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Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

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Edition 2
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Documentation History

All Editions and Updates of this manual and their creation date are listed below. The first Edition of the manual is Edition 1. The Edition number increments by 1 whenever the manual is revised. Updates, which are issued between Editions, contain replacement pages to correct or add additional information to the current Edition of the manual. Whenever a new Edition is created, it will contain all of the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this documentation history page.

Edition 1 . . . . . September, 1989
Edition 2 . . . . . April, 1995

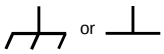
Safety Symbols



Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.



Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.



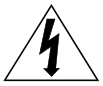
Frame or chassis ground terminal—typically connects to the equipment's metal frame.



Alternating current (AC).



Direct current (DC).



Indicates hazardous voltages.

WARNING Calls attention to a procedure, practice, or condition that could cause bodily injury or death.

CAUTION Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNINGS

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Ground the equipment: For Safety Class 1 equipment (equipment having a protective earth terminal), an uninterruptible safety earth ground must be provided from the mains power source to the product input wiring terminals or supplied power cable.

DO NOT operate the product in an explosive atmosphere or in the presence of flammable gases or fumes.

For continued protection against fire, replace the line fuse(s) only with fuse(s) of the same voltage and current rating and type. DO NOT use repaired fuses or short-circuited fuse holders.

Keep away from live circuits: Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.

DO NOT operate damaged equipment: Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DO NOT service or adjust alone: Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT substitute parts or modify equipment: Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

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Manufacturer's Name: Hewlett-Packard Company
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Manufacturer's Address: 815 14th Street S.W.
Loveland, Colorado 80537

declares, that the product:

Product Name: 4X4 Relay Matrix Module

Model Number: E1361A

Product Options: All

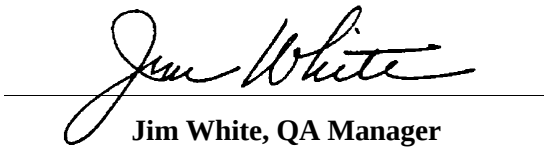
conforms to the following Product Specifications:

Safety: IEC 1010-1 (1990) Incl. Amend 1 (1992)/EN61010-1 (1993)
CSA C22.2 #1010.1 (1992)
UL 1244

EMC: CISPR 11:1990/EN55011 (1991): Group1 Class A
IEC 801-2:1991/EN50082-1 (1992): 4kVCD, 8kVAD
IEC 801-3:1984/EN50082-1 (1992): 3 V/m
IEC 801-4:1988/EN50082-1 (1992): 1kV Power Line
.5kV Signal Lines

Supplementary Information: The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Tested in a typical configuration in an HP B-Size VXI mainframe.



April, 1995 **Jim White, QA Manager**

European contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department HQ-TRE, Herrenberger Straße 130, D-71034 Böblingen, Germany (FAX +49-7031-14-3143).

Notes

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Please write any comments or suggestions below--be specific.

Chapter 1
Getting Started

Using This Chapter

This chapter includes an HP E1361A Relay Matrix description, addressing guidelines, and an example program to check initial operation. Chapter contents are:

- Instrument Definition . . . . . Page 11
- Matrix Description . . . . . Page 11
- Programming the Matrix . . . . . Page 13
- Initial Operation . . . . . Page 15

Instrument Definition

HP plug-in modules installed in an HP mainframe are treated as independent instruments each having a unique secondary HP-IB address. Each instrument is also assigned a dedicated error queue, input and output buffers, status registers and, if applicable, dedicated mainframe memory space for readings or data. An instrument may be composed of a single plug-in module (such as a counter) or multiple plug-in modules (for a switchbox or scanning voltmeter instrument).

Matrix Description

The HP E1361A 4 X 4 Relay Matrix module is a B-Size VXIbus and VMEbus register-based product which can be used for matrix switching or scanning. The matrix can operate in a B-Size VXIbus or VMEbus mainframe or (with an adapter) in a C-Size VXIbus mainframe.

The relay matrix consists of 16 latching relays (channels 00 through 15). The module is factory-configured as a 4 X 4 matrix. By removing jumpers, you can configure the module into a dual 4 X 2 matrix arrangement.

For the matrix, switching consists of closing a specified channel relay to provide row and column connections. Scanning consists of closing a set of relays, one relay at a time. You can open or close any combination of relays.

Basic Operation

Figure 1-1 shows simplified user connections for a matrix in the 4 X 4 configuration. To connect a specified row (0-3) to a specified column (0-3), close the relay at the crosspoint of the row and column. For example, close crosspoint relay 32 to connect row 3 to column 2. In the 4 X 4 matrix configuration, user row inputs can be to either Bank A or Bank B rows.

When a relay is closed, HIGH (H) and LOW (L) for the specified row and column are simultaneously connected. When a relay is opened the row/column inputs to the relay are disconnected. Since channel relays are latching, all relays remain in their current state during power-up or power-down. At reset, all relays are opened.

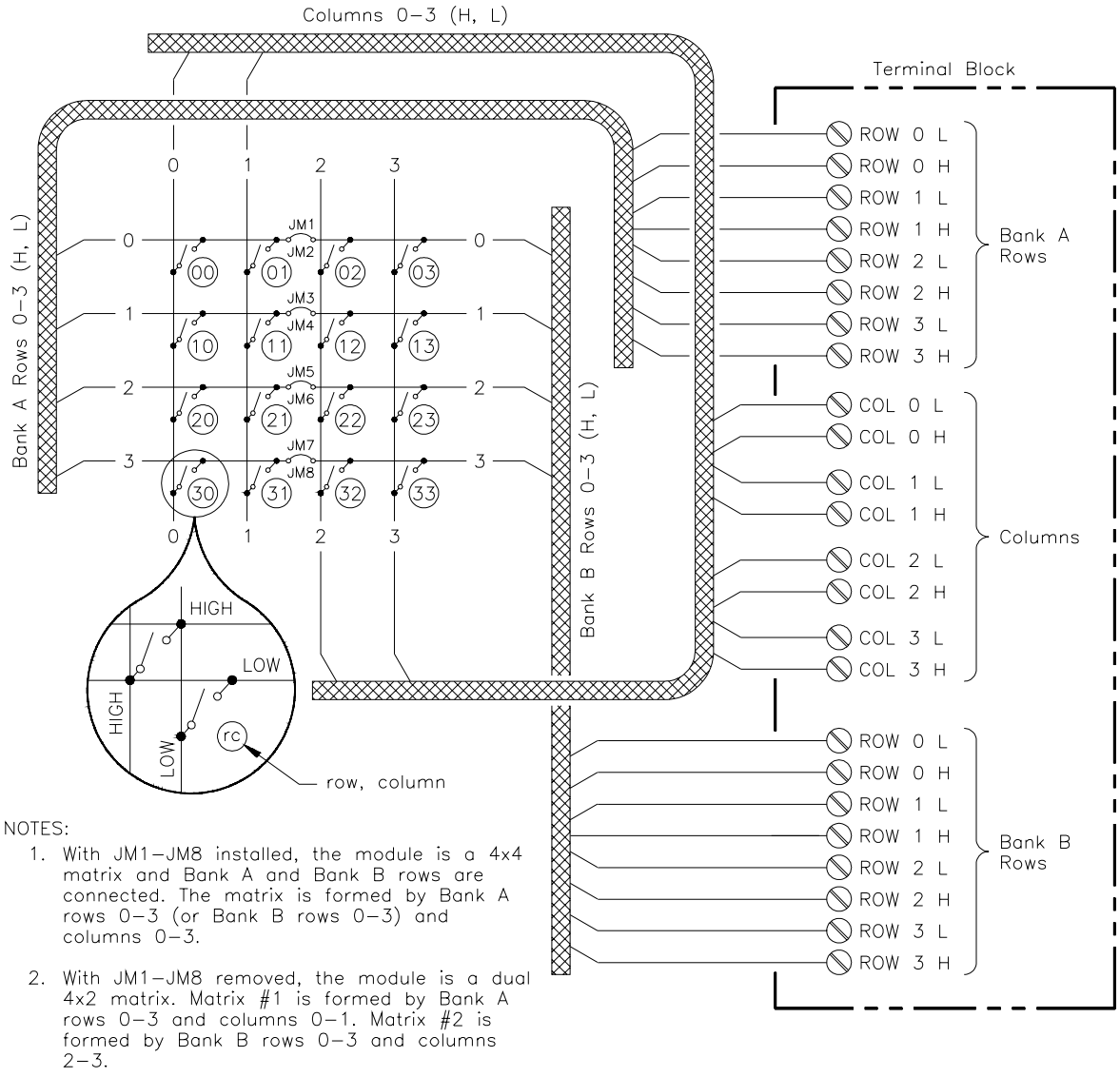


Figure 1-1. Relay Matrix Simplified Diagram

Typical Configuration

The relay matrix module accepts user inputs up to 250 V dc or 250 V ac RMS at 1 A dc or ac RMS (non-inductive). Maximum rated power capacity is 30 W or 40 VA per channel. Channel closure time is about 15 msec, so maximum scan rate is about 50 Hz.

As noted, the matrix may be configured for 4 X 4 or dual 4 X 2 matrix applications. For 4 X 4 matrix operation, no additional user configuration is required. To configure the matrix for dual 4 X 2 operation, you can remove factory-installed jumpers JM1 through JM8 (see Chapter 2 for jumper locations).

For a SCPI (Standard Commands for Programmable Instruments) environment, single or multiple relay matrixes can be configured as a *switchbox* instrument. For a switchbox instrument, all channels within the instrument can be addressed using a single interface address.

Programming the Matrix

To program the relay matrix using SCPI, you must select the computer language, interface address and SCPI commands to be used. Guidelines to select SCPI commands for the relay matrix follow. See the *HP 75000 Series B Installation and Getting Started Guide* for interface addressing and computer language information.

Note This discussion applies only to SCPI (Standard Commands for Programmable Instruments) programming. See Appendix B, "Relay Matrix Registers" for information on relay matrix registers.

Specifying SCPI Commands

To address specific channels (relays) within a relay matrix, you must specify the SCPI command and matrix channel address. Use CLOSe *channel_list* to close specified relay(s); OPEN *channel_list* to open the relays; and SCAN *channel_list* to close the set of relays specified.

