch settling time.

[2] Assuming no IEEE-488 commands are pending execution.

[3] Display Off.

IEEE-488 COMMAND EXECUTION TIME

COMMAND	EXECUTION TIME[1]
CLOS (@1!1)	<8ms + Relay Settle Time
OPEN (@1!1)	<8ms + Relay Settle Time
MEM:REC M1	<9ms + 2×Relay Settle Time (BBM ON)
	< 9ms + Relay Settle Time (BBM OFF)

[1] Measured from the time at which the command terminator is taken from the bus to relay energize. With display OFF.

GENERAL

DISPLAY: Dual-line vacuum fluorescent. 1st line: 20-character alphanumeric. 2nd line: 32-character alphanumeric. Channel status LED grid.

LIGHT PEN OPTION: Provides interactive programming of channels, cross points, scan lists, and memory.

REAR PANEL CONNECTORS:

IEEE-488; 9-pin DB9 Female; 8-pin micro DIN for Trigger Link; 8-pin micro DIN for Trigger Link expansion; BNC for External Trigger; BNC for Channel Ready

POWER: 100V to 240V rms, 50/60Hz, 110VA maximum.

EMC: Complies with European Union Directive 89/336/EEC, EN61326-1.

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1.

EMI/RFI: Meets VDE 0871B and FCC Class B.

ENVIRONMENT: Operating: 0°C to 50°C, <80% RH (0°C to 35°C). **Storage:** –25°C to +65°C.

DIMENSIONS, WEIGHT: 178mm high × 438mm wide × 448mm deep (7 in × 17¼ in × 17⅝ in). Net weight 9.1kg (20 lb).

IEEE-488 BUS

STANDARDS CONFORMANCE: Conforms to SCPI-1990, IEEE-488.2 and IEEE-488.1.

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

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

INTERFACE FUNCTIONS: SH1, AH1,T5, TE0, L4, LE0, SR1, RL1, PP0, DC1,DT1, C0, E1.

Specifications subject to change without notice.

HW 9/12/01
Rev. C

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1 General Information

1.1 Introduction

This section contains general information about the Model 7002 Switch System.

1.2 Features

1.3 Warranty Information

1.4 Manual Addenda

1.5 Safety Symbols and Terms

1.6 Specifications

1.7 Inspection

1.8 Optional Accessories

1.2 Features

Some important Model 7002 features include:

- High Density Switching — Up to 400 channels (or matrix crosspoints) per mainframe using 10 switching cards.
- Switching Cards — In addition to the switching cards designed specifically for the Models 7001 and 7002 (i.e. Models 7011, 7012, 7013 and 7014), you can use the switching cards that were originally designed for the Keithley Models 705 and 706 scanners.
- Analog Backplane — Can be used to internally connect the rows or banks of a Model 701X series card installed in one slot to the rows or banks Model 701X series cards installed in the other slots.
- Close/Open or Scan — The Model 7002 can simply close and/or open one or more channels, or scan through a specified list of channels.
- Channel LED Display — The real-time LED display monitors the state (closed or open) of all available channels.
- Memory — Up to 500 channel patterns (pattern of open and closed channels) and 10 customized instrument set-ups can be saved in memory for later recall.
- IEEE-488 Bus — Bus operation conforms to the IEEE-488.2 and SCPI standards.
- Trigger Link — New trigger concept to provide more versatile and precise external triggering. This is in addition to the standard in/out BNC external triggering technique.
- An optional light pen provides point and click programming from the front panel.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7002 require warranty service, contact the Keithley representative or au-

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thorized repair facility in your area for further information. When returning the instrument 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.

1.4 Manual addenda

Any improvements or changes concerning the instrument or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

1.5 Safety symbols and terms

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

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

The symbol  on an instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading used in this 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 used in this manual explains hazards that could damage the instruments. Such damage may invalidate the warranty.

1.6 Specifications

Model 7002 specifications may be found at the front of this manual.

1.7 Inspection

The Model 7002 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. The following items are included with every Model 7002 order:

- Model 7002 Switch System
- Model 7002 Instruction Manual
- Accessories as ordered.

If an additional instruction manual is required, order the manual package, Keithley part number 7002-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 Optional accessories

The following accessories are available from Keithley for use with the Model 7002.

Model 7002-RMK-1 Fixed Rack Mount Kit: Mounts a Model 7002 to a standard 19-inch rack.

Model 7002-RMK-2 Slide Rack Mount Kit: Similar to the Model 7002-RMK-1 except the unit can slide in and out of the rack.

Model 7078-PEN: Provides point and click programming from the front panel (includes holder).

Model 8502 Trigger Link Adapter: Allows you to connect the Trigger Link of the Model 7002 to an instrument that uses the standard BNC (In/Out) external triggering technique.

Models 8501-1 and 8501-2 Trigger Link Cables: The Model 8501-1 is one meter in length, and the Model 8501-2 is two meters in length.

Model 7007 Shielded IEEE-488 Cables: Connects the Model 7002 to the IEEE-488 bus using shielded cables to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter in length and has an EMI shielded IEEE-488 connector at each end. The Model 7007-2 is identical to the Model 7007-1, but is two meters in length.

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2
Card Installation

ATTENTION FIRST TIME USERS

If you are a first time user, it is recommended that you perform the Operation Demo in Section 3, Getting Started, before installing any switching cards into the mainframe. This demo will acquaint you with basic front panel operation.

WARNING

The procedures in this section are intended for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.

2.1 Introduction

The Model 7002 is designed to be used with the Model 701X series switch cards (i.e. Model 7011, 7012, 7013, and 7014), and with cards that were originally designed to be used with the Keithley Model 705/706 scanners.

Installation procedures in this section are organized as follows:

2.2 Model 701X series card installation: Explains how to install a Model 701X series card (such as the Model 7011, 7012, 7013, or 7014) in the Model 7002.

2.3 Non-701X series card installation: Explains how to install cards designed for the Model 705/706 scanner in the Model 7002.

2.2 Model 701X series card installation

WARNING

Turn off power from all instrumentation (including the Model 7002 mainframe) and disconnect their line cords. Make sure all power is removed and stored energy in external circuitry is discharged.

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NOTE

If using the screw terminal connector card, make sure your external circuitry is wired to the card (as explained in the instruction manual for the card) before installing the card assembly in the Model 7002 mainframe.

CAUTION

To prevent contamination to the switch card that could degrade performance, only handle the card assembly by the edges and shields. If contamination occurs, clean the card as explained in its instruction manual.

Card installation

Perform the following steps to install the card assembly in the Model 7002 mainframe:

1. Mate the connector card to the relay card if they are separate. Make sure to handle the cards by the edges and shields to prevent contamination.
2. Facing the rear panel of the Model 7002, select the slot (CARD 1 through CARD 10) that you wish to install the card in.
3. Referring to Figure 2-1, feed the card assembly into the desired slot such that the edges of the relay card ride in the rails.
4. With the ejector arms in the outward (unlocked) position, push the card assembly into the mainframe until the arms engage into the ejector cups. Then push both arms inward to lock the card all the way into the mainframe.
5. For the multi-pin connector card, tighten the screw shown in Figure 2-1.

Notes:

1. Once a Model 701X series card is installed in the mainframe, the Model 7002 automatically identifies it on power-up. This ID allows the Model 7002 to configure itself for proper operation.
2. When a Model 701X series card is installed, the slot assignment (Card TYPE) is performed automatically on power-up. A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraph 4.8 and 4.11 for details).

Card removal

To remove the card assembly, first loosen the screw (if applicable), unlock the card by pulling the ejector arms outward, then pull the card assembly out of the mainframe. Remember to handle the card assembly by the edges and shields to avoid contamination that could degrade performance.

2.3 Non-701X series cards

WARNING

Turn off power from all instrumentation (including the Model 7002 mainframe) and disconnect their line cords. Make sure all power is removed and stored energy in external circuitry is discharged.

NOTE

If using a card that requires connections to be made on the card, make sure your external circuitry is wired to the card (as explained in the instruction manual for the card) before installing the card in the Model 7002 mainframe.

CAUTION

To prevent contamination to the switch card that could degrade performance, only handle the card by the edges. If contamination occurs, clean the card as explained in its instruction manual.

Card installation

Perform the following steps to install the card in the Model 7002 mainframe:

1. Facing the rear panel of the Model 7002, select the slot that you wish to install the card in.
2. Using Figure 2-1 as a guideline, feed the card into the desired slot such that the edges of the card ride in the rails.

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3. With the ejector arms in the outward (unlocked) position, push the card assembly into the mainframe until the arms engage into the ejector cups. Then push both arms inward to lock the card into the mainframe.

NOTE

The Model 7002 cannot automatically identify non-701X cards. After the mainframe is powered-up, you must enter the model number using the TYPE menu item in the CARD CONFIG MENU.

Card removal

To remove the card, first unlock it by pulling the ejector arms outward, then pull the card out of the mainframe. Remember to handle the card by the edges to avoid contamination that could degrade performance.

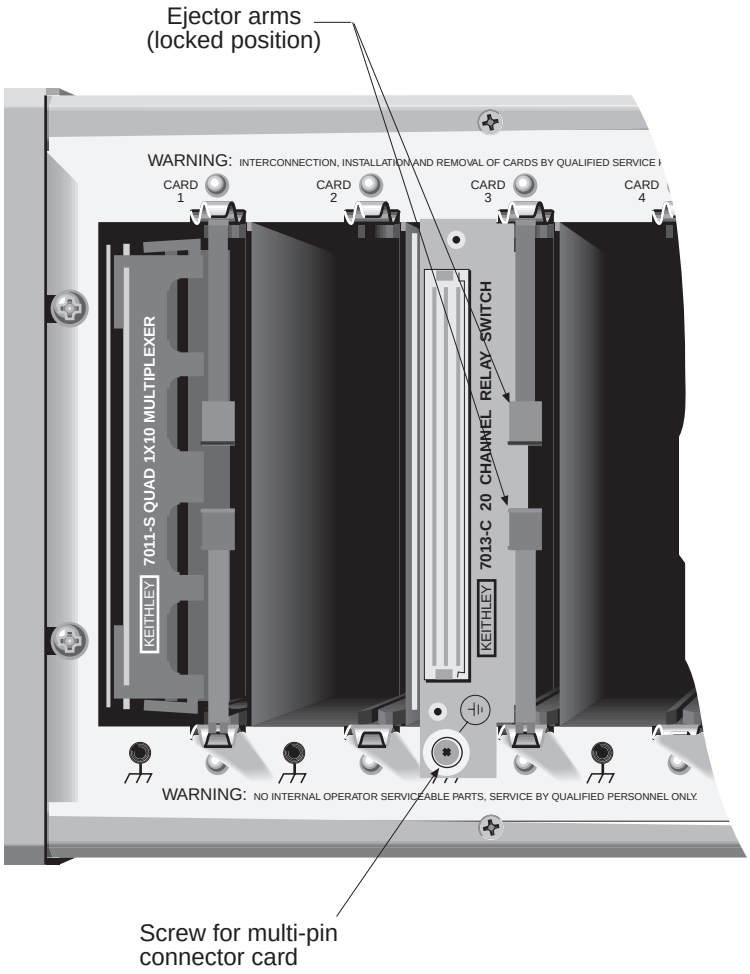


Figure 2-1
Card installation

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3

Getting Started

3.1 Introduction

This section contains introductory information on using your Model 7002 Switch System. For detailed front panel and IEEE-488 bus operation, refer to Sections 4 and 5, respectively.

The information in this section is arranged as follows:

3.2 **Front and rear panel configuration:** Summarizes the controls, light pen receptacle, and the two displays on the front panel of the instrument.

3.3 **Light pen option:** Summarizes the basic operations that can be performed with the optional light pen.

3.4 **Display modes:** Covers the two basic display modes and explains how to toggle from one display mode to the other.

3.5 **Channel assignments:** Explains the channel assignment formats for programming the Model 7002, and explains how the channel LEDs correspond to the channel assignments.

3.6 **Overview of scan process:** Provides a brief overview of the scan process as it passes through the three layers of the trigger model.

3.7 **Operation demo:** Demonstrates basic operation using the built-in 40-channel multiplexer simulator. Recommended for first time users.

3.8 **Switching card considerations:** Provides some thoughts about switching cards that should be considered before operating a switching system.

3.9 **Front panel operation summary:** Summarizes the general procedures to open/close channels and scan channels.

3.10 **Introduction to IEEE-488.2 and SCPI:** Discusses some fundamental information concerning operation over the IEEE-488 bus.

3.2 Front and rear panel configurations

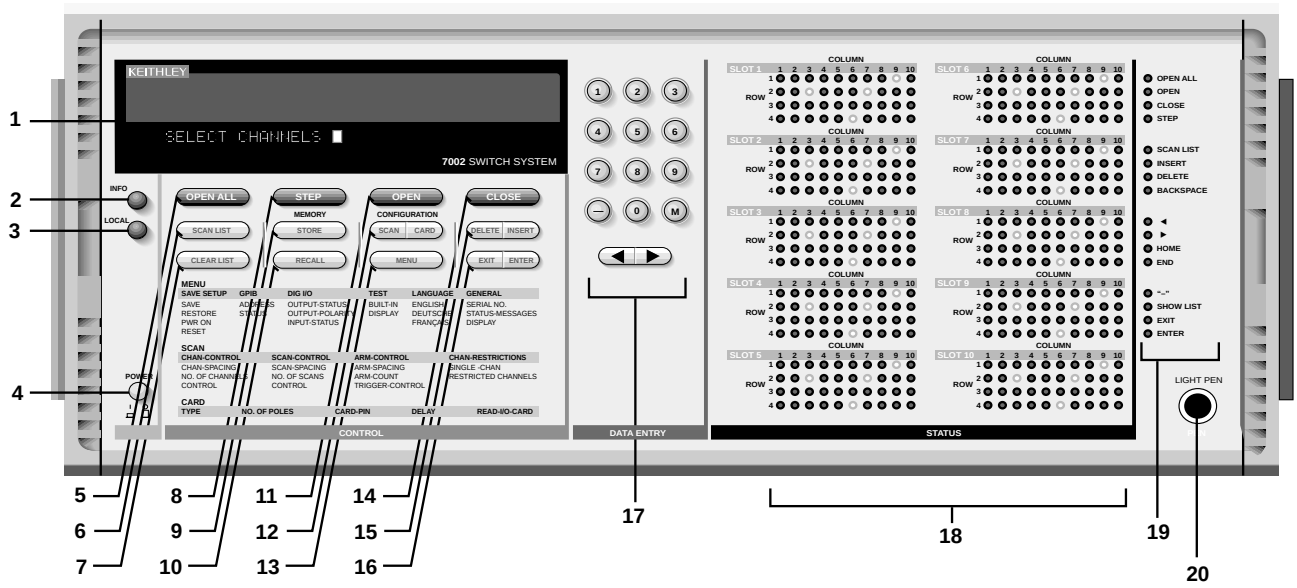
3.2.1 Front panel

The front panel of the Model 7002 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 ◄ /► .

3.2.2 Rear panel

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

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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 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 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
Insert 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.

18 Channel LEDs
Provides status (on/off or list inclusion).
With light pen, use to open/close or include in selected list.

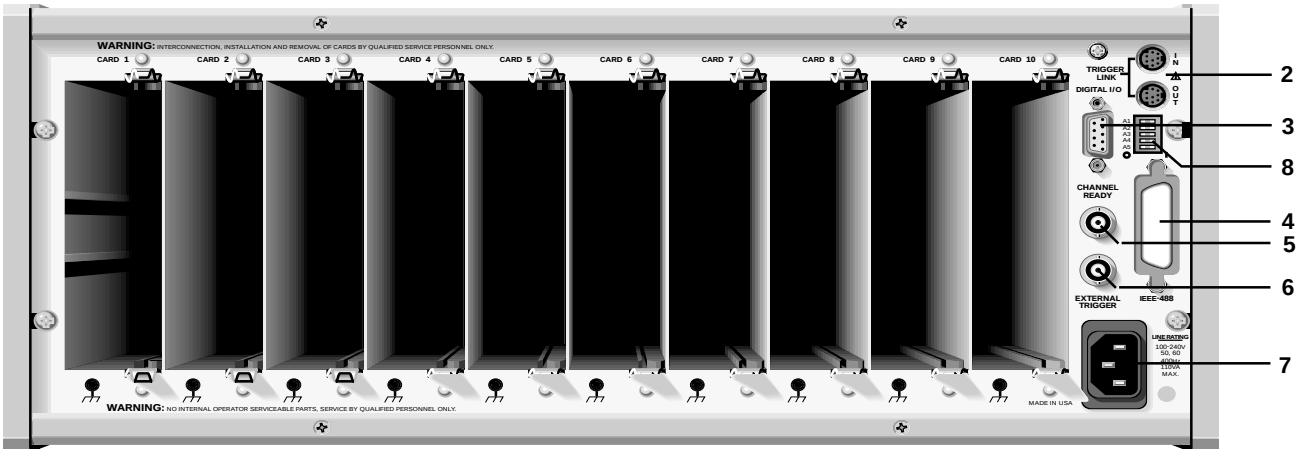
19 Control LEDs (Light Pen)

OPEN ALL	Same as OPEN ALL key.
OPEN	Same as OPEN key.
CLOSE	Same as CLOSE key.
STEP	Same as STEP key.
SCAN LIST	Same as SCAN LIST key. Indicates selected list.
INSERT	Same as INSERT key.
DELETE	Same as DELETE key.
BACKSPACE	Move cursor left and delete entry.
◄	Same as ◄ key.
►	Same as ► key.
HOME	Move cursor to beginning of selected list.
END	Move cursor to end of selected list.
-	Same as - key
SHOW LIST	Toggles between display modes (relay status or list). Indicates selected mode.
EXIT	Same as EXIT key.
ENTER	Same as ENTER key.

20 LIGHT PEN
Receptacle for plug of light pen.

Figure 3-1
Model 7002 front panel

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1 CARD 1-10
Ten slots for ten switch cards.

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

3 DIGITAL I/O
DB-9 connector. Port consist of four TTL output lines and one TTL input line.

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

5 CHANNEL READY
Female BNC connector for TTL output trigger pulse.

6 EXTERNAL TRIGGER
Female BNC connector for TTL input trigger pulse.

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

8 IEEE-488 Address Switches
Use to set address for special order units that do not have front panel controls.

Figure 3-2
Model 7002 rear panel

3.3 Light pen option

Point and click programming using the light pen provides an easy and fast method to enter channels into the channel list and scan list. You simply point the pen at the desired channel LED and press the button on the barrel.

Figure 3-3A shows how the light pen plugs into the front panel, and Figure 3-3B shows how the light pen is used. When an LED is clicked, it blinks for a couple of seconds and then assumes the appropriate state.

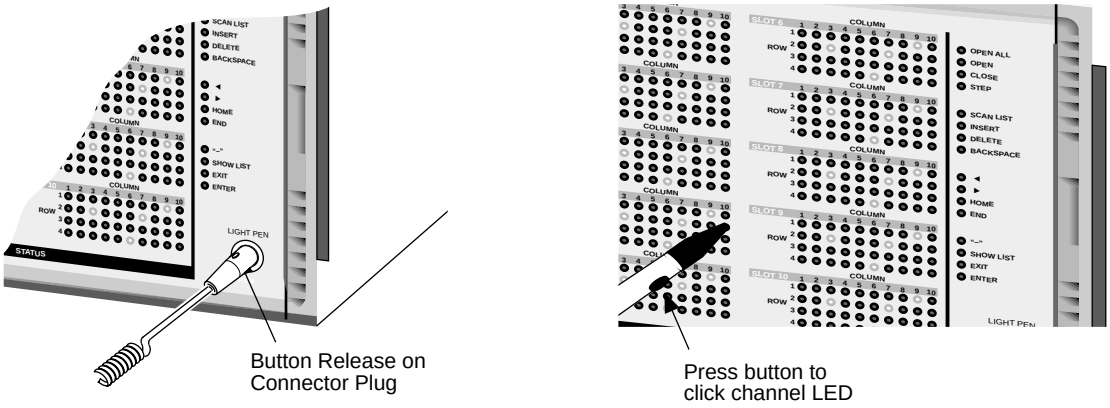
Control LEDs are also provided to perform other operations using the light pen. Most of these LEDs simply perform the same operations as their front panel key counterparts. Figure 3-1 summarizes the operations of all the control LEDs.

3.4 Display modes

There are two basic display modes; the relay status display mode and the list display mode. In the relay status display mode (see Figure 3-4), the channel LEDs provide the open/close status of the available channels. This is the display mode you want to be in when closing/opening channels or scanning so that you can observe the real-time state of each switch in your system.

In a list display mode (see Figure 3-5), the channel LEDs indicate which channels are included in the list (channel list or scan list). Figure 3-6 provides an example of channel status for the two display modes. If you create a list while in this display mode, be sure to toggle back to the relay status display mode before closing/opening channels or scanning.

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A) Light Pen Connector

B) Light Pen Operation

Figure 3-3
Optional light pen

VFD:

EDIT ERR REM TALK LSTN SRQ REAR REL FILT MATH 4W AUTO ARM TRIG SMPL

RELAY STATUS

SELECT CHANNELS

A) Channel List Selected

VFD:

EDIT ERR REM TALK LSTN SRQ REAR REL FILT MATH 4W AUTO ARM TRIG SMPL

RELAY STATUS

SCAN CHANNELS

B) Scan List Selected

Figure 3-4
Relay status display mode

VFD:

EDIT ERR REM TALK LSTN SRQ REAR REL FILT MATH 4W AUTO ARM TRIG SMPL

CHANNEL LIST DISPLAY

SELECT CHANNELS

A) Channel List Display Mode

VFD:

EDIT ERR REM TALK LSTN SRQ REAR REL FILT MATH 4W AUTO ARM TRIG SMPL

SCAN LIST DISPLAY

SCAN CHANNELS

B) Scan List Display Mode

Figure 3-5
List display modes

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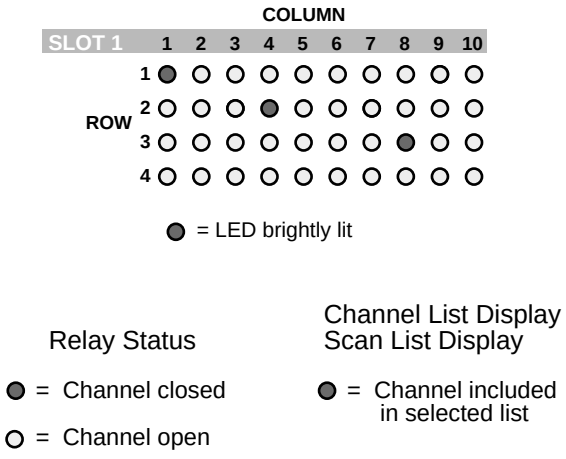


Figure 3-6
Status interpretation of channel LEDs

3.4.1 Changing the display mode (keypad method)

1. Press the MENU key to display the MAIN MENU.
2. Using the cursor keys (◀ and ▶), place the cursor on GENERAL and press ENTER.
3. Place the cursor on DISPLAY and press ENTER to display the following MENU:

   CONFIG LED DISPLAY
   RELAY-STATUS CURRENT LIST

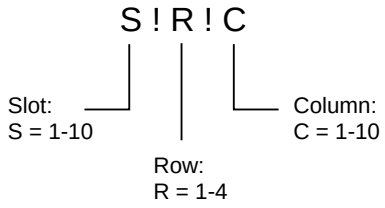
   RELAY STATUS selects the relay status display mode, and CURRENT LIST selects the list display mode.
4. Place the cursor on the desired display mode and press ENTER.
5. Use EXIT to back out of the menu structure.

3.4.2 Changing the display mode (light pen method)

The SHOW LIST LED toggles between the relay status display mode and the list display mode. To change the display mode, simply click the SHOW LIST LED.

3.5 Channel assignments

Channel assignment format depends on the type of card installed in the mainframe. A matrix card uses a three integer format to specify slot, row, and column, while a non-matrix type card uses a two integer format to specify slot and channel. The channel assignment formats are illustrated in Figure 3-7.



Example: 2 ! 3 ! 6 = Slot 2, Row 3, Column 6

A) Matrix Cards



Example: 5 ! 24 = Slot 5, Channel 24

B) Non-Matrix Cards

Figure 3-7
Channel assignment formats

Channel LEDs

The 400 channel LEDs on the front panel are arranged in 10 arrays of 40 LEDs each. Each LED array corresponds to a mainframe slot. The channel assignment for each LED of an array is determined by the type of card and which slot it is installed in. LEDs that are completely turned off indicate that switching channels are not available at those locations.

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For a matrix card, each channel LED in the array corresponds to a row/column crosspoint. The channel assignments for matrix cards are shown in Figure 3-8A. For example, if a 40 × 10 matrix card is installed in slot 5, then the channel assignments are designated 5!1!1 through 5!4!10.

For a non-matrix type card, each channel LED in the array corresponds to one of up to 40 channels. The channel assignments for non-matrix type cards are shown in Figure 3-8B. For example, if a 40-channel multiplexer card is installed in slot 9, then the channel assignments are designated 9!1 through 9!40.

	1	2	3	4	5	6	7	8	9	10
1	S!1!1	S!1!2	S!1!3	S!1!4	S!1!5	S!1!6	S!1!7	S!1!8	S!1!9	S!1!10
2	S!2!1	S!2!2	S!2!3	S!2!4	S!2!5	S!2!6	S!2!7	S!2!8	S!2!9	S!2!10
3	S!3!1	S!3!2	S!3!3	S!3!4	S!3!5	S!3!6	S!3!7	S!3!8	S!3!9	S!3!10
4	S!4!1	S!4!2	S!4!3	S!4!4	S!4!5	S!4!6	S!4!7	S!4!8	S!4!9	S!4!10

where; S is the slot number (1-10)

A) Matrix Cards

	1	2	3	4	5	6	7	8	9	10
1	S!1	S!2	S!3	S!4	S!5	S!6	S!7	S!8	S!9	S!10
2	S!11	S!12	S!13	S!14	S!15	S!16	S!17	S!18	S!19	S!20
3	S!21	S!22	S!23	S!24	S!25	S!26	S!27	S!28	S!29	S!30
4	S!31	S!32	S!33	S!34	S!35	S!36	S!37	S!38	S!39	S!40

where; S is the slot number (1-10)

B) Non-Matrix Type Cards

Figure 3-8
Channel assignment formats

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3.6 Overview of scan process

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

The simplified model for scan operation is shown in Figure 3-9. As shown, scan operation consists of three layers; the arm layer, scan layer and channel layer.

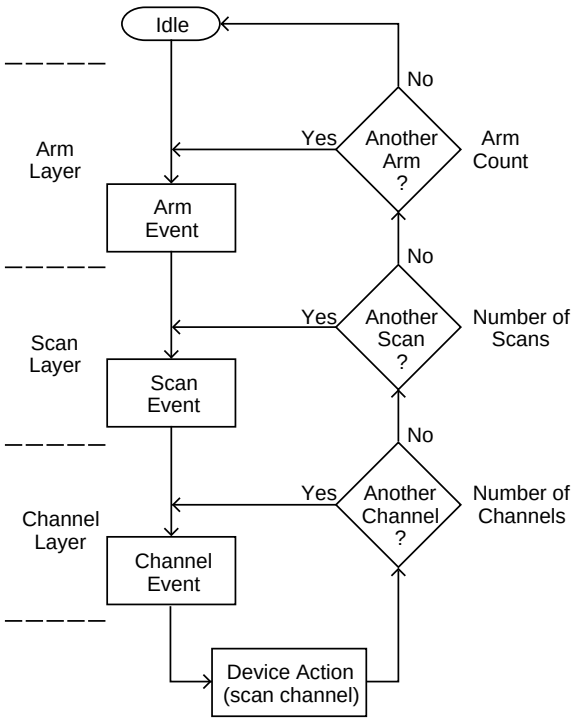


Figure 3-9
Simplified model of scan operation

Idle

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

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

Arm layer

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

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

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

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

Scan layer

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

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The scan count (number of scans) can be set to a finite value (1 to 9999) or for an infinite number of scans.

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

Channel layer

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

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

3.7 Operation demo

A fast and easy way to acquaint yourself with basic front panel operation is to use the following operation demo. This demo uses the built-in 40-channel multiplexer simulator. This will allow you to simulate operation without the need of a switching card.

3.7.1 Initial configuration

WARNING

Before turning the Model 7002 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.

Step 1 of the following procedure will RESET the Model 7002 to a default configuration that is required for the demonstration procedures (paragraphs 3.7.2 and 3.7.3). Step 2 will assign the 40-channel multiplexer simulator to slot 9.

Step 1. RESET instrument

1. Press the MENU key. The MAIN MENU will be displayed.
2. Place the cursor on SAVESETUP using the ◄ and ► cursor keys and press the ENTER key. The SETUP MENU will be displayed.
3. Place the cursor on RESET and press ENTER. The "RESETTING INSTRUMENT" message will be displayed.
4. Press ENTER again. The "RESET COMPLETE" message will be displayed.
5. Press ENTER to return the display to the SETUP MENU.
6. Press EXIT twice to exit from the MAIN MENU.

Step 2. Select multiplexer simulator

NOTE

The simulator cannot be selected if there is a Model 701X series card installed in slot 9.

1. Press the CARD CONFIGURATION key. The CARD CONFIG MENU will be displayed.
2. Place the cursor on TYPE and press ENTER to select SET CARD TYPE. The card type for the currently selected slot will be displayed. For example:

```
SET CARD TYPE   NONE
SLOT-#1   #2   #3   #4   #5   ►
```

   In the above example, if #3 flashes, it indicates that slot 3 is assigned to be empty (NONE).

3. Place the cursor on slot #9. If slot 9 is already assigned as 9990, then proceed to step 5. Otherwise, press ENTER.
4. Use the cursor keys to display number 9990 and press ENTER. Assignment number 9990 assigns the slot to operate as a 40-channel multiplexer.
5. Press EXIT twice to exit from the MAIN MENU.

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3.7.2 Close and open channels

The following procedures assume that the initial configuration procedure in paragraph 3.7.1 has been performed. This initialization will assign the 40-channel multiplexer simulator to slot 9.

Step 1. Create channel list

Perform the following steps to create a channel list that includes channels 2, 4, and 6 through 10 of slot 9.

1. **If desired, select the list display mode:**

   A channel list can be created while in the relay status display mode. However, if you want channel LED status to correspond to the channels contained in the channel list, place the instrument in the list display mode as follows:

   ■ **Keypad method**

   Paragraph 3.4.1 explains how to change the display mode.

   ■ **Light pen method**

   The SHOW LIST LED toggles between the two display modes. To change the display mode, click SHOW LIST.

2. **If the channel list is not currently selected, perform the following:**

   ■ **Keypad method**

   Press the SCAN LIST key.

   SELECT CHANNELS

   ■ **Light pen method**

   Click the SCAN LIST LED.

   SELECT CHANNELS

3. **Individual Channel Entry – Enter channels 2 and 4 into the channel list:**

   ■ **Keypad method**

   a. Press “9” and then “2” to enter channel 2 of slot 9 into the list.

      SELECT CHANNELS 9!2

   b. Press ENTER (or ▶) to enter the channel separator (comma).

      SELECT CHANNELS 9!2,

   c. Press “9” and “4” to enter the second channel, and then press ENTER (or ▶) to enter the separator.

      SELECT CHANNELS 9!2, 9!4,

   ■ **Light pen method**

   a. Click the channel LED that corresponds to channel 2 of slot 9.

      SELECT CHANNELS 9!2,

   b. Click channel 4 of slot 9.

      SELECT CHANNELS 9!2, 9!4,

4. **Range Entry – Enter channels 6 through 10:**

   ■ **Keypad method**

   a. Press “9” and then “6” to enter the range limit.

      SELECT CHANNELS 9!2, 9!4, 9!6

   b. Press “–” to enter the range separator. Note that the slot for the next channel is automatically entered.

      SELECT CHANNELS 9!2, 9!4, 9!6-9!

   c. Press “1”, “0” and then ENTER (or ▶) to enter the other range limit.

      SELECT CHANNELS 9!2, 9!4, 9!6-9!10,

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■ **Light pen method**

a. Click channel 6 of slot 9.

SELECT CHANNELS 9!2, 9!4, 9!6,

b. Click the "–" LED. Note that the slot for the next channel is automatically entered.

SELECT CHANNELS 9!2, 9!4, 9!6-9!

c. Click channel 10 of slot 9.

SELECT CHANNELS 9!2, 9!4, 9!6-9!10,

Step 2. Close and Open Channels

Perform the following steps to close the channels specified in the channel list:

1. **Select the relay status display mode:**

The instrument must be in the RELAY STATUS display mode in order to view the open and closed channels on the LED display. If the RELAY STATUS display mode is not currently selected, perform the following:

■ **Keypad method**

Paragraph 3.4.1 explains how to change the display mode.

RELAY STATUS

■ **Light pen method**

SHOW LIST toggles between the two display modes. To change the display mode, click SHOW LIST.

RELAY STATUS

2. **Close and open channels:**

■ **Keypad method**

a. Press CLOSE to close the channels specified in the channel list.

b. Press OPEN (or OPEN ALL) to open the channels specified in the channel list. Note that OPEN ALL also opens channels not specified in the list.

■ **Light pen method**

a. Click CLOSE to close the channels specified in the channel list.

b. Click OPEN (or OPEN ALL) to open the channels specified in the channel list. Note that OPEN ALL also opens channels not specified in the list.

3.7.3 Scan channels

The following procedures assume that the initial configuration procedures in paragraph 3.7.1 has been performed. This initiation will assign the 40-channel multiplexer simulator to slot 9.

Create scan list

Perform the following steps to create a scan list that includes channels 1 through 20 of slot 9.

1. **If desired, select the list display mode:**

A scan list can be created while in the relay status display mode. However, if you want channel LED status to correspond to the channels contained in the channel list, then place the instrument in the list display mode as follows:

■ **Keypad method**

Paragraph 3.4.1 explains how to change the display mode.

■ **Light pen method**

The SHOW LIST LED toggles between the two display modes. To change the display mode, click SHOW LIST.

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2. If the scan list is not currently selected, perform the following:

■ **Keypad method**

Press the SCAN LIST key.

SCAN CHANNELS

■ **Light pen method**

Click the SCAN LIST LED.

SCAN CHANNELS

3. Enter channels 1 through 20 into scan list:

If the scan list is not empty, press CLEAR LIST to remove all channels from the list.

■ **Keypad method**

a. Press "9" and then "1" to enter the range limit.

SCAN CHANNELS 9!1

b. Press "–" to enter the range separator. Note that the slot for the next channel is automatically entered.

SCAN CHANNELS 9!1-9!

c. Press "2", "0" and then ENTER (or ▶) to enter the other range limit.

SCAN CHANNELS 9!1-9!20,

■ **Light pen method**

a. Click the LED that corresponds to channel 1 of slot 9.

SCAN CHANNELS 9!1,

b. Click the "–" LED. Note that the slot for the next channel is automatically entered.

SCAN CHANNELS 9!1-9!

c. Click channel 20 of slot 9.

SCAN CHANNELS 9!1-9!20,

Select relay status display mode

The instrument must be in the RELAY STATUS display mode in order to view the open and closed channels on the LED display. If the RELAY STATUS display mode is not currently selected, perform the following:

■ **Keypad method**

Paragraph 3.4.1 explains how to change the display mode.

RELAY STATUS

■ **Light pen method**

SHOW LIST toggles between the two display modes. To change the display mode, click SHOW LIST.

RELAY STATUS

NOTE

The STEP and OPEN ALL keys are used to control the following scans. For light pen use, you can instead use the STEP and OPEN ALL LEDs.

Manual scan

The RESET defaults configure the instrument to manually scan an infinite number of channels. After the 20th channel is scanned, operation will wrap around to the beginning of the scan list (Channel 1).

1. Press STEP to take the Model 7002 out of the idle state. The ARM indicator will turn on.
2. Press the STEP key to scan the first channel. This channel will remain closed until another channel is scanned.
3. Press the STEP key to scan the second channel. The first channel will open and the second channel will close.
4. Each press of the STEP key will open the previous channel and close the next channel.

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5. When finished, press OPEN ALL to abort the scan and open all channels. The instrument goes into the idle state (ARM indicator turns off).

Automatic scan

Perform the following steps to automate the 20-channel scan. A 0.5 second delay will be used between each channel.

1. Press OPEN ALL if there are any channels closed or the ARM indicator is on.
2. Press the SCAN CONFIGURATION key. The CONFIGURE SCAN menu will be displayed.
3. Using the ◄ and ► keys, place the cursor on CHAN-CONTROL and press ENTER. The CHANNEL CONTROL menu will be displayed.
4. Place the cursor on CHANNEL-SPACING and press ENTER. The SELECT CHAN SPACING menu will be displayed:

   SELECT CHAN SPACING
   TIMER EXTERNAL GPIB MANUAL ►
   ◄ TRIGLINK IMMEDIATE HOLD

5. Place the cursor on IMMEDIATE and press ENTER. The display will return to the CHANNEL CONTROL menu.
6. Press EXIT twice to exit from the CONFIGURE SCAN menu.
7. Press CARD CONFIGURATION. The CARD CONFIG MENU will be displayed.

   CARD CONFIG MENU
   TYPE #-OF-POLES CARD PAIR ►
   ◄ DELAY READ-I/O-CARD

8. Place the cursor on DELAY and press ENTER. The SET DELAY FOR: menu will be displayed.
9. Place the cursor on SLOT #9 and press ENTER. The delay period (in seconds) will be displayed.

   (09) DELAY = 00000.000

10. Use the keypad to set the delay for 0.5 seconds.

    (09) DELAY = 00000.500

    This delay will occur after each channel closes.

11. Press ENTER. The display will return to the SET DELAY FOR: menu.
12. Press EXIT twice to back out of the menu structure.
13. To start the scan, simply press STEP. The instrument leaves the idle state (ARM indicator on) and immediately closes the first channel. After a 0.5 second delay the first channel will open and the second channel will close. This automatic scan will continue at the 0.5 second scan rate.
14. To stop the scan, press OPEN ALL.

TIMER controlled scans

An internal timer can be used to control the time interval between the scans. The 20-channel scan will be modified by using TIMER to place a 15-second interval between the start of each scan.

1. Press OPEN ALL to ensure that the instrument is in the idle state.
2. Press SCAN CONFIGURATION. The CONFIGURE SCAN menu will be displayed.
3. Place the cursor on SCAN-CONTROL and press ENTER. The SCAN CONTROL menu will be displayed.
4. Place the cursor on SCAN-SPACING and press ENTER. The SELECT SCAN SPACING menu will be displayed.

   SELECT SCAN SPACING
   TIMER EXTERNAL GPIB MANUAL ►
   ◄ TRIGLINK IMMEDIATE HOLD

5. Place the cursor on TIMER and press ENTER. The timer interval (in seconds) will be displayed.

   INTERVAL = 00000.001

6. Use the keypad to key in an interval of 15 seconds.

   INTERVAL = 00015.000

7. Press ENTER. The display will return to the SCAN CONTROL menu.
8. Press EXIT twice to exit from the CONFIGURE SCAN menu.
9. To start the scan, press STEP. The first scan will start immediately and stop after the 20th channel closes. After 5 additional seconds expire (15 seconds after the start of the scan), the next scan will start.
10. When finished, press OPEN ALL.

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3.8 Switching card considerations

Before operating a switch system, familiarize yourself with the following switching card information.

3.8.1 Switching card simulators

Instrument operation can be performed without any switching cards installed in the Model 7002 by using the switching card simulators. By selecting the appropriate switching card simulator, the Model 7002 will operate as if a 40-channel switching card or a 4 × 10 matrix card were installed. This is useful if you want to develop a test program without having a card installed.

When a slot is assigned the model number 9990, the mainframe will operate as if a 40-channel switching card is installed. When a slot is assigned model number 9991, the mainframe will operate as if a 4 × 10 matrix card is installed. These simulator model numbers are assigned by setting card TYPE in the CARD CONFIG MENU (see paragraph 3.8.3).

NOTE

A simulator cannot be assigned to a slot that already has a Model 701X series card installed in it.

3.8.2 Installing switching cards

The procedure to install switching cards in the mainframe is explained in Section 2 of this manual. If using a switching card simulator as explained in the previous paragraph, leave the appropriate slot empty.

3.8.3 Card type

On power-up, the Model 7002 senses 701X type cards that are installed and automatically configures itself for proper operation. If a non-701X type card is installed in a slot, then you will have to assign the model number of the card to that slot.

Perform the following steps to check or change card assignments for the mainframe slots:

1. Press CARD CONFIGURATION to display the CARD CONFIG MENU.
2. Place the cursor on TYPE and press ENTER to select SET CARD TYPE. The card type for the currently selected slot will be displayed. For example:

   SET CARD TYPE 7012
   SLOT-#1 #2 #3 #4 #5 ▶

   In the above example, if #3 flashes, it indicates that the Model 7012 is installed in slot 3.

3. To check card assignment types for the other slots, simply use the cursor keys (◀ and ▶) to place the cursor on the slot number. Card type assignments are defined as follows:

   NONE = Slot is assigned as an empty slot (channel LEDs disabled).

   701X = High density card installed (i.e. Model 7011, 7012, 7013, 7014).

   9990 = Slot is assigned to operate as a simulator (40-channel multiplexer).

   9991 = Slot is assigned to operate as a simulator (4×10 matrix).

   7052 thru 7402 = Slot is assigned to operate for the selected model number.

4. Perform the following steps to change the card type assignment for a slot:
   a. Place the cursor on the desired slot number and press ENTER. For example:

      SLOT 5 CARD: NONE

      The above message indicates that slot 5 is assigned as an empty slot.

   b. Use the cursor keys to display the appropriate assignment. For example, if you have a Model 7052 installed in slot 5, assign 7052 to slot 5 as shown:

      SLOT 5 CARD: 7052

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Note that if a Model 701X series card is installed, you will not be able to change the assignment for that slot.

c. With the appropriate card type assignment displayed, press ENTER.

5. When finished, use the EXIT key to back out of the menu structure.

NOTE

A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraphs 4.8 and 4.11 for details).

3.9 Front panel operation summary

The Operation Demo (paragraph 3.7) takes you through a step-by-step procedure to open/close channels and to scan through a 20 channel scan list. 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 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.

3.9.1 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.

Display mode consideration

When defining a channel list or a scan list (Step 1 of the following procedure), you may want to place the instrument in the list display mode so that channel LED status corresponds to the channels in the selected list. However, after defining the channel list and/or scan list, return the instrument to the relay status display mode so that channel LED status will correspond to open and closed channels.

Paragraph 3.4.1 explains how to change the display mode using the keypad. With the light pen, the display mode is changed by clicking the SHOW LIST LED.

Step 1. Select list

SELECT CHANNELS (channel list)
SCAN CHANNELS (scan list)

■ **Keypad Method**

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

■ **Light Pen Method**

Click the SCAN LIST LED to toggle between the channel list and scan list. The EXIT LED also selects the channel list.

Step 2. Enter channels

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

Formats:	S!R!C (Matrix card)	S!C (Non-matrix card)
where;	S = slot	S = slot
	R = row	C = channel
	C = column	

■ **Keypad Method**

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

■ **Light Pen Method**

1. Click the channel LED to enter the channel into the list.
2. Use the hyphen (- LED) between channels to specify a range of channels (i.e. 1!1-1!10 = channels 1 through 10).

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3.9.2 Close and Open channels

Perform the following steps to control (close/open) the channels defined in the channel list.

Step 1. Make sure the RELAY STATUS display mode is selected.

If the instrument is not in the RELAY STATUS display mode, perform the following to select it:

■ **Keypad Method**

Press MENU. From the MAIN MENU select GENERAL. From the GENERAL MENU select DISPLAY. From the CONFIG LED DISPLAY menu select RELAY STATUS. Use EXIT to back out of the menu structure.

Note: Refer to paragraph 3.4.1 if you need a more detailed procedure to change the display mode.

■ **Light Pen Method**

Click the SHOW LIST LED.

Step 2. Close and Open Channels

■ **Keypad Method**

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.

■ **Light Pen Method**

Click the CLOSE LED to close the channels specified in the channel list. Clicking the OPEN LED will open the channels specified in the channel list. The OPEN ALL LED opens all channels, including any channels not included in the list.

3.9.3 Scan channels

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

Step 1. Make sure the RELAY STATUS display mode is selected

If the instrument is not in the RELAY STATUS display mode, perform the following to select it:

■ **Keypad Method**

Press MENU. From the MAIN MENU select GENERAL. From the GENERAL MENU select DISPLAY. From the CONFIG LED DISPLAY menu select RELAY STATUS. Use EXIT to back out of the menu structure.

Note: Refer to paragraph 3.4.1 if you need a more detailed procedure to change the display mode.

■ **Light Pen Method**

Click the SHOW LIST LED.

Step 2. 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.

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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 (or STEP LED) 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.

EXTERNAL – In general, each external trigger (via the External Trigger BNC connector) selects the next channel in the scan.

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 (or the STEP LED is clicked) 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.

NOTE: EXTERNAL and TRIGLINK are beyond the scope of Getting Started. Refer to Section 4 to use these selections.

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. See paragraph 4.13 to set DELAYs.

Step 3. 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 (or the STEP LED is clicked). 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 2.

A scan can be aborted at any time by pressing the OPEN ALL key (or clicking the OPEN ALL LED).

3.10 Introduction to IEEE-488.2 and SCPI

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

SCPI overview

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

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

Compatibility

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

NOTE

The term GPIB (General Purpose Interface Bus) is used in this manual and in the menu structure of the instrument. GPIB is simply another term for the IEEE-488 bus.

3.10.1 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.

3.10.2 Primary address

The primary address of the Model 7002 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.

3.10.3 Abbreviated common command summary

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

Table 3-1
Abbreviated common command summary

Mnemonic	Name	Description
*CLS	Clear status	Clears Error Queue and event registers.
*RST	Reset	Returns the 7002 to *RST default conditions (see Table 5-5).
*TRG	Trigger	Issues a bus trigger (same as group execute trigger command; GET).
*SAV <n>	Save	Saves the current setup configuration in memory (n = 0 to 9).
*RCL <n>	Recall	Returns the instrument to the setup configuration stored in memory (n = 0 to 9).

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3.10.4 Abbreviated SCPI command summary

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

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

Table 3-2
Abbreviated SCPI command summary

:SYSTem	Subsystem command path.
:PRESet	Set scan to a default configuration (see Table 5-5).
[:ROUTe]	Subsystem command path.
:CLOSe <list>	Path and command to close specified channels:
:STATe?	Request channels that are closed.
:OPEN <list>|ALL	Open specified (or all) channels.
:SCAN <list>	Path and command to specify channel list:
:POINts?	Query number of channels in scan list.
:INITiate	Initiate one trigger (scan) cycle.
:ABORt	Reset trigger system.
:ARM	Subsystem command path to configure scan:
:LAYer2	Path to program scan layer:
:COUNt <n>	Program number of scans (1 to 9999, or INFinite).
:DELay <n>	Program delay (0 to 99999.999 seconds
:SOURce <name>	Select control source: HOLD, Immediate, TIMer, MANual, BUS, TLINk, EXTernal.
:TIMer <n>	Set timer interval (0.001 to 99999.999 sec).
:TRIGger	Subsystem command path to program channel layer:
:COUNt <n>	Program number of channels (1 to 9999, or INFinite).
:AUTo <b>	Enable (on) or disable (off) automatic scan list count.
:DELay <n>	Program delay (0 to 99999.999 sec)
:SOURce <name>	Select control source: HOLD, Immediate, TIMer, MANual, BUS, TLINk, EXTernal.
:TIMer <n>	Set timer interval (0.001 to 99999.999 sec).

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

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3.10.5 Abbreviated syntax rules

Some of the basic syntax rules for programming the Model 7002 are covered in this paragraph. Detailed syntax information is provided in paragraph 5.9.

Commands and parameters

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

:OPEN ALL

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

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

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

Typical parameter types used to program the instrument include:

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

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

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

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

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

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

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

DEFault: Uses the *RST default parameter value

MINimum: Uses the lowest allowable parameter value

MAXimum: Uses the largest allowable parameter value

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

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

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

Query Commands

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

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

Whenever a query command is sent, the Model 7002 must be addressed to talk in order to send the response message to the computer. HP BASIC 4.0 example:

```
10  OUTPUT 707; ":clos:stat?"   ! Send query command.
20  ENTER 707; A$               ! Address 7002 to talk.
30  PRINT A$                    ! Display response message on CRT.
40  END
```

Program Messages

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

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

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

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

:trig:sour imm; :trig:del 0.5

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

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

:trig:sour imm; del 0.5

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

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

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

3.10.6 Programming examples

The following programming examples are written in Hewlett-Packard BASIC 4.0 programming language. The programs assume that the Model 7002 is set to primary address 7.

Programming example #1:
Closing and opening channels

The following program will close channels 1, 3, 4, 5, and 6 of slot 1, and then open them after a short delay:

```
10  OUTPUT 707; "*RST;  open all"
20  OUTPUT 707; ":clos (@ 1!1, 1!3:1!6)"
30  OUTPUT 707; ":clos:stat?"
40  ENTER 707; A$
50  PRINT A$
60  WAIT 3
70  OUTPUT 707; ":open (@ 1!1, 1!3:1!6)"
80  END
```

Line 10 Opens any channels that are closed.
Line 20 Close channels 1, 3, 4, 5, and 6 of slot 1.
Line 30 Request the closed channels.
Line 40 Address 7002 to talk.
Line 50 Display closed channels.
Line 60 Three second delay.
Line 70 Open the channels specified in the channel list.

Programming example #2:
Manual scanning

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

```
10  OUTPUT 707; ":syst:pres"
20  OUTPUT 707; ":scan (@1!1:1!10)"
30  OUTPUT 707; ":init"
40  END
```

Line 10 Return 7002 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
Line 20 Define scan list.
Line 30 Take 7002 out of idle state.

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 out of remote (press LOCAL key), each press of the STEP key will scan the next channel in the scan list.

Programming example #3:
Bus trigger controlled scan

The program in Example #2 is modified so that the channel scan will be controlled by bus triggers (*TRG or GET):

```
10  OUTPUT 707; ":syst:pres"
```


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```
20  OUTPUT 707; ":scan (@1!1:1!10)"
25  OUTPUT 707; ":trig:sour   bus"
30  OUTPUT 707; ":init"
40  END
```

Line 10 Return 7002 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).

Line 20 Define scan list.

Line 25 Program channel control source for bus triggers.

Line 30 Take 7002 out of idle state.

When the above program is run, the scan will arm and then wait for bus triggers to control the channel scan. Any of the following two programming statements can be used to provide a bus trigger:

```
OUTPUT 707; "*TRG"
TRIGGER   707
```

Every time one of the above statements is executed, a bus trigger will occur causing the next channel in the scan list to be scanned.

Programming example #4: Timer controlled channel scan

The program in Example #2 is modified so that the channel scan will be controlled by a timer:

```
10  OUTPUT 707; ":syst:pres"
20  OUTPUT 707; ":scan (@1!1:1!10)"
25  OUTPUT 707; ":trig:sour   tim"
26  OUTPUT 707; ":trig:tim   0.5"
30  OUTPUT 707; ":init"
40  END
```

Line 10 Returns 7002 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).

Line 20 Define scan list.

Line 25 Program channel control source for timer.

Line 26 Set timer for 0.5 second interval.

Line 30 Take 7002 out of idle state.

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

Programming example #5: Timer controlled scan

The program in Example #4 is modified to perform two scans, the first scan will start immediately and the second scan will start 10 seconds after the start of the first scan:

```
10  OUTPUT 707; ":syst:pres"
20  OUTPUT 707; ":scan (@1!1:1!10)"
22  OUTPUT 707; ":arm:lay2:coun   2"
23  OUTPUT 707; ":arm:lay2:sour   tim"
24  OUTPUT 707; ":arm:lay2:tim 10"
25  OUTPUT 707; ":trig:sour   tim"
26  OUTPUT 707; ":trig:tim   0.5"
30  OUTPUT 707; ":init"
40  END
```

Line 10 Return 7002 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).

Line 20 Define scan list.

Line 22 Program scan count to 2.

Line 23 Program scan control source for timer.

Line 24 Set scan layer timer for 10 second interval.

Line 25 Program channel control source for timer.

Line 26 Set channel layer timer for 0.5 second interval.

Line 30 Take 7002 out of idle state to start the scan.

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4

Front Panel Operation

4.1 Introduction

This section covers all aspects of front panel operation. Paragraphs in this section are organized as follows:

4.2 Power-up procedure: Covers information on connecting the instrument to line power, and the power-up sequence.

4.3 Displays: Covers the two displays of the Model 7002; the vacuum fluorescent display (VFD) that is used for alphanumeric information and the LED display that provides status information for each channel.

4.4 Analog backplane: Explains how two or more Model 701X switching cards may be internally connected together through the analog backplane of the Model 7002.

4.5 Light pen option: Explains how to use the optional light pen and summarizes the operations that can be performed with it.

4.6 Display modes: Covers the two display modes that can be used for normal operation; the relay status display mode and the list display mode.

4.7 Channel assignments: Explains the channel assignment formats necessary to program the Model 7002.

4.8 Channel list and Scan list: Explains how to create a channel list (for open/close operations) and a scan list (for scanning operations).

4.9 Closing and opening channels: Explains how to close and open channels.

4.10 Scanning channels: Explains how to scan channels.

4.11 Channel patterns: Explains how to create (store) channel patterns, and how to recall them from memory.

4.12 Menu: Covers miscellaneous operations and selections controlled from the MAIN MENU.

4.13 Card configuration: Covers the various configuration operations for the 10 slots (Card 1 through Card 10) using the CARD CONFIG MENU.

4.14 Scan configuration: Covers the CONFIGURE SCAN menu, which is used to configure the three layers of the scan operation.

4.15 Digital I/O port: Covers the input/output port, which consists of four output lines and one input line.

4.16 External triggering: Covers external triggering using the rear panel BNC connectors.

4.17 Trigger link: Covers external triggering using the trigger link.

4.2 Power-up procedure

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

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4.2.1 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 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.

4.2.2 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.

4.2.3 Power-up sequence

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

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

   No Comm Link

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

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

   Model 7002
   BXX BYY BZZ IEEE Addr = 07

   where:

   BXX is the firmware revision level for the main CPU.

   BYY is the firmware revision level for the VFD display.

   BZZ is the firmware revision level for the LED display.

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

NOTE

On power-up, the Model 7002 detects Model 701X series cards that are installed and automatically configures the occupied slots for proper operation. Non-701X series cards are not detected. The slots that are occupied by these cards must initially be assigned to the appropriate model numbers. See paragraph 4.13.1 to check and/or change the card type for each slot that does not contain a Model 701X series card.

4.3 Front panel displays

The Model 7002 uses two displays. The vacuum fluorescent display (VFD) provides alphanumeric information while the LED array display provides status information for each channel.

4.3.1 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.

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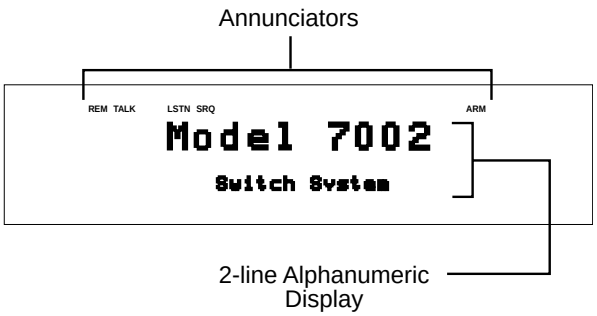


Figure 4-1
Vacuum fluorescent display (VFD)

Display messages

Display messages include the various configuration menus, error messages, status messages, and messages associated with operation of the light pen option. Error and status messages for the Model 7002 are summarized in Table 4-1. Light pen messages are covered in paragraph 4.5.3.

In addition, the front panel INFO key provides context-sensitive operating information. Pressing EXIT or INFO a second time will cancel the message.

Table 4-1
Error and status 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)
-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)

Table 4-1 (continued)
Error and status messages

Note: Messages associated with light pen operation are located in paragraph 4.5.3.

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Table 4-1 (continued)
Error and status messages

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

EE = Error event
SE = Status event

Annunciators

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

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

REM — Turns on to indicate that the Model 7002 is in remote when used over the IEEE-488 bus. The Model 7002 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 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 can be placed in the active listener state by addressing it to listen.

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

4.3.2 LED display

The LED display (see Figure 4-2) is primarily made up of 10 arrays of light emitting diodes (LEDs). Each 40 LED array corresponds to a mainframe slot. The significance of these channel LEDs depends on which display mode is currently selected; (relay status display mode or a list display mode), and whether or not the LED Graticule is enabled (see paragraph 4.6).

There is also a column of 16 LEDs located to the right of the channel LEDs. Two of these LEDs, SCAN LIST and SHOW LIST, indicate display mode status.

Note that all of the front panel LEDs can function as control switches with the addition of the light pen option (see paragraph 4.5 for details).

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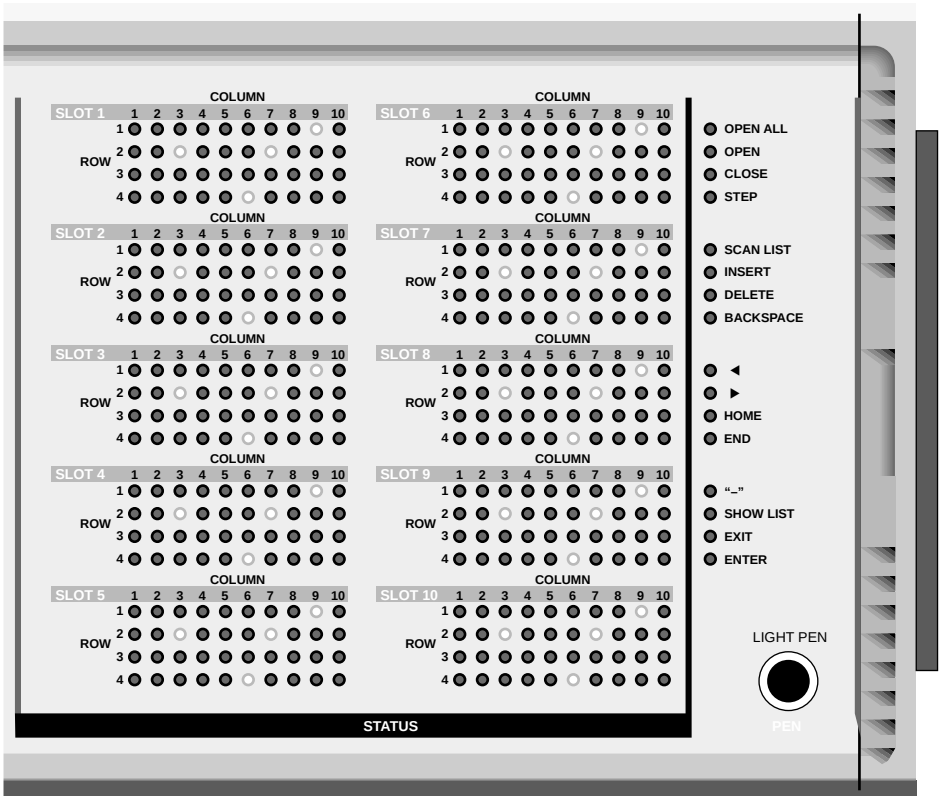


Figure 4-2
LED display

4.4 Analog backplane

The Model 7002 has a three-pole (High, Low and Guard) analog backplane that allows the rows (or banks) of a Model 701X series card installed in one slot to be connected to the rows (or banks) of 701X series cards installed in other slots. Figure 4-3 shows a simplified drawing of the analog backplane. This drawing shows one of the four backplane rows. Figure 4-4 provides more detail by showing how each slot is connected to the backplane.

NOTE

As shown in Figure 4-3, there are jumpers that can be removed if you wish to isolate slots 1 through 5 from slots 6 through 12. Refer to the service section of this manual for details on the removal of these jumpers.

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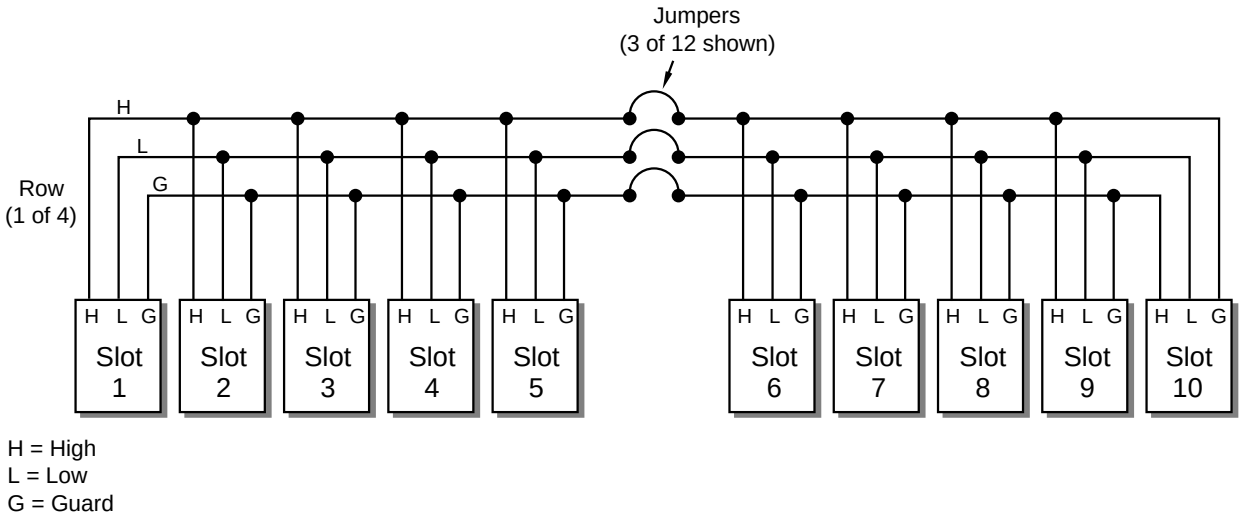


Figure 4-3
Analog backplane (simplified)

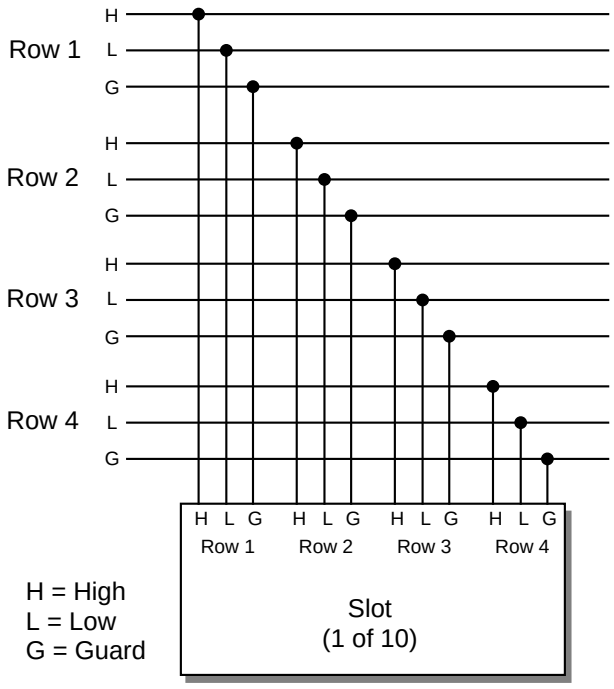


Figure 4-4
Analog backplane (detail for each slot)

In order to connect the rows (or banks) of two or more cards through the backplane, the backplane jumpers on the cards must be installed. For example, if the backplane jumpers of three Model 7012 matrix cards are installed, the rows of the three cards are connected together simply by installing them in the mainframe. The result is a 4×30 matrix. If the backplane jumpers on two or all three of the cards are removed, the three cards would be electrically isolated from each other resulting in three separate 4×10 matrices. Figure 4-5 shows how the Model 7012 is connected to the analog backplane. Note that the matrix card has only two poles (high and low). The third pole of the analog backplane (guard) is not used.

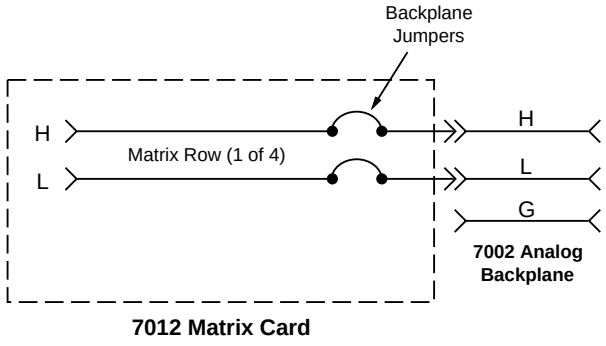


Figure 4-5
Matrix row connections to analog backplane

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Not all Model 701X series cards can be connected to the analog backplane of the Model 7002. The Model 7013 relay card is made up of 20 individual IN/OUT relay channels. Each channel is electrically isolated from each other. A Model 7013 installed in a slot of the mainframe is electrically isolated from any other card installed in the mainframe.

NOTE

The Model 7002 does not provide an analog backplane for non-701X series cards (such as the Model 7052). A non-701X series cards installed in a mainframe slot is electrically isolated from any other card installed in the mainframe. The only way to connect one of these cards to a card in another slot is to wire them together.

4.5 Light pen option

When plugged in, the optional light pen allows you to perform point and click programming using the front panel LEDs. Each LED functions as an electronic switch that is activated (clicked) by the light pen.

4.5.1 Light pen connection

The Model 7002 should be turned off when connecting the light pen.

The LIGHT PEN receptacle is located at the lower right-hand corner of the front panel. There is a release button on the plug for the light pen. With the button at the 12 o'clock position, push the light pen plug into the receptacle. Light pen operation is automatically activated when it is plugged into the mainframe.

The light pen can be removed by pressing the release button and pulling the plug out of the receptacle.

4.5.2 Light pen operations

To activate (click) an LED, place the head of the light open near the desired LED and press the button on the barrel of the pen. An LED that is clicked blinks for a couple of seconds and then assumes the appropriate state. Note that the associated operation occurs immediately after the LED is clicked and does not wait for the blinking to finish. The blinking simply provides feedback to indicate that you clicked the LED.

Channel LEDs

The significance of these LEDs depends on which display mode is currently selected and whether or not the LED Graticule is enabled (see paragraph 4.6). Table 4-2 summarizes the significance of the channel LEDs.

In the relay status display mode (RELAY STATUS displayed on the VFD), clicking a channel LED adds that channel to the list currently displayed on the VFD. For example, if you click an LED for an available channel, the LED blinks for a couple of seconds to indicate that the channel has been added to the list. Keep in mind that the status (open or closed) of the channel is not affected. Clicking an LED simply adds the channel to the list.

In the channel list display mode (CHANNEL LIST DISPLAY displayed on the VFD), clicking a channel LED adds (or removes) that channel to (or from) the channel list. For example, a dimly lit (or off) channel LED indicates that channel is not included in the channel list. If you click this dimly lit LED, it blinks for a couple of seconds and then goes to the brightly lit state to indicate that the channel has been added to the channel list. Clicking this brightly lit LED a second time causes it to become dimly lit (or off) indicating that it has been deleted from the channel list.

In the scan list display mode (SCAN LIST DISPLAY displayed on the VFD), clicking a channel LED adds that channel to the scan list. For example, if you click a dimly lit (or off) channel LED, it blinks for a couple of seconds and then goes to the brightly lit state to indicate that the channel has been added to the scan list. Each subsequent click of this LED again adds the channel to the scan list.

Control LEDs

The 16 control LEDs are located to the right of the channel LEDs. Some of these allow you to perform the same operations that are normally performed using the front panel keys.

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Clicking one of the following LEDs is analogous to pressing the similarly labeled front panel key.

OPEN ALL	SCAN LIST	▶
OPEN	INSERT	-
CLOSE	DELETE	EXIT
STEP	◀	ENTER

When one of the above LEDs is clicked, the LED will blink for a couple of seconds to indicate that the associated operation is being performed. Note that the SCAN LIST LED also provides status. When the SCAN LIST LED is brightly lit, the scan list is currently selected, and when dimly lit (or off), the channel list is selected.

The following four LEDs do not have front panel key counterparts and are explained as follows:

BACKSPACE — Clicking this LED moves the VFD cursor back (left) to the previous channel entry and removes it from the list. The channel entry could be a single channel or a range of channels. If the cursor is at the home position (first entry in the list), clicking BACKSPACE deletes that channel entry. This is analogous to pressing the ◀ key and then the DELETE key.

HOME — Clicking this LED will move the VFD cursor to the beginning of the list.

END — Clicking this LED will move the VFD cursor to the end of the list.

SHOW LIST — Clicking this LED toggles the instrument between the list display mode (LED brightly lit) and the relay status display mode (LED dimly lit or off).

4.5.3 Light pen messages

The following VFD messages are associated with light pen operations:

Message	Explanation
LIGHT PEN MIS-READ	LED not activated when light pen button is pressed. Occurs when the light pen is too far away from the LED or is not pointed at the LED.
INVALID SELECTION	LED not available for activation. Occurs when clicking an LED for a channel that does not exist (channel LED completely off).
EXIT from menu before using the light pen.	LED not available while in a menu. Occurs when an LED (other than Exit or Enter) is clicked while in a menu structure.

When any of the above messages occur, the operation associated with the LED is simply not performed.

4.6 Display modes

There are two basic display modes for the Model 7002:

Relay status display mode — Use this display mode when opening/closing or scanning channels. The channel LEDs provide the real-time state (on or off) of each channel in the switch system

List display mode — You can use this display mode when creating a channel list or a scan list. The brightly lit channel LEDs correspond to channels that are included in the selected list.

In addition to the two basic display modes, you can also control the LED graticule. Disabling the LED graticule provides increased contrast between on and off LEDs by eliminating the dimly lit state. Each LED will either be off or brightly lit (see paragraph 4.6.4 for more information).

4.6.1 Relay status display mode

In the relay status mode, the channel LEDs provide real-time status (open or closed) of each available channel. This display mode is denoted by the “RELAY STATUS” message on

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the VFD which also includes the currently selected list. The following table summarizes the various display messages and LED annunciators for the relay status display mode:

Selected list	VFD message	SHOW LIST LED	SCAN LIST LED
Channel list	See Figure 4-6A	Dimly lit (or off*)	Dimly lit (or off*)
Scan list	See Figure 4-6B	Dimly lit (or off*)	Brightly lit

*LED is off if the LED Graticule is disabled (see paragraph 4.6.4).



A) Channel List Selected (Power-up default)



B) Scan List Selected

Figure 4-6
VFD relay status mode

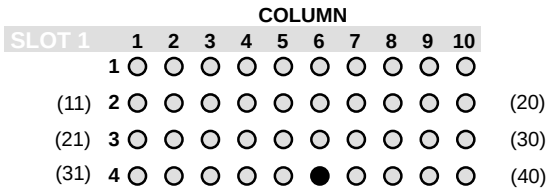
The significance of each channel LED while in the relay status display mode is explained in Table 4-2.

Basic channel designations for each LED array depend on the type of card installed in the slot. If a non-matrix type card (i.e. Model 7011 multiplexer) is installed, the channels are numbered 1 through 40. Figure 4-7A shows that channel 36 of a non-matrix type card is closed.

If, however, a matrix card (i.e. Model 7012) is installed, the channels are designated as row/column crosspoint coordinates. Figure 4-7B shows the matrix crosspoint at row 4, column 6 (R4C6) closed.

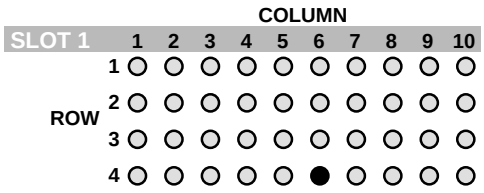
NOTE

When programming the Model 7002, the slot number must be included with the basic channel designation. Paragraph 4.7 explains how to determine channel assignments for programming the mainframe.



Channel 36 of slot 1 closed

A) Non-matrix type card



R4C6 crosspoint of slot 1 closed

B) Matrix card

● = Closed channel (Brightly lit LED)

Figure 4-7
Interpreting channel LEDs (relay status display mode)

4.6.2 List display modes

In a list display mode, the channel LEDs indicate which channels are included in the selected list. There are two list display modes; the channel list display mode and the scan list display mode. The following table summarizes the various display messages and LED annunciators for the two list display modes:

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Display mode	VFD message	SHOW LIST LED	SCAN LIST LED
Channel list	See Figure 4-8A	Brightly lit	Dimly lit (or off*)
Scan list	See Figure 4-8B	Brightly lit	Brightly lit

*LED is off if the LED Graticule is disabled (see paragraph 4.6.4).



A) Channel List Selected



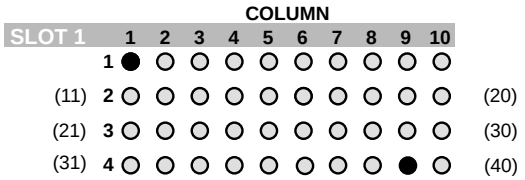
B) Scan List Selected

Figure 4-8
VFD list display modes

The significance of each channel LED while in a list display mode is summarized in Table 4-2.

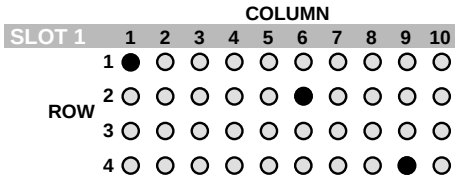
A channel LED that is brightly lit indicates that it is included in the selected list. Note that the channel LEDs do not provide complete information about the scan list. They do not indicate the order that the channels are to be scanned and they do not indicate whether a channel is used more than one time in the scan list. The complete scan list, including the order of the channel scan and repeated channels, is provided by the VFD.

Channel designations for the list display mode are the same as for the relay status display mode. Figure 4-9A, shows that channels 1, 16 and 39 are included in the selected list. Figure 4-9B shows that matrix crosspoints R1C1 (row 1, column 1), R2C6 and R4C9 are included in the selected list.



List includes channels 1, 16, and 39 of slot 1.

A) Non-matrix type card



List includes matrix crosspoints
R1C1, R2C6 and R4C9 of slot 1.

B) Matrix card

● = Channel included in list (Brightly lit LED)

Figure 4-9
Interpreting channel LEDs (list display mode)

NOTE

When programming the Model 7002, the slot number must be included with the basic channel designation. Paragraph 4.7 explains how to determine channel assignments for programming the mainframe.

4.6.3 Changing the display mode

During normal operation, the instrument is either in the relay status display mode or in a list display mode. The following information explains how to change the display mode.

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Front panel keys method

Perform the following steps to change the display mode using the front panel keys:

1. Press MENU to display the MAIN MENU.
2. Using the cursor keys (◀ and ▶), place the cursor on GENERAL and press ENTER to display the GENERAL MENU.
3. Place the cursor on DISPLAY and press ENTER to display the CONFIG LED DISPLAY menu. The cursor position will indicate the currently selected display mode. RELAY-STATUS is the relay status display mode, and CURRENT-LIST is the list display mode.
4. Place the cursor on the alternate display mode selection and press ENTER.
5. Press EXIT two times to back out of the menu structure.
6. The SCAN LIST key toggles between the channel list and the scan list. To select the alternate list, press SCAN LIST.

Light pen method

Perform the following steps to change the display mode using the optional light pen:

1. The SHOW LIST LED toggles the instrument between the relay status display mode (LED dimly lit or off) and the list display mode (LED brightly lit). If you wish to select the alternate display mode, click SHOW LIST.
2. The SCAN LIST LED toggles the display between the scan list (LED brightly lit) and the channel list (LED dimly lit or off). If the desired list is not already selected, click this LED to select the alternate list.

4.6.4 LED graticule control

LED Graticule control allows you to increase contrast between on and off LEDs by eliminating the dimly lit state for LEDs. With the LED Graticule disabled (off), LEDs will be either off or brightly lit. A disadvantage to disabling the LED graticule is that it is not obvious which channels are available in the test system. Enabling (on) the LED Graticule restores the dimly lit state. Table 4-2 explains the significance of the channel LEDs for the two graticule modes.

LED Graticule control is performed from the MAIN MENU as follows:

```
Press      MENU
Select       GENERAL
Select         DISPLAY
Select           GRATCULE-CONTROL
                 ON   OFF
```

Select OFF to disable the LED Graticule or ON to enable it. Note that the detailed procedure to disable or enable the LED Graticule is contained in paragraph 4.12.6.

The instrument will power-up with the LED Graticule enabled unless the graticule OFF condition is saved as the USER SETUP power-on default (see USER SETUP in paragraph 4.12.1).

Front panel RESET, and the *RST and :SYSTem:PRESet bus commands will enable the LED Graticule.

NOTE

If the main CPU firmware is not compatible with the LED display firmware, the following error will occur when trying to disable the LED Graticule:

ERROR:ID CODE = +551
Incorrect software revision

If this error should occur, contact Keithley to resolve the firmware incompatibility.

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Table 4-2
Significance of channel LEDs

Display mode	LED Graticule	Channel LEDs		
		Off	**Dimly lit**	**Brightly lit**
Relay status	On	Channel not available	Channel open	Channel closed
	Off	Channel not available or Channel open	—	Channel closed
List	On	Channel not available	Channel not included in selected list	Channel included in selected list
	Off	Channel not available or channel not included in selected list	—	Channel included n selected list

4.7 Channel assignments

Channel assignments used to program the mainframe are based on the switching card type, basic channel designation, and the slot in which the card is installed.

4.7.1 Non-matrix type cards

A non-matrix type card, such as the Model 7011 multiplexer card, simply consists of 40 channels (1-40) as shown in Figure 4-7A and Figure 4-9A. When programming the Model 7002, you need to designate the slot in which the card is installed. Thus, 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
CHANNEL 4!20 = Slot 4, Channel 20
CHANNEL 9!2 = Slot 9, Channel 2
CHANNEL 2!36 = Slot 2, Channel 36

Mainframe channel assignments for non-matrix type switching cards are shown in Figure 4-10.

4.7.2 Matrix cards

Channels for a matrix card, such as the Model 7012, are organized as row/column crosspoints as shown in Figure 4-7B and Figure 4-9B. When programming the Model 7002, you need to designate the slot in which the card is installed. Thus, combining the slot number with the crosspoint coordinates (row/column) provides the CHANNEL assignment for the mainframe. Slot, row, and column are separated by exclamation points (!). For the following examples, “CHANNEL” refers to the programming channel assignment for the mainframe.

CHANNEL 7!1!1 = Slot 7, Row 1, Column 1
CHANNEL 2!3!6 = Slot 2, Row 3, Column 6

Mainframe channel assignments for matrix cards are shown in Figure 4-11.

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Slot 1	1	2	3	4	5	6	7	8	9	10
1	1!1	1!2	1!3	1!4	1!5	1!6	1!7	1!8	1!9	1!10
2	1!11	1!12	1!13	1!14	1!15	1!16	1!17	1!18	1!19	1!20
3	1!21	1!22	1!23	1!24	1!25	1!26	1!27	1!28	1!29	1!30
4	1!31	1!32	1!33	1!34	1!35	1!36	1!37	1!38	1!39	1!40

Slot 2	1	2	3	4	5	6	7	8	9	10
1	2!1	2!2	2!3	2!4	2!5	2!6	2!7	2!8	2!9	2!10
2	2!11	2!12	2!13	2!14	2!15	2!16	2!17	2!18	2!19	2!20
3	2!21	2!22	2!23	2!24	2!25	2!26	2!27	2!28	2!29	2!30
4	2!31	2!32	2!33	2!34	2!35	2!36	2!37	2!38	2!39	2!40

-
-
-
-

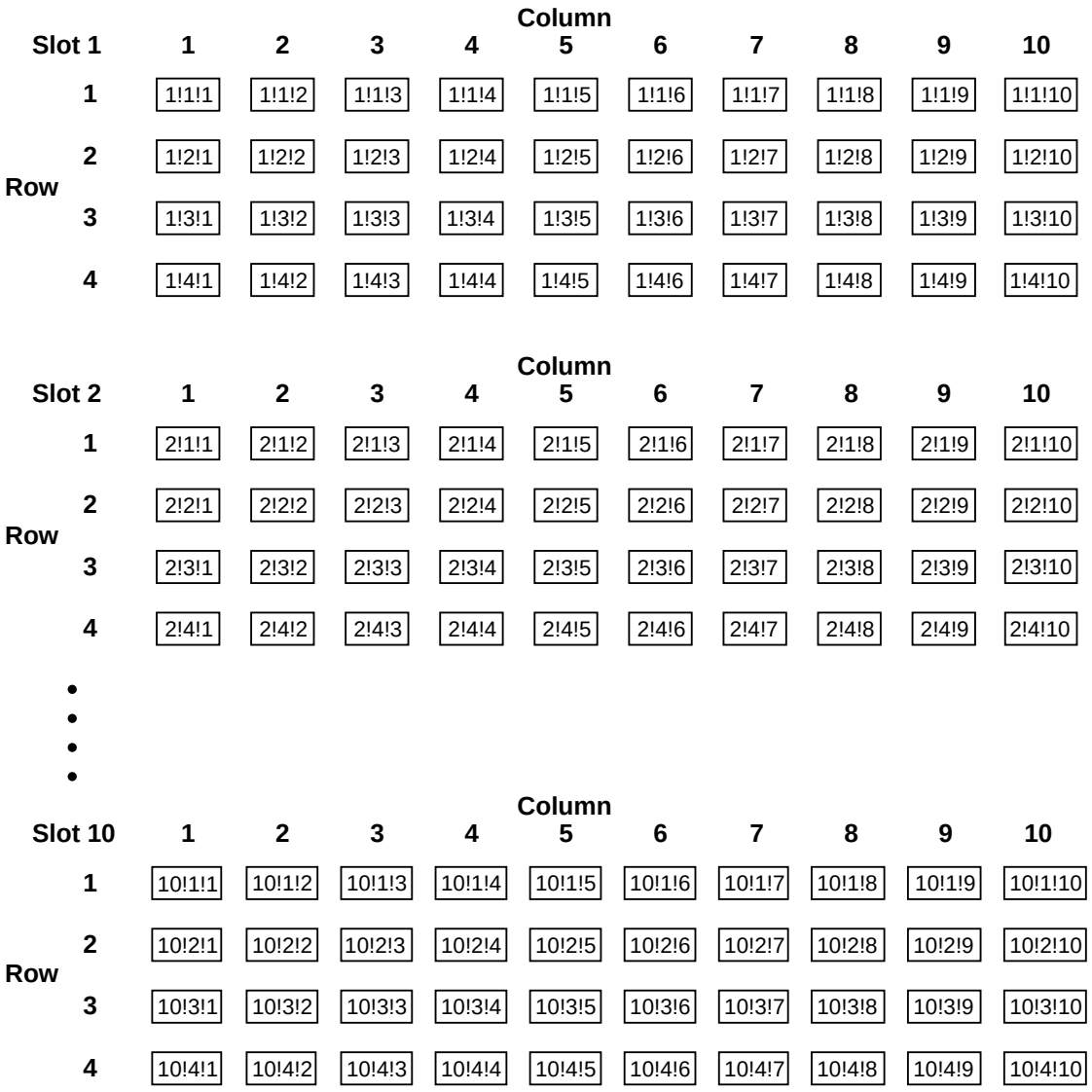
Slot 10	1	2	3	4	5	6	7	8	9	10
1	10!1	10!2	10!3	10!4	10!5	10!6	10!7	10!8	10!9	10!10
2	10!11	10!12	10!13	10!14	10!15	10!16	10!17	10!18	10!19	10!20
3	10!21	10!22	10!23	10!24	10!25	10!26	10!27	10!28	10!29	10!30
4	10!31	10!32	10!33	10!34	10!35	10!36	10!37	10!38	10!39	10!40

Format: S!C where; S is the slot number (1-10)
C is the channel number (1-40)

Examples: 2!36 = Slot 2, Channel 36
8!12 = Slot 8, Channel 12

Figure 4-10
Channel assignments (non-matrix type cards)

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Format: S!R!C where; S is the slot number (1-10)
R is the row number (1-4)
C is the column number (1-10)

Examples: 2!3!6 = Slot 2, Row 3, Column 6
8!4!9 = Slot 8, Row 4, Column 9

Figure 4-11
Channel assignments (matrix cards)

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4.8 Channel list and scan list

The Model 7002 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 paragraph 4.9 (Closing and opening channels) and 4.10 (Scanning channels).

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.

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

1. A channel in the Scan List becomes unavailable. A channel can become unavailable by changing a slot assignment (Card TYPE) or by changing to a pole mode that reduces the number of available channels.
2. A channel in the Scan List becomes restricted. A channel becomes restricted by adding it to the restricted channel list.
3. Two or more channels in the Scan List become interlocked. Channels become interlocked by specifying them in the Interlock lists.

The following examples demonstrate how the Scan List is lost:

1. Assume the Scan List includes channel 1!21 and the assignment for slot 1 is changed to a multiplexer card that has only 20 channels. Since channel 1!21 no longer exits, the entire Scan List is cleared.
2. Assume the Scan List includes channel 1!1 and the assignment for slot 1 is changed to a matrix card. Since channel 1!1 is an incorrect format for a matrix card, it no longer exists. The entire Scan List is cleared.
3. Assume the Scan List includes channel 1!21 and the slot (slot 1) is configured for 2-pole operation. Changing the pole-mode of slot 1 to 4-pole operation makes channel 1!21 unavailable and clears the entire Scan List.
4. Assume Channel Pattern M1 is included in the Scan List and M1 includes channel 1!1 as a closed channel. If channel 1!1 becomes unavailable, the entire Scan List is cleared. Also note that Channel Pattern M1 is also cleared (see paragraph 4.11).
5. Assume the Scan List includes channel 1!1. If channel 1!1 is then added to the restricted channel list, the entire Scan List is cleared.
6. Assume the Scan List includes channels 1!1 and 1!2. If these two channels are then interlocked to each other, the entire Scan List is cleared.
7. Assume the Scan List includes channel 1!1 and Card Pair 1&6 is enabled. Note that with the card pair enabled, channel 6!1 is indirectly included in the Scan List. If channel 6!1 is then added as a restricted channel, the entire Scan List will clear since one of its channels has become restricted.
8. Assume the Scan List includes channels 1!1 and 1!2, and Card Pair 1&6 is enabled. Note that with the card pair enabled, channels 6!1 and 6!2 are indirectly included in the Scan List. If channels 6!1 and 6!2 are then specified as interlocked channels, the entire Scan List will clear since an interlock violation was introduced into the Scan List.

Notes:

1. When a scan list is modified over the IEEE-488 bus, the displayed scan list will not update until a display state change occurs (i.e., pressing the SCAN LIST key).
2. A channel list is lost after the instrument is turned off. However, a channel pattern stored in memory can be recalled at any time. The channel list won't be reinstated but the channel pattern will be reinstated (see paragraph 4.11.2).
3. A scan list can contain up to 400 channels (including repeats). An entry that causes the list to exceed 400 channels will generate the following error:

   ERROR: ID CODE = -223
   Too much data

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

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SCAN CHANNELS 1!1-1!40, 2!1-2!40, 3!1-3!40, 4!1-4!40, 5!1-5!40, 5!1, 6!1-6!40, 7!1-7!40, 8!1-8!40, 9!1-9!40, 10!1-10!40,

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

Use the following procedures to create a channel list and/or a scan list. The first procedure (paragraph 4.8.1) creates a list using the front panel keys, while the second procedure (paragraph 4.8.2) creates a list using the optional light pen.

4.8.1 Keypad entry method

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.

NOTE

If you want to display the channels of the selected list on the LED display, make sure that the list display mode is selected. Paragraph 4.6.3 explains how to change the display mode.

A previously defined list can be cleared from the display by pressing the CLEAR LIST key.

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:

   Non-matrix type card — For a non-matrix type card, 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

   Matrix card — For a matrix card, use the keypad to first enter the row number (1 through 4), and then the column number. The separator between row and column will automatically be inserted after you enter the row number. For example, if you entered row 3, column 6 (with slot 2 previously selected), the entered channel data will look like one of these:

   SELECT CHANNELS 2!3!6
   SCAN CHANNELS 2!3!6

   NOTE

   The Model 7002 can store up to 500 channel patterns in memory locations M1 through M500. A channel pattern is simply a pattern of open and closed channels. A channel pattern can be entered by simply keying in the memory location using the “M” key on the keypad. For example, assume memory location M1 contains a specific channel pattern. Enter the channel pattern by simply keying in M1 from the keypad. The entered channel data will look like one of these:

   SELECT CHANNELS M1
   SCAN CHANNELS M1

   Paragraph 4.11.1 explains how to store channel patterns into memory.

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

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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.
   b. Key in the new channel entry, and press the right cursor key (▶) or ENTER to add the comma.
2. Deleting a channel — Perform the following steps to delete a channel:
   a. Place the cursor at the beginning of the channel to be deleted.
   b. Press the DELETE key to delete the channel entry.
3. Inserting a channel — Perform the following steps to insert a channel anywhere in the list:
   a. Position the cursor at the desired location in the list. The channel will be inserted between the cursor and the channel entry before it.
   b. Press the INSERT key. The following message will be displayed:

      ```
      INSERTING ENTRY
      ```

   c. Key in the new channel entry, and press the right cursor key (▶) or ENTER to add the comma.
   d. Press INSERT a second time to cancel the insert edit function.
4. Deleting all channels — The entire list can be cleared by pressing CLEAR LIST.

Summary of channel list and scan list entry keys:

KEYPAD:

Number keys — Enter slot and channel numbers (row and column for matrix).

"M" and number keys — Enter memory location of channel pattern (i.e. M1).

"-" — Define a range of channels (i.e. 1!1-1!9).

" ▶ " — Enter channel separator (,).

" ◀ and ▶ " — After terminating list, use cursor keys to select channel entry to be edited.

ENTER: Enter channel separator (,) and list terminator (,) (i.e 1!1,).

INSERT: Create new channel entry at selected location in the list.

DELETE: Clear selected channel entry.

CLEAR LIST: Clear displayed list.

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4.8.2 Light pen entry method

Perform the following steps to create a channel list or scan list using the optional light pen:

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 LED toggles between the channel list and the scan list. If the desired list is not already displayed, click SCAN LIST.

NOTE

If you want to display the channels of the selected list on the LED display, make sure that the list display mode is selected. The SHOW LIST LED toggles between the relay status display mode and the list display mode.

Note: A previously defined list can be cleared from the display by pressing the CLEAR LIST key.

Step 2. Enter channels into list.

1. Perform one of the following steps:
   a. Channel List — The channel LEDs are either single action type switches or toggle action type switches. In the relay status display mode, each click of a channel LED simply adds that channel to the channel list. In the channel list display mode, the first click of a channel LED adds the channel to the channel list. Clicking this LED a second time deletes the channel from the list.
   b. Scan List — The channel LEDs are single action type switches in this list mode. Every time a channel LED is clicked, the channel is added to the scan list.
2. A range of channels is entered into the list using the "-" LED as follows:
   a. Click the first channel of the range.
   b. Click the "-" LED to enter the range hyphen. If in a list display mode, the LED for the first channel in the range will blink.
   c. Click the last channel of the range. If in the list display mode, the LEDs for all the channels in the range become brightly lit. Keep in mind that range entries are limited to the same slot. If you click a channel of a different slot as the last channel in the range, the range entry will be cancelled and the last clicked channel will be added to the list.

NOTE

Channel patterns from memory must be entered using the front panel keys. See the NOTE in Step 2 of paragraph 4.8.1.

Step 3. Edit list as required.

Edit LEDs are available to make changes to a list. These LEDs allow you to change channels, delete channels, or insert channels anywhere in the scan list. When editing, a channel range (i.e. 1!1-1!6) is treated as a single entry.

1. Changing a channel entry:
   a. Place the cursor on the channel entry to be changed. Clicking the HOME LED moves the cursor to the beginning of the list and clicking END LED moves the cursor to the end of the list. Each click of the ◄ LED moves the cursor one entry to the left and each click of the ► LED moves the cursor one entry to the right.
   b. Click in the new channel entry. The new entry overwrites the old entry.
2. Deleting a channel entry — There are two ways to delete a channel entry:
   a. BACKSPACE — Clicking the BACKSPACE LED moves the cursor back (left) to the previous channel entry and removes it from the list. If the cursor is at the home position (first entry in the list), clicking BACKSPACE deletes that channel entry.
   b. DELETE — A channel entry can be deleted by placing the cursor on it and clicking the DELETE LED. Use HOME, END, ◄ and ► to maneuver the cursor.
3. Inserting a channel entry:
   a. Position the cursor at the desired location in the list. The channel entry will be inserted between the cursor and the channel entry before it. Use HOME, END, ◄ and ► to maneuver the cursor.
   b. Click the INSERT LED. The LED becomes brightly lit and the following message is displayed on the VFD:

      INSERTING ENTRY

   c. Click in the channel entry.

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d. Click the INSERT LED a second time to disable the channel insert function.

4. Deleting all channel entries — There is no LED that will delete multiple channel entries with a single click. To delete all entries in the list, press the CLEAR LIST key.

4.9 Closing and opening channels

NOTE

Before performing any close/open operations, make sure the switching cards you are using are properly configured. The CARD CONFIG MENU is used to configure various aspects of operation for the installed card(s). See paragraph 4.13 for details.

One of the basic operations of the Model 7002 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 (see paragraph 4.14.4). With Single Channel mode enabled, only the lowest numbered channel in the lowest numbered slot will close.

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 (or SCAN LIST LED) toggles between the scan list and the channel list. If the channel list is not currently selected, press SCAN LIST (or click the SCAN LIST LED). The following channel list prompt is displayed:

```
SELECT CHANNELS
```

Note that when the scan list is selected, pressing EXIT (or clicking the EXIT LED) will also select the channel list.

Step 2. Define channel list.

NOTE

If you want to display the channel list on the LED display, make sure the list display mode is selected. Paragraph 4.6.3 explains how to change the display mode using the front panel keys. With the optional light pen, the SHOW LIST LED toggles between the relay status display mode and the list display mode.

Enter channels into the channel list. Paragraph 4.8.1 explains how to enter channels using the keypad and paragraph 4.8.2 explains how to enter channels using the optional light pen. 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). Note that a channel pattern cannot be entered into the list using the light pen.

Step 4. Close (or open) listed channels.

Perform the appropriate close/open operation as follows:

NOTE

Make sure the relay status display mode is selected in order to monitor the real-time status (open or closed) of each channel on the LED display. Paragraph 4.6.3 explains how to change the display mode using the front panel keys. With the optional light pen, the SHOW LIST LED toggles between the relay status display mode and the list display mode.

1. Press the CLOSE key (or click the CLOSE LED) to close the listed channels. If in the relay status display mode, the corresponding channel LEDs become brightly lit to indicate which channels are closed.
2. Press the OPEN key (or click the OPEN LED) to open channels that are listed in the channel list. Note that only the listed channels will open. Any closed channels that are not included in the channel list will not be opened by OPEN. To open unlisted channels, press OPEN ALL.

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Notes:

1. CLOSE and OPEN are only functional when the channel list is selected. OPEN ALL opens all channels and is functional at all times no matter what is currently being displayed.
2. Depending on the type of switching card used, it is possible to exceed the current rating of the +6V supply by closing too many channels. If this occurs, a scan will abort (go into idle), all channels will open, and the following message will be displayed:

   ERROR: ID CODE = +350
   Too many channels closed

Summary of Close/Open keys and LEDs:

CLOSE — Close channels defined in channel list
OPEN — Open channels defined in channel list
OPEN ALL — Open all channels.

4.10 Scanning channels

The Model 7002 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.

4.10.1 Scan process (Trigger Model)

The following information describes front panel control of the scan process. The flowchart (Trigger Model) in Figure 4-12 summarizes scan operation from the front panel.

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 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 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.

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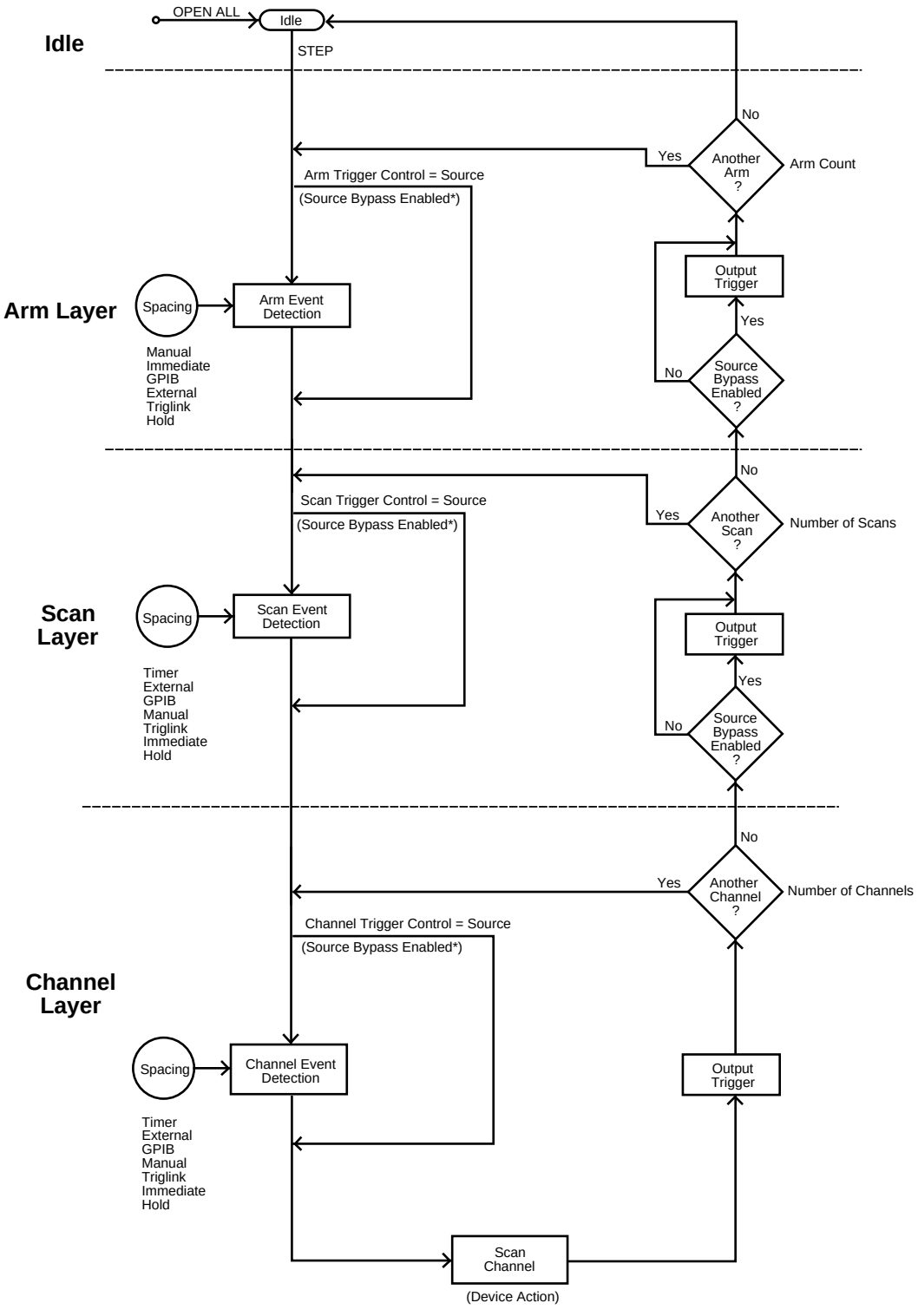


Figure 4-12
Trigger model (front panel scan process)

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Arm layer

NOTE

The arm layer is programmed from the SETUP ARM CONTROL menu (see paragraph 4.14.3).

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

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

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

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

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

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

Scan layer

NOTE

The scan layer is programmed from the SCAN CONTROL menu (see paragraph 4.14.2).

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 1msec 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.

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Channel layer

NOTE

The channel layer is programmed from the CHANNEL CONTROL menu (see paragraph 4.14.1).

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 (1msec 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 (see paragraph 4.13.4). For Model 701X series cards, the internal relay settling time is 6msec; 3msec after the relay closes and 3msec after the relay opens. The user programmed delay is in addition to the relay settling time.

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

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

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

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

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

See paragraph 4.17 for details on the Trigger Link.

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

4.10.2 Scan procedure

Perform the following steps to scan channels:

NOTE

Before performing scan operation, make sure the switching cards that you are using are properly configured. The CARD CONFIG menu is used to configure various aspects of operation for the installed card(s). See paragraph 4.13 for details.

Step 1. Press OPEN ALL (or click OPEN ALL LED).

Before configuring a scan, you should place the Model 7002 in the idle state by pressing OPEN ALL (or clicking the OPEN ALL LED). This will stop any scan that is currently in process, open all channels, and place the Model 7002 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 (or SCAN LIST LED) toggles between the scan list and the channel list. If the scan list is not currently selected, press SCAN LIST (or click the SCAN LIST LED). The following scan list prompt is displayed:

```
SCAN CHANNELS
```


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Step 3. Define scan list.

NOTE

If you want to display the channels of the scan list on the LED display, make sure the list display mode is selected. Paragraph 4.6.3 explains how to change the display mode using the front panel keys. With the optional light pen, the SHOW LIST LED toggles between the relay status display mode and the list display mode.

Enter channels into the scan list. Paragraph 4.8.1 explains how to enter channels using the keypad and paragraph 4.8.2 explains how to enter channels using the optional light pen. 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, and channels 1 through 10 of slot 4, and the channel pattern stored at memory location 1 (M1). Note that a channel pattern cannot be entered into the list using the light pen.

Channels will be scanned in the order that 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. Detailed information on using the CHANNEL CONTROL menu is provided in paragraph 4.14.1 and Table 4-6.

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

1. From the CONFIGURE SCAN menu, select CHAN CONTROL.
2. From the CHANNEL CONTROL menu, select CHANNEL SPACING.
3. From the SELECT CHAN SPACING menu, select one of the following to control the process of scanning channels:
   a. TIMER — Use to set a time interval (1msec to 99999.999 seconds) between channels.
   b. EXTERNAL — With this selection, external triggers control channel spacing. Each trigger applied to the rear panel EXTERNAL TRIGGER connector will select the next channel of the scan.
   c. GPIB — With this selection, bus triggers (GET or *TRG) control channel spacing. Each bus trigger received by the Model 7002 will select the next channel of the scan.
   d. 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.
   e. TRIGLINK — With this selection, triggers received over the Trigger Link will control channel spacing. Each trigger will select the next channel in the scan.
   f. IMMEDIATE — With this selection, events are not used to control channel spacing. Only the time delay for relay settling and an optional DELAY (see paragraph 4.13.4) 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

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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. Detailed information on using the SCAN CONTROL menu is provided in paragraph 4.14.2.

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 (1msec to 99999.999 seconds) between scans.
   b. EXTERNAL — With this selection, external triggers control scan spacing. A trigger applied to the rear panel EXTERNAL TRIGGER connector will allow operation to proceed to the channel layer.
   c. GPIB — With this selection, bus triggers (GET or *TRG) control scan spacing. A bus trigger received by the Model 7002 will allow operation to proceed to the channel layer.
   d. 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.
   e. 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.
   f. 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.

Step 6. Configure the Arm Layer of the scan.

The arm layer is programmed from the ARM CONTROL menu of the CONFIGURE SCAN menu. Detailed information on using the ARM CONTROL menu is provided in paragraph 4.14.3.

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 will allow operation to proceed to the scan layer.
   d. EXTERNAL — With this selection, external triggers control arm spacing. A trigger applied to the rear panel EXTERNAL TRIGGER connector will allow operation to proceed to the scan layer.
   e. 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.

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NOTE

After the scan is configured, keep pressing the EXIT key (or clicking the EXIT LED) to back out of the menu structure and return to the normal display mode.

Step 7. Start the scan

NOTE

Make sure the relay status display mode is selected in order to monitor the real-time status of each channel on the LED display. Paragraph 4.6.3 explains how to change the display mode using the front panel keys. With the optional light pen, the SHOW LIST LED toggles between the relay status display mode and the list display mode.

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

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.

4.10.3 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. For example, if the instrument is waiting for an EXTERNAL trigger event, you can instead press STEP to provide the event.

NOTE

The STEP and OPEN ALL keys have LED counterparts. Thus, with the optional light pen, you can click these LEDs instead of pressing the keys.

Example 1:

ARM SPACING = IMMEDIATE

SCAN SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

CHANNELSPACING=TIMER,EXTERNAL,GPIB,MANUALorTRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002 in the idle state.
2. Press STEP to take the 7002 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

CHANNELSPACING=TIMER,EXTERNAL,GPIB,MANUALorTRIGLINK

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

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Example 3:

ARM SPACING = MANUAL, GPIB, EXTERNAL or TRIGLINK
SCAN SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK
CHANNELSPACING=TIMER,EXTERNAL,GPIB,MANUALorTRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002 in the idle state.
2. Press STEP to take the 7002 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, EXTERNAL or TRIGLINK
SCAN SPACING = IMMEDIATE
CHANNELSPACING=TIMER,EXTERNAL,GPIB,MANUALorTRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7002 in the idle state.
2. Press STEP to take the 7002 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.
9. The next channel spacing event will select the second channel and disarm (idle) the scan.

Scanning notes:

1. The STEP key (or LED) is always functional during a scan and can be used to provide a spacing event. For example, if programmed for TIMER channel spacing, the STEP key (or LED) can also be used to select the next channel.
2. Forbidden Channels cannot be entered into the scan list.
3. With Single Channel enabled, only the lowest numbered channel in a channel pattern (i.e. M1) will close when selected.
4. Card Pair is functional during a scan. The channels included in the scan list and the corresponding channels for the other slot will be scanned.

Summary of scan keys and LEDs:

OPEN ALL — Use to stop a scan, open all channels, and place the Model 7002 in the scan idle state.

STEP — Use to take the Model 7002 out of the idle state; and also, use to manually step through a scan.

4.11 Channel patterns (STORE and RECALL)

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

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

1. A closed channel in the Channel Pattern becomes unavailable. A channel can become unavailable by changing a slot assignment (Card TYPE) or by changing to a pole mode that reduces the number of available channels.
2. A closed channel in the Channel Pattern becomes restricted. A channel becomes restricted by adding it to the restricted channel list.

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3. Two or more closed channels in the Channel Pattern become interlocked. Channels become interlocked by specifying them in the Interlock lists.

The following examples demonstrate how a Channel Pattern is lost:

1. Assume a Channel Pattern includes channel 1!21 as a closed channel and the assignment for slot 1 is changed to a multiplexer card that has only 20 channels. Since channel 1!21 no longer exists, the Channel Pattern is cleared.
2. Assume a Channel Pattern includes channel 1!1 as a closed channel and the assignment for slot 1 is changed to a matrix card. Since channel 1!1 is an incorrect format for a matrix card, it no longer exists. The Channel Pattern is cleared.
3. Assume a Channel Pattern includes channel 1!21 and the slot (slot 1) is configured for 2-pole operation. Changing the pole-mode of slot 1 to 4-pole operation makes channel 1!21 unavailable and clears the Channel Pattern.
4. Assume a Channel Pattern includes channel 1!1. If channel 1!1 is then added to the restricted channel list, the Channel Pattern is cleared.
5. Assume a Channel Pattern includes channel 1!1 and 1!2. If these two channels are then interlocked to each other, the Channel Pattern is cleared.
6. Assume a Channel Pattern includes channel 1!1 and Card Pair 1&6 is enabled. Note that with the card pair enabled, channel 6!1 is indirectly included in the Channel Pattern. If channel 6!1 is then added as a restricted channel, the Channel pattern will clear since one of its channels has become restricted.
7. Assume a Channel Pattern includes channels 1!1 and 1!2, and Card Pair 1&6 is enabled. Note that with the card pair enabled, channels 6!1 and 6!2 are indirectly included in the Channel Pattern. If channels 6!1 and 6!2 are then specified as interlocked channels, the Channel Pattern will clear since an interlock violation was introduced into the Channel Pattern.

Note that if a Channel Pattern is included in the Scan List (i.e. M1) and the Channel Pattern is lost (as explained above), then the Scan List will also be lost (see paragraph 4.8).

4.11.1 Storing channel patterns (STORE)

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

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

1. Decide on which storage method you wish to use:
   a. If you want to store an actual pattern of open and closed channels into memory, go ahead and open and close the desired channels.
   b. If you want to store a list of the closed channels for the channel pattern, go ahead and define the channel list.
2. Press STORE to display the following menu:

   STORE TO MEMORY
   RELAY-PATTERN CURRENT-LIST

3. Place the cursor on the appropriate selection:
   a. Place the cursor on RELAY PATTERN if storing the actual pattern of open and closed channels.
   b. Place the cursor on CURRENT-LIST if storing the defined channel list.
4. With the cursor on the appropriate selection, press ENTER. One of the following typical messages will be displayed:

   STORE CHANS AT #001 or STORE LIST AT #001

   Both messages indicate that storage will occur at memory location 1 (M1).

   NOTE

   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 ▶) and the numeric keypad to key in the desired memory location (001 to 500).

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6. To store the channel pattern or list at the displayed memory location, press ENTER.

4.11.2 Recalling channel patterns (RECALL)

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

Recalling a channel pattern using RECALL

Perform the following steps to use RECALL:

1. Press RECALL to display the following typical message:

   RECALL CHANS AT #001

   The above message indicates that the channel pattern will be recalled from memory location M1.

   NOTE

   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 ▶) and the number keys to key in the desired memory location (001 to 500).
3. To recall the channel pattern from the displayed memory location, press ENTER. The instrument will return to the channel status display state and display the recalled channel pattern.

   CAUTION

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

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

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

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

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.

4.12 MENU

Various instrument operations to configure the Model 7002 are performed using the front panel MENU. The MENU structure is shown and summarized in Table 4-3.

General rules to use MENU:

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

   MAIN MENU
   SAVESETUP GPIB DIGITAL-I/O ▶
   ◀ TEST LANGUAGE GENERAL

2. Pressing the EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the MAIN MENU is displayed, pressing EXIT or MENU will disable MENU.

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Table 4-3
MENU structure

Menu item	Description
SAVESETUP	Setup Menu:
SAVE	Save setup at a memory location (up to 10).
RESTORE	Return 7002 to setup stored at a memory location.
PWRON	Power-on Menu:
FACTORY DEFAULT	Power-on to factory default setup conditions.
USER SETUP	Power-on to setup stored at a memory location.
RESET	Return 7002 to original power-on setup.
GPIB	GPIB Setup Menu:
ADDRESS	Check/change IEEE-488 address.
STATUS	Display IEEE-488 status byte.
DIGITAL-I/O	Digital I/O Menu:
OUTPUT-STATUS	Check/change states of digital output channels.
OUTPUT-POLARITY	Check/change polarity of digital output port.
INPUT-STATUS	Read digital input channel.
TEST	Self-Test Menu:
BUILT-IN TESTS	Test Digital Board:
AUTO	Run all tests automatically.
MANUAL	Select tests to run.
DISPLAY TESTS	Test Display Board:
KEYS	Verify operation of front panel keys.
PATTERNS	Verify operation of VFD display.
LED BOARD	Verify operation of LED display.
CHAR SET	Display ASCII character set.
LANGUAGE	Choose 7002 Language:
ENGLISH	Display messages in English.
GERMAN	Display messages in German.
FRENCH	Display messages in French.
GENERAL	General Menu:
SERIAL #	Displays serial number, SCPI version, and software revision.
STATUS-MESSAGES	Enables/disables status message mode.
DISPLAY	Display Menu:
LED DISPLAY SETUP	LED Display Control:
SHOW-LIST	Change Display Mode.
GRATICULE-CONTROL	Disable/enable LED Graticule.
BREAK BEFORE MAKE	Enables/disables Break-Before-Make.

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 (◀ and ▶).
4. A displayed arrow (◀ or ▶) indicates that there is more information or additional menu items to select from. When " ▶ " is displayed, use the ▶ cursor key to display the additional message(s); and conversely, when " ◀ " is displayed, use the ◀ cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry.

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8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.
9. The ENTER, EXIT, ◄ and ► keys have LED counterparts. Thus, with the optional light pen, you can click these LEDs instead of pressing the keys.

4.12.1 SAVESETUP

The SAVESETUP menu is used for the following operations:

- Save the current setup conditions in memory for future recall. Up to 10 setups can be saved in memory.
- Restore the instrument to setup conditions stored in memory.
- Set up the power-on (PWRON) configuration. The instrument can be set to power-on to the factory default setup conditions, or power-on to the setup conditions stored at a specified memory location.
- Reset the instrument to the original power-on setup conditions.

Perform the following steps to display the SAVESETUP menu:

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

```
SETUP MENU
SAVE   RESTORE   PWRON   RESET
```

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

```
SAVE SETUP #0 (0-9)
```

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

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

```
RESTORE SETUP #0
```

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

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

```
SET POWER-ON DEFAULT
FACTORY-DEFAULT   USER-SETUP
```

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

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

```
PWRON DEFAULT = #0
```


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

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

```
RESETTING INSTRUMENT
```

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

```
RESET COMPLETE
```

Press ENTER to return to the SETUP MENU.

NOTE

When finished with SAVE SETUP, use EXIT to back out of the menu structure.

Table 4-4
Default conditions

Item	Factory default	RESET
Display mode	Relay status	No change
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 sec	0 sec
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
LED Graticule	On	On

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

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4.12.2 GPIB

The GPIB menu is used for the following operations:

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

Perform the following steps to display the GPIB menu:

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

```
GPIB SETUP MENU
ADDRESS   STATUS
```

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

```
ADDRESS = 07 (0-30)
```

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

NOTE

There is an IEEE-488 address switch located on the rear panel of the unit. This switch is used to set the IEEE-488 address on specially built units that do not have front panel controls and is explained in paragraph 5.3. For units that do have front panel controls, the switch is non-functional.

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

```
SHOW STATUS BYTE
EVA = 0   QSB = 0   MAV = 0   ESB = 0 ►
◄   MSS = 0   OSB = 0
```

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

NOTE

When finished with GPIB, use EXIT to back out of the menu structure.

4.12.3 DIGITAL-I/O

The DIGITAL-I/O menu is used to configure the Model 7002's digital I/O port (refer to paragraph 4.15). Perform the following operations through this menu:

- Check and/or change the OUTPUT-STATUS (on or off) of the four digital output channels.
- Check and/or change the OUTPUT-POLARITY of the digital output port. Polarity can be active-high (ON = +5V) or active-low (ON = 0V).
- Check the INPUT-STATUS (on or off) of the single digital input channel.

NOTE

The digital output port can be used as a sink in order to control external circuits (i.e., low power relay drive) that use up to 30V. See paragraph 4.15.1 for details.

Perform the following steps to display the DIGITAL-I/O MENU:

1. Press MENU to display the MAIN MENU.
2. Use the cursor keys (◄ and ►) to place the cursor on DIGITAL-I/O and press ENTER to access the following menu:

```
DIGITAL-I/O MENU
OUTPUT-STATUS   OUTPUT-POLARITY ►
◄ INPUT-STATUS
```


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OUTPUT-STATUS — Use this menu item to check and/or change the state (on or off) of the four digital output channels. The actual level of an "on" channel is determined by the polarity, which is controlled by the next menu item (OUTPUT-POLARITY). To select OUTPUT-STATUS, place the cursor on OUTPUT-STATUS and press ENTER. If for example, all the digital output channels are off, the following message will be displayed:

```
DIGITAL OUTPUT LINES
1 = OFF   2 = OFF   3 = OFF   4 = OFF
```

1. To retain the displayed states of the output channels, press ENTER or EXIT. The instrument will return to the DIGITAL-I/O MENU.
2. To change the state of one or more digital output channels, perform the following steps:
   a. Position the cursor at the channel that you wish to change.
   b. Press any one of the keys on the keypad. These keys simply toggle between "ON" and "OFF".
   c. Repeat steps A and B for each channel that you wish to change.
   d. With the desired states displayed, press ENTER. The instrument will return to the DIGITAL-I/O MENU.

OUTPUT-POLARITY — Use this menu item to check and/or change the polarity of the digital output port. The polarity of each channel can be active-high (ON = +5V) or active-low (ON = 0V). To select OUTPUT-POLARITY, place the cursor on OUTPUT-POLARITY and press ENTER. The following message will be displayed:

```
SELECT OUTPUT LINE
TTL1   TTL2   TTL3   TTL4
```

1. Place the cursor on the appropriate channel and press ENTER. A message indicating the polarity of the selected channel will be displayed. For example:

   ```
   TTL1 LOGIC SENSE
   ACTIVE-HIGH   ACTIVE-LOW
   ```

   Cursor position will indicate the current polarity of the channel.
2. To retain the currently selected polarity, press ENTER or EXIT. The display will return to the SELECT OUTPUT LINE Menu.
3. To change polarity, place the cursor on the alternate selection using the cursor keys (◄ or ►) and press ENTER. The instrument will return to the SELECT OUTPUT LINE Menu.
4. When finished, press EXIT to return to the DIGITAL I/O MENU.

INPUT-STATUS — Use this menu item to read (on or off) the digital input channel. Polarity is fixed at active-high (ON = 5V).

To select INPUT-STATUS, place the cursor on INPUT-STATUS and press ENTER. If for example, the digital input channel is "on", the following message will be displayed:

```
DIGITAL INPUT LINE
Status = ON
```

Press ENTER or EXIT to return the instrument to the Digital I/O Menu.

NOTE

When finished with DIGITAL I/O, use EXIT to back out of the menu structure.

4.12.4 TEST

The TEST menu is to be used as a diagnostic tool to isolate problems with the Model 7002. Refer to Section 7 Maintenance for information on using these test procedures.

4.12.5 LANGUAGE

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

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

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

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

   CHOOSE MENU LANGUAGE
   ENGLISH GERMAN FRENCH

   The cursor will be located on the currently selected language. Note that if a language other than English is currently selected, the menu will be displayed in the selected language.
3. To retain the currently selected language, press EXIT or ENTER. The display will return to the MAIN MENU.
4. To select one of the other languages, place the cursor on the desired language selection and press ENTER. The instrument will return to the MAIN MENU.

   Note: The selected language becomes the power-up default.

NOTE

When finished with LANGUAGE, use EXIT to back out of the menu structure.

4.12.6 GENERAL

The GENERAL MENU is used for the following operations:

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

Perform the following steps to use the GENERAL MENU:

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

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

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

Serial #XXXXXX
SCPI Version 1992.0 ▶
◀ software rev AXX/AYY /AZZ

where; AXX is the software revision of the main CPU.
AYY is the software revision of the VFD display CPU.
AZZ is the software revision of the LED display CPU.

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

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

STATUS MESSAGES
OFF ON

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

DISPLAY — This selection is used to change the display mode and to disable/enable the LED Graticule for the LED display.

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Place the cursor on DISPLAY and press ENTER to display the following menu:

```
LED DISPLAY SETUP
SHOW-LIST   GRATICULE-CONTROL
```

Show List — This menu item is used to change the display mode. In the relay status display mode, the channel LEDs correspond to open and closed channels. In the list display mode, brightly lit channel LEDs correspond to the channels included in the selected list. Note that with the optional light pen, the SHOW LIST LED toggles between the two display modes.

Perform the following steps to change the display mode:

1. Place the cursor on SHOW-LIST and press ENTER to display the following message:

   ```
   CONFIG LED DISPLAY
   RELAY-STATUS   CURRENT-LIST
   ```

   RELAY STATUS selects the relay status display mode, and CURRENT LIST selects the list display mode.

2. Place the cursor on the appropriate selection and press ENTER. The display returns to the LED DISPLAY SETUP menu.

Graticule Control — This selection is used to disable or enable the LED Graticule. When enabled, all available channels are denoted by channel LEDs that are turned on (dimly lit or brightly lit). Channels not available are denoted by channel LEDs that are turned off.

Contrast between on and off LEDs can be increased by disabling the LED Graticule. When disabled, there is no dimly lit state for the LEds. An LED that would normally be dimly lit is instead turned completely off. Each LED is either off or brightly lit. A disadvantage of this is that it is more difficult to determine which channels are available in the test system.

Perform the following steps to disable or enable the LED Graticule:

1. Place the cursor on GRATICULE-CONTROL and press ENTER to display the following message:

   ```
   GRATICULE PATTERN
   ON   OFF
   ```

   OFF disables the LED Graticule and ON enables it.

2. Place the cursor on the appropriate selection and press ENTER. The display returns to the LED DISPLAY SETUP menu.

Notes:

1. FACTORY DEFAULT power-on, RESET, *RST and :SYSTem:PRESet enables (ON) the LED Graticule. If you want the instrument to power-up with the LED Graticule disabled, you will have to save the OFF condition as the USER SETUP power-on default.
2. If the main CPU firmware is not compatible with the LED display firmware, the following error will occur when trying to disable the LED Graticule.

   ```
   ERROR: ID CODE = +551
   Incorrect software revision
   ```

   If this error should occur, contact Keithley to resolve the firmware incompatibility.

BREAK-BEFORE-MAKE — This selection is used to enable or disable Break-Before-Make. When enabled, the previous channel will open before the next channel closes during a scan. This ensures that two scanned channels will not be closed at the same time. When recalling a channel pattern from memory, all other channels will open before the channels in the pattern close.

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

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

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

```
BREAK BEFORE MAKE
ON   OFF
```

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

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

NOTE

When finished with the GENERAL MENU, use EXIT to back out of the menu structure.

4.13 Card configuration

Various operations to configure the slots of the mainframe are performed from the CARD CONFIG MENU. The menu structure is shown and summarized in Table 4-5.

Table 4-5
CARD CONFIG MENU structure

Menu item	Description
TYPE SLOT	Set Card Type: Assign model number to card in specified slot.
#-OF-POLES SLOT	Select # Of Poles: Select pole mode for card in specified slot.
CARD-PAIR	Enable or disable Card Pair.
DELAY SLOT	Set Delay For: Set delay for card in specified slot.
READ-I/O-CARD	Identify I/O Cards.

General rules to use CARD CONFIG MENU:

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

```
CARD CONFIG MENU
TYPE   #-OF-POLES   CARD-PAIR ▶
◀ DELAY   READ-I/O-CARD
```

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

4.13.1 TYPE

Use TYPE to assign a model number to each non-701X series card installed in the mainframe. This menu selection also allows you to assign a slot to operate as a simulator. By assigning a slot the value 9990, the mainframe will operate as if a 40-channel multiplexer card is installed. If you assign a slot the value 9991, the mainframe will operate as if a 4×10 matrix card is installed in that slot. These simulators allow you to develop a test program even though the card is not installed in the mainframe.

The TYPE menu selection displays an assignment message for each slot. In general, the Model 7002 mainframe detects

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(on power-up) Model 701X series cards that are installed. All other type cards are not detected and thus, the slot must be assigned the appropriate model number by the user. This user assigned model number is "remembered" by the mainframe after it is turned off. However, if the mainframe detects a 701X series card in the slot on the subsequent power-up, it disregards the model number assigned by the user and assigns the model number of the 701X series card to the slot. You can use Table 4-6 to interpret the displayed messages for TYPE.

Each used slot must be assigned the correct model number (either automatically by the mainframe for 701X series cards or manually by the user) in order for the mainframe to operate correctly. The model number assignment automatically determines the settling time for the relays.

Changing a slot assignment (Card TYPE) could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraphs 4.8 and 4.11 for details).

Table 4-6
TYPE assignments

Assignment message	Interpretation*
SLOT CARD: 701X**	701X series card installed in specified slot.
SLOT CARD: NONE	No card installed in slot, or specified slot is not assigned.
SLOT CARD: 7YYY***	Non-701X series model number assigned to specified slot by the user. The card may or may not be installed in the slot. Also, a different non-701X series card may be installed.
SLOT CARD: 9990	Specified slot assigned by user to simulate a 40-channel multiplexer. A non-701X card may be installed.

Table 4-6 (continued)
TYPE assignments

Assignment message	Interpretation*
SLOT CARD: 9991	Specified slot assigned by user to simulate a 4 × 10 matrix. A non-701X card may be installed.

* Assumes that power is cycled whenever a card is installed or removed from the mainframe.
** Model 701X series card, such as the Model 7011, 7012, 7013 or 7014.
*** Models 7052 though 7402.

Perform the following steps to assign card TYPE to a slot.

1. Press the CARD CONFIGURATION key to display the CARD CONFIG MENU.
2. Place the cursor on TYPE and press ENTER to select SET CARD TYPE. The card type for the currently selected slot will be displayed. For example:

   SET CARD TYPE NONE
   SLOT-#1 #2 #3 #4 #5 ▶

   In the above example, #3 flashes to indicate that slot 3 is assigned to be empty (NONE). To check card assignment types for the other slots, simply use the cursor keys (◀ and ▶) to place the cursor on the slot number.

3. Determine the correct assignment for the slot using the following guidelines:
   a. If the slot is empty and is not going to be used, assign it as "NONE". This will turn off the front panel channel LEDs for the slot since it is not going to be used.
   b. If using a non-701X series card (Models 7052 through 7402) that is installed in the slot, assign the slot as that model number. For example, if the Model 7062 is installed in slot 1, assign slot 1 as "7062".
   c. If the slot is going to be used to simulate a 40-channel mux, assign it as "9990". To simulate a 4 × 10 matrix, assign it as "9991". Note that a non-701X series card left installed will be controlled while using the slot as a simulator.
4. Perform the following steps to change the card type assignment for a slot:
   a. Place the cursor on the desired slot number and press ENTER. For example:

      SLOT 5 CARD: NONE

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The message indicates that slot 5 is assigned as an empty slot.

b. Use the cursor keys to display the appropriate assignment. For example, if you have a Model 7052 installed in slot 5, assign 7052 to slot 5 as follows:

SLOT 5 CARD: 7052

Note that if a Model 701X series card is installed, you will not be able to change the assignment for that slot.

c. With the appropriate card type assignment displayed, press ENTER.

5. When finished, use the EXIT key to back out of the menu structure.

4.13.2 #-OF-POLES

The pole configuration of some switching cards can be altered. For example, the Model 7011 is normally used as a 2-pole, 40-channel multiplexer card. However, since Banks A and B can be isolated from Banks C and D, you can configure the card for 4-pole operation. In the 4-pole mode, channels are paired together to form twenty 4-pole channels. See the Model 7011 Instruction Manual for details.

Switch cards that have an additional pole mode capability are summarized as follows:

	Pole Mode		
Card	1-Pole	2-Pole	4-Pole
7011	N/A	40 channels	20 channels
7056	20 channels	10 channels	N/A
7156	20 channels	10 channels	N/A

If you attempt to select an invalid pole mode, a settings conflict error will occur and the entry will be ignored.

Changing the pole mode for a slot could cause channels to become unavailable. As can be seen from the above table for the Model 7011 mux card, 20 channels become unavailable when changing from 2-pole to 4-pole operation. If one or more of those unavailable channels were included in the Scan List and/or in a Channel Pattern, then the entire Scan List and/or the affected Channel Pattern will be lost (cleared). See paragraph 4.8 and 4.11 for details.

Perform the following steps to check or change the pole mode of a switching card installed in the mainframe:

1. Press the CARD CONFIGURATION to display the CARD CONFIG MENU.
2. Place the cursor on #-OF-POLES and press ENTER to display the following menu:

SELECT # OF POLES
SLOT-#1 #2 #3 #4 #5 ▶
◀ SLOT-#6 #7 #8 #9 #10

3. Place the cursor on the appropriate slot number and press ENTER. The pole mode selections for that slot will be displayed. For example, if you selected slot 7, the following message will be displayed:

OF POLES SLOT-7
1-POLE 2-POLE 4-POLE

Cursor position (flashing menu item) indicates which pole mode is currently selected.

4. To retain the current pole mode selection press ENTER or EXIT. To change the pole mode, place the cursor on the desired selection and press ENTER. Either action will return the instrument to the SELECT # OF POLES menu.
5. When finished, use the EXIT key to back out of the menu structure.

4.13.3 CARD PAIR

As the name implies, CARD PAIR simply pairs a card in one slot to a similar type switching card in another slot. When a CARD PAIR is enabled, corresponding channels of both cards operate together as a pair. For example, closing channel 2 of slot 1 will also close channel 2 of slot 6. Conversely, closing channel 2 of slot 6 will close channel 2 of slot 1. CARD PAIR is especially useful when performing four-wire scanning.

The following card pairs are available:

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Slot 1 paired to Slot 6
Slot 2 paired to Slot 7
Slot 3 paired to Slot 8
Slot 4 paired to Slot 9
Slot 5 paired to Slot 10

For Model 701X series cards, slots 1 through 5 can be electrically isolated from slots 6 through 10 by removing the row jumpers on the backplane extender board (see paragraph 4.4). With a CARD PAIR enabled, you can control two cards that are electrically isolated from each other.

CARD PAIR can only be enabled for cards that are similar and have the same number of channels. For example, if you try to pair a mux card to a matrix card, a settings conflict error will occur and the card pair will remain disabled.

If enabling a Card Pair adds a restricted channel or interlocked channels to the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared. See paragraphs 4.8 and 4.11 for more information.

Perform the following steps to check or change CARD PAIR:

1. Press CARD CONFIGURATION to display the CARD CONFIG MENU.
2. Place the cursor on CARD PAIR and press ENTER to display the following card pair selections:

   CHOOSE CARD PAIR
   1&6 2&7 3&8 4&9 5&10

3. Place the cursor on the desired card pair and press ENTER. If, for example, you select card pair 1&6, the following message is displayed:

   SET CARD PAIR 1&6
   OFF ON

   The cursor position indicates the state (on or off) of CARD PAIR for the two channels.
4. Place the cursor on the desired state (ON or OFF) and press ENTER.
5. When finished, use the EXIT key to back out of the menu structure.

4.13.4 DELAY

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

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

Perform the following steps to set a delay:

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

   SET DELAY FOR:
   SLOT-#1 #2 #3 #4 #5 ▶
   ◀ SLOT-#6 #7 #8 #9 #10

3. Place the cursor on the slot that you wish to set a delay for and press ENTER. If for example, you select slot 6 and it currently is set for a one second delay, the following message is displayed:

   (06) DELAY=00001.000

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

4.13.5 READ-I/O-CARD

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

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

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4.14 Scan configuration

Various operations to configure a scan are performed from the CONFIGURE SCAN menu. The menu structure is shown and summarized in Table 4-7.

General rules to use CONFIGURE SCAN:

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

   CONFIGURE SCAN
   CHAN-CONTROL SCAN-CONTROL ▶
   ◀ ARM-CONTROL CHAN-RESTRICTIONS

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

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Table 4-7
CONFIGURE SCAN menu structure

Menu item	Description
CHAN-CONTROL	Configure Channel Layer:
CHANNEL-SPACING	Select channel spacing:
TIMER	Use a timer to select each channel in the scan.
EXTERNAL	Use an external trigger to select each channel.
GPIB	Use a bus trigger to select each channel.
MANUAL	Use STEP key to select each channel.
TRIGLINK	Use a Trigger Link trigger to select each channel.
ASYNCHRONOUS	Use separate lines for In/Out triggers.
SEMI-SYNCHRONOUS	Use same line for In/Out triggers.
IMMEDIATE	Use to scan channels immediately.
HOLD	Use to hold up the scan in the channel layer.
NUMBER-OF-CHANS	Define number of channels to scan:
USE-SCANLIST-LENGTH	Count = number of channel entries in scan list.
CHAN-COUNT	User defined count:
INFINITE	Repeat channel scanning indefinitely.
ENTER-CHAN-COUNT	Count = user defined value (1 to 9999)
CONTROL	Select trigger control mode:
SOURCE	Enable the Source Bypass.
ACCEPTOR	Disable the Source Bypass.
SCAN-CONTROL	Configure Scan Layer:
SCAN-SPACING	Select scan spacing:
TIMER	Use the timer to control scan spacing.
EXTERNAL	Use external triggers to control scan spacing.
GPIB	Use bus triggers to control scan spacing.
MANUAL	Use STEP key to control scan spacing.
TRIGLINK	Use Trigger Link triggers to control scan spacing.
IMMEDIATE	Use to pass operation immediately into the channel layer.
HOLD	Use to hold up the scan in the scan layer.
NUMBER-OF-SCANS	Define number of scans to be performed:
INFINITE	Repeat scan indefinitely.
ENTER-SCAN-COUNT	Count = user defined value (1 to 9999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
ARM-CONTROL	Configure Arm Layer:
ARM SPACING	Select arm spacing control:
MANUAL	Use STEP key to arm scanner.
IMMEDIATE	Use to arm scanner immediately.
GPIB	Use a bus trigger to arm scanner.
EXTERNAL	Use an external trigger to arm scanner.
TRIGLINK	Use a Trigger Link trigger to arm scanner.
HOLD	Use to hold up the scan in the arm layer.
ARM-COUNT	Define number of times to arm scanner:
INFINITE	Continuously re-arm scanner.
ENTER-ARM-COUNT	User defined count value (1 to 9999).
TRIGGER-CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.

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Table 4-7 (continued)
CONFIGURE SCAN menu structure

Menu item	Description
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.

4.14.1 CHAN-CONTROL

Channel control is used for the following operations:

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

Perform the following steps to configure the channel layer:

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

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

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

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

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

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

   ```
   INTERVAL = 00000.001
   ```

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

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

External — With this selection, external triggers are used to control channel spacing for the scan. Each trigger stimulus applied to the Model 7002 will open the current channel and close the next channel of the scan. The external trigger is applied to the rear panel “EXTERNAL TRIGGER” BNC connector. In the external trigger mode, the Model 7002 can be used to trigger another instrument. After a channel is closed and settled, a trigger pulse is applied to the rear panel “CHANNEL READY” BNC connector. This trigger pulse can, for example, be used to trigger a DMM to take a reading. External triggering is covered in detail in paragraph 4.16.

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

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

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

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

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

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

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

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

Triglink — With this selection, channel spacing of the scan is controlled by the Trigger Link of the Model 7002. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Each trigger stimulus applied to the Model 7002 will open the current channel and close the next channel of the scan. See paragraph 4.17 for details on using the Trigger Link.

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

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

```
SET TRIGGERLINK MODE
ASYNCHRONOUS   SEMI-SYNCHRONOUS
```

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

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

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

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

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

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

SEMI-SYNCHRONOUS — In this mode, the input and output triggers for the Model 7002 are assigned to the same

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line. Perform the following steps to select the semi-synchronous mode, and to select the trigger line:

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

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

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

Immediate — With this selection, events (such as the TIMER and EXTERNAL triggers) do not control channel spacing. Once the scan starts, the Model 7002 will step through it as fast as the internal settling time and user programmed delay (see paragraph 4.13.4) will allow.

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

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

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

NUMBER OF CHANNELS
USE-SCANLIST-LENGTH CHAN-COUNT

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

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

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

CHANNEL COUNT
INFINITE ENTER-CHAN-COUNT

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

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

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

   CHANNEL COUNT = 0010

   The above message indicates that the current count is set to 10.

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

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

TRIGGER CONTROL
SOURCE ACCEPTOR

Cursor position indicates the current selection.

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

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

Place the cursor on the desired selection and press ENTER.

NOTE

When finished with the channel layer, use EXIT to back out of the MENU structure.

4.14.2 SCAN CONTROL

Scan control is used for the following operations:

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

Perform the following steps to configure the scan layer:

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

SCAN CONTROL
SCAN-SPACING NUMBER-OF-SCANS ►
◄ CONTROL

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

SELECT SCAN SPACING
TIMER EXTERNAL GPIB MANUAL ►
◄ TRIGLINK IMMEDIATE HOLD

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

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

Perform the following steps to use the timer:

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

INTERVAL = 00000.001

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

External — With this selection, external triggers are used to control scan spacing. A trigger stimulus applied to the Model 7002 will pass operation into the channel layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 4.16 for detailed information on external triggering.

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

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

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

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

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

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

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

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

Triglink — With this selection, scan spacing is controlled by the Trigger Link of the Model 7002. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the channel layer when the Model 7002 receives a trigger over the Trigger Link. See paragraph 4.17 for details on using the Trigger Link.

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

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

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

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

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

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

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

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

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

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

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

```
NUMBER OF SCANS
INFINITE   ENTER-SCAN-COUNT
```

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

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

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

   ```
   SCAN COUNT = 0001
   ```

   The above scan count indicates that the Model 7002 will perform one scan. A value of “0000” indicates that the scan count is set to infinite.
2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the SCAN CONTROL menu.

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

```
TRIGGER CONTROL
SOURCE   ACCEPTOR
```

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

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

Place the cursor on the desired selection and press ENTER.

NOTE

When finished with the scan layer, use EXIT to back out of the menu structure.

4.14.3 ARM CONTROL

Arm control is used for the following operations:

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

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Perform the following steps to configure the arm layer:

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

SETUP ARM CONTROL
ARM-SPACING ARM-COUNT ►
◄ TRIGGER-CONTROL

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

ARM SPACING
MANUAL IMMEDIATE GPIB ►
◄ EXTERNAL TRIGLINK HOLD

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

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

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

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

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

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

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

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

External — With this selection, external triggers are used to control arm spacing. A trigger stimulus applied to the Model 7002 will pass operation into the scan layer. The external trigger is applied to the rear panel “EXTERNAL TRIGGER” BNC connector. See paragraph 4.16 for detailed information on external triggering.

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

To select external triggering from the SELECT ARM SPACING menu, place the cursor on EXTERNAL and press ENTER. The instrument will return to the SETUP ARM CONTROL menu.

Triglink — With this selection, arm spacing is controlled by the Trigger Link of the Model 7002. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the scan layer when the Model 7002 receives a trigger over the Trigger Link. See paragraph 4.17 for details on using the Trigger Link.

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

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

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

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

To select a trigger input line for the Model 7001, place the cursor on the desired line number and press ENTER. The following message will be displayed:

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

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

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

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

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

ARM COUNT
INFINITE ENTER-ARM-COUNT

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

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

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

   ARM COUNT = 0001

   The above arm count indicates that the scanner will arm one time. An arm count of "0000" indicates that infinite is selected.
2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the SETUP ARM CONTROL menu.

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

TRIGGER CONTROL
SOURCE ACCEPTOR

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

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

Place the cursor on the desired selection and press ENTER.

NOTE

When finished with the arm layer, use EXIT to back out of the menu structure.

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4.14.4 Channel restrictions

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

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

Perform the following steps to set up channel restrictions:

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

   CHANNEL RESTRICTIONS
   SINGLE-CHAN RESTRICTED-CHANS ▶
   ◀ INTERLOCK

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

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

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

   SINGLE CHANNEL MODE
   OFF ON

   Cursor position indicates the current state of Single Channel.

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

Operating notes:

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

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

   When the CLOSE operation is performed, only channel 1!1 will close.
2. When Single Channel is enabled, all previously stored channel patterns are cleared from memory.
3. A channel pattern that consists of one closed channel can be saved in memory while Single Channel is enabled. If a channel pattern is saved from a list that contains more than one channel, then only the lowest numbered channel in the lowest numbered slot will close when recalled.
4. Single Channel cannot be enabled if two or more channels are already closed (Settings Conflict error).

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

Perform the following steps to specify restricted channels:

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

   RESTRICTED CHANNELS
   SELECT CHANNELS

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

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Operating notes:

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

   ERROR:ID CODE = 550
   Forbidden channel error

2. Whenever you enter a restricted channel into a scan list, the "Forbidden channel error" will occur. The restricted channel will go into the list, but the channel will be skipped when the scan is performed.
3. If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, a saved state error (+510) occurs and the entire Scan List and/or Channel Pattern is cleared (lost). See paragraphs 4.8 and 4.11 for more information.

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

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

Interlock #1: List A = 1!1, 1!2, 1!3
List B = 1!4, 1!5, 1!6

Now assume that the following channel list is defined:

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

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

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

Perform the following steps to specify interlocked channels:

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

   SELECT INTERLOCK
   #1 #2 #3 #4 #5

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

   INTERLOCK #1
   LIST-A LIST-B

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

   INTERLOCK #1 LIST-A
   SELECT CHANNELS

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

Operating notes:

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

   ERROR:ID CODE = 550
   Forbidden channel error

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3. Interlocked channels can be scanned as long as only one channel is closed at a time. However, if a scan is performed while a channel is left closed, any channels in the scan list that are interlocked to the closed channel will be skipped when the scan is performed.
4. If a channel is closed, you can enter a channel that is interlocked to it into the scan list but the "Forbidden channel error" message will occur to indicate that it will not be scanned (see note 3).
5. If you specify channels to be interlocked, and they are already included in the Scan List and/or a Channel Pattern (interlock violation), a saved state error (+510) occurs and the entire Scan List and/or Channel Pattern is cleared (lost). For example, if the Scan List includes channels 1!1 and 1!2, and you specify those two channels to be interlocked (1!1 in List A and 1!2 in List B), then the Scan List is cleared. See paragraphs 4.8 and 4.11 for more information.

4.15 Digital I/O port

The Model 7002's Digital I/O port is a 9-pin D- sub-miniature connector (J1006) located on the rear panel. The ports location and pin designations are shown in Figure 4-13.

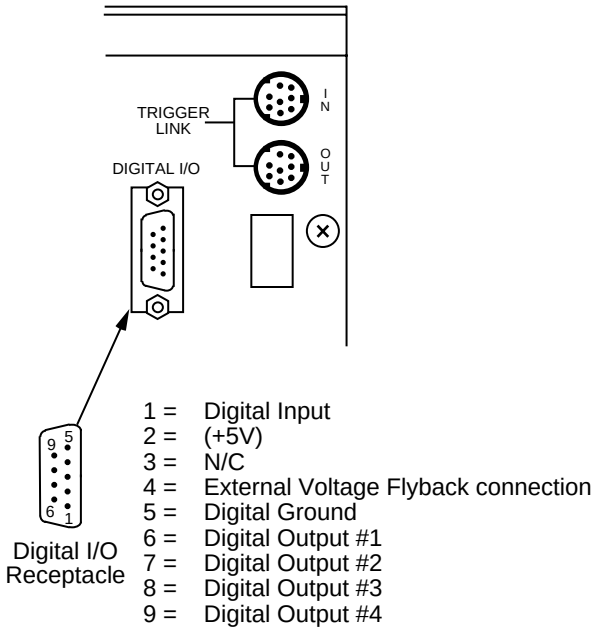


Figure 4-13
Digital I/O port

The Model 7002's Digital I/O port can be used to control external circuitry. The port provides four output lines and one input line. Each open-collector output can be set high (+5V) or low (0V) and will sink up to 100mA. The four output lines can also operate external supplies from +5V to +30V.

Use the DIGITAL I/O MENU to select the following options (information on each menu item is contained in paragraph 4.12.3):

- OUTPUT-STATUS

  ON or OFF selectable for each output line (1 through 4). Use this option to check or change the output state. For example, the following OUTPUT-STATUS display is set to ON for digital output #1 and OFF for outputs #2 through #4:

  DIGITAL OUTPUT LINES
  1=ON 2=OFF 3=OFF 4=OFF

  Changing the display to the following turns digital output #1 to OFF and output #2 to ON. Outputs #3 and #4 remain OFF.

  DIGITAL OUTPUT LINES
  1=OFF 2=ON 3=OFF 4=OFF

- OUTPUT-POLARITY

  ACTIVE-HIGH or ACTIVE-LOW selectable for each output line (TTL1 through TTL4). Use this option to check or change the logic sense. Select the desired output line (TTL1 through TTL4), and check or change the output-polarity. For example, the following shows the display used to check or change TTL3 (digital output #3):

  SELECT OUTPUT LINE
  TTL1 TTL2 TTL3 TTL4

  Selecting TTL3 and pressing ENTER changes the display to:

  TTL3 LOGIC SENSE
  ACTIVE-HIGH ACTIVE-LOW

  ACTIVE-HIGH is the current setting for digital output #3.

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- INPUT

  ON or OFF. Use this option to check or change the status of the digital input line. Sense is fixed at active-high (ON=5V).

4.15.1 Controlling digital circuitry

Each of the four digital, open-collector outputs (connector J1006, pins 6, 7, 8, and 9) includes a built-in pull up resistor to +5V. The ouput transistor is capable of sinking up to 100mA from voltages up to +30V.

Early versions of the Model 7002 have an additional 10kΩ resistor connected between the collector and the internal built-in test circuitry. Under certain combinations of output states, this resistor limits the output high to 2.5V. For example:

Output #1 set high (+5V)

Output #2, #3, and #4 set low (0V)

Actual output of digital output #1 is restricted to +2.5V

If using the digital output to sink current from external devices, a Model 7002 containing the additional 10kΩ resistor will function correctly. The transistor switch is open, restricting current flow through the external device in the high state (+5V). However, if the output is directly used as an input to a typical logic input, the 2.5V high state may not be reliably detected as a high. To correct this condition (if a 2.5V high is unacceptable), use one of the following solutions:

- Add external 1kΩ pull-up resistors to the logic circuit inputs, or between the outputs and the +5V (pin 2) of the Model 7002.
- Remove the built-in test resistors (R127, R131, R134, and R135).
- Use an external voltage supply.

External voltage supply

Each output can be operated from external voltage supplies (voltage range from +5V to +30V applied through the device being driven). Refer to Figure 4-14 for a simplified schematic of the digital I/O port. The high current sink capacity of the output driver allows direct control of relays, solenoids and lamps (no additional circuitry needed). Each output channel contains a fly-back diode for protection when switching inductive loads (such as a low power solenoid or relay coils). To use these fly-back diodes, connect the external supply voltage to pin 4 of J1006 (the digital I/O port). Make sure the external supply voltage is between +5V and +30V and current required by the device does not exceed 100mA.

CAUTION

Do not apply more than 100mA maximum current or exceed +30V maximum voltage on pin 4 of J1006 (the digital I/O port). Applying current or voltage exceeding these limits may damage the instrument.

An externally powered relay connected to the digital output port is shown in Figure 4-15. Other externally powered devices can be similarly connected by replacing the relay with the device. When using the Model 7002's collector outputs to turn on externally powered devices, set the corresponding digital output line parameters as follows (set parameters through the MAIN MENU>DIGITAL-I/O>OUTPUT-STATUS and OUTPUT-POLARITY menus):