Matrix Channel Addresses

For the relay matrix, the channel address (*channel_list*) has the form (@nnrc) where nn = matrix card number (01-99), r = matrix row number (0-3), and c = matrix column number (0-3).

You can address single channels (@nnrc); multiple channels (@nnrc,nnrc,...); sequential channels (@nnrc:nnrc); groups of sequential channels (@nnrc:nnrc,nnrc:nnrc); or any combination.

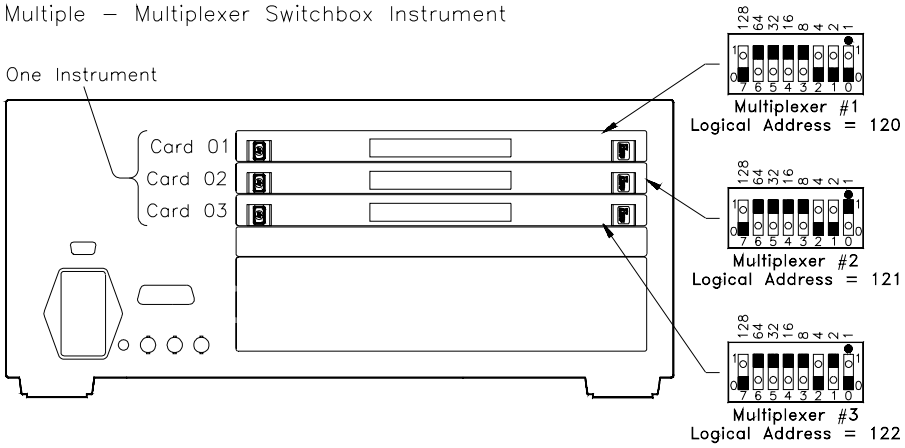
Matrix Card Numbers

The matrix card number depends on the switchbox configuration (single-module or multiple-module) set for the matrixes. (Leading zeroes can be ignored for the card number.) For a single-module switchbox, the card number is always 01.

For a multiple-module switchbox, the card numbers are 01, 02,...,nn. The module with the lowest logical address is card number 01, the module with the next-lowest logical address is card number 02, etc. (See the appropriate *Installation and Getting Started Guide* for a definition of logical addresses.)

Example: Multiple-Module Switchbox Card Numbers

Assume the three relay matrixes in the following figure form a switchbox instrument with logical addresses of 120, 121, and 122. The module with the lowest logical address is card number 01. The card numbers are shown in the following figure.



Matrix Channel Numbers

Relay matrix channel numbers are 00-03, 10-13, 20-23, and 30-33. Specifying a channel number specifies the associated crosspoint relay. For example, CLOS (@123) closes crosspoint relay 23 of card 01 which connects row 2 to column 3.

Channels can be addressed using channel numbers or channel ranges. For a single-module switchbox, channel ranges can span across the channels. For a multiple-module switchbox, channel ranges can span across the channels of all modules in the switchbox. Use commas (,) to form a channel list or use a colon (:) to form a channel range.

Only valid channels can be accessed in a channel list or channel range. Also, the channel list or channel range must be from a lower channel number to a higher channel number. For example, CLOS (@100:233) is acceptable, but CLOS (@233:100) generates an error.

Example: Relay Matrix Channel Lists/Ranges

Channel Lists:

```
CLOS (@100,112)      Close relays 00 and 12 on card 01
OPEN (@203,210)      Open relays 03 and 10 on card 02
```

Channel Ranges:

```
OPEN (@100:133)      Open all relays on card 01
SCAN (@100:133)      Scan all relays on card 01
```

Initial Operation

An example program follows which uses Hewlett-Packard BASIC and SCPI language to get you started using the relay matrix. The example assumes an HP 9000 Series 200/300 controller and a Hewlett-Packard Interface Bus (HP-IB). [HP-IB is the Hewlett-Packard implementation of the IEEE 488.2-1987 standard.]

The program closes channel 31 of a 4 X 4 relay matrix at logical address 120 (secondary address = 120/8 = 15) to connect row 3 to column 1 and queries the result. The result is returned to the controller and displayed (1 = relay closed, 0 = relay open).

Example: Connect Row 3 to Column 1 (4 X 4 Matrix)

```
10  OUTPUT 70915;"CLOS (@131)"      Connect row 3 to col 1
20  OUTPUT 70915;"CLOS? (@131)"     Query relay 31 state
30  ENTER 70915;Value               Enter result into Value
40  PRINT Value                     Display result
50  END
```

Chapter 2
Configuring the HP E1361A Relay Matrix

Using This Chapter

This chapter shows how to make user connections to the relay matrix and some ways to configure the matrix module. Chapter contents are:

- Warnings and Cautions . . . . . Page 17
- Connecting User Inputs . . . . . Page 18
- Typical Matrix Configurations . . . . . Page 20
- Changing Matrix Components. . . . . Page 22

Warnings and Cautions

Warning **SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, configure, or remove the relay matrix. Use only wire rated for the highest input voltage and remove all power sources from the mainframe and installed modules before installing or removing a module.**

Warning **CHANNEL WIRING INSULATION. All channels that have a common connection must be insulated so that the user is protected from electrical shock in the event that two or more channels are connected together. This means wiring for all channels must be insulated as though each channel carries the voltage of the highest voltage channel.**

Caution **MAXIMUM VOLTAGE/CURRENT. Maximum allowable voltage per crosspoint relay for the relay matrix is 250 V dc or 250 V ac RMS (350 V ac peak). Maximum current per relay is 1 A dc or 1 A ac RMS (non-inductive). Maximum power input is 40 W (dc) or 40 VA (ac) per relay. Exceeding any limit may damage the relay matrix module.**

Caution **STATIC-SENSITIVE DEVICE. Use anti-static procedures when removing, configuring, and installing a module. The relay matrix is susceptible to static discharges. Do not install a matrix module without its metal shield attached.**

Connecting User Inputs

The relay matrix consists of a component card and a terminal block. User inputs to the matrix are to the HIGH (H) and LOW (L) terminal connectors on the terminal block. Figure 2-1 shows the terminal block features and Figure 2-2 shows how to connect user (field) wiring to the terminal block.