```
OUTPUT-STATUS=ON
TTLX LOGIC-SENSE=ACTIVE-LOW
```

NOTE

The X in TTLX represents the digital output line number (TTL1 through TTL4). This parameter is set through the OUTPUT-POLARITY menu by selecting the desired digital output line number and pressing Enter.

In the low state (0V), the output transistor sinks current through the external device. In the high state, the output transistor is off (transistor switch is open). This interrupts current flow through the external device. Most applications use active-low (ON=0V) LOGIC-SENSE. Use the LOGIC-SENSE menu to check or change the sense of each digital output line.

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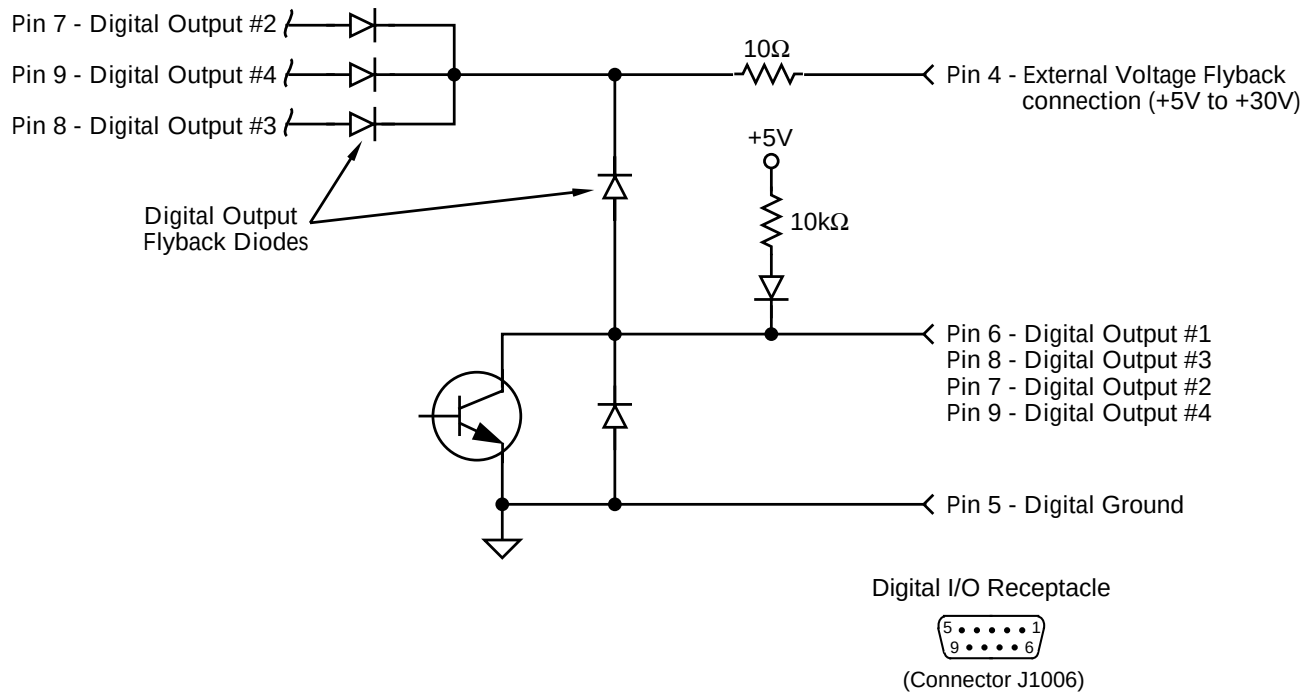


Figure 4-14
Digital I/O port simplified schematic

+5V Output

A +5V output is available at pin 2 of the digital I/O connector (J1006). An internal 22Ω resistor is in series with the connector pin.

In order to maintain a minimum TTL level (4.75V), do not use a load that will draw more than 11mA. Currents above 11mA will pull down the voltage below the TTL minimum. Current at this pin will limit at ~225mA.

CAUTION

NEVER connect pin 2 (the +5V OUTPUT) to higher voltages. Voltages at pin 2 exceeding ±5V may cause damage to the Model 7002's internal circuitry.

Outputs used as logic inputs

To use the digital outputs as logic inputs to active TTL, Low-power TTL, or CMOS inputs:

1. Connect the Model 7002 digital outputs to the logic inputs.
2. Connect the digital grounds.
3. Using the OUTPUT-STATUS menu, check the setting of the Model 7002 output lines. The OUTPUT-STATUS value for each output used should be ON.
4. Using the OUTPUT-POLARITY menu, check the logic-sense setting of the Model 7002 output lines (TTL1 through TTL4). Make sure the correct LOGIC-SENSE value is selected for each output line. The LOGIC-SENSE value varies according to the type of TTL, Low-power TTL, or CMOS inputs used (ACTIVE-HIGH or ACTIVE-LOW).

When low (0V), the output sink can drive at least 10 standard TTL inputs. When high (+5V), the 10kΩ pull-up resistor will source >100µA while remaining at a >3.75V output (a reliable logic high).

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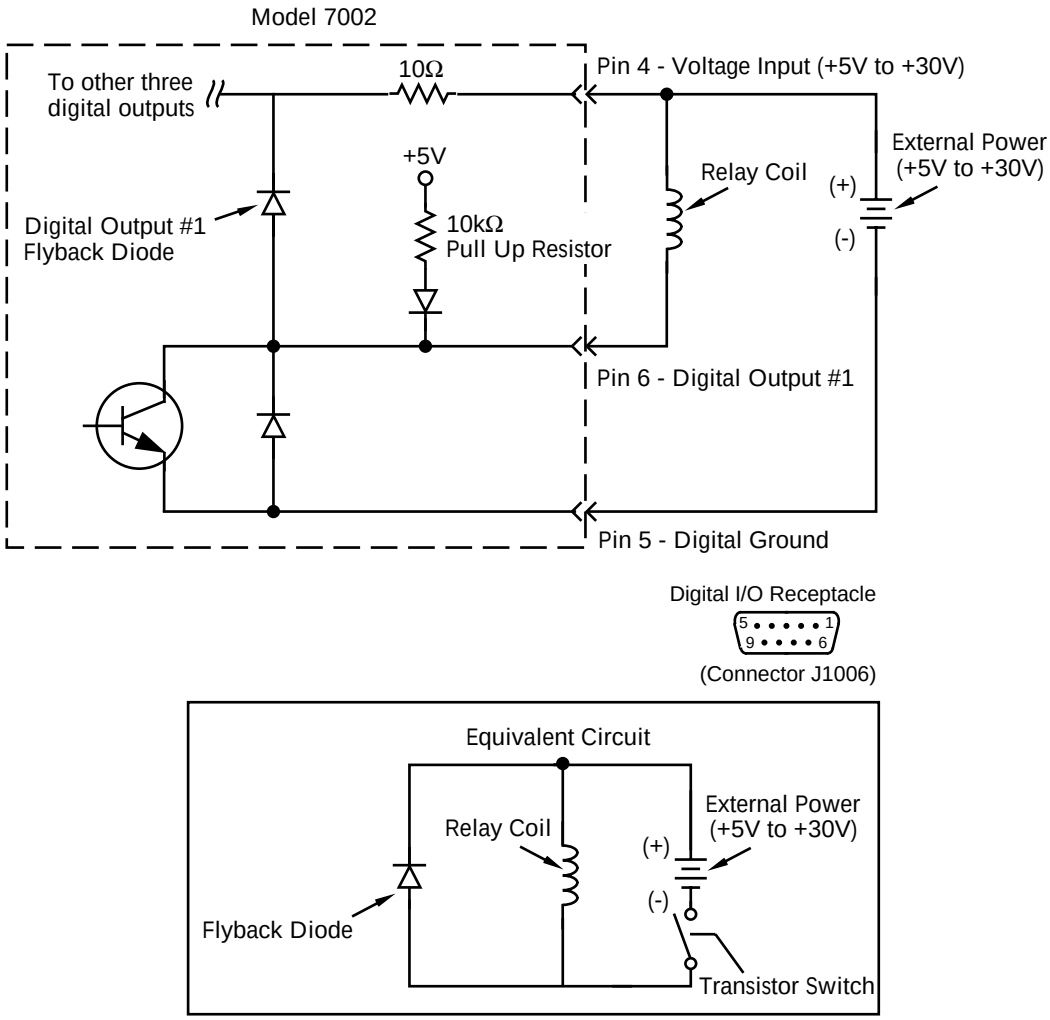


Figure 4-15
Sample externally powered relay

4.15.2 Digital input channel

The Model 7002 has one digital input channel that is used to read a TTL input level. A TTL high on the input will be read as “ON”.

The digital input channel is read from the DIGITAL I/O MENU (see paragraph 4.12.3).

4.16 External triggering

The Model 7002 has BNC connectors on the rear panel (see Figure 4-16) associated with external triggering. The EXTERNAL TRIGGER input jack allows the Model 7002 to be triggered by other instruments and the CHANNEL READY output jack allows the Model 7002 to trigger other instruments.

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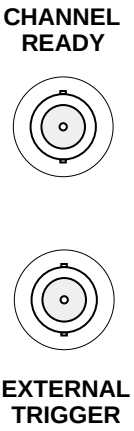


Figure 4-16
External triggering connectors (BNC)

4.16.1 External trigger

The EXTERNAL TRIGGER input jack requires a falling-edge, TTL-compatible pulse with the specifications shown in Figure 4-17.

In general, external triggers can be used as events to control scan operation. In order for the Model 7002 to respond to external triggers, the appropriate layers of scan operation must be properly configured. Paragraph 4.8 explains how to program the three layers of the scan.

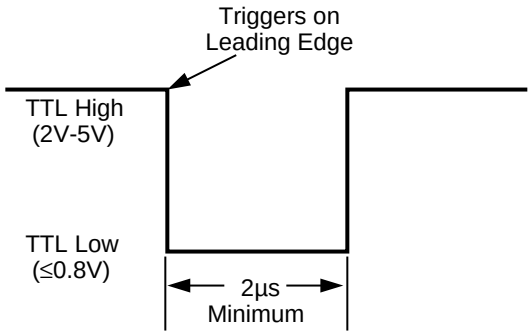


Figure 4-17
External trigger pulse specifications

4.16.2 Channel ready

The CHANNEL READY output jack provides a TTL-compatible output pulse that can be used to trigger other instrumentation. The specifications for this trigger pulse are shown in Figure 4-18.

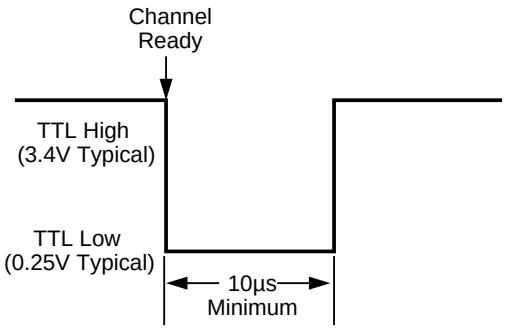


Figure 4-18
Channel ready and asynchronous Trigger Link Output pulse specifications

Typically, you would want the Model 7002 to output a trigger after each channel closes and settles (settling time includes the internally set relay settle time and the user programmed DELAY period; see paragraph 4.13.4). An output trigger will occur after each scanned channel as long as channel spacing is set to external. See paragraph 4.14.1 for details on programming the channel layer.

The Model 7002 can also output a trigger while in the scan and/or arm layers of operation. Figure 4-12 shows where these triggers occur in the trigger model. An output trigger will occur on each return path through the scan layer if the scan layer Source Bypass is enabled (Control = Source) and Scan Spacing is programmed for External. An output trigger will occur on each return path through the arm layer if the arm layer Source Bypass is enabled (Control = Source) and Arm Spacing is programmed for External. See paragraph 4.14.2 and 4.14.3 for programming the scan and arm layer.

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4.16.3 External triggering example

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a DMM such as the Keithley Model 196. Such a test system is shown in Figure 4-19 which uses a Model 7011 multiplexer card to switch 10 DUTs to the DMM.

The external trigger connections for this test system are shown in Figure 4-20. Channel Ready (output) of the Model 7002 is connected to External Trigger Input of the Model 196, and External Trigger (input) of the Model 7002 is connected to Voltmeter Complete Output of the Model 196.

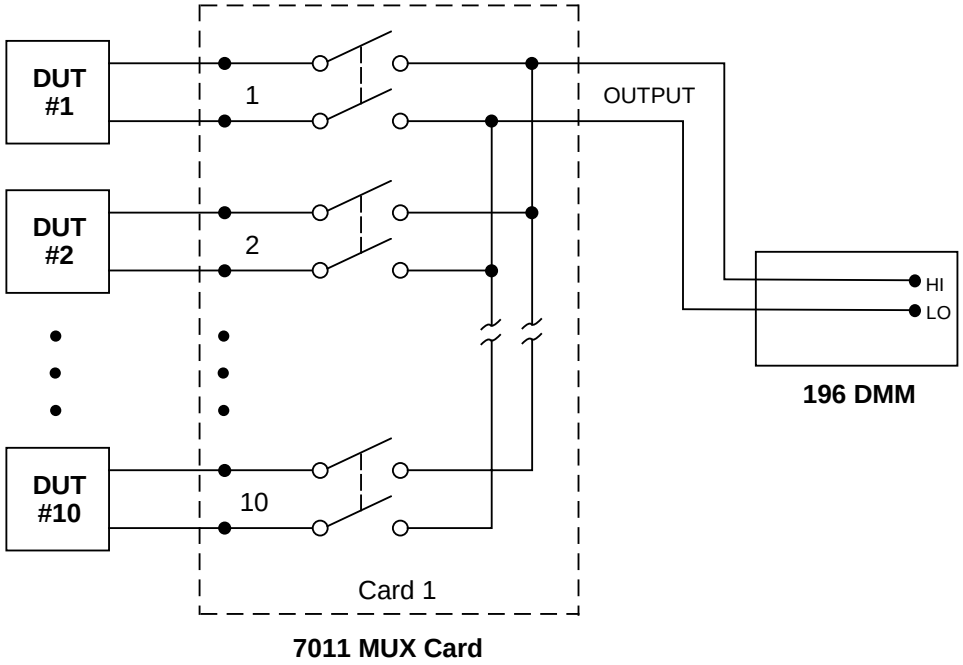


Figure 4-19
DUT test system

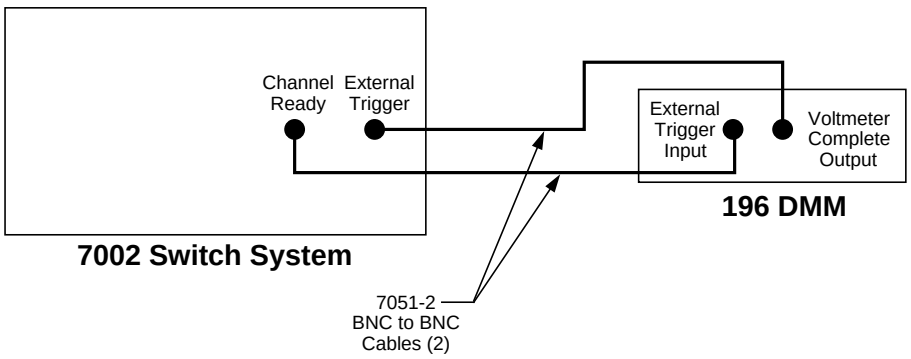


Figure 4-20
External trigger connectors

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For this test system, the Model 196 is configured for external triggering and the scan is configured as follows:

Scan List = 1!1-1!10,

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

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

Channel Layer:
- Channel Spacing = External
- Number of Channels = Use Scan List Length*
- Channel Trigger Control = Source*

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

Notice that Channel Trigger Control is set for Source. With this selection, scan operation will initially bypass the need for an external trigger to close the first channel. Since arm spacing and scan spacing are set for Immediate, the scan will start immediately as soon as the scanner is taken out of the idle state by pressing the STEP key.

When the front panel STEP key is pressed, the scanner will arm and close the first channel. After Channel 1!1 settles (channel ready), a trigger is sent from Channel Ready of the Model 7002 to External Trigger Input of the Model 196 to trigger a measurement of DUT #1. After the Model 196 completes the measurement, it will output a trigger from Voltmeter Complete Output to External Trigger input of the Model 7002, which closes the next channel. After Channel 1!2 settles, a trigger is sent to the Model 196 to trigger a measurement of DUT #2. When the measurement is completed, a trigger is sent to the Model 7002 to close the next channel. After this channel settles, a trigger is sent to the DMM to trigger a measurement. This process continues until all 10 channels are scanned and measured. The data store of the Model 196 could be used to store the measurements as they occur.

4.17 Trigger Link

The Model 7002 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. The 8-pin micro DIN sockets used for the Trigger Link are shown in Figure 4-21.

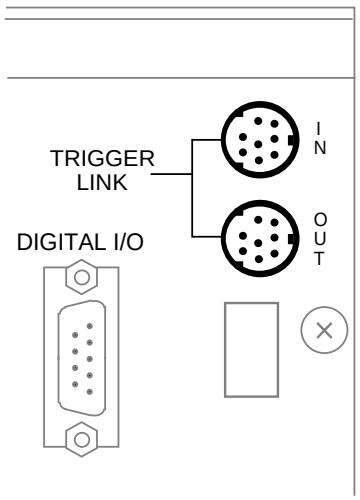


Figure 4-21
Trigger link connectors

NOTE

The two rear panel Trigger Link connectors are actually connected in parallel to each other. Thus, the IN and OUT labels are a misnomer. It does not matter which connector you use when connecting the Trigger Link to another instrument.

In general, Trigger Link input triggers to the Model 7002 are used to control scan operation. In order for the Model 7002 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 would be used to trigger another instrument to measure the currently selected channel.

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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.

4.17.1 Asynchronous operation

In the asynchronous operating mode, Trigger Link functions fundamentally in the same manner as External Triggering (see paragraph 4.16). Like External Triggering, the asynchronous mode uses separate lines for input and output triggers. The asynchronous mode also uses the same TTL-compatible pulses as External Triggering. The input trigger specifications for asynchronous mode are shown in Figure 4-17 and the output trigger specifications are shown in Figure 4-18.

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 (see paragraph 4.13.4) times out, the Model 7002 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 paragraph 4.14.2).

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.

Asynchronous Trigger Link example #1

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a meter. Such a test system is shown in Figure 4-22 which uses a Model 7011 multiplexer card to switch 10 DUTs to a meter that is equipped with Trigger Link.

The Trigger Link connections for this test system are shown in Figure 4-23. Trigger Link of the Model 7002 is connected to Trigger Link of the meter. Notice that only one Trigger Link cable is needed.

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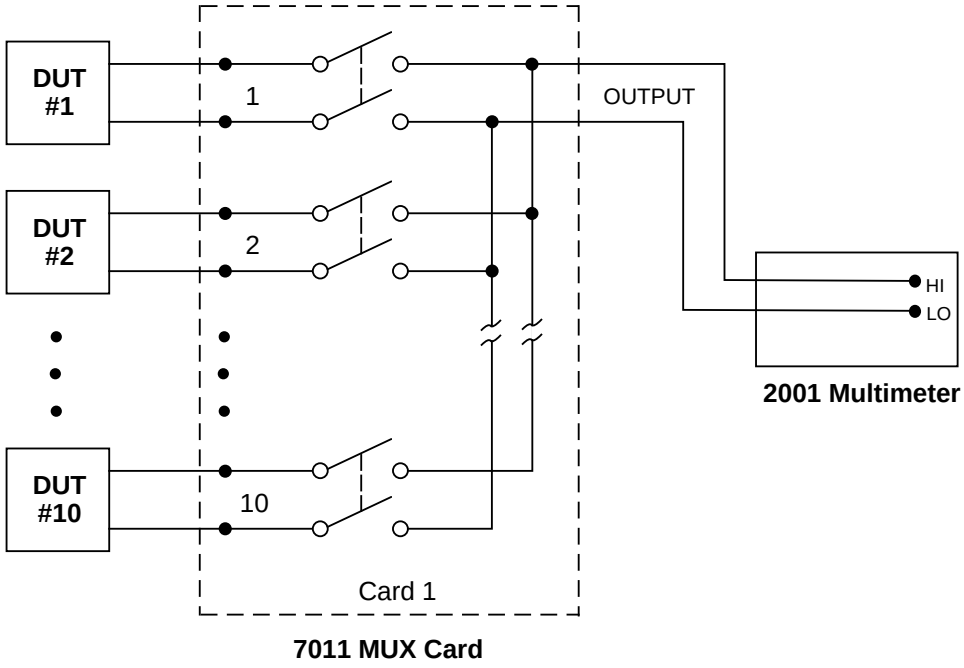


Figure 4-22
DUT test system

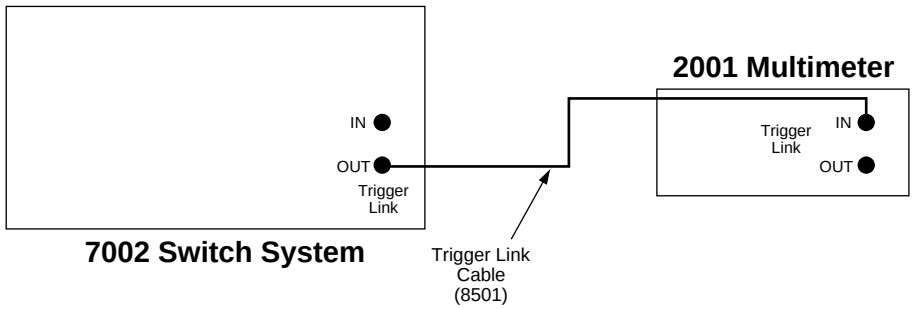


Figure 4-23
Trigger link connections (asynchronous example)

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

Model 7002:

Scan List = 1!1-1!10,

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

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

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

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

2001 Multimeter:

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

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

Measure Layer:
- Measure Source = TrigLink
- Trigger Link Mode = Asynchronous
- Input Line = #1
- Output Line = #2
- Measure Trigger Control = Acceptor
- Measure Count = 10

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

To run the test simply press STEP on the Model 7002. The following explanation on operation is referenced to the operation model shown in Figure 4-24.

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

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

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

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

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

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

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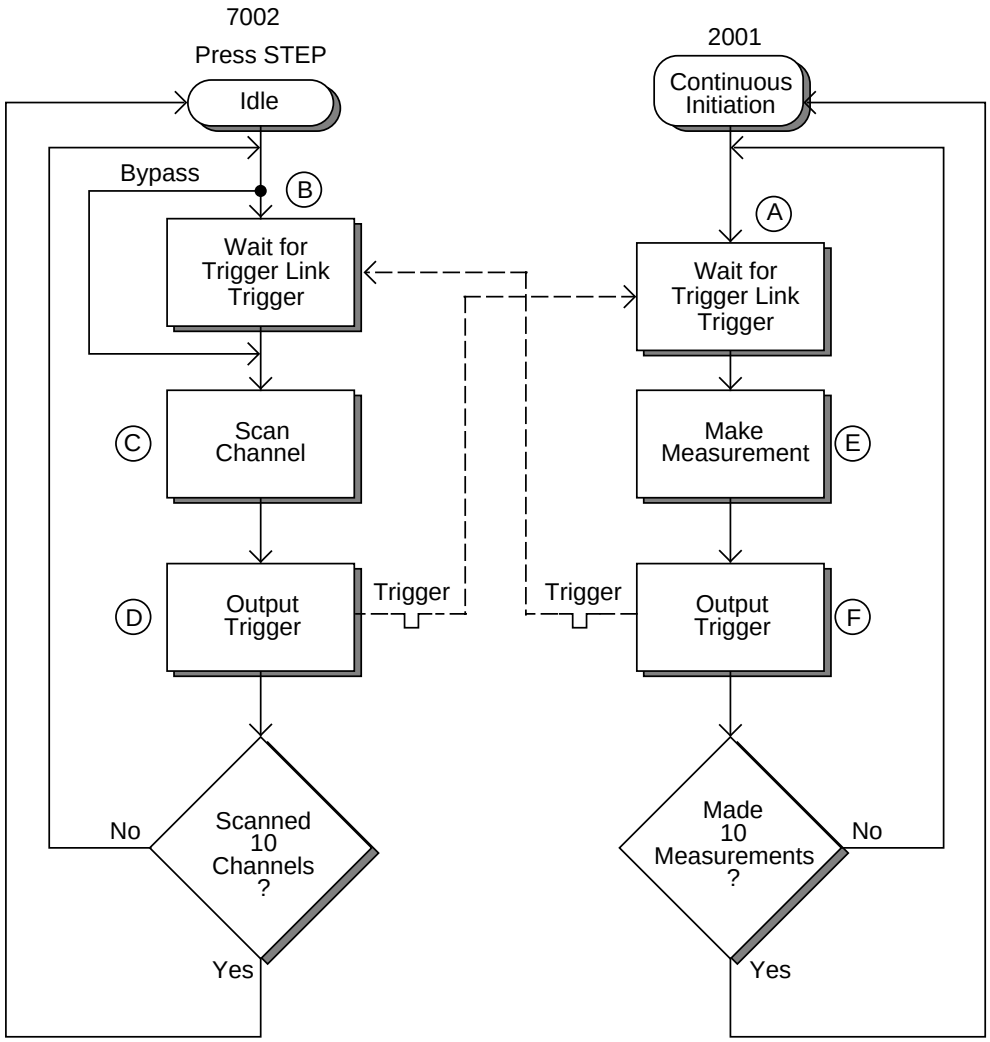


Figure 4-24
Operation model for asynchronous Trigger Link example #1

External Triggering and Trigger Link — As previously mentioned, the trigger pulses for the asynchronous Trigger Link are identical to the trigger pulses used for External Triggering. The only thing that prevents them from being used together are connection incompatibilities. Trigger Link uses 8-pin micro DIN connectors while External Triggering uses BNC connectors.

This connection problem can be resolved by using the Model 8502 Trigger Link Adapter. The adapter has two 8-pin micro DIN connectors and six BNC connectors. The DIN connectors connect directly to a Trigger Link connector on the Model 7002 using a trigger link cable. The BNC connectors mate directly to the External Triggering BNC connectors on other instruments using standard male BNC to BNC cables.

Figure 4-25 shows how a Keithley Model 196 can be connected to the Trigger Link of the Model 7002 using the adapter. With this adapter, the Model 196 could be substituted for the meter with Trigger Link (2001) in the previous example (asynchronous Trigger Link example #1). With the Model 196 set for external triggering, the test would start when STEP on the Model 7002 is pressed.

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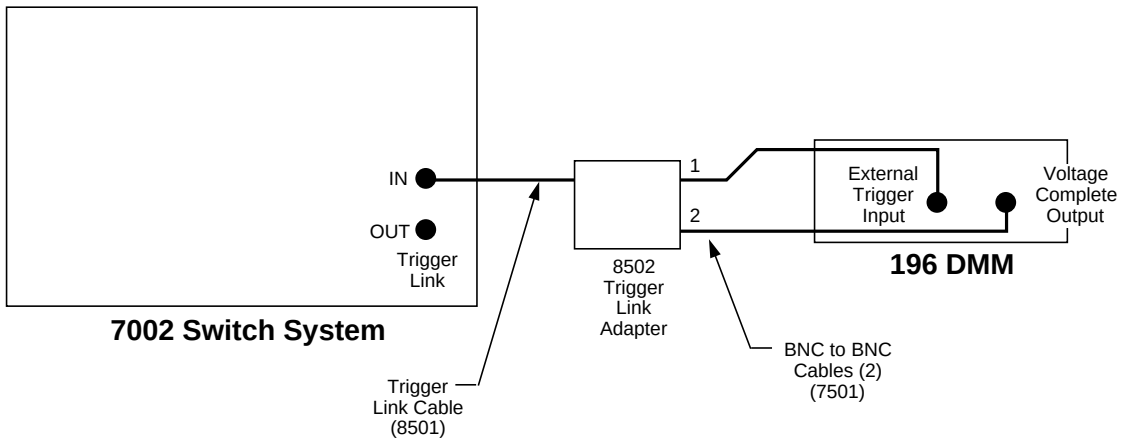


Figure 4-25
Connections using Trigger Link adapter

Asynchronous Trigger Link example #2

In this example, the test system (Figure 4-26) includes a Model 196 DMM to measure each DUT at two different bias levels that are provided by the Model 230 voltage source. With the source set to the first voltage level, the 10 channels will be scanned and measured. The source will then be set to the second voltage level and the 10 channels will again be scanned and measured.

Since this example uses instruments that do not have Trigger Link (Model 196 and 230), the Model 8502 Trigger Link Adapter is required. Connections are shown in Figure 4-27.

For this example, the Models 196 and 230 are programmed for External Triggering and the Model 230 is set to source the first voltage level. The Model 7002 is configured as follows:

Model 7002:

Scan List = 1!1-1!10,

Arm Layer:

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

Scan Layer:

- Scan Spacing = TrigLink
- Input Line = # 2
- Output Line = #1
- Scan Trigger Control = Source
- Number of Scans = 2

Channel Layer:

- Channel Spacing = TrigLink
- Trigger Link Mode = Asynchronous
- Input Line = #4
- Output Line = #3
- Channel Trigger Control = Source*
- Number of Channels = Use Scanlist Length*

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

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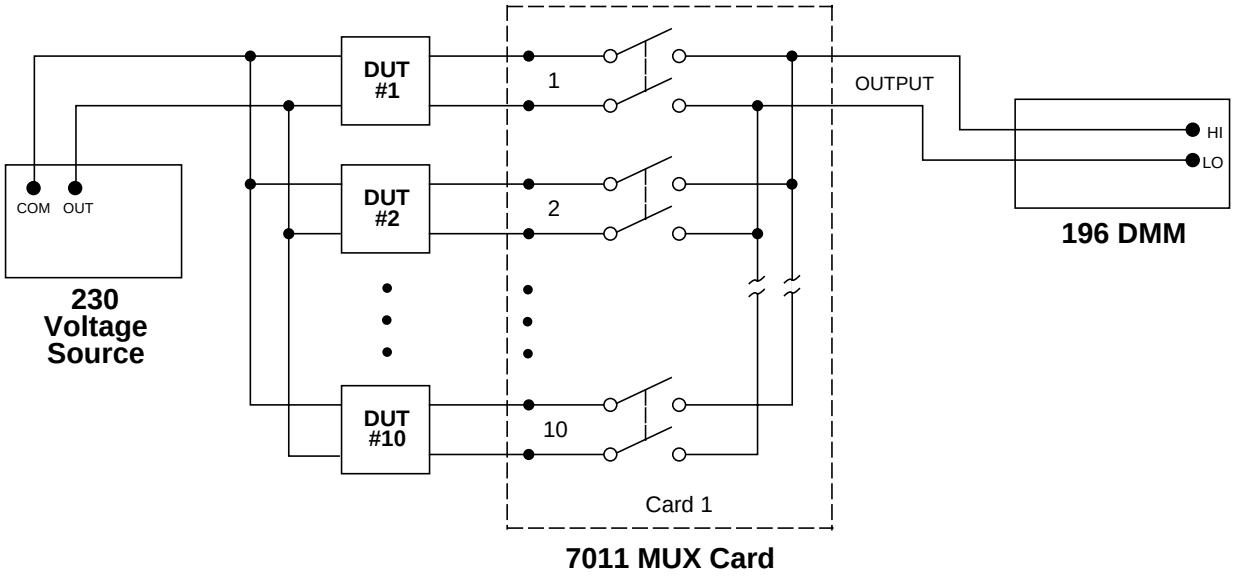


Figure 4-26
DUT test system (asynchronous example #2)

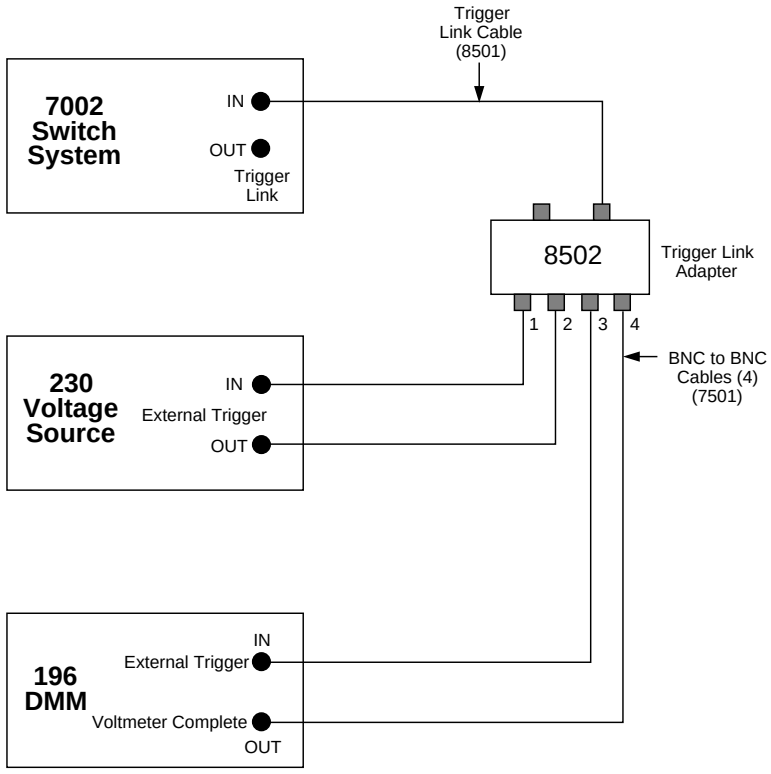


Figure 4-27
Trigger Link connections (asynchronous example #2)

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To run the test, simple press STEP on the Model 7002. The following explanation on operation is referenced to the operation model shown in Figure 4-28.

Ⓐ Pressing STEP takes the Model 7002 out of the idle state. Since the arm layer is programmed for Immediate Spacing, operation drops down to the scan layer at point A.

Ⓑ Since Scan Trigger Control is set for Source, the scan will not wait at point A for a trigger. Instead, it will bypass "Wait for Trigger Link Trigger" and proceed to point B. Note that this Bypass is only in effect on the first pass through the model.

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

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

Ⓔ The trigger pulse from the Model 7002 will trigger the Model 196 to make a measurement of DUT #1. After the measurement has completed, the DMM will output a trigger pulse (point E).

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

Ⓕ After the last channel is scanned and measured, operation proceeds to point F where the Model 7002 outputs a trigger pulse. Since the Model 7002 is programmed to perform two scans, its operation will loop back up to point A where it will wait for an input trigger. Note that Bypass is no longer in effect.

Ⓖ The trigger pulse from the Model 7002 triggers the Model 230 to output the next programmed voltage level. After the voltage level is set, the Model 230 will output a trigger pulse (point G).

The trigger pulse applied to the Model 7002 from the Model 230 places operation at point B. The Bypass is again in effect because this is the beginning of a new scan. This allows operation to drop down to point C where the first channel will again be closed and eventually measured. As previously explained all ten channels are scanned and measured.

After the last channel of the second scan is closed and measured, the Model 7002 returns to the idle state.

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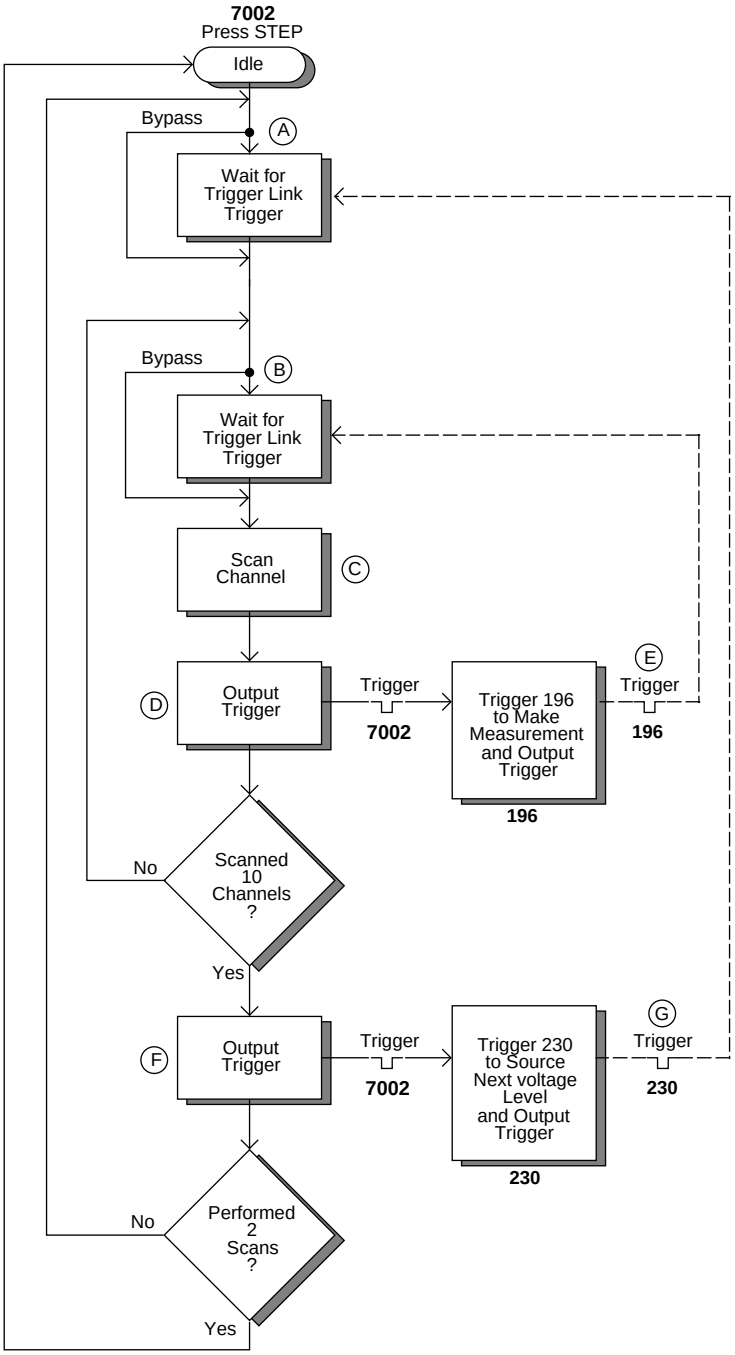


Figure 4-28
Operation model for asynchronous Trigger Link example #2

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4.17.2 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 4-29). 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.

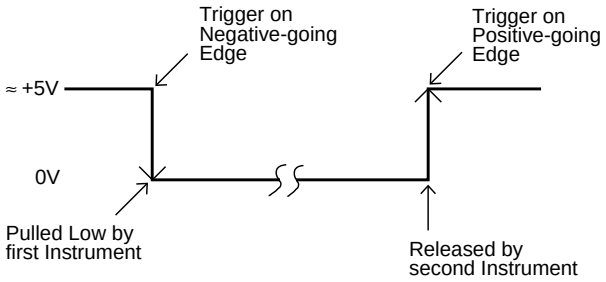


Figure 4-29
Semi-synchronous trigger link pulse specifications

For example, assume that a Model 2001 Multimeter is connected to two Model 7002s for semi-synchronous operation as shown in Figure 4-30. All three instruments are programmed to use trigger line #1. The two Model 7002s have relay settling times of 10msec and 50msec respectively.

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

Semi-synchronous trigger link example

This example uses the same test system (Figure 4-22) that was used for the asynchronous Trigger Link example #1. However, triggering will be done using the semi-synchronous mode. Trigger Link connections are shown in Figure 4-31.

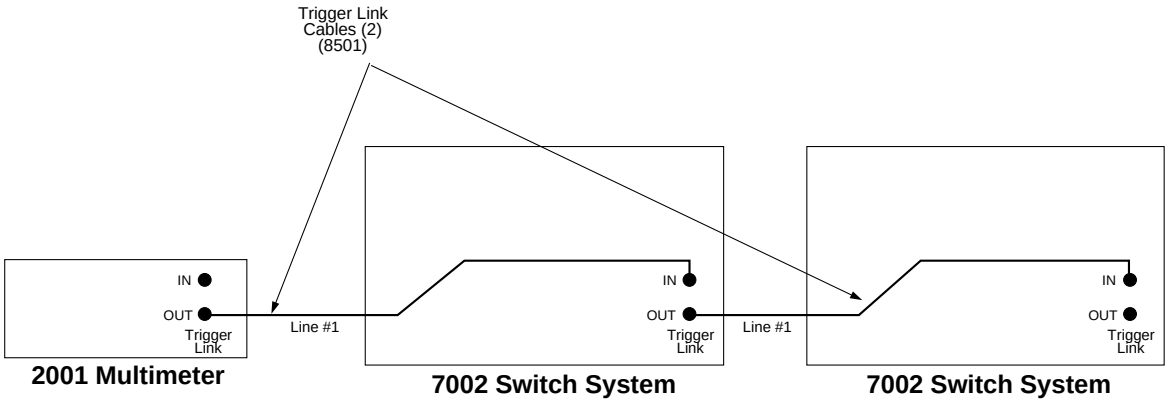


Figure 4-30
Typical semi-synchronous mode connections

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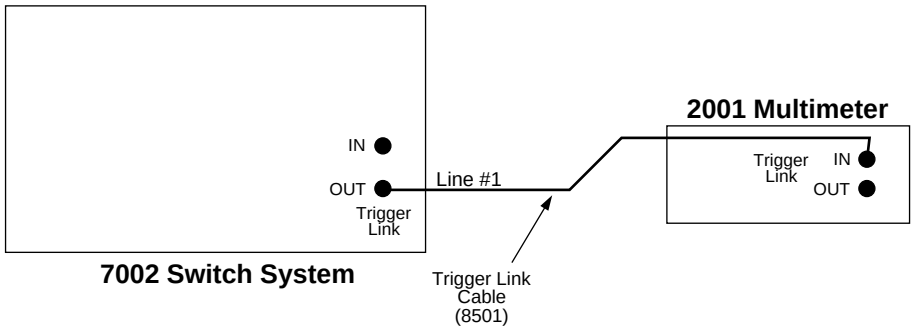


Figure 4-31
Trigger Link connections (semi-synchronous example)

The two instruments are configured as follows:

Model 7002:

Scan List = 1!1-1!10,

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

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

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

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

Model 2001:

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

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

Measure Layer:
- Measure Source = TrigLink
- Trigger Link Mode = Semi-Synchronous
- Semi-Sync Line = #1
- Trigger Control = Acceptor
- Measure Count = 10

To run the test, simply press STEP on the Model 7002. The following explanation on operation is referenced to the operation model shown in Figure 4-32.

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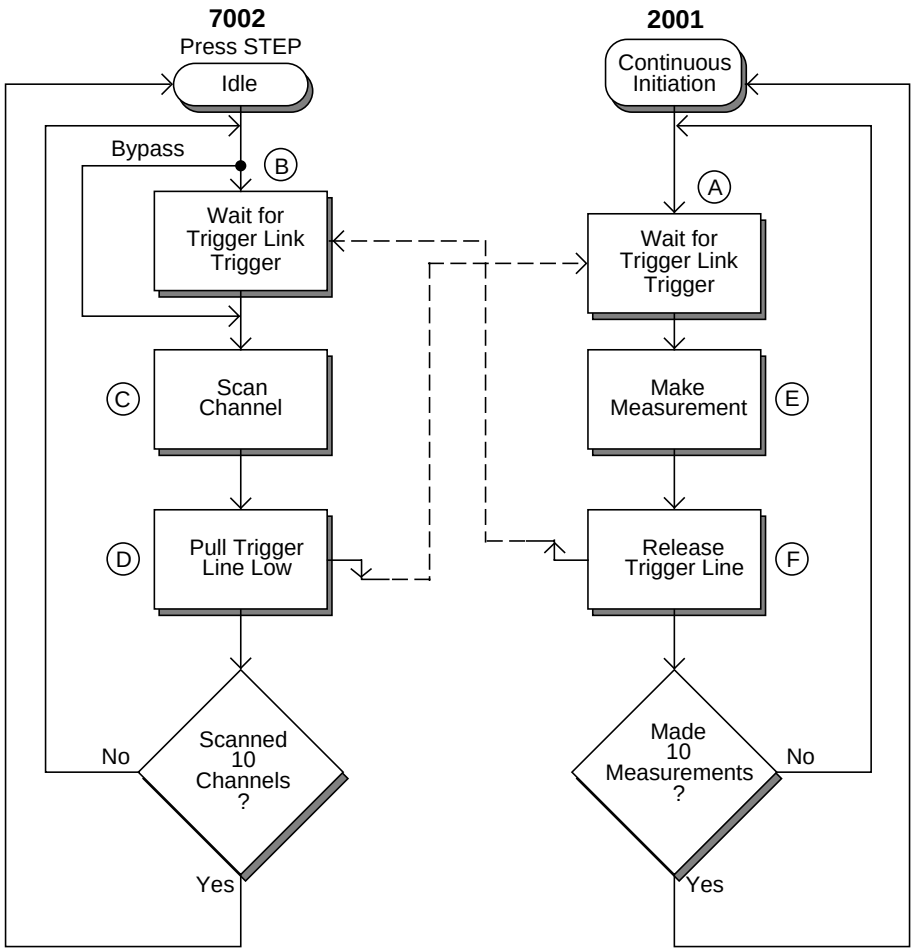


Figure 4-32
Operation model for semi-synchronous Trigger Link example

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

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

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

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

E & **F** Remember that 2001 operation is at point A waiting for a trigger. When the trigger line was pulled low by the Model 7002, the leading negative-going edge triggers the

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meter to measure DUT #1 (point E). Note that the 2001 holds the trigger line low. After the measurement has completed, the 2001 will release the trigger line (point F) and then loop back to point A where it will wait for another input trigger.

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

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5

IEEE-488 Reference

5.1 Introduction

This section contains reference information on programming the Model 7002 over the IEEE-488 bus and is organized as follows:

5.2 IEEE-488 bus connections: Explains instrument connections to the IEEE-488 bus.

5.3 Primary address selection: Explains how to set the primary address from the front panel.

5.4 Controller programming: Summarizes programming statements using HP BASIC 4.0.

5.5 Front panel aspects of IEEE-488 operation: Covers status indicators, messages that pertain to bus operation, and the use of the LOCAL key.

5.6 Status structure: Explains the various registers and queues that make up the status structure of the Model 7002.

5.7 Trigger model: Explains the scan process (Trigger Model) over the IEEE- 488 bus.

5.8 General bus commands: Covers the general IEEE-488 commands required for basic operations, such as placing the unit in remote.

5.9 Programming syntax: Covers the syntax rules for common commands and SCPI commands.

5.10 Common commands: Covers the IEEE-488.2 common commands used by the Model 7002.

5.11 SCPI command subsystems: Covers the SCPI commands used by the Model 7002.

The IEEE-488 is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. In 1978 and 1987, the standards were upgraded to IEEE-488-1978 and IEEE-488.1-1987, respectively. The Model 7002 conforms to these standards.

The Model 7002 also conforms to the IEEE-488.2-1987 standard and the SCPI 1992 (Standard Commands for Programmable Instruments) standard. IEEE-488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, and what registers should exist to record the state of the instrument. This subset of commands (common commands) is used to perform basic operations, such as reading status registers, triggering measurements, and resetting the device.

The SCPI standard defines a command language protocol. It goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of an instrument. It also defines what format the parameters for

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those commands should be in and the format for values returned by the instruments.

5.2 IEEE-488 bus connections

The Model 7002 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. Current standards call for metric threads, which are identified with dark colored screws. Earlier versions had different screws, which were silver colored. Do not attempt to use these types of connectors on the instrument, which is designed for metric threads.

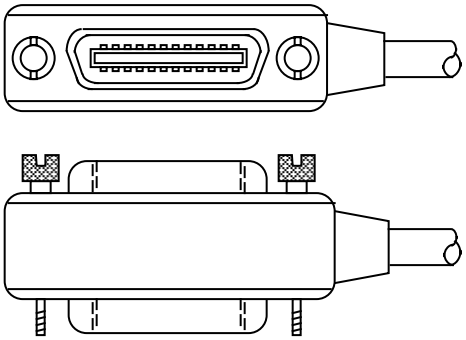


Figure 5-1
IEEE-488 connector

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.

NOTE

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley.

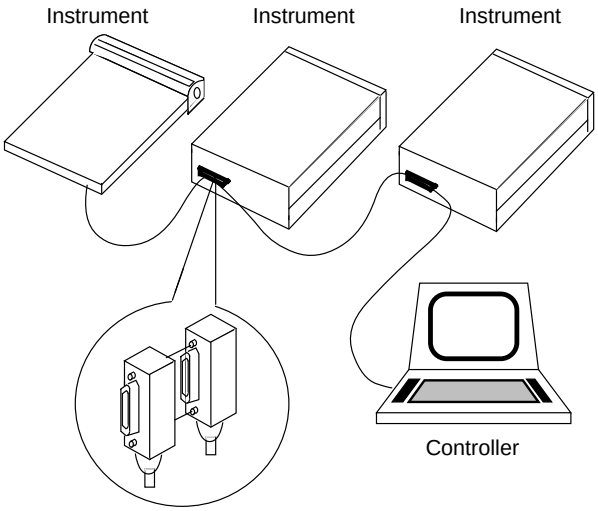


Figure 5-2
IEEE-488 connections

Connect the Model 7002 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. Most controllers are equipped with an IEEE-488 style connector, but a few may require a different type of connecting cable. Consult the instruction manual for your controller for the proper connecting method.

NOTE

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

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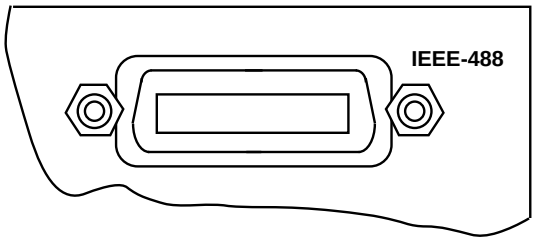


Figure 5-3
IEEE-488 connector location

Custom cables may be constructed by using the information in Table 5-1 and Figure 5-4. Table 5-1 lists the contact designations for the bus, and Figure 5-4 shows the contact configuration.

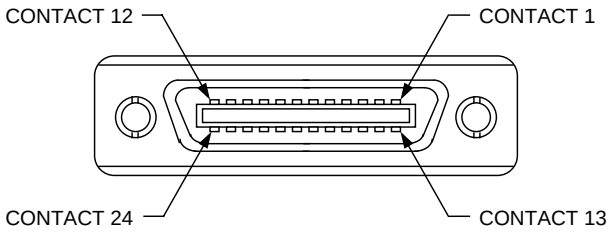


Figure 5-4
Contact configuration

CAUTION

IEEE-488 common is connected to digital common. Maximum voltage between digital common and earth ground is 0V.

Table 5-1
IEEE contact designations

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

* Numbers in parentheses refer to signal ground return of referenced contact number. EOI and REN signal lines return on contact 24.

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5.3 Primary address selection

The Model 7002 must receive a listen command before responding to addressed commands. Similarly, the unit must receive a talk command before transmitting data. The Model 7002 is shipped from the factory with a programmed primary address of 7.

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 (◀ and ▶) 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.

NOTE

Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.

Rear panel address switches

On the rear panel (just above the IEEE-488 connector) are IEEE-488 address switches. These switches are used for special order units that do not have front panel controls. These switches are non-functional for all other units.

For units that do not have front panel controls, use the switches to change the IEEE-488 address. At the factory, the IEEE-488 address is set to 7.

The five switches are binary coded, with A1 being the LSB and A5 being the MSB. The decimal weight of each switch (when in the "1" position) is defined as follows:

A1 (1 position) = Decimal 1
A2 (1 position) = Decimal 2
A3 (1 position) = Decimal 4
A4 (1 position) = Decimal 8
A5 (1 position) = Decimal 16

The sum of the decimal weights determine the address. For example, for address 20 set A3 and A5 to "1", and A1, A2 and A4 to the "0".

After changing the IEEE-488 address, you must cycle power in order for the instrument to read the address switch.

Address 31 is not a valid address selection. If you set the switches for address 31, the instrument will default to address 0.

5.4 Controller programming

The programming instructions covered in this section use examples written with Hewlett-Packard BASIC version 4.0. This language was chosen because of its versatility in controlling the IEEE-488 bus. This section covers those statements that are essential to Model 7002 operation.

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NOTE

Controller programming information for using the IBM PC interface through the Capital Equipment Corporation (CEC), I\O Tech, and National IEEE-488 interfaces is located in the Appendix.

A partial list of HP BASIC 4.0 statements is shown in Table 5-2. The statements have a one or three digit argument that must be specified. The first digit is the interface select code, which is set to 7 at the factory. The last two digits of those statements requiring a 3-digit argument specify the primary address.

Those statements with a 3-digit argument show a primary address of 7 (the factory set primary address). For a different address, you would, of course, change the last two digits to the required value. For example, to send a GTL command to a device using a primary address of 17, the following statement would be used: LOCAL 717.

Some of the statements have two forms; the exact configuration depends on the command to be sent over the bus. For example, CLEAR 7 sends a DCL command, while CLEAR 716 sends the SDC command to a device with a primary address of 16.

Table 5-2
HP BASIC 4.0 IEEE-488 statements

Action	BASIC statement
Transmit string to device 07.	OUTPUT 707;A$
Obtain string from device 07.	ENTER 707;A$
Send GTL to device 07.	LOCAL 707
Send SDC to device 07.	CLEAR 707
Send DCL to all devices.	CLEAR 7
Send remote enable.	REMOTE 7
Cancel remote enable.	LOCAL 7
Serial poll device 07.	SPOLL (707)
Send local lockout.	LOCAL LOCKOUT 7
Send GET to device 07.	TRIGGER 707
Send IFC.	ABORT 7

5.5 Front panel aspects of 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.

5.5.1 Error and status messages

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

5.5.2 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 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 send-

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ing 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. See paragraph 5.6.8 for details.

5.5.3 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.

5.6 Status structure

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

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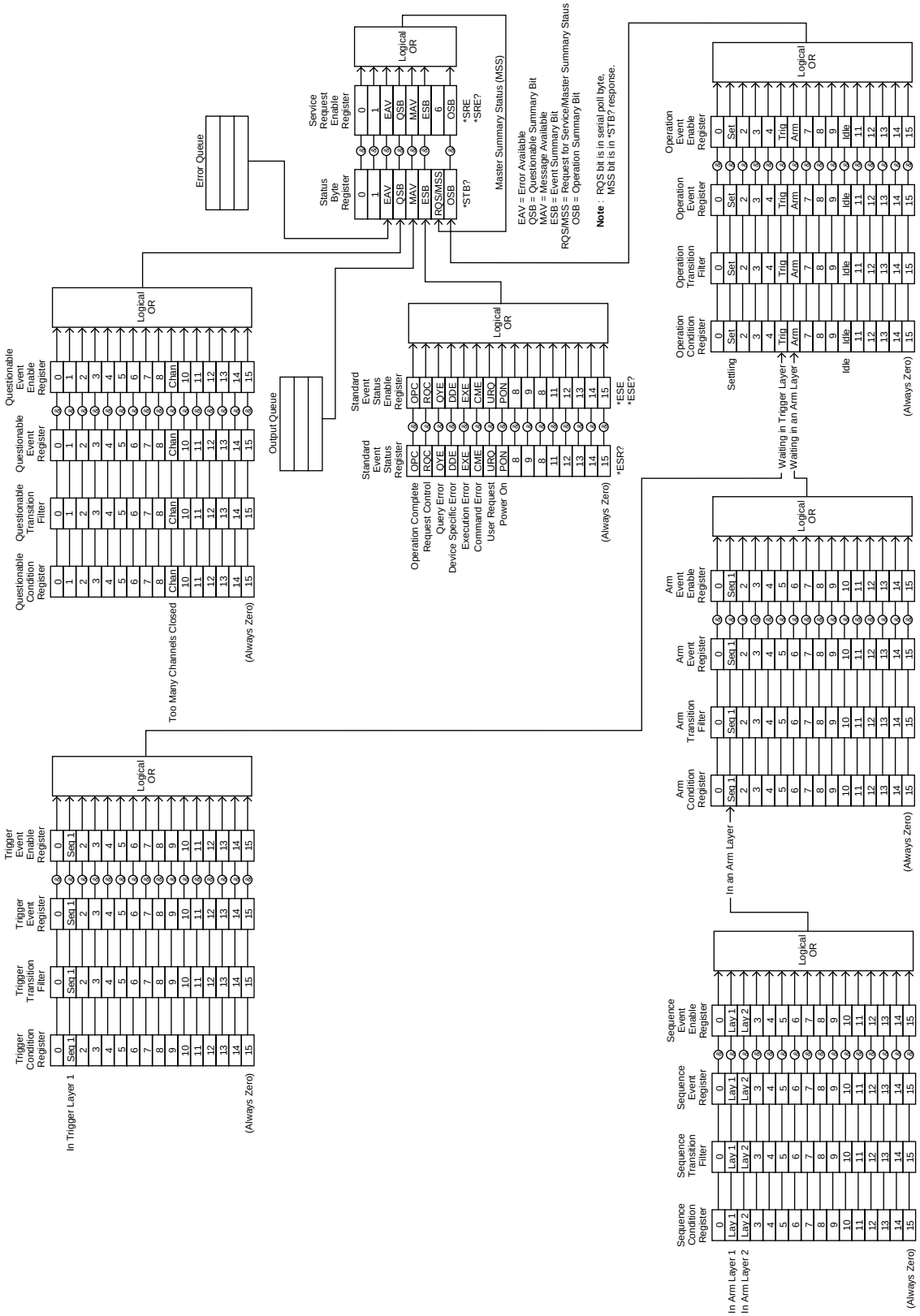


Figure 5-5
Model 7002 status register structure

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5.6.1 Standard event status

The reporting of standard events is controlled by two 16-bit registers; the Standard Event Status Register and the Standard Event Status Enable Register. Figure 5-6 shows how these registers are structured.

In general, the occurrence of a standard event sets the appropriate bit in the Standard Event Status Register. This register can be read at any time to determine which, if any, standard events have occurred. Also, with the proper use of the Standard Event Status Enable Register, a standard event can set the Event Summary Bit (ESB) of the Status Byte Register. This allows the programmer to take advantage of the service request (SRQ) feature. See paragraph 5.6.8 for details.

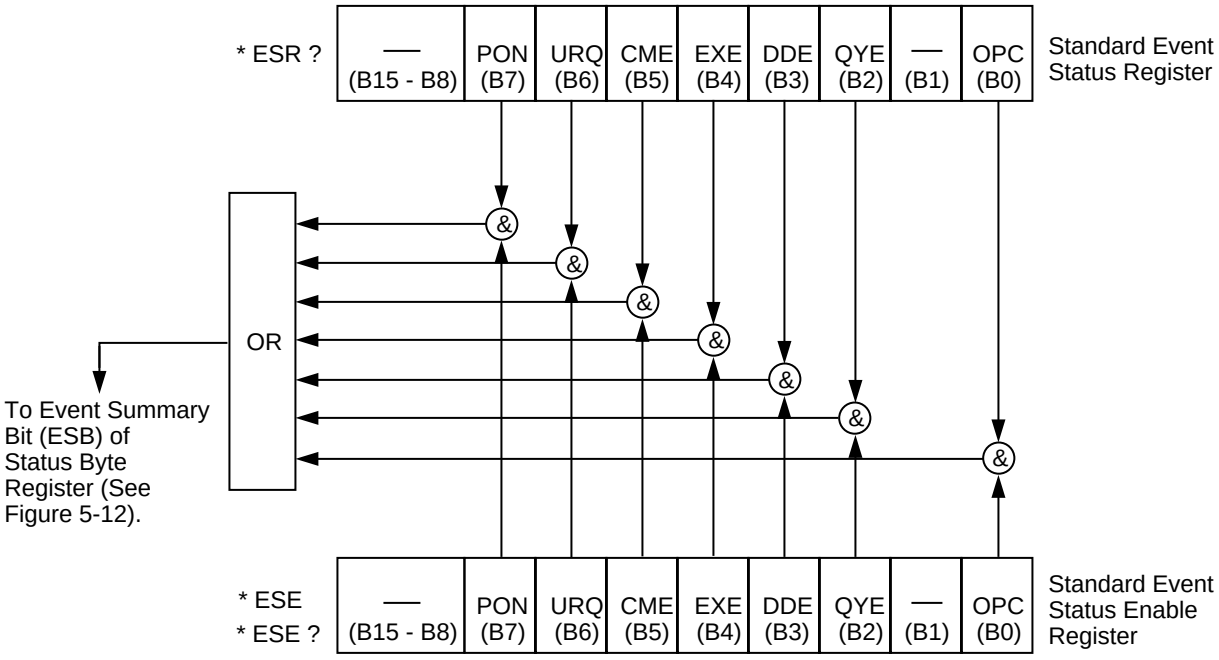


Figure 5-6
Standard event status

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Standard Event Status Register — This is a latched read only register that is used to record the occurrence of standard events. Each used bit in the register represents a standard event. Descriptions of these standard events are provided in paragraph 5.10.4.

When a standard event occurs, the appropriate bit in the Standard Event Status Register sets. For example, if you attempt to read data from an empty Output Queue, a Query Error (QYE) will occur and set bit B2 of the status register. A set bit in this register will remain set until an appropriate operation is performed to clear the register. The Standard Event Status Register can be read at any time by using the following common query command (see paragraph 5.10.4 for details):

*ESR?

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

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

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

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

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

The individual bits of the Standard Event Status Enable Register can be set or cleared by using the following common command (see paragraph 5.10.2):

*ESE <NRf>

The Standard Event Status Enable register can be read at any time by using the following common query command (see paragraph 5.10.3 for details):

*ESE?

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

1. Cycling power.
2. *ESE 0

5.6.2 Operation event status

The reporting of operation events is controlled by a set of 16-bit registers; the Operation Condition Register, the Transition Filter, the Operation Event Register, and the Operation Event Enable Register. Figure 5-7 shows how these registers are structured.

Notice in Figure 5-5 that bits B5 (Waiting in Trigger Layer) and B6 (Waiting in An Arm Layer) of the Operation Condition Register are controlled by the arm register set and the trigger set and the trigger register set (see paragraph 5.6.3 and 5.6.5 for details). Each of the bits that is used in these registers represents an operation event. Descriptions of the operation event bits are provided in paragraph 5.16.

The operation status registers are controlled by the :STATus:OPERation commands in the :STATus subsystem (see paragraph 5.16).

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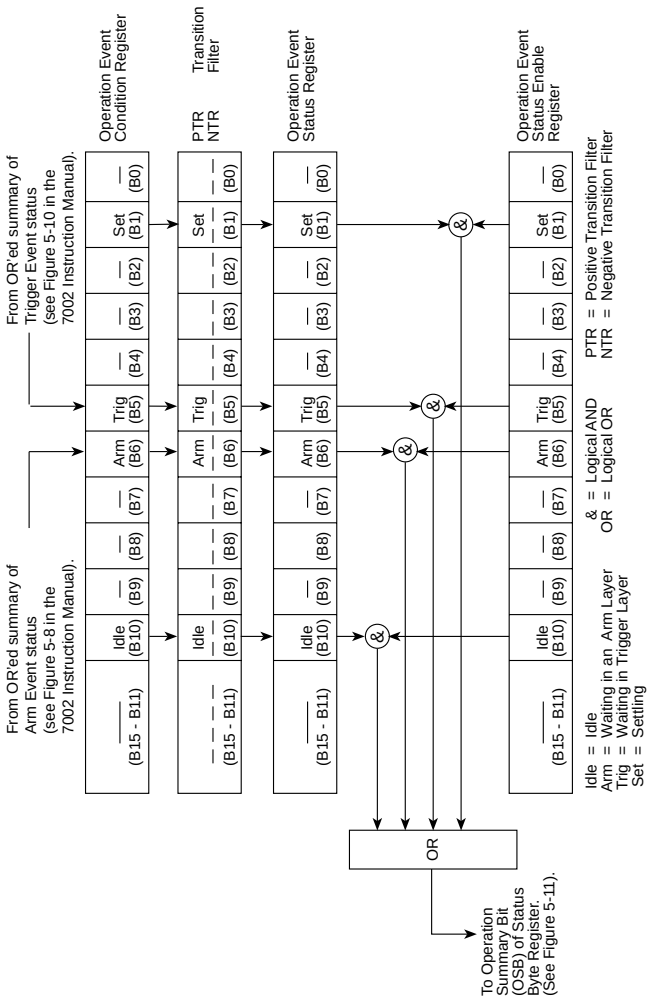


Figure 5-7
Operation event status

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

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

:STATus:OPERation:CONDition?

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

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

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

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

:STATus:OPERation:PTR <NRf>
:STATus:OPERation:NTR <NRf>

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

:STATus:OPERATION:PTR?
:STATus:OPERation:NTR?

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

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

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

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

:STATus:OPERation?

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

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

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

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

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

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

:STATus:OPERation:ENABle <NRf>

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

:STATus:OPERation:ENABle?

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

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

5.6.3 Arm event status

The reporting of the arm event is controlled by a set of 16-bit registers; the Arm Condition Register, the Transition Filter, Arm Event Register, and the Arm Event Enable Register. Figure 5-8 shows how these registers are structured. Notice in Figure 5-5 that bit B1 (In An Arm Layer) of the Arm Condition Register is controlled by the sequence event register set (see paragraph 5.6.4 for details). In general, bit B1 sets when the instrument is in the arm layer (Arm Layer 1) or scan layer (Arm Layer 2) of operation. An explanation of the operation process over the bus is provided in paragraph 5.7.

The various registers used for arm event status are described as follows: Note that these registers are controlled by the :STATus:OPERation:ARM commands of the :STATus subsystem (see paragraph 5.16).

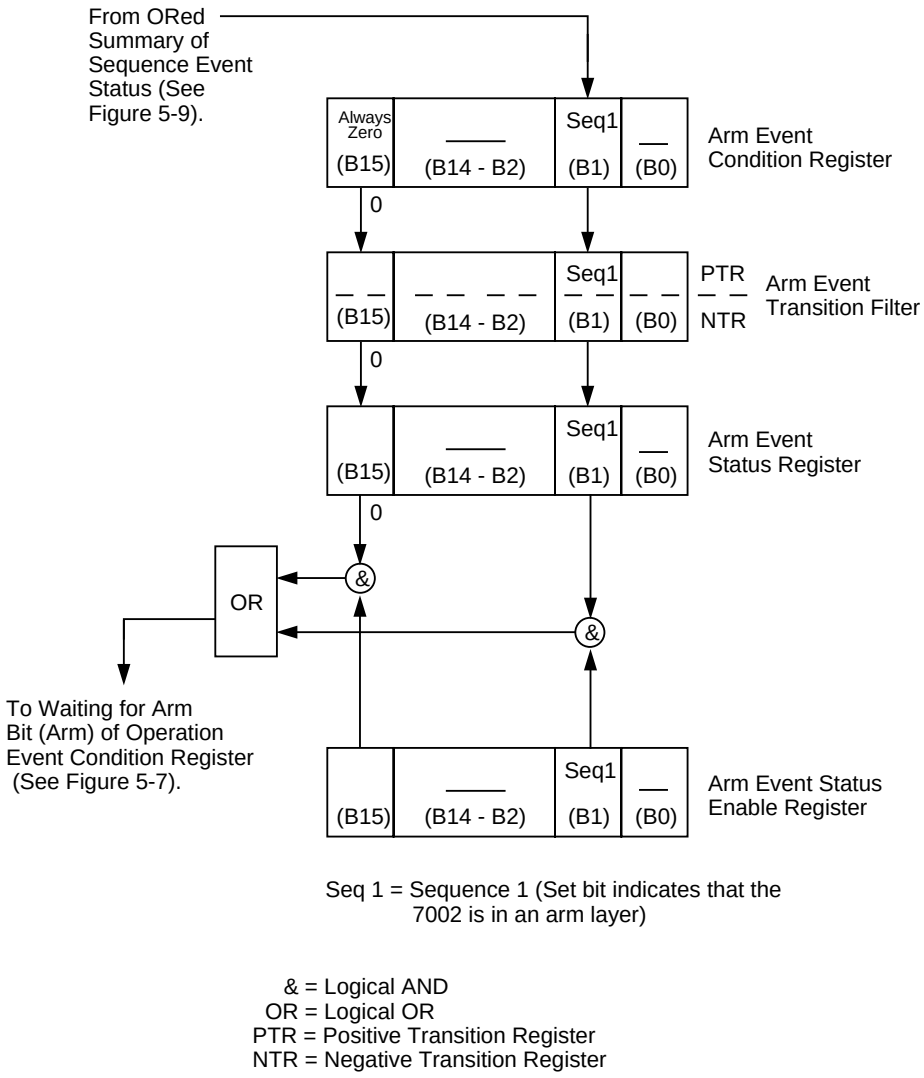


Figure 5-8
Arm event status

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

:STATus:OPERation:ARM:CONDition?

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

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

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

:STATus:OPERation:ARM:PTR <NRf>
:STATus:OPERation:ARM:NTR <NRf>

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

:STATus:OPERation:ARM:PTR?
:STATus:OPERation:ARM:NTR?

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

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

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

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

:STATus:OPERation:ARM:EVENt?

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

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

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

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

Bit B1 in the Arm Event Register is unmasked when the corresponding bit (B1) in the Arm Event Enable Register is set

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

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

:STATus:OPERation:ARM:ENABle <NRf>

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

:STATus:OPERation:ARM:ENABle?

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

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

5.6.4 Sequence event status

The reporting of sequence events is controlled by a set of 16-bit registers; the Sequence Condition Register, the Transition Filter, the Sequence Event Register and the Sequence Event Enable Register. Figure 5-9 shows how these registers are structured.

Two bits of this register set are used by the Model 7002 to report sequence events. Bit B1 (In Arm Layer 1) is set when instrument is in (or exited) the arm layer (Arm Layer 1) of operation. Bit B2 (In Arm Layer 2) is set when the instrument is in (or exited) the scan layer (Arm Layer 2). The operation process over the bus is explained in paragraph 5.7.

The various registers used for sequence event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM:SEQuence commands of the :STATus subsystem (see paragraph 5.16).

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

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

:STATus:OPERation:ARM:SEQuence:CONDition?

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

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

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

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

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

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

:STATus:OPERation:ARM:SEQuence:PTRansition?
:STATus:OPERation:ARM:SEQuence:NTRansition?

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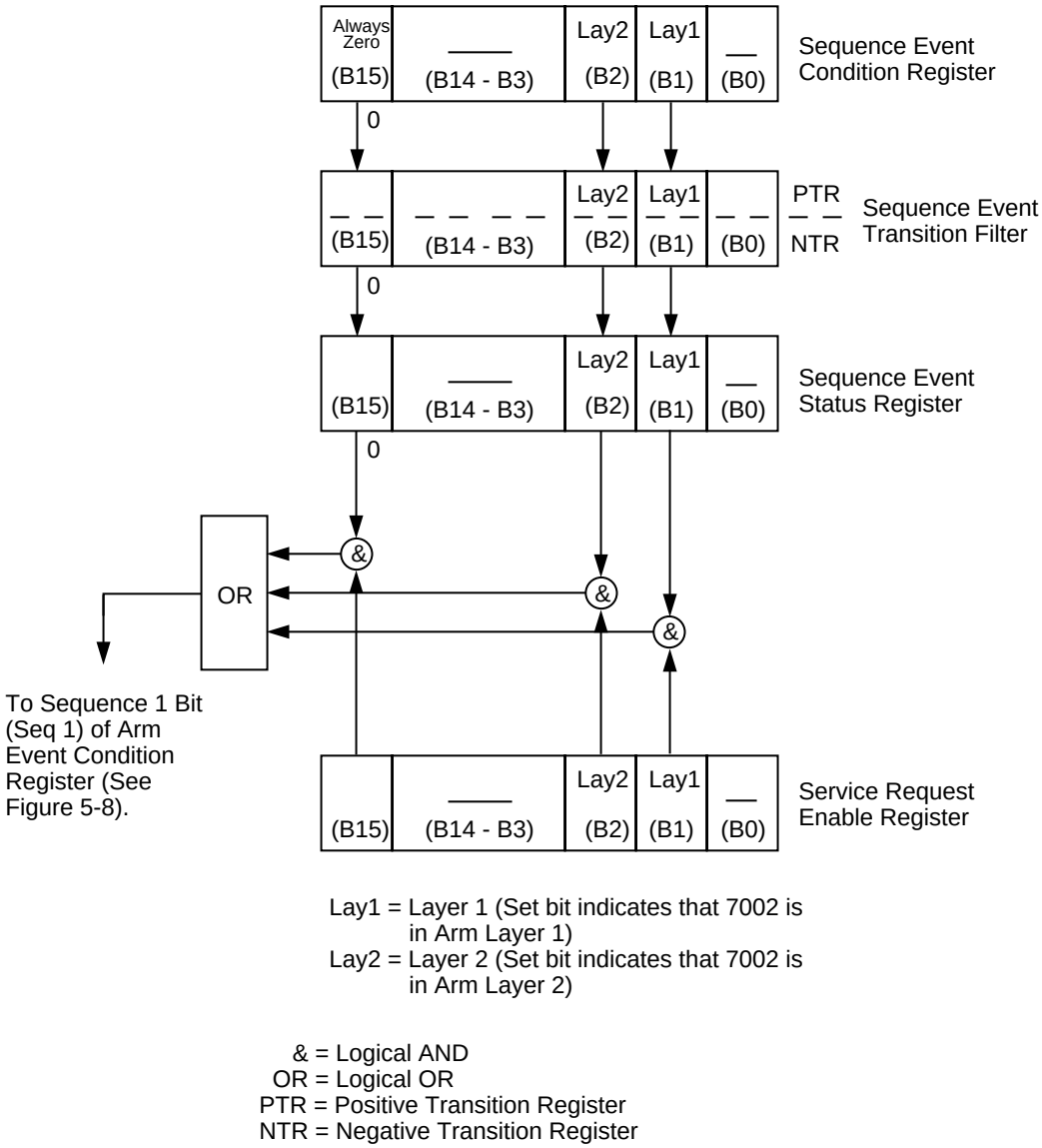


Figure 5-9
Sequence event status

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

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

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

Sequence Event Register — This is a latched, read-only register whose bits are set by the Sequence Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing sequence. The bits of this register are logically

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ANDed with the bits of the Sequence Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B1 of the Arm Condition Register (see paragraph 5.6.3). The following SCPI query command can be used to read the Sequence Event Register:

:STATus:OPERation:ARM:SEQuence?

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

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

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

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

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

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

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

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

:STATus:OPERation:ARM:SEQuence:ENABle?

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

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

5.6.5 Trigger event status

The reporting of the trigger event is controlled by a set of 16-bit registers; the Trigger Condition Register, the Transition Filter, the Trigger Event Register, and the Trigger Event Enable Register. Figure 5-10 shows how these registers are structured.

Bit B1 (Seq1) of the register set is used for the trigger event (In Trigger Layer). In general, Bit B1 sets when the instrument is in (or has exited) the measure layer of operation. An explanation of the Model 7002 operation process is provided in paragraph 5.7. The various registers used for trigger event status are described as follows: Note that these registers are controlled by the :STATus:OPERation:TRIGger commands of the :STATus subsystem (see paragraph 5.16).

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

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

:STATus:OPERation:TRIGger:CONDition?

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

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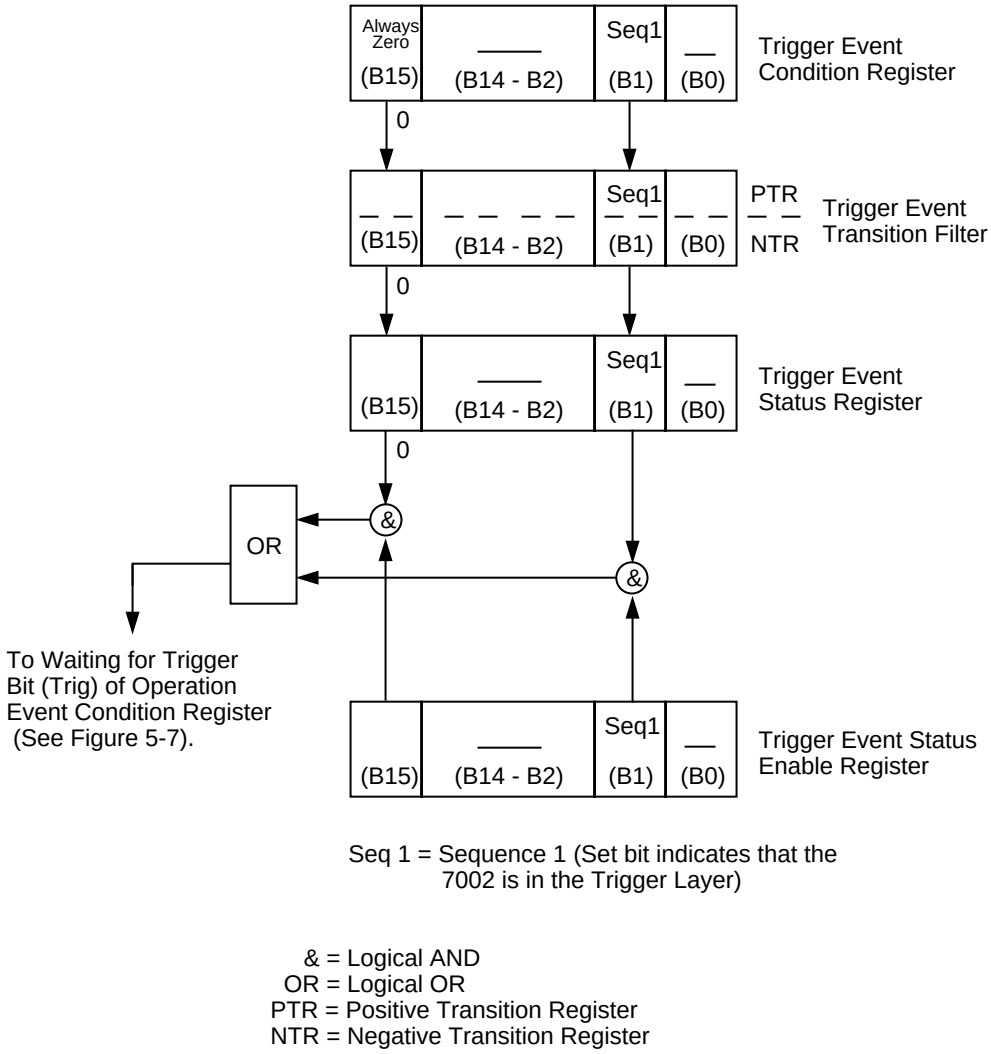


Figure 5-10
Trigger event status

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

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

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

:STATus:OPERation:TRIGger:PTRansition <NRf>
:STATus:OPERation:TRIGger:NTRanstion <NRf>

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

:STATus:OPERation:TRIGger:PTRansition?
:STATus:OPERation:TRIGger:NTRansition?

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

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

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

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

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

:STATus:OPERation:TRIGger:EVENt?

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

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

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

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

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

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

:STATus:OPERation:TRIGger:ENABle <NRf>

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

:STATus:OPERation:TRIGger:ENABle?

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

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

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5.6.6 Questionable event status

The reporting of questionable events is controlled by a set of 16-bit registers; the Questionable Condition Register, the Transition Filter, the Questionable Event Register and the Questionable Event Enable Register. Figure 5-11 shows how the registers are structured. Each of the bits that is used in these registers represent a questionable event. Descriptions of the questionable event bits are provided in paragraph 5.16.

The questionable status registers are controlled by the :STATus:QUEStionable commands in the :STATus subsystem (see paragraph 5.16).

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

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

:STATus:QUEStionable:CONDition?

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

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

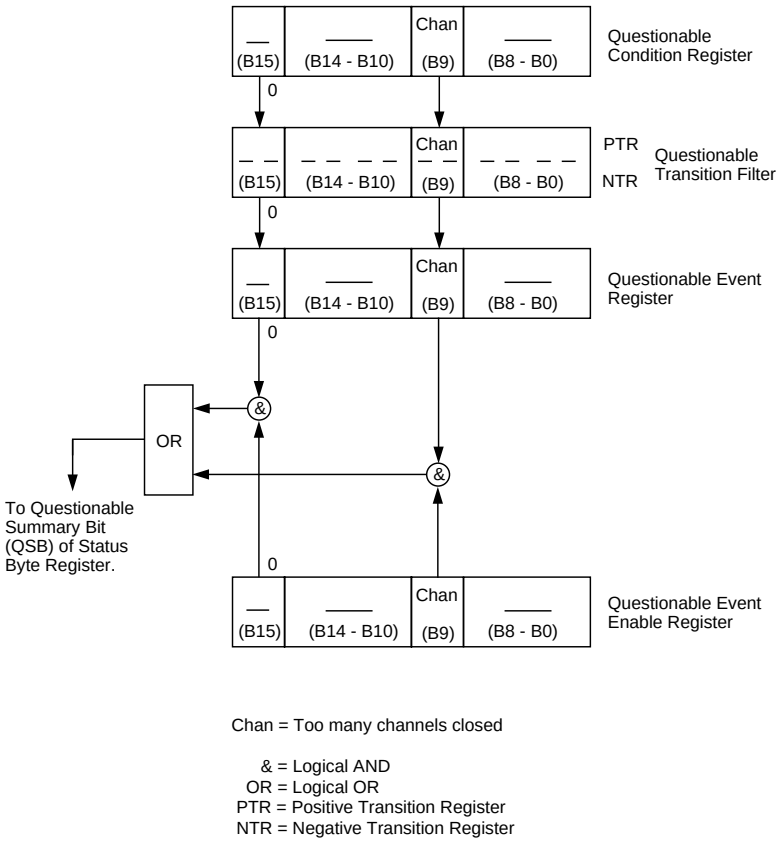


Figure 5-11
Questionable event status

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

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

:STATus:QUEStionable:PTR <NRf>
:STATus:QUEStionable:NTR <NRf>

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

:STATus:QUEStionable:PTR?
:STATus:QUEStionable:NTR?

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

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

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

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

:STATus:QUEStionable:EVENt?

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

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

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

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

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

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

:STATus:QUEStionable:ENABle <NRf>

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

:STATus:QUEStionable:ENABle?

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

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

5.6.7 Queues

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

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

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

A message from the Output Queue is read by addressing the Model 7002 to talk. The following programming example in HP BASIC 4.0 sends a query command, sends the data message to the computer, and then displays it on the CRT.

```
10  OUTPUT 707; "*IDN?"     ! Request identification code
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display ID code
40  END
```

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

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

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

:SYSTem:ERRor?
:STATus:QUEue?

Refer to paragraphs 5.16.7 (:STATus:QUEue?) and 5.17.4 (:SYSTem:ERRor?) for complete information on reading error messages.

5.6.8 Status byte and service request (SRQ)

Service request is controlled by two 8-bit registers; the Status Byte Register and the Service Request Enable Register. The structure of these registers is shown in Figure 5-12.

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

Bit B6 in the Status Byte Register is either:

- The Master Summary Status (MSB) bit, sent in response to the *STB? command, indicates the status of any set bits with corresponding enable bits set.

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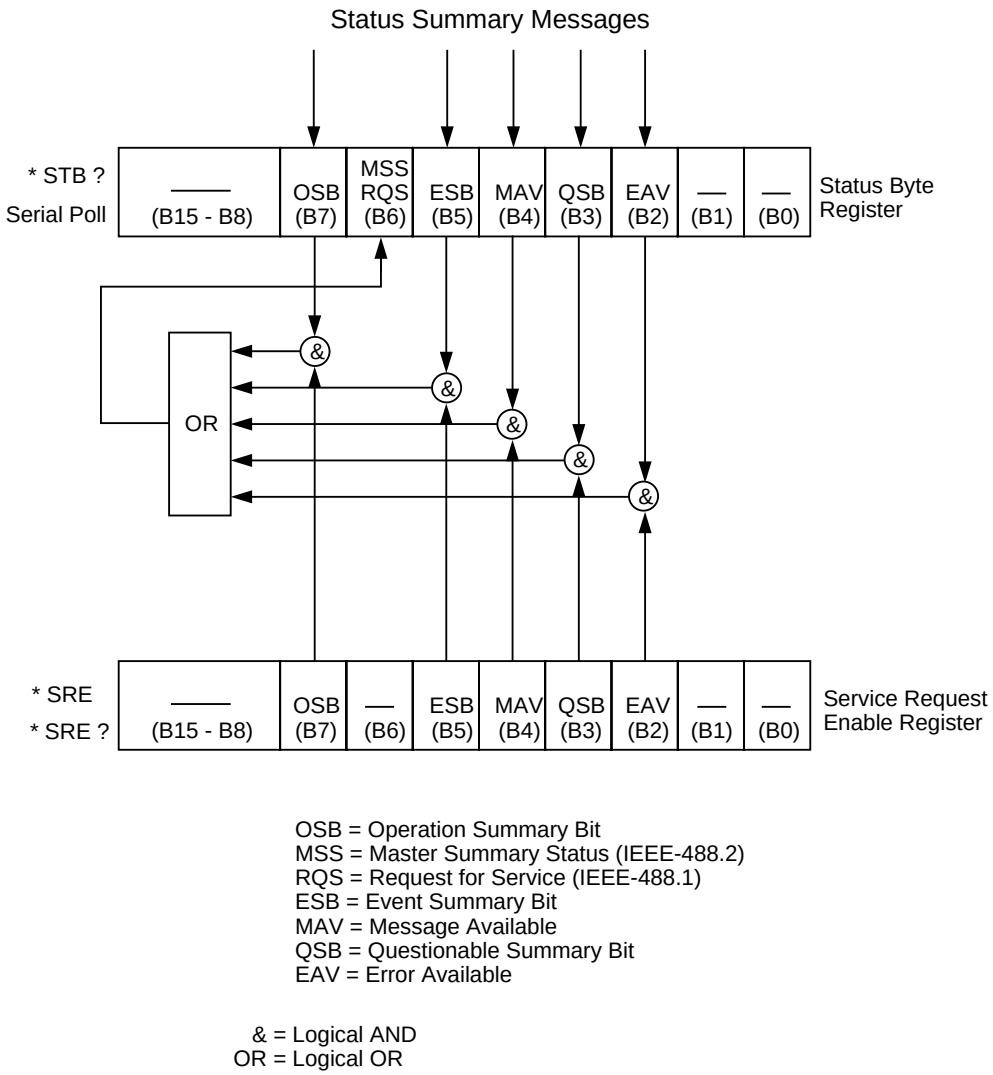


Figure 5-12
Status byte and service request (SRQ)

- The Request for Service (RQS) bit, sent in response to a serial poll, indicates which device was requesting service by pulling on the SRQ line.

For description of the other bits in the Status Byte Register, refer to paragraph 5.10.14.

The IEEE-488.2 standard uses the following common query command that simply reads the Status Byte Register contents:

*STB?

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

The IEEE-488.1 standard has a serial poll sequence that will also read the Status Byte Register and is better suited to detect a service request (SRQ). When using the serial poll, bit

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B6 is called the RQS bit. Serial polling causes bit B6 (RQS) to reset. Serial polling is discussed in more detail later in this paragraph (see "Serial Poll and SRQ").

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

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

NOTE

The MAV bit may or may not be cleared.

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

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

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

The individual bits of the Service Request Enable Register can be set or cleared by using the following common command (see paragraph 5.10.12 for details):

*SRE <NRf>

The Service Request Enable Register can be read using the following common query command (see paragraph 5.10.13 for details):

*SRE?

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

Serial poll and SRQ

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

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

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

The following HP BASIC 4.0 programming example demonstrates how serial poll can be used to detect an SRQ.