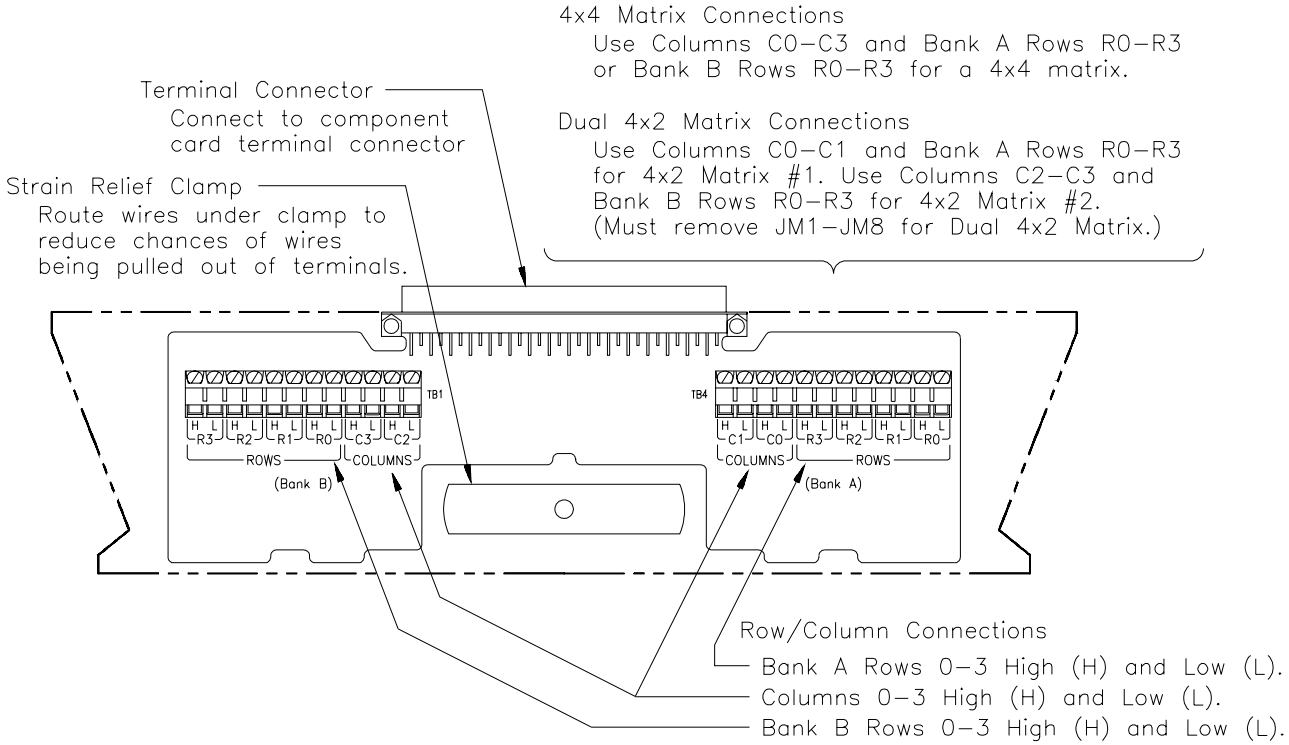


Figure 2-1. Relay Matrix Terminal Block

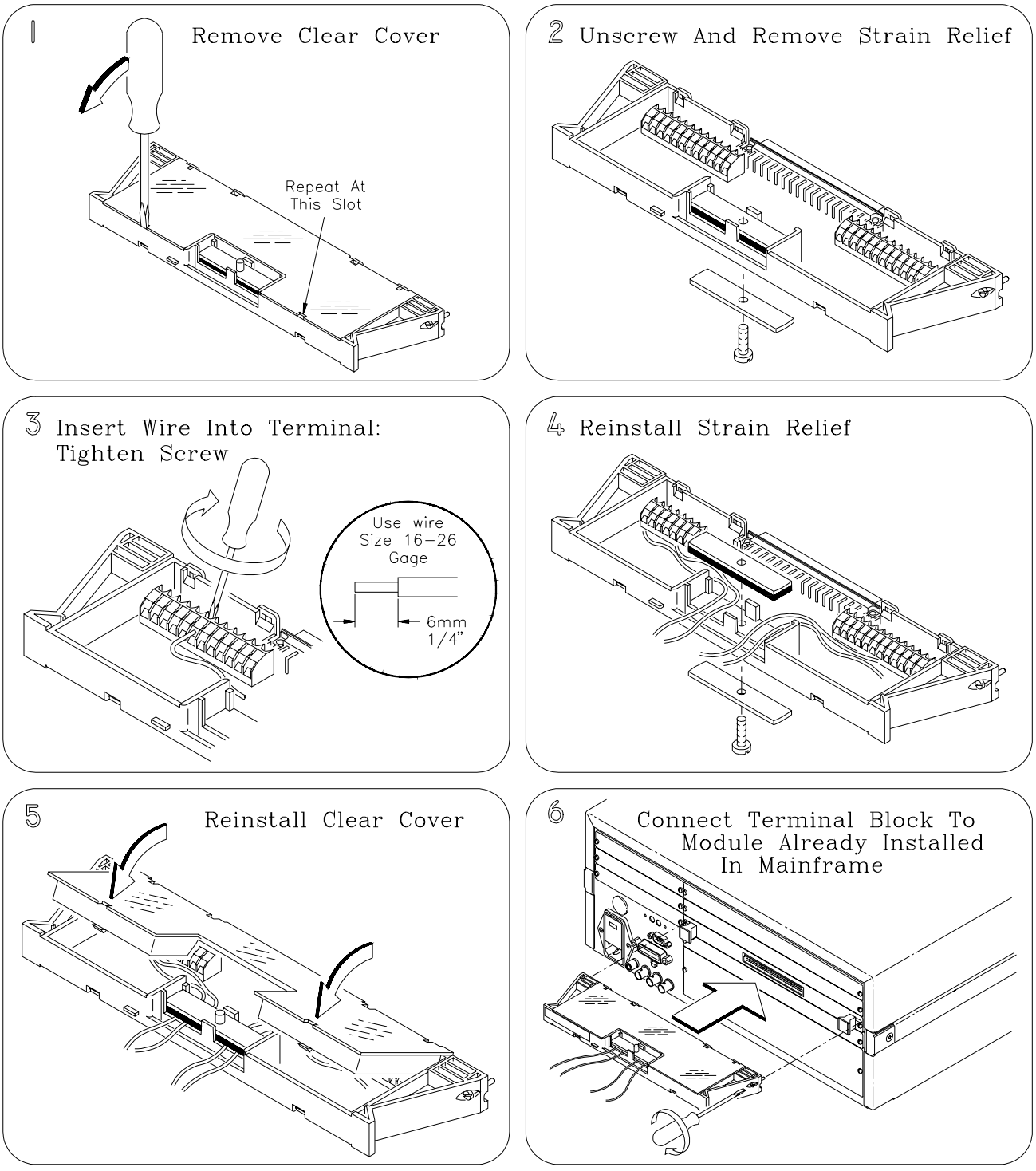


Figure 2-2. Wiring the Relay Matrix Terminal Block

Typical Matrix Configurations

The relay matrix can be configured as a 4 X 4 matrix or, by removing jumpers, can be configured as a dual 4 X 2 matrix. By connecting matrix cards, you can build larger matrixes.

4 X 4 Matrix Configuration

Figure 2-3 shows the relay matrix in a 4 row by 4 column matrix configuration. For this configuration, you can connect row inputs to either Bank A or Bank B rows, since the rows are connected by jumpers JM1-JM8. Note that both HIGH and LOW are switched for each relay. The circled number is the relay number and is also the channel number for programming.

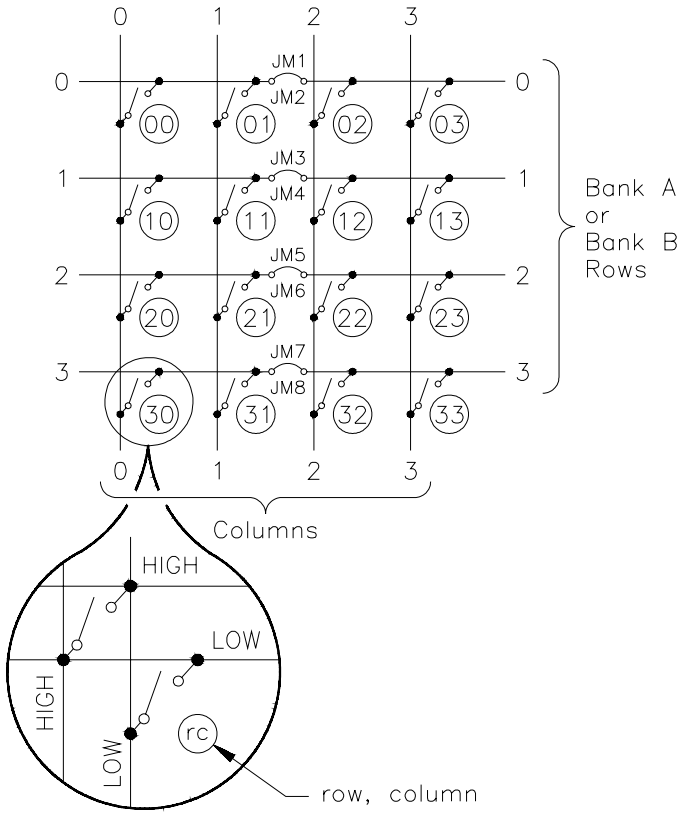


Figure 2-3. 4 X 4 Matrix

Dual 4 X 2 Matrix Configuration

By removing jumpers JM1-JM8 on the component card (see Figure 2-7 for location), you can configure the relay matrix into a dual 4 X 2 matrix. As shown in Figure 2-4, matrix #1 is formed by Bank A rows 0-3 and columns 0-1, while matrix #2 is formed by Bank B rows 0-3 and columns 2-3. Again, both HIGH and LOW are switched and the circled number is the relay/channel number.

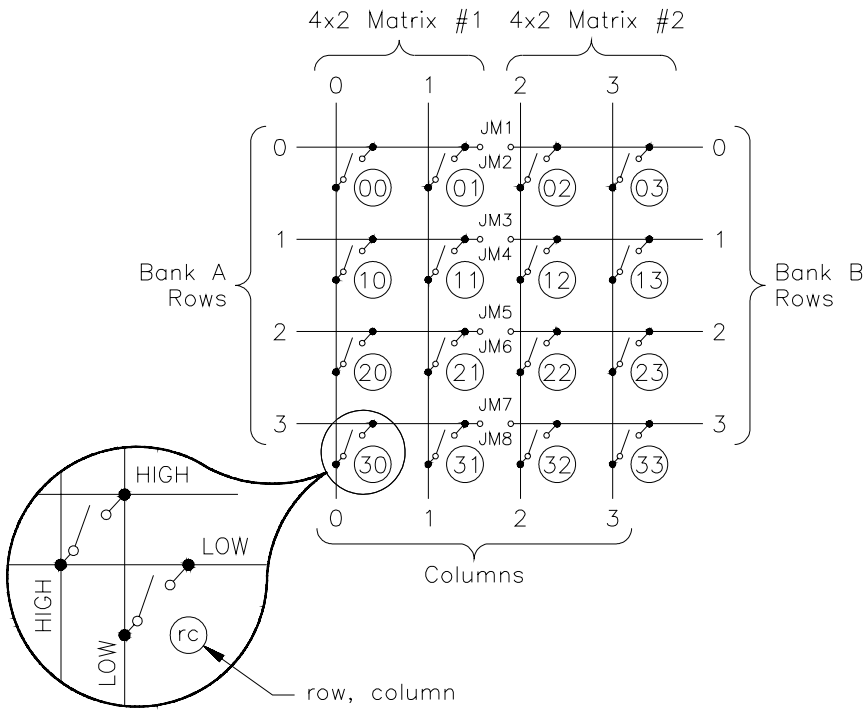


Figure 2-4. Dual 4 X 2 Matrix

Building Larger Matrixes

By making external (user) connections between relay matrix cards, you can build larger matrixes. For example, Figure 2-5 shows a 4 X 12 matrix using three relay matrix cards. To form this configuration, connect card #1 Bank B rows to card #2 Bank A rows, connect card #2 Bank B rows to card #3 Bank A rows, and connect user row inputs to card #3 Bank B rows.

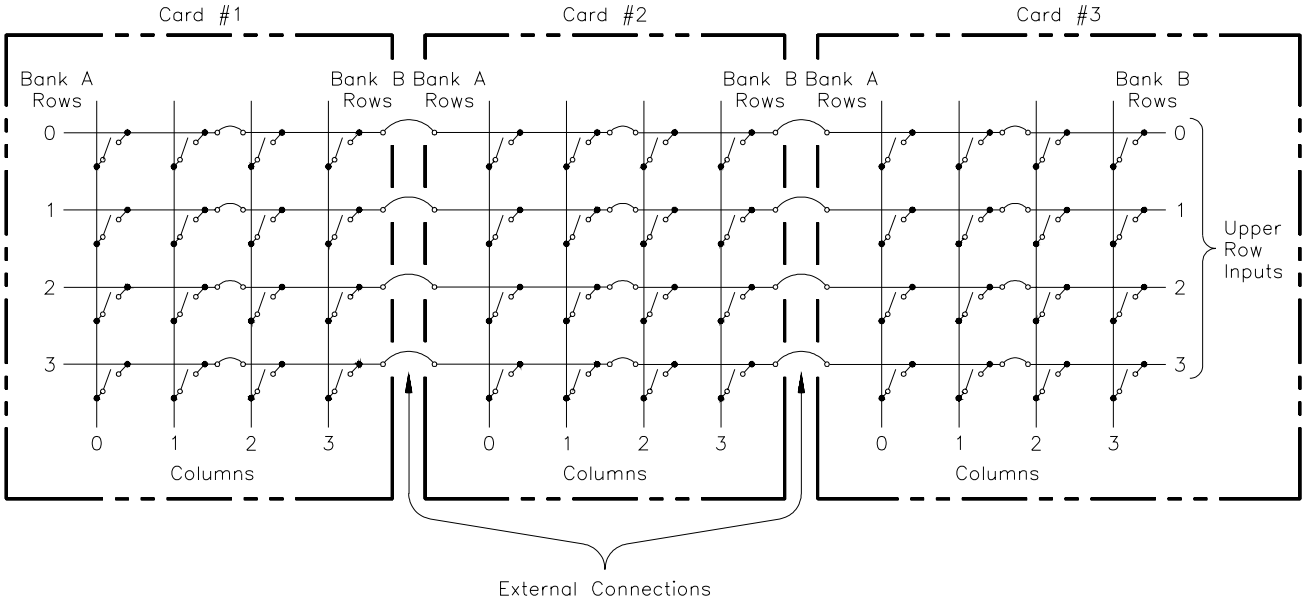


Figure 2-5. Typical 4 X 12 Matrix

High-Voltage Matrix Configuration

By connecting all columns together for a relay matrix in a dual 4 X 2 configuration, you can configure the matrix as an 8 X 1 high-voltage (up to 250 V) (2-wire) multiplexer. See Figure 2-6 for a typical representation.