```
10  REMOTE 707
20  CLEAR 707
```


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```
30  OUTPUT 707;"*ESE 32"      ! Unmask command error bit (B5) in Standard Event Enable Register.
40  OUTPUT 707;"*SRE 32"      ! Unmask event summary bit (B5) in Service Request Enable Register.
50  OUTPUT 707;"*ESE"         ! Program command error (missing parameter) to generate SRQ.
60  WAIT 1
70  S=SPOLL (707)             ! Serial poll 7002.
80  IF BIT (S,6) THEN Service ! Go to Service (line 200).
90  END
200 SUB Service
210 PRINT "B7 B6 B5 B4 B3     ! Identify bits.
    B2 B1 B0"
220 FOR I=7 TO 0 STEP -1      ! Loop eight times.
230 PRINT BIT (S,I)           ! Display bit values
240 NEXT I
250 SUBEND
```

Program analysis:

Line 10 Place 7002 in remote.

Line 20 Perform a device clear.

Line 30 Set bit B5 of Standard Event Enable Register. This unmasks the command error event.

Line 40 Set bit B5 of the Service Request Enable Register. This unmasks the event summary message.

Line 50 Send an illegal command in order to generate an SRQ.

Line 60 Wait for a second to ensure completion of command execution.

Line 70 If SRQ occurred, bit B6 in Status Byte Register will be set and program will go to Service subroutine.

Line 200 to 240 Service subroutine displays the bit values (0 or 1) of the Status Byte Register. For this example, bit B5 (ESB) and bit B6 (RQS) will be set.

The actual serial poll sequence is explained in paragraph 5.6.8.

5.7 Trigger Model (IEEE-488 operation)

The following information describes the operation process of the Model 7002 over the IEEE-488 bus. The flowchart in Figure 5-13, 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 (see paragraph 5.18). Notice that key SCPI commands are included in the Trigger Model.

Idle and initiate

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

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

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

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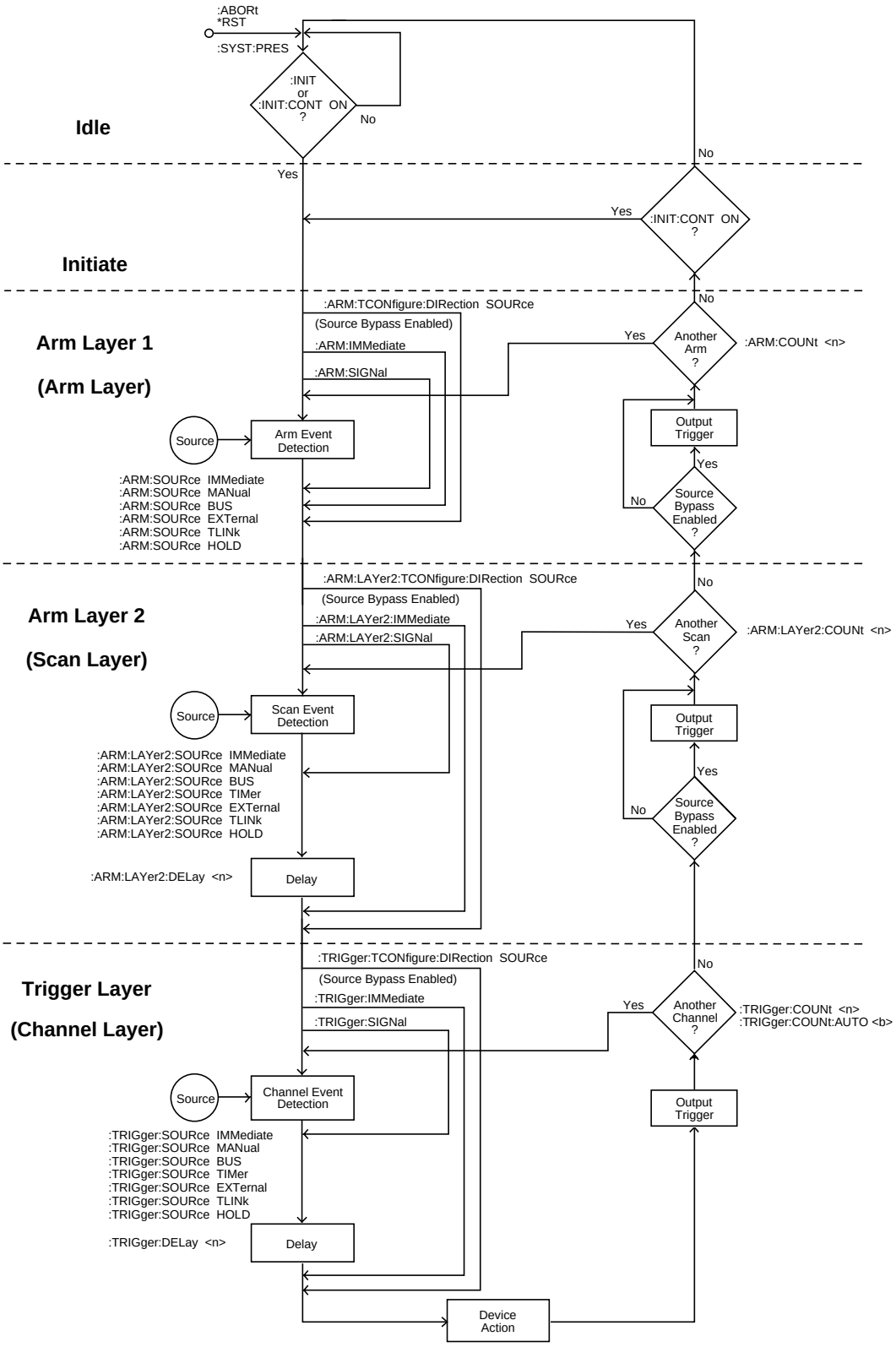


Figure 5-13
Trigger Model (IEEE-488 bus operation)

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Arm layer1

NOTE

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

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

With the Manual control source selected (:ARM :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:SOURce BUS), the instrument will wait until a bus trigger (GET or *TRG) is received. With the External control source selected (:ARM:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:SOURce HOLD), the instrument will not respond to any of the control source events.

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

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through Arm Layer 1. If programmed for another arm (arm count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes into Idle. Enabling the Source Bypass also enables the Output Trigger. When operation returns to Arm Layer 1 from Arm Layer 2, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM :TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:IMMediate command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).
3. Each time the :ARM:SIGNal command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).

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

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

Arm layer2

NOTE

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

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

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

With the Manual control source selected (:ARM:LAYer2:SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:LAYer2:SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:ARM:LAYer2:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:LAYer2:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:LAYer2:SOURce HOLD), the instrument will not respond to any of the control source events.

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

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

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

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to arm layer 2 from the trigger layer, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM:TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:LAYer2:IMMediate command is sent, operation will loop around the scan control source and the Delay. It is used when you do not wish to wait for a programmed scan event to occur (or when the Hold control source is selected).
3. Each time the :ARM:LAYer2:SIGNal command is sent, operation will loop around the scan control source. This path functions the same as :ARM:LAYer2:IMMediate except that it does not loop around the Delay.

After all other operations in the next layer have been completed, the instrument can be returned to Arm Layer 2 by programming the instrument for additional scans. The :ARM:LAYer2:COUNt <n> command can be used to set the scan count to a finite value (where <n> = 1 to 9999) or for an infinite (<n> = INF) number of scans. The *RST command sets the scan count to one and the :SYSTem:PRESet command sets the scan count to infinite.

After the instrument leaves arm layer 2, operation proceeds to the Channel Layer (Trigger Layer).

Trigger layer

NOTE

For front panel operation, this layer is called the channel layer.

In general, measure events control the channel scan rate. With the Immediate control source selected (:TRIGger:SOURce IMMediate), operation immediately proceeds to the Delay. The *RST command also sets the measure control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:TRIGger :SOURce TIMer), the first channel will be scanned immediately. Each additional will be scanned at a rate determined by the programmed timer interval (1msec to 999999.999 seconds).

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With the Manual control source selected (:TRIGger :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7002 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. The :SYSTem:PRESet command also selects the Immediate control source.

With the Bus control source selected (:TRIGger :SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:TRIGger:SOURCE EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:TRIGger:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:TRIGger :SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed channel event is detected, the instrument will wait for the programmed Delay to time out. The :TRIGger:DELay <n> command is used to set the Delay (where n = 0 to 999999.999 seconds).

The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

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

1. When the Source Bypass is enabled (:ARM :TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through the Trigger Layer. If programmed to scan another channel, (channel count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back to Arm Layer 2.
2. Each time the :TRIGger:IMMediate command is sent, operation will loop around the control source and the Delay. It is used when you do not wish to wait for a programmed channel event to occur (or when the Hold control source is selected).
3. Each time the :TRIGger:SIGNal command is sent, operation will loop around the channel control source. This path functions the same as :TRIGger:IMMediate except that it does not loop around the Delay.

At this point the first (or next) channel in the Scan List will be scanned (Device Action). When scanning channels, the previous channel will open and the next channel will close (break-before-make). Also included in the Device Action is the internal settling time delay for the relay and any additional programmed settling time delay using the :STIMe command of the :ROUTe Subsystem (see paragraph 5.13).

After a channel is scanned, an Output Trigger will occur. If the channel control source is programmed for Immediate, Manual, Bus or Timer, the output trigger pulse will be available at the CHANNEL READY connector. If the Trigger Link control source is selected, Output Trigger action will occur as follows:

1. If the asynchronous Trigger Link mode is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (:trig :tcon:dir acc), the Trigger Link line will be released (goes high).
3. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (:trig :tcon:dir sour), the Trigger Link line will be pulled down low and then released.

Note: See paragraph 4.17 for details on using the Trigger Link.

After a channel is scanned and an output trigger occurs, the instrument will (if programmed to do so) return to the beginning of the trigger layer to scan another channel. The :TRIGger:COUNt <n> command is used to set the channel count to a finite value (where <n> = 1 to 9999) or for a continuous scan of the Scan List (<n> = INF). The :TRIGger:COUNt :AUTo ON command is used to automatically set the channel count to the length of the Scan List. The *RST command sets the channel count to one and the :SYSTem:PRESet command enables the automatic channel count.

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5.8 General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. Commands supported by the Model 7002 are listed in Table 5-3 which also lists BASIC statements necessary to send each command. Note that commands requiring that a primary address be specified assume that the primary address is set to 7. This is the address that is set at the factory.

5.8.1 REN (remote enable)

The remote enable command is sent to the Model 7002 by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN true does not actually place the instrument in the remote state. Instead the instrument must be addressed to listen after setting REN true before it goes into remote.

Note that the instrument need not be in remote to be a talker.

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

REMOTE 707

After the RETURN key is pressed, the instrument is in the remote state, as indicated by the REM annunciator. If not, check to see that the instrument is set to the proper primary address 07, and check to see that the bus connections are properly made.

Note that all front panel controls except for LOCAL (and, of course, POWER) are inoperative while the instrument is in remote. You can restore normal front panel operation by pressing the LOCAL key.

Table 5-3
General bus commands and associated BASIC statements

Command	HP BASIC 4.0 statement	Effect on Model 7002
REN	REMOTE 7	Goes into effect when next addressed to listen.
IFC	ABORT 7	Goes into talker and listener idle states.
LLO	LOCAL LOCKOUT 7	LOCAL key locked out.
GTL	LOCAL 707	Cancel remote, restore front panel operation.
DCL	CLEAR 7	Returns 7002 to known conditions.
SDC	CLEAR 707	Returns all devices to known conditions.
GET	TRIGGER 707	Initiates a trigger.
SPE, SPD	SPOLL (707)	Serial Polls the Model 7002.

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5.8.2 IFC (interface clear)

The IFC command is sent by the controller to place the Model 7002 in the local, talker, and listener idle states. The unit responds to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those states.

Note that this command does not affect the status of the instrument; settings, data, and event registers are not changed.

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

Programming Example — Before demonstrating the IFC command, turn on the TALK indicator with the following statement:

ENTER 707; A$

At this point, the TALK light should be on. The IFC command can be sent by entering the following statement into the computer:

ABORTIO 7

After the RETURN key is pressed, the TALK indicator turns off, indicating that the instrument has gone into the talker idle state.

5.8.3 LLO (local lockout)

The LLO command is used to prevent local operation of the instrument. After the unit receives LLO, all its front panel controls except POWER are inoperative. In this state, pressing LOCAL will not restore control to the front panel.

Programming Example — The LLO command is sent by entering the following statements:

REMOTE 707

LOCAL LOCKOUT 7

After the second statement is executed, the instrument's front panel controls are locked out, including the LOCAL key.

To restore front panel operation after asserting LLO, as in the following example, enter:

LOCAL 7

5.8.4 GTL (go to local) and local

The GTL command is used to take the instrument out of the remote state. Operation of the front panel keys is restored. If LLO is in effect, the front panel LOCAL key will be disabled when the Model 7002 is put into remote. To cancel LLO, you must set REN false.

Programming Example — Place the instrument in the remote state with the following statement:

REMOTE 707

Now send GTL with the following statement:

LOCAL 707

Note that the instrument goes into the local state, and that operation of the front panel keys has now been restored (assuming that LLO is not in effect).

5.8.5 DCL (device clear)

The DCL command may be used to clear the Model 7002 and return it to a known state. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously.

When the Model 7002 receives a DCL command, it will clear the Input Buffer and Output Queue, cancel deferred commands, and clear any command that prevents the processing of any other device command. A DCL will not affect instrument settings, stored data, the channel list or scan list.

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Programming Example — Use the following statement to perform a DCL:

```
CLEAR 7
```

When the RETURN key is pressed, the instrument will perform the DCL.

5.8.6 SDC (selective device clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only selected instruments instead of clearing all instruments simultaneously, as is the case with DCL.

Programming Example — Use the following statement to perform an SDC:

```
CLEAR 707
```

This sends the following IEEE-488 commands: UNT UNL LISTEN 07 SDC. When the statement is executed, the instrument performs the SDC.

5.8.7 GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan and/or channel event to control the scanning process. The Model 7002 will react to this trigger if it is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem (see paragraph 5.18).

With the instrument programmed and waiting for a GPIB trigger, the following programming statement will provide the GET:

```
TRIGGER 707
```

This sends IEEE-488 commands UNT UNL LISTEN 07 GET. When the ENTER key is pressed, the trigger event occurs. (The command TRIGGER 7 just sends GET. Any other listeners are triggered when the ENTER key is pressed.)

5.8.8 SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 7002 serial poll byte. The serial poll byte contains important information about internal functions, as described in paragraph 5.6.8. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 7002.

Programming Example — The SPOLL statement automatically performs the serial poll sequence. To demonstrate serial polling, enter in the following statements into the computer:

```
S=SPOLL (707)
PRINT “SPOLL BYTE =”;S
```

After the first statement, the controller conducts the serial polling sequence. After the second statement is executed, the decimal value of the serial poll byte is displayed on the controller CRT.

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5.9 Programming syntax

The following programming syntax information covers both common commands and SCPI commands. For information not covered here, refer to the documentation for the IEEE-488.2 standard and SCPI.

Command words

One or more command words make up the program message that is sent to the computer to perform one or more operations.

1. **Commands and command parameters:** Both common commands and SCPI commands may or may not use a parameter. Examples:

*SAV 0	Parameter (0) required.
*RST	No parameter used with this command.
:INITiate:CONTinuous <b>	Parameter (<b>) required.
:SYSTem:PRESet	No parameter used with this command.

Note that there must be at least one space between the command word and the parameter.

Brackets [ ]: Throughout this manual, you will find command words that are enclosed in brackets ([]). These brackets are simply used to denote an optional command word that does not need to be included in the program message. For example:

:INITiate[:IMMediate]

The brackets indicate that :IMMediate is implied (optional) and does not have to be used. Thus, the above command can be sent in one of two ways:

:INITiate or :INITiate:IMMediate

Notice that the optional command is used without the brackets. **Do not include the brackets when using an optional command word.**

Parameter types: Some of the more common parameter types used in this manual are explained as follows:

<b> Boolean: Used to enable or disable an instrument operation. In general, 0 or OFF disables the operation, and 1 or ON enables the operation. Specifically, a Boolean parameter is processed as follows:

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- While ignoring the sign (+ or -), the parameter value is rounded to an integer.
- A zero result is interpreted as OFF, and a non-zero result is interpreted as ON.

Example:

```
:INITiate:CONTinuous ON          Enable continuous initiation
```

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

```
<name>  =  AHIGH
        =  ALOW
:OUTPut:TTL:LSENse  AHIGH
```

<NRf> Numeric representation format: This parameter is a number that can be expressed as an integer (e.g., 8), a real number (e.g., 23.6) or an exponent (2.3E6) When necessary, the Model 7002 will round real and exponential parameter values to an integer. Example:

```
:SAV  36                  Save setup in memory location 36.
```

<n> Numeric value: A numeric value parameter can consist of an NRf number or one of the following name parameters; DEFault, MINimum or MAXimum. When the DEFault parameter is used, the instrument will be programmed to the *RST default value. When the MINimum parameter is used, the instrument will be programmed to the lowest allowable value. When the MAXimum parameter is used, the instrument will be programmed to the largest allowable value. Examples:

```
:TRIGger:TIMer  0.1       Sets timer to 100msec.
:TRIGger:TIMer  DEFault   Sets timer to 1msec.
:TRIGger:TIMer  MINimum   Sets timer to 1msec.
:TRIGger:TIMer  MAXimum   Sets timer to 999999.999sec.
```

<list> List: This parameter type is used to indicate that a list of channels is required with the command word. The following example demonstrates the proper format for specifying a list:

```
:CLOSe (@ 1!1, 1!3)          Close channels 1 and 3 of Slot 1.
```

Angle brackets < >: In this manual, angle brackets (<>) are used to denote parameter type. **Do not** include the brackets in the program message. For example:

```
:SOURce:TTL2  <b>
```


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The <b> indicates that a Boolean type parameter is required. Thus, to set digital input line #2 true, you must send the command with the ON or 1 parameter as follows:

:SOURce:TTL2 ON or :SOURce:TTL2 1

2. **Query commands:** This type of command requests (queries) the currently programmed status. It is identified by the question mark (?) at the end of the fundamental form of the command. Most commands have a query form. Examples:

*OPT?	Common query command.
:TRIGger:TIMer?	SCPI query command.

All commands that require a numeric parameter (<n>) can also use the DEFault, MINimum, and MAXimum parameters for the query form. These query forms are used to determine the *RST default value, and the upper and lower limits for the fundamental command. Examples:

:TRIGger:TIMer?	DEFault	Queries the *RST default value.
:TRIGger:TIMer?	MINimum	Queries the lowest allowable value.
:TRIGger:TIMer?	MAXimum	Queries the largest allowable value.

3. **Case sensitivity:** Common commands and SCPI commands are not case sensitive. You can use upper or lower case, and any case combination. Examples:

*RST	=	*rst
:SCAN?	=	:scan?
:SYSTem:PRESet	=	:system:preset

4. **Long-form and short-form versions:** A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in this section provide the commands in the long-form version. However, the short-form version is indicated by upper case characters. Examples:

:SYSTem:PRESet	Long-form
:SYST:PRES	Short-form
:SYSTem:PRES	Long and short-form combination

Note that each command word must be in long-form or short-form, and not something in between. For example, :SYSTe:PRESe is illegal and will generate an error. The command will not be executed.

There are no short-form versions for common commands.

Short-form rules: The following rules can be used to determine the short-form version of any SCPI command:

a. If the length of the command word is four letters or less, there is no short-form version. Examples:

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:open = :open
:line = :line

b. The following rules apply to command words that exceed four letters:

a. If the fourth letter of the command word is a vowel, delete it and all the letters after it. Examples:

:immediate = :imm
:timer = :tim

b. If the fourth letter of the command word is a consonant, retain it but drop all the letters after it. Examples:

:output = :outp
:asynchronous = :asyn

c. If there is a question mark (?; query) or a non-optional number included in the command word, it must be included in the short-form version. Examples:

:delay? = :del?
:layer2 = :lay2

d. As previously explained, command words or characters that are enclosed in brackets ([]) are optional and need not be included in the program message. Example:

:STATus:OPERation[:EVENt]?

The brackets ([]) indicate that :EVENt is optional. Thus, either of the following two command program messages are valid:

:STATus:OPERation:EVENt? = :STATus:OPERation?

Notice that when using the optional word or character, the brackets ([]) are not included in the program message.

The complete short-form version of the above command is as follows:

:stat:oper?

Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Each common command is simply a three letter acronym preceded by an asterisk (*). SCPI commands are categorized into subsystems and are structured

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as command paths. The following command paths are contained in the :STATus subsystem and are used to help explain how command words are structured to formulate program messages.

:STATus	Path (Root)
:OPERation	Path
:PTRansition <NRf>	Command and parameter
:NTRansition <NRf>	Command and parameter
:ENABle <NRf>	Command and parameter
:PRESet	Command

1. **Single command messages:** There are three levels to the above command structure. The first level is made up of the root command (:STATus) and serves as a path. The second level is made up of another path (:OPERation) and a command (:PRESet). The third path is made up of three commands for the :OPERation path. The four commands in this structure can be executed by sending four separate program messages as follows:

   :stat:oper:ptr <NRf>
   :stat:oper:ntr <NRf>
   :stat:oper:enab <NRf>
   :stat:pres

   In each of the above program messages, the path pointer starts at the root command (:stat) and moves down the command levels until the command is executed.

2. **Multiple command messages:** Multiple commands can be sent in the same program message as long as they are separated by semicolons (;). Example showing two commands in one program message:

   :stat:pres; :stat:oper:enab <NRf>

   When the above message is sent, the first command word is recognized as the root command (:stat). When the next colon is detected, the path pointer moves down to the next command level and executes the command. When the path pointer sees the colon after the semicolon (;), it resets back to the root level and starts over.

   Commands that are on the same command level can be executed without having to retype the entire command path. Example:

   :stat:oper:enab <NRf>; ptr <NRf>; ntr <NRf>

   After the first command (:enab) is executed, the path point is at the third command level in the structure. Since :ptr and :ntr are also on the third level, they can be typed in without repeating the entire path name. Notice that the leading colon for :ptr and :ntr are not included in the program message. If a colon were included, the path pointer would reset to the root level and expect a root command. Since neither :ptr nor :ntr are root commands, an error would occur.

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3. **Command path rules:**

   a. Each new program message must begin with the root command, unless it is optional (e.g., [:SENSe]). If the root is optional, simply treat a command word on the next level as the root.

   b. The colon (:) at the beginning of a program message is optional and need not be used. Example:

      :stat:pres = stat:pres

   c. When the path pointer detects a colon (:) it will move down to the next command level. An exception is when the path pointer detects a semicolon (;), which is used to separate commands within the program message (see next rule).

   d. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.

   e. The path pointer can only move down. It cannot be moved up a level. Executing a command at a higher level requires that you start over at the root command.

4. **Using common commands and SCPI commands in same message:** Both common commands and SCPI commands can be used in the same message as long as they are separated by semicolons (;). A common command can be executed at any command level and will not affect the path pointer. Example:

   :stat:oper:enab <NRf>; ptr <NRf>; *ESE <NRf>; ntr <NRf>

5. **Program Message Terminator (PMT):** Each program message must be terminated with an LF (line feed), EOI (end or identify) or an LF + EOI. The bus will hang if your computer does not provide this termination. The following example shows how a multiple command program message must be terminated:

   :rout:open all; scan (@1:5) <PMT>

6. **Command execution rules:**

   a. Commands are executed in the order that they are presented in the program message.

   b. An invalid command will generate an error and, of course, not be executed.

   c. Valid commands that precede an invalid command in a multiple command program message will be executed.

   d. Valid commands that follow an invalid command in a multiple command program message will be ignored. Example:

      :rout:open all; harve; scan?

      :open all will execute. Harve is an invalid command and will generate an error. The scan query will be ignored.

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Response messages

A response message is the message sent by the instrument to the computer in response to a query command program message.

1. **Sending a response message:** After sending a query command, the response message is placed in the Output Queue. When the Model 7002 is then addressed to talk, the response message is sent from the Output Queue to the computer. The following example in HP BASIC 4.0 demonstrates this process:

```
10   OUTPUT 707; ":rout:scan?"     ! Send query command.
20   ENTER 707; A$                 ! Address Model 7002 to talk.
30   PRINT A$                      ! Display response message on CRT.
40   END
```

   There are two special query commands that are used to read the Error Queue. As error and status messages occur they are stored in the Error Queue. This queue is a first-in first-out (FIFO) register. Either of the following two SCPI commands can be used to read the Error Queue:

   :STATus:QUEue?
   :SYSTem:ERRor?

   After sending either of the above commands, the oldest message in the Error Queue will be moved to the Output Queue. When the Model 7002 is then addressed to talk (as explained above), the response message will be sent to the computer.

2. **Multiple response messages:** If you send more than one query command in the same program message (see Multiple command messages), the multiple response message for all the queries will be sent to the computer when the Model 7002 is addressed to talk. The responses are sent in the order that the query commands were sent and will be separated by semicolons (;). Items within the same query are separated by commas (,). The following example shows the response message for a program message that contains four single item query commands:

   0; 1; 1; 0

3. **Response Message Terminator (RMT):** Each response message is terminated with an LF (line feed) and EOI (end or identify). The following example shows how a multiple response message is terminated:

   0; 1; 1; 0 <RMT>

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Message exchange protocol

The message exchange protocol can be summarized by the two following rules:

Rule 1. You must always tell the Model 7002 what to send to the computer.

The following two steps must always be performed, in this order, to send information from the instrument to the computer:

1. Send the appropriate query command(s) in a program message.
2. Address the Model 7002 to talk.

Rule 2. The complete response message (including the RMT) must be received by the computer before another program message can be sent to the Model 7002.

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5.10 Common commands

Common commands are device commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Table 5-4 summarizes the common commands used by the Model 7002 and are presented in alphabetical order. The following detailed descriptions include programming examples using HP BASIC 4.0.

Programming syntax information for common commands and SCPI commands is located just after the tab labeled “SCPI Command Subsystems”.

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Table 5-4
IEEE-488.2 common commands and queries

Mnemonic	Name	Description	Para.
*CLS	Clear status	Clears all event registers, and Error Queue.	5.10.1
*ESE <NRf>	Event status enable command	Sets the contents of the Standard Event Status Enable Register.	5.10.2
*ESE?	Event status enable query	Request the programmed value of the Standard Event Status Enable Register.	5.10.3
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.	5.10.4
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.	5.10.5
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.	5.10.6
*OPC?	Operation complete query	Places an ASCII “1” into the output queue when all pending selected device operations have been completed.	5.10.7
*OPT?	Option identification query	Request the assigned model number for all slots.	5.10.8
*RCL <NRf>	Recall command	Returns the Model 7002 to the setup configuration stored in the designated memory location.	5.10.9
*RST	Reset command	Returns the Model 7002 to the *RST default conditions.	5.10.10
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.	5.10.11
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.	5.10.12
*SRE?	Service request enable query	The Model 7002 returns the value of the Service Request Enable Register.	5.10.13
*STB?	Read status byte query	Returns the value of the Status Byte Register.	5.10.14
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.	5.10.15
*TST?	Self-test query	When this query is sent, the Model 7002 will perform a checksum test on ROM and return the results.	5.10.16
*WAI	Wait-to-continue command	Wait until all previous commands are executed.	5.10.17

Note: At least one space is required between the command and the parameter.

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5.10.1 *CLS — clear status

Purpose

To clear status registers and error queue.

Format

***CLS**

Description

The *CLS command is used to clear (reset to 0) the bits of the following registers in the Model 7002:

Standard Event Status Register

Operation Event Register

Questionable Event Register

Error Queue

Trigger Event Register

Sequence Event Register

Arm Event Register

This command also forces the instrument into the operation complete command idle state and operation complete query idle state.

Programming example

```
OUTPUT 707; "*CLS"          ! Clear registers and Error Queue
```


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5.10.2 *ESE — event status enable

Purpose To set the contents of the Standard Event Status Enable Register.

Format ***ESE <NRf>**

Parameters

<NRf>	= 0	Clear (reset) register
	= 1	Set OPC (B0) of enable register
	= 4	Set QYE (B2) of enable register
	= 8	Set DDE (B3) of enable register
	= 16	Set EXE (B4) of enable register
	= 32	Set CME (B5) of enable register
	= 64	Set URQ (B6) of enable register
	= 128	Set PON (B7) of enable register

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description The *ESE command is used to set the contents of the Standard Event Status Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of the bits in the register.

This register is used as a mask for the Standard Event Status Register. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked (enabled), the occurrence of that event will set the ESB bit. For information on the Standard Event Status Register and descriptions of the standard event bits, see paragraph 5.10.4. The Status Byte Register is described in paragraph 5.6.8.

A cleared bit (bit set to “0”) in the enable register will prevent (mask) the ESB bit in the Status Byte Register from setting when the corresponding standard event occurs. A set bit (bit set to “1”) in the enable register will allow (enable) the ESB bit to set when the corresponding standard event occurs. For details on the status register structure, refer to paragraph 5.6.

The Standard Event Status Enable Register is shown in Figure 5-14. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to be set is the value that is sent with the *ESE command. For example, to set the CME and QYE bits of the Standard Event Status Enable Register, send the following command:

*ESE 36

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where; CME (bit B5) = Decimal 32
QYE (bit B2) = Decimal 4
parameter = 36

If a command error (CME) occurs, bit B5 of the Standard Event Status Register will set. If a query error (QYE) occurs, bit B2 of the Standard Event Status Register will set. Since both of these events are unmasked (enabled), the occurrence of any one of them will cause the ESB bit in the Status Byte Register to set.

The contents of the Standard Event Status Event Register can be read by using the *ESE? query command (see next paragraph).

Programming example

```
OUTPUT 707; "*ESE  24"      ! Set bits B3 (DDE) and B4 (EXE) of the Standard Event
                              Status Enable Register.
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	–	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	–	0/1

Value: 1 = Enable Standard Event
0 = Disable (Mask) Standard Event

Events: PON = Power On
URQ = User Request
CME = Command Error
DDE = Device-dependent Error
EXE = Execution Error
QYE = Query Error
OPC = Operation Complete

Figure 5-14
Standard Event Status Enable Register

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5.10.3 *ESE? — event status enable query

Purpose

To read the contents of the Standard Event Status Enable Register.

Format

***ESE?**

Description

This command is used to acquire the value (in decimal) of the Standard Event Status Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *ESE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, bits B4 and B5 of the Standard Event Status Enable Register are set. For information on the Standard Event Status Enable Register, refer to paragraph 5.6.

The *ESE? query command does not clear the Standard Event Status Enable Register.

Programming example

```
10  OUTPUT 707; "*ESE?"     ! Send query command
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display value of register contents
40  END
```


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5.10.4 *ESR? — event status register query

Purpose To read the contents of the Standard Event Status Register and clear it.

Format ***ESR?**

Defaults

Power-up	Clears register
*CLS	Clears register
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description This command is used to acquire the value (in decimal) of the Standard Event Status Register (see Figure 5-15). The binary equivalent of the returned decimal value determines which bits in the register are set. When the *ESR? command is sent, the decimal value is placed in the Output Queue and the Standard Event Status Register is cleared. When the Model 7002 is addressed to talk, the value in the Output Queue is sent to the computer.

A set bit in this register indicates that a particular event has occurred. For example, for an acquired decimal value of 48, the binary equivalent is 0011 0000. For this binary value, bits B4 and B5 of the Standard Event Status Register are set. These set bits indicate that a device-dependent error and command error have occurred.

The bits of the Standard Event Status Register are described as follows:

Bit B0, Operation Complete (OPC) — Set bit indicates that all pending selected device operations are completed and the Model 7002 is ready to accept new commands. This bit will only set in response to the *OPC? query command (see paragraph 5.10.7).

Bit B1 — Not Used

Bit B2, Query Error (QYE) — Set bit indicates that you attempted to read data from an empty Output Queue.

Bit B3, Device-Dependent Error (DDE) — Set bit indicates that an instrument operation did not execute properly due to some internal condition.

Bit B4, Execution Error (EXE) — Set bit indicates that the Model 7002 detected an error while trying to execute a command.

Bit B5, Command Error (CME) — Set bit indicates that a command error has occurred. Command errors include:

1. IEEE-488.2 syntax error: Model 7002 received a message that does not follow the defined syntax of the IEEE-488.2 standard.

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2. Semantic error: Model 7002 received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
3. The instrument received a Group Execute Trigger (GET) inside a program message.

Bit B6, User Request (URQ) — Set bit indicates that the LOCAL key on the Model 7002 front panel was pressed.

Bit B7, Power On (PON) — Set bit indicates that the Model 7002 has been turned off and turned back on since the last time this register has been read.

Programming example

```
10  OUTPUT 707; "*ESE?"     ! Request register value
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display value
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

Figure 5-15
Standard Event Status Register

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5.10.5 *IDN? — identification query

Purpose

To read the identification code of the Model 7002.

Format

***IDN?**

Description

The *IDN? query command places the identification code of the Model 7002 in the Output Queue. When the Model 7002 is addressed to talk, the identification code will be sent to the computer.

The identification code includes the manufacturer, model number, serial number, and firmware revision levels, and is sent in the following format:

KEITHLEY INSTRUMENTS INC., MODEL 7002, wwwwwww, xxxxx,/yyyyy/zzzzz

where; wwwwwww is the serial number
xxxxx is the firmware revision level of the digital board
yyyyy is the firmware revision level of the VFD display
zzzzz is the firmware revision level of the LED display

Programming example

```
10  OUTPUT 707; "*IDN?"      ! Request 7002 ID data
20  ENTER 707; A$            ! Address 7002 to talk
30  PRINT A$                 ! Display identification code
```


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5.10.6 *OPC — operation complete

Purpose

To set the Operation Complete bit in the Standard Event Status Register after all overlapped commands are complete.

Format

***OPC**

Description

On power-up, or when *CLS or *RST is executed, the Model 7002 goes into the Operation Complete Command Idle State (OCIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 7002:

:INITiate
:INITiate:CONTinuous ON
*TRG

When the *OPC command is sent, the Model 7002 exits from OCIS and enters the Operation Complete Command Active State (OCAS). In OCAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is complete (No-Operation-Pending flag set to true), the Operation Complete (OPC) bit in the Standard Event Status Register sets, and the instrument goes back into OCIS.

Note that the instrument always goes into OCAS when *OPC is executed. If there are no pending command operations (e.g. trigger model in idle state), the Model 7002 immediately sets the OPC bit and returns to OCIS.

When used with the :INITiate or :INITiate:CONTinuous ON command, the OPC bit of the Standard Event Status Register will not set until the Model 7002 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

When used with the *TRG command, the OPC bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event (see Trigger Model in paragraph 5.7).

In order to use *OPC exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, the OPC bit will set when the *TRG command is finished.

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NOTE

See *OPC?, *TRG and *WAI for more information.

Programming example

```
10   OUTPUT 707; ":open   all"
20   OUTPUT 707; "*RST"
30   OUTPUT 707; ":scan   (@ 1!1:1!10)"
40   OUTPUT 707; ":trig:coun:auto   on"
50   OUTPUT 707; ":trig:del   0.5"
60   OUTPUT 707; ":init"
70   OUTPUT 707; "*OPC"
80   OUTPUT 707; "*ESR?"
90   ENTER 707; A$
100  PRINT A$
110  END
```

Line 10 Opens all channels.
Line 20 Selects default configuration (see Table 5-5).
Line 30 Defines scan list (channels 1 through 10).
Line 40 Enables automatic scan-list-length for channel count.
Line 50 Sets a 0.5 second delay between each channel.
Line 60 Starts the scan (takes 7002 out of idle state).
Line 70 Set OPC bit after the scan ends.
Line 80 Request value of Standard Event Status Register.
Line 90 Address 7002 to talk.
Line 100 Display value of register (Bit 0 will be set).

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, Bit 0 in the Standard Event Status Register will set. The register is then read to verify that Bit 0 is set.

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5.10.7 *OPC? — operation complete query

Purpose

Place a “1” in the Output Queue after all overlapped commands are completed.

Format

***OPC?**

Description

On power-up, or when *CLS or *RST is executed, the Model 7002 goes into the Operation Complete Command Query Idle State (OQIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 7002:

:INITiate
:INITiate:CONTinuous ON
*TRG

When the *OPC? command is sent, the Model 7002 exits from OQIS and enters the Operation Complete Command Active State (OQAS). In OQAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is completed (No-Operation-Pending flag set to true), an ASCII character “1” is placed into the Output Queue, the Message Available (MAV) bit in the Status Byte sets, and the instrument goes back into OQIS. Addressing the Model 7002 to talk will send the ASCII “1” to the computer.

Note that the instrument always goes into OQAS when *OPC? is executed. If there are no pending command operations (e.g. trigger model in idle state), the Model 7002 immediately places an ASCII “1” in the Output Queue, sets the MAV bit and returns to OQIS.

When used with the :INITiate or :INITiate:CONTinuous ON command, an ASCII “1” will not be sent to the Output Queue and the MAV bit will not set until the Model 7002 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

When used with the *TRG command, an ASCII “1” will not be placed into the Output Queue and the MAV bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event (see Trigger Model in paragraph 5.7).

In order to use *OPC? exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, an ASCII “1” will be place in the Output Queue and the MAV bit will set when the *TRG command is finished.

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After *OPC? is executed, additional commands cannot be sent to the Model 7002 until the pending overlapped commands have finished. For example, :INITiate:CONTinuous ON followed by *OPC? will lock up the instrument and will require a device clear (DCL or SDC) before it will accept any more commands.

NOTE

See *OPC, *TRG and *WAI for more information.

Programming example

```
10   OUTPUT 707; ":open   all"
20   OUTPUT 707; "*RST"
30   OUTPUT 707; ":scan   (@ 1!1:1!10)"
40   OUTPUT 707; ":trig:coun:auto   on"
50   OUTPUT 707; ":trig:del   0.5"
60   OUTPUT 707; ":init"
70   OUTPUT 707; "*OPC?"
80   ENTER 707; A$
90   PRINT A$
100  OUTPUT 707; "*STB?"
110  ENTER 707; B$
120  PRINT B$
130  END
```

Line 10 Opens all channels.
Line 20 Selects default configuration (see Table 5-5).
Line30 Defines scan list (channels 1 through 10).
Line 40 Enables automatic scan-list-length for channel count.
Line 50 Sets a 0.5 second delay between each channel.
Line 60 Starts the scan (takes 7002 out of idle state).
Line 70 Place a "1" in the Output Queue after the scan ends.
Line 80 Address the 7002 to talk.
Line 90 Display the contents of the Output Queue ("1").
Line 100 Request value of Status Byte Register.
Line 110 Address 7002 to talk.
Line 120 Display value of register (B4 will be set).

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, an ASCII "1" will be placed in the Output Queue. The Output Queue and Status Byte Register will then be read to verify the contents.

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5.10.8 *OPT? — option identification query

Purpose

To read the identification code of optional switch cards installed in the Model 7002.

Format

***OPT?**

Description

The *OPT? query command places the option identification code in the Output Queue. When the Model 7002 is addressed to talk, the code is sent from the Output Queue to the computer.

The option identification code indicates the assigned model number for each slot of the mainframe. For example, if a Model 7011 and 7012 are installed in slots 1 and 3 respectively, and the other slots are empty, the following message will be sent to the computer:

7011, NONE, 7012, NONE, NONE, NONE, NONE, NONE, NONE, NONE

Programming example

```
10  DIM A$[50]
20  OUTPUT 707; "*OPT?"     ! Request option ID code
30  ENTER 707; A$           ! Address 7002 to talk
40  PRINT A$                ! Display option ID code
```


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5.10.9 *RCL — recall

Purpose

To return the Model 7002 to a setup configuration previously stored in memory.

Format

***RCL <n>**

Parameters

<NRf> = 0 to 9 Memory location

Description

The Model 7002 can store up to 10 setup configurations in memory locations 0 to 9. Over the bus, the *SAV command is used to save setup configurations (see paragraph 5.10.11).

The *RCL command is used to return the Model 7002 to a setup configuration stored at one of the memory locations. For example, if a setup configuration was previously stored at memory location 9, the Model 7002 can be returned to those setup conditions by sending the following command:

*RCL 9

Note: The Model 7002 is shipped from the factory with :SYSTem:PRESet defaults stored in all ten memory locations (see Table 5-5).

Programming example

The following example assumes that a setup configuration has been stored at memory location 6 (see paragraph 5.10.11 for information on storing setup configurations).

```
OUTPUT 707; "*RCL 6"          ! Recall setup stored at memory location 6.
```


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5.10.10 *RST — reset

Purpose

To reset the Model 7002.

Format

***RST**

Description

When the *RST command is sent, the Model 7002 performs the following operations:

1. Returns the Model 7002 to the *RST default conditions (see Table 5-5).
2. Cancels all pending commands.
3. Cancels response to any previously received *OPC and *OPC? commands.

The following instrument states are not affected by this command:

IEEE-488 address
Standard Event Status Register
Status Byte Register

Programming example

```
OUTPUT 707; "*RST"          ! Return 7002 to *RST defaults
```


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Table 5-5
Default conditions

Command name	*RST value	:SYSTem:PRESet value
:INITiate		
:CONTinuous	OFF	OFF
:ARM		
:SEQuence[1]		
:LAYer[1]		
:COUNt	1	1
:SOURce	IMMediate	IMMediate
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:LAYer2		
:COUNt	1	INFinite
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.001	0.001
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:TRIGger		
:SEQuence1		
:COUNt	1	Scan list length
:AUTO	OFF	ON
:DELay	0	0
:SOURce	IMMediate	MANual
:TIMer	0.001	0.001
:TCONfigure		
:PROTocol	ASYNchronous	ASYNchronous
:DIRection	ACCeptor	SOURce
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:SSYNchronous		
:LINE	1	1
[:ROUTe]		
:CONFigure		
:BBMake	ON	ON
:SLOTX where X=1 to 10		
:STIMe	0	0
:CPAirX where X=1 to 5	OFF	OFF
:SCHannel	OFF	OFF
:DISPlay		
:SMESsage	OFF	OFF
:WINDow3		
:GRATicule	ON	ON

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5.10.11 *SAV — save

Purpose

To save the current setup configuration in memory.

Format

***SAV <NRf>**

Parameters

<NRf> = 0 to 9 Memory location

Description

The Model 7002 can store up to 10 setup configurations at memory locations 0 to 9 by using the *SAV command. For example, to store the current setup configuration at memory location 6, send the following command:

*SAV 6

Table 5-5 lists the setup items (along with the bus commands to program them), that can be saved by the *SAV command. The *RCL command is used to return the instrument to a saved setup.

Programming example

```
OUTPUT 707; "*SAV 6"          ! Store setup at memory location 6.
```


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5.10.12 *SRE — service request enable

Purpose

To set the contents of the Service Request Enable Register.

Format

***SRE <NRf>**

Parameters

<NRf>	= 0	Clears enable register
	= 4	Set EAV bit (Bit 2)
	= 8	Set QSB bit (Bit 3)
	= 16	Set MAV bit (Bit 4)
	= 32	Set ESB bit (Bit 5)
	= 128	Set OSB bit (Bit 7)

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description

The *SRE command is used to set the contents of the Service Request Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the register.

This enable register is used along with the Status Byte Register to generate service requests (SRQ). With a bit in the Service Request Enable Register set, an SRQ will occur when the corresponding bit in the Status Byte Register is set by an appropriate event. For details on register structure, refer to paragraph 5.6.

The Service Request Enable Register is shown in Figure 5-16. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to set is the value that is sent with the *SRE command. For example, to set the ESB and MAV bits of the Service Request Enable Register, send the following command:

*SRE 34

where;	ESB (bit B5) = Decimal	32
	MAV (bit B4) = Decimal	16
	<NRf> =	48

The contents of the Service Request Enable Register can be read using the *SRE? query command (see next paragraph).

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Programming example

```
OUTPUT 707; "*SRE   32"        ! Set ESB bit
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	—	ESB	MAV	QSB	EAV	—	—
Decimal Weighting	128 (2^7)	—	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	—
Value	0/1	—	0/1	0/1	0/1	0/1	—	—

Value : 1 = Enable Service Request Event
0 = Disable (Mask) Service Request Event

Events : OSB = Operation Summary Bit
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

Figure 5-16
Service Request Enable Register

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5.10.13 *SRE? — service request enable query

Purpose

To read the contents of the Service Request Enable Register.

Format

***SRE?**

Description

The *SRE? command is used to acquire the value (in decimal) of the Service Request Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *SRE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 17, the binary equivalent is 0001 0001. This binary value indicates that Bits 4 and 0 of the Service Request Enable Register are set (see previous paragraph).

Programming example

```
10  OUTPUT 707; "*SRE?"     ! Request contents of SRER
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display value register
```


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5.10.14 *STB? — status byte query

Purpose To read the contents of the Status Byte Register.

Format ***STB?**

Description The *STB? query command is used to acquire the value (in decimal) of the Status Byte Register. The Status Byte Register is shown in Figure 5-17. The binary equivalent of the decimal value determines which bits in the register are set. The set bits in this register define the operating status of the Model 7002.

When the *STB? query command is sent, the decimal value is placed in the Output Queue. When the Model 7002 is addressed to talk, the value is sent from the Output Queue to the computer.

All bits, except Bit 6, in this register are set by other event registers and queues. Bit 6 sets when one or more enabled conditions occur.

The *STB? query command does not clear the status byte register. This register can only be cleared by clearing the related registers and queues. Register and queue structure are explained in paragraph 5.6.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. This binary value indicates that Bits 4 and 5 of the Status Byte Register are set.

The bits of the Status Byte Register are described as follows:

Bit 0 — Not used.

Bit 1 — Not used.

Bit 2, Error Available (EAV) — Set bit indicates that an error message is present in the Error Queue. The error message can be read using one of the following SCPI commands:

:SYSTem:ERRor?
:STATus:QUEue?

See paragraphs 5.17 and 5.16 for details.

Bit 3,Questionable Summary Bit (QSB) — Set bit indicates that too many channels have closed.

Bit 4, Message Available (MAV) — Set bit indicates that a message is present in the Output Queue. The message is sent to the computer when the Model 7002 is addressed to talk.

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Bit 5, Event Summary Bit (ESB) — Set bit indicates that an enabled standard event has occurred. The event can be identified by reading the Standard Event Status Register using the *ESE? query command (see paragraph 5.10.2).

Bit 6, Master Summary Status (MSS) / Request Service (RQS) — Set bit indicates that one or more enabled conditions have occurred to generate a service request (SRQ). Note that the IEEE-488.1 standard designates Bit 6 as the RQS bit and is read by performing a Serial Poll.

Bit 7, Operation Summary Bit (OSB) — Set bit indicates that an enabled operation event has occurred. The event can be identified by reading the Operation Event Status Register using the following SCPI command structure:

:STATus:OPERation?

See paragraph 5.16 for details.

Programming example

```
10  OUTPUT 707; "*SRE?"     ! Request contents of register
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display value of register
40  END
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	MSS, RQS	ESB	MAV	QSB	EAV	—	—
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	—
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : OSB = Operation Summary Bit
MSS = Master Summary Status
RQS = Request Service
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

Figure 5-17
Status Byte Register

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5.10.15 *TRG — trigger

Purpose

To issue a GPIB trigger to the Model 7002.

Format

***TRG**

Description

The *TRG command is used to issue a GPIB trigger to the Model 7002. It has the same effect as a group execute trigger (GET). The *TRG command is an overlapped command, while GET is not. See *OPC, *OPC? and *WAI for more information.

The *TRG command is used as an arm, scan and/or channel event to control the scan cycle. The Model 7002 will react to this trigger if GPIB is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem (see paragraph 5.18).

Programming example

```
OUTPUT 707; "*TRG"          ! Trigger 7002
```


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5.10.16 *TST? — self-test query

Purpose

To run the self-tests and acquire the results.

Format

***TST?**

Description

The *TST? query command is used to perform a checksum test on ROM and place the coded result (0 or 1) in the Output Queue. When the Model 7002 is addressed to talk, the coded result is sent from the Output Queue to the computer.

A returned value of zero (0) indicates that the test passed, and a value of one (1) indicates that the test has failed.

Programming example

```
10  OUTPUT 707; "*TST?"     ! Run and request test result
20  ENTER 707; A$           ! Address 7002 to talk
30  PRINT A$                ! Display coded result
```


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5.10.17 *WAI — wait-to-continue

Purpose

To prevent the execution of further commands until all previous overlapped commands are completed.

Format

***WAI**

Description

There are two types of device commands; Sequential commands and overlapped commands. A Sequential command is a command whose operations are allowed to finish before the next command is executed. An overlapped command is a command that allows the execution of subsequent commands while device operations of the overlapped command are still in progress. The *WAI command is used to hold off the execution of subsequent commands until the device operations of all previous overlapped command are finished. The *WAI command is not needed for Sequential commands.

NOTE

See *OPC, *OPC? and *TRG for more information.

The :INIT command takes the Model 7002 out of the idle state to enable the scan function. The device operations of the :INIT command are not considered complete until the Model 7002 goes back into the idle state. Typically, this occurs when all programmed scan operations are completed. By sending the *WAI command after the :INIT command, all subsequent commands will not execute until the Model 7002 goes back into the idle state.

The *TRG command issues a bus trigger which could be used to provide the arm, scan and channel events for the Trigger Model. By sending the *WAI command after the *TRG command, subsequent commands will not be executed until the pointer for the Trigger Model has finished moving in response to *TRG and has settled at its next state.

Programming example

```
10   OUTPUT 707; ":open   all"
20   OUTPUT 707; "*RST"
30   OUTPUT 707; ":scan   (@ 1!1:1!10)"
40   OUTPUT 707; ":trig:coun:auto   on"
50   OUTPUT 707; ":trig:del   0.5"
60   OUTPUT 707; ":init"
70   OUTPUT 707; "*WAI"
80   OUTPUT 707; ":clos   (@ 1!11:1!20)"
90   END
```

Line 10 Opens all channels.
Line 20 Selects default configuration (see Table 5-5).
Line 30 Defines scan list (channels 1 through 10).
Line 40 Enables automatic scan-list-length for channel count.
Line 50 Sets a 0.5 second delay between each channel.
Line 60 Starts the scan (takes 7002 out of idle state).

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Line 70 Wait until scan is finished.
Line 80 Close channels 11 through 20.

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, channels 11 through 20 will close. Without the *WAI command (Line 70), channels 11 through 20 will close at the same time that the scan starts.

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SCPI command subsystems

SCPI commands are categorized into subsystems. The subsystems are presented in alphabetical order as follows:

5.11 **:DISPlay subsystem** — Explains the commands used to control user defined text messages.

5.12 **:OUTPut subsystem** — Explains the commands used to program the polarity (active-high or active-low) of the digital output port bits.

5.13 **:ROUTe subsystem** — Covers commands used to open and close channels, define a scan list, specify restricted (forbidden) channels, and interlocked channels, and enable/disable Single Channel and Card Pair. Also covered are slot configuration commands used to program the relay settling time, pole-mode and card type of each slot. Finally, memory commands used to store (save) and recall channel patterns are explained here.

5.14 **Sense subsystems** — Explains the command used to read the digital input port of the Model 7002 (and digital cards).

5.15 **:SOURce subsystem** — Covers the commands used to set the state (0 or 1) of the digital output port bits.

5.16 **:STATus subsystem** — Covers the commands used to control the status registers of the Model 7002.

5.17 **:SYSTem subsystem** — Covers miscellaneous commands used to read the software revision level of the Model 7002, read the error queue, and set the power-on setup configuration.

5.18 **Trigger subsystem** — Covers commands used to scan.

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5.11 :DISPlay subsystem

The display subsystem controls the display circuitry of the Model 7002 and is summarized in Table 5-6.

Table 5-6
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow3	Path to control LED Graticule.
:GRATicule <b>	Enable (1 or ON) or disable (0 or OFF) the LED Graticule.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).

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.

:TEXT commands

:DATA <a>

:DISPlay[:WINDow[1]]:TEXT:DATA <a> Define message for top display
:DISPlay:WINDow2:TEXT:DATA <a> Define message for bottom display

Parameter <a> = ASCII characters for message.

Short-form formats

String :disp:text:data ‘aa...a’
:disp:wind2:text:data ‘aa...a’

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Indefinite block	:disp:text:data #0aa...a :disp:wind2:text:data #0aa...a
Definite block	:disp:text:data #XYaa...a :disp:wind2:text:data #XYaa...a

where; Y = number of characters in message:
Up to 20 for top display.
Up to 32 for bottom display.
X = number of digits that make up Y (1 or 2).

Defaults

Power-up	Null string
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:DATA?	Query the defined text message
Short-form formats:	:disp:text:data? :disp:wind2:text:data?
Response message:	User defined text message

Description

These commands define the text messages that you wish to display. The message can be as long as 20 characters for the top display, and up to 32 characters for the bottom display. A space is counted as a character. Excess message characters (over 20 and 32 respectively) will cause error.

A string message must be enclosed in single quotes or double quotes. Both of the following sting messages are valid:

‘Keithley Model 7002’ or “Keithley Model 7002”

An indefinite block message must be the only command in the program message or the last command in the program message. If you include a command after an indefinite block message (on the same line), it will be treated as part of the message and will be displayed instead of executed.

Programming example

```
10  OUTPUT 707; ":disp:text:data  'Keithley Model 7002'; data?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Defines the user defined message for the top display, and then queries the defined message.
Line 20 Addresses the 7002 to talk.
Line 30 Displays (on the CRT) the user defined message.

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:STATe <b>

:DISPlay[:WINDow[1]]:TEXT:STATe <b> Control message; top display
:DISPlay:WINDow2:TEXT:STATe <b> Control message; bottom display

Parameters

<b>	= 0 or OFF	Disable text message for specified display
	= 1 or ON	Enable text message for specified display

Short-form formats

:disp:text:stat <b>
:disp:wind2:text:stat <b>

Defaults

Power-up	OFF
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:STATe?	Query state of message mode for specified display
Short-form formats:	:disp:text:stat? :disp:wind2:text:stat?
Response message:	1 (on) or 0 (off)

Description

These commands enable and disable the text message modes. When enabled, a defined message (see previous command) will be shown on the top or bottom portion of the display. When disabled, the message will be removed from the display, and the Model 7002 will resume normal operation.

A user defined text message remains displayed only as long as the instrument is in remote. Taking the instrument out of remote (by pressing the LOCAL key or sending LOCAL 707), cancels the message and disables the text message mode.

Programming example

```
10  OUTPUT 707; ":disp:text:stat  on; stat?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Displays a defined user message (see previous command) on the top display, and then queries the state (on or off) of the display.
Line 20 Addresses the 7002 to talk.
Line 30 Displays (on the CRT) the state of the message mode (1; on).

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:WINDow3 Command

:GRATicule <b>

:DISPlay:WINDow3:GRATicule <b> Control LED Graticule

Parameters

<b> = 0 or OFF Disable LED Graticule
= 1 or ON Enable LED Graticule

Short-form formats

:disp:wind3:grat <b>

Defaults

Power-up	ON
*RST	ON
:SYSTem:PRESet	ON

Query command

:GRATicule? Query state of LED Graticule

Short-form format: :disp:wind3:grat?
Response message: 1 (on) or 0 (off)

Description

This command is used to control the LED Graticule. When enabled, all available channels are denoted by channel LEDs that are turned on (dimly lit or brightly lit). Channels not available are denoted by channel LEDs that are turned off.

Contrast between on and off LEDs can be increased by disabling the LED Graticule. When disabled, there is no dimply lit state for the LEDs. An LED that would normally be dimly lit is instead turned completely off. Each LED is either off or brightly lit.

NOTE

If the main CPU firmware is not compatible with the LED display firmware, the following error will occur when trying to disable the LED Graticule.

ERROR:ID CODE = +551
Incorrect software revision

If this error should occur, contact Keithley to resolve the firmware incompatibility.

Programming example

```
10  OUTPUT 707; ":disp:wind3:grat  on; grat?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Disables the LED Graticule and then queries the state of the LED Graticule.

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Line 20 Addresses the 7002 to talk.
Line 30 Displays (on the CRT) the state of the LED Graticule (0; off).

:SMESSage <b>

:DISPlay:SMESSage <b> Control status messages

Parameters

<b>	= 0 or OFF	Disable status messages
	= 1 or ON	Enable status messages

Short-form formats

:disp:smes <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query command

:SMESSage?	Query state of status message mode
Short-form formats:	:disp:smes?
Response message:	1 (on) or 0 (off)

Description

This command is used to enable/disable the status message mode for the Model 7002. The status message mode is a diagnostic tool that provides real-time messages that relate to the current operating state of the instrument. When the status message mode is disabled, only the error events (EE) in Table 4-1 will be reported to the display.

Programming example

```
10  OUTPUT 707; ":disp:smes  on; smes?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Enables the status message mode, and then queries the state of the message mode.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the state of the status message mode (1; on).

:ENABle <b>

:DISPlay:ENABle <b> Control display circuitry

Parameters

<b>	= 0 or OFF	Disable display circuitry
	= 1 or ON	Enable display circuitry

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Short-form formats

:disp:enab <b>

Defaults

Power-up	ON
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:ENABle?	Query state of display
Short-form formats:	:disp:enab?
Response message:	1 (on) or 0 (off)

Description

This command is used to enable and disable the front panel display circuitry. Disabling the display circuitry allows the instrument to operate at a higher speed. While disabled, the display will be frozen with the following message:

FRONT PANEL DISABLED
Press LOCAL to resume.

As reported by the message, all front panel controls (except LOCAL) will be disabled. Normal display operation can be resumed by using the :ENABle command to enable the display or by putting the Model 7002 into local.

Programming example

```
10   OUTPUT 707; ":disp:enab   off; enab?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Disables the display, and then queries the state of the display.
Line 20 Addresses the 7002 to talk.
Line 30 Displays (on the CRT) the programmed state of the display (0; off).

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5.12 :OUTPut subsystem

The OUTPut subsystem is used to set polarities for the digital output port. Commands in this subsystem are summarized in Table 5-7.

Table 5-7
OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 4.

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.

:LSENse <name>

:OUTPut:TTL[1]:LSENse <name>	Set polarity of line #1
:OUTPut:TTL2:LSENse <name>	Set polarity of line #2
:OUTPut:TTL3:LSENse <name>	Set polarity of line #3
:OUTPut:TTL4:LSENse <name>	Set polarity of line #4

Parameters

<name>	= AHIGh	Set polarity of specified line to active high.
	= ALOW	Set polarity of specified line to active low.

Short-form formats

:outp:ttl:lsen <name>
:outp:ttl2:lsen <name>
:outp:ttl3:lsen <name>
:outp:ttl4:lsen <name>

Defaults

Power-up	Active high
*RST	No effect
:SYSTem:PRESet	No effect

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Query command

:LSENse?	Query polarity of specified line
Short-form formats:	:outp:ttl:lsen? :outp:ttl2:lsen? :outp:ttl3:lsen? :outp:ttl4:lsen?
Response message:	AHIG or ALOW

Description

These commands are used to set the polarity of the digital output lines. When set for active high (AHIGh) polarity, the specified output line is true (ON) when the output level is high. The output line is false (OFF) when the output level is low.

When set for active low (ALOW) polarity, the output line is true (ON) when the output level is low. The output line is false (OFF) when the output level is high.

Programming example

```
10    OUTPUT 707; ":outp:ttl:lsen   alow; lsen?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Sets the polarity of line #1 to active low.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the polarity of line #1 (ALOW).

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5.13 [:ROUTe] subsystem

The ROUTe subsystem is used to control signal routing through the switch system and is summarized in Table 5-8. The brackets indicate that :ROUTe is optional and need not be included in the command message.

Table 5-8
ROUTe command summary

Command	Description	Reference
[:ROUTe]		
:CLOSe <list>	Close specified channels.	5.13.1
: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.	5.13.2
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).	
:SCAN <list>	Define scan list.	5.13.3
:POINts?	Query number of channels in scan list.	
:SCAN?	Query scan list.	
:FCHannels <list>	Specify channels that cannot be closed.	5.13.4
:FCHannels?	Query channels that cannot be closed.	
:INTerlockX	Specify interlock (X = [1] to 5).	5.13.5
:LIST[1]	Define List 1 for specified interlock.	
:LIST[1]?	Query List 1 for specified interlock.	
:LIST2	Define List 2 for specified interlock.	
:LIST2?	Query List 2 for specified interlock.	
:CONFigure	Configuration command path:	
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.	5.13.6
:BBMake?	Query Break-Before-Make.	
:SCHannel <b>	ENable (1 or ON) or Disable (0 or OFF) Single Channel.	5.13.7
:SCHannel?	Query Single Channel.	
:CPAirX <b>	Enable (1 or ON) or Disable (0 or OFF) Card Pair X (X = [1] to 5).	5.13.8
:CPAirX?	Query Card Pair X (X = [1] to 5).	
:SLOTX	Path to configure SLOT X (X = [1] to 10):	
:CTYPe <name>	Assign card ID number for specified slot.	5.13.9
:CTYPe?	Query card ID number for specified slot.	
:POLE <NRf>	Select pole mode (1, 2 or 4) for specified slot.	5.13.10
:POLE?	Query pole mode for specified slot.	
:STIMe <n>	Specify delay (0 to 99999.999 sec) for specified slot.	5.13.11
:STIMe?	Query delay for specified slot.	
:MEMory	Path to program memory:	
:SAVE	Path to save channel patterns:	
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).	5.13.12
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).	5.13.13
:RECall M<num>	Recall channel pattern from memory (1 to 500).	5.13.14

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least on space is required between a command word and the parameters.

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5.13.1 :CLOSe <list>

[:ROUTe]:CLOSe <list> Close specified channels

Parameter

<list> = (@ chanlist)

where; chanlist is the specified list of channels (channel list) to be closed.

Short-form formats

:clos (@ chanlist)

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:CLOSe? <list>	Query state of specified channels.
Short-form formats:	:clos? (@ chanlist)
Response message:	1 = specified channel(s) closed. 0 = specified channel(s) not closed.

Description

The :CLOSe command is used to close the channel(s) specified by the channel list (chanlist) in the <list> parameter. The following examples demonstrate various forms for expressing channel entries for a chanlist.

Chanlist

1!2!4	Single channel (Slot 1, Row 2, Column 4).
2!36	Single channel (Slot 2, Channel 36).
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!4!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The :CLOSe? <list> query command is used to determine the state (closed or not closed) of each specified channel. After sending this command and addressing the Model 7002 to talk, the values for the specified channels will be sent to the computer. A value of “1” indicates that the channel is closed, and a “0” indicates that the channel is not closed (open).

For example, assume channels 2, 3 and 6 are closed and the following query command is sent:

:clos? (@ 1:10)

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After addressing the Model 7002 to talk, the following response message will be sent to the computer:

0,1,1,0,0,1,0,0,0,0

Programming example

This example assumes that all channels are initially open.

```
10   OUTPUT 707; ":clos   (@ 1!2, 1!3, 1!6); clos?   (@ 1!1:1!10)"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Closes channels 2, 3 and 6, and then queries all ten channels.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays the state of all ten channels (0,1,1,0,0,1, 0,0,0,0).

:STATe?

[:ROUTe]:CLOSe:STATe? Query closed channels

Short-form formats

:clos:stat?

Description

This query command is used to request the channels that are currently closed. For example if channels 1!2!3 and 2!36 are closed, the following message will be sent to the computer after sending this command and addressing the Model 7002 to talk:

(@1!2!3, 2!36)

Programming example

```
10   OUTPUT 707; ":clos   (@ 1!1, 1!5:1!10); clos:stat?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Two commands on this line. CLOSe closes the listed channels and STATe? queries the list of closed channels.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays (on the CRT) the list of closed channels.

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5.13.2 :OPEN <list>|ALL

[:ROUTe]:OPEN <list>|ALL Open specified (or all) channels

Parameters

<list> = (@ chanlist)	Open listed channels
ALL	Open all channels

where; chanlist is the specified list of channels (channel list) to be opened.

Short-form formats

:open (@ chanlist)
:open all

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:OPEN? <list>	Query state of specified channels.
Short-form formats:	:open? (@ chanlist)
Response message:	1 = specified channel(s) open. 0 = specified channel(s) not open.

Description

The :OPEN command is used to open one or more channels. The <list> parameter is used to define a channel list (chanlist) the specifies which channels to open. The ALL parameter is used to simply open all channels.

The following examples demonstrate various forms for expressing channel entries for a chanlist.

Chanlist

1!2!4	Single channel (Slot 1, Row 2, Column 4).
2!36	Single channel (Slot 2, Channel 36).
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!1!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The :OPEN? <list> query command is used to determine the state (open or not open) of each specified channel. After sending this command and addressing the Model 7002 to talk, the val-

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ues for the specified channels will be sent to the computer. A value of "1" indicates that the channel is open, and a "0" indicates that the channel is not open (closed).

For example, assume channels 2, 3 and 6 are open and the following query command is sent:

:open? (@ 1:10)

After addressing the Model 7002 to talk, the following response message will be sent to the computer:

0,1,1,0,0,1,0,0,0,0

Programming example

This example assumes that all channels are closed.

```
10   OUTPUT 707; ":open (@ 1!2, 1!3, 1!6); open? (@ 1!1:1!10)"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Open channels 2, 3 and 6, and then queries all ten channels.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays the state of all ten channels (0,1,1,0,0,1, 0,0,0,0).

5.13.3 :SCAN <list>

[:ROUTe]:SCAN <list> Define scan list

Parameter

<list> = (@ scanlist)

where; scanlist is the specified list of channels (scan list) to be scanned.

Short-form formats

:scan (@ scanlist)

Defaults

Power-up	Last defined scan list
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:SCAN?	Query scan list
Short-form formats:	:scan?
Response message:	Currently defined scan list

Description

The :SCAN command is used to define a scan list. The list of channels to be scanned (scanlist) are included in the <list> parameter.

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The following examples demonstrate various forms for expressing channel entries for a scanlist.

Scanlist	
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!1!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The Scan List is not lost (cleared) after the instrument is turned off. However, the Scan List is cleared if a channel in the Scan List becomes unavailable, restricted or interlocked to another channel in the list.

:POINts?

[:ROUTe]:SCAN:POINts? Query scan list length

Short-form formats

:scan:poin?

Description

This query command is used to request the number of channels in the scan list. A channel pattern (i.e. M1) in the scan list is counted as one channel. For example, assume the following scan list:

(@ 1!1:1!5, 1!10, M2)

After the POINt? command is sent and the Model 7002 is addressed to talk, the following message will be sent to the computer:

7

The “7” indicates that the scan list length is seven channels.

Programming example

```
10  OUTPUT 707; ":scan   (@1!2, 1!4); scan:poin?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 :SCAN defines the scan list and POINts? queries the number of channels in the scan list.

Line 20 Addresses the 7002 to talk.

Line 30 Displays (on the CRT) the number of channels (2) in the scan list.

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5.13.4 :FCHannels <list>

[:ROUTe]:FCHannels <list> Define “forbidden” channel list

Parameter

<list> = (@ forblist)

where; forblist is the specified list of “forbidden” channels that cannot be closed.

Short-form formats

:fch (@ forblist)

Defaults

Power-up	Last defined “forbidden” channel list
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:FCHannels?	Query “forbidden” channel list
Short-form formats:	:fch?
Response message:	List of “forbidden” channels

Description

The :FCHannels <list> command is used to define a list of channels that cannot be closed. The following examples demonstrate various forms for expressing a forblist:

Forblist

1!1	Single channel (Slot 1, Channel 1).
1!6, 1!18, 2!3!6	Channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 1!20	Range entry and single entry separated by commas.
M36	Channel pattern stored at memory location M36.

A “forbidden” channel list can be cancelled by sending an empty forblist as follows:

:fch (@)

If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared (lost).

Programming example

```
10   OUTPUT 707; ":fch   (@ 1!1, 1!4); fch?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Define the “forbidden” channel list and query the list.
Line 20 Address the Model 7002 to talk.
Line 30 Display the list.

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5.13.5 :INTerlock:LIST Commands

:LIST[1] <list>
:LIST2 <list>

:[ROUTe]:INTerlock[1]:LIST[1] <list>	Define List 1 for Interlock #1
:[ROUTe]:INTerlock[1]:LIST2 <list>	Define List 2 for Interlock #1
:[ROUTe]:INTerlock2:LIST[1] <list>	Define List 1 for Interlock #2
:[ROUTe]:INTerlock2:LIST2 <list>	Define List 2 for Interlock #2
:[ROUTe]:INTerlock3:LIST[1] <list>	Define List 1 for Interlock #3
:[ROUTe]:INTerlock3:LIST2 <list>	Define List 2 for Interlock #3
:[ROUTe]:INTerlock4:LIST[1] <list>	Define List 1 for Interlock #4
:[ROUTe]:INTerlock4:LIST2 <list>	Define List 2 for Interlock #4
:[ROUTe]:INTerlock5:LIST[1] <list>	Define List 1 for Interlock #5
:[ROUTe]:INTerlock5:LIST2 <list>	Define List 2 for Interlock #5

Parameter

<list> = (@ locklist)

where; locklist is the list of channels to be interlocked to channels in the second list.

Short-form formats

:int:list (@ locklist)
:int:list2 (@ locklist)
:int2:list (@ locklist)
:int2:list2 (@ locklist)
:int3:list (@ locklist)
:int3:list2 (@ locklist)
:int4:list (@ locklist)
:int4:list2 (@ locklist)
:int5:list (@ locklist)
:int5:list2 (@ locklist)

Defaults

Power-up	Last defined interlock lists
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:LIST[1]?	Query List 1 for specified interlock	
:LIST2?	Query List 2 for specified interlock	
Short-form formats:	:int:list?	(Interlock #1, List 1)
	:int:list2?	(Interlock #1, List 2)
	:int2:list?	(Interlock #2, List 1)
	:int2:list2?	(Interlock #2, List 2)
	:int3:list?	(Interlock #3, List 1)
	:int3:list2?	(Interlock #3, List 2)
	:int4:list?	(Interlock #4, List 1)
	:int4:list2?	(Interlock #4, List 2)

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	:int5:list?	(Interlock #5, List 1)
	:int5:list2?	(Interlock #5, List 2)
Response message:	List of channels	

Description

These commands are used to define the lists for the interlocks. The Model 7002 has five channel interlocks. Each interlock is made up of two user-defined lists of channels. Each channel in one list is interlocked to each channel in the other list. In general, channels that are interlocked cannot be closed at the same time. More detailed information on the interlocks can be found in Section 4 of this manual.

Lists for up to five interlocks can be defined. The following examples demonstrate various forms for expressing a locklist:

Locklist

1!1	Single channel.
1!6, 2!3!6, 6!6	Multiple channels.
3!1:3!10	Range of channels.
3!1:3!10, 5!2	Range entry and single channel entry.
M36	Channel pattern stored at memory location M36.

An interlock can be disabled by emptying one or both of its lists. For example, the following program message disables Interlock #1:

:int:list (@)

If you specify channels to be interlocked and they are already included in the Scan List and/or a Channel Pattern (interlock violation), then the entire Scan List and/or Channel Pattern is cleared (lost).

Programming example

```
10    OUTPUT 707; ":int:list   (@ 1!2)"
20    OUTPUT 707; ":int:list2   (@ 3!6)"
30    OUTPUT 707; ":int:list?; list2?"
40    ENTER 707; A$
50    PRINT A$
60    END
```

Line 10 Places channel 1!2 in List 1 of Interlock #1.
Line 20 Places channel 3!6 in List 2 of Interlock #1.
Line 30 Queries Lists 1 and 2 of Interlock #1.
Line 40 Addresses 7002 to talk.
Line 50 Displays Lists 1 and 2 (@ 1!2); (@ 3!6).

After the above program is run, channels 1!2 and 3!6 will be interlocked to each other. That is, these two channels cannot both be closed at the same time.

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:CONFigure Commands:

5.13.6 :BBMake <b>

[:ROUTe]:CONFigure:BBMake <b> Control Break-Before-Make switching

Parameters

<b>	= 0 or OFF	Disable Break-Before-Make switching
	= 1 or ON	Enable Break-Before-Make switching

Defaults

Power-up	Saved power-on setup
*RST	On
:SYSTem:PRESet	On

Query command

:BBMake?	Query Break-Before-Make
Short-form formats:	:conf:bbm?
Response message:	1 (on) or 0 (off)

Description

When scanning, recalling saved channel patterns or in the Single Channel mode, enabling Break-Before-Make will assure that the currently closed channel will open before the next channel closes.

When Break-Before-Make is disabled, the assurance that the current channel will open before the next channel closes is lost. In other words, two channels could momentarily be closed at the same time. An advantage to disabling Break-Before-Make is an increase in speed.

Programming example

```
10   OUTPUT 707; ":conf:bbm   off; bbm?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Disables Break-Before-Make and then queries its status.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the status of Break-Before-Make (0; off).

5.13.7 :SCHannel <b>

[:ROUTe]:CONFigure:SCHannel <b> Control Single Channel mode

Parameters

<b>	= 0 or OFF	Disable Single Channel mode.
	= 1 or ON	Enable Single Channel mode.

Short-form formats

:conf:sch <b>

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Defaults

Power-up	Saved power-on setup
*RST	Off
:SYSTem:PRESet	Off

Query command

:SCHannel?	Query status of Single Channel
Short-form formats:	:conf:sch?
Response message:	0 (off) or 1 (on)

Description

The Single Channel mode (when enabled) is used to prevent more than one channel from closing at a time. When a single channel is closed, the previous closed channel will open. This ensures that even with random channel closures, only one channel can be closed at a time. Toggling the Single Channel mode from off to on causes all channels to open. For complete details on Single Channel, see Section 4.

Programming example

```
10   OUTPUT 707; ":conf:sch   on; sch?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Enables Single Channel and then queries its status.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the status of Single Channel (1; on).

5.13.8 :CPAirX <b> where; X = [1] to 5

[:ROUTe]:CONFigure:CPAir[1] <b>	Control Card Pair 1
[:ROUTe]:CONFigure:CPAir2 <b>	Control Card Pair 2
[:ROUTe]:CONFigure:CPAir3 <b>	Control Card Pair 3
[:ROUTe]:CONFigure:CPAir4 <b>	Control Card Pair 4
[:ROUTe]:CONFigure:CPAir5 <b>	Control Card Pair 5

Parameters

<b>	= 0 or OFF	Disable specified Card Pair.
	= 1 or ON	Enable specified Card Pair.

Short-form formats

```
:conf:cpa  <b>
:conf:cpa2  <b>
:conf:cpa3  <b>
:conf:cpa4  <b>
:conf:cpa5  <b>
```

Defaults

Power-up	Saved power-on setup
*RST	Disables all Card Pairs
:SYSTem:PRESet	Disables all Card Pairs

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Query command

:CPAirX?	Query status of specified Card Pair
where; X = [1] to 5	
Short-form formats:	:conf:cpa?
	:conf:cpa2?
	:conf:cpa3?
	:conf:cpa4?
	:conf:cpa5?
Response message:	0 (off) or 1 (on)

Description

With a Card Pair enabled, the corresponding channels of two slots are controlled concurrently. For example, when channel 5 of CARD 1 (Slot 1) is closed, channel 5 of CARD 6 (Slot 6) is also closed. Slot pairings are defined as follows:

Card Pair 1 enabled - Slot 1 is paired to Slot 6
Card Pair 2 enabled - Slot 2 is paired to Slot 7
Card Pair 3 enabled - Slot 3 is paired to Slot 8
Card Pair 4 enabled - Slot 4 is paired to Slot 9
Card Pair 5 enabled - Slot 5 is paired to Slot 10

Card Pair can only be enabled for similar type cards. For example, you will not be able to enable Card Pair 1 if a multiplexer card is installed in Slot 1 and a matrix card is installed in Slot 6.

If enabling a Card Pair adds a restricted channel or interlocked channels to the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared (lost).

Programming example

```
10    OUTPUT 707; ":conf:cpa2   on; cpa2?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Enables Card Pair 2 and then queries its status.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the status of Card Pair 2 (1; on).

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5.13.9 :CTYPe <name>

[:ROUTe]:CONFigure:SLOT[1]:CTYPe <name>	Assign card ID number for SLOT 1
[:ROUTe]:CONFigure:SLOT2:CTYPe <name>	Assign card ID number for SLOT 2
[:ROUTe]:CONFigure:SLOT3:CTYPe <name>	Assign card ID number for SLOT 3
[:ROUTe]:CONFigure:SLOT4:CTYPe <name>	Assign card ID number for SLOT 4
[:ROUTe]:CONFigure:SLOT5:CTYPe <name>	Assign card ID number for SLOT 5
[:ROUTe]:CONFigure:SLOT6:CTYPe <name>	Assign card ID number for SLOT 6
[:ROUTe]:CONFigure:SLOT7:CTYPe <name>	Assign card ID number for SLOT 7
[:ROUTe]:CONFigure:SLOT8:CTYPe <name>	Assign card ID number for SLOT 8
[:ROUTe]:CONFigure:SLOT9:CTYPe <name>	Assign card ID number for SLOT 9
[:ROUTe]:CONFigure:SLOT10:CTYPe <name>	Assign card ID number for SLOT 10

Parameters

<name>	= C7052	<name>	= C7067
	= C7053		= C7152
	= C7054		= C7153
	= C7056		= C7154
	= C7057		= C7156
	= C7058		= C7158
	= C7059		= C7164
	= C7061		= C7166
	= C7062		= C7168
	= C7063		= C7169
	= C7064		= C7402
	= C7065		= C9990
	= C7066		= C9991

Short-form formats

:conf:slot:ctyp <name>	:conf:slot6:ctyp <name>
:conf:slot2:ctyp <name>	:conf:slot7:ctyp <name>
:conf:slot3:ctyp <name>	:conf:slot8:ctyp <name>
:conf:slot4:ctyp <name>	:conf:slot9:ctyp <name>
:conf:slot5:ctyp <name>	:conf:slot10:ctyp <name>

Defaults

Power-up	Each slot uses the last programmed type, or a 701X card type that is detected.
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:CYTPe?	Query card ID assignment for specified slot.
Short-form formats:	:conf:slot:ctyp?
	:conf:slot2:ctyp?
	:conf:slot3:ctyp?
	:conf:slot4:ctyp?
	:conf:slot5:ctyp?
	:conf:slot6:ctyp?