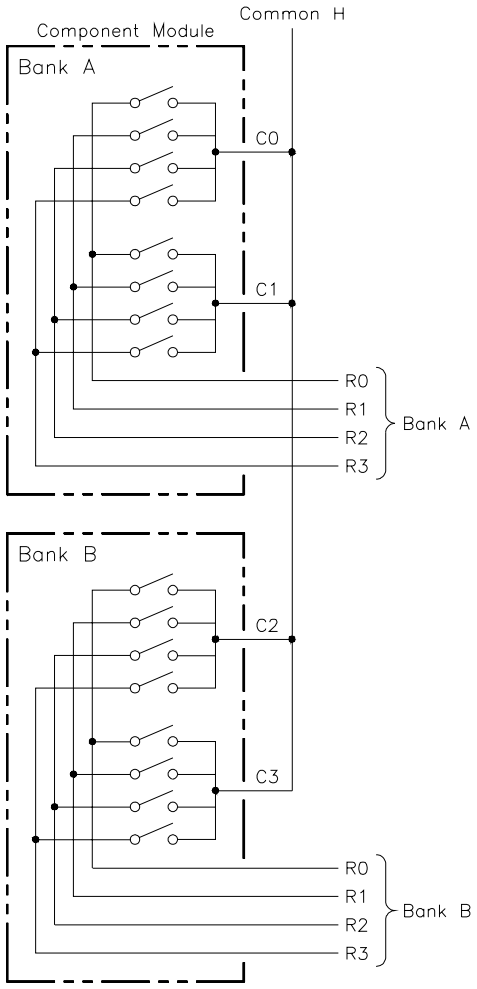


Figure 2-6. Typical 8 X 1 Multiplexer Arrangement

Changing Matrix Module Components

As required, you can change the following matrix components:

- Remove the channel jumpers (JM1-JM8).
- Change the Logical Address switch setting.
- Change the interrupt priority jumper positions.
- Replace fuses on the matrix component card.

See Figure 2-7 for component locations.

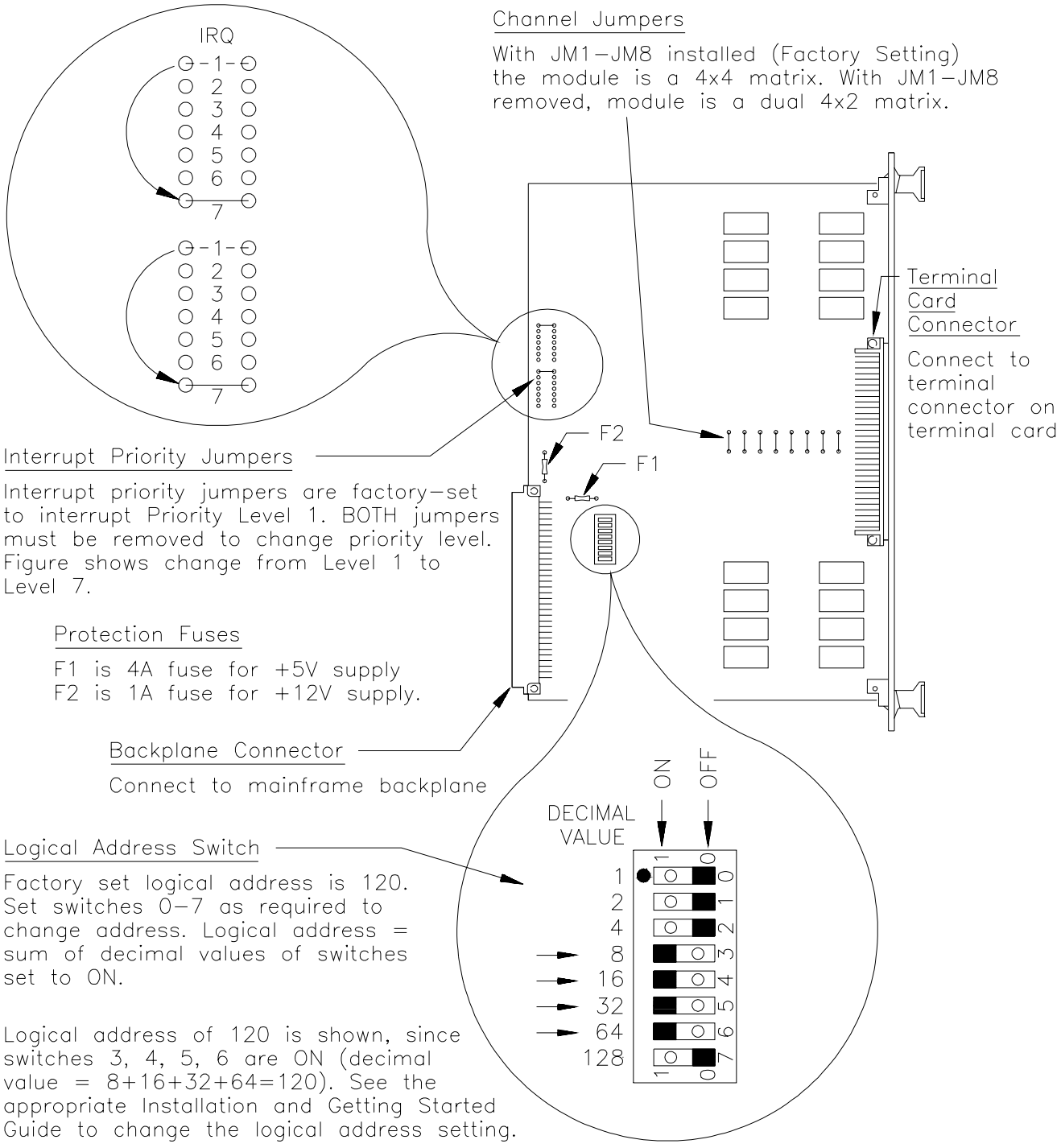


Figure 2-7. Relay Matrix Component Locations

Connecting User Inputs

The relay matrix module typically consists of a relay component module and a terminal block. Usually, you will make connections to the terminal block. If you desire to connect direct to the relay component module and not use the terminal block, Figure 2-8 shows the pin-out for the front panel connector.

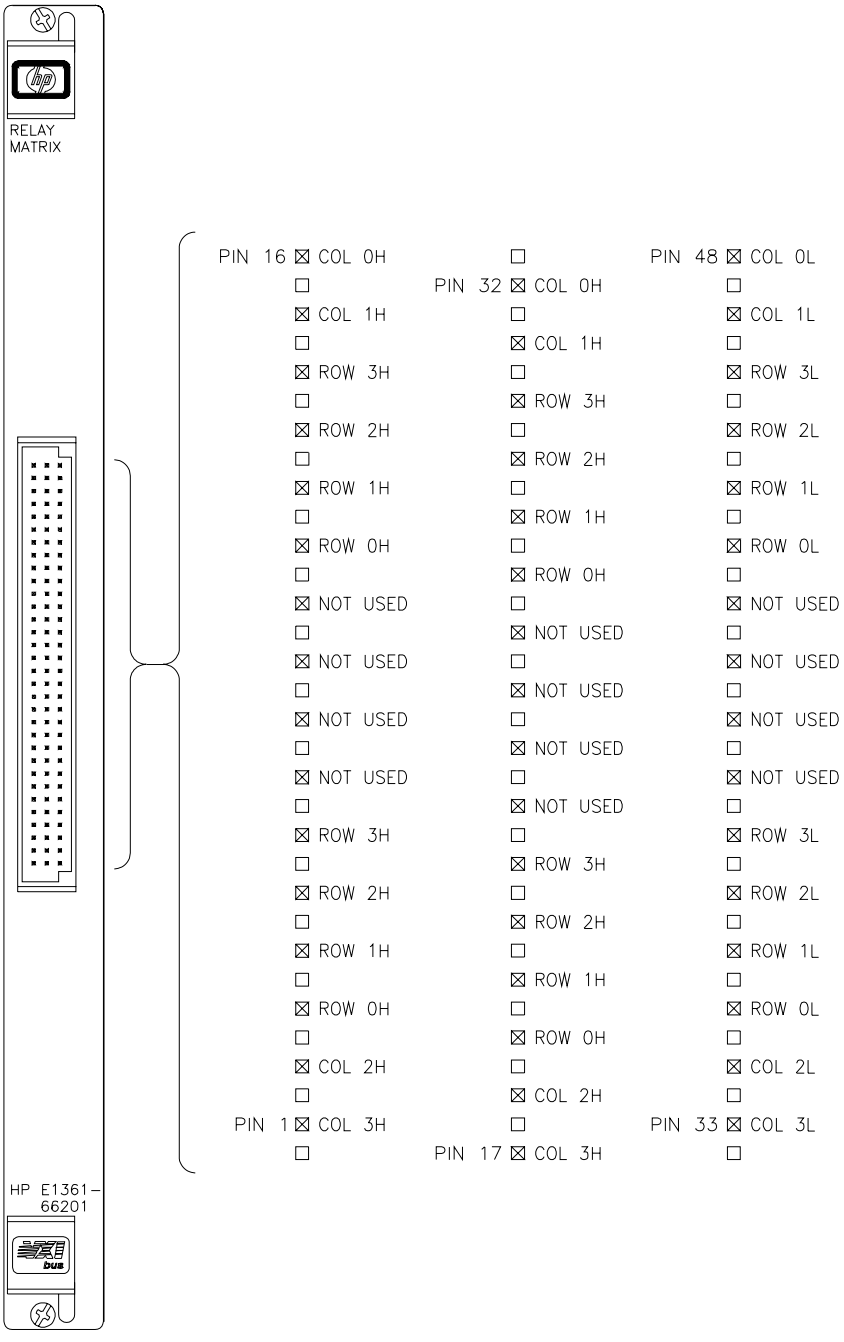


Figure 2-8. 4 X 4 Relay Matrix Front Panel

Chapter 3
Using the HP E1361A Relay Matrix

Using This Chapter

This chapter provides examples to use the relay matrix for switching channels. See Chapter 5, Relay Matrix Command Reference, for command information. Chapter contents are:

- Relay Matrix Commands . . . . . Page 25
- Switching Channels . . . . . Page 25

Relay Matrix Commands

Table 3-1. Relay Matrix Commands in Chapter 3

Command	Description
[ROUT:]CLOS<*channel_list*>	Close the channels in the *channel list*.
[ROUT:]CLOS?<*channel_list*>	Query the state of the channels in the *channel list*.
[ROUT:]OPEN <*channel_list*>	Open the channels in the *channel list*.