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:conf:slot7:ctyp?
:conf:slot8:ctyp?
:conf:slot9:ctyp?
:conf:slot10:ctyp?

Response message: Assigned card ID (e.g. C7156)

Description

After installing a non-701X series card in a mainframe slot, use the :CYTPe command to assign the ID (identification) number (type) for that slot. For example, if a Model 7156 card is installed in Slot 1, send type parameter C7156 with the command.

Type C9990 or C9991 can be used to assign a slot as a card simulator. By assigning C9990, the instrument will operate as if a 40 channel switch card were installed in the specified slot. By assigning C9991, the instrument will operate as if a 4 x 10 matrix were installed.

A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear.

Programming example

This program assumes that Slot 1 is empty.

```
10    OUTPUT 707; ":conf:slot1:ctyp   C9990; ctyp?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Assigns simulator C9990 to Slot 1 and then queries the model number.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the card ID number assigned to Slot 1 (C9990).

5.13.10 :POLE <NRf>

[:ROUTe]:CONFigure:SLOT[1]:POLE <NRf>	Select pole mode for card in Slot 1
[:ROUTe]:CONFigure:SLOT2:POLE <NRf>	Select pole mode for card in Slot 2
[:ROUTe]:CONFigure:SLOT3:POLE <NRf>	Select pole mode for card in Slot 3
[:ROUTe]:CONFigure:SLOT4:POLE <NRf>	Select pole mode for card in Slot 4
[:ROUTe]:CONFigure:SLOT5:POLE <NRf>	Select pole mode for card in Slot 5
[:ROUTe]:CONFigure:SLOT6:POLE <NRf>	Select pole mode for card in Slot 6
[:ROUTe]:CONFigure:SLOT7:POLE <NRf>	Select pole mode for card in Slot 7
[:ROUTe]:CONFigure:SLOT8:POLE <NRf>	Select pole mode for card in Slot 8
[:ROUTe]:CONFigure:SLOT9:POLE <NRf>	Select pole mode for card in Slot 9
[:ROUTe]:CONFigure:SLOT10:POLE <NRf>	Select pole mode for card in Slot 10

Parameters

<NRf> = 1 Select 1-pole mode
= 2 Select 2-pole mode
= 4 Select 4-pole mode

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Short-form formats

:conf:slot:pole <NRf>	:conf:slot6:pole <NRf>
:conf:slot2:pole <NRf>	:conf:slot7:pole <NRf>
:conf:slot3:pole <NRf>	:conf:slot8:pole <NRf>
:conf:slot4:pole <NRf>	:conf:slot9:pole <NRf>
:conf:slot5:pole <NRf>	:conf:slot10:pole <NRf>

Defaults

Power-up	Last selected pole mode for each slot
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:POLE? Query pole mode for specified slot

Short-form formats:	:conf:slot:pole?	:conf:slot6:pole?
	:conf:slot2:pole?	:conf:slot7:pole?
	:conf:slot3:pole?	:conf:slot8:pole?
	:conf:slot4:pole?	:conf:slot9:pole?
	:conf:slot5:pole?	:conf:slot10:pole?
Response message:	1 (1-pole mode)	
	2 (2-pole mode)	
	4 (4-pole mode)	

Description

Some cards have the capability to operate as more than one switch type. For example, the Model 7011 multiplexer card can be used for 40-channel, 2-pole switching, or for 20-channel, 4-pole switching.

The switch cards that have an additional pole mode capability are summarized as follows:

Pole Mode:

Card	1-Pole	2-pole	4-pole
7011	N/A	40 channels	20 channels
7056	20 channels	10 channels	N/A
7156	20 channels	10 channels	N/A

Keep in mind that the card must be wired appropriately for the selected pole mode. For more information on Pole-Mode, see Section 4 of this manual.

The factory default is the 2-pole mode for all cards. The :POLE command is used to select an alternate pole mode for the card in the specified slot. An invalid pole mode cannot be selected and will result in an error message.

Changing the pole mode for a slot could cause a channel to become unavailable. As can be seen from the above table for the Model 7011 mux card, 20 channels become unavailable when changing from 2-pole to 4-pole operation. If one or more of these unavailable channels were

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included in the Scan List and/or in a Channel Pattern, then the entire Scan List and/or affected Channel Pattern will be lost (cleared).

Programming example

```
10  OUTPUT 707; ":conf:slot1:pole  4; pole?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Selects the 4-pole mode for Slot 1 and then queries the pole mode.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the pole mode for Slot 1 (4).

5.13.11 :STIMe <n>

[:ROUTe]:CONFigure:SLOT[1]:STIMe <n>	Set delay for Slot 1
[:ROUTe]:CONFigure:SLOT2:STIMe <n>	Set delay for Slot 2
[:ROUTe]:CONFigure:SLOT3:STIMe <n>	Set delay for Slot 3
[:ROUTe]:CONFigure:SLOT4:STIMe <n>	Set delay for Slot 4
[:ROUTe]:CONFigure:SLOT5:STIMe <n>	Set delay for Slot 5
[:ROUTe]:CONFigure:SLOT6:STIMe <n>	Set delay for Slot 6
[:ROUTe]:CONFigure:SLOT7:STIMe <n>	Set delay for Slot 7
[:ROUTe]:CONFigure:SLOT8:STIMe <n>	Set delay for Slot 8
[:ROUTe]:CONFigure:SLOT9:STIMe <n>	Set delay for Slot 9
[:ROUTe]:CONFigure:SLOT10:STIMe <n>	Set delay for Slot 10

Parameters

<n>	= 0 to 99999.999	Settling time in seconds
	= DEFault	0 sec
	= MINimum	0 sec
	= MAXimum	99999.999 sec

Short-form formats

:conf:slot:stim <n>	:conf:slot6:stim <n>
:conf:slot2:stim <n>	:conf:slot7:stim <n>
:conf:slot3:stim <n>	:conf:slot8:stim <n>
:conf:slot4:stim <n>	:conf:slot9:stim <n>
:conf:slot5:stim <n>	:conf:slot10:stim <n>

Defaults

Power-up	0 sec
*RST	0 sec
:SYSTem:PRESet	0 sec

Query commands

:STIMe?	Query programmed delay for specified slot
:STIMe? DEFault	Query *RST default delay
:STIMe? MINimum	Query minimum delay
:STIME? MAXimum	Query maximum delay

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Short-form formats:	:conf:slot:stim?	:conf:slot:stim? xxx
	:conf:slot2:stim?	:conf:slot2:stim? xxx
	:conf:slot3:stim?	:conf:slot3:stim? xxx
	:conf:slot4:stim?	:conf:slot4:stim? xxx
	:conf:slot5:stim?	:conf:slot5:stim? xxx
	:conf:slot6:stim?	:conf:slot6:stim? xxx
	:conf:slot7:stim?	:conf:slot7:stim? xxx
	:conf:slot8:stim?	:conf:slot8:stim? xxx
	:conf:slot9:stim?	:conf:slot9:stim? xxx
	:conf:slot10:stim?	:conf:slot10:stim? xxx
	where; xxx = def, min or max	
Response message:	0 to 99999.999	

Description

An internally set relay settling time is provided to allow for switch bounce when it closes. At power-up, a settling time is automatically set based on the acquired identification information from the card. The :STIMe command allows you to increase the delay for each slot.

The delay value can be entered using the exponent form. For example, instead of sending a parameter value of 2000 (seconds), you can instead send 2E3. To cancel this delay, send this command using a parameter value of 0.

For complete information on this delay, see DELAY in Section 4.

Programming example

```
10   OUTPUT 707; ":conf:slot1:stim   10; stim?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Sets a 10 second delay for Slot 1 and then queries the delay period.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the delay period (10).

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:MEMory Commands:

5.13.12 :SAVE[:RELays] M<num>

[:ROUTe]:MEMory:SAVE[:RELays] M<num> Save current channel pattern at specified memory location

Parameter

<num> = a whole number from 1 to 500 Specify memory location

Short-form formats

:mem:save M<num>

Defaults

Power-up	No effect
*RST	No effect
:SYSTem PRESet	No effect

Description

This command is used to save (store) the current channel pattern at a memory location. For example, if channels 1!1, 1!6, 1!8 and 2!5 are currently closed, you can save that channel pattern to memory location 236. When M236 is later recalled or scanned, the four channels of that channel pattern will close, and all other channels will open.

Up to 500 channel patterns can be saved in memory locations 1 to 500. A channel pattern can be recalled from memory using the :RECall command. Note: An alternate method to save a channel pattern is to use the :SAVE:LIST command. This allows you to define the channel pattern without having to close or open channels.

A Channel Pattern is not lost (cleared) after the instrument is turned off. However, a Channel Pattern is cleared if a closed channel in the pattern becomes unavailable, restricted or interlocked to another channel in the pattern.

Programming example

```
OUTPUT 707; ":clos   (@ 1!1:1!10)"     ! Closes ch 1-10 of Slot 1
OUTPUT 707; ":mem:save   M36"          ! Saves pattern to M36
```

1st Line Closes channels 1-10 of Slot 1.
2nd Line Saves channel pattern to memory location 36.

5.13.13 :SAVE:LIST <list>, M <num>

[:ROUTe]:MEMory:SAVE:LIST <list>, M <num> Save specified channel pattern at a specified memory location

Parameter

<num> = a whole number from1 to 500 Specify memory location
<list> = (@ chanlist) Specify channel pattern

where; chanlist is the specified list of closed channels

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Short-form formats

:mem:save:list <list>, M<num>

Defaults

Power-up	No effect
*RST	No effect
:SYSTem PRESet	No effect

Description

This command is used to define and save (store) a channel pattern at a memory location. The <NRf> parameter specifies the memory location for the channel pattern. The <list> parameter defines the channel pattern. When the channel pattern is recalled or scanned, the channels listed in the chanlist will close. The following examples demonstrate various forms for expressing channel entries for a chanlist.

Chanlist

1!2!4	Single channel (Slot 1, Row 2, Column 4).
2!36	Single channel (Slot 2, Channel 36).
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!1!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).

Up to 500 channel patterns can be saved in memory locations 1 to 500. A channel pattern can be recalled from memory using the :RECall command.

Note: An alternate method to save a channel pattern is to use the :SAVE:[RELays] command. With this method, you close the desired channels and then save that channel pattern at a memory location.

A Channel Pattern is not lost (cleared) after the instrument is turned off. However, a Channel Pattern is cleared if a closed channel in the pattern becomes unavailable, restricted or interlocked to another channel in the pattern.

Programming example

OUTPUT 707; ":mem:save:list (@ 1!1:1!10), M24"

Saves defined channel list (ch 1-10, Slot 1) to memory location 24.

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5.13.14 :RECall M<NRf>

[:ROUTe]:MEMory:RECall M<NRf> Recall channel pattern from memory

Parameter

<NRf> = 1 to 500 Specify memory location

Short-form formats

:mem:rec M<NRf>

Description

This command is used to recall a channel pattern stored at a memory location. Channel patterns can be recalled from memory locations 1 to 500. As soon as the channel pattern is recalled, channels will immediately close and/or open as dictated by the channel pattern. The front panel channel status display will also update to reflect the channel pattern.

The Model 7002 is shipped from the factory with blank channel patterns stored in all 500 memory locations. A blank channel pattern has no closed channels. All channels for all slots will open.

Channel patterns can be stored in memory using the :SAVe[:RECall] or :SAVE:LIST command.

Programming example

OUTPUT 707; ":mem:rec M24"

Recall channel pattern from memory location 24.

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5.14 Sense subsystems

The sense subsystems are used to read digital input ports. The :SENSe1 Subsystem is used to read the built-in digital input lines. The :SENSe2 through :SENSe11 Subsystems are used to read the inputs of digital cards installed in slots 1 through 10 respectively.

Table 5-9
SENSe command summary

Command	Description
:SENSe[1] :TTL[1] :DATA?	Command path to read internal input line. Read internal digital input line.
: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.

:SENSe[1] Subsystem

:TTL[1]:DATA?

:SENSe[1]:TTL[1]:DATA? Read internal input port

Short-form formats

:sens:ttl:data?

Description

This command is used to read the single line of the digital input port. After sending this command and addressing the Model 7002 to talk, a value indicating the status of the port will be sent to the computer.

A value of “1” indicates that the input port is high (ON), and a value of “0” indicates that the port is low (OFF).

Programming example

```
10   OUTPUT 707; ":sens:ttl:data?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Read the input port.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the status of the input port (0 or 1).

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:SENSe2 thru :SENSe11 Subsystems

:DATA? <list>

:SENSe2:DATA? <list>	Read specified inputs of slot 1
:SENSe3:DATA? <list>	Read specified inputs of slot 2
:SENSe4:DATA? <list>	Read specified inputs of slot 3
:SENSe5:DATA? <list>	Read specified inputs of slot 4
:SENSe6:DATA? <list>	Read specified inputs of slot 5
:SENSe7:DATA? <list>	Read specified inputs of slot 6
:SENSe8:DATA? <list>	Read specified inputs of slot 7
:SENSe9:DATA? <list>	Read specified inputs of slot 8
:SENSe10:DATA? <list>	Read specified inputs of slot 9
:SENSe11:DATA? <list>	Read specified inputs of slot 10

Parameter

<list> = (@ chanlist)

where: chanlist is the specified list of input channels to be read.

Short-form formats

:sens2:data?	:sens7:data?
:sens3:data?	:sens8:data?
sens4:data?	:sens9:data?
sens5:data?	:sens10:data?
sens6:data?	:sens11:data?

Description

These commands are used to read the specified inputs of digital I/O cards installed in the slots of the mainframe. After sending one of these commands and addressing the Model 7002 to talk, a value indicating the status of each specified input channel is sent to the computer. A value of "1" indicates that the input channel is high (on) and a value of "0" indicates that the input channel is low (off).

The conventional form for the <list> parameter includes the slot and input channel number. However, for these commands, you do not need to include the slot number. For example, you can send either of the following two commands to read input channel 23 of slot 6:

:SENSe7:DATA? (@6!23) or :SENSe7:DATA? (@23)

After the mainframe is addressed to talk, the response message will indicate the state of input channel 23 of slot 6. In another example, you can send either of the following two commands to read all 40 input channels of an I/O card in slot 8.

:SENSe9:DATA? (@8!1:8!40) or :SENSe9:DATA? (@ 1:40)

The response message will include a "0" (off) or "1" (on) for each of the 40 input channels (i.e. "0, 0, 0, 1, 0 ... 1"). You can send up to two of the query commands in the same program message. For example, the following program message is valid:

:sens2:data? <list>; :sens3:data? <list>

Sending three or more of these queries in the same program message will cause the Model 7002 to lock up and will require that you send an IFC and then a DCL to restore operation.

Sending one of these query commands for a slot which does not have an I/O card installed will result in the following error message:

ERROR: ID CODE = -241
Hardware missing

Programming example

```
10    OUTPUT 707; ":sens3:data? (@36)"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Reads input channel 36 of slot 2.
Line 20 Addresses the mainframe to talk.
Line 30 Displays the status of channel 36.

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5.15 :SOURce subsystem

This subsystem is used to set the logic level (true or false) of each digital output line. The commands for this subsystem are summarized in Table 5-10.

Table 5-10
SOURce command summary

Command	Description
:SOURce	
:TTL[1]	Digital output line #1.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL2	Digital output line #2.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL3	Digital output line #3.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL4	Digital output line #4.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

[:LEVel] <b>

:SOURce:TTL[1]:[LEVel] <b>	Control digital output line #1
:SOURce:TTL2:[LEVel] <b>	Control digital output line #2
:SOURce:TTL3:[LEVel] <b>	Control digital output line #3
:SOURce:TTL4:[LEVel] <b>	Control digital output line #4

Parameters

<b>	= 1 or ON	Set output line true
	= 0 or OFF	Set output line false

Short-form formats

:sour:ttl <b>
:sour:ttl2 <b>
:sour:ttl3 <b>
:sour:ttl4 <b>

Defaults

Power-up	OFF (all lines)
*RST	No effect
:SYSTem:PRESet	No effect

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Query command

[:LEVel]?	Query logic level of specified line
Shortform formats:	:sour:ttl?
	:sour:ttl2?
	:sour:ttl3?
	:sour:ttl4?
Response message:	0 (false) or 1 (true)

Description

These commands are used to set the logic levels for the digital output port. The actual level (high or low) of a digital output line depends on its programmed polarity (see OUTPut Subsystem). If the polarity of a line is active-high, then that line will be high when it is set to be true (1 or ON), and low when it is set to be false (0 or OFF). Conversely, if the polarity is active-low, the line will be low when it is set to be true, and high when it is set to be false.

Programming example

```
10   OUTPUT 707; ":sour:ttl   on; ttl?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Sets output line #1 to true, and then queries the state of the output line.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the state of output line #1 (1; on).

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5.16 :STATus subsystem

The status subsystem is used to control the status registers of the Model 7002. These registers and the overall status structure are explained in paragraph 5.6.

The commands in this subsystem are summarized in Table 5-11.

Table 5-11
STATus command summary

Command	Description	Reference
:STATus		
:OPERation	Path to control operation event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:ARM	Path to control arm event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:SEQuence	Path to control the sequence event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:TRIGger	Path to control trigger event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:QUEStionable	Path to control questionable event registers:	
[:EVENt]?	Query the event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query the enable register.	

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Table 5-11 (continued)
STATus command summary

Command	Description	Reference
:STATus		
:QUEStionable		
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query the negative transition register.	
:CONDition?	Query the condition register.	5.16.5
:PRESet	Return status registers to default states.	5.16.6
:QUEue	Path to access error queue:	5.16.7
[:NEXT]?	Query most recent error message.	
:ENABle <list>	Specify error and status messages for queue.	
:ENABle?	Query enabled messages.	
:DISable <list>	Specify messages not to be placed in queue.	
:DISable?	Query disabled messages.	

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.

5.16.1 [:EVENt]?

:STATus:OPERation[:EVENt]?	Query Operation Event Register
:STATus:OPERation:TRIGger[:EVENt]?	Query Trigger Event Register
:STATus:OPERation:ARM[:EVENt]?	Query Arm Event Register
:STATus:OPERation:ARM:SEQUENCE[:EVENt]?	Query Sequence Event Register
:STATus:QUEStionable[:EVENt]?	Query Questionable Event Register

Short-form formats

:stat:oper?
:stat:oper:trig?
:stat:oper:arm?
:stat:oper:arm:seq?
:stat:ques?

Defaults

Power-up	Clears (0) all bits
*CLS	Clears (0) all bits
:STATus:PRESet	No effect

Description

These query commands are used to query the event registers. After sending one of these commands and addressing the Model 7002 to talk, a decimal value is sent to the computer. The binary equivalent of this value determines which bits in the appropriate register are set. The event registers are shown in Figure 5-18 through Figure 5-22. Note that querying an event register clears the bits in that register.

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For example, assume that querying the Operation Event Register results in an acquired decimal value of 34. The binary equivalent is 0000 0000 0010 0010. For this binary value, bits B5 and B1 of the Operation Event Register are set.

The significance of a set bit in these registers depend on how the transition filter is programmed (see :PTRansition and :NTRansition commands). If an event is programmed for a positive transition (PTR), the corresponding bit in this register will set when the event occurs (0 to 1 transition). If the event is instead programmed for a negative transition (NTR), the bit will set when the event becomes not true (1 to 0 transition).

Operation event register:

Bit B0 — Not used.

Bit B1, Settling (Set) — Set bit indicates that the scan is currently in the settling period for a relay (PTR) or the settling period has expired (NTR).

Bits B2, B3 and B4 — Not used.

Bit B5, Waiting for Trigger (Trig) — Set bit indicates that the instrument is waiting in the Trigger Layer of the trigger model (PTR) or that it has left the Trigger Layer (NTR).

Bit B6, Waiting for Arm (Arm) — Set bit indicates that the instrument is waiting in an Arm Layer of the trigger model (PTR) or operation has passed from the arm layers into the trigger layer (NTR).

Bits B7, B8 and B9 — Not used.

Bit B10, Idle — Set bit indicates that the instrument is in the idle state (PTR) or has left the idle state to perform a scan (NTR).

Bits B11 through B15 — Not used.

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Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	——	1024 (2^{10})	—	—	—	64 (2^{6})	32 (2^{5})	—	—	—	2 (2^{1})	—
Value	——	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Operation Event Set
0 = Operation Event Cleared

Events : Idle = Idle state of the 7002
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling

Figure 5-18
Operation Event Register

Trigger Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in the Trigger Layer (PTR), or that the instrument has exited from the Trigger Layer (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^{1})	—
Value	——	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : Seq 1 = Sequence 1

Figure 5-19
Trigger Event Register

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Arm Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in an arm layer (PTR), or that the instrument has exited from the arm layers (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Seq 1 = Sequence 1

Figure 5-20
Arm Event Register

Sequence Event Register:

Bit B0 — Not used.

Bit B1, Layer 1 (Lay1) — Set bit indicates that instrument operation is in Arm Layer 1 (PTR), or that operation has exited from Arm Layer 1 (NTR).

Bit B2, Layer 2 (Lay2) — Set bit indicates that instrument operation is in Arm Layer 2 (PTR), or that operation has exited from Arm Layer 2 (NTR).

Bits B3 through B15 — Not used.

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Bit Position	B15 - B3	B2	B1	B0
Event	———	Lay2	Lay1	—
Decimal Weighting	———	4 (2^2)	2 (2^1)	—
Value	———	0/1	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Lay1 = Layer 1
Lay2 = Layer 2

Figure 5-21
Sequence Event Register

Questionable Event Register:

Bit B0 through B8 — Not used.

Bit B9, Too Many Channels Closed (Chan) — Set bit indicates that too many channels have closed (PTR), or that those channels have subsequently opened (NTR). This error occurs when the required relay drive current exceeds the current capability of the +6V supply.

Bit B10 through B15 — Not used.

Bit Position	B15 - B10	B9	B8 - B0
Event	———	Chan	———
Decimal Weighting	———	512 (2^9)	———
Value	———	0/1	———

Value : 1 = Questionable Event Set
0 = Questionable Event Cleared

Event : Chan = Too Many Channels Closed

Figure 5-22
Questionable Event Register

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Programming example

```
10  OUTPUT 707; ":stat:oper?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Queries the register.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the decimal value that defines which bits in the register are set.

5.16.2 :ENABle <NRf>

:STATus:OPERation:ENABle <NRf>	Program Operation Event Enable Register
:STATus:OPERation:TRIGger:ENABle <NRf>	Program Trigger Event Enable Register
:STATus:OPERation:ARM:ENABle <NRf>	Program Arm Event Enable Register
:STATus:OPERation:ARM:SEQUENCE:ENABle <NRf>	Program Sequence Event Enable Register
:STATus:QUEStionable:ENABle <NRf>	Program Questionable Event Enable Register

Parameters

<NRf>	= 0	Clear enable register
	= 2	Set bit B1 of enable register
	= 4	Set bit B2 of enable register
	= 32	Set bit B5 of enable register
	= 64	Set bit B6 of enable register
	= 512	Set bit B9 of enable register
	= 1024	Set bit B10 of enable register

Short-form formats

:stat:oper:enab <NRf>
:stat:oper:trig:enab <NRf>
:stat:oper:arm:enab <NRf>
:stat:oper:arm:seq:enab <NRf>
:stat:ques:enab <NRf>

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query commands

:ENABle?	Query enable register
Short-form formats:	:stat:oper:enab?
	:stat:oper:trig:enab?
	:stat:oper:arm:enab?
	:stat:oper:arm:seq:enab?
	:stat:ques:enab?
Response message:	Decimal value (see Note)

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Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B5 and B6 are set.

Description

These commands are used to set the contents of the event enable registers (see Figure 5-23 through Figure 5-27). An :ENABle command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the appropriate register.

Each event enable register is used as a mask for events (see [:EVENt] for descriptions of events). When a bit in an event enable register is cleared (0), the corresponding bit in the event register is masked and thus, cannot set the corresponding summary bit of the next register set in the status structure. Conversely, when a bit in an event enable register is set (1), the corresponding bit in the event register is unmasked. When the unmasked bit in the event register sets, the summary bit of the next register set in the status structure will set.

The decimal weighting of the bits for each event enable register are included in Figure 5-23 through Figure 5-27. The sum of the decimal weights of the bits that you wish to set is sent as the parameter (<NRf>) for the appropriate :ENABle command. For example, to set the Idle and Set bits of the Operation Event Enable Register, send the following command:

:stat:oper:enab 1026

where;	Idle (bit B10)	=	1024
	Set (bit B1)	=	2
	<NRf>	=	1026

Programming example

```
10 OUTPUT 707; ":stat:oper:enab 96; enab?"
20 ENTER 707; A$
30 PRINT A$
40 END
```

Line 10 Sets Bits B5 and B6 of the Operation Event Enable Register, and then queries the register.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (96).

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Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	———	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	———	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	———	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Operation Event
0 = Disable (Mask) Operation Event

Events : Idle = Idle state of the 7002
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling

Figure 5-23
Operation Event Enable Register

Bit Position	(B15 - B2)	B1	B0
Event	———	Seq1	—
Decimal Weighting	———	2 (2^1)	—
Value	———	0/1	—

Value : 1 = Enable Trigger Event
0 = Disable (Mask) Trigger Event

Events : Seq 1 = Sequence 1

Figure 5-24
Trigger Event Enable Register

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Bit Position	(B15 - B2)	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Enable Arm Event
0 = Disable (Mask) Arm Event

Event : Seq 1 = Sequence 1

Figure 5-25
Arm Event Enable Register

Bit Position	(B15 - B3)	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (2^2)	2 (2^1)	—
Value	——	0/1	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Lay1 = Layer 1
Lay2 = Layer 2

Figure 5-26
Sequence Event Enable Register

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Bit Position	(B15 - B10)	B9	(B8 - B0)
Event	——	Chan	——
Decimal Weighting	——	512 (2^9)	——
Value	——	0/1	——

Value : 1 = Enable Questionable Event
0 = Disable (Mask) Questionable Event

Event : Chan = Too many channels closed.

Figure 5-27
Questionable Event Enable Register

5.16.3 :PTRansition <NRf>

:STATus:OPERation:PTRansition <NRf>	Program Operation Transition Filter (PTR).
:STATus:OPERation:TRIGger:PTRansition <NRf>	Program Trigger Transition Filter (PTR).
:STATus:OPERation:ARM:PTRansition <NRf>	Program Arm Transition Filter (PTR).
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>	Program Sequence Transition Filter (PTR).
:STATus:QUEStionable:PTRansition <NRf>	Program Questionable Transition Filter (PTR).

Parameters

<NRf>	= 0	Clear PTR register
	= 2	Set bit B1 of PTR register
	= 4	Set bit B2 of PTR register
	= 32	Set bit B5 of PTR register
	= 64	Set bit B6 of PTR register
	= 512	Set Bit B9 of PTR register
	= 1024	Set bit B10 of PTR register

Short-form formats

:stat:oper:ptr <NRf>
:stat:oper:trig:ptr <NRf>
:stat:oper:arm:ptr <NRf>
:stat:oper:arm:seq:ptr <NRf>
:stat:ques:ptr <NRf>

Defaults

Power-up Sets (1) all bits

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*CLS	No effect
:STATus:PRESet	Sets (1) all bits

Query commands

:PTRansition?	Query PTR register
Short-form formats:	:stat:oper:ptr? :stat:oper:trig:ptr? :stat:oper:arm:ptr? :stat:oper:arm:seq:ptr? :stat:ques:ptr?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0010 0110 0000. For this binary value, bits B6 and B5 are set.

Description

These commands are used to program the positive transition (PTR) registers. A positive transition is defined as a 0 to 1 state change in the condition register. Thus, when a an event is programmed for a positive transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 0 to 1. For example, if bit B1 of the Positive Transition Register of the Operation Transition Filter is set, then the relay settling event is programmed for a positive transition. The Set bit (B1) in the Operation Event Register will set at the start of the relay settling period. For details on register structure, see paragraph 5.6.

The PTR registers are shown in Figure 5-28A through Figure 5-32A and include the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) operation events for positive transitions, send the following command:

```
:stat:oper:ptr  96
```

where;	Arm (bit B6)	=	64
	Trig (bit B5)	=	32
	<NRf>	=	96

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Effects of positive transitions on the Operation Event Register:

Operation Event	Positive Transition Effect On Operation Event Register
Settling	Sets B1 at the start of the settling period.
Trigger Layer	Sets B5 when waiting in the Trigger Layer.
Arm Layer	Sets B6 when waiting in an Arm Layer.
Idle	Sets B10 when entering the idle state.

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	———	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	———	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	———	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	———	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	———	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	———	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-28
Operation Transition Filter

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Effects of positive transitions on the Trigger Event Register:

Trigger Event	Positive Transition Effect On Trigger Event Register
Sequence 1	Sets B1 when waiting in Trigger Layer.

Bit Position	(B15 - B2)	B1	B0
Event	———	Seq1	—
Decimal Weighting	———	2 (2^1)	—
Value	———	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B2)	B1	B0
Event	———	Seq1	—
Decimal Weighting	———	2 (2^1)	—
Value	———	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-29
Trigger Transition Filter

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Effects of positive transitions on the Arm Event Register:

Arm Event	Positive Transition Effect On Arm Event Register
Sequence 1	Sets B1 when in an Arm Layer.

Bit Position	(B15 - B2)	B1	B0
Event	———	Seq1	—
Decimal Weighting	———	2 (2^1)	—
Value	———	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B2)	B1	B0
Event	———	Seq1	—
Decimal Weighting	———	2 (2^1)	—
Value	———	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-30
Arm Transition Filter

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Effects of positive transitions on the Sequence Event Register:

Sequence Event	Positive Transition Effect On Sequence Event Register
Layer 1	Sets B1 when in Arm Layer 1.
Layer 2	Sets B2 when in Arm Layer 2.

Bit Position	(B15 - B3)	B2	B1	B0
Event	———	Lay2	Lay1	—
Decimal Weighting	———	4 (2^2)	2 (2^1)	—
Value	———	0/1	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B3)	B2	B1	B0
Event	———	Lay2	Lay1	—
Decimal Weighting	———	4 (2^2)	2 (2^1)	—
Value	———	0/1	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-31
Sequence Transition Filter

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Effects of positive transitions on the Questionable Event Register:

Questionable Event	Positive Transition Effect On Questionable Event Register
Chan	Sets B9 when too many channels have closed.

Bit Position	(B15 - B10)	B9	(B8 - B0)
Event	——	Chan	——
Decimal Weighting	——	512 (2^9)	——
Value	——	0/1	——

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B10)	B9	(B8 - B0)
Event	——	Chan	——
Decimal Weighting	——	512 (2^9)	——
Value	——	0/1	——

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

B) Negative Transition (NTR) Register

Figure 5-32
Questionable Transition Filter

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Programming example

```
10  OUTPUT 707; ":stat:oper:ptr  1026; ptr?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets Bits B1 and B10 of the PTR Operation Transition Filter, and then queries the register.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (1026).

5.16.4 :NTRansition <NRf>

:STATus:OPERation:NTRansition <NRf>	Program Operation Transition Filter (NTR).
:STATus:OPERation:TRIGger:NTRansition <NRf>	Program Trigger Transition Filter (NTR).
:STATus:OPERation:ARM:NTRansition <NRf>	Program Arm Transition Filter (NTR).
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>	Program Sequence Transition Filter (NTR).
:STATus:QUEStionable:NTR <NRf>	Program Questionable Transition Filter (NTR).

Parameters

<NRf>	= 0	Clear NTR register
	= 2	Set bit B1 of NTR register
	= 4	Set bit B2 of NTR register
	= 32	Set bit B5 of NTR register
	= 64	Set bit B6 of NTR register
	= 512	Set bit B9 of NTR register
	= 1024	Set bit B10 of NTR register

Short-form formats

```
:stat:oper:ntr <NRf>
:stat:oper:trig:ntr <NRf>
:stat:oper:arm:ntr <NRf>
:stat:oper:arm:seq:ntr <NRf>
:stat:ques:ntr <NRf>
```

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query commands

:NTRansition?	Query NTR register
Short-form formats:	:stat:oper:ntr?
	:stat:oper:trig:ntr?
	:stat:oper:arm:ntr?
	:stat:oper:arm:seq:ntr?
	:stat:ques:ntr?
Response message:	Decimal value (see Note)

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Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B6 and B5 are set.

Description

These commands are used to program the negative transition (NTR) registers. A negative transition is defined as a 1 to 0 state change in the condition register. Thus, when an event is programmed for a negative transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 1 to 0. For example, if bit B1 of the Negative Transition Register of the Operation Transition Filter is set, then the operation event is programmed for a negative transition. The Set bit (B1) in the Operation Event Register will set at the end of the relay settling period. For details on register structure, see paragraph 5.6.

The NTR registers are shown in Figure 5-28B through Figure 5-32B and include the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) events for negative transitions, send the following command:

:stat:oper:ntr 96

where;	Arm (bit B6)	=	64
	Trig (bit B5)	=	32
	<NRf>	=	96

Effects of negative transitions on the Operation Event Register:

Operation Event	Negative Transition Effect On Operation Event Register
Settling	Sets B1 at the end of the settling period.
Trigger Layer	Sets B5 when leaving the Trigger Layer.
Arm Layer	Sets B6 when leaving an Arm Layer.
Idle	Sets B10 when leaving the idle state.

Effects of negative transitions on the Trigger Event Register:

Trigger Event	Negative Transition Effect On Trigger Event Register
Sequence 1	Sets B1 when leaving the Trigger Layer.

Effects of negative transitions on the Arm Event Register:

Arm Event	Negative Transition Effect On Arm Event Register
Sequence 1	Sets B1 when leaving an Arm Layer.

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Effects of negative transitions on the Sequence Event Register:

Sequence Event	Negative Transition Effect On Sequence Event Register
Layer 1	Sets B1 when leaving Arm Layer 1.
Layer 2	Sets B2 when leaving Arm Layer 2.

Effects of negative transitions on the Questionable Event Register:

Questionable Event	Negative Transition Effect On Questionable Event Register
Chan	Sets B9 when the channels open after the occurrence of the “too many channels closed” error.

Programming example

```
10  OUTPUT 707; ":stat:oper:ntr   1026; ntr?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets Bits B1 and B10 of the NTR Operation Transition Filter, and then queries the register.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the decimal value that defines which bits in the register are set (1026).

5.16.5 :CONDition?

:STATus:OPERation:CONDition?	Query Operation Condition Register
:STATus:OPERation:TRIGger:CONDition?	Query Trigger Condition Register
:STATus:OPERation:ARM:CONDition?	Query Arm Condition Register
:STATus:OPERation:ARM:SEQuence:CONDition?	Query Sequence Condition Register
:STATus:QUEStionable:CONDition?	Query Questionable Condition Register

Short-form formats

```
:stat:oper:cond?
:stat:oper:trig:cond?
:stat:oper:arm:cond?
:stat:oper:arm:seq:cond?
:stat:ques:cond?
```

Description

These query commands are used to query the contents of the condition registers. Each set of event registers (except the Standard Event register set) has a condition register. A condition register is similar to its corresponding event register, except that it is a real-time register that constantly updates to reflect the current operating status of the instrument.

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See [:EVENt] for register bit descriptions. Note from the status structure (paragraph 5.6) that the condition registers precede the transition filters. Thus, only the PTR descriptions apply to the condition registers.

After sending one of these commands and addressing the Model 7002 to talk, a decimal value is sent to the computer. The binary equivalent of this decimal value indicates which bits in the register are set.

For example, if sending :stat:oper:cond? returns a decimal value of 1024 (binary 0000 0100 0000 0000), bit B10 of the Operation Condition Register is set indicating that the instrument is in the idle state.

Programming example

```
10  OUTPUT 707; ":stat:oper:cond?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Queries the Operation Condition Register.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the decimal value that defines which bits in the register are set.

5.16.6 :PREset

:STATus:PREset Return 7002 to default conditions

Short-form format

:stat:pres

Description

When this command is sent, the SCPI event registers are affected as follows:

1. All bits of the positive transition filter registers are set to one (1).
2. All bits of the negative transition filter registers are cleared to zero (0).
3. All bits of the following registers are cleared to zero (0):
   a. Operation Event Enable Register.
   b. Questionable Event Enable Register.
4. All bits of the following registers are set to one (1):
   a. Trigger Event Enable Register.
   b. Arm Event Enable Register.
   c. Sequence Event Enable Register.

Note: Registers not included in the above list are not affected by this command.

Programming example

The following programming example demonstrates how to use the :PRESet command of the STATus subsystem:

OUTPUT 707; ":stat:pres"

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5.16.7 :QUEue commands

[:NEXT]?

:STATus:QUEue[:NEXT]? Query Error Queue

Short-form format

:stat:que?

Defaults

Power-Up	Clears Error Queue
*CLS	Clears Error Queue
:STATus:PRESet	No effect

Description

As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages.

The Error Queue is a first-in, first-out (FIFO) register. Every time you query the queue, the "oldest" message is read and that message is then removed from the queue. The queue will hold up to 10 messages. If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the Error Queue is empty. When the Error Queue is empty, the message "0, 'No error'" is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. The messages are listed in Table 4-1.

After this command is sent and the Model 7002 is addressed to talk, the "oldest" message in the queue is sent to the computer.

Note: The :STATus:QUEue[:NEXT]? query command performs the same function as the :SYSTem:ERRor? query command (see System Subsystem).

Programming example

The following program will read the "oldest" message in the Error Queue:

```
5   DIM A$ [30]
10  OUTPUT 707; ":stat:que?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 5 Increase string size to accommodate the length of the messages.
Line 10 Requests the "oldest" message in the queue.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays the message on the CRT.

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:ENABle <list>

:STATus:QUEue:ENABle <list> Enable messages for Error Queue

Parameters

list = (numlist)

where; numlist is a specified list of messages that you wish to enable for the Error Queue.

Short-form format

:stat:que:enab (numlist)

Defaults

Power-up	Enable error events, disable status events
*CLS	No effect
:STATus:PRESet	Enable error events, disable status events

Query commands

:ENABle?	Query list of enabled messages
Short-form format:	:stat:que:enab?
Response message:	numlist

Description

On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want enabled. Messages not specified will be disabled and prevented from entering the queue.

When this command is sent, all messages will first be disabled, then the messages specified in the list will be enabled. Thus, the returned list (:ENABle?) will contain all the enabled messages.

Messages are specified by numbers (see Table 4-1). The following examples show various forms for expressing a message numlist:

Numlist	= -110	Single message.
	= -110, -140, -222	Messages separated by commas.
	= -110:-222	Range of messages (-100 through -222).
	= -110:-222, -230	Range entry and single entry separated by a comma.

Note: To disable all messages from entering the Error Queue, send the following command:

:stat:que:enab ()

To enable all Model 7002 messages, send the following command: :stat:que:enab (-150: +550)

Programming example

```
10  OUTPUT 707; ":stat:que:enab  (0:-999); enab?"
20  ENTER 707; A$
30  PRINT A$
40  END
```


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Line 10 Enables all SCPI defined messages.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays the enable messages (0:-999).

:DISable <list>

:STATus:QUEue:DISable <list> Disable messages for Error Queue

Parameters

<list> = (numlist)

where; numlist is a specified list of messages that you wish to disable for the Error Queue.

Short-form format

:stat:que:dis (numlist)

Defaults

Power-up	Disable status events, enable error events
*CLS	No effect
:STATus:PRESet	Disable status events, enable error events

Query commands

:DISable?	Query list of disabled messages
Short-form format:	:stat:que:dis?
Response message:	numlist

Description

On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want disabled. Disabled messages are prevented from going into the Error Queue.

Messages are specified by numbers (see Table 4-1). The following examples show various forms for expressing a message numlist:

Numlist	= -110	Single message.
	= -110, -140, -222	Messages separated by commas.
	= -110:-222	Range of messages (-100 through -222).
	= -110:-222, -230	Range entry and single entry separated by a comma.

Programming example

```
10 OUTPUT 707; ":stat:que:dis (-140:-150); dis?"
20 ENTER 707; A$
30 PRINT A$
40 END
```

Line 10 Disables messages -140 through -150.
Line 20 Addresses the Model 7002 to talk.
Line 30 Displays the disabled messages (-140:-150).

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5.17 :SYSTem subsystem

The system subsystem contains miscellaneous commands and are summarized in Table 5-12.

Table 5-12
SYSTem command summary

Command	Description	Reference
:SYSTem		
:PRESet	Return to :SYST:PRES defaults.	5.17.1
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.	5.17.2
:POSetup?	Query power-on setup.	
:VERSion?	Query revision level of SCPI standard.	5.17.3
:ERRor?	Query Error Queue.	5.17.4

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.

5.17.1 :PRESet

:SYSTem:PRESet Return to :SYSTem:PRESet defaults

Short-form format

:syst:pres

Description

This command returns the instrument to states optimized for front panel operation. Table 5-5 defines the default conditions for this command.

Programming example

```
OUTPUT 707; ":syst:pres"        ! Return 7002 to default states
```

5.17.2 :POSetup <name>

:SYSTem:POSetup <name> Program power-on defaults

Parameters

<name> = RST Select *RST defaults on power up
= PRESet Select :SYSTem:PRESet defaults on power up
= SAVX Select saved defaults on power up

where; X = 0 to 9

Short-form format

:syst:pos <name>

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Query commands

:POSetup?	Query power-on setup
Short-form format:	:syst:pos?
Response message:	RST, PRES or SAV0-SAV9

Description

This command is used to program the power-on defaults. With RST selected, the instrument will power up to the *RST default conditions. With PRES selected, the instrument will power up to the :SYStem:PRESet default conditions. Table 5-5 defines the default conditions for these commands.

With one of the SAV parameters selected, the instrument will power on to the setup that is saved in the specified memory location using the *SAV command.

Programming example

```
10  OUTPUT 707; ":syst:pos   pres; pos?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Two commands in this program message; the first selects :SYSTem:PRESet power-on defaults, and the second queries the power-on setup.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the power-on setup (PRES).

5.17.3 :VERSion?

:SYSTem:VERSion? Read SCPI version

Short-form format

:syst:vers?

Description

This query command is used to read the version of the SCPI standard being used by the Model 7002. After sending this command and addressing the Model 7002 to talk, the version code will be sent to the computer. Example code:

1991.0

The above response message indicates the version of the SCPI standard.

Programming example

```
10  OUTPUT 707; ":syst:vers?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Reads the version of the SCPI standard.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the SCPI standard version.

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5.17.4 :ERRor?

:SYSTem:ERRor? Read Error Queue

Short-form format

:syst:err?

Defaults

Power-up	Clears Error Queue
*RST	No effect
*CLS	Clears Error Queue
DCL, SDC	No effect
:SYSTem:PRESet	No effect
:STATus:PRESet	No effect

Description

As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages. The Error Queue is a first-in, first-out (FIFO) register. Every time you read the queue, the "oldest" message is read and that message is then removed from the queue.

If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the queue is empty. When the Error Queue is empty, the message "0, 'No error'" is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. Table 4-1 lists the messages.

After this command is sent and the Model 7002 is addressed to talk, the "oldest" message in the queue is sent to the computer.

Note: The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command (see STATus subsystem).

Programming example

```
10  DIM A$ [30]
20  OUTPUT 707; ":syst:err?"
30  ENTER 707; A$
40  PRINT A$
50  END
```

Line 10 Increases string size to accommodate message.
Line 20 Reads the Error Queue.
Line 30 Addresses the 7002 to talk.
Line 40 Displays the message from the Error Queue.

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5.18 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 5-13). These commands and subsystems are summarized in Table 5-13.

Table 5-13
Trigger command summary

Command	Description	Reference
:INITiate	Subsystem command path:	5.18.1
[:IMMediate]	Initiate one trigger cycle.	
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.	
:CONTinuous?	Query continuous initiation.	
:ABORt	Reset trigger system.	5.18.2
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:	
[:LAYer[1]]	Path to program arm layer 1:	
:IMMediate	Immediately go to Layer2.	5.18.3
:COUNt <n>	Program arm count (1 to 9999, or INF).	5.18.4
:COUNt?	Query arm count.	
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:SIGNal	Loop around control source.	5.18.8
:TCONfigure	Path to configure Triggers:	5.18.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass:	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:LAYer2	Path to program arm layer 2:	
:IMMediate	Immediately go to Trigger Layer.	5.18.3
:COUNt <n>	Program scan count (1 to 9999 or INF).	5.18.4
:COUNt?	Query scan count.	
:DELay <n>	Program delay (0 to 99999.999 sec)	5.18.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 99999.999 sec).	5.18.7
:TIMer?	Query timer.	
:SIGNal	Loop around control source.	5.18.8

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Table 5-13 (continued)
Trigger command summary

Command	Description	Reference
:ARM[:SEQuence[1]]		
:LAYer2		
:TCONfigure	Path to configure Triggers:	5.18.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:TRIGger[:SEQuence[1]]	Path to program trigger layer:	
:IMMediate	Immediately perform a scan step.	5.18.3
:COUNt <n>	Program measure count (1 to 9999, or INF).	5.18.4
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).	
:AUTO?	Query auto-count.	
:COUNt?	Query measure count.	
:DELay <n>	Program delay (0 to 99999.999 sec)	5.18.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 99999.999 sec).	5.18.7
:TIMer?	Request the programmed timer interval.	
:SIGNal	Loop around control source.	5.18.8
:TCONfigure	Path to configure Triggers:	5.18.9
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.	
:PROTocol?	Query protocol.	
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:SSYNchronous	Path to configure semi-synchronous Trigger Link:	
:LINE <NRf>	Select trigger line (1 to 6).	
:LINE?	Query trigger line.	

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

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NOTE

Front panel operation and IEEE-488 operation use different nomenclature for the three layers of the Trigger Model and is summarized as follows:

Trigger Model Layer Nomenclature

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

5.18.1 :INITiate commands

[:IMMediate]

:INITiate[:IMMediate] Take 7002 out of idle

Short-form format

:init

Description

This command takes the Model 7002 out of the idle state. After the completion of a scan, the instrument will return to the idle state (if continuous initiation is disabled; see next command). This is an overlapped command (see *OPC, *OPC?, *TRG and *WAI).`

Programming example

```
OUTPUT 707; ":init"          ! Takes 7002 out of the idle state.
```

:CONTinuous <b>

:INITiate:CONTinuous <b> Control continuous initiation

Parameters

<b> = 0 or OFF Disable continuous initiation
= 1 or ON Enable continuous initiation

Short-form format

:init:cont <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

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Query commands

:CONTinuous?	Query continuous initiation
Short-form format:	:init:cont?
Response message:	1 (on) or 0 (off)

Description

When continuous initiation is selected (ON), the instrument is taken out of the idle state. At the conclusion of all programmed operations, the instrument will return to Arm Layer 1. This is an overlapped command (see *OPC, *OPC?, *TRG and *WAI).

NOTE

In the event of a "Too many channels closed" error, all channels will open, the instrument will go into idle, and continuous initiation will disable (:INITiate:CONTinuous OFF).

Programming example

```
OUTPUT 707; ":init:cont   on"      ! Select continuous initiation
```

5.18.2 :ABORt

:ABORt	Abort operation

Short-form format

:abor

Description

When this action command is sent, the Model 7002 will abort its current operations and return to the top of the Trigger Model (idle state). If the *OPC command has been sent, the OPC bit in the Standard Event Status Register will set. If continuous initiation is disabled, the instrument will go into the idle state. If continuous initiation is enabled, operation will continue on into Arm Layer 1.

The abort command will reset the Source Bypasses of the Trigger Model and reset the scan pointer back to the first channel in the scan list.

Programming example

```
OUTPUT 707; ":abor"          ! Abort operation
```

5.18.3 :IMMediate

:ARM[:SEQuence[1]][:LAYer[1]]:IMMediate	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:IMMediate	Bypass scan control source and delay
:TRIGger:[:SEQuence[1]]:IMMediate	Bypass channel control source and delay

Short-form formats

:arm:imm
:arm:lay2:imm
:trig:imm

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Description

These action commands are used to bypass the specified layer of the Trigger Model. They are used when you do not wish to wait for the programmed event. Note from the Trigger Model (Figure 5-13) that :arm:lay2:imm and :trig:imm also bypass the Delay.

The instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and the command will be ignored. When the command is sent, the bypass will occur and operation will continue on.

Note that :IMMediate is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the specified trigger model layer.

Programming example

```
OUTPUT 707; ":arm:imm"          ! Bypass arm control source
```

5.18.4 :COUNt <n>

:ARM[:SEQuence[1]][:LAYer[1]]:COUNt <n>	Set Arm Layer 1 count
:ARM[:SEQuence[1]]:LAYer2:COUNt <n>	Set Arm Layer 2 count
:TRIGger[:SEQuence[1]]:COUNt <n>	Set Trigger Layer count

Parameters

<n>	= 1 to 99999	Specify count
	= INF	Sets count to infinite
	= DEFault	Sets count to 1
	= MINimum	Sets count to 1
	= MAXimum	Sets count to 9999

Short-form formats

:arm:coun <n>
:arm:lay2:coun <n>
:trig:coun <n>

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (Arm Layer 1)
	INF (Arm Layer 2)
	Scan-list-length (Trigger Layer)

Query commands

:COUNt?	Query programmed count
:COUNt? DEFault	Query *RST default count
:COUNt? MINimum	Query lowest allowable count
:COUNt? MAXimum	Query largest allowable count

Short-form formats:

:arm:coun?	:arm:lay2:coun?
:arm:coun? xxx	:arm:lay2:coun? xxx
:trig:coun?	
:trig:coun? xxx	

where; xxx = def, min or max

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Response messages: 1 to 9999 (for finite count)
+9.9e37 (for infinite count)

Description

These commands are used to specify how many times operation will loop around in the specified layer of operation. For example, if the channel count (:trig:coun) is set to 10, operation will continue to loop around in the Trigger Layer until 10 channels are scanned. After the 10th channel, operation will proceed back up to Arm Layer 2.

If you select a finite channel count (:trig:coun) that is greater than the scan-list-length, the first scan will end after the programmed number of channels are scanned. If programmed for another scan, the scan process will continue from the last scanned channel.

If you select an infinite channel count (:trig:coun), the scan will loop back to the beginning of the scan list after all channels in the list have been scanned. This process will continue indefinitely.

Note that this command is coupled to :TRIGger:COUNt:AUTO (auto-count). When auto-count is enabled, the channel count is set to the scan-list-length. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Programming example

```
10  OUTPUT 707; ":trig:coun  10; coun?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets the channel count to 10, and then queries the programmed arm count.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the programmed channel count (10).

:AUTO <b>

:TRIGger[:SEQuence[1]]:COUNt:AUTO <b> Control auto-count for Trigger Layer

Parameters

<b>	= 1 or ON	Enable auto-count (scan-list-length)
	= 0 or OFF	Disable auto-count

Short-form format

:trig:coun:auto <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

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Query commands

:AUTO?	Query auto-count
Short-form format:	:trig:coun:auto?
Response message:	1 (on) or 0 (off)

Description

With auto-count enabled, the channel count is automatically set to the scan-list-length. For example, if there are currently 36 channels in the scan list, then enabling auto-count will set the channel count to 36. While auto-count is enabled, changing the scan list count will change the trigger count.

If the scan list is empty, enabling auto-count will set the channel count to 1.

This command is coupled to :TRIGger:COUNt which is used to manually set the channel count. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Programming example

```
10  OUTPUT 707; ":scan   (@ 1!1:1!10)
20  OUTPUT 707; ":trig:coun:auto   on; auto?; :trig:coun?"
30  ENTER 707; A$
40  PRINT A$
50  END
```

Line 10 Defines a scan list (channels 1-10 of Slot 1).

Line 20 Enables auto-count, queries the state of auto-count and then queries the channel count.

Line 30 Addresses the 7002 to talk.

Line 40 Displays the state of auto-count and the channel count (1; 10).

5.18.5 :DELay <n>

:ARM[:SEQuence[1]]:LAYer2:DELay <n>	Set Arm Layer 2 delay
:TRIGger[:SEQuence[1]]:DELay <n>	Set Trigger Layer delay

Parameters

<n>	= 0 to 99999.999	Specify delay in seconds
	= DEFault	0 second delay
	= MINimum	0 second delay
	= MAXimum	99999.999 second delay

Short-form formats

```
:arm:lay2:del  <n>
:trig:del  <n>
```

Defaults

Power-up	Saved power-on setup
*RST	0 sec
:SYSTem:PRESet	0 sec

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Query commands

:DELay?	Query the programmed delay
:DELay? DEFault	Query the *RST default delay
:DELay? MINimum	Query the lowest allowable delay
:DELay? MAXimum	Query the largest allowable delay
Short-form formats:	:arm:lay2:del? :trig:del?
	:arm:lay2:del? xxx :trig:del? xxx
	where; xxx = def, min or max
Response message:	0 to 99999.999 (seconds)

Description

These delay periods are used to delay operation in the specified layer (Arm Layer 2 and/or Trigger Layer). After the programmed event occurs, the instrument will wait until the delay period expires before proceeding on in the Trigger Model.

Note that Arm Layer 1 does not use a Delay.

Programming example

```
10  OUTPUT 707; ":trig:del  1; del?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets a one second delay for the Trigger Layer, and then queries the programmed delay.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the programmed delay (l).

5.18.6 :SOURce <name>

:ARM[:SEQuence[1]][:LAYer[1]]:SOURce <name>	Specify arm event control source
:ARM[:SEQuence[1]]:LAYer2:SOURce <name>	Specify scan event control source
:TRIGger[:SEQuence[1]]:SOURce <name>	Specify channel event control source

Parameters

<name>	= HOLD	Hold operation in specified layer
	= IMMediate	Pass operation through specified layer
	= MANual	Select manual event
	= BUS	Select GPIB trigger as event
	= TLINk	Select Trigger Link as event
	= EXTernal	Select External Triggering as event
	= TIMer	Select timer as event Note: TIMer not available for Arm Layer 1

Short-form formats

```
:arm:sour  <name>
:arm:lay2:sour  <name>
:trig:sour  <name>
```


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Defaults

Power-up	Saved power-on setup
*RST	IMMediate (all layers)
:SYSTem:PRESet	IMMediate (Arm Layer 1 and Arm Layer 2), MANual (TRIGger Layer)

Query commands

:SOURce?	Query programmed control source.
Short-form formats:	:arm:sour? :arm:lay2:sour? :trig:sour?
Response message:	HOLD, MAN, IMM, BUS, TLIN, EXT or TIM

Description

These commands are used to select the event control source for the specified layer. With HOLD selected, operation will stop and wait indefinitely in the specified layer. While in HOLD, operation can be continued by sending the :IMMediate command or the :SIGNal command. Keep in mind however, that if the layer count >1, HOLD will again be enforced when operation loops back around.

With IMMediate selected (do not confuse :SOURce IMMediate with :IMMediate), operation will immediately pass through the specified layer.

A specific event can be used to control operation through a layer. With BUS selected, operation will continue when a GPIB trigger (GET or *TRG) is sent. With TLINk selected, operation will continue when an input trigger via the Trigger Link is received. With EXTernal selected, operation will continue when an External Trigger is received.

A TIMer event is available for Arm Layer 2 and the Trigger Layer. With TIMer selected for the specified layer, the event occurs at the beginning of the timer interval, and every time the timer times out. For example, if the Trigger Layer timer is programmed for a 30 second interval, the first pass through the Trigger Layer control source will occur immediately. Subsequent trigger events will then occur every 30 seconds. The interval for the timer is set using the :TIMer command. This timer interval is independent of the :DELay setting.

Programming example

```
10  OUTPUT 707; ":trig:sour   imm; sour?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets the channel control source to immediate, and then queries the programmed control source.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the programmed channel control source (IMM).

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5.18.7 :TIMer <n>

:ARM:SEQuence[1]]:LAYer2:TIMer <n> Set interval for Arm Layer 2 timer
:TRIGger:SEQuence[1]]:TIMer <n> Set interval for Trigger Layer timer

Parameters

<n>	= 0.001 to 99999.999	Specify timer interval in seconds
	= DEFault	0.1 second (Trigger Layer counter) 1 second (Arm Layer 2 counter)
	= MINimum	0.001 second
	= MAXimum	99999.999 seconds

Short-form formats

:arm:lay2:tim <n>
:trig:tim <n>

Defaults

Power-up	Saved power-on setup
*RST	0.001 second interval
:SYSTem:PRESet	0.001 second interval

Query commands

:TIMer?	Query programmed timer interval
:TIMer? DEFault	Query *RST default timer interval
:TIMer? MINimum	Query lowest allowable timer interval
:TIMer? MAXimum	Query largest allowable timer interval
Short-form format:	:arm:lay2:tim? :trig:tim? :arm:lay2:tim? xxx :trig:tim? xxx where; xxx = def, min or max
Response message:	.001 to 99999.999

Description

These commands are used to set the interval for the Arm Layer 2 and Trigger Layer timers. Note that the timer is in effect only if the timer is the selected control source. Also, note that Arm Layer 1 does not use a timer.

Programming example

```
10 OUTPUT 707; ":trig:tim 0.25; tim?"
20 ENTER 707; A$
30 PRINT A$
40 END
```

Line 10 Sets the Trigger Layer timer for a 1/4 second interval, and then queries the programmed timer interval.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the timer interval (.25).

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5.18.8 :SIGNal

:ARM[:SEQuence[1]][:LAYer[1]]:SIGNal	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:SIGNal	Bypass scan control source
:TRIGger[:SEQuence[1]]:SIGNal	Bypass channel control source

Short-form format

:arm:sign

Description

These action commands are used to bypass the specified control source and are used when you do not wish to wait for the programmed event. Keep in mind that the instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and this command will be ignored.

When this command is sent, the specified control source will be bypassed. This will allow operation to continue. Only the layer's source event between is bypassed; any :DELay time will be observed.

Note that :SIGNal is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the control source.

Programming example

```
OUTPUT 707; ":trig:sign"          ! Bypass channel control source.
```

5.18.9 TCONfigure commands

:PROTocol <name>

:TRIGger[:SEQuence[1]]:TCONfigure:PROTocol <name> Specify Trigger Link protocol

Parameters

<name>	= ASYNchronous	Asynchronous Trigger Link mode
	= SSYNchronous	Semi-synchronous Trigger Link mode

Short-form format

:trig:tcon:prot <name>

Defaults

Power-up	Saved power-on setup
*RST	ASYNchronous
:SYSTem:PRESet	ASYNchronous

Query commands

:PROTocol?	Query programmed Trigger Link protocol
Short-form format:	:trig:tcon:prot?
Response message:	ASYN or SSYN

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Description

This command is used to select the protocol for the Trigger Layer Trigger Link. With ASYNchronous selected, separate trigger lines are used for input and output triggers. With SSYNchronous selected, a single trigger line is used for both input and output triggers.

Note that Arm Layer 1 and Arm Layer 2 only use the asynchronous Trigger Link mode and therefore, the protocol does not have to be selected.

Programming example

```
10  OUTPUT 707; ":trig:tcon:prot   ssyn; prot?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Selects semi-synchronous Trigger Link protocol, and then queries the selected protocol.
Line 20 Addresses the 7002 to talk.
Line 30 Displays the Trigger Link protocol (SSYN).

:DIRection <name>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:DIRection <name>	Control arm Source Bypass
ARM[:SEQuence[1]]:LAYer2:TCONfigure:DIRection <name>	Control scan Source Bypass
:TRIGger[:SEQuence[1]]:TCONfigure:DIRection <name>	Control channel Source Bypass

Parameters

<name>	= SOURce	Enable Source Bypass
	= ACCeptor	Disable Source Bypass

Short-form formats

```
:arm:tcon:dir  <name>
:arm:lay2:tcon:dir  <name>
:trig:tcon:dir  <name>
```

Defaults

Power-up	Saved power-on setup
*RST	ACCeptor (all layers)
:SYSTem:PRESet	ACCeptor (Arm Layer 1 and Arm Layer 2)
	SOURce (Trigger Layer)

Query commands

:DIRection?	Query Source Bypass state
Short-form formats:	:arm:tcon:dir?
	:arm:lay2:tcon:dir?
	:trig:tcon:dir?
Response message:	SOUR or ACC

Description

When a Source Bypass is enabled and the External or Trigger Link arm control source is selected, operation will loop around the appropriate control source on the initial pass through that lay-

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er. Note that the Source Bypass for Arm Layer 2 and the Trigger Layer also loops around the Delay.

If programmed for another pass through the specified layer (count >1), the bypass loop will not be in effect even though it will still be enabled. The bypass loop will be in effect if operation first goes back into the previous layer (or idle).

Enabling the Source Bypass for Arm Layer 1 and Arm Layer 2 also enables their Output Triggers. When operation leaves Arm Layer 1 or Arm Layer 2, the appropriate output trigger pulse will occur. If the Trigger Link (TLINk) control source is selected, the output trigger will be available on the programmed Trigger Link output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY Output connector. The Output Trigger in these two layers is disabled when the Source Bypass is disabled.

The Output Trigger in the Trigger Layer is always enabled and occurs after the Device Action.

With ACCeptor selected, the bypass is disabled. Operation will not proceed through the specified layer until the appropriate event occurs.

Programming example

```
10  OUTPUT 707; ":trig:tcon:dir   sour; dir?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Enables the Source Bypass for the Trigger Layer and then queries the state of the Source Bypass.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the state of the Source Bypass (SOUR; enabled).

:ASYNchronous:ILINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Arm Layer 1
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Arm Layer 2
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Short-form formats

```
:arm:tcon:asyn:ilin   <NRf>
:arm:lay2:tcon:asyn:ilin   <NRf>
:trig:tcon:asyn:ilin   <NRf>
```


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Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (all layers)

Query commands

:ILINe?	Query programmed input line #
Short-form format:	:arm:tcon:asyn:ilin? :arm:lay2:tcon:asyn:ilin? :trig:tcon:asyn:ilin?
Response message:	1 to 6

Description

These commands are used to select an input line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output (see :OLINe) cannot share the same line. If you assign the input to a line that is already being used for the output, an error will occur and the command will be ignored.

Programming example

```
10  OUTPUT 707; ":trig:tcon:asyn:ilin  3; ilin?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Assigns the asynchronous Trigger Link input of the Trigger Layer to line #3, and then queries the programmed input line.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the programmed input line # (3).

:ASYNchronous:OLINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Arm Layer 1
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Arm Layer 2
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Short-form formats

:arm:tcon:asyn:olin <NRf>
:arm:lay2:tcon:asyn:olin <NRf>
:trig:tcon:asyn:olin <NRf>

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Defaults

Power-up	Saved power-on setup
*RST	2 (all layers)
:SYSTem:PRESet	2 (all layers)

Query commands

:OLINe?	Query programmed output line #
Short-form formats:	:arm:tcon:asyn:olin? :arm:lay2:tcon:asyn:olin? :trig:tcon:asyn:olin?
Response message:	1 to 6

Description

These commands are used to select an output line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output cannot share the same line. If you assign the output to a line that is already being used for the input, an error will occur and the command will be ignored.

Programming example

```
10  OUTPUT 707; ":trig:tcon:asyn:olin  4; olin?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Assigns the asynchronous Trigger Link output of the Trigger Layer to line #4, and then queries the programmed output line.

Line 20 Addresses the 7002 to talk.

Line 30 Displays the programmed output line # (4).

:SSYNchronous:LINE <NRf>

:TRIGger[:SEQuence[1]]:TCONfigure:SSYNchronous — Specify semi-synchronous Trigger Link line for the Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Short-form format

:trig:tcon:ssyn:line <NRf>

Defaults

Power-up	Saved power-on setup
*RST	1 (Trigger Layer)
:SYSTem:PRESet	1 (Trigger Layer)

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Query commands

:LINE?	Query programmed output line #
Short-form format:	:trig:tcon:ssyn:line?
Response message:	1 to 6

Description

This command is used to select one of the six trigger lines for the semi-synchronous Trigger Link.