Switching Channels

- As factory-configured, the relay matrix module is a 4 X 4 matrix. By removing factory-installed jumpers JM1-JM8, the matrix is configured for dual 4 X 2 matrix operation.

- Use CLOS *channel_list* to close crosspoint relay(s) or use OPEN *channel_list* to open crosspoint relay(s). *channel_list* has the form (@nnrc) where nn = matrix card number (00-99), r = matrix row number (0-3), and c = matrix column number (0-3). The crosspoint relay number is also the channel number.

- SCAN *channel_list* can be used to scan (close) a specified set of channels. You can scan any combination of channels for a single-module or multiple-module switchbox. See Chapter 4, "Understanding the Relay Matrix" for scanning information.

Example: 4 X 4 Matrix Switching

This example closes channel 30 (relay 30) of a relay matrix in 4 X 4 configuration to connect the user input to row 3 with the user input to column 0. See Figure 3-1 for typical user connections. To close channel 30, execute:

```
CLOS (@130)          Close relay 30 (1 is card number)
```

To open channel 30 (relay 30), use OPEN (@130).

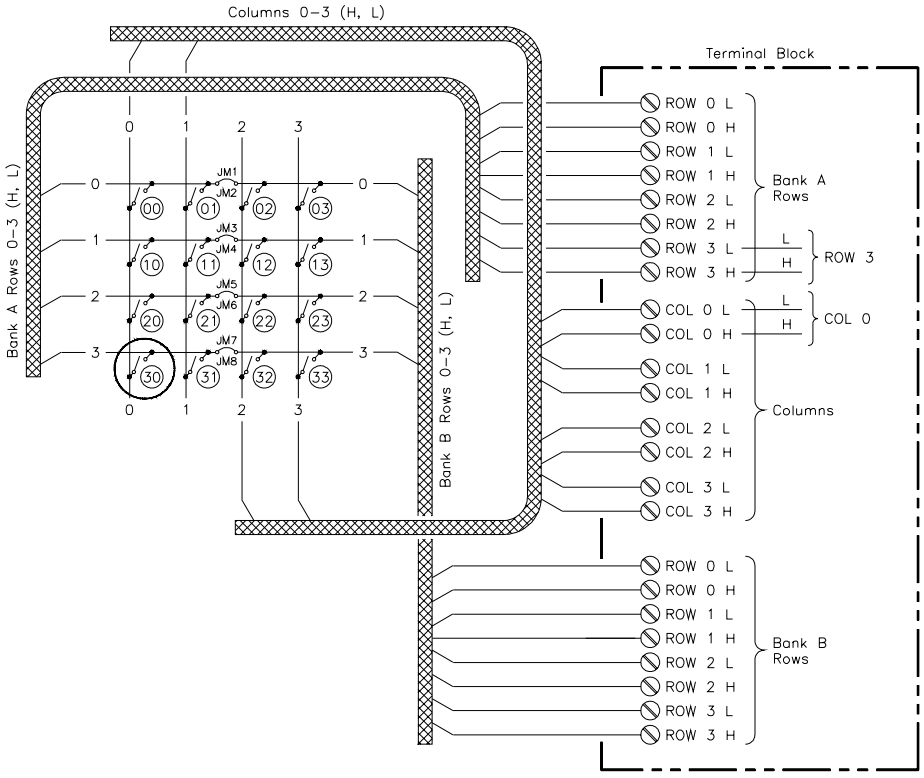


Figure 3-1. Example: 4 X 4 Matrix Switching

Example: Dual 4 X 2 Matrix Switching

This example closes relays 00 and 02 (channels 00 and 02) for a relay matrix in dual 4 X 2 configuration. Closing relay 00 connects the user input to Bank A Row 0 with the user input to Column 0. Closing relay 02 connects the user input to Bank B Row 0 with the user input to Column 2.

See Figure 3-2 for typical user connections (note that JM1-JM8 must be removed for dual 4 X 2 matrix configuration). To close channels 00 and 02 (relays 00 and 02), execute:

```
CLOS (@100,102)      Close channel 00 and 02 relays. 1 is the card number and 00 and 02 are the channel numbers.
```

To open channels 00 and 02, use OPEN (@100,102).

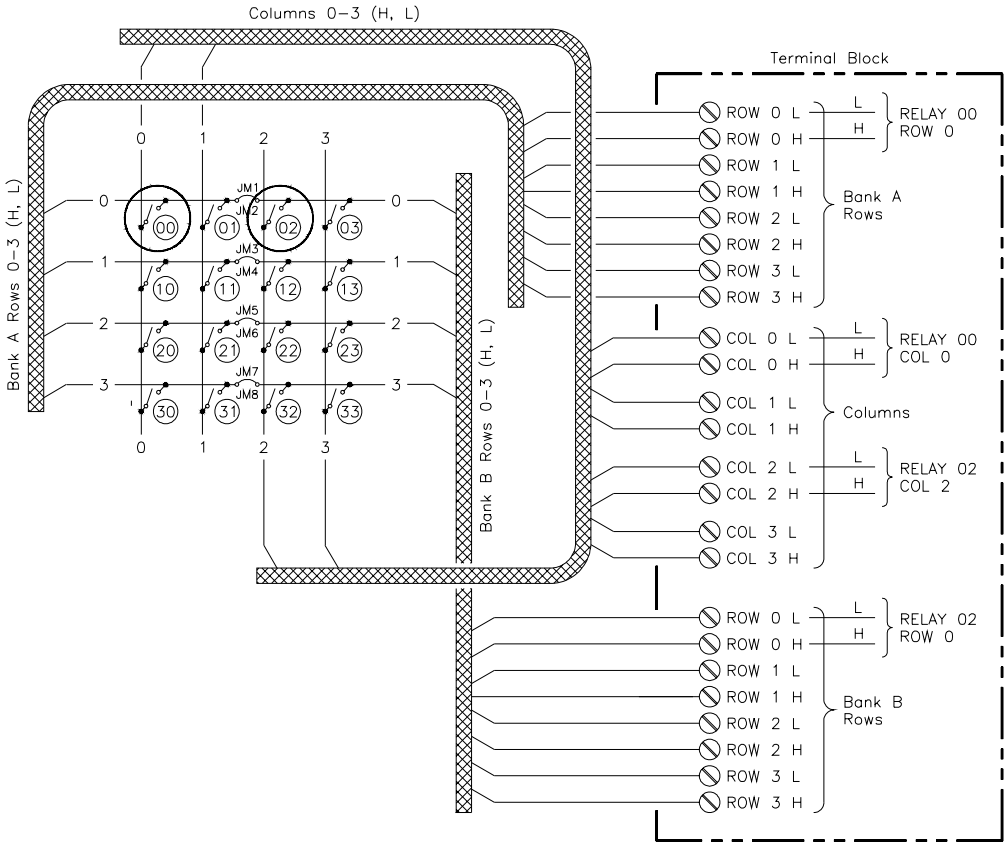


Figure 3-2. Example: Dual 4 X 2 Matrix Switching

Switching Channels Comments

Query Channel States. Use ROUTe:CLOS? <*channel_list*> or ROUTe:OPEN? <*channel_list*> to query channel states (open/closed). For each channel in the <*channel_list*>, ROUTe:CLOS? returns a 1 for each closed channel and a 0 for each open channel. ROUTe:OPEN? returns a 1 for each open channel and a 0 for each closed channel. (These are software queries which do not account for relay hardware failures.)

Channel Closure Order. ROUTe:CLOSe <*channel_list*> can be used to close multiple channels, but the sequence in which the channels are closed with a single command is not guaranteed.

Chapter 4
Understanding the HP E1361A Matrix

Using This Chapter

This chapter explains techniques to scan relay matrix channels and shows how to use the Scan Complete bit. It also explains the response of the switchbox instrument to special 488.2 commands and the SCPI SYSTem:ERRor? query. The chapter contents are:

- Scanning Channels Commands . . . . . Page 29
- Using Scanning Trigger Sources . . . . . Page 29
- Scanning with External Instruments . . . . . Page 29
- Using the Scan Complete Bit. . . . . Page 34
- Special 488.2 Commands. . . . . Page 35
- SCPI Error Responses . . . . . Page 35

Scanning Channels Commands

Scanning relay matrix channels consists of closing a set of channels one at a time. Single scan, multiple (2 to 32767) scans, or continuous scanning modes are available. See Figure 4-1 for scanning commands.

Using Scanning Trigger Sources

The TRIG:SOUR command specifies the source to advance the scan. You can use the TRIG command to advance the scan when TRIG:SOUR BUS or TRIG:SOUR HOLD is set. The OUTPut command can be used to enable the HP E1300A/E1301A Trig Out port. Figure 4-2 shows scanning trigger sources.

Scanning with External Instruments

Scanning relay matrix channels has the same effect as executing multiple CLOSe commands. Thus, scanning is useful when the outputs from a number of devices under test (DUT) are to be measured with an instrument. Two examples using the HP BASIC programming language are on pages 32 and 33.

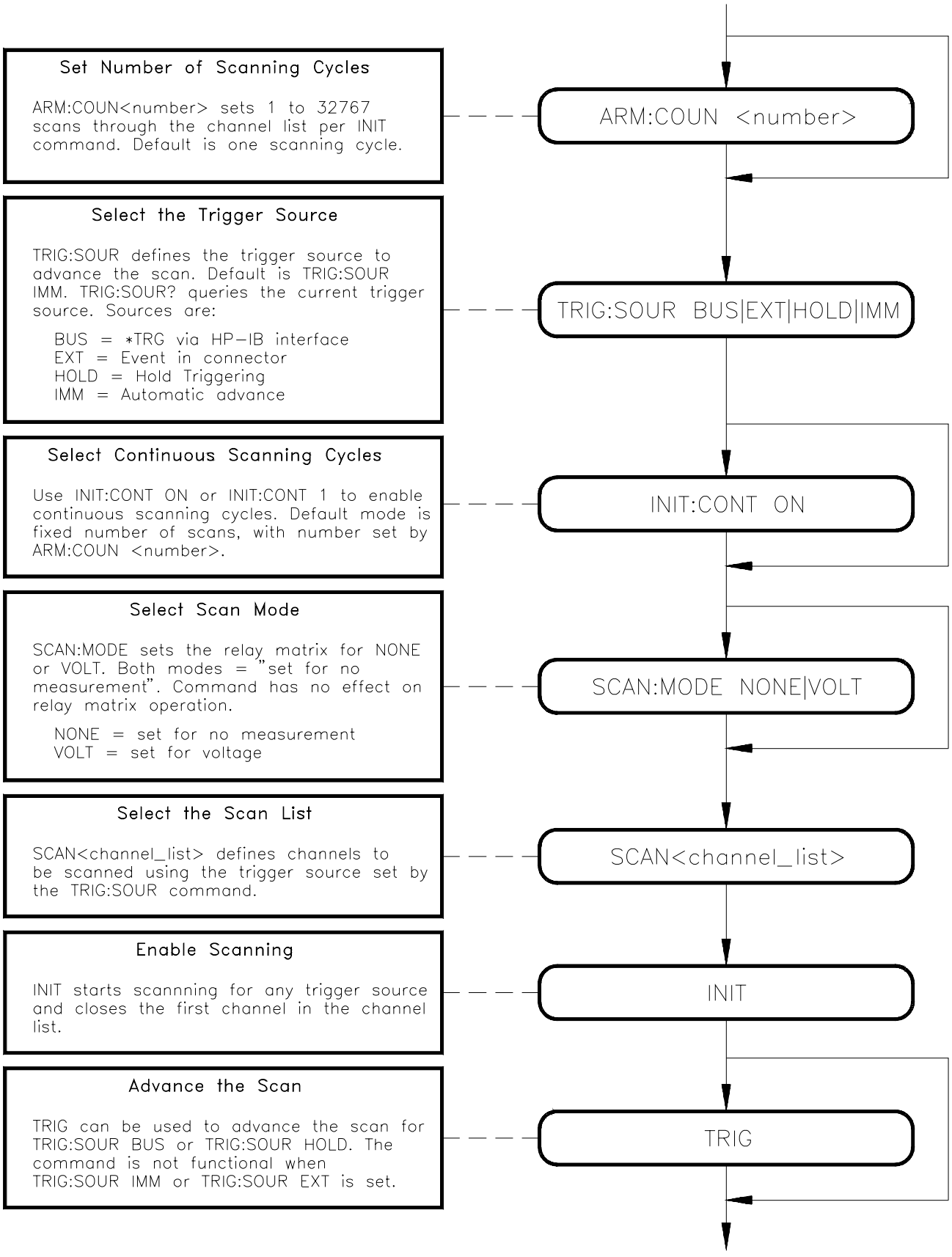


Figure 4-1. Scanning Channels Commands

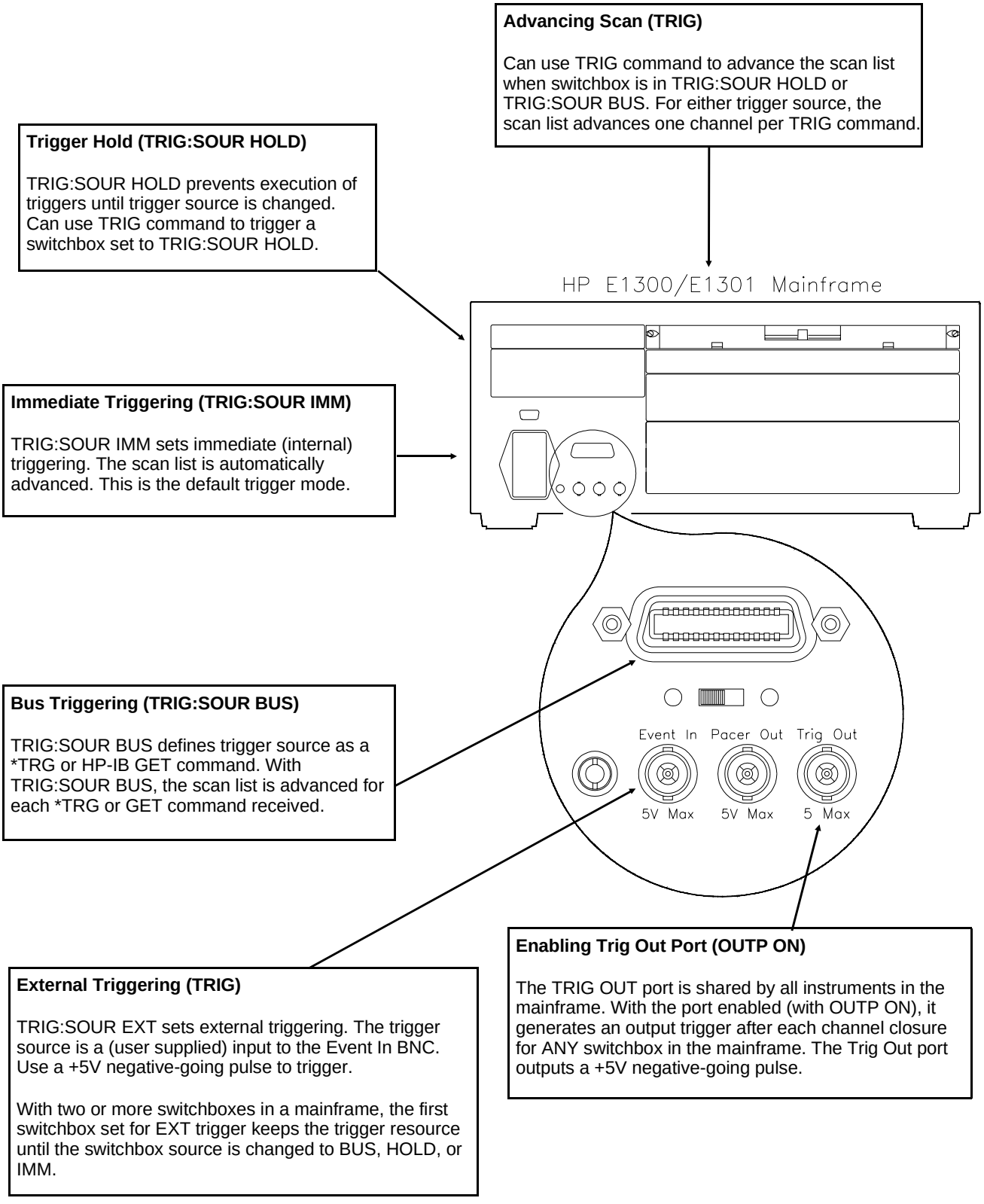


Figure 4-2. Scanning Trigger Sources

Example: Scanning with External Device

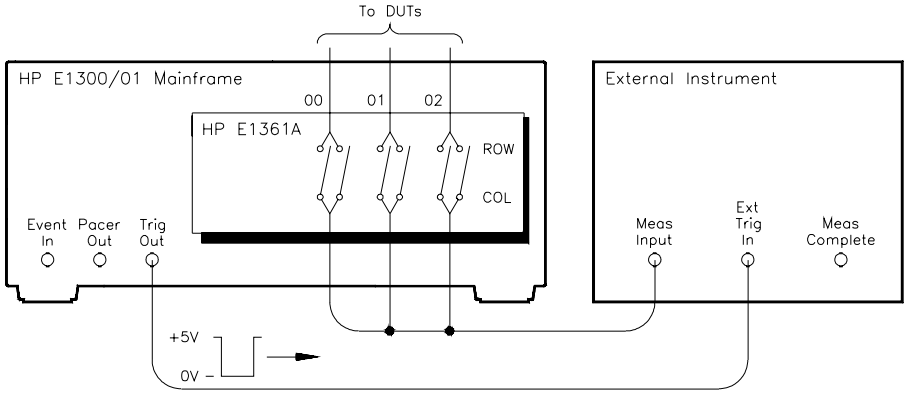
This example uses the HP E1300A/E1301A Mainframe Trig Out port to synchronize relay matrix channel closures to an external measurement device. See the following figure for typical user connections. For measurement synchronization, the HP E1300A/E1301A Trig Out BNC port is connected to the instrument External Trigger In port.

For this example, the HP E1300A/E1301A and the instrument are connected via HP-IB with HP E1300A/E1301A address of 709 and instrument address of 722. The relay matrix logical address is 120 (secondary address = 120/8 = 15). The measurements are transferred directly to the computer. (Appropriate instrument commands must be added to line 10 and you may need to add a WAIT statement at line 65 for slow measurements.)