Programming example

```
10  OUTPUT 707; ":trig:tcon:ssyn:line  6; line?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Selects line #6 for the Trigger Link, and then queries the programmed line #.
Line 20 Addresses the 7002 to talk.
Line 30 Displays selected line # (6).

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6
Theory of Operation

6.1 Introduction

This section supplies a functional description of the Model 7002 in block diagram form, as well as details of the various circuit board assemblies and functional blocks within the instrument. Some of this information is presented in the form of simplified schematics. Detailed schematics and component layouts are located at the end of Section 8.

6.2 Overall functional description

On page 2 is a block diagram showing interconnection of the Model 7002 digital board, front panel display boards, and system backplane. The board functions can be summarized as follows:

Digital board — a predominantly digital board which contains the main microprocessor, operating system, memory, IEEE-488 interface, and support circuitry.

Backplane board — provides the mechanical and electrical interface between the digital board and any cards plugged into the Model 7002 card slots.

VFD Display board — includes the vacuum fluorescent display (VFD), a secondary microprocessor for control of the display, the display drivers, and front panel key matrix.

LED display board — includes the 416 LEDs, a secondary microprocessor for control of the display, the display drivers and MOSFET switches and light pen latching circuits.

Two switching-type power supply boards furnish +6VDC and +14.6VDC to the other boards and display.

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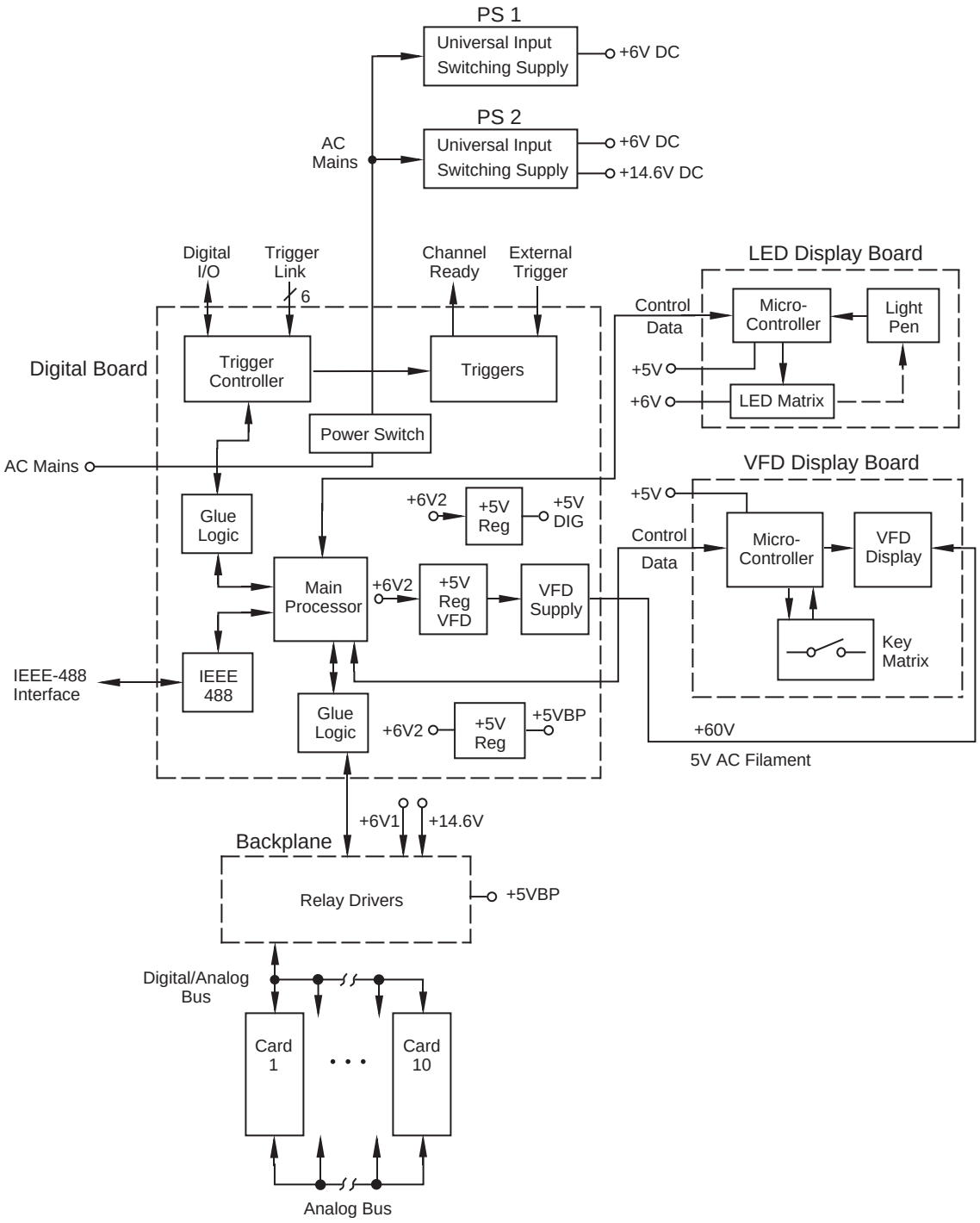


Figure 6-1
Model 7002 system block diagram

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6.3 Control function

The Model 7002 is controlled by three internal microprocessors. The primary controller resides on the digital board, and is responsible for supervising the overall operation of the Model 7002. The two secondary controllers are located on the display boards and are primarily responsible for supervising operation of the displays and communicating with the main processor.

The primary controller consists of the following components:

- 68302 16-bit microprocessor
- 16MHz oscillator
- Power-up reset circuitry
- 128K × 16-bit EPROM
- Two 32K × 8-bit RAM with battery backup
- 2K × 8-bit EEPROM

The VFD display microcontroller and associated components consist of the following:

- 6805 8-bit microcontroller
- 5812 and 5818 source drivers

The LED display microcontroller and associated components consist of the following:

- 6805 8-bit microcontroller
- 5895 source drivers
- N-channel MOSFET switches

6.3.1 Reset circuitry

For the following discussion, also refer to digital board schematic 7002-106.

Voltage supervision and monitoring is provided by a DS1236 micro-manager chip (U115). On power-up, the instrument remains in a reset condition (/RST low) until Vcc (+5V supply) exceeds 4.6V. With Vcc >4.6V, /RST goes high. If Vcc falls below 4.55V, /RST is reasserted low and remains low until Vcc again exceeds 4.6V.

/RST is an open collector output which is tied to Vcc through a 470Ω resistor (R155). /RST is tied to the RESET and HALT pins of the 68302 processor, each through a 560Ω resistor (R152 and R154). These two resistors enable the 68302 main processor to activate a reset condition in addition to when Vcc falls below 4.55V.

6.3.2 Address decoding

Address decoding is performed internally by the 68302 processor. No additional circuitry is required for this function.

6.3.3 Memory

For the following discussion, also refer to digital board schematic 7002-106.

The Model 7002's operating software is stored in U105, a 23C2048 EPROM memory. The revision level of the software is displayed by the instrument upon power-up.

During system operation, relay setups, scan lists, forbidden channels, and other temporary storage tasks are accomplished through U107 and U108, which are 128K × 8 static CMOS RAM chips. Power source and chip select lines are routed through U115, a DS1236 micro-manager. Figure 6-2 includes a simplified schematic of the RAM and battery back-up circuitry.

The micro-manager performs the functions of switching the RAM power source between Vcc and the lithium memory back-up battery BT100. It also disables the chip select (CS1) to the RAM when Vcc is outside the specified limits (see the previous information describing the reset circuitry).

If battery power drops below a specified limit while Vcc is not present, the micro-manager chip (U115) disables the chip select to the RAM after Vcc is restored. Then the CPU tries to read a special pattern in the RAM. If the CPU detects errors, it overrides the pattern and places the mainframe in a known state.

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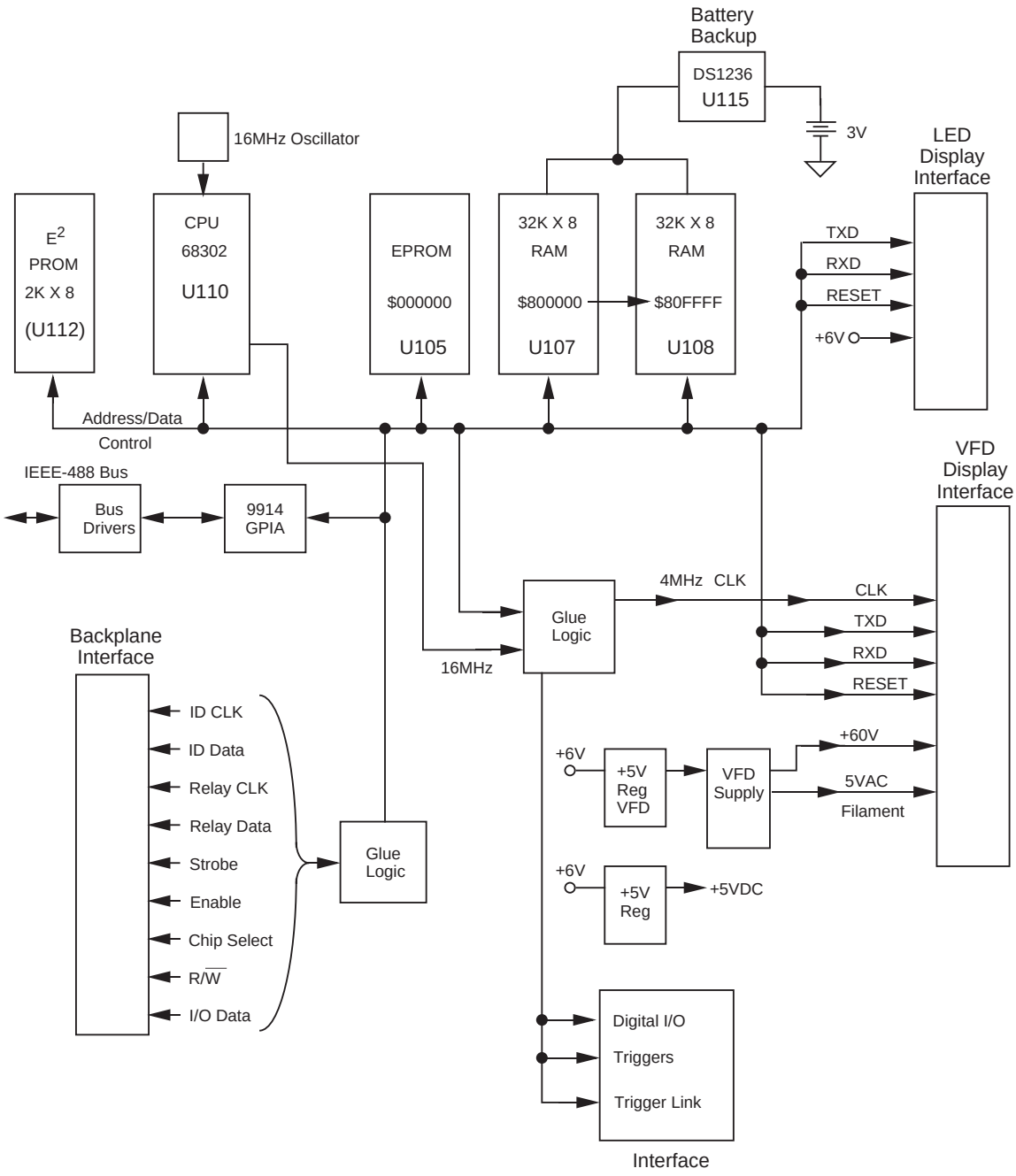


Figure 6-2
Block diagram — digital circuitry and memory

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6.4 Relay control circuitry

The relay control circuits collectively reside on the backplane card and each relay or matrix card assembly plugged into the Model 7002 mainframe.

The backplane board acts as a conduit for:

- Control signals from the digital board to the switch cards.
- Responses from the switch cards to the digital board.
- Power lines to the cards.
- Expansion of analog signals among the cards.
- Incorporation of relay drivers for the Model 705/706 switch cards.

The following paragraphs describe operation of the relay control circuitry on the digital board, as well as a typical matrix card. Also refer to backplane board schematic 7011-176.

6.4.1 Backplane interface

For the following discussion, refer to Figure 6-3 which is a simplified schematic of the backplane interface.

During power-up, the main microprocessor (U110) reads card identification data via the backplane interface from the EEPROM on each Model 701X series card installed in the mainframe. As each slot is addressed, identification data is serially transmitted to the main CPU via the IDDATA line.

During the course of normal operation, relay control data is sent to the switch cards. Relay control data is transmitted serially via the DATA line from the digital board.

A multiplexing scheme is used to deliver relay control data to the appropriate slot. Four multiplexers (U220 through U223) are used to route the relay control data and the other control signals to the appropriate slot. A four line address bus selects the appropriate slot. For example, an address of “0000” connects DATA, CLK, /CS and IDDCLOCK to slot 1. Notice that for a non-701X series card, the relay control data (DATA) is latched in the relay drivers. For a 701X series card, the relay control data is latched in the switch card.

With the relay control data latched, “1111” is sent over the address bus to connect the DATA line to the DATA16 line. The bit pattern from DATA is serially loaded into the shift/store registers U224 and U225. The bit pattern determines which slot will be strobed. The registers are then enabled, and the strobe signal is sent to the slot to configure the relays according to the relay control data.

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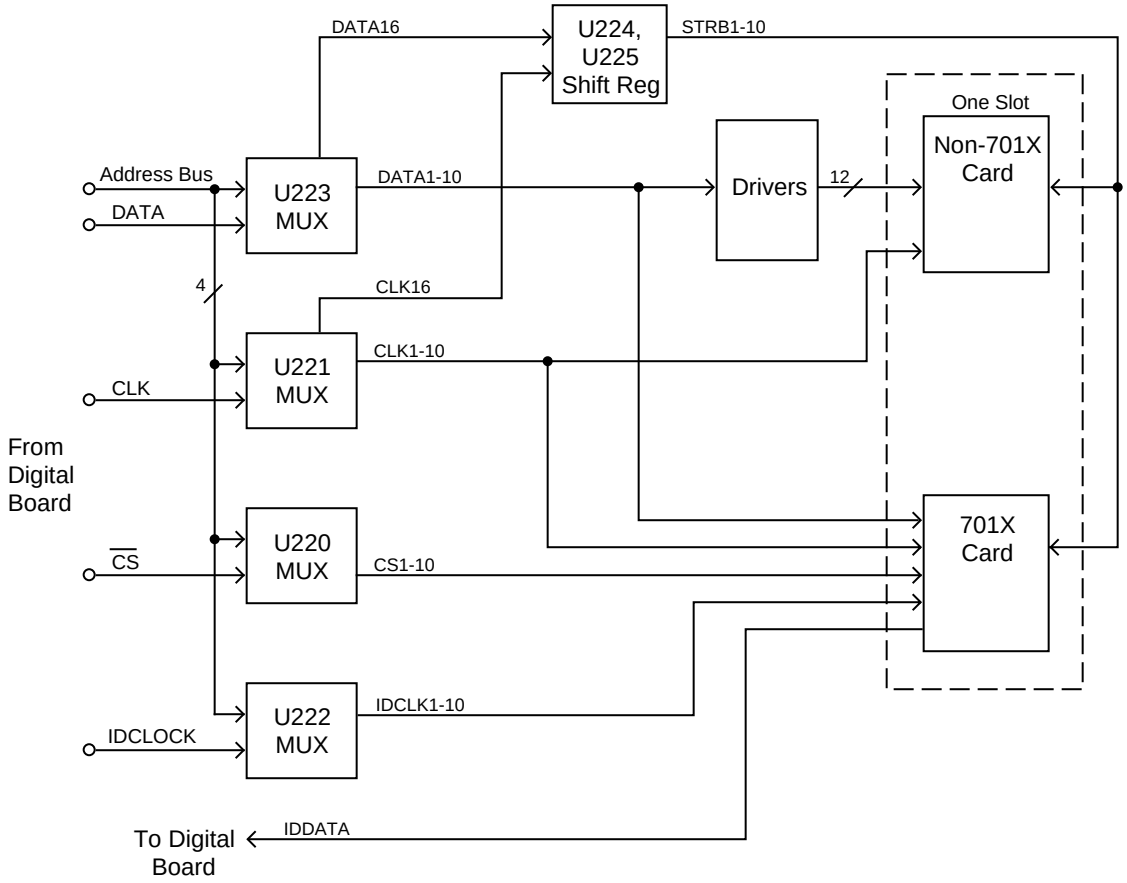


Figure 6-3
Backplane interface simplified schematic

6.4.2 Switch card interface

The simplified block diagram of the backplane (Figure 6-4) shows two different switch card interfaces. One of these interfaces supports the Model 7052-7169 series switch cards while the other supports the Model 701X series switch cards.

The Model 7052-7169 switch card interface connectors J2000A/J2000B provide +6V, 12 sink drive lines, and a 3-line serial bus to support an additional 8 drive lines located on an installed switch card. This interface supports all Model 705 and 706 cards.

The typical 701X switch card interface connectors J2001A/J2001B provide +6V, +14.6V, +5V, a 4-line serial bus for relay driver communication, a 2-line serial bus for card identification, a 3-line serial bus for I/O data communication, and four 3-line analog bus expansions between slots. The serial bus communication supports 40 drive lines or 40 I/O lines on each installed switch card. This 32-pin DIN connector supports the Model 701X switch cards.

6.4.3 ID data circuits

Upon power-up, the mainframe reads card identification from any Model 701X cards plugged into the mainframe. This ID data includes such information as card ID, hardware settling times, and relay configuration information.

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ID data is contained within an EEPROM which is located on the relay card. The system performs the following sequence of operations at power-up in order to read the information:

1. The IDDATA line (pin 6 of the EEPROM located on the relay card) is set low while the IDCLK line (pin 5) is held high. This action initiates a start command for the ROM located on the relay card to transmit data serially to the mainframe (see Figure 6-5).
2. The mainframe sends the ROM address location to be read over the IDDATA line. The ROM then transmits an acknowledge signal back to the mainframe, and then transmits data at that location back to the mainframe (refer back to Figure 6-4).
3. The mainframe then transmits an acknowledge signal indicating that it requires more data. The ROM on the relay card will then sequentially transmit data after each acknowledge signal it receives.
4. Once all data are received, the mainframe sends a stop command. The stop command consists of a low-to-high transition of the IDDATA line while the IDCLK line is held high (see Figure 6-6).

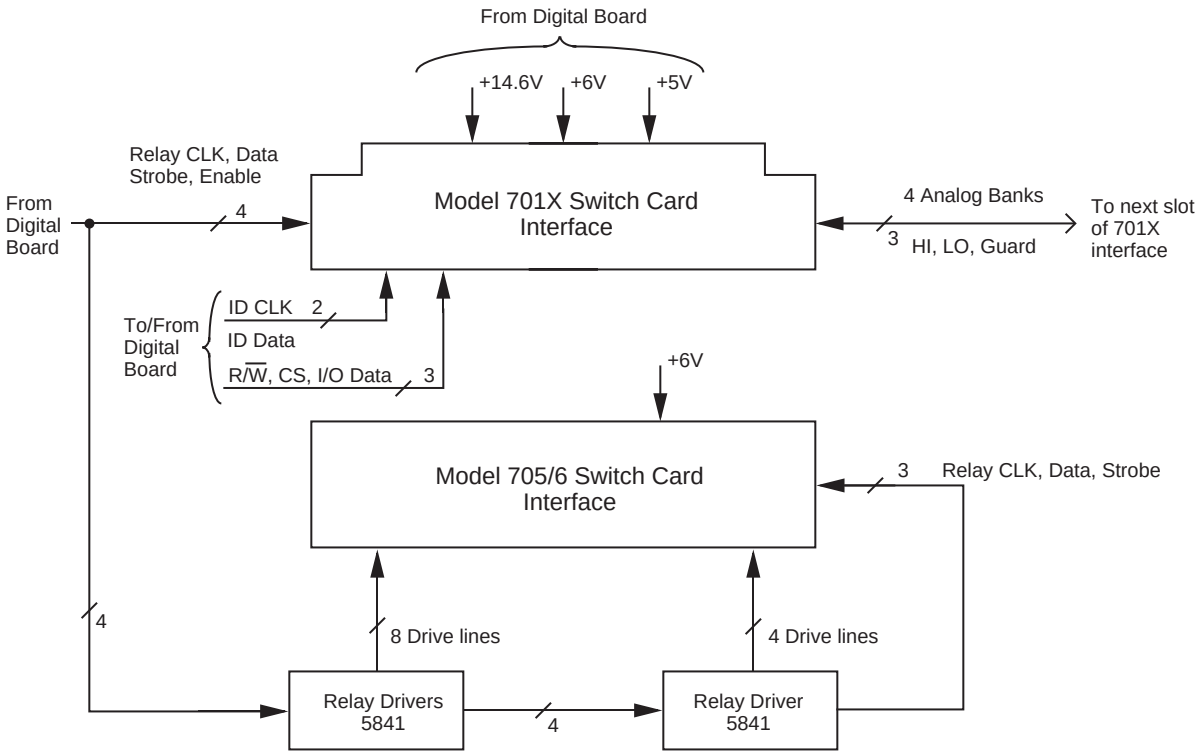


Figure 6-4
Block diagram — backplane interface (one slot)

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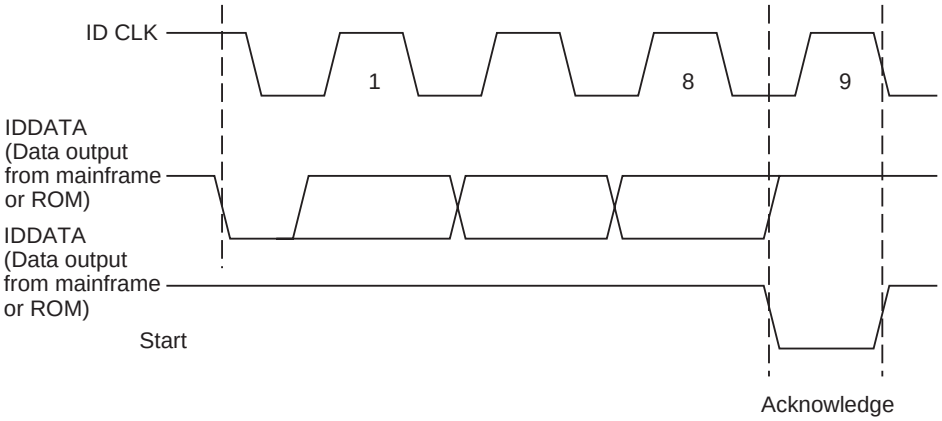


Figure 6-5
Timing diagram, IDCLK and IDDATA

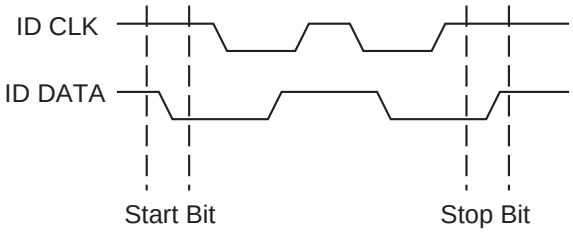


Figure 6-6
Start and stop sequences

6.4.4 Relay control

Card relays are controlled by serial data transmitted via the relay DATA line. Five bytes for each card are shifted in serial fashion into latches located in the card and backplane relay driver ICs. The serial data is clocked in by the CLK line. As data overflows one register, it is fed out the Q's line of the register down the chain.

Once all five bytes have been shifted into the drivers, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers. The appropriate relays are also energized (assuming the driver outputs are enabled, as discussed below). Note that a relay driver output goes low to energize the corresponding relay.

6.4.5 Power-on safeguard

A power-on safeguard ensures that relays do not randomly energize on power-up and power-down. This safeguard disables the relay drivers on the switch cards during power-up and power down.

When the 68302 microprocessor goes in the RESET mode, line PB7 (OUTPUT ENABLE) on U110 goes high disabling all relay drivers. After the RESET condition clears, PB7 goes low and enables all the relay drivers. Note that PB7 stays low (enabling the relay drivers) until the 68302 microprocessor goes into a reset condition.

6.5 VFD display board circuitry

A block diagram of the VFD display board is shown in Figure 6-7. Major components include the display microcontroller, the dot and grid drivers, the vacuum fluorescent display (VFD), and the key matrix.

The 68HC05 (U402) is the display microcontroller that controls the VFD and interprets key data. The microcontroller has four peripheral I/O ports, which are used for the various control and read functions. Display data is serially transmitted to the microcontroller from the digital board via the TXB line to the microcontroller PD0 terminal. In a similar manner, key data is serially sent back to the digital board through the RXB line via PD1.

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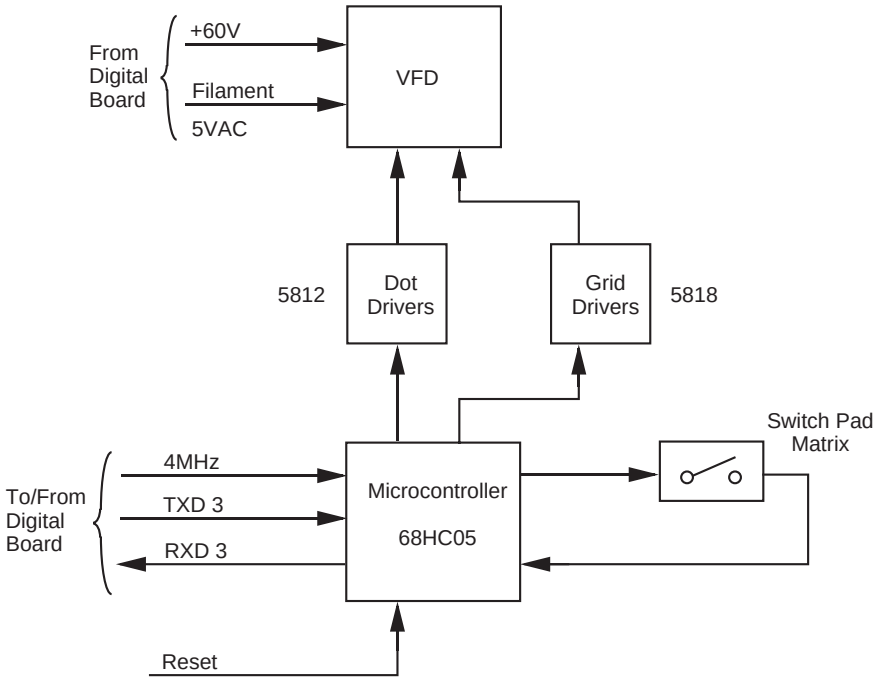


Figure 6-7
Display board block diagram

Note that the 4MHz display clock is generated on the digital board.

The dual-line VFD (vacuum fluorescent display) module has a top line consisting of 20 alpha-numeric characters and annunciators. It is used to display patterns as well as text. The bottom line of the display is a 32-character alphanumeric, which is used to display text only.

Each character is organized as a 5×7 matrix of dots or pixels, and includes a long under-bar segment used as a cursor.

The display uses a common multiplexing scheme in which each character is refreshed in sequence. Dual UCN5812's are the dot drivers while a UCN5818 is the grid driver. The dot drivers and grid drivers are serially transmitted from PD3 and PC1, respectively. The clock for the dot drivers is from PD4 of the microcontroller, while the clock for the grid driver is taken from PC0 of the microcontroller.

The VFD requires both +60VDC and +5VAC for the filaments. These VFD voltages are routed from the digital board.

The front panel keys are organized into a row-column matrix to minimize the number of microcontroller peripheral lines required to read the keyboard. A key is read by strobing the columns and reading all rows for each strobed column. Keypress data is interpreted by the display microcontroller and sent back to the main microprocessor using proprietary encoding schemes. The main microprocessor then sends code to the LED display board to update the state of the LEDs.

6.6 LED display board circuitry

A block diagram of the VFD display board is shown in Figure 6-8. Major components include the display microprocessor, drivers, N-Channel MOSFET switches, LEDs and light pen latching circuits. The LEDs provide status and, with the light pen, programming capability.

The 68HC05 (U502) is the microcontroller that controls the LEDs and interprets light pen operations. The microcontroller has four peripheral I/O ports, which are used for the various control and read functions. Display data is serially transmitted to the microcontroller from the digital board via

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the TXD line to the PD0 terminal of the microcontroller. In a similar manner, light pen data is serially sent back to the digital board through the RXD line via PD1.

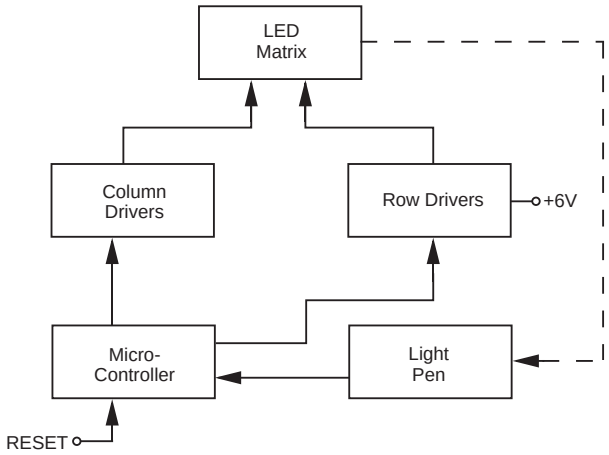


Figure 6-8
LED display board block diagram

As shown in the schematic (drawing 7002-156), the LEDs are arranged in five matrices (two slots per matrix). A matrix format minimizes the number of microcontroller peripheral lines required to read and control LEDs. An LED that is clocked by the light pen is read by strobing the columns and reading all rows to detect the light strobe. The data for that LED is then interpreted by the LED display microcontroller and sent back to the main microprocessor on the digital board using proprietary encoding schemes. Coded data is then sent to both display boards to update the VFD messages and the state of the LEDs.

The microcontroller selects columns by turning on the appropriate N-channel MOSFET (Q501 through Q511). The control LEDs for the light pen make up the eleventh column and are controlled by Q507. The microcontroller selects rows by controlling the source drivers (U505 through U509).

There are two latching circuits configured around the flip-flops of U510. One latching circuit controls the /CTS (Clear to Send) line. When the light pen is clicked, the output of the flip-flop goes high for 5msec. During this period, new serial-in data is held off to allow current data to be processed. The other flip-flop latches the output signal of the light pen when the light signal from the LED is detected.

The serial-in and serial-out data for the microcontroller is similar to RS-232 communications except that TTL levels are used. The communication parameters for both send and receive are as follows:

9600 baud

NO parity

8 data bits

1 start bit

1 stop bit

The +6V supply (Vcc) is used to drive the LEDs, while the +5V supply is used to power all the other circuits on the board. Crystal (Y501) is used to generate the 4MHz display clock.

6.7 External control signals

CHANNEL READY and EXTERNAL TRIGGER are TTL-compatible, and support communication with existing instrument products or other user-supplied equipment through BNC connectors.

TRIGGER LINK (see Figure 6-9) consists of six TTL-compatible signals that can be bused between instruments via a pair of 8-pin TRIGGER LINK IN and TRIGGER LINK OUT micro-DIN connectors located on the Model 7002 rear panel. The TRIGGER LINK can be programmed in asynchronous mode to operate as an additional CHANNEL READY or EXTERNAL TRIGGER signal, or in semi-synchronous mode.

DIGITAL I/O (see Figure 6-10) has four programmable outputs, one TTL output, and an additional line that provides external pull-up voltage for the outputs. DIGITAL I/O is provided through a DB-9 connector located on the Model 7002 rear panel.

All external control signals can be controlled through the front panel or programmed via the IEEE-488 bus.

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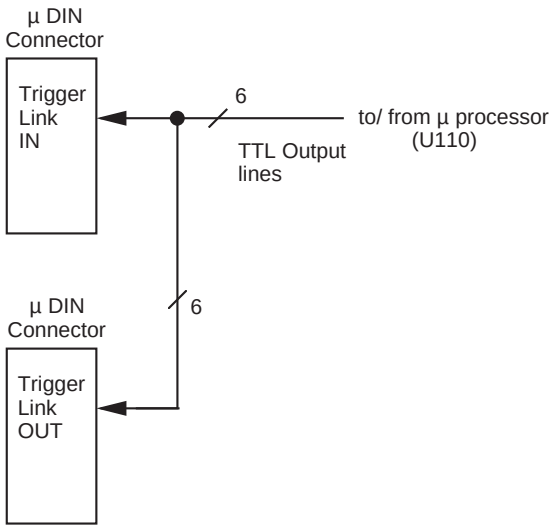


Figure 6-9
Trigger link

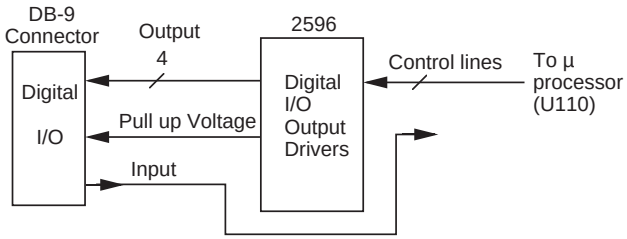


Figure 6-10
Digital I/O

6.8 IEEE-488 interface

The IEEE-488 interface is composed of three ICs. A 9914 (U104) General-Purpose Interface Adapter (GPIA) automatically performs many bus control, data I/O, and handshaking functions, thus minimizing overhead to the system microprocessors. Bus drive capabilities are provided by a 75161 and 75160 (U101 and U102). The 75161 supports bus management and handshake lines, while the 75160 drives the data lines.

6.9 Power supplies

The Model 7002 uses two identical AC-input switching power supplies. Each supply can provide regulated +6VDC and +14.6VDC. Each supply has an internal line fuse and automatically adjusts to the voltage of the AC line power.

AC line power is routed through the digital board to the POWER switch, which is also on the digital board. Two 5A fuses (F100 and F101) are used to protect the digital board from damage in the event that the AC line power becomes shorted. The AC line power is then routed to the two power supply boards.

One power supply is routed to the backplane and is used to provide +6V and +14.6V for the relay power supply circuitry.

The +6V of the other power supply is used to drive the LEDs. On the digital board, the +6V is regulated to +5V using three LM2940 regulators. One +5V supply is used by the VFD module (U118) to generate +60VDC and 5VAC for the VFD display. All other digital board circuitry is powered by the other +5V supply. The third +5V supply powers the backplane +5V card slots.

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7
Maintenance

7.1 Introduction

This section of the manual will assist you in performing maintenance and troubleshooting of the Model 7002.

WARNING

The information in this section is intended for qualified service personnel. Some of these procedures may expose you to hazardous voltages. Do not perform these procedures unless you are qualified to do so.

Section 7 includes the following:

7.2 Service options: Suggests courses of action for obtaining service.

7.3 Handling and cleaning of backplane boards: Covers general precautions to take when handling and cleaning the backplane PC boards.

7.4 Static-sensitive devices: Covers precautions necessary when handling static-sensitive parts.

7.5 Routine maintenance: Describes normal maintenance items which you may expect to perform during the life of the instrument.

7.6 Disassembly: Provides the disassembly procedures necessary to perform routine maintenance and to remove the circuit boards.

7.7 Diagnostics: Describes running the built-in tests of the circuitry and display.

7.8 Test descriptions and notes: Provides details on the diagnostic tests plus additional information to assist you in isolating problems.

7.9 Troubleshooting: Outlines a series of additional checks and tests which may be used to diagnose malfunctions.

7.2 Service options

You have several options for maintenance and repair of the Model 7002. The choice will depend upon your ability to diagnose the problems, as well as your repair facilities:

1. You may return the entire instrument to Keithley.
2. If you have the necessary equipment and expertise, you may perform your own routine maintenance.
3. If repairs are needed and you can isolate a failure to a specific circuit board, you may contact Keithley to obtain a replacement for the board. Troubleshooting and diagnostic procedures in this section are designed to help pinpoint problems to the board level.

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NOTE

The digital and display boards are built using surface mount techniques, and require specialized equipment and skills for repair. Keithley recommends that these repairs be referred to the factory. The backplane and power supply boards use conventional assembly techniques and can be repaired at the component level, but board replacement is still recommended.

Without proper tools or training, you may inflict further damage which cannot be repaired at the factory. Such damages may void the warranty.

7.3 Handling and cleaning of backplane boards

Row signal paths for Model 701X series switching cards are extended onto the backplane boards of the mainframe. Thus, a contaminated backplane will degrade card isolation specifications. If an isolation problem is due to a contaminated backplane, then the two backplane boards will have to be removed and cleaned. Paragraph 7.6.7 explains how to remove the backplane boards.

7.3.1 Handling backplane boards

Observe the following precautions when handling backplane boards:

- Handle the boards only by the edges.
- When servicing the boards, wear clean cotton gloves.
- Do not touch any board traces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off the boards.

7.3.2 Solder repairs and cleaning

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean foam-tipped swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab the repaired area (or contaminated area) with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, the board should be allowed to dry in a 50°C low-humidity environment for several hours.

7.4 Static-sensitive devices

CMOS devices are designed to operate at high impedance levels for lower power consumption. As a result, any static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. Use the precautions below when handling static-sensitive devices:

CAUTION

Many CMOS devices are installed in the Model 7002. Generally, all ICs and transistors should be handled as static-sensitive devices.

1. Transport such devices only in containers designed to prevent static build-up. Typically, these parts will be received in anti-static containers of plastic or foam. Always leave the devices in question in their original containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Also, ground yourself with a suitable wrist strap.
3. Handle the devices only by the body; do not touch the pins or terminals.
4. Any printed circuit board into which the device is to be inserted must also be properly grounded to the bench or table.
5. Use only anti-static type de-soldering tools.
6. Use only soldering irons with properly grounded tips.
7. Once the device is installed on the PC board, it is usually adequately protected, and normal handling can resume.

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7.5 Routine maintenance

The following procedures summarize routine maintenance for the Model 7002.

7.5.1 Line voltage selection

The Model 7002 power supply boards automatically adjusts to line voltage and frequency. There are no internal switches for this purpose.

7.5.2 Replacing power supply fuses

The Model 7002 uses two identical power supplies. The circuit board for each power supply has a single fuse installed in a pair of fuse clips.

A blown fuse indicates that an electrical malfunction has occurred. Try to determine the cause of the failure before installing the replacement.

The correct fuse type for each power supply board is as follows:

Line voltage	Type	Rating
All	5 × 20mm	2A, 250V, Fast Blow

CAUTION

Use only the specified fuse type, or instrument damage may occur.

Fuse replacement procedure:

WARNING

To prevent electrical shock that could result in severe injury or death, disconnect the instrument from the power line and all other equipment.

1. To gain access to the power supply boards, remove the top and bottom covers as explained in paragraphs 7.6.1 and 7.6.2.
2. The two power supply boards are mounted on the front of the backplane bracket. Note that the fuse for each power supply is located on the left end of the board.

NOTE

For the following steps, it may be advantageous to place the unit on its side.

3. Unplug the cable next to the fuse to be replaced. This will provide more room to work.
4. Using a thin-bladed screwdriver (or some other similar tool), pry the fuse out of the clips.
5. Snap the new fuse into the clips. Be sure to use only the specified type fuse.
6. Plug the cable back into its connector and replace the top and bottom covers.

7.5.3 Replacing AC power line fuses

AC line power is routed through the digital board to the power supplies. There are two 5A axial fuses installed on the digital board. These fuses are used to prevent damage to the digital board in the event that the AC power line becomes shorted.

A blown fuse indicates that the AC power line has shorted. Determine the cause of the failure before installing the replacement.

The correct fuse type for the AC power line is as follows:

Circuit designations	Type	Type	Keithley part no.
F100 & F101	5A, 250V, Fast Blow	Axial, insulated	FU-97

CAUTION

Use only the specified fuse type, or instrument damage may occur.

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Fuse replacement procedure:

WARNING

To prevent electrical shock that could result in severe injury or death, disconnect the instrument from the power line and all other equipment.

1. To gain access to the digital board, remove the left side panel as explained in paragraph 7.6.3.
2. Locate the two fuses (F100 and F101). They are located near the bottom left hand corner of the digital board adjacent to the plug for the AC line power receptacle.
3. Unsolder the blown fuse(s) and remove it from the board.
4. Solder in the new fuse(s). Be sure to use only the specified type fuse.
5. Reassemble the instrument.

7.5.4 Changing the battery

WARNING

Disconnect the instrument from the power line and all other equipment before changing the battery.

The volatile memories in the Model 7002 are protected by a replaceable battery when power is off. Typical life for the battery is approximately ten years. This battery should be suspected if the instrument no longer retains scan lists or other user-programmed operating parameters. If the battery is absent or totally exhausted, the display will show the message “No Comm Link” shortly after the Model 7002 is switched on. (This is just one of the causes of the “No Comm Link” message. See paragraphs 7.7.1 and 7.8.1 for more causes.)

The battery is a 3V wafer-type lithium cell, Duracell type DL2450 or equivalent (Keithley part number BA-44), which is located on the digital board.

Replacement of the memory back-up battery requires removal of the left side panel. (See paragraph 7.6.3 for the disassembly procedure.)

WARNING

The precautions below must be followed to avoid possible personal injury.

1. Wear safety glasses or goggles when working with lithium batteries.
2. Do not short the battery terminals together.
3. Keep lithium batteries away from all liquids.
4. Do not attempt to recharge lithium batteries.
5. Observe proper polarity when inserting the battery into its holder.
6. Do not incinerate or otherwise expose the battery to excessive heat (>60°C).
7. Bulk quantities of lithium batteries should be disposed of as a hazardous waste.

To replace the battery, first locate its holder (labeled BT100). Use a small non-metallic tool to lift the battery so that it can be slid out from under the retainer spring clip.

The new battery should be reinstalled with the “+” terminal facing up. Lift up on the retaining clip and place the edge of the battery under the clip. Slide the battery fully into the holder. Recheck previously stored settings and re-enter the configuration as necessary.

NOTE

Proper operation of RAM requires that a battery (even one that is discharged) be installed. Do not remove the old battery unless you have a new one to put in its place.

7.5.5 Removing backplane row jumpers

The rows of slots 1 through 5 can be electrically isolated from the rows of slots 6 through 10 by removing the 12 jumpers on the backplane extender board.

Perform the following steps to remove the backplane row jumpers:

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CAUTION

Contamination of the backplane boards will degrade the isolation specifications of the switching cards. Make sure to only handle these two boards by the edges. Handling and cleaning procedures can be found in paragraph 7.3.

1. Remove the backplane extender card as explained in paragraph 7.6.7.
2. Refer to Figure 7-1 to locate the 12 backplane row jumpers.
3. Using a pair of wire cutters, cut out all 12 jumpers.
4. Reassemble the Model 7002.

7.5.6 Changing firmware

WARNING

Disconnect the instrument from the power line and all other equipment before changing the firmware.

Changing of the firmware may be necessary as upgrades become available. The firmware revision levels of the main CPU and display CPU are displayed briefly on the front panel when the Model 7002 is switched on.

The firmware for the main CPU is located in EPROM U105, a leadless IC which resides in a chip carrier on the digital board.

Replacement of the main CPU firmware requires removal of the left side panel. (See paragraph 7.5.3).

Removal and replacement of the firmware EPROM should be performed only by qualified personnel using appropriate IC extraction tools.

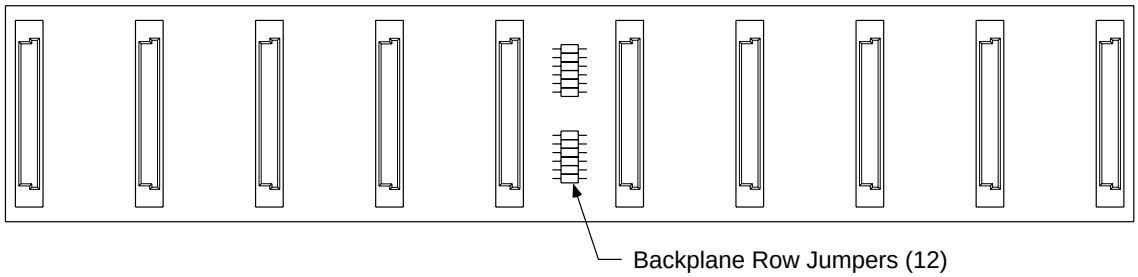


Figure 7-1
Backplane extender board

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7.6 Instrument disassembly

The following disassembly procedures are taken to the level that will allow routine maintenance and removal of the PC boards. If needed, further disassembly of the instrument framework can be accomplished with the aid of the disassembly drawings located at the end of this section.

WARNING

Disconnect the power cord from the rear of the instrument and allow several minutes for stored electrical energy to discharge before opening the case. Also remove the IEEE-488 cable, the light pen and any boards installed in the mainframe.

Table 7-1 summarizes the required disassembly for routine maintenance.

The procedures to remove the PC boards are summarized as follows:

Power Supplies Removal — Use the procedure in paragraph 7.6.5.

Digital Board Removal — Use the procedure in paragraph 7.6.6.

Backplane Boards Removal — Use the procedure in paragraph 7.6.7.

Display Boards — Use the procedure in paragraph 7.6.8.

A PC board should only be removed if you are going to make repairs to it or send it back for replacement.

Recommended tools

- Phillips screwdriver
- Thin bladed knife
- 1/4 in. nut driver

Reference drawings — Before disassembling the unit you should acquaint yourself with the assembly drawings located at the end of this section. Even though each procedure references a drawing, you may find some of the other drawings helpful when trying to remove or install a part.

Reassembly — In general, assembly is the reverse order of disassembly. Many items can only be installed one way. However, it is recommended that you note the orientation of all removed items to ensure proper reassembly.

Table 7-1
Disassembly for routine maintenance

Routine maintenance	Required disassembly	Paragraph
Power supplies fuse replacement	Remove top cover. Remove bottom cover.	7.6.1 7.6.2
AC power line fuse replacement	Remove left side panel.	7.6.3
Battery replacement	Remove left side panel.	7.6.3
Change CPU firmware	Remove left side panel.	7.6.3
Backplane row jumpers removal	Remove backplane extender board.	7.6.7

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7.6.1 Top cover removal

Reference Drawing: 7002-056.

1. While facing the rear panel, locate the two screws securing the top cover to the rear panel.
2. Remove these two screws and slide the top cover off the chassis.

7.6.2 Bottom cover removal

Reference Drawing: 7002-056.

1. Turn the instrument upside-down.
2. There are four feet attached to the bottom. The two feet in front have built-in tilt bails. Each foot is secured by a single screw. Remove the four feet.

NOTE

If the unit has been rack mounted, the feet may have been removed and replaced with screws. If so, remove the four screws.

3. Facing the rear panel, remove the two screws securing the bottom cover to the rear panel and slide the bottom cover off the chassis.
4. Return the instrument to the upright position.

7.6.3 Left side panel removal

Reference Drawing: 7002-055.

1. If the bottom cover is currently installed, perform the following steps. Otherwise, proceed to step 2.
   a. Position the unit so that you are facing the left side panel and turn the unit upside-down.
   b. While still facing the left side panel, locate the two feet that are adjacent to the side panel. The foot near the front of the instrument has a built-in tilt bail. Each foot is secured to the side panel (through the bottom cover) by a single screw. Remove the two feet.

NOTE

If the unit has been rack mounted, the feet may have been removed and replaced with screws. If so, remove the two screws.

   c. Return the instrument to the upright position.
2. Position the unit so that you are facing the left side panel.
3. Locate the two decorative strips located along the top and bottom edges of the side panel. These strips are used to conceal the screws that secure the side panel to the chassis. The strips are secured to the side panel by Velcro fasteners.
4. Using a thin bladed knife, pry one end of the top decorative strip away from the side panel enough to allow you to grasp it and simply pull the strip off. Do the same for the bottom decorative strip.
5. Remove the eight screws that are now exposed along the top and bottom edges of the side panel.
6. The left side panel is secured to the rear panel. Position the unit so that you are facing the rear panel.
7. Loosen the two screws at the end of the rear panel where the left side panel meets the rear panel.
8. Pull the left side panel away from the chassis.

7.6.4 Front panel assembly removal

Reference Drawing: 7002-055.

1. Locate the two decorative strips on each side of the unit. They are located along the top and bottom edges of each side panel. These strips conceal the screws that secure the side panels to the front panel assembly. The strips are secured to the side panels by Velcro fasteners.
2. Using a thin bladed knife, pry one end of a decorative strip away from the side panel enough to allow you to grasp it and simply pull the strip off. Do the same for the other three decorative strips.
3. Remove the four screws (two on each side) that secure the side panels to the front panel assembly.
4. While facing the front panel, carefully pull the front panel assembly away from the chassis. Note that there are display cables connected to the digital board.
5. At the digital board, disconnect the two display cables.
6. Reassembly Note: The Vacuum Fluorescent Display (VFD) cable connects to upper connector on the digital board, and the LED display cable connects to the lower connector.

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7.6.5 Power supplies removal

Reference Drawing: 7002-051.

1. Remove the top cover as explained in paragraph 7.6.1.
2. Remove the front panel assembly as explained in paragraph 7.6.4.
3. While facing the front of the unit, locate the two power supply boards. They are mounted on the large aluminum backplane bracket.
4. At each power supply board, unplug the two cables.
5. Two screws are used to secure each board to the bracket. Remove these screws.
6. Each board is still secured to the bracket by two fasteners. They are located at the upper left hand corner and lower right hand corner of each board. Carefully pull each board off of the fasteners.

7.6.6 Digital board removal

Reference Drawing: 7002-054.

1. Remove the top cover as explained in paragraph 7.6.1.
2. Remove the bottom cover as explained in paragraph 7.6.2.
3. Remove the left side panel as explained in paragraph 7.6.3 to expose the digital board.
4. Disconnect the following cables from the digital board:
   a. Unplug the ribbon cable from the Vacuum Fluorescent Display (VFD) board at connector J1014.
   b. Unplug the ribbon cable from the LED display board at connector J1013.
   c. Unplug the three cables from the power supplies at connectors J1010, J1011 and J1012.
   d. Unplug the ribbon cable from the Digital I/O (on rear panel) at connector J1006.
   e. Unplug the cable from Channel Ready and External Trigger (on rear panel) at connector J1007.
   f. Unplug the cable from the AC line power receptacle at connector J1008.
5. Position the unit so that you are facing the rear panel.
6. Using the 1/4 in. nut driver, remove the two nuts that secure the IEEE-488 connector to the rear panel.
7. Remove the screw located above the Digital I/O connector.
8. Position the unit so that you are facing the digital board.
9. Remove the five screws that secure the digital board to the chassis.
10. The digital board plugs into the backplane board assembly at connector P1009. To remove the digital board, carefully push it towards the rear of the unit until it unplugs from the connector.

7.6.7 Backplane boards removal

CAUTION

Contamination of the backplane boards will degrade switching card isolation specifications. Be sure to only handle the boards by the edges. Handling and cleaning precautions are contained in paragraph 7.3.

Reference Drawings: 7002-051 and 7002-050.

1. Remove the digital board as explained in paragraph 7.6.6.
2. Remove the rear panel by removing the two screws that secure the rear panel to the other side panel.
3. While facing the rear of the unit, note that there are ten shields that divide the mainframe slots. Also note that the other ends of these shields/dividers are attached to the backplane by clip fasteners.
4. Carefully pull back on each shield/divider until it disengages from the clip fastener on the backplane board. You do not have to remove the shields/dividers from the chassis.
5. While facing the front end of the unit, remove the three screws that secure the backplane bracket assembly to the top, front mounting rail.
6. Turn the unit upside down and remove the three screws that secure the backplane bracket assembly to the bottom, front mounting rail.
7. Pull the backplane bracket assembly out of the mainframe. Note that the two power supplies are also mounted to this bracket.
8. While facing the backplane board, remove the eight screws that secure the backplane assembly to the bracket. These screws are located along the top and bottom edges of the backplane board.
9. Separate the backplane assembly from the bracket.

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10. The backplane assembly consists of the backplane board and the backplane extender board. To separate these two boards, remove the 10 screws that hold them together and carefully unplug the extender board from the backplane board.

NOTE

The 12 jumpers that connect the rows of slots 1 through 5 to the rows of slots 6 through 10 are located on the backplane extender board. Removing (cutting) these jumpers will electrically isolate slots 1 through 5 from slots 6 through 10 (see paragraph 7.5.5).

7.6.8 Display boards removal

Reference Drawing: 7002-040

1. Remove the front panel assembly as explained in paragraph 7.6.4.
2. The Vacuum Fluorescent Display (VFD) board is secured to the front panel by four screws. Remove the four screws and lift the VFD display out of the front panel assembly.

NOTE

The front panel switch pads can be removed by simply pulling them out of the front panel assembly.

3. Perform the following steps to remove the LED display board:
   A. Unplug the receptacle for the light pen at the LED board.
   B. The LED board is secured to the front panel by four screws. Remove the four screws and lift the LED board out of the front panel assembly.

7.7 Diagnostics

The Model 7002 includes a series of on-board diagnostic tests which may be invoked through the front panel and performed without any disassembly of the instrument. These diagnostics will help verify functionality of the Model 7002, and will assist you in isolating problems to the board level.

7.7.1 Preparations for running the diagnostics

Before running the diagnostic tests:

1. Power down the Model 7002.
2. Disconnect the IEEE-488 cable and any BNC or trigger cables from the rear panel.
3. Remove any cards which may be plugged into the backplane. (Note that card removal is not necessary for the non-volatile memory test.)

NOTE

Some tests, notably the IEEE-488 interface tests, may incorrectly indicate a failure if run with cables connected.

7.7.2 Initial power-up test

Install a line cord and apply power. The Model 7002 should sequence through ROM revision levels, and IEEE-488 address.

7.7.3 Non-volatile memory test

1. Press CARD CONFIGURATION.
2. Under the CARD CONFIG MENU, select TYPE and press ENTER.
3. Under the SET CARD TYPE menu, select SLOT-#1 and press ENTER.
4. Press the ◄ or ► cursor keys until the display shows:
   SLOT1 CARD: 9990

   then press ENTER.

   This programs the setup memory for a generic 40-channel scanner card (9990).

5. Use the EXIT key to back out of the menu structure.
6. Press the SCAN LIST key.
7. Press the CLEAR LIST key.

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8. Press “1”, “1”, ENTER. The display should show:

   SCAN CHANNELS 1!1,

   This programs a scan list which should be retained in battery backed up RAM. After programming setups, the Model 7002 must retain these assignments when power is switched off, or until reprogrammed.
9. Turn off power and wait a few minutes.
10. Turn on power.
11. Repeat steps 1, 2 and 3 to verify that slot 1 is still set for type 9990. Use EXIT to back out of the menu structure.
12. Press SCAN LIST. Verify:

    SCAN CHANNELS 1!1,

    If the Model 7002 does not retain the settings, one of the following problems may exist:

    - Failure to retain the card number 9990 indicates a fault with EEPROM.
    - Failure to retain the SCAN LIST indicates a fault with battery backed up RAM.

7.7.4 Built-in-tests

The Model 7002’s main circuitry can be verified through the use of the “Built-In-Tests” (BIT). The BIT can be executed in automatic or manual modes. Manual mode can be used to execute individual tests, or to cycle tests indefinitely for specialized troubleshooting.

Automatic test mode

Automatic testing provides a quick scan of most major Model 7002 circuit blocks, and can be invoked using the following steps:

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU, select BUILT-IN-TESTS and press ENTER.
4. Under BUILT-IN-TESTS, select AUTO and press ENTER.
5. Under CONTINUOUS REPEAT?, select NO and press ENTER. This will run the test once. For continuous cycling of the tests, select YES, and press ENTER. The tests will execute until you press EXIT. Automatic continuous mode may be used to scan for intermittent faults.

As the tests cycle, the display will show the message:

NNN.NN Running A or
NNN.NN Running AC

where “A” signifies “Automatic”, “AC” signifies “Automatic/Continuous”, and NNN.NN is the number of the test being run.

At the conclusion of successful testing, the display should indicate no faults:

All tests complete
Press any key to continue

If a test fails, an asterisk “*” will appear in the top line of the display, and the second line will advise on further steps:

All tests complete *
Press ENTER to review or EXIT

To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. A detailed description of BIT faults may be found later in this section.

Manual test mode

Manual testing permits execution of individual Built-In-Tests options to help isolate faults. The BIT may be executed in manual mode as follows:

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU, select the BUILT-IN-TESTS option and press ENTER.
4. Under the BUILT-IN-TESTS menu, select MANUAL option and press ENTER.
5. Press the ◀ and ▶ cursor keys to select the desired test number, then press ENTER to invoke the test. The INFO key can be pressed for a short description of any test function.

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- 100 — EPROM test
- 101 — RAM test
- 102 — EEPROM test
- 103 — Digital I/O:

  103.1-103.4 — Digital output bits 1-4

  103.5 — Digital input
- 104 — IEEE-488 test

  104.1 — Handshake test

  104.2 — IEEE-488 data
- 105 — Trigger tests

  105.1-105.6 — System trigger bus

  105.7 — External trigger/channel ready

  105.8 — Group execute trigger (GET)

  105.11-105.18 — Trigger shorts tests

6. Select the SINGLE, CONTINUOUS, or STEP looping mode, and press ENTER to invoke the desired mode:
   - SINGLE — Runs the selected test once.
   - CONTINUOUS — Runs the selected test repeatedly.
   - STEP — Runs the test once, pausing after each test sub-section.
7. As the tests cycle, the display will show the message

   NNN.NN Running M or
   NNN.NN Running MC or
   NNN.NN Paused MS

   where "M" signifies "Manual", "MC" signifies "Manual/Continuous", "MS" signifies "Manual/Step", and NNN.NN is the number of the test being run.

In the STEP mode, press ENTER to move through the individual tests.

At the conclusion of successful testing the display should indicate no faults:

All tests complete
Press any key to continue

If a test fails, an asterisk "*" will appear in the top line of the display, and the second line will advise on further steps:

All tests complete *
Press ENTER to review or EXIT

To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. A detailed description of BIT faults may be found later in this section (paragraph 7.8.3).

7.7.5 Display test — keys

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF-TEST MENU, select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY TESTS, select KEYS and press ENTER. The display will show "No keys pressed".
5. Press each key (except POWER) in turn and verify that the corresponding key name is displayed.
6. Verify that the display returns to "No keys pressed" when each key is released, i.e., no sticking keys.
7. When you are done with the key test, press EXIT twice to exit.

7.7.6 Display test — patterns

The display PATTERNS test is a visual check of the vacuum fluorescent display (VFD) module. See Figure 7-2.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY TESTS select PATTERNS and press ENTER.
5. There are five test patterns in the test:

Pattern screen 1

A checkerboard pattern of 18 dots appears for all 20 characters in the top row and 32 characters in the bottom row. The annunciators will be shown as in Figure 7-2.

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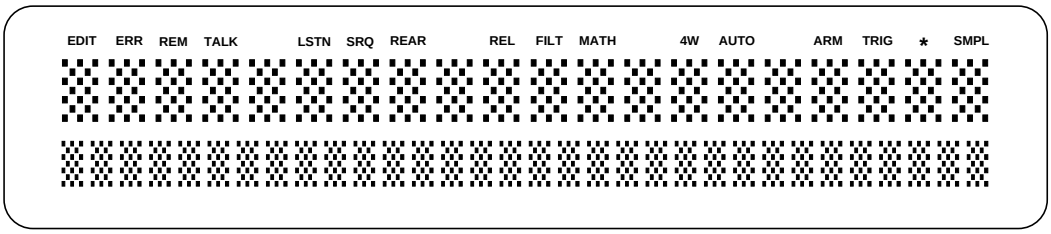


Figure 7-2
First pattern for display test

Pattern screen 2

The alternate checkerboard pattern of 17 dots appears for all 20 characters in top row and 32 characters in the bottom row. The annunciators disappear and are replaced by the numbers:

1 2 3 4 5 6 7 8 9 10

Pattern screen 3

A horizontal bar moves through the seven rows of the first 5×7 character position. One and only one bar must be visible at a time. Movement will continue until any key is pressed.

Pattern screen 4

A vertical bar moves through the five columns of the first 5×7 character position. One and only one bar must be visible at a time. Movement will continue until any key is pressed.

Pattern screen 5

All 35 dots of each 5×7 character block will turn on one character at a time. The upper row blocks include a number and (except for positions 5, 9, 13, and 16) an annunciator. Verify that one and only one block illuminates fully for each character position.

The first test pattern automatically appears when the display test commences. Press any key except EXIT to move to each successive pattern.

6. Verify all five patterns, then press EXIT to return to the SELF-TEST MENU.

7.7.7 Display test — LED board

The display LED-BOARD test is a visual check of the light emitting diodes.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU select the DISPLAY-TESTS option and press ENTER.
4. Under the DISPLAY TESTS menu, select LED-BOARD and press ENTER to start the test. The test can be aborted at any time by pressing any front panel key as indicated by the following message that is displayed while the test is in progress:

   LED TEST PATTERNS
   Press any key to exit.

The test initially turns off all the LEDs and then turns on the LEDs for column 1. The test will then disable the LEDs for column 1 and turn on the LEDs for column 2. The test will sequence through all the columns including the control LEDs for the light pen. The test will then sequence through each row of the 10 slots. Note that the control LEDs for the light pen will be included in the rows for slots 6 through 10. Note that the LEDs for the column tests are brighter than the LEDs for the row tests.

Light pen test — With the LED test running, further tests can be performed using the light pen:

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1. While aiming the light pen away from the LED display, press the button on the pen. All LEDs will become dimly lit. Press the light pen button a second time. All LEDs will become brightly lit. Press the button a third time. All LEDs will turn off. Each press of the light pen button repeats the above test sequence.
2. While all LEDs are dimly lit or brightly lit, individual LEDs can be tested by clicking them with the light pen. When the LED is clicked, it will blink on (brightly lit) and off for a couple of seconds.
3. When finished, press any front panel key to exit from the display test.

7.7.8 Display test — char set

This test is used to display the ASCII character set.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU, select the DISPLAY TESTS option.
4. Under DISPLAY TESTS, select CHAR-SET and press ENTER to display the ASCII character set.
5. Press any key (except EXIT) to scroll through the character set.
6. When finished, use the EXIT key to back out of the menu structure.

7.8 Test descriptions and notes

The following information provides additional details for interpreting any error messages which may result during the Built-In-Tests. These notes are intended to help you isolate faults to the board level, rather than the component level.

7.8.1 Initial power-up test

Upon power-up, the Model 7002 writes test patterns to all volatile memory locations and checks that they read back properly. It then reads all ROM locations and verifies that a calculated checksum matches a checksum stored in ROM. If either of these tests fail, the digital board processor will continue to loop on these tests. If any of these tests fail, the display will indicate “No Comm Link” after the Model 7002 has been on for several seconds. This message indicates that the digital board has not communicated with the display board within the time-out interval.

After memory tests, the Model 7002 checks configuration data stored in non-volatile memory, configures the instrument according to power-up setups, and displays startup information. Configuration data is stored such that the Model 7002 may determine if it is valid. When a Model 7002 has power applied with uninitialized memory, it may briefly display a “configuration error” message.

7.8.2 Non-volatile memory tests

The Model 7002 uses two kinds of non-volatile memory, a 24C16 EEPROM (Electrically Erasable Programmable Read-Only Memory) and battery backed RAM. The EEPROM stores the IEEE-488 address, power-on setup memories and other mainframe configuration items. The battery backed RAM stores the scan list, forbidden channels, and relay card setup memories.

On initial power-up (or after replacing the battery or memory parts) the Model 7002 may indicate a configuration error. Such messages should not occur after programming setups.

The non-volatile memory test in this procedure stores a CARD TYPE in the EEPROM and a SCAN LIST in the battery backed RAM. Correct storage of these items after a few power line cycles provides a confidence test that the non-volatile memory is functioning properly.

NOTE

This test instructed you to set the CARD TYPE to “9990”. The CARD TYPE setting will be changed if a Model 701X card is inserted in a card slot, and may result in an error message. The test must be performed with all card slots empty.

7.8.3 Built-in-tests

The following provides further details on the Built-In-Tests. If these tests detect a fault, they will report the following message at the conclusion of the test:

```
All tests complete *
Press ENTER to review or EXIT
```


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To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. Refer to the appropriate test numbers below for further explanations. The following discussions also suggest the most likely board failure for each type of error. You may also find it helpful to refer to the schematic diagrams.

Test 100 (EPROM)

Failure of Test 100 suggests a digital board error.

All ROM bytes (except for the checksum bytes) are read, a checksum is calculated and compared to the stored checksum. A fault of this test indicates that one or more ROM locations cannot be read properly. Check U105 and associated logic.

Test 101 (RAM)

Failure of Test 101 suggests a digital board error.

This is an abbreviated version of power-on RAM testing. Memory locations are written and read back. It is highly unlikely that this test will ever fail. A unit with faulty RAM will probably fail the power-on memory test or lock up intermittently. Check U107, U108, and associated logic.

Test 102 (EEPROM)

Failure of Test 102 suggests a digital board error.

An attempt is made to read a byte of information from the 24C16 configuration EEPROM (U112) and an acknowledge signal is verified. A fault in this test indicates a problem with the 24C16 component or associated signals. The test does not verify the validity of configuration information stored in the EEPROM. Check U112.

Test 103 (Digital I/O)

Failure of Test 103 suggests a digital board error.

NOTE

With some firmware revisions, the digital output tests (103.1 through 103.4) will not pass if the built-in resistors are not present. (See paragraph 4.15.1).

Digital I/O on the Model 7002 consists of four open-collector outputs, and one TTL-level input. Outputs originate from the 68302 microprocessor PA4-PA7 (U110). PA4 drives OUT1, PA5 drives OUT2, etc. These signals are buffered by a 2596 open collector driver (U109).

Digital input is buffered by protection circuitry (CR112,CR113, R136, R137) and read by the 68302 at PB8.

Tests 103.1-103.2 — Digital output bits 1-4

Failure of Tests 103.1-103.2 suggests a digital board error.

These tests make use of the fact that the 68302 Port A registers are bidirectional even though in normal use they are programmed as outputs only.

Diodes and resistors are connected around the 2596 so that digital output 1 feeds back to PA5, 2 feeds back to PA6, 3 to PA7, and 4 to PA4. (Note that signal numbers are scrambled at the 2596 open collector driver. The numbers in the above description refer to the digital output signal numbers, not to the numbers on the 2596.)

During Test 103.1, PA4 and PA6 are programmed as outputs, PA5 and PA7 are programmed as inputs. As PA4 (digital output 1) is toggled high and low the signal is verified at PA5.

During Test 103.2, PA5 and PA7 are programmed as outputs, PA4 and PA6 are programmed as inputs. As PA5 (digital output 2) is toggled high and low the signal is verified at PA6.

Tests 103.3-103.4 — Digital outputs 3 and 4 (test similar to 103.1-103.2).

Success of these tests assures the basic functionality of PA4-7, the 2596 and associated components. A failure may be caused by shorted or defective components or by open or shorted PC board traces.

Tests 103.5 — Digital Input

Failure of Test 103.5 suggests a digital board error.

This test verifies that the digital input signal is pulled high at PB8 of the microprocessor (U110). Success of this test does not guarantee functionality. A failure may be caused by a defective component or a short circuit.

Test 104 (IEEE-488 Test)

Failure of Test 104 suggests a digital board error.

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The IEEE-488 interface in the Model 7002 consists of the 9914 GPIB chip (U106), and the 75160 (U102) and 75161 (U101) bus drivers. The 75160 buffers DIO1-8 data lines, the 75161 buffers the bus handshake lines and other control signals. The circuitry to test these parts is contained in the 5064 ASIC (U103).

Test 104.1 — Handshake Test

Failure of Test 104.1 suggests a digital board error.

Circuitry in the 5064 is set up to simulate an IEEE-488 handshake. Bytes are written to the 9914 Data Out register (U106) and the interrupt status register is checked to verify that a Byte-Out handshake is completed.

These tests verify the basic functionality of the 9914, 75161, and the handshake portion of the ASIC (Signals BNRFD, BNDAC, and BDAV). Failures may indicate that a part is defective, or that the PC board is faulty. Check U101, U103, U106.

Test 104.2 — IEEE-Data

Failure of Test 104.2 suggests a digital board error.

Bytes are written to the 9914 Data Out register (U106) to drive and release bus line DIO1. The state of this signal is verified at the 68302 through PB0 (BITB1).

These tests verify the basic functionality of the 9914 and 75160. Failures may indicate that a part is defective or that the PC board is faulty. Check U102 and U106.

Test 105 —Trigger tests

Failure of Test 105 suggests a digital board error.

Triggers in the Model 7002 are controlled by circuitry in the 5064 ASIC (U103). This part has seven trigger outputs (STO1-STO7) and eight trigger inputs (STI1-STI8).

The system trigger bus is controlled by STI1-STI6 and STO1-STO6.

STO7 is connected to the CHANNEL READY BNC connector. STI7 is connected to the EXTERNAL TRIGGER BNC connector.

STI8 is connected to the Group Execute Trigger signal (GET) of the 9914 IEEE-488 bus controller (U106).

Tests 105.1-105.6 — System Trigger Bus

Failure of Tests 105.1-105.6 suggests a digital board error.

System trigger inputs are normally pulled up to +5V through protection diodes and 1kΩ resistors (CR102-107, R108, R110, R112, R114, R117, R118). The Model 7002 may generate a trigger on any of the six trigger bus inputs by turning on a FET (Q100-105) controlled by the associated system trigger output pin (STO) of the ASIC.

In Test 105.1, STI1 is set up as the trigger input. The trigger 1 FET is then turned on and off through STO1, and it is verified that this trips the trigger circuitry in the ASIC. This test is then repeated for triggers 2-6 in tests 105.2 - 105.6.

Success indicates proper operation of the trigger bus. A fault may indicate a defective ASIC, FET, diode, resistor, or open-circuit board trace.

Test 105.7 — External Trigger/Channel Ready

Failure of Test 105.7 suggests a digital board error.

This test is similar to System Trigger Tests 105.1-105.6 except that there is no internal connection between EXTERNAL TRIGGER and CHANNEL READY. Consequently, the meaning of a fault is reversed from that of Tests 105.1-105.6, i.e., a fault is registered if a trigger does occur. This would indicate that a short exists between EXTERNAL TRIGGER and CHANNEL READY. This fact may be used to test the external BNC connectors. By shorting CHANNEL READY to EXTERNAL TRIGGER with a BNC cable, Test 105.7 should fail. If it does not, the signal path is faulty.

Test 105.8 — Group Execute Trigger (GET)

Failure of Test 105.8 suggests a digital board error.

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Trigger 8 (STI8) is set up as input. The 9914 (U106) is then programmed to generate a GET signal. A failure may indicate a problem with the ASIC or with the 9914.

Tests 105.11-105.18 — Trigger Shorts tests

Failure of Tests 105.11-105.18 suggests a digital board error.

In Test 105.11, STI1 is programmed as the trigger input. Each of the other triggers (STI2-STI7 and GET) is programmed to toggle in turn. If a trigger is detected at STI1, a short is indicated and the test fails. The test is repeated for STI2-STI8 in Tests 105.12-105.18.

Ordinarily, built-in-tests should be run with no external connections, however, the Trigger Shorts tests may be used to verify proper operation at the external TRIGGER LINK connectors (J1004, J1005). For example, by shorting pins 1 and 2, and selecting BIT 105, faults 105.11 and 105.12 should occur indicating that a short was detected between system trigger 1 and system trigger 2.

7.9 Troubleshooting

The following information is designed to help you troubleshoot the Model 7002 if a problem develops which resists diagnosis by the built-in tests. The BIT does not test to a 100% confidence level, but will detect and identify a majority of problems.

WARNING

Troubleshooting procedures may require you to apply power and operate the Model 7002 while it is partially disassembled, thus exposing you to lethal voltages. To avoid risk of personal injury, refer any such procedures and testing to qualified personnel.

7.9.1 Digital board

The digital board contains most of the logic in the Model 7002, and is tested extensively by the BIT. If the BIT runs, the digital board (or at minimum, the microprocessor, RAM, EPROM, and EEPROM) is functional.

Raw power supply voltages can be measured at the point where they are cabled to the digital board from the power supplies. Regulators on the digital board reduce the power supply +6VDC level to +5VDC. This voltage can be measured on regulators U116 and U117. The +60VDC used to power the vacuum fluorescent display is provided by U118 (OUT+). The lithium battery should measure 3-3.25VDC between the case (+) terminal and chassis ground.

Most connections between the digital board and other boards are made through mass termination connectors, so there is a minimal chance of problems due to broken wires.

Symptom — Diagnostics do not run:

- Suspect a faulty digital board, display board, or power supply.

Symptom — A “No Comm Link” error indicates that the digital and display boards are not communicating. If this error occurs, check for:

- Defective battery.
- Bad cable between digital board and display board.
- Defective digital board.
- Defective display board.

7.9.2 Display boards

The display test verifies individual characters, annunciators and LEDs on the display boards. If the instrument powers up and executes this test, the display boards and digital board logic are most likely operating properly. Problems with individual characters, annunciators or LEDs, should be easily identified. If a display is dead, check the condition of the ribbon cable connecting the digital and display board. Serial communication and power for the display boards (including 60VDC) are transmitted over the display cables.

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Symptom — No display:

- Defective power supplies. Check voltages.
- Blown fuses (power supply boards). Check fuses.
- Loose power cables from power supplies to digital board.
- Loose cable from AC receptacle to digital board.
- Blown fuse(s) on digital board (F100 and F101).
- Loose ribbon cables from digital board to display boards.
- Defective power switch (digital board).
- Defective display boards.
- Defective 60V supply (located on digital board).

Symptom — Front panel buttons not working as expected:

- Check the display boards (run BIT).
- Check for broken or damaged contacts on keyboard button membranes.

Symptom — Display tests run but show incorrect characters on the VFD display:

- Change display board.

7.9.3 Power supply

The Model 7002 power supplies will resist problems affecting conventional power supplies. The power supplies automatically adjust to a broad range of mains voltage (90-260VAC) and frequencies (47-440Hz), so the fuses should not fail because of incorrect mains voltage setting.

If a power supply fails, the instrument will be inoperative. Power supply input and output voltages may be checked at the connectors at each end of the boards. Table 7-2 lists the output voltages that should be available at the digital board.

Symptom — Repeated blowing of fuses indicates a faulty power supply or other boards:

- Disconnect the various wiring harnesses or remove boards and check for short circuits.

7.9.4 Backplane boards

The backplane boards interface plug-in relay cards to the digital board. If communication through the backplane board is faulty, check the cards and the condition of the card edge connectors on the backplane boards.

Symptom — Incorrect identification of relay cards plugged into backplane:

- Move the affected relay card into the other backplane slot. If it is correctly identified, suspect the backplane board. If not, suspect the relay card.

Symptom — Test circuit configurations not functioning properly:

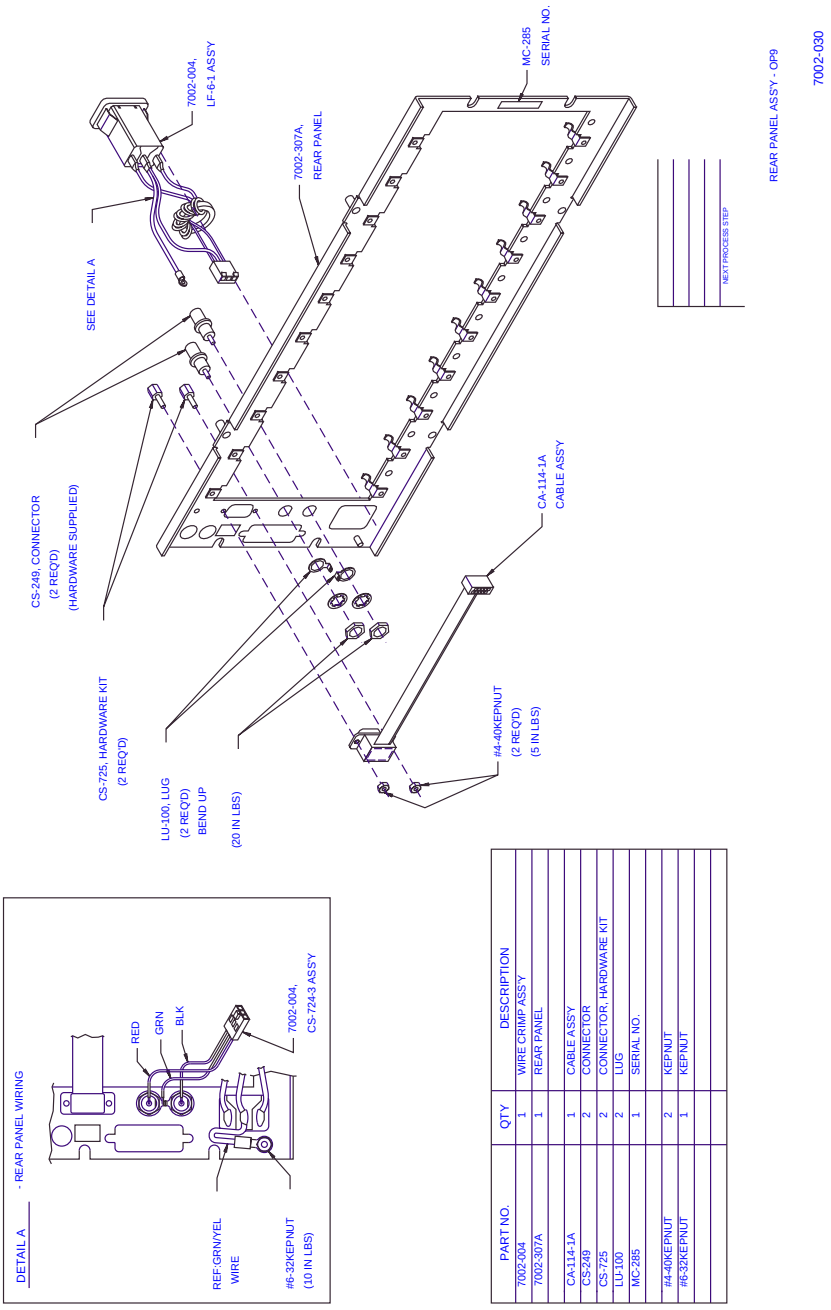
- Defective or improperly seated relay cards.
- Defective backplane board.

Table 7-2
Power supply checks

Test point	Output voltage	Tolerance	Rated load	Ripple/noise	Reference to
J1011-1	+14.6VDC	±5%	1.67A	100mV	Digital ground
J1011-4	+6VDC	±3%	2.5A	50mV	Digital ground
J1012-4	+6VDC	±3%	2.5A	50mV	Digital ground

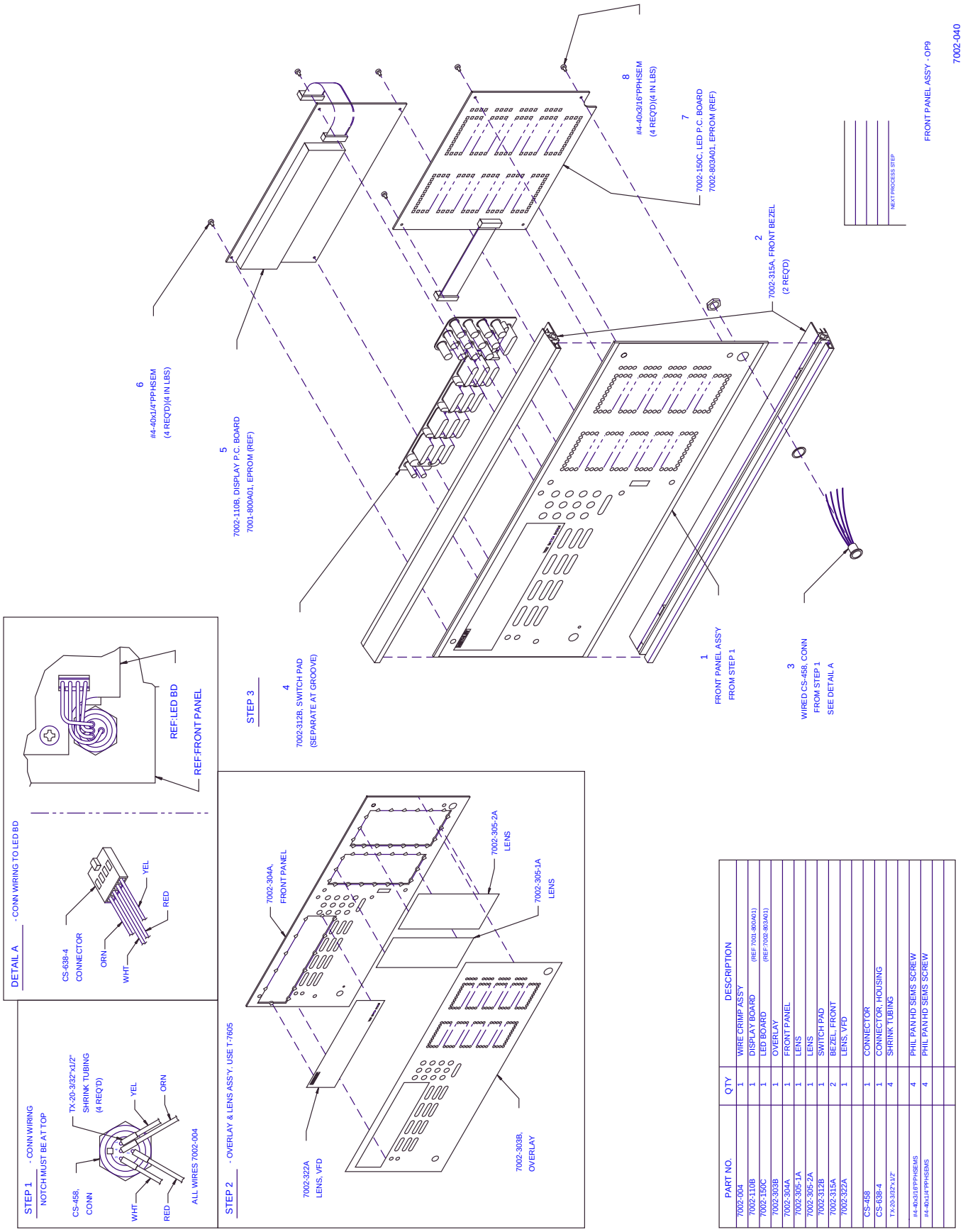
Notes:
1. Tolerance is measured with output at 60% rated load.
2. Ripple/noise is measured by using a 12-inch twisted wire terminated with a 47µF capacitor.

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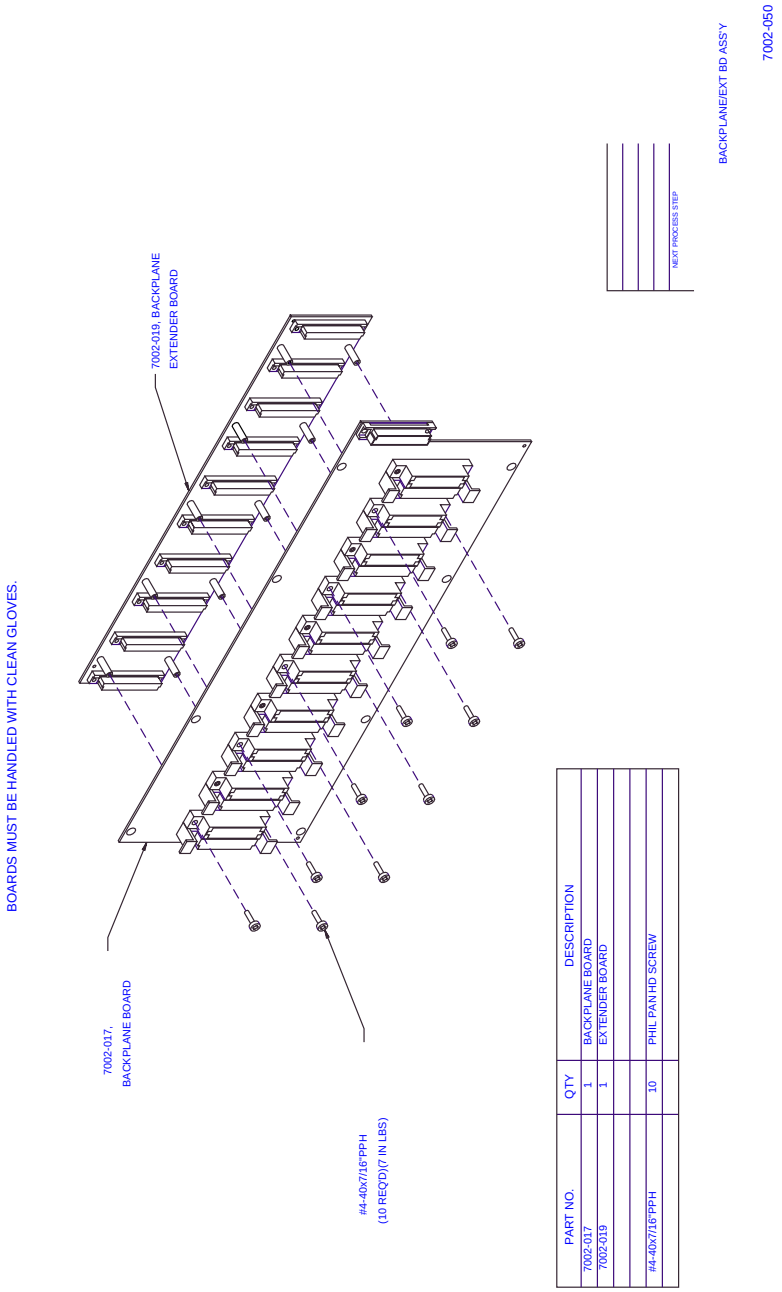
PART NO.	QTY	DESCRIPTION
7002-004	1	WIRE CRIMP ASS'Y
7002-307A	1	REAR PANEL
CA-114-1A	1	CABLE ASS'Y
CS-249	2	CONNECTOR
CS-725	2	CONNECTOR, HARDWARE KIT
LU-100	2	LUG
MC-285	1	SERIAL NO.
#4-40KEPNUT	2	KEPNUT
#6-32KEPNUT	1	KEPNUT

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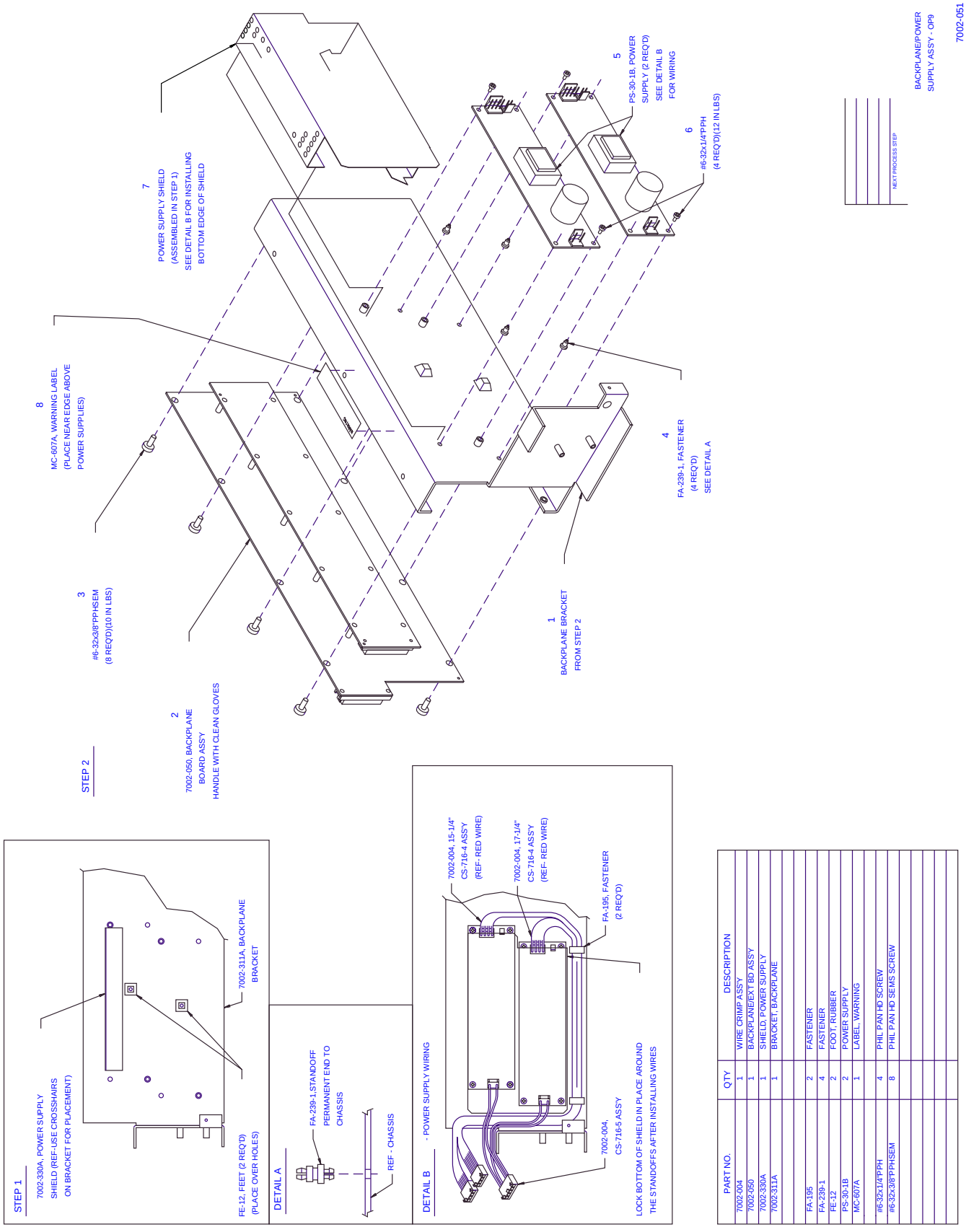


PART NO.	QTY	DESCRIPTION
7002-004	1	WIRE CRIMP ASSY
7002-110B	1	DISPLAY BOARD (REF 7001-800A01)
7002-150C	1	LED BOARD (REF 7002-803A01)
7002-303B	1	OVERLAY
7002-304A	1	FRONT PANEL
7002-305-1A	1	LENS
7002-305-2A	1	LENS
7002-312B	1	SWITCH PAD
7002-315A	2	BEZEL, FRONT
7002-322A	1	LENS, VFD
CS-458	1	CONNECTOR
CS-638-4	1	CONNECTOR, HOUSING
TX-20-3/32"x1/2"	4	SHRINK TUBING
#4-40x3/16"PPHSEMS	4	PHIL PAN HD SEMS SCREW
#4-40x1/4"PPHSEMS	4	PHIL PAN HD SEMS SCREW

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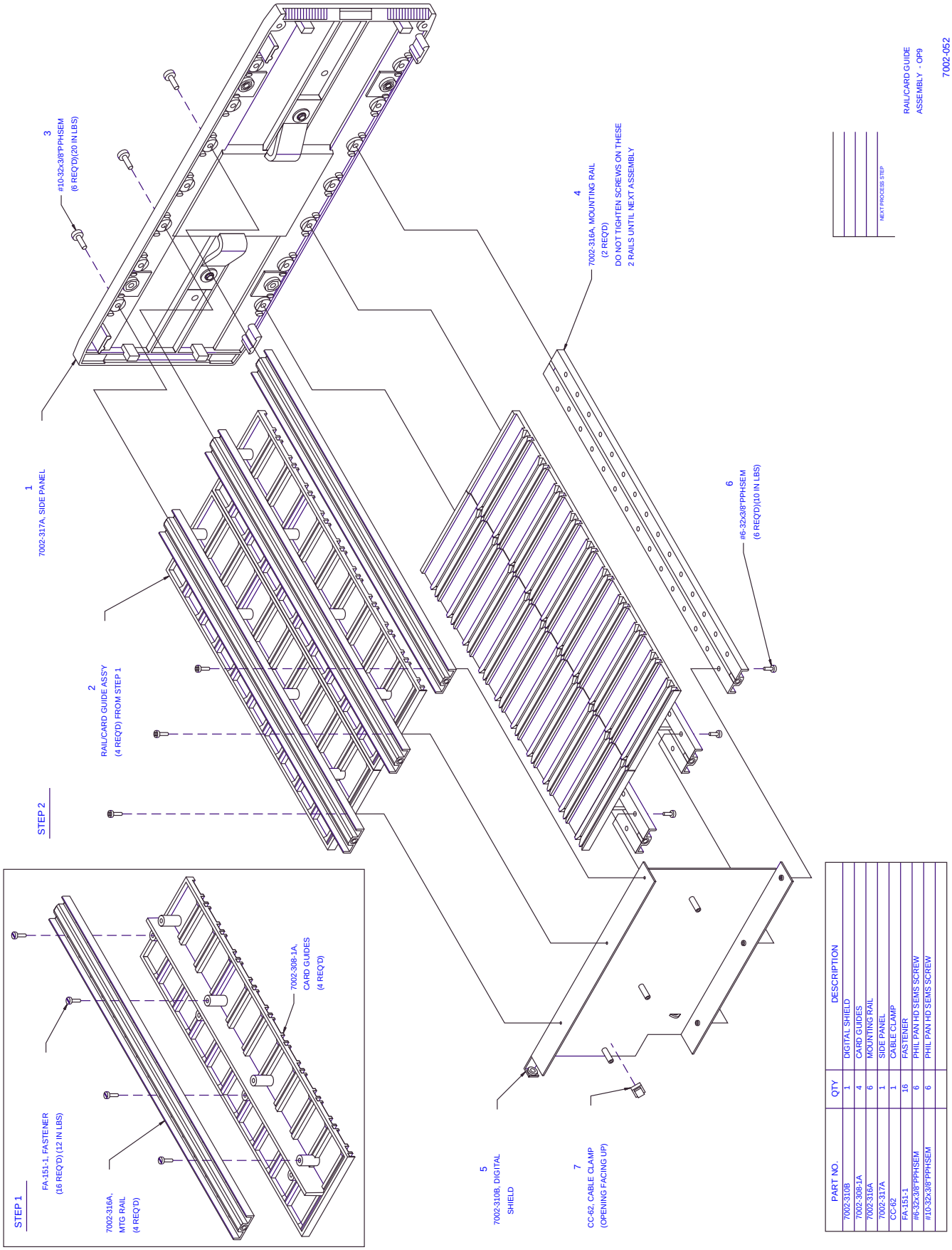


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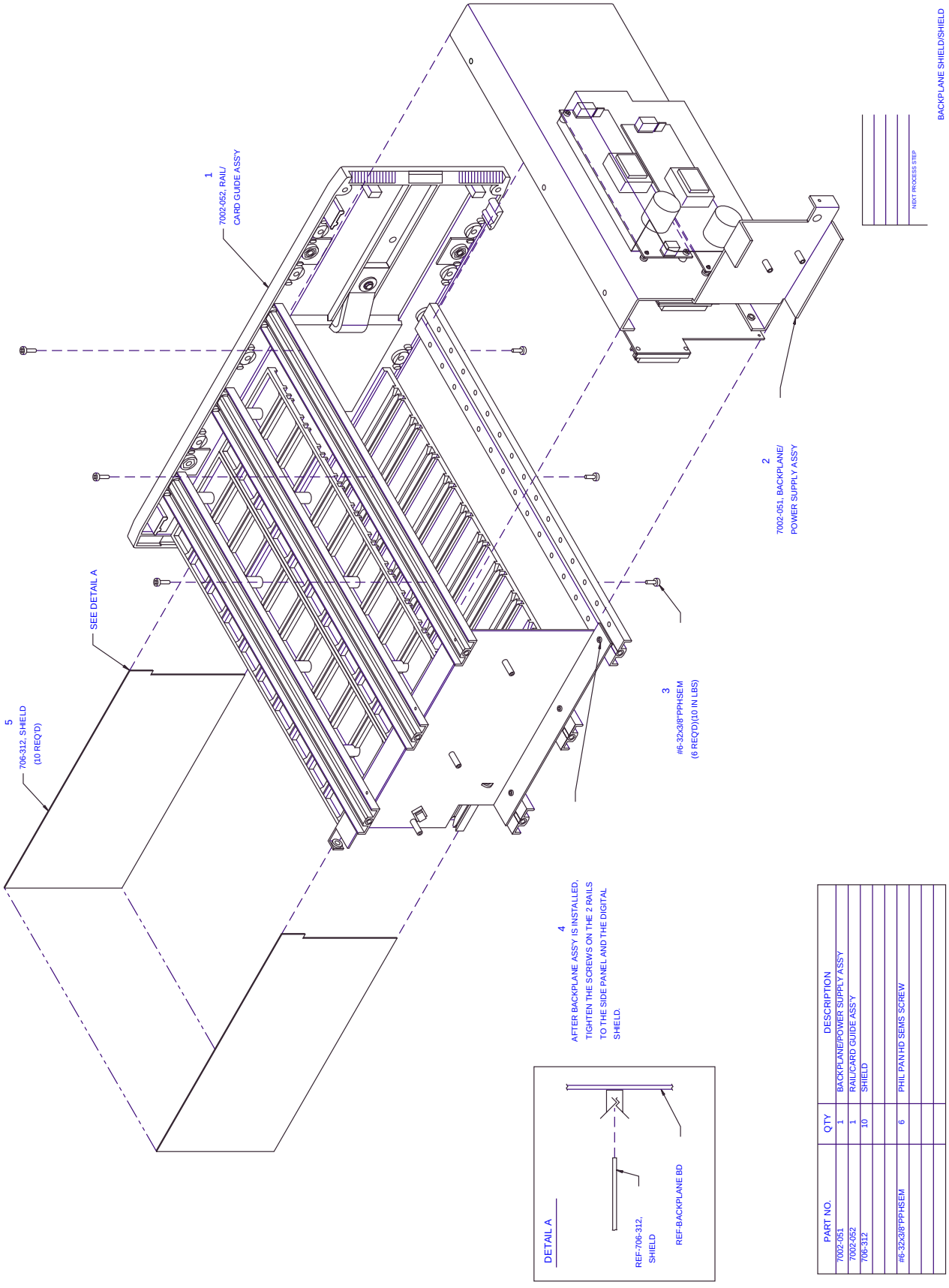
PART NO.	QTY	DESCRIPTION
7002-004	1	WIRE CRIMP ASSY
7002-050	1	BACKPLANE/EXT BD ASSY
7002-330A	1	SHIELD, POWER SUPPLY
7002-311A	1	BRACKET, BACKPLANE
FA-195	2	FASTENER
FA-239-1	4	FASTENER
FE-12	2	FOOT, RUBBER
PS-30-1B	2	POWER SUPPLY
MC-607A	1	LABEL, WARNING
#6-32x1/4"PPH	4	PHIL PAN HD SCREW
#6-32x3/8"PPHSEM	8	PHIL PAN HD SEMS SCREW

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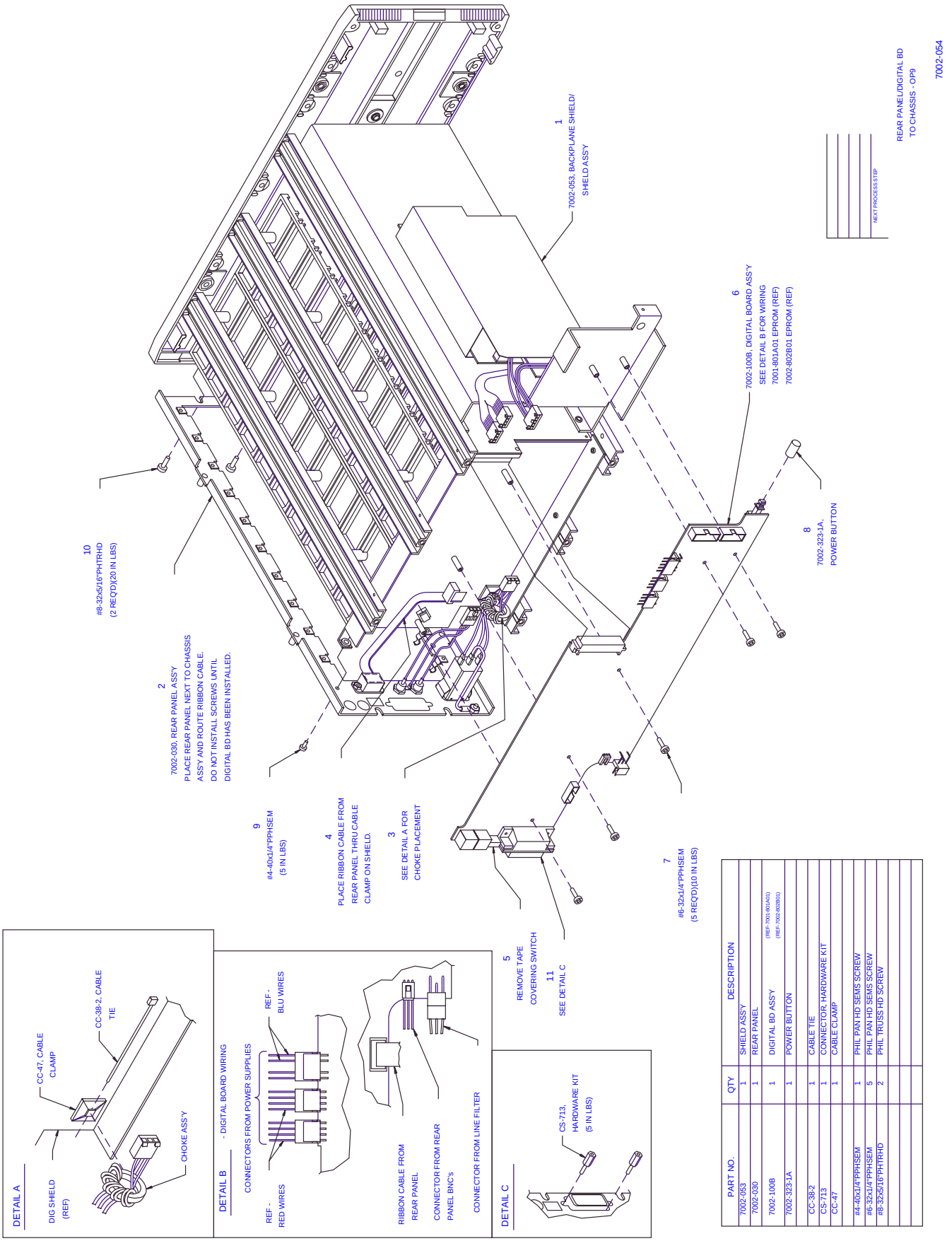
PART NO.	QTY	DESCRIPTION
7002-310B	1	DIGITAL SHIELD
7002-308-1A	4	CARD GUIDES
7002-316A	6	MOUNTING RAIL
7002-317A	1	SIDE PANEL
CC-62	1	CABLE CLAMP
FA-151-1	16	FASTENER
#6-32x3/8"PPHSEM	6	PHIL PAN HD SEMS SCREW
#10-32x3/8"PPHSEM	6	PHIL PAN HD SEMS SCREW

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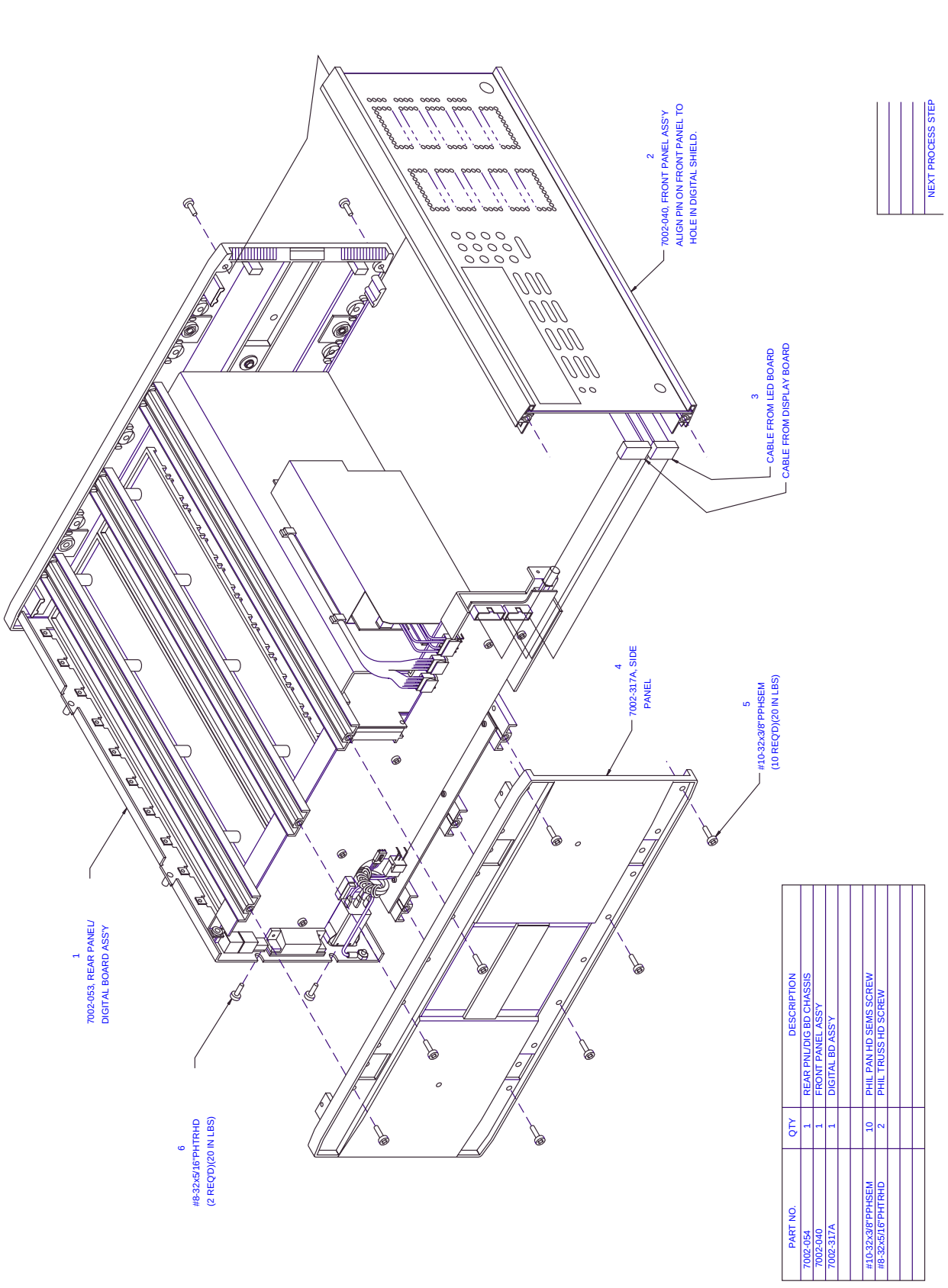
PART NO.	QTY	DESCRIPTION
7002-051	1	BACKPLANE/POWER SUPPLY ASS'Y
7002-052	1	RAIL/CARD GUIDE ASS'Y
706-312	10	SHIELD
#6-32x3/8"PPHSEM	6	PHIL PAN HD SEMS SCREW

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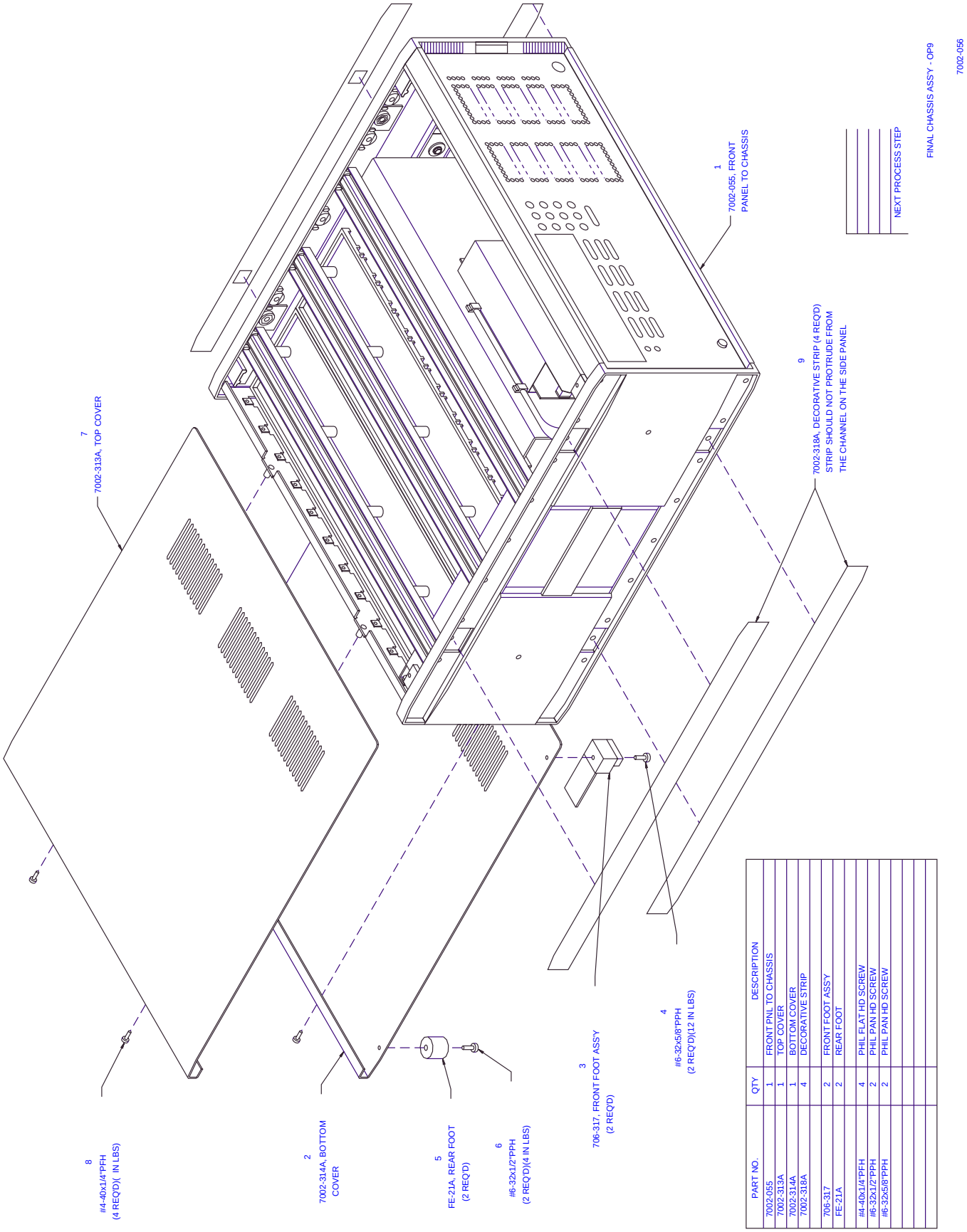
PART NO.	QTY	DESCRIPTION
7002-053	1	SHIELD ASS'Y
7002-030	1	REAR PANEL
7002-100B	1	DIGITAL BD ASS'Y (REF-7001-801A01) (REF-7002-802B01)
7002-323-1A	1	POWER BUTTON
CC-38-2	1	CABLE TIE
CS-713	1	CONNECTOR, HARDWARE KIT
CC-47	1	CABLE CLAMP
#4-40x1/4"PPHSEM	1	PHIL PAN HD SEMS SCREW
#6-32x1/4"PPHSEM	5	PHIL PAN HD SEMS SCREW
#8-32x5/16"PHTRHD	2	PHIL TRUSS HD SCREW

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PART NO.	QTY	DESCRIPTION
7002-054	1	REAR PNL/DIG BD CHASSIS
7002-040	1	FRONT PANEL ASS'Y
7002-317A	1	DIGITAL BD ASS'Y
#10-32x3/8"PPHSEM	10	PHIL PAN HD SEMS SCREW
#8-32x5/16"PHTRHD	2	PHIL TRUSS HD SCREW

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PART NO.	QTY	DESCRIPTION
7002-055	1	FRONT PNL TO CHASSIS
7002-313A	1	TOP COVER
7002-314A	1	BOTTOM COVER
7002-318A	4	DECORATIVE STRIP
706-317	2	FRONT FOOT ASSY
FE-21A	2	REAR FOOT
#4-40x1/4"PFH	4	PHIL FLAT HD SCREW
#6-32x1/2"PPH	2	PHIL PAN HD SCREW
#6-32x5/8"PPH	2	PHIL PAN HD SCREW

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8
Replaceable Parts

8.1 Introduction

This section contains replacement parts information, schematic diagrams and component layout drawings, for the Model 7002.

8.2 Parts lists

The following parts lists for the Model 7002 are integrated with the component layouts and schematic diagrams:

Digital board parts list

Backplane board parts list

Backplane extender board parts list

VFD display board parts list

LED display board parts list

Miscellaneous parts list

8.3 Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see inside front cover for addresses). When ordering parts, be sure to include the following information:

- Instrument model number (Model 7002)
- Instrument serial number
- Part description
- Circuit designation (if applicable)
- Keithley part number

8.4 Factory service

If the instrument is to be returned to Keithley Instruments for repair, perform the following:

1. Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
2. Complete the service form at the back of this manual and include it with the instrument.
3. Carefully pack the instrument in the original packing carton.
4. Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

8.5 Component layout and schematic diagrams

The component layouts and schematic diagrams are provided in the following pages and are integrated with the parts lists.

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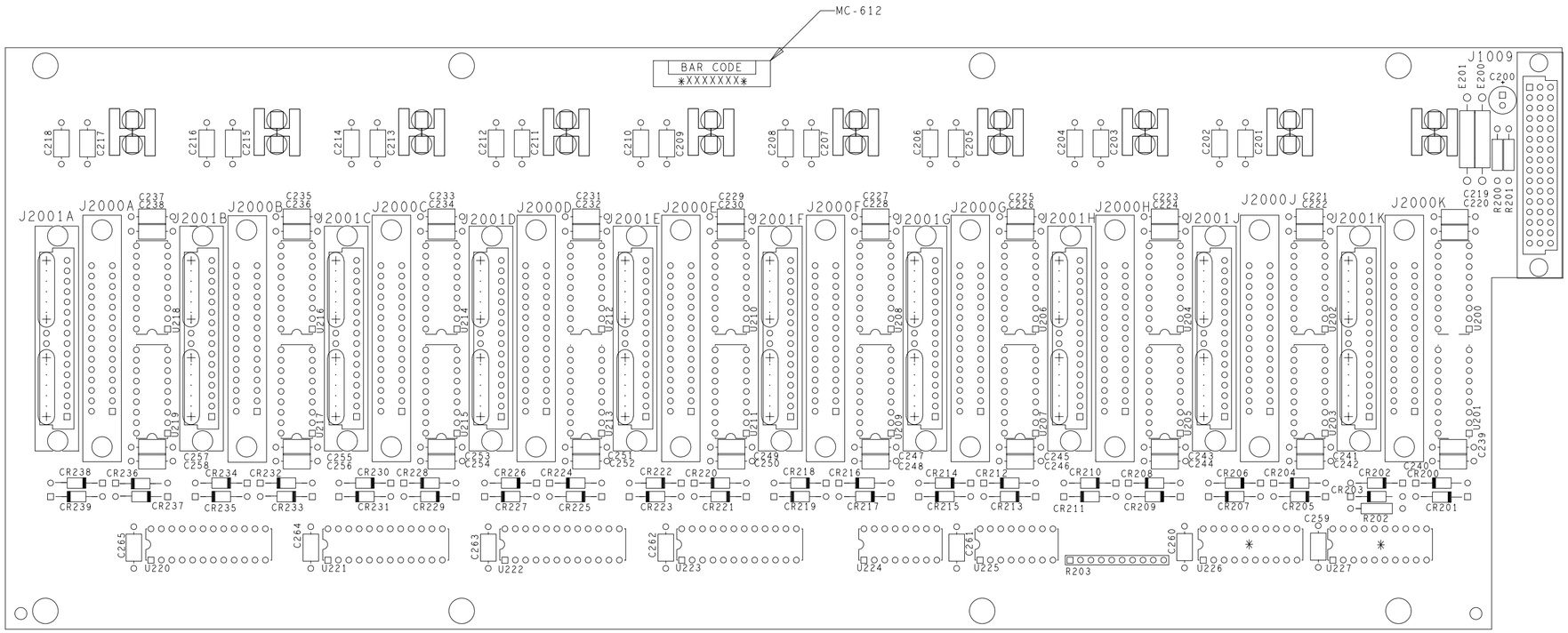
Table 8-1
Backplane board, parts list

Circuit designation	Description	Keithley part number
C200	CAP, 10µF, -20+100%, 25V, ALUM ELEC	C-314-10
C201-265	CAP, .1µF, 20%, 50V, CERAMIC	C-365-.1
CR200-239	DIODE, SILICON, IN4148 (DO-35)	RF-28
E200-201	BEAD, FERRITE	CT-9
FA200-209	FASTENER, CLIP	FA-99
J1009	CONNECTOR, 48-PIN, 3 ROWS	CS-748-3
J2000A-J2000K	CONN, 30-PIN EDGE	CS-454-2
J2001A-J2001K	CONNECTOR, 32-PIN, 3 ROWS	CS-793-1
R200,201	RES, 1.8K, 5%, 1/4W, COMPOSITION OR FILM	R-76-1.8K
R202	RES, 1K, 5%, 1/4W, COMPOSITION OR FILM	R-76-1K
R203	RES, NET, 1K, 2%, 1.70W	TF-180-3
U200-219	IC, 8-BIT SERIAL-IN LATCH DRIVER, 5841A	IC-536
U220-223	IC, 4-16 LINE DECODER, 74HCT154	IC-878
U224,225	IC, 8-STAGE SHIFT/STORE REG, 74HCT4094	IC-691

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NO. 7002-170

LTR.	ECA NO.	REVISION	ENG.	DATE
A		PRELIMINARY		
B	921216	RELEASED	MS	12/17/92
B1	15724	ADDED NOTE "DO NOT INSTALL"	AS	3/23/93
C	26140	CONVERTED FROM DAZIX TO CADENCE ARTWORK CHANGED FROM REVB TO C	MLH	6/29/01



*NOTE: DO NOT INSTALL U226 & U227

NOTE: FOR COMPONENT INFORMATION, REFER TO PRODUCT STRUCTURE

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MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY

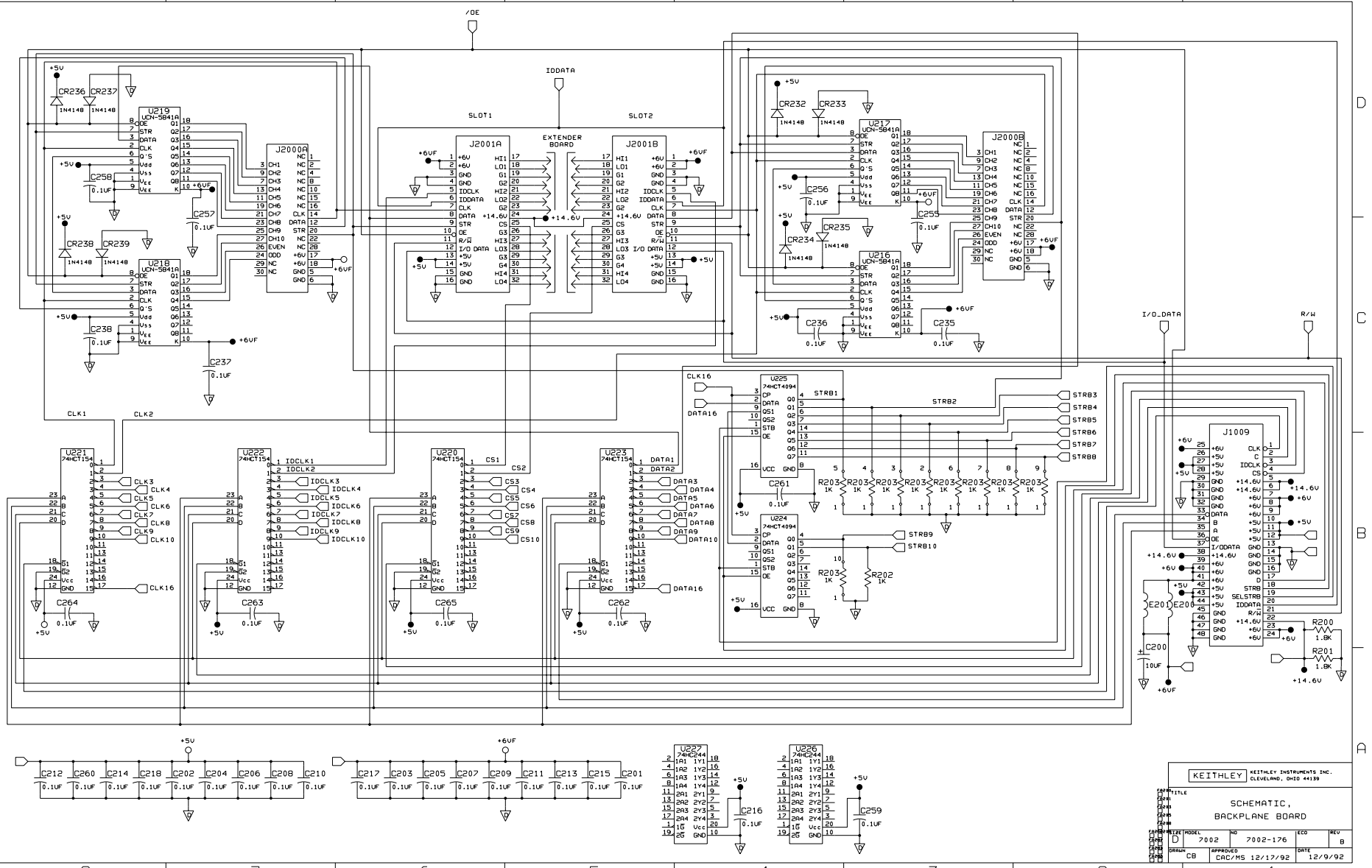
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CLEVELAND, OHIO 44139

DIM ARE IN IN. UNLESS OTHERWISE NOTED
DIM. TOL. UNLESS OTHERWISE SPECIFIED
XX=+.01 ANG.=+1
XXX=+.005 FRAC.=+1/64
DO NOT SCALE THIS DRAWING

DATE 8/17/92 | SCALE 1:1
DRN CB | APPR. WJK/MS

TITLE COMPONENT LAYOUT BACKPLANE BOARD

C NO. 7002-170

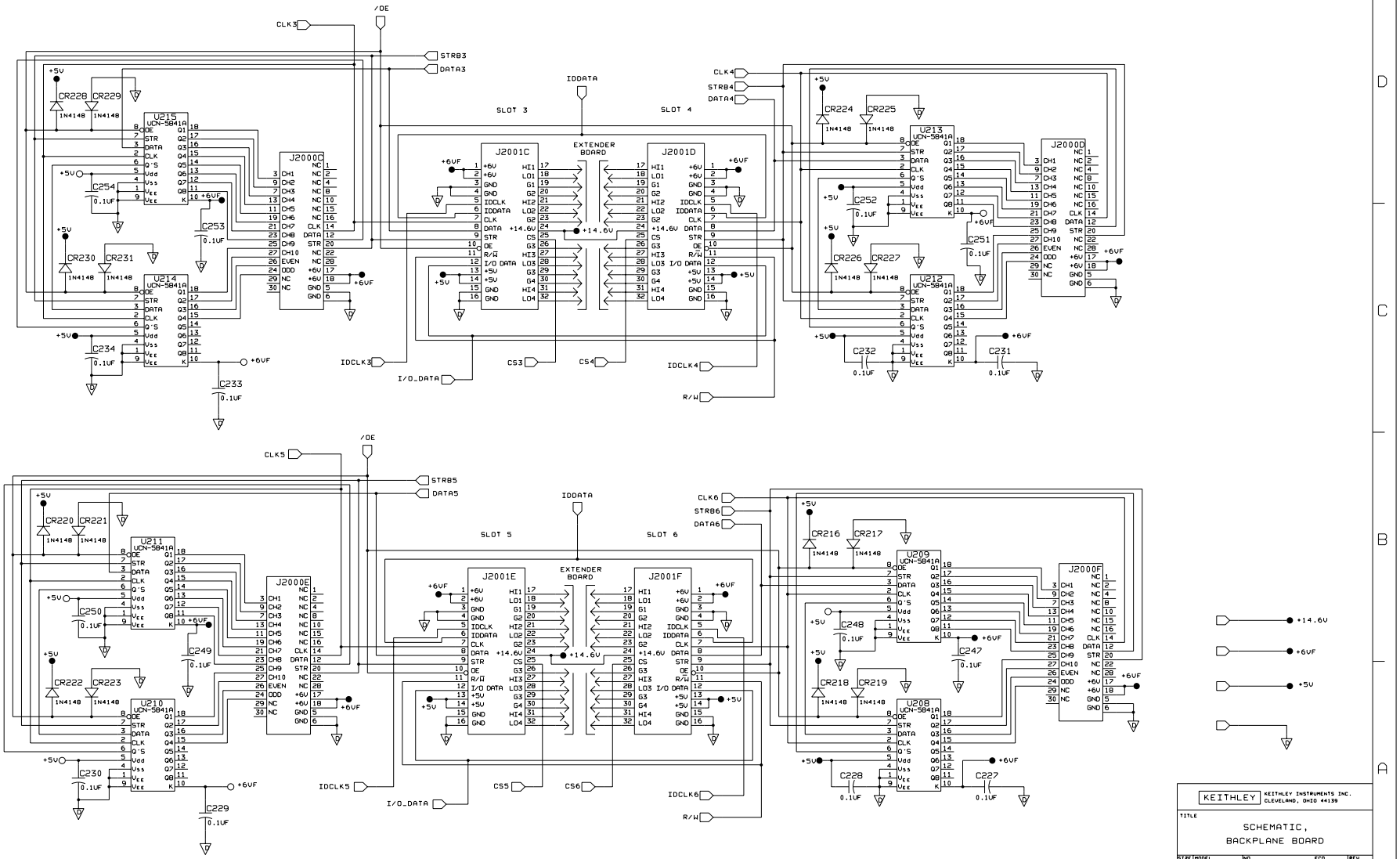


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TITLE
SCHEMATIC,
BACKPLANE BOARD

SIZE	MODEL	NO	ECO	REV
D	7002	7002-176		B

DRAWN	APPROVED	DATE
CB	CAC/MS 12/17/92	12/9/92

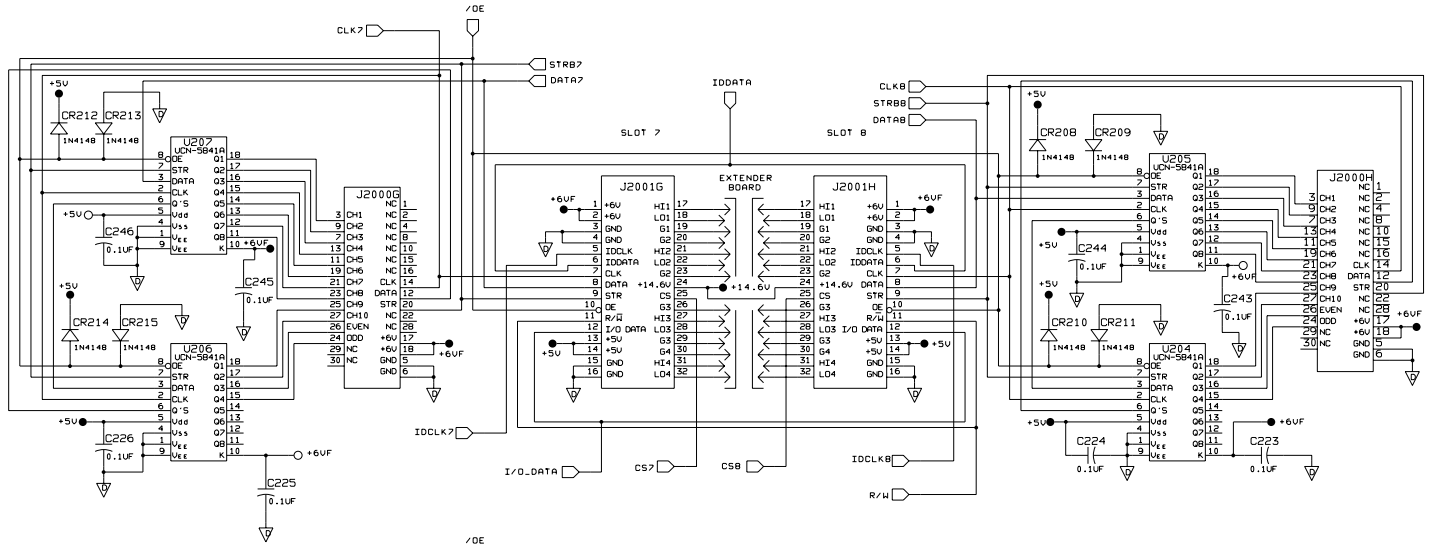


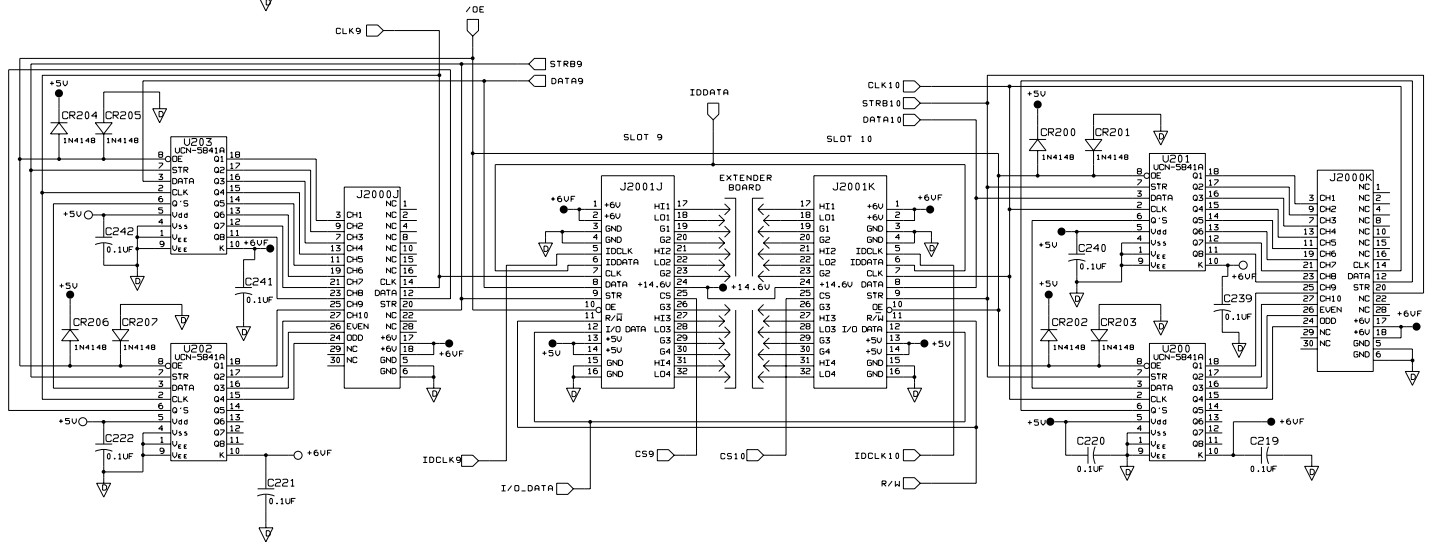
KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

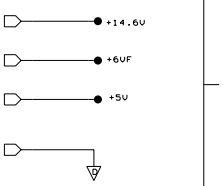
TITLE: SCHEMATIC, BACKPLANE BOARD

SIZE	MODEL	NO	ECO	REV
D	7002	7002-176		B

DRAWN	APPROVED	DATE
CB	CAC/MS 12/17/92	12/9/92







KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

TITLE: SCHEMATIC BACKPLANE BOARD

SIZE	MODEL	NO	ECO	REV
D	7002	7002-176		B

DRAWN	APPROVED	DATE
CB	CAD/MS 12/17/92	12/9/92

Table 8-2
Digital board, parts list

Circuit designation	Description	Keithley part number
	DIGITAL BOARD SURFACE TOP	7002-DIG-4T
	4-40 PEM NUT	FA-131
	DIGITAL BOARD ASSEMBLY	7002-100
	DIGITAL BOARD ASSEMBLY	V-7002-100
	VENDOR PC BOARD ASSY WITH F/WARE REVS	7002-VENPC-8
	BAR CODE S/N LABEL	MC-612
	DIGITAL BOARD THRU HOLE	7002-DIG-4
	LABEL	MC-624
	IC, EPROM, EMP5064 (PLCC)	LSI-122
	HOLE SIZE	7002-102
	IC, 4M EPROM, HN27C4096(SMT)	LSI-128
BT100	BATTERY, LITHIUM-MANGANESE CELL 3V	BA-44
C100-105,111,113,114, 116, 117,135-146	CAP, 270pF, 20%, 100V, CERAMIC/FERRITE	C-386-270P
C106,109,110,112,115,118, 120-125,130, 132,133, 147,153,155,158,160,161, 162	CAP, .1µF, 20%, 50V, CERAMIC (1206)	C-418-.1
C107,108,119,131,134	CAP, .01µF, 20%, 50V, CERAMIC (1206)	C-418-.01
C126,127	CAP, 3000P, 20%, 250V, EMI SUPP FILTER	C-475-3000P
C128,129	CAP, 33pF, 10%, 100V, CERAMIC (1206)	C-451-33P
C148-152	CAP, 270pF, 20%, 100V, CERAMIC/FERRITE	C-386-270P
C154	CAP, 22µF, -20+100%, 25V, ALUM ELEC	C-314-22
C156,157,159	CAP, 220µF, -20+100%, 25V, ALUM ELEC	C-314-220
CR100,101	DIODE, ARRAY, MMAD1103, (SOIC)	RF-80
CR102-120	DIODE, SILICON, IN4148 (DO-35)	RF-28
DS100	PILOT LIGHT RED, HI-INTENSITY LED	PL-88-1
F100,101	FUSE, 5A, 125V	FU-97
	FOR U116, 117 HEAT SINK	HS-33
J1003	CONN, RIGHT ANGLE, 24PIN	CS-507
J1004,1005	CONN, MICRODIN W/GND FINGERS	CS-792
J1006	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-10
J1007	CONN, MALE 3 PIN	CS-612-1
J1008		175-316B
J1010	CONN, RT ANGLE MALE MOLEX	CS-805-5
J1011,1012	CONN, RT. ANGLE, MALE MOLEX .156	CS-715-4
J1013	CONNECTOR, HEADER STRAIGHT SOLDER PIN	CS-368-14
J1014	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
L100	POWER FILTER CHOKE, 10UH, 3A	CH-20-2
L101,102	CHOKE, 10UH	CH-20-3
M104	BATTERY HOLDER	BH-34
P1009	CONN, 48-PIN, 3-ROWS	CS-775-2
Q100-105	TRANS, N CHAN MOSPOW FET, 2N7000 (TO-92)	TG-195

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Table 8-2 (continued)
Digital board, parts list

Circuit designation	Description	Keithley part number
R100,109,111,113,115,116, 119,127	RES, 10K, 5%, 125MW, METAL FILM (1206)	R-375-10K
R101,102,104-107	RES, 39, 5%, 125MW, METAL FILM (1206)	R-375-39
R103	RES NET, 10K, 2%, 1.875W (SOMIC)	TF-219-10K
R108,110,112,114,117,118	RES, 5.1K, 5%, 125MW, METAL FILM (1206)	R-375-5.1K
R120,123,143,153,157	RES, 4.7K, 5%, 125MW, METAL FILM (1206)	R-375-4.7K
R121	RES, 1.5K, 5%, 250MW, METAL FILM (1210)	R-376-1.5K
R122,140,156	RES, 10K, 5%, 250MW, METAL FILM (1210)	R-376-10K
R124-126,128,132	RES, 10, 5%, 125MW, METAL FILM (1206)	R-375-10
R129-131,133-135,137,139, 145,158,159	RES, 10K, 5%, 125MW, METAL FILM (1206)	R-375-10K
R136	RES, 2K, 5%, 125MW, METAL FILM (1206)	R-375-2K
R138,165	RES, 100, 5%, 250MW, METAL FILM (1210)	R-376-100
R141,142,163,164	RES, 2K, 1%, 125MW, METAL FILM (1206)	R-391-2K
R144	RES, 680K, 5%,125MW, METAL FILM (1206)	R-375-680K
R146	RES NET, 4.7K, 2%, 1.875W (SOMIC)	TF-219-4.7K
R147-151	RES, 100, 5%, 125MW, METAL FILM (1206)	R-375-100
R152,154	RES, 560, 5%, 250MW, METAL FILM (1210)	R-376-560
R155,616	RES, 470,5%, 125MW, METAL FILM (1206)	R-375-470
R160	RES, 9.1K, 5%, 125MW, METAL FILM (1206)	R-375-9.1K
R161,162	RES, 4.7K, 5%, 250MW, METAL FILM (1210)	R-376-4.7K
S100	SWITCH, HORIZON MNT, DIP ROCKER, SPST	SW-487-5
S101	SWITCH, PUSHBUTTON (6 POLE)	SW-466
TP100,101	CONN, TEST POINT	CS-553
U100,113,114	IC, OCT BFR/LINE DRIVE, 74HCT244 (SOLIC)	IC-651
U101	IC, OCTAL INTER BUS TRANS, 75161 (SOLIC)	IC-647
U102	IC, OCTAL INTERFACE BUS, 75160 (SOLIC)	IC-646
U103	PROGRAM	7001-801-**
U104	IC, QUAD 2 IN NOR, 74HCT02 (SOIC)	IC-809
U105	PROGRAM	7002-802-**
	SOCKET, 44 PIN QUAD (FOR U105)	SO-128-44
U106	IC, GPIB ADAPTER, 9914A (PLCC)	LSI-123
U107,108	IC, 125KX8 STAT CMOS RAM, HM628128LFP-10	LSI-133-100
U109	IC, 350MA SATURATED SINK DRIVER	IC-578
U110	IC, 16-BIT MICRO, MC68302FE, UDN-2596A	LSI-106
U111	IC, QUAD 2 INPUT OR, 74HCT32 (SOIC)	IC-808
U112	IC, SERIAL E EPROM, X24C16(8-PIN DIP)	IC-736
U115	IC, MICROMANAGER, DS1236S (SOLIC)	IC-884
U116,117	IC, +5V VOLTAGE REGULATOR, LM2940CT	IC-576
U118	MOD, DC-AC/DC, 5DV-5VAC/60DC, E705-E905VF	MO-30
	USED FOR 175-316 CONN RT ANGLE MALE MOLEX	CS-715-3
VR100	DIODE, ZENER 8.2V, IN4101 (DO-7)	DZ-82
VR101,102	DIODE, ZENER 4.7V, IN4732A (DO-41)	DZ-67
W101-104	JUMPER	J-15
Y100	CRYSTAL, 16MHZ	CR-30-16M

** Order current firmware revision level for main CPU.

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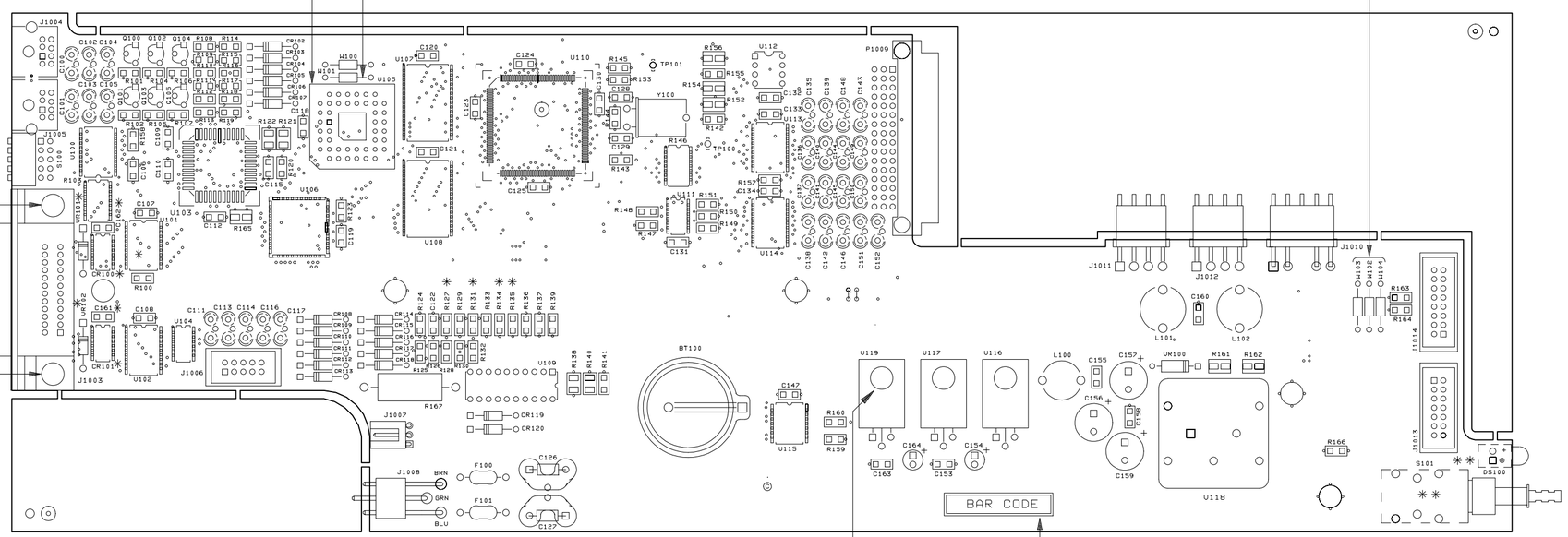
NO. 7002-100

LTR.	ECO NO.	REVISION	ENG.	DATE
A		PRELIMINARY		12/18/92
B	921218	RELEASED	MS	12/18/92
C	15628	ARTWORK WAS REV B. ADDED C163,C164,R167,U119, C1)HS-33 & 4-40XS/16PPHSEM. CHG'D BD OUTLINE.	AS	3/22/93
C1	15804	ADDED 7001-B01A01 TO U103 AND 7002-B02B01 TO U105.	AS	4/16/93
C2	15888	7002-B02B02 WAS 7002-B02B01	SZ	5/27/93
D	16013	ARTWORK WAS REV C. CHG'D S100 PART NO	SZ	1/6/94
D1	17423	U105 WAS 7002-B02B02 U103 WAS 7001-B01A01 INCORPORATED	SZ	5/25/95
D2	17783	U105 WAS 7002-B02B03	SZ	10/30/95
D3	18319	U105 WAS 7002-B02B05	SZ	2/26/96
D4	18206	ADDED **DO NOT POPULATE NOTE R127, R131, R134, R135	SZ	3/14/96
D5	18786	U105 WAS 7002-B02B06	SZ	6/24/96
D6	24222	DELETED EPROM NUMBERS	SZ	3/23/00
D7	23407	CR100,CR101,VR101,VR102 ADDED TO NO POPS LIST	SZ	9/15/00
D8	24335	REPLACED COMPONENTS FOR C126,C127	LM	11/20/00
D9	25060	CHANGED R108,R110,R112,R114,R117,R118 FROM R-375-5.1K TO R-375-1K	DHC	3/22/01
D10	23047	ADDED C161, C162 TO DO NOT POPULATE	DHC	5/17/01

DO NOT INSTALL W101

SO-128-44

DO NOT INSTALL
W102,W103,W104



4-40 X 5/16 PPH
2 PLACES
INSTALL SCREWS FROM
SIDE 01

HS-33
4-40 x 5/16 PPH SEM
3 PLACES
INSTALL SCREWS FROM
SIDE 06

MC-612
(SIDE 06)

** INSTALL DS100 AND S101 ON SOLDER SIDE

* DO NOT POPULATE:
SMT: R127, R131, R134, R135, CR100, CR101, C161, C162
PTH: VR101, VR102

NOTE: FOR COMPONENT INFORMATION REFER TO PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING

KEITHLEY KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DIMENSIONAL TOLERANCES
UNLESS OTHERWISE SPECIFIED
XX=±.015 ANG.=±1°
XXX=±.005 FRAC.=±1/64
SURFACE MAX. 63

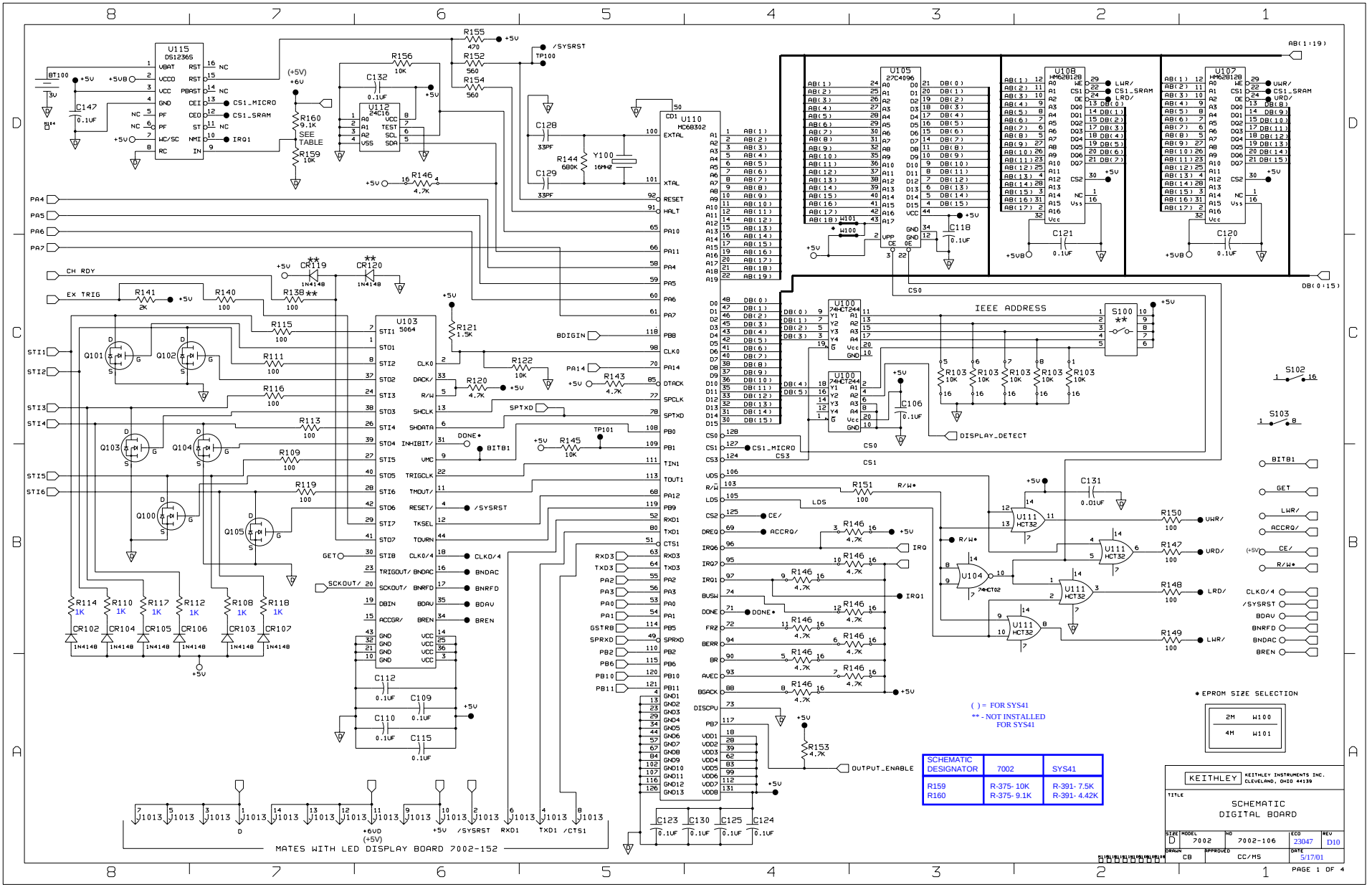
DATE 12/18/92
DRN. KEK
MATERIAL
FINISH

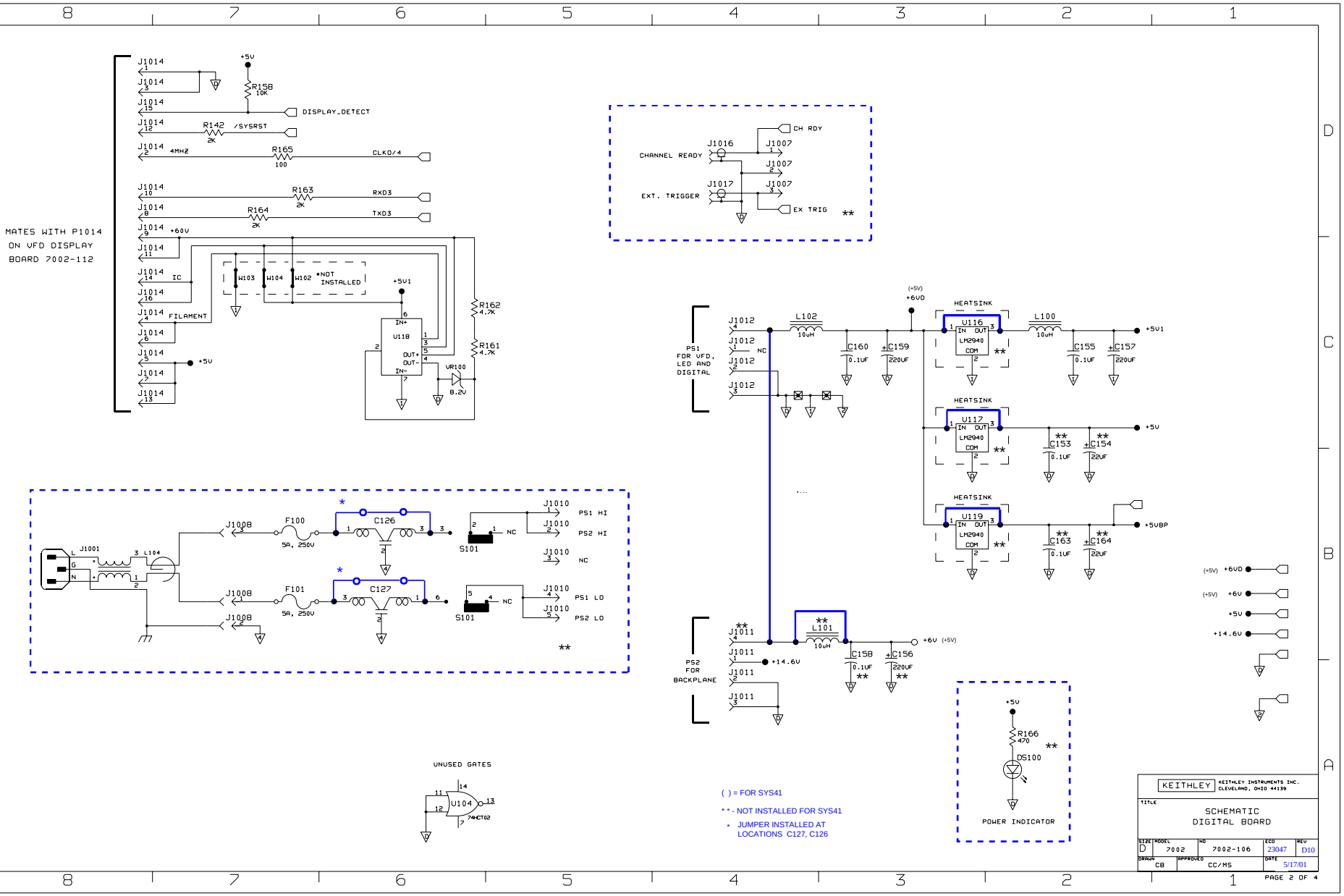
SCALE 1:1
ENG. APPR. WJK/CC

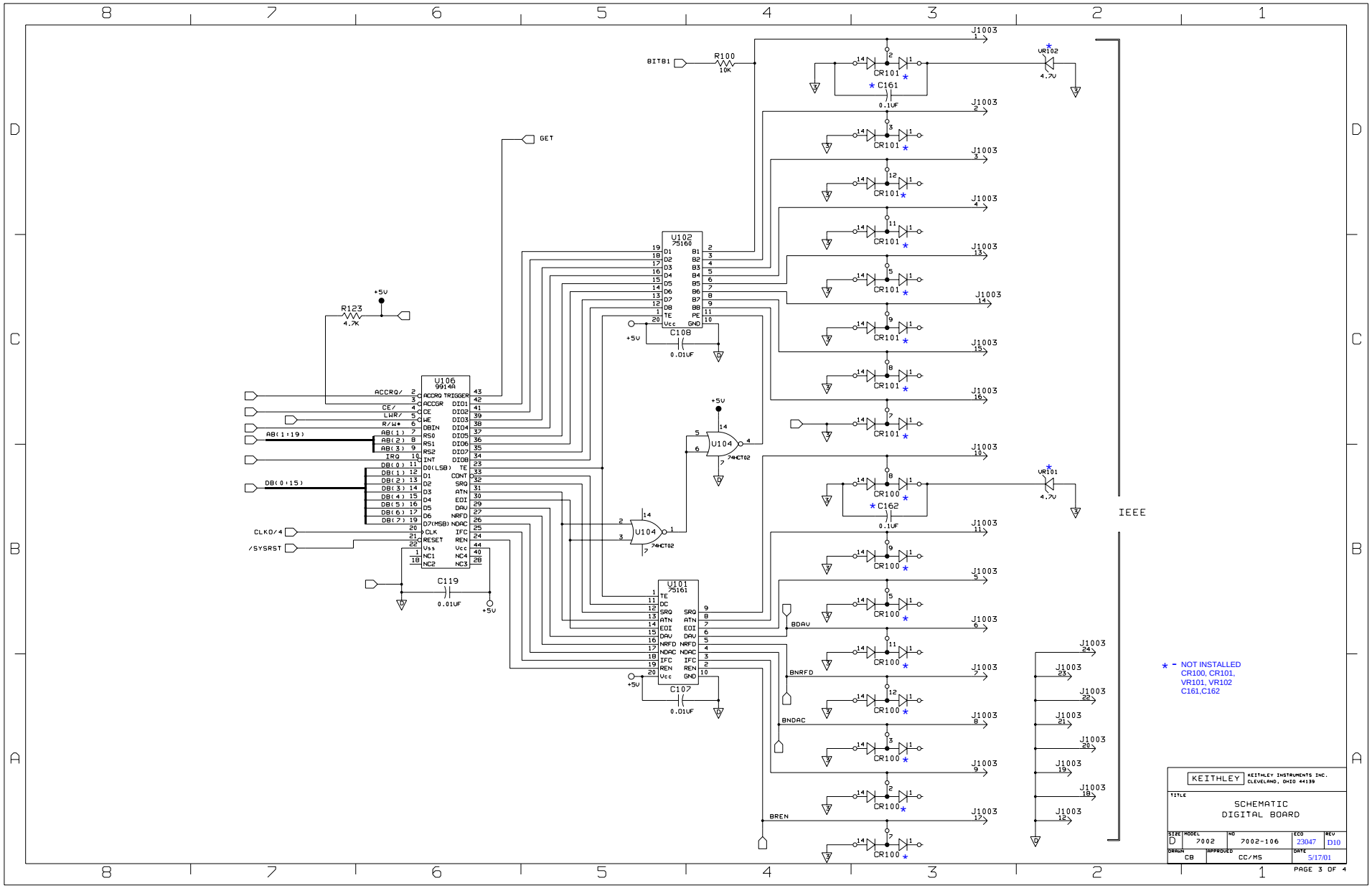
TITLE COMPONENT LAYOUT
DIGITAL BOARD

C NO. 7002-100

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U115 DS1236S
U112 24C16
U110 MC68302
U105 27C4096
U108 HM62B128
U107 HM62B128
U103 5064
U100 74HCT244
U111 HCT32
U104 74HCT02
IEEE ADDRESS
S100
S102
S103
DISPLAY_DETECT
BITB1
GET
LWR/
ACCRQ/
CE/
R/W*
CLKO/4
/SYSRST
BDAV
BNRFD
BNDAC
BREN
UWR/
URD/
LRD/
IRQ
IRQ1
OUTPUT_ENABLE
CS1_MICRO
CS1_SRAM
IRQ1
EX TRIG
CH RDY
SPTXD
MATES WITH LED DISPLAY BOARD 7002-152
* EPROM SIZE SELECTION
2M W100
4M W101
( ) = FOR SYS41
** - NOT INSTALLED FOR SYS41
SCHEMATIC DESIGNATOR | 7002 | SYS41
R159 | R-375- 10K | R-391- 7.5K
R160 | R-375- 9.1K | R-391- 4.42K
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC
DIGITAL BOARD
SIZE D | MODEL 7002 | NO 7002-106 | ECO 23047 | REV D10
DRAWN CB | APPROVED CC/MS | DATE 5/17/01
PAGE 1 OF 4


MATES WITH P1014
ON VFD DISPLAY
BOARD 7002-112
J1014
+5V
R158
10K
DISPLAY_DETECT
R142
2K
/SYSRST
4MHZ
R165
100
CLKO/4
R163
2K
RXD3
R164
2K
TXD3
+60V
IC
FILAMENT
W103
W104
W102
*NOT
INSTALLED
+5V1
R162
4.7K
R161
4.7K
U118
IN+
OUT+
OUT-
IN-
VR100
8.2V
J1016
CHANNEL READY
J1017
EXT. TRIGGER
J1007
CH RDY
EX TRIG
**
PS1
FOR VFD,
LED AND
DIGITAL
J1012
NC
L102
10uH
C160
0.1UF
+C159
220UF
(+5V)
+6VD
HEATSINK
U116
IN OUT
LM2940
COM
L100
C155
+C157
+5V1
U117
C153
+C154
+5V
U119
C163
+C164
+5VBP
PS2
FOR
BACKPLANE
J1011
+14.6V
L101
C158
+C156
+6V
J1001
L1104
J1008
F100
5A, 250V
C126
S101
J1010
PS1 HI
PS2 HI
NC
F101
5A, 250V
C127
PS1 LO
PS2 LO
UNUSED GATES
U104
74HCT02
( ) = FOR SYS41
** - NOT INSTALLED FOR SYS41
* JUMPER INSTALLED AT
LOCATIONS C127, C126
R166
470
DS100
POWER INDICATOR
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC
DIGITAL BOARD
SIZE D
MODEL 7002
NO 7002-106
ECO 23047
REV D10
DRAWN CB
APPROVED CC/MS
DATE 5/17/01
PAGE 2 OF 4


BIT81
R100
10K
J1003
VR102
4.7V
CR101
C161
0.1UF
GET
R123
4.7K
+5V
U102
75160
C108
0.01UF
U106
9914A
ACCRQ/
CE/
LWR/
R/W*
AB(1:19)
IRQ
DB(0:15)
CLKO/4
/SYSRST
U104
74HCT02
U101
75161
C119
C107
BDAV
BNRFD
BNDAC
BREN
VR101
4.7V
CR100
C162
IEEE
* - NOT INSTALLED
CR100, CR101,
VR101, VR102
C161,C162
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
TITLE
SCHEMATIC
DIGITAL BOARD
SIZE D
MODEL 7002
NO 7002-106
ECO 23047
REV D10
DRAWN CB
APPROVED CC/MS
DATE 5/17/01
PAGE 3 OF 4

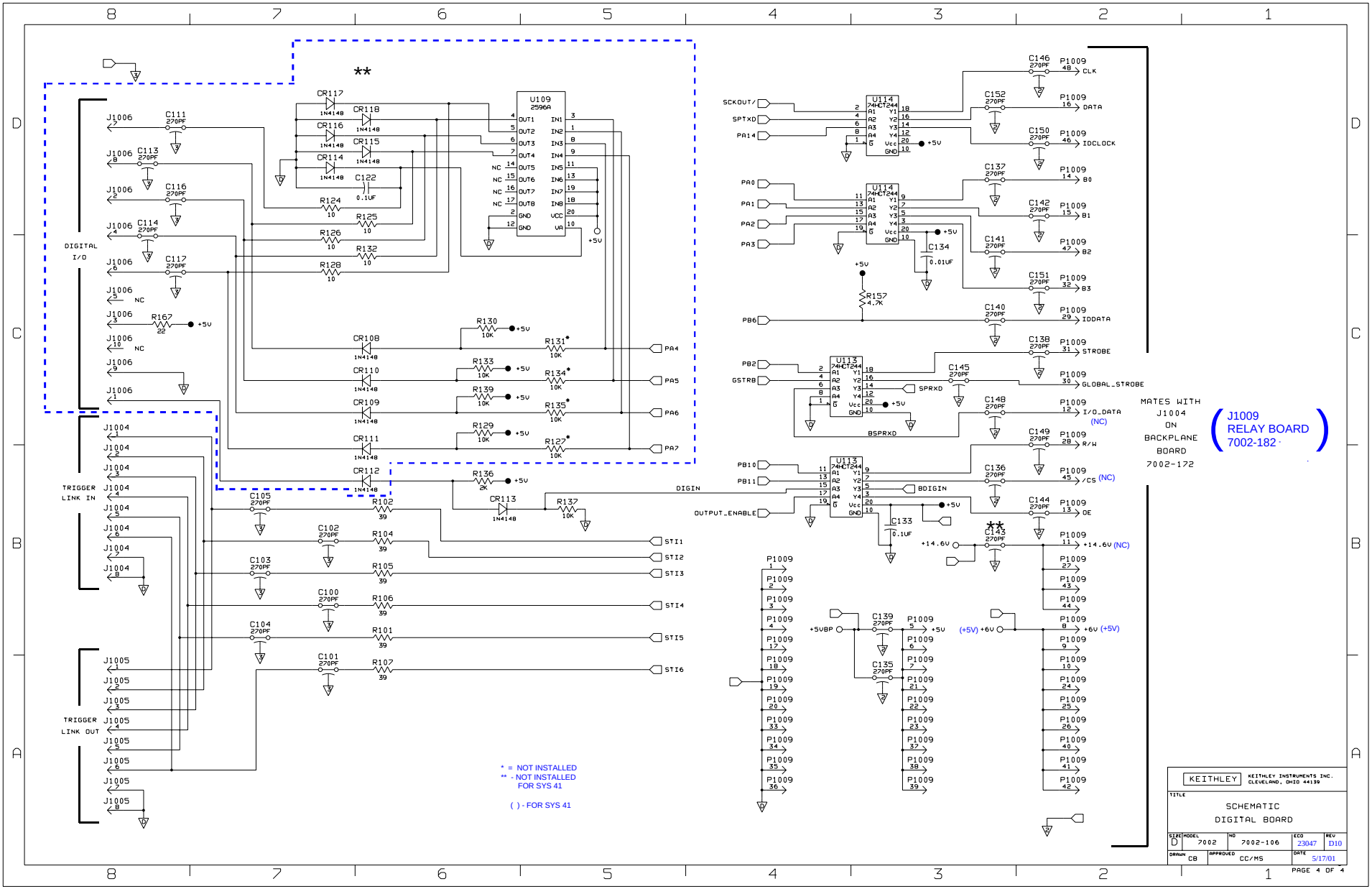

DIGITAL I/O
TRIGGER LINK IN
TRIGGER LINK OUT
U109 2596A
U114 74HCT244
U113 74HCT244
CR117 CR118 CR116 CR115 CR114 1N4148
C122 0.1UF
R124 R125 R126 R132 R128 10
R167 22
R130 R131 R133 R134 R139 R135 R129 R127 10K
R136 2K
R137 10K
CR108 CR110 CR109 CR111 CR112 CR113
C105 C102 C103 C100 C104 C101 270PF
R102 R104 R105 R106 R101 R107 39
STI1 STI2 STI3 STI4 STI5 STI6
DIGIN
OUTPUT_ENABLE
SCKOUT/
SPTXD
PA14
PA0 PA1 PA2 PA3
PB6
PB2
GSTRB
PB10
PB11
SPRXD
BSPRXD
BDIGIN
C134 0.01UF
C133 0.1UF
R157 4.7K
C146 C152 C150 C137 C142 C141 C151 C140 C138 C145 C148 C149 C136 C144 C143
P1009 CLK DATA IDCLOCK B0 B1 B2 B3 IDDATA STROBE GLOBAL_STROBE I/O_DATA (NC) R/W /CS (NC) OE +14.6V (NC)
C139 C135
+5VBP
(+5V) +6V (+5V)
MATES WITH J1004 ON BACKPLANE BOARD 7002-172
J1009 RELAY BOARD 7002-182
* = NOT INSTALLED
** - NOT INSTALLED FOR SYS 41
( ) - FOR SYS 41
KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139
SCHEMATIC
DIGITAL BOARD
SIZE D MODEL 7002 NO 7002-106 ECO 23047 REV D10
DRAWN CB APPROVED CC/MS DATE 5/17/01
PAGE 4 OF 4

Table 8-3
VFD display board, parts list

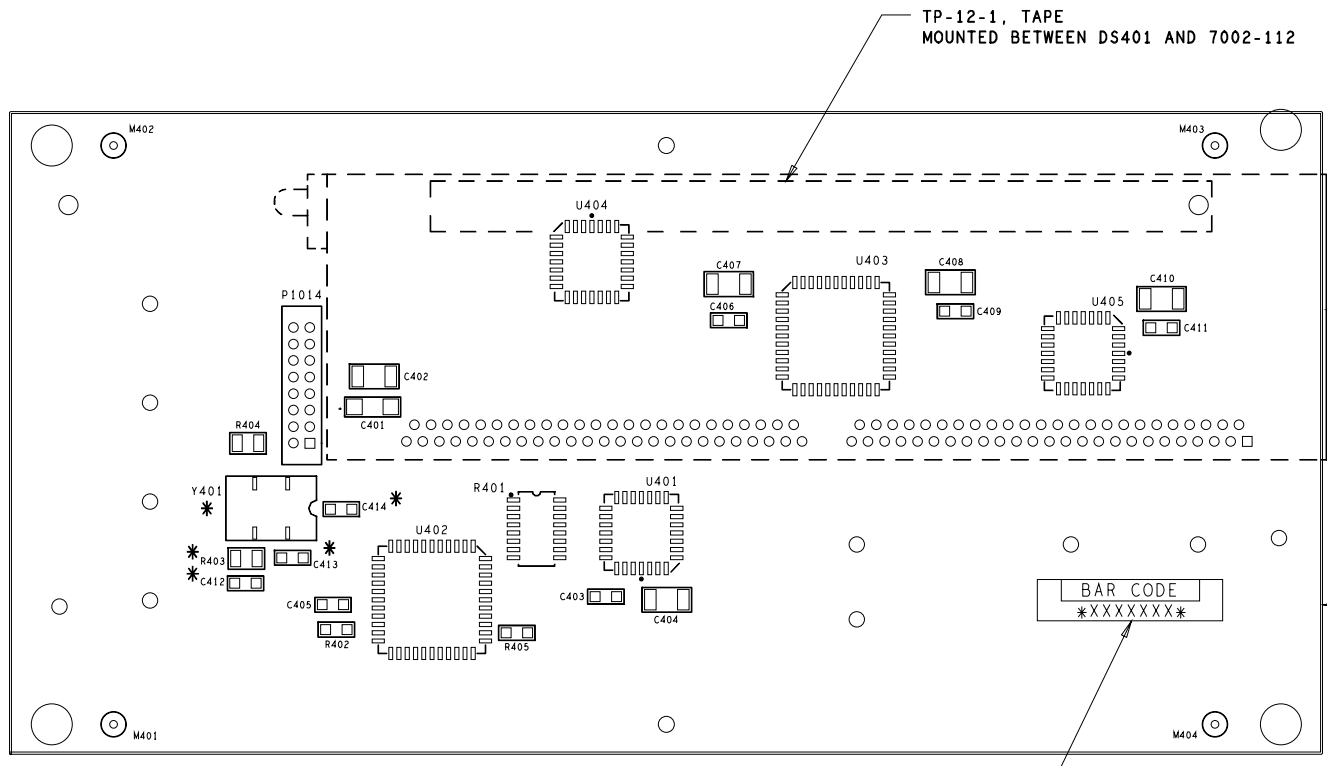
Circuit designation	Description	Keithley part number
C401	CAP, 22µF, 20%, 6.3, TANTALUM (C6032)	C-417-22
C402,404,407,408,410	CAP, .1µF, 20%,100V, CERAMIC (1812)	C-436-.1
C403,405,406,409,411	CAP, .1µF, 20%, 50V, CERAMIC (1206)	C-418-.1
DS401	VACUUM FLUORESCENT DISPLAY	DD-51
	FOR DS401 TAPE, 3/4 WIDE X 1/32 THICK	TP-12-1
P1014	CABLE ASSEMBLY, 14 CONDUCTOR	CA-27-17
R401	RES NET, 15K, 2%, 1.875W (SOMIC)	TF-219-15K
R402	RES, 13K, 5%, 125MW, METAL FILM (1206)	R-375-13K
R404	RES, 100, 5%, 250MW, METAL FILM (1210)	R-376-100
R405	RES, 10K, 5%, 125MW, METAL FILM (1206)	R-375-10K
U401,404,405	IC, LATCHED DRIVERS, UCN-5812EPF-1 (PLCC)	IC-732
U402	PROGRAM	7001-800-**
U403	IC, 32-BIT, SERIAL UCN5818EPF-1 (PLCC)	IC-830

** Order current firmware revision level for LED display.

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NO. 7002-110

LTR.	ECA NO.	REVISION	ENG.	DATE
A		PRELIMINARY		
B	921204	RELEASED	MS	12/10/92
B1	15689	P1014 WAS P1005.	AS	03/14/93
B2	16802	ADDED 7001-800A02.	SZ	11/01/94
C	22278	REVISED ARTWORK FROM REV B TO C. REVISED DISPLAY LAND PATTERN CONFIGURATION.	JBN/AS	02/26/00



* NOT POPULATED: SMT: C412-C414,R403,Y401

NOTE: FOR FURTHER COMPONENT INFORMATION, REFER TO MODEL 7002 PRODUCT STRUCTURE.

7002		
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DIM ARE IN IN. UNLESS OTHERWISE NOTED	DATE 11/20/92	SCALE 3:2	TITLE COMPONENT LAYOUT, DISPLAY BOARD
DIM. TOL. UNLESS OTHERWISE SPECIFIED	DRN MAH	APPR. WJK/MS	
XX=±.01 ANG.=±1 XXX=±.005 FRAC.=±1/64	DO NOT SCALE THIS DRAWING		C NO. 7002-110

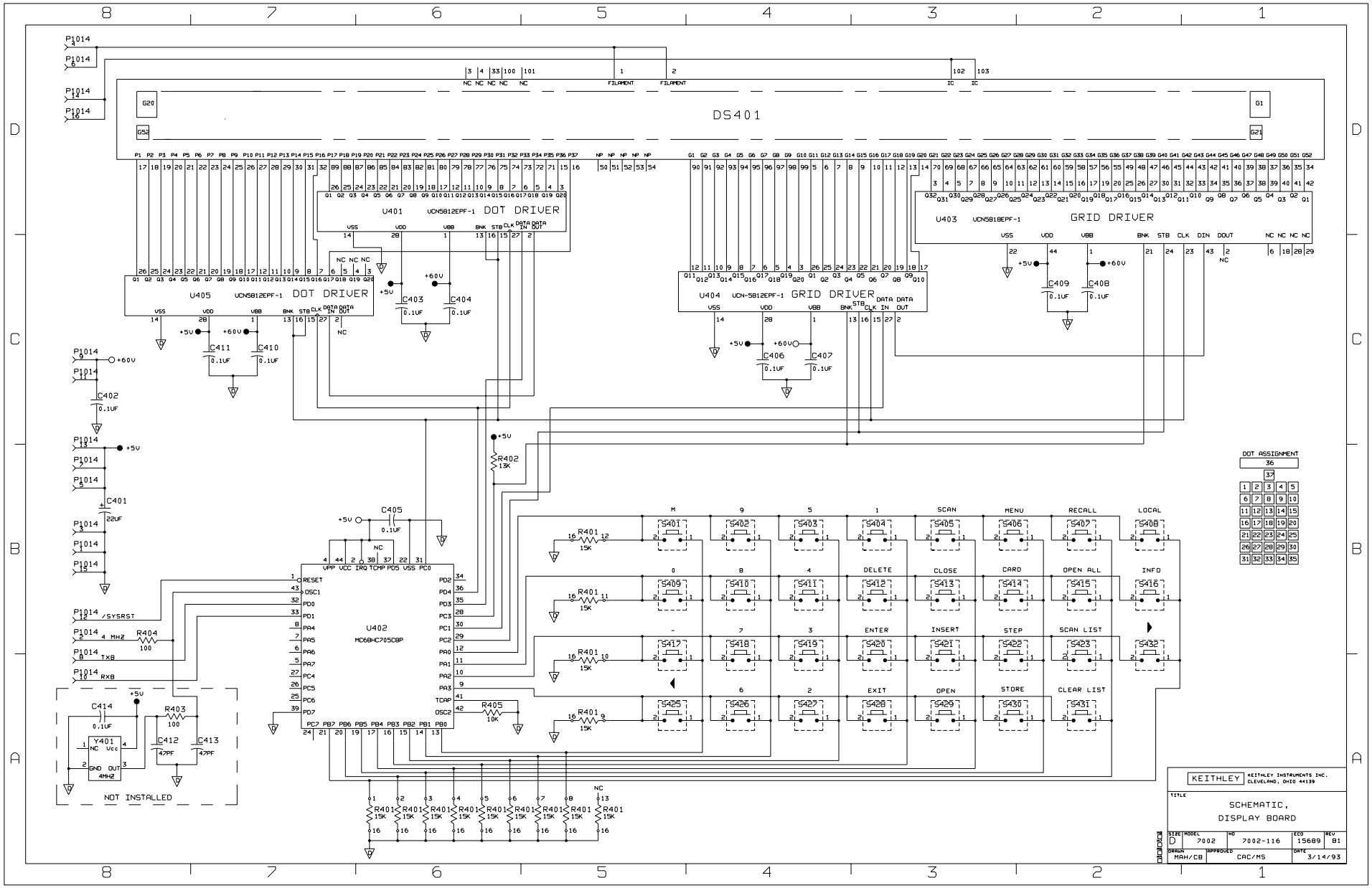

DS401
U401 VCN5812EPF-1 DOT DRIVER
U405 VCN5812EPF-1 DOT DRIVER
U403 VCN5818EPF-1 GRID DRIVER
U404 VCN-5812EPF-1 GRID DRIVER
U402 MC68HC705CBP
NOT INSTALLED
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC,
DISPLAY BOARD
7002
7002-116
15689
B1
MAH/CB
CAC/MS
3/14/93

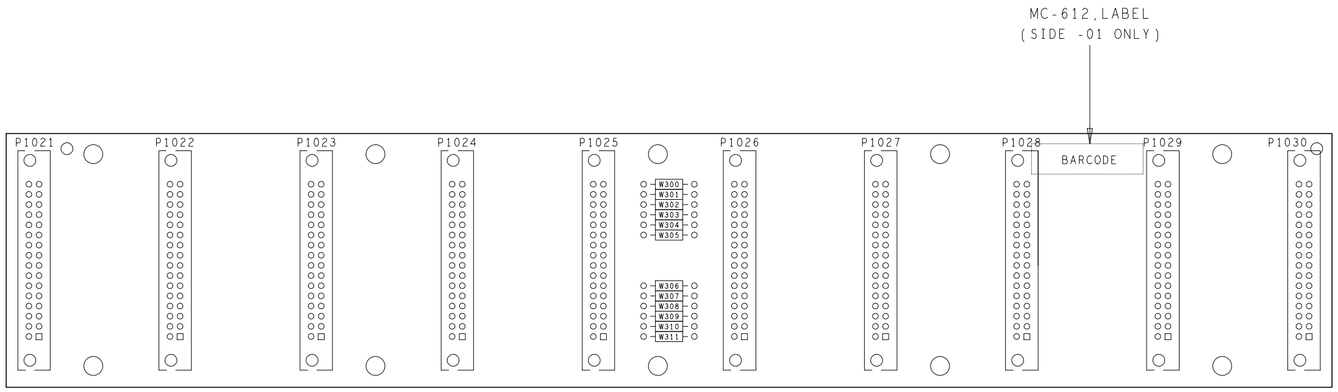
Table 8-4
Backplane extender board, parts list

Circuit designation	Description	Keithley part number
P2002-2011	CONNECTOR, 16-PIN, 2 ROWS	CS-794-1
W300-311	JUMPER	J-15

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NO. 7002-190

LTR.	ECA NO.	REVISION	ENG.	DATE
A		PRELIMINARY		
B	921218	RELEASED	MS	12/18/92
B1	15724	RELOCATED MC-612	AS	3/23/93
B2	25846	ARTWORK CONVERSION-DAZIX TO CADENCE	TA/AS	11/18/01



NOTE: FOR COMPONENT INFORMATION, REFER TO PRODUCT STRUCTURE

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7002		1
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY

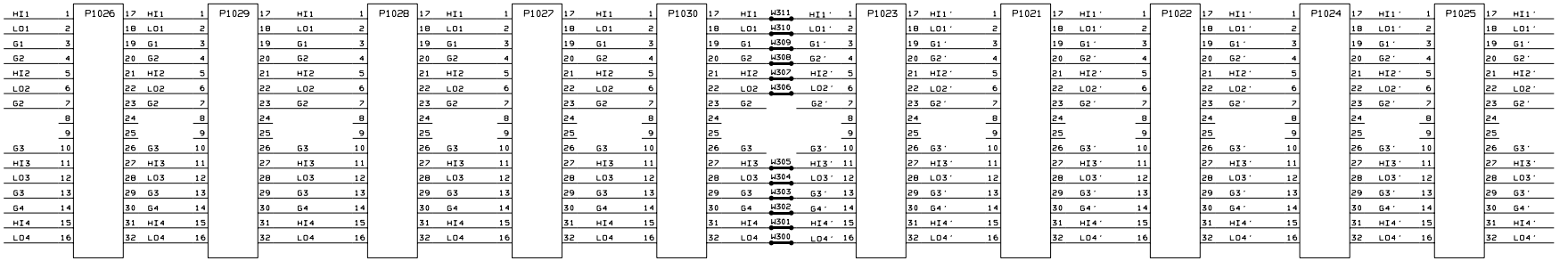
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DIM ARE IN IN. UNLESS OTHERWISE NOTED
DIM. TOL. UNLESS OTHERWISE SPECIFIED
XX=±.01 ANG.=±1
XXX=±.005 FRAC.=±1/64

DATE 8/17/92 SCALE 1:1
DRN CB APPR. WJK/MS
DO NOT SCALE THIS DRAWING

TITLE COMPONENT LAYOUT, BACKPLANE EXTENDER BOARD

C NO. 7002-190



KEITHLEY — KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139

TITLE

SCHEMATIC,

BACKPLANE EXTENDER BOARD

SIZE	MODEL	NO	ECO	REV
D	7002	7002-196	921218	B

DRAWN	APPROVED	DATE
CB		12/15/92

Table 8-5
LED display board, parts list

Circuit designation	Description	Keithley part number
C501,502	CAP, 33ρF, 10%, 100V, CERAMIC (1206)	C-451-33P
C503-505, 509-515	CAP, .1µF, 20%, 50V, CERAMIC (1206)	C-418-.1
C516	CAP, 10µF, 20%, 25V, TANTALUM (D7243)	C-440-10
CR501,502	DIODE, DUAL SWITCHING, BAV99L (SOT-23)	RF-82
DS501-916	PILOT LIGHT	PL-92-1
J1015	CONN, BERG 4-PIN	CS-724-4
P1013	CABLE ASSEMBLY	CA-32-7B
Q501-511	TRANS, N-MEGAFET, RFD 14N05LSM (D-PAK)	TG-267
R501-505	RES NET, 150, 2%, 1.875W (SOMIC)	TF-218-150
R506	RES, 10M, 5%, 125MW, METAL FILM (1206)	R-375-10M
R508-510	RES, 10K, 5%, 125MW, METAL FILM (1206)	R-375-10K
R511,512	RES, 100, 5%, 125MW, METAL FILM (1206)	R-375-100
RT501	THERMISTOR	RT-16
U502	PROGRAM	7002-803-**
U505-509	IC, 8-BIT, SERIAL-INPUT, UCN5895EP PLCC	IC-879
U510	IC, DUAL D-TYPE F/F, 74HCT74 (SOIC)	IC-891
U511	IC, HEX INVERTERS, 74HCT04 (SOIC)	IC-880
Y501	CRYSTAL, 4MHZ	CR-36-4M

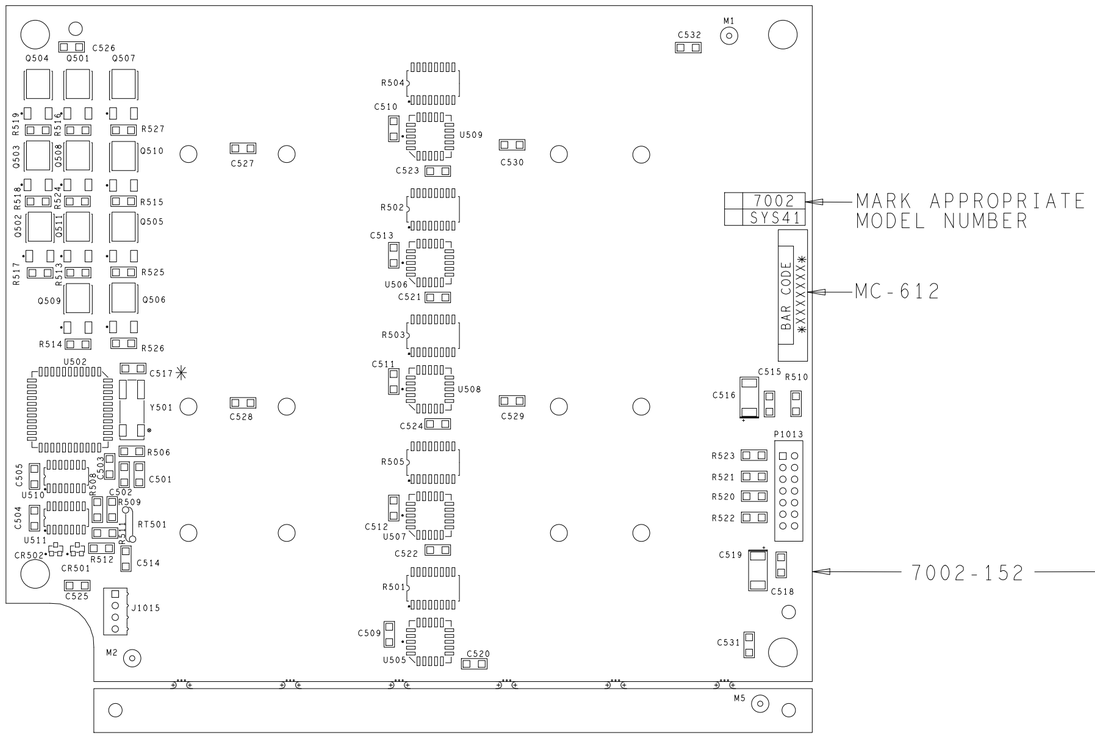
** Order current firmware revision level for LED display.

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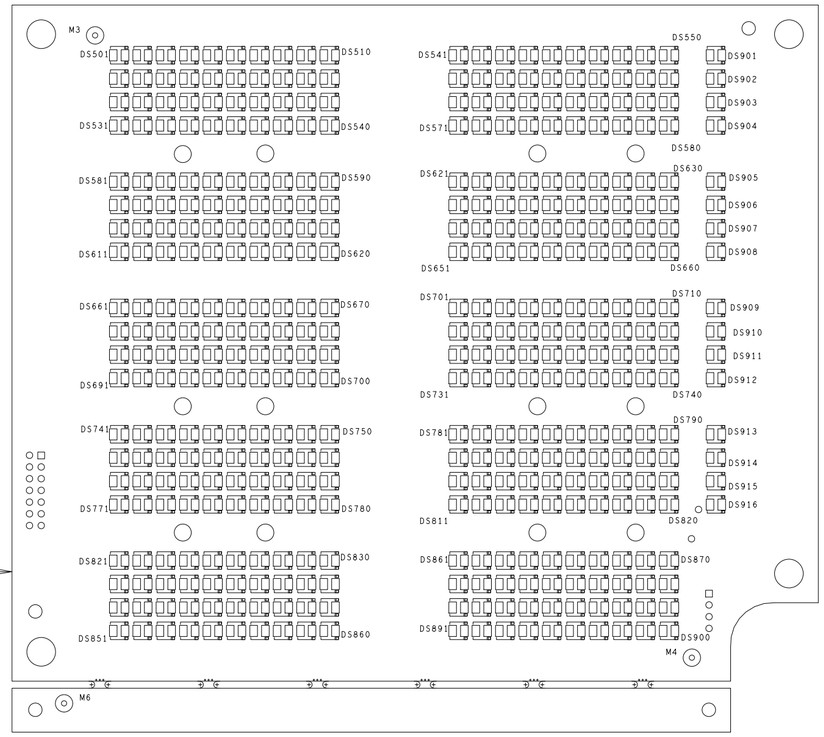
NO. 7002-150

LTR.	ECA NO.	REVISION	ENG.	DATE
E	26043	CONVERTED FROM DAZIX TO CADENCE ARTWORK CHANGED FROM REVD TO E ADDED CHECK BOX FOR MODELS	ELS	5/31/01

PRIMARY SIDE COMPONENTS (SIDE -04)



SECONDARY SIDE COMPONENTS (SIDE -01)



* DO NOT POPULATE: SMT: C517

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NOTE: FOR COMPONENT INFORMATION REFER TO PRODUCT STRUCTURE

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DIM ARE IN IN. UNLESS OTHERWISE NOTED
DIM. TOL. UNLESS OTHERWISE SPECIFIED
XX=±.01 ANG.=±1
XXX=±.005 FRAC.=±1/64
DO NOT SCALE THIS DRAWING

DATE 6/19/92 | SCALE 1:1
DRN MAH | APPR. WK/MS

TITLE COMPONENT LAYOUT, LED DISPLAY BOARD

C NO. 7002-150



KEITHLEY — KEITHLEY INSTRUMENTS INC., CLEVELAND, OHIO 44139

TITLE: SCHEMATIC, LED DISPLAY BOARD

SIZE	MODEL	NO	ECO	REV
D	7002	7002-156	18506	D1

DRAWN	APPROVED	DATE
MAH	CAC/MS	4/1/96

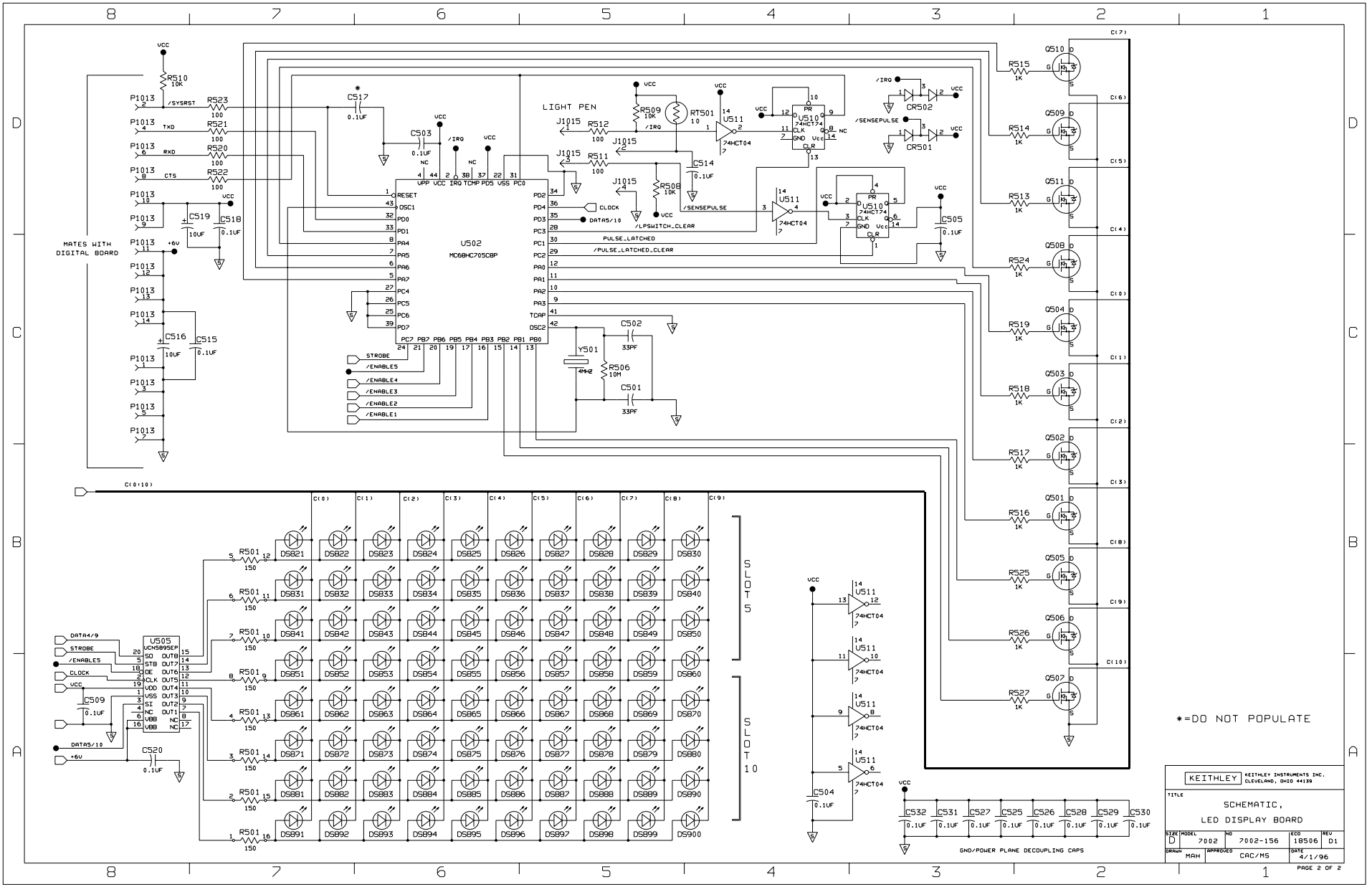

LIGHT PEN
MATES WITH DIGITAL BOARD
U502
MC68HC705C8P
U505
VCM5895EP
U510
74HCT74
U511
74HCT04
CR501
CR502
Y501
4MHZ
/SYSRST
TXD
RXD
CTS
/IRQ
/SENSEPULSE
/LPSWITCH_CLEAR
PULSE_LATCHED
/PULSE_LATCHED_CLEAR
CLOCK
DATA5/10
STROBE
/ENABLE5
/ENABLE4
/ENABLE3
/ENABLE2
/ENABLE1
DATA4/9
/ENABLES
SLOT 5
SLOT 10
*=DO NOT POPULATE
GND/POWER PLANE DECOUPLING CAPS
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139
SCHEMATIC,
LED DISPLAY BOARD
7002
7002-156
18506
D1
MAH
CAC/MS
4/1/96
PAGE 2 OF 2

Table 8-6
Miscellaneous parts list

Circuit designation	Description	Keithley part number
	DIGITAL SHIELD, BOTTOM	7002-310B
	POWER SUPPLY	PS-30-1B
	REAR FOOT	FE-21A
	SHIELD	706-312
	DECORATIVE STRIP	7002-318A
	MOUNTING RAIL	7002-316A
	CHOKE	CH-54
	BOTTOM COVER	7002-314A
	LENS	7002-305-2A
	SWITCHPAD	7002-312B
	CONNECTOR	CS-276
	LENS, VFD	7002-322A
	LENS	7002-305-1A
	FRONT BEZEL	7002-315A
	BACKPLANE BRACKET	7002-311A
	FRONT FOOT ASSEMBLY	706-317
	SIDE PANEL	7002-317A
	TOP COVER	7002-313A
	OVERLAY	7002-303B
	CARD GUIDES TO RAILS FASTENER	FA-151-1
	FOR BNC CONN LUG	LU-100
	FOR BOTTOM DIGITAL SHIELD TIE MOUNT	CC-47
	FOR CA-114-1 CABLE CLAMP	CC-62
	FOR CA-114-1 SCREWLOCK, FEMALE	CS-725
	FOR IEEE CONN CONNECTOR, HARDWARE KIT	CS-713
	FOR LF-6-1 ASS'Y LUG	LU-88
	FOR P1008 (LINE FILTER WIRES) CONN, FEMALE, 3 PIN, SHAPELESS	CS-287-3
	FOR P1015 (LIGHT PEN WIRES) CONNECTOR	CS-236
	FOR POWER SUPPLIES FOOT, BLACK MOLDED POLY	FE-12
	FOR POWER SUPPLIES SAFETY COVER	7002-330A
	FOR POWER SUPPLY WIRES CABLE CLAMP	CC-50-1
	FOR SW-466 POWER BUTTON	7002-323-1A
	FOR WIRES AROUND CHOKE CABLE CLAMP	CC-38-4
J1001	CONN, AC RECEPTACLE (LINE FILTER)	LF-6-1
J1002	CONNECTOR, 4-PIN MALE	CS-458
J1016,1017	CONNECTOR, BNC	CS-249
J1018	CABLE ASSEMBLY	CA-114-1A
P1007	(2-POWER SUPPLY) CONN, MOLEX HEADER	CS-716-3
P1007	(FOR BNC WIRES) CONNECTOR, HOUSING	CS-638-3
P1010	(POWER SUPPLY WIRES) CONNECTOR, HOUSING	CS-716-5
P1011,1012	(POWER SUPPLY WIRES) CONNECTOR, FEMALE, 4-PIN, SHAPELESS	CS-716-4
P1015	(LIGHT PEN WIRES) CONN, BERG HOUSING	CS-638-4
	PS-30-1 TO BACKPLANE BRACKET STANDOFF, PLASTIC	FA-239-1
	LINE CORD	CO-7

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A

Interface Function Codes

The interface function codes, which are part of the IEEE-488 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Model 7002 are listed in Table A-1. The codes define Model 7002 capabilities as follows:

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

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

T (Talker Function) — The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities (T5) exist only after the instrument has been addressed to talk.

L (Listener Function) — The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities (L4) of the instrument exist only after it has been addressed to listen.

SR (Service Request Function) — SR1 defines the ability of the instrument to request service from the controller.

RL (Remote-Local Function) — RL1 defines the ability of the instrument to be placed in the remote or local modes.

PP (Parallel Poll Function) — The instrument does not have parallel polling capabilities (PP0).

DC (Device Clear Function) — DC1 defines the ability of the instrument to be cleared (initialized).

DT (Device Trigger Function) — DTI defines the ability of the Model 7002 to have trigger capabilities.

C (Controller Function) — The instrument does not have controller capabilities (C0).

TE (Extended Talker Function) — The instrument does not have extended talker capabilities (TE0).

LE (Extended Listener Function) — The instrument does not have extended listener capabilities (LE0).

E (Bus Driver Type) — The instrument has open-collector bus drivers (E1).

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Table A-1
Model 7002 interface function codes

Code	Interface function
SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T5	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service Request capability
RL1	Remote/Local capability
PP0	No Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No Controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capability
LE0	No Extended Listener capability

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B

Controller Programs

The following programs have been supplied as a simple aid to the user and are not intended to suit specific needs. Each program allows you to send a command message to the instrument and obtain and display a response from the instrument for query commands.

Programs for the following controllers are included:

- A BASIC program for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface (Keithley Model PC-488-CEC IEEE-488 Interface Card).
- A BASIC program for an IBM PC/XT/AT with IOtech Driver488 Software.
- A BASIC program for a Hewlett-Packard Model 9000 Series 200/300 computer.
- A program written with the ASYST software package (available from Keithley Instruments) for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface.
- A BASIC program for an IBM PC/XT/AT with a National GPIB PC Interface.

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IBM PC/XT/AT with Capital Equipment Corporation PC<>488 Interface (Keithley PC-488-CEC)

Introduction

General information about controlling a Model 7002 with an IBM PC/XT/AT computer and Capital Equipment Corporation PC<>488 interface is given here. Refer to the CEC PC<>488 Programming and Reference Manual for complete information.

Initializing the system

The first step in any program is to initialize the system using the INITIALIZE routine. This routine sets the primary IEEE-488 bus address of the PC<>488, specifies the type of controller to be used, and sends an interface clear (IFC) to the other devices on the bus.

After booting up the IBM using DOS and entering BASICA, the statements of Program 1 can be used at the start of any program to initialize the system.

Line 30 sets the address of the PC<>488 to 21, however, any other valid address could be used as long as it does not conflict with the address of any other device on the bus.

Interface basic programming statements

This paragraph covers the PC<>488 statements that are essential to Model 7002 operation. A partial list of programming statements is contained in Table B-1. The IBM BASIC CALL statement is used to execute the desired action. Before a CALL routine can be used, BASIC needs to know the offset address of the routine. In the table, the first statement of each programming sequence defines the offset address of the CALL routine.

Example program

The following program sends a command message from an IBM PC/XT/AT computer to the Model 7002 and displays the response to a query on the CRT. The computer must be equipped with a CEC interface card and DOS 2.0 (or later revision) operating system.

Directions

1. Using the front panel MENU key, set the primary IEEE-488 address of the Model 7002 (GPIB selection) to 7.

2. With the power off, connect the Model 7002 to the IEEE-488 interface card installed in the IBM computer.

3. Type in BASICA on the computer keyboard to get into interpretive BASIC language.

4. Enter the lines of Program 2 using the return key after each line.

5. Run the program and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

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Table B-1
BASIC statements necessary to send bus commands

Action	**PC<>488 statements**
Transmit command string (CMD$) to device 7.	SEND =9 ADDRESS%=7 CALL SEND(ADDRESS%,CMD$,STATUS%)
Obtain string from device 7.	ENTER=21 ADDRESS%=7 RESPONSE$=SPACE$(50) CALL ENTER(RESPONSE$,LENGTH%,ADDRESS%,STATUS%)
Send GTL to device 7.	TRANSMIT=3 CMD$=”LISTEN 7 GTL” CALL TRANSMIT(CMD$,STATUS%)
Send SDC to device 7.	TRANSMIT=3 CMD$=”LISTEN 7 SDC” CALL TRANSMIT(CMD$,STATUS%)
Send DCL to all devices.	TRANSMIT=3 CMD$=”LISTEN 7 DCL” CALL TRANSMIT(CMD$,STATUS%)
Send remote enable.	TRANSMIT=3 CMD$=”REN LISTEN 7” CALL TRANSMIT(CMD$,STATUS%)
Serial poll device 7.	SPOLL=12 ADDRESS%=7 CALL SPOLL%(ADDRESS%,POLL%,STATUS%)