The sequence of operation is:

1. INIT (line 50) closes channel 100.
2. Closure causes trigger output from the Trig Out port.
3. Trigger to Ext Trig In initiates channel 100 measurement.
4. Result is sent to the computer (lines 60-80).
5. TRIGGER (line 90) advances the scan to channel 101.
6. Steps 2-5 are repeated for channels 101-102.

```
10   OUTPUT 722;"TRIG EXT;…"          ! Configure instrument
20   OUTPUT 70915;"OUTP ON"           ! Enable Trig Out port
30   OUTPUT 70915;"TRIG:SOUR BUS"     ! HP-IB bus triggering
40   OUTPUT 70915;"SCAN (@100:102)"   ! Scan channels 00-02
50   OUTPUT 70915;"INIT"              ! Enable scan
60   FOR I=1 TO 3                     ! Start count loop
70   ENTER 722;A                      ! Enter reading
80   PRINT A                          ! Display reading
90   TRIGGER 70915                    ! Advance scan
100  NEXT I                           ! Increment count
110  END
```



Example: Scanning Using Trig Out and Event In Ports

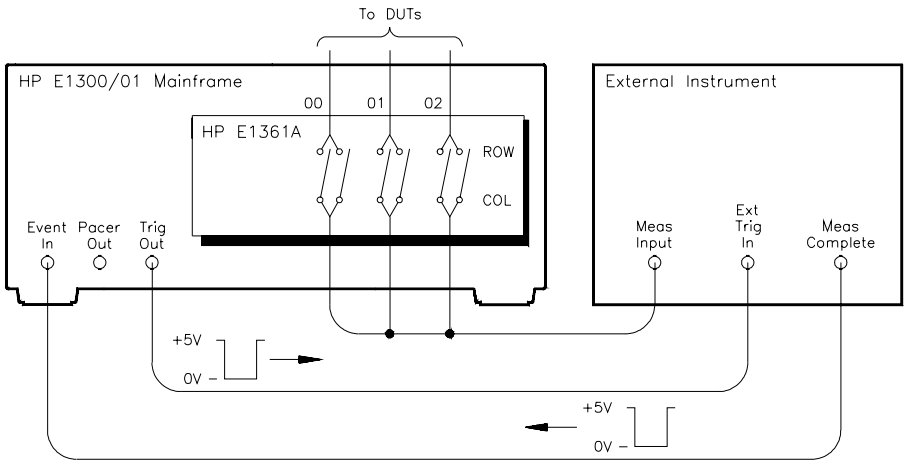
This example uses the HP E1300A/E1301A Mainframe Trig Out and Event In ports to synchronize relay matrix channel closures with an external measurement device. See the following figure for typical user connections. For this example, the mainframe and instrument are connected via HP-IB with mainframe address of 709 and instrument address of 722. The relay matrix logical address is 120 (secondary address = 120/8 = 15).

With this example, since synchronization with the computer cannot be ensured, the external instrument must have internal memory capacity to store the readings. Also, you must add the appropriate instrument commands to line 10.

The sequence of operation is:

1. INIT (line 50) closes channel 100.
2. Closure causes trigger to be output from Trig Out port.
3. Trigger to Ext Trig In starts channel 100 measurement.
4. Channel 100 measurement result is stored in instrument.
5. Trigger is then output from Measurement Complete port.
6. Trigger to Event In port advances scan to channel 101.
7. Steps 2-6 are repeated for channels 101-102.

```
10  OUTPUT 722;"TRIG EXT;…"          ! Configure instrument
20  OUTPUT 70915;"OUTP ON"           ! Enable Trig Out port
30  OUTPUT 70915;"TRIG:SOUR EXT"     ! Event In triggering
40  OUTPUT 70915;"SCAN (@100:102)"   ! Scan channels 00-02
50  OUTPUT 70915;"INIT"              ! Enable scan
60  END
```



Using the Scan Complete Bit

You can use the Scan Complete bit (bit 8) in the Operation Status Register of a switchbox to determine when a scanning cycle completes (no other bits in the register apply to the switchbox). Bit 8 has a decimal value of 256 and you can read it directly with the STAT:OPER? command. See the STATus:OPERation[:EVENt]? command in Chapter 5 for an example.

When enabled by the STAT:OPER:ENAB 256 command, the Scan Complete bit will be reported as bit 7 of the Status Register. Use the HP-IB Serial Poll or the IEEE 488.2 Common Command *STB? to read the Status Register. When bit 7 of the Status Register is enabled by the *SRE 128 Common Command to assert an HP-IB Service Request (SRQ), you can interrupt the computer when the Scan Complete bit is set, after a scanning cycle completes. This allows the computer to do other operations while the scanning cycle is in progress.

The following example monitors bit 7 in the Status Register to determine when the scanning cycle completes. The computer used in this example is an HP 9000 Series 200/300 used with HP BASIC as the programming language. The computer interfaces with an HP E1300A/E1301A mainframe over HP-IB. The HP-IB select code is 7, the HP-IB primary address is 09, and the HP-IB secondary address is 15.

Example: Scan Complete Interrupt

```
10  OUTPUT 70915;"*CLS"                    ! Clear all switchbox status
                                           structure.
20  OUTPUT 70915;"STAT:OPER:ENAB 256"! Enable Scan Complete bit to
                                           set bit 7 in Status register.
30  OUTPUT 70915;"*SRE 128"                ! Enable bit 7 of Status
                                           Register to assert SRQ.
40  OUTPUT 7915;"TRIG:SOUR EXT"            ! External trigger mode
50  OUTPUT 70915;"SCAN (@100:105)"         ! Select channels to be scanned
60  OUTPUT 70915;"INIT"                    ! Start scanning cycle
70  WHILE NOT BIT(SPOLL(70915),7)          ! Wait for scan complete
80  PRINT "DO OTHER OPERATION HERE"! Enter program lines for
                                           computer to do other operations
90  END WHILE
100 PRINT "INTERRUPT GENERATED"            ! Program goes to this line after
                                           interrupt is generated by a
                                           completed scanning cycle
110 END
```

Special 488.2 Commands

This section contains information about the response of the switchbox instrument to three IEEE 488.2 common commands.

Storing States

The *SAV <*numeric_state*> command saves the current instrument state. The state number (0-9) is specified by the *numeric_state* parameter. The settings saved by this command are:

- ARM:COUNt
- TRIGger:SOURce
- OUTPut:STATe
- INITiate:CONTinuous
- SCAN (the scan list is set to invalid; therefore, the command does not save a scan list.)
- SCAN:MODE
- SCAN:PORT

Recalling States

The *RCL <*numeric_state*> command recalls the state when the last *SAV was executed for the specified numeric_state parameter (0-9). If no *SAV was executed for the *numeric_state*, *RST default settings are used. Refer to the *SAV settings list for the settings recalled by *RCL**.**

Response to *RST

The *RST command opens all channels, invalidates the current channel list for scanning, and sets the following:

- ARM:COUNt 1
- TRIGger:SOURce IMM
- INIT:CONTinuous OFF
- OUTPut OFF
- SCAN:MODE NONE
- SCAN:PORT NONE

SCPI Error Responses

The SYSTem:ERRor? query requests a value from the instrument's error register. This register contains an integer in the range [-32768 to 32767]. The response takes the following form:

<*err_number*>,<*err_message*>

The <*err_number*> is the value of the instrument's error register. The <*err_message*> is a short description of the error, followed by further information about the error.

If no error occurs, the switchbox responds with 0,"No error". If there has been more than one error, the instrument will respond with the first one in its error queue. Subsequent queries continue to read the error queue until it is empty. The maximum <*err_message*> string length is 255 characters.

Chapter 5
HP E1361A Relay Matrix Command Reference

Using This Chapter

This chapter summarizes SCPI (Standard Commands for Programmable Instruments) commands and summarizes IEEE 488.2 Common (*) Commands in this manual.

See the *HP 75000 Series B B-Size VXIbus Mainframe* (HP E1300A/E1301A) *User's Manual* or the *HP 75000 Series C HP E1405A User's Manual* for additional information on SCPI and common commands. Chapter contents are:

- Command Types . . . . . Page 37
- SCPI Command Format . . . . . Page 38
- SCPI Command Reference . . . . . Page 40
- IEEE 488.2 Common Commands . . . . . Page 59
- Command Quick Reference . . . . . Page 60

Command Types

Commands are separated into two types: IEEE 488.2 Common Commands and SCPI Commands.

Common Command Format

The IEEE 488.2 standard defines the common commands that perform functions like reset, self-test, status byte query, etc. Common commands are four or five characters in length, always begin with the asterisk character (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of common commands are shown below:

```
*RST        *ESR 32        *STB?
```

SCPI Command Format

SCPI commands perform functions like closing switches, querying instrument states, and retrieving data. A subsystem command structure is a hierarchical structure that usually consists of a top level (or root) command, one or more lower level commands, and their parameters. The following example shows part of a typical subsystem:

```
[ROUTe:]
    CLOSe <channel_list>
    SCAN <channel_list>
        :MODE?
```

ROUTe: is the root command, CLOSe and SCAN are second level commands, and :MODE? is a third level command.

Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

```
ROUTe:SCAN:MODE?
```

Colons separate the root command from the second level command (ROUTe:SCAN) and the second level from the third level (SCAN:MODE?).

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated form or the entire command. For example, if the command syntax shows MEASure, then both MEAS and MEASURE are acceptable forms. Other forms of MEASure, such as MEASU or MEASUR will generate an error. Use upper or lower case letters. Therefore, MEASURE, measure, and MeAsUrE are acceptable.

Implied Commands

Implied commands are those which appear in square brackets ([ ]) in the command syntax. (Note that the brackets are not part of the command and are not sent to the instrument.) Suppose you send a second level command but do not send the preceding implied command. In this case, the instrument assumes you intend to use the implied command and it responds as if you had sent it. Examine the SOURce subsystem shown below:

```
[SOURce:]
    PULSe
        :COUNt <count>
        :COUNt? [<MIN | MAX>]
        :PERiod <period>
        :PERiod? [<MIN | MAX>]
```

The root command SOURce: is an implied command. To set the instrument's pulse count to 25, you can send either of the following command statements:

SOUR:PULS:COUN 25 *or* PULS:COUN 25

Parameters

Parameter Types. The following table contains explanations and examples of the parameter types you might see later in this chapter.