```
10  DEF=SEG&HC400                    ‘ Memory address.
20  INITIALIZE=0                     ‘ Offset address of routine.
30  MY.ADDRESS%=21                   ‘ Set PC<>488 address.
40  CONTROLLER%=0                    ‘ Set for system control.
50  CALL INITIALIZE (MY.ADDRESS%,    ‘ Initialize system.
    CONTROLLER%)
```

Program 1

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```
10  DEF SEG=&HC400                    ‘ Memory address.
20  INITIALIZE=0                      ‘ Define call offsets.
30  SEND=9:ENTER=21
40  MY.ADDRESS%=21                    ‘ Set PC<>488 address.
50  INST.ADDRESS%=7                   ‘ Set 7002 address.
60  CONTROLLER%=0                     ‘ Set for system control.
70  CALL INITIALIZE (MY.ADDRESS%,     ‘ Initialize system.
    CONTROLLER%)
80  LINE INPUT “ENTER COMMAND         ‘ Prompt for command message.
    MESSAGE “;CMD$
90  CALL SEND (INST.ADDRESS%, CMD$    ‘ send command message.
    STATUS%)
100 IF RIGHT$(CMD$, 1) <> “?”         ‘ Test for query. If command is a
    THEN GOTO 80                       query, goto 80.
110 RESPONSE$=SPACE$(80)              ‘ Make room for data.
120 CALL ENTER (RESPONSE$,LENGTH%,    ‘ Get response to query from 7002.
    INST.ADDRESS%,STATUS%)
130 PRINT RESPONSE$                   ‘ Display response to query.
140 GOTO 80                           ‘ Display response to query.
150 END
```

Program 2

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IBM PC/XT/AT or PS/2 with IOtech Driver488 Software

Introduction

Driver488 software is an IEEE-488 driver for IBM PC and compatible computers. When combined with an IEEE-488 interface board, the package can control devices from languages including BASIC, Pascal, Fortran, and C. Driver488 software is compatible with:

- IOtech GP488B or GP488/2 boards
- National Instruments GPIB-PC, PCII, PCIIA, or PCIII boards
- Capital Equipment #01000-00300 board
- IBM GPIB Adapter

The following GW-BASIC program sends a command message to the Model 7002 and displays the instrument response for queries on the CRT. The computer must be equipped with an IEEE-488 interface board, the DOS 3.00 (or later) operating system, and a language with DOS I/O capability. Driver488 controller software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 7002 to 7.
2. With power off, connect the Model 7002 to the IEEE-488 interface installed in the IBM computer.
3. Type in GWBASIC on the computer and get into the Microsoft interpretive BASIC language.
4. Enter the lines below using the return key after each line.
5. Run the program and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1          ' Open file for output.
20  IOCTL#1,"BREAK"                               ' Reset
30  PRINT#1,"RESET"
40  OPEN "\DEV\IEEEIN" FOR INPUT AS #2            ' Open file for input.
50  PRINT#1, "FILL ERROR"                         ' Enable SEQUENCE error detect.
60  LINE INPUT "ENTER COMMAND MESSAGE ";A$        ' Prompt for an get commands.
70  IF LEN(A$)=0 THEN 140                         ' Check for null.
80  PRINT #1,"OUTPUT 07;"+A$                      ' Send commands.
90  IF RIGHT$(A$, 1)<> "?" THEN GOTO 60           ' Check for query.
100 PRINT #1,"ENTER 07"                           ' Address 7002 to talk.
110 LINE INPUT#2,B$                               ' Get response.
120 PRINT B$                                      ' Display response message.
130 goto 60                                       ' Repeat.
140 END
```


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Hewlett-Packard Model 9000 Series 200/300

Introduction

The following program sends a command message to the Model 7002 from a Hewlett-Packard Model 9000 Series 200/300 computer and displays the response to queries on the computer CRT. The computer must be equipped with HP BASIC 4.0.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary IEEE-488 address of the Model 7002 to 7.

2. With the power off, connect the Model 7002 to the IEEE-488 interface card installed in the HP computer.

3. Enter the lines in the program below, using the ENTER/ RETURN key after each line.

4. Press the RUN key and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  DIMA$[50], B$[50]
20  remote 707                                  ! Place 7002 in remote.
30  LINPUT “ENTER COMMAND MESSAGE”, A$          ! Prompt for command.
40  OUTPUT 707; A$                              ! Address 7002 to listen; send command.
50  L=LEN(A$)
60  IF A$[L,L] <> “?” THEN GOTO 30              ! If command is not a query, goto 30.
70  ENTER 707; B$                               ! If query, address 7002 to talk.
80  PRINT B$                                    ! Display response to query command.
90  GOTO 30                                     ! Repeat
100 END
```


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IBM PC/XT/AT or Compatible with CEC PC<>488 Interface and ASYST Software

Introduction

ASYST contains analysis, graphing, and data acquisition software in three integrated modules. Minimum requirements for ASYST include:

- IBM PC/XT/AT or 100% compatible (including PS/2, 386 or 486-based computers in real mode)
- DOS 2.0 (DOS 3.0 or above recommended)
- Intel 8087, 80287, or 80387 math coprocessor
- 640K RAM
- 25-pin parallel port
- Hard disk and one floppy
- IBM CGA, EGA, VGA, or 100% compatible; Hercules monochrome graphics
- LIM (Lotus/Intel/Microsoft) expanded memory is recommended

For this example, an optional software module is required for IEEE-488 interfacing. The computer must also be equipped with a CEC interface card (PC<>488 Model 300 or 310, or 4 × 488).

The ASYST program listed here sends a command string from an IBM computer to the Model 7002 and displays the response for queries on the computer's CRT.

Directions

1. Using the front panel menu, set the primary address of the Model 7002 to 07.

2. With the power off, connect the Model 7002 to the IEEE-488 interface card installed in the IBM computer.

3. Boot ASYST software. Enter the Main Configuration Menu: use the <F2> key from the OK prompt, or select CONFIG from the menu bar.

4. In addition to the usual configuration requirements of ASYST, the GPIB must be configured. From the Overlay Configuration menu, select GPIB from the Available Overlays list; then select GPIB Master and Type 1 NEC GPIB driver from the pop-up menu.

5. From the GPIB Configuration menu, select a bus number, the board number for a Capital Equipment PC<>488 (NEC uPD7210 type), a primary address (0), the hexadecimal I/O address (2B8, also known as the memory address), and an unused interrupt line.

6. Save your changes and return to the OK prompt or the menu bar.

7. Use the command line editor to enter the example program. From the OK prompt, type EDIT 7002.DMO; from the menu bar, select EDIT and type 7002.DMO. Save the program and exit the editor.

8. When prompted, load the program with the L key, or type LOAD 7002.DMO from the OK prompt.

9. When the program loads properly, type MAIN from the OK prompt to start execution.

10. Type in the desired command string at the "Enter command string:" prompt. For example, to close multiplexer channels, type in :CLOS (@1!1:1!5) and press the return key. The Model 7002 will show closed channels on card 1. To query for closed channels, type in :CLOS:STAT? and press the return key. The Model 7002 closed channel list will then appear on the computer display.

11. Type <Control-Break> to exit the program loop of 7002.DMO and return to the OK prompt. The program-defined words can be removed from the ASYST dictionary by typing FORGET 7002.

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```
BUS.INIT                                    \ Initialize bus
SEND.INTERFACE.CLEAR                        \ TAKE CONTROL OF BUS
REMOTE.ENABLE.ON                            \ Allow remote operation
SYNCHRONOUS.GPIB                            \ Make sure ASYST is in sync. mode
?GPIB.DEVICES                               \ List controller parameters
07 GPIB.DEVICE 7002                         \ Set 7002 address and name
   EOI.ON                                   \ Enable end or identify
   EOS.ON                                   \ Enable end of string terminator
   10 EOS.CHARACTER                         \ Use LF terminator
   1000 TIMEOUT                             \ Set timeout for 1sec
?GPIB.DEVICE                                \ List 7002 parameters
100 STRING COMMAND                          \ Allocate 100 bytes for user input
100 STRING RESPONSE                         \ Allocate 100 bytes for 7002 response

:GET.OUTPUT                                 \ Definition for 7002 output
   RESPONSE GPIB.READ                       \ Get response
   CR RESPONSE "TYPE                        \ Display response
;

: GET.INPUT                                 \ Definition for user input
   CR ." Enter command string: "            \ Prompt user
   "INPUT COMMAND ":=                       \ Get commands
   "?" COMMAND "WITHIN                      \ Test for query
   IF 7002                                  \ If query, make 7002 current device
      COMMAND GPIB.WRITE                    \ Send commands to 7002
      GET.OUTPUT                            \ Get response from 7002
   ELSE 7002                                \ If not query, make 7002 current device
      COMMAND GPIB.WRITE                    \ Send commands to 7002
   THEN
;

: MAIN                                      \ Definition for main program
  BEFIN                                     \ Start loop
  ME                                        \ Make controller current device
  GET.INPUT                                 \ Get commands from user
  AGAIN                                     \ Return for more commands
;                                           \ <Control-Break> to exit
```


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IBM PC/XT/AT with National GPIB PC Interface

Introduction

The following program sends a command message to the Model 7002 from an IBM PC/XT/AT computer and displays a response message on the CRT. The computer must be equipped with the National GPIB PC Interface and the DOS 2.00 (or later revision) operating system. Interface software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 7002 to 7.
2. With the power off, connect the Model 7002 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Place the interface software disk in the default drive, type LOAD “DECL”, and press the return key.
5. Add the lines below to lines 1-6 which are now in memory. Modify the address in lines 1 and 2, as described in the National instruction manual.
6. Run the program and type in the desired command message. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  CLS                                          Clear screen.
20  NA$=”GPIB0”:CALL IBFIND (NA$,BRD0%)          Find board descriptor.
30  NA$=”DEV1”:CALL IBFIND(NA$,M7002%)           Find instrument descriptor.
40  V%=7:CALL IBPAD(M7002%,V%)                   Set primary address to 7.
50  V%=&H102:CALL IBPOKE(BRD0%,V%)               Set timeouts.
60  V%=1:CALL IBSRE(BRD0%,V%)                    Set REN true.
70  INPUT “ENTER COMMAND MESSAGE “:CMD$          Prompt for command.
80  IF CMD$=”EXIT” THEN 160                      See if program is to be halted.
90  IF CMD$+ “ “ THEN 70                         Check for null input.
100 CALL IBWRT (M7002%,CMD$)                     Send command message.
110 IF RIGHT$(CMD$, 1) <> “>” THEN GOTO 70       Check for query command.
120 RD$=SPACE$(100)                              Define reading input buffer.
130 CALL IBRD(M7002%,RD$)                        Address 7002 to talk.
140 PRINT RD$                                    Display message response.
150 GOTO 70                                      Repeat.
160 V%=0:CALL IBONL(M7002%,V%)                   Close the instrument file.
170 CALL IBONL(BRD0%,V%)
180 END
```


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C

ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
0	00	NUL	
1	01	SOH	GTL
2	02	STX	
3	03	ETX	
4	04	EOT	SDC
5	05	ENQ	PPC
6	06	ACK	
7	07	BEL	
8	08	BS	GET
9	09	HT	TCT
10	0A	LF	
11	0B	VT	
12	0C	FF	
13	0D	CR	
14	0E	SO	
15	0F	SI	

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
16	10	DLE	
17	11	DC1	LLO
18	12	DC2	
19	13	DC3	
20	14	DC4	DCL
21	15	NAK	PPU
22	16	SYN	
23	17	ETB	
24	18	CAN	SPE
25	19	EM	SPD
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	

* Message sent or received with ATN true.

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Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	”	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	’	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	’	MLA 12
45	2D	-	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	«	MTA 30
95	5F	_	UNL

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

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Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
96	60	«	MSA 0, PPE
97	61	a	MSA 1, PPE
98	62	b	MSA 2, PPE
99	63	c	MSA 3, PPE
100	64	d	MSA 4, PPE
101	65	e	MSA 5, PPE
102	66	f	MSA6, PPE
103	67	g	MSA 7, PPE
104	68	h	MSA 8, PPE
105	69	i	MSA 9, PPE
106	6A	j	MSA 10, PPE
107	6B	k	MSA 11, PPE
108	6C	l	MSA 12, PPE
109	6D	m	MSA 13, PPE
110	6E	n	MSA 14, PPE
111	6F	o	MSA 15, PPE
112	70	p	MSA 16, PPD
113	71	q	MSA 17, PPD
114	72	r	MSA 18, PPD
115	73	s	MSA 19, PPD
116	74	t	MSA 20, PPD
117	75	u	MSA 21, PPD
118	76	v	MSA 22, PPD
119	77	w	MSA 23, PPD
120	78	x	MSA 24, PPD
121	79	y	MSA 25, PPD
122	7A	z	MSA 26, PPD
123	7B	{	MSA 27, PPD
124	7C	|	MSA 28, PPD
125	7D	}	MSA 29, PPD
126	7E	~	MSA 30, PPD
127	7F	DEL	

* Message sent or received with ATN true. Numbers represent secondary address resulting in MSA (My Secondary Address).

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D

IEEE-488 Bus Overview

Introduction

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

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

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

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

Bus Description

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

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

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type of instrument, any particular device can be a talker only, a listener only, or both a talker and listener.

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

.

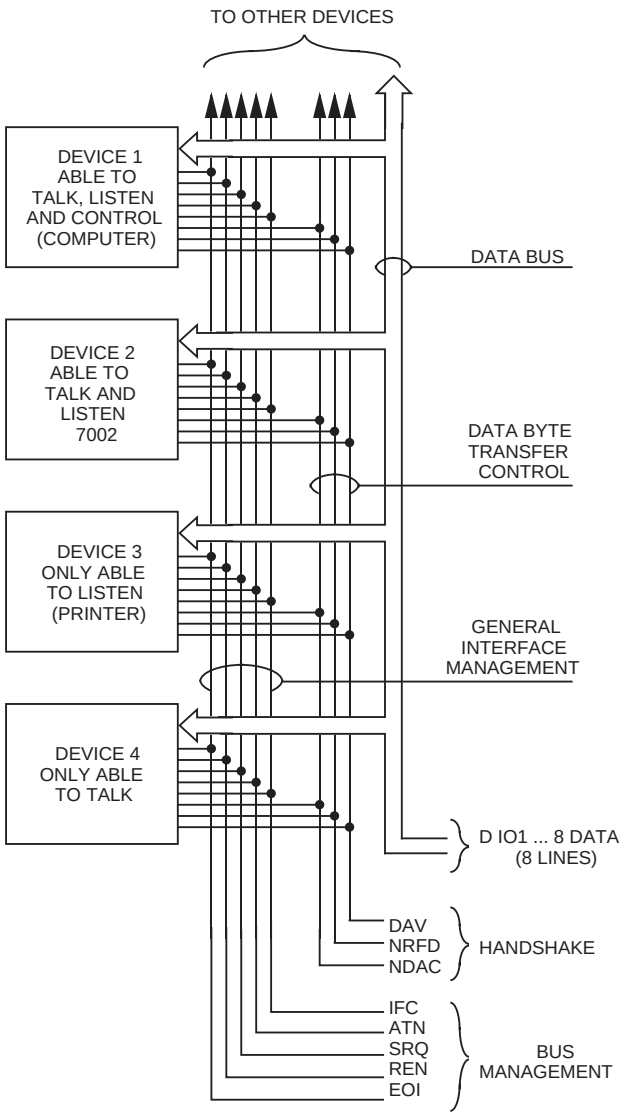


Figure D-1
IEEE-488 bus configuration

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

A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary address. The primary address may have any value between 0 and 31, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by ORing the primary address with $20. For example, if the primary address is 27 decimal ($07), the actual listen address is $27 ($27 = $07 + $20). In a similar manner, the talk address is obtained by ORing the primary address with $40. With the present example, the talk address derived from a primary address of 7 decimal would be $47 ($47 = $07 + $40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of $60-$7F. Note, however, that many devices, including the Model 7002, do not use secondary addressing.

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

Bus Lines

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

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Data lines

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

Bus management lines

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

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

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

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

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

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

Handshake lines

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

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

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

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

NDAC (Not Data Accepted) — NDAC is also controlled by the accepting device. The state of NDAC tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in Figure D-2. Once data is placed on the data lines, the source checks to see that NRFD is high, indicating that all active devices are ready. At the same time, NDAC should be low from the previous byte transfer. If these conditions are not met, the source must wait until NDAC and NRFD have the correct status. If the source is a controller, NRFD and NDAC must be stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

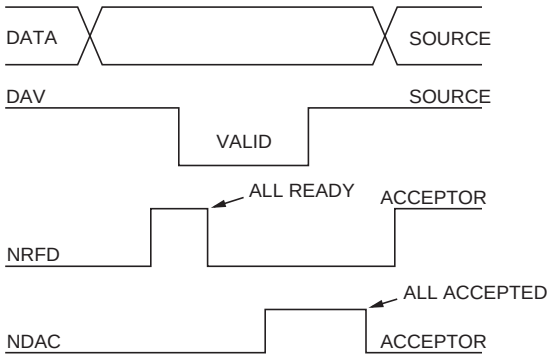


Figure D-2
IEEE-488 handshake sequence

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating to accepting devices that the byte on the data lines is now valid. NRFD will then go low, and NDAC will go high once all devices have accepted the data. Each

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device will release NDAC at its own rate, but NDAC will not be released to go high until all devices have accepted the data byte.

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

Bus Commands

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

1. Uniline Commands — Sent by setting the associated bus lines true. For example, to assert REN (Remote Enable), the REN line would be set low (true).
2. Multiline Commands — General bus commands which are sent over the data lines with the ATN line true (low).
3. Common Commands — Commands that are common to all devices on the bus; sent with ATN high (false).
4. SCPI Commands — Commands that are particular to each device on the bus; sent with ATN (false).

These bus commands and their general purpose are summarized in Table D-1.

Table D-1
IEEE-488 bus command summary

Command type	**Command**	**State of ATN line**	**Comments**
Uniline	REN (Remote Enable)	X	Set up devices for remote operation.
	EOI	X	Marks end of transmission.
	IFC (Interface Clear)	X	Clears interface.
	ATN (Attention)	Low	Defines data bus contents.
	SRQ	X	Controlled by external device.
Multiline Universal	LLO (Local Lockout)	Low	Locks our local operation.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Returns device to local.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from the bus.
	UNT (Untalk)	Low	Removes any talkers from the bus.
Common	—	High	Programs IEEE-488.2 compatible instruments for common operations.
SCPI	—	High	Programs SCPI compatible instruments for particular operations.

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Uniline commands

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

REN (Remote Enable) — REN is sent to set up instruments on the bus for remote operation. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the LOCAL button (if the device is so equipped) may be locked out when REN is true. Generally, REN should be sent before attempting to program instruments over the bus.

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

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

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

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

Universal multiline commands

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

LLO (Local Lockout) — LLO is sent to the instrument to lock out the LOCAL key and thus all their front panel controls.

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

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

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

Addressed multiline commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands. Both the commands and the address preceding it are sent with ATN true.

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

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

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

Address commands

Addressed commands include two primary command groups and a secondary address group. ATN is true when these commands are asserted. The commands include:

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LAG (Listen Address Group) — These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with $20.

TAG (Talk Address Group) — The talk commands are derived from the primary address by ORing the address with $40. Talk commands are used to address devices to talk.

SCG (Secondary Command Group) — Commands in this group provide additional addressing capabilities. Many devices (including the Model 7002) do not use these commands.

Unaddress commands

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

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

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

Common commands

Common commands are commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a common operation, such as reset. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

SCPI commands

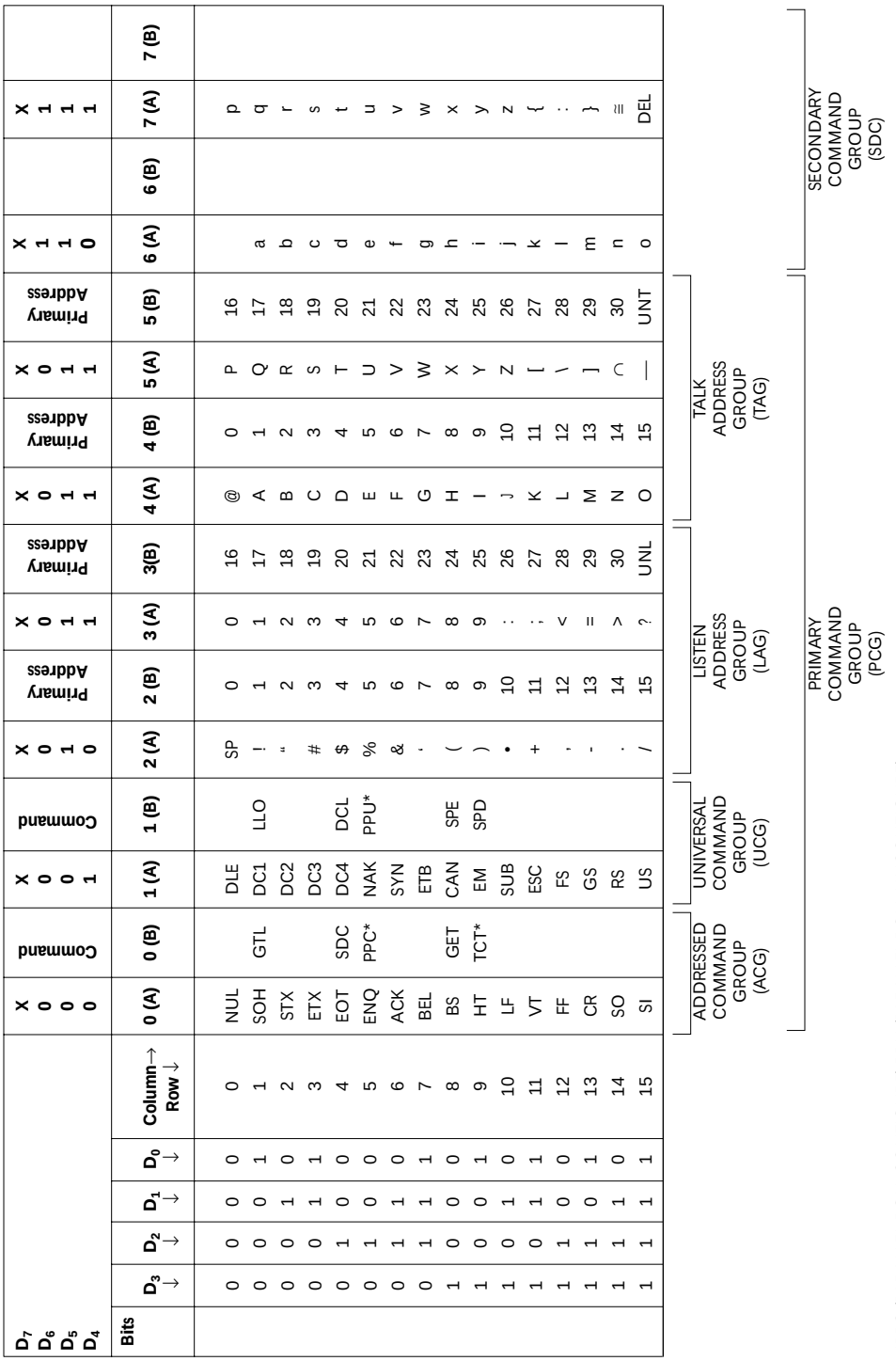
SCPI commands are commands that are particular to each device on the bus. These commands are designated by the instrument manufacturer, and are based on the instrument model defined by the Standard Commands for Programmable Instruments (SCPI) Consortium's SCPI standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a particular operation, such as setting a range or closing a relay. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

Command codes

Command codes for the various commands that use the data lines are summarized in Figure D-3. Hexadecimal and the decimal values for the various commands are listed in Table D-2.

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D7 D6 D5 D4	Bits	D3 →	D2 →	D1 →	D0 →	Column → Row ↓	X 0 0 0 0	0 (A)	Command	X 0 0 0 1	1 (A)	Command	X 0 1 0	2 (A)	Primary Address	X 0 1 1	3 (A)	Primary Address	X 1 0 0	4 (A)	Primary Address	X 1 0 1	5 (A)	Primary Address	X 1 1 0	6 (A)	X 1 1 1	7 (A)	7 (B)
		0	0	0	0	0		NUL			DLE			SP		0	0		@	0		P	16			p	
		0	0	0	1	1		SOH		GTL	DC1	LLO		!		1	1		A	1		Q	17		a	q		
		0	0	1	0	2		STX			DC2			"		2	2		B	2		R	18		b	r		
		0	0	1	1	3		ETX			DC3			#		3	3		C	3		S	19		c	s		
		0	1	0	0	4		EOT		SDC	DC4	DCL		$		4	4		D	4		T	20		d	t		
		0	1	0	1	5		ENQ		PPC*	NAK	PPU*		%		5	5		E	5		U	21		e	u		
		0	1	1	0	6		ACK			SYN			&		6	6		F	6		V	22		f	v		
		0	1	1	1	7		BEL			ETB			'		7	7		G	7		W	23		g	w		
		1	0	0	0	8		BS		GET	CAN	SPE		(		8	8		H	8		X	24		h	x		
		1	0	0	1	9		HT		TCT*	EM	SPD		)		9	9		I	9		Y	25		i	y		
		1	0	1	0	10		LF			SUB			•		10	:		J	10		Z	26		j	z		
		1	0	1	1	11		VT			ESC			+		11	;		K	11		[	27		k	{		
		1	1	0	0	12		FF			FS			,		12	<		L	12		\	28		l	:		
		1	1	0	1	13		CR			GS			-		13	=		M	13		]	29		m	}		
		1	1	1	0	14		SO			RS			.		14	>		N	14		∩	30		n	≅		
		1	1	1	1	15		SI			US			/		15	?		O	15		—	UNT		o	DEL		

Figure D-3
Command codes

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Table D-2
Hexadecimal and decimal command codes

Command	Hex value	Decimal value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
SCG	60-7F	96-127
UNL	3F	63
UNT	5F	95

Typical command sequences

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. Table D-3 lists a typical bus sequence for sending the addressed multiline commands. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself.

Table D-4 gives a typical common command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the common command string.

IEEE command groups

Command groups supported by the Model 7002 are listed in Table D-5. Common commands and SCPI commands are not included in this list.

Table D-3
Typical addressed command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	’	27	39
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 7.

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Table D-4
Typical common command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	'	27	39
3	Data	Set high	*	2A	42
4	Data	Stays high	R	52	82
5	Data	Stays high	S	53	83
6	Data	Stays high	T	54	84

Assumes primary address = 7.

Table D-5
IEEE command groups

HANDSHAKE COMMAND GROUP	
	NDAC = NOT DATA ACCEPTED NRFD = NOT READY FOR DATA DAV = DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN = ATTENTION DCL = DEVICE CLEAR IFC = INTERFACE CLEAR REN = REMOTE ENABLE SPD = SERIAL POLL DISABLE SPE = SERIAL POLL ENABLE
ADDRESS COMMAND GROUP	
LISTEN	LAG = LISTEN ADDRESS GROUP MLA = MY LISTEN ADDRESS UNL = UNLISTEN
TALK	TAG = TALK ADDRESS GROUP MTA = MY TALK ADDRESS UNT = UNTALK OTA = OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP	
	ACG = ADDRESSED COMMAND GROUP GTL = GO TO LOCAL SDC = SELECTIVE DEVICE CLEAR
STATUS COMMAND GROUP	
	RQS = REQUEST SERVICE SRQ = SERIAL POLL REQUEST STB = STATUS BYTE EOI = END

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E

IEEE-488 Conformance Information

Information

The IEEE-488.2 standard requires specific information about how the Model 7002 implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. Table E-1 provides a summary of the requirements, and provides the information or references the manual for that information.

Table E-1
IEEE-488 documentation requirements

	Requirement	**Description or Reference**
(1)	IEEE-488 Interface Function Codes.	See Appendix C
(2)	Behavior of 7002 when the address is set outside the range 0-30.	Error message occurs. Previous address is retained.
(3)	Behavior of 7002 when valid address is entered.	No error message. Display returns to GPIB SETUP MENU.
(4)	Power-On Setup Conditions.	*RST; see paragraph 5.10.10. :SYST:PRES and :SYST:POS; see paragraph 5.17.
(5)	Message Exchange Options:	
(a)	Input buffer size.	256 bytes.
(b)	Queries that return more than one response message.	None.
(c)	Queries that generate a response when parsed.	All queries (Common Commands and SCPI).
(d)	Queries that generate a response when read.	None.
(e)	Coupled commands.	:TRIG:COUNT is coupled to :TRIG:COUNT:AUTO. Enabling Auto sets count to the scan list length.

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Table E-1 (continued)
IEEE-488 documentation requirements

(6)	Functional elements required for SCPI commands.	Contained in SCPI command subsystems tables.
(7)	Buffer size limitations for block data.	Up to 20 characters for block display messages.
(8)	Syntax restrictions.	Contained in paragraphs 5.11 through 5.18 (SCPI Command Subsystems).
(9)	Response syntax for every query command.	Contained in paragraphs 5.9 (Common Commands) and 5.11 through 5.18 (SCPI Command Subsystems).
(10)	Device-to-device message transfer that does not follow rules of the standard.	None.
(11)	Block data response size.	None.
(12)	Common Commands implemented by 7002.	See paragraph 5.10.
(13)	Calibration query information.	Not applicable.
(14)	Trigger macro for *DDT.	Not applicable.
(15)	Macro information.	Not applicable.
(16)	Response to *IDN (identification).	See paragraph 5.10.5.
(17)	Storage area for *PUD and *PUD?	Not applicable.
(18)	Resource description for *RDT and *RDT?	Not applicable.
(19)	Effects of *RST, *RCL and *SAV.	*RST; see paragraph 5.10.10, *RCL; see paragraph 5.10.9, *SAV; see paragraph 5.10.11.
(20)	*TST information.	See paragraph 5.10.16.
(21)	Status register structure.	See paragraph 5.6.
(22)	Sequential or overlapped commands.	All are sequential except :INIT, :INIT:CONT ON and *TRG which are overlapped.
(23)	Operation complete messages.	*OPC; see paragraph 5.10.6, *OPC?; see paragraph 5.10.7, *WAI; see paragraph 5.10.17.

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F

SCPI Conformance Information

Introduction

The Model 7002 complies with SCPI version 1991.0. Table F-1 lists the SCPI confirmed commands and Table F-2 lists the non-SCPI commands.

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Table F-1
Syntax of SCPI confirmed commands implemented by Model 7002

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).
[:ROUTe]	
:CLOSe <list>	Close specified channels.
:STATe?	Query list of closed channels.
:CLOSe? <list>	Query state of specified channels (1 = closed, 0 = open).
:OPEN <list>|ALL	Open specified (or all) channels.
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).
:SCAN <list>	Define scan list.
:POINts?	Query number of channels in scan list.
: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.

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Table F-1 (continued)
Syntax of SCPI confirmed commands implemented by Model 7002

Command	Description
:STATus	
:OPERation	
:ARM	
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Query the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query the enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query the negative transition register.
:CONDition?	Query the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Query most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Query enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Query disabled messages.
:SYSTem	
:PRESet	Return to :SYST:PRES defaults.
:VERSion?	Query revision level of SCPI standard.
:ERRor?	Query Error Queue.

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Table F-1 (continued)
Syntax of SCPI confirmed commands implemented by Model 7002

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Immediatey go to Layer2.
:COUNt <n>	Program arm count (1 to 9999, or INF).
:COUNt?	Query arm count.
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, EXTernal.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:LAYer2	Path to program arm layer 2:
:IMMediate	Immediately go to Trigger Layer.
:COUNt <n>	Program scan count (1 to 9999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 99999.999 sec)
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Query timer.
:SIGNal	Loop around control source.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Immediately perform a scan step.
:COUNt <n>	Program measure count (1 to 9999, or INF).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).
:AUTO?	Query auto-count.
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 99999.999 sec)
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.

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Table F-2
Syntax of non-SCPI commands implemented by Model 7002

Command	Description
:DISPlay	
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:WINDow3	Path to control LED Graticule
:GRATicule <b>	Enable (1 or ON) or disable (0 or OFF) LED Graticule.
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 4.
:SCAN?	Query scan list.
:FCHannels <list>	Specify channels that cannot be closed.
:FCHannels?	Query channels that cannot be closed.
:INTerlockX	Specify interlock (X = [1] to 5).
:LIST[1]	Define List 1 for specified interlock.
:LIST[1]?	Query List 1 for specified interlock.
:LIST2	Define List 2 for specified interlock.
:LIST2?	Query List 2 for specified interlock.
:CONFigure	Configuration command path:
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel <b>	Enable (1 or ON) or Disable (0 or OFF) Single Channel.
:SCHannel?	Query Single Channel.
:CPAirX <b>	Enable (1 or ON) or Disable (0 or OFF) Card Pair X (X = [1] to 5).
:CPAirX?	Query Card Pair X (X = [1] to 5).
:SLOTX	Path to configure SLOT X (X = [1] to 10):
:CTYPe <name>	Assign card ID number for specified slot.
:CTYPe?	Query card ID number for specified slot.
:POLE <NRf>	Select pole mode (1, 2 or 4) for specified slot.
:POLE?	Query pole mode for specified slot.
:STIMe <n>	Specify delay (0 to 99999.999 sec) for specified slot.
:STIMe?	Query delay for specified slot.
:MEMory	Path to program memory:
:SAVE	Path to save channel patterns:
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).
:RECall M<num>	Recall channel pattern from memory (1 to 500).

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Table F-2 (continued)
Syntax of non-SCPI commands implemented by Model 7002

Command	Description
:SENSe[1] :TTL1 :DATA?	 Command path to read internal input line. Read internal digital input line.
:SENSeX :DATA?	Specify slot; X=2 (slot 1) through 11 (slot 10). Read digital input for the specified slot.
:SOURce :TTL[1] [:LEVel] <b> [:LEVel]? :TTL2 [:LEVel] <b> [:LEVel]? :TTL3 [:LEVel] <b> [:LEVel]? :TTL4 [:LEVel] <b> [:LEVel]?	 Digital output line #1. Set line true (1 or ON) or false (0 or OFF) Query state of digital output line. Digital output line #2. Set line true (1 or ON) or false (0 or OFF) Query state of digital output line. Digital output line #3. Set line true (1 or ON) or false (0 or OFF) Query state of digital output line. Digital output line #4. Set line true (1 or ON) or false (0 or OFF) Query state of digital output line.
:SYSTem :POSetup <name> :POSetup?	 Select power-on setup: RST, PRESet, SAV0-SAV9. Query power-on setup.
:ARM[:SEQuence[1]] [:LAYer[1]] :SOURce TLINK :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe? :SOURce TLINK :LAYer2 :TCONfigure :DIRection <name> :DIRection? :ASYNchronous :ILINe <NRf> :ILINe? :OLINe <NRf> :OLINe?	Subsystem command path to configure arm layers: Path to program arm layer 1: Select control source. Path to configure Triggers: Enable (SOURce) or disable (ACCeptor) Bypass: Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line. Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal. Path to program arm layer 2: Path to configure Triggers: Enable (SOURce) or disable (ACCeptor) Bypass. Query direction. Path to configure asynchronous Trigger Link: Select input line (1 to 6). Query input line. Select output line (1 to 6). Query output line.

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Table F-2 (continued)
Syntax of non-SCPI commands implemented by Model 7002

Command	Description
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:SOURce TLINK	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.

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G

IEEE-488.2 Common Commands

Mnemonic	Name	Description
*CLS	Clear status	Clears all event registers, and Error Queue.
*ESE <NRf>	Event status enable command	Sets the contents of the Standard Event Status Enable Register.
*ESE?	Event status enable query	Request the programmed value of the Standard Event Status Enable Register.
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.
*OPC?	Operation complete query	Places an ASCII “1” into the output queue when all pending selected device operations have been completed.
*OPT?	Option identification query	Request the assigned model number for all slots.
*RCL <NRf>	Recall command	Returns the Model 7002 to the setup configuration stored in the designated memory location.
*RST	Reset command	Returns the Model 7002 to the *RST default conditions.
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.
*SRE?	Service request enable query	The Model 7002 returns the value of the Service Request Enable Register.
*STB?	Read status byte query	Returns the value of the Status Byte Register.

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Mnemonic	Name	Description
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.
*TST?	Self-test query	When this query is sent, the Model 7002 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.

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H

SCPI Command Subsystems

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

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Table H-1
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message “a” using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow3	Path to control LED Graticule.
:GRATicule <b>	Enable (1 or ON) or disable (0 or OFF) LED Graticule.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).

Table H-2
OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 4.

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Table H-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).
:LIST[1]	Define List 1 for specified interlock.
:LIST[1]?	Query List 1 for specified interlock.
:LIST2	Define List 2 for specified interlock.
:LIST2?	Query List 2 for specified interlock.
:CONFigure	Configuration command path:
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.
:BBMake?	Query Break-Before-Make.
:SCHannel <b>	ENable (1 or ON) or Disable (0 or OFF) Single Channel.
:SCHannel?	Query Single Channel.
:CPAirX <b>	Enable (1 or ON) or Disable (0 or OFF) Card Pair X (X = [1] to 5).
:CPAirX?	Query Card Pair X (X = [1] to 5).
:SLOTX	Path to configure SLOT X (X = [1] to 10):
:CTYPe <name>	Assign card ID number for specified slot.
:CTYPe?	Query card ID number for specified slot.
:POLE <NRf>	Select pole mode (1, 2 or 4) for specified slot.
:POLE?	Query pole mode for specified slot.
:STIMe <n>	Specify delay (0 to 99999.999 sec) for specified slot.
:STIMe?	Query delay for specified slot.
:MEMory	Path to program memory:
:SAVE	Path to save channel patterns:
[:RELays] M<num>	Save current channel pattern at specified memory location (1 to 500).
:LIST <list>, M<num>	Save defined channel pattern at specified memory location (1 to 500).
:RECall M<num>	Recall channel pattern from memory (1 to 500).

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Table H-4
SENSe command summary

Command	Description
:SENSe[1] :TTL1 :DATA?	Command path to read internal input line. Read internal digital input line.
:SENSeX :DATA? <list>	Specify slot; X=2 (slot 1) through 11 (slot 10). Read specified input channels for the specified slot.

Table H-5
SOURce command summary

Command	Description
:SOURce	
:TTL[1]	Digital output line #1.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL2	Digital output line #2.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL3	Digital output line #3.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL4	Digital output line #4.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.

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Table H-6
STATus command summary

Command	Description
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:ARM	Path to control arm event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Query event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query enable register.
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query negative transition register.
:CONDition?	Query condition register.
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Query the event register.
:ENABle <NRf>	Program the enable register.
:ENABle?	Query the enable register.

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Table H-6 (continued)
STATus command summary

Command	Description
:STATus	
:QUEStionable	
:PTRansition <NRf>	Program the positive transition register.
:PTRansition?	Query the positive transition register.
:NTRansition <NRf>	Program the negative transition register.
:NTRansition?	Query the negative transition register.
:CONDition?	Query the condition register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Query most recent error message.
:ENABle <list>	Specify error and status messages for queue.
:ENABle?	Query enabled messages.
:DISable <list>	Specify messages not to be placed in queue.
:DISable?	Query disabled messages.

Table H-7
SYSTem command summary

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

Table H-8
Trigger command summary

Command	Description
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:CONTinuous?	Query continuous initiation.
:ABORt	Reset trigger system.
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:
[:LAYer[1]]	Path to program arm layer 1:
:IMMediate	Immediatey go to Layer2.
:COUNt <n>	Program arm count (1 to 9999, or INF).
:COUNt?	Query arm count.

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Table H-8 (continued)
Trigger command summary

Command	Description
:ARM[:SEQuence[1]]	
[:LAYer[1]]	
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass:
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:LAYer2	Path to program arm layer 2:
:IMMediate	Immediately go to Trigger Layer.
:COUNt <n>	Program scan count (1 to 9999 or INF).
:COUNt?	Query scan count.
:DELay <n>	Program delay (0 to 99999.999 sec)
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Query timer.
:SIGNal	Loop around control source.
:TCONfigure	Path to configure Triggers:
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:TRIGger[:SEQuence[1]]	Path to program trigger layer:
:IMMediate	Immediately perform a scan step.
:COUNt <n>	Program measure count (1 to 9999, or INF).
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).
:AUTO?	Query auto-count.
:COUNt?	Query measure count.
:DELay <n>	Program delay (0 to 99999.999 sec)
:DELay?	Query delay.
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.
:SOURce?	Query control source.
:TIMer <n>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Request the programmed timer interval.
:SIGNal	Loop around control source.

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Table H-8 (continued)
Trigger command summary

Command	Description
:TRIGger[:SEQuence[1]]	
:TCONfigure	Path to configure Triggers:
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.
:PROTocol?	Query protocol.
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.
:DIRection?	Query direction.
:ASYNchronous	Path to configure asynchronous Trigger Link:
:ILINe <NRf>	Select input line (1 to 6).
:ILINe?	Query input line.
:OLINe <NRf>	Select output line (1 to 6).
:OLINe?	Query output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link:
:LINE <NRf>	Select trigger line (1 to 6).
:LINE?	Query trigger line.

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QuickBasic and QuickC Programs

Introduction

The following two programs demonstate simple scans using two popular programming languages; Microsoft QuickBasic and QuickC.

The QuickBasic program performs a 40 channel scan twenty times using the timer to control the scan rate. The QuickC program performs a continuous 160 channel scan using Group Execute Trigger (GET) as the channel control event.

Both programs use the Keithley Model KPC-488.2AT IEEE-488 Interface Card installed in a PC or PC-compatible computer.

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Microsoft QuickBasic 4.5 Program

Copyright (c) 1993, Keithley Instruments, Inc.

Introduction

The following program will scan 40 channels twenty times using the trigger layer (channel layer) timer to control the scan rate (8 channels per second).

Requirements:

- Keithley Model KPC-488.2AT IEEE-488 Interface Card installed in a PC or PC-compatible computer.
- Model 7011 Multiplexer Card installed in slot 1 of the Model 7002.

NOTE

In the absense of a Model 7011 switch card, this program can be run by assigning slot 1 of the Model 7002 as a multiplexer simulator (9990). See paragraph 4.13.1 for details.

Program:

```
'$INCLUDE: 'IEEEQB.BI'

' Initialize global variables.

     CLS
     ScanAddr% = 7                              ' Address of 7002 Switch System

' Initialize GPIB.

     CALL initialize(21, 0)                     ' Initialize Interface Card
     CALL setoutputEOS(10, 0)                   ' Set Output EOS to LF
     CALL setinputEOS(10)                       ' Set Input EOS to LF
     CALL settimeout(5000)                      ' Set TIMEOUT to 5 seconds

     cmd$ = "*CLS": GOSUB send7002

' Reset and Idle 7002.

     cmd$ = "*RST;:Init:Cont Off;:Abort": GOSUB send7002
     cmd$ = ":Open All": GOSUB send7002

' Set up Scan Channels in 7002

     cmd$ = ":Route:Open ALL": GOSUB send7002
     cmd$ = ":Route:Scan (@1!1:1!40)": GOSUB send7002
     cmd$ = ":Configure:BBMake 1": GOSUB send7002

' Set up 7002 triggering parameters

     cmd$ = ":Arm:Lay1:Sour Bus": GOSUB send7002
     cmd$ = ":Arm:Lay1:Coun 1": GOSUB send7002
     cmd$ = ":Arm:Lay1:Tcon:Dir ACC": GOSUB send7002
     cmd$ = ":Arm:Lay2:Sour Tim": GOSUB send7002
     cmd$ = ":Arm:Lay2:Tim 5": GOSUB send7002
     cmd$ = ":Arm:Lay2:Coun 20": GOSUB send7002
     cmd$ = ":Trig:Sour Timer": GOSUB send7002
```


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```
      cmd$ = ":Trig:Tim 0.125": GOSUB send7002
      cmd$ = ":Trig:Count 40": GOSUB send7002
      cmd$ = ":Arm:Lay2:Delay 0": GOSUB send7002
      cmd$ = ":Trig:Delay 0": GOSUB send7002
      cmd$ = ":Trig:Tcon:Dir ACC": GOSUB send7002

' Arm 7002

      cmd$ = ":INIT": GOSUB send7002

' Start test

      cmd$ = "*TRG": GOSUB send7002

END

send7002:
      CALL send(ScanAddr%, cmd$, status%)
RETURN
```


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Microsoft QuickC 2.0 Program

Copyright (c) 1993, Keithley Instruments, Inc.

Introduction

The following program will continuously scan 160 channels using Group Execute Trigger (GET) as the channel control event.

Requirements:

- Keithley Model KPC-488.2AT IEEE-488 Interface Card installed in a PC or PC-compatible computer.
- Model 7011 Multiplexer Card installed in slot 1 of the Model 7002.

NOTE

In the absense of a Model 7011 switch card, this program can be run by assigning slot 1 of the Model 7002 as a multiplexer simulator (9990). See paragraph 4.13.1 for details.

Program:

```
#include    <stdio.h>
#include    <stdlib.h>
#include    <string.h>
#include    <graph.h>
#include    <time.h>
#include    <ieee-c.h>

#define     k7002     07

main()
            { time_t  tstart,tend;

            int       stat, l;
            long      cntr;

            char      status, keych;
            char      cmd[255];
            char      ki2001[100];
            char      operstat[80];

            _clearscreen(_GWINDOW);
            initialize(21,0);                   /* Set Controller to Addr 21 */
            setoutputEOS(10,0);                 /* Set output EOS to 'LF' */
            setinputEOS(10);                    /* Set input EOS to 'LF' */
            settimeout(5000);                   /* Set timeout to 5 sseconds */

/*** Reset 7002 ***/

            send(k7002,"*RST",&status);          /* Send *RST to 7002 */

            time(&tstart);do time(&tend); while( (tend-tstart) <= 1);

/*** Open all relays on 7002 ***/

            send(k7002,"Open All",&status);
```


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```
/***  Set the 7002 for the 7011 in slot 1 and the C9990 in slots 8,9,10

      Set the 7002 to set the ARM Layer 1 & 2 for immediate triggering,
      the Trigger layer set for bus triggering. Set the Operation Event
      Register to enable the Settling bit. ***/

            send(k7002,":Init:Cont Off;:Abor",&status);
            send(k7002,":Route:Conf:Slot1:Pole 2",&status);
            send(k7002,":Route:Conf:Slot8:Ctype C9990",&status);
            send(k7002,":Route:Conf:Slot9:Ctype C9990",&status);
            send(k7002,":Route:Conf:Slot10:Ctype C9990",&status);

            strcpy(cmd,":Arm:Lay1:Sour Imm;:Arm:Lay2:Sour Imm;\
                  :Trig:Seq1:Sour Bus");
            send(k7002,cmd,&status);
            send(k7002,":Stat:Oper:PTR 2;NTR 0;:*CLS",&status);

/*** Send scan list to 7002 ***/

            send(k7002,"Scan (@1!1:1!40,8!1:8!40,9!1:9!40,10!1:10!40)",&status);

/*** Arm 7002 ***/

            send(k7002,"Init:Cont On",&status);

            time(&tstart);do time(&tend); while( (tend-tstart) <= 1);

            printf("\nPress any key to quit.....");

            while( !kbhit() )
            { transmit("UNL LISTEN 7 GET",&status);
                  do{                           /* Check to see if 7002 and
                                                   switch are settling. */
                        send(k7002,":Stat:Oper:Even?",&status);
                        enter(&operstat,80,&l,k7002,&status);
                        stat = atoi(operstat) & 2; }
                  while (stat == 2);
            }
}
```


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Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent
❑ IEEE failure
❑ Front panel operational
❑ Analog output follows display
❑ Obvious problem on power-up
❑ All ranges or functions are bad
❑ Particular range or function bad; specify _____
❑ Batteries and fuses are OK
❑ Checked all cables

Display or output (check one)

❑ Drifts
❑ Unstable
❑ Overload
❑ Unable to zero
❑ Will not read applied input

❑ Calibration only
❑ Data required
❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

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