Table 5-1. SCPI Parameter Types

Parameter Type	Explanations and Examples
Numeric	Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. 123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MIN, MAX, and INF.
Boolean	Represents a single binary condition that is either true or false. ON, OFF, 1, 0.
Discrete	Selects from a finite set of values. These parameters use mnemonics to represent each valid setting. An example is TRIGger:SOURce <*source*> where <*source*> can be BUS, EXT, HOLD, or IMM.

Optional Parameters. Parameters shown within square brackets ([ ]) are optional parameters. (Note that the brackets are not part of the command and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument chooses a default value.

For example, consider the ARM:COUNt? [MIN | MAX] command. If you send the command without specifying a parameter, the present ARM:COUNt value is returned. If you send the MIN parameter, the command returns the minimum count available. If you send the MAX parameter, the command returns the maximum count available. Be sure to place a space between the command and the parameter.

Linking Commands

Linking IEEE 488.2 Common Commands with SCPI Commands:
Use a semicolon between the commands. For example:

```
*RST;OUTP ON  or  TRIG:SOUR HOLD;*RST
```

Linking Multiple SCPI Commands:
Use both a semicolon (;) and a colon (:) between the commands.
For example:

```
ARM:COUN 1;:TRIG:SOUR EXT
```

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI) commands for the relay matrix. Commands are listed alphabetically by subsystem and also within each subsystem.

The ABORt command subsystem stops a scan in progress when the scan is enabled via the interface and the trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

Subsystem Syntax

```
ABORt
```

Comments

- **ABORt Actions:** ABORt invalidates the current channel list and sets ARM:COUNt 1 (one scanning cycle per INITiate command), sets INITiate:CONTinuous OFF (no continuous scanning cycles), and sets TRIGger:SOURce IMMediate (immediate internal triggering).
- **Stopping Scan Enabled Via Interface:** When a scan is enabled via an interface, an interface CLEAR command or the HP E1301A front panel "Reset Instr" or "Clear Instr" keys can be used to stop the scan. When the scan is enabled via the interface and TRIG:SOUR BUS or HOLD is set you can use ABORt or the HP E1301A front panel "Reset Instr" or "Clear Instr" keys to stop the scan.
- **Stopping Scan Enabled From Front Panel:** When a scan is enabled from the HP E1301A front panel, you can use *RST entered via the interface or the front panel "Reset Instr" or "Clear Instr" keys to stop the scan.
- **Related Commands:** ARM, INITiate:CONTinuous, [ROUTe:]SCAN, TRIGger

Example

Stopping a Scan with ABORt

This example stops a (continuous) scan in progress.

```
TRIG:SOUR BUS                 *TRG command is trigger source
INIT:CONT ON                  Set continuous scanning
SCAN (@100:103)               Scan channels 00-03
INIT                          Start scan, close channel 00
  .
  .
ABOR                          Abort scan in progress
```

The ARM subsystem selects the number of scanning cycles (1 to 32767) for each INITiate command.

Subsystem Syntax

```
ARM
    :COUNt <number> MIN | MAX
    :COUNt? [MIN | MAX]
```

:COUNt

ARM:COUNt <*number*> MIN | MAX allows scanning cycles to occur a multiple of times (1 to 32767) with one INITiate command when INITiate:CONTinuous OFF | 0 is set. MIN sets 1 cycle and MAX sets 32767 cycles.

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1-32767 | MIN | MAX

Comments

- **Number of Scans:** Use only values between 1 and 32767 for the number of scanning cycles.
- **Related Commands:** ABORt, INITiate:IMMediate
- ***RST Condition:** ARM:COUNt 1

Example **Setting Ten Scanning Cycles**

This example sets a relay matrix for 10 scans of channels 00 through 03. When the scan sequence completes, channels 00 through 03 (relays 00 through 03) are closed.

```
ARM COUN 10                 Set 10 scans per INIT command
SCAN (@100:103)             Scan channels 00-03
INIT                        Start scan, close channel 00
```

:COUNt?

ARM:COUNt? [MIN | MAX] returns the current number of scanning cycles set by ARM:COUNt. The current number of scan cycles is returned when MIN or MAX is not supplied. With MIN or MAX as a parameter, MIN returns 1 and MAX returns 32767.

Parameters

Parameter Name	Parameter Type	Range of Values
MIN | MAX	numeric	MIN = 1, MAX = 32767

Comments

- **Related Commands:** INITiate[:IMMediate]

Example Query Number of Scans

This example sets a switchbox for 10 scanning cycles of channels 00 through 03 and queries the number of scan cycles set. The ARM:COUN? command returns 10.

```
ARM COUN 10          Set 10 scans per INIT command
ARM COUN?            Query number of scans
```

The DISPlay subsystem monitors the channel state of a selected module (or card) in a switchbox. This subsystem operates only with mainframes which have a display, such as the HP 75000 Series B mainframe (HP Model Number E1301A).

Subsystem Syntax

```
DISPlay
    :MONitor
        :CARD <number | AUTO>
        [:STATe] <mode>
```

MONitor:CARD

DISPlay:MONitor:CARD <*number* | AUTO> selects the module in a switchbox to be monitored.

Parameters

Parameter Name	Parameter Type	Range of Values
number | AUTO	numeric	1-99

Comments

- **Selecting a Specific Module to be Monitored:** Use the DISPlay:MONitor:CARD command to send the card number for the switchbox to be monitored.
- **Selecting the Present Module to be Monitored:** Use the DISPlay:MONitor:CARD AUTO command to select the last module addressed by a switching command (e.g., [ROUTe:]CLOSe).
- ***RST Condition:** DISPlay:MONitor:CARD AUTO

Example **Select Module #2 in a Switchbox for Monitoring**

```
DISP:MON:CARD 2          Selects module #2 in a switchbox
```

MONitor[:STATe]

DISPlay:MONitor[:STATe] <*mode*> turns the monitor mode ON or OFF.

Parameters

Parameter Name	Parameter Type	Range of Values
mode	boolean	ON | OFF | 1 | 0

Comments

- **Monitoring Switchbox Channels:** DISPlay:MONitor[:STATe] ON or DISPlay:MONitor[:STATe] 1 turns the monitor mode ON to show the channel state of the selected module. DISPlay:MONitor[:STATe] OFF or DISPlay:MONitor[:STATe] 0 turns the monitor mode OFF.
- **Selecting the Module to be Monitored:** Use the DISPlay:MONitor:CARD <*number*>AUTO command to select the module.

- **Monitor Mode on an HP E1301A Mainframe Display:** A typical display for the HP E1361A 4 X 4 Relay Matrix module follows, where all channels (all relays) are closed. R0 = row 0, etc.

  R0:0,1,2,3 R1:0,1,2,3 R2:0,1,2,3 R3:0,1,2,3

- ***RST Condition:** DISPlay:MONitor[:STATe] OFF | 0

Example **Enabling the Monitor Mode**

```
DISP:MON:CARD 2          Selects module#2 in a switchbox
DISP:MON 1               Turns monitor mode ON
```

The INITiate command subsystem selects continuous scanning cycles and starts the scanning cycle.

Subsystem Syntax

```
INITiate
    :CONTinuous <mode>
    :CONTinuous?
    [:IMMediate]
```

:CONTinuous

INITiate:CONTinuous <*mode*> enables or disables continuous scanning cycles for the switchbox.

Parameters

Parameter Name	Parameter Type	Range of Values
mode	boolean	ON | OFF | 1 | 0

Comments

- **Continuous Scanning Operation:** Continuous scanning is enabled with the INITiate:CONTinuous ON or INITiate:CONTinuous 1 command. Sending the INITiate:IMMediate command closes the first channel in the channel list. Each trigger from a trigger source selected by the TRIGger:SOURce command advances the scan through the channel list. A trigger at the end of the channel list closes the first channel in the channel list and the scan cycle repeats.

- **Non-Continuous Scanning Operation:** Non-continuous scanning is enabled with the INITiate:CONTinuous OFF or INITiate:CONTinuous 0 command. Sending the INITiate:IMMediate command closes the first channel in the channel list. Each trigger from a trigger source selected by the TRIGger:SOURce command advances the scan through the channel list. At the end of the scanning cycle, the last channel in the channel list is closed.

- **Stopping Continuous Scan:** See the ABORt command.

- **Related Commands:** ABORt, ARM:COUNt, TRIGger, TRIGger:SOURce

- ***RST Condition:** INITiate:CONTinuous OFF

Example **Enabling Continuous Scanning**

This example enables continuous scanning of channels 00 through 03 of a single-module switchbox. Since TRIGger:SOURce IMMediate (default) is set, use an interface clear command (such as CLEAR) to stop the scan.

```
INIT:CONT ON                 Enable continuous scanning
SCAN (@100:103)              Defines channel list
INIT                         Start scan cycle, close channel 00
```

:CONTinuous?

INITiate:CONTinuous? queries the scanning state. With continuous scanning enabled, the command returns 1. With continuous scanning disabled, the command returns 0.

Example

Query Continuous Scanning State

This example enables continuous scanning of a switchbox and queries the state. Since continuous scanning is enabled, INIT:CONT? returns 1.

```
INIT:CONT ON                    Enable continuous scanning
INIT:CONT?                      Query continuous scanning state
```

[:IMMediate]

INITiate[:IMMediate] starts the scanning process and closes the first channel in the channel list. Successive triggers from the source selected by the TRIGger:SOURce command advance the scan through the channel list.

Comments

- **Starting the Scanning Cycle:** The INITiate:IMMediate command starts scanning by closing the first channel in the channel list. Each trigger received advances the scan to the next channel in the channel list. An invalid channel list definition causes an error (see [ROUTe:]SCAN).
- **Stopping Scanning Cycles:** See ABORt.

Example

Enabling a Single Scan

This example enables a single scan of channels 00 through 03 of a single-module switchbox. The trigger source to advance the scan is immediate (internal) triggering set with (default) TRIGger:SOURce IMMediate.

```
SCAN (@100:103)                 Scan channels 00-03
INIT                            Begin scan, close channel 00
                                (use immediate triggering).
```

The OUTPut command subsystem enables or disables the "Trig Out" port of the HP E1300A/E1301A Mainframe or on the HP E1405A/E1406A Command Module.

Subsystem Syntax

```
OUTPut
    [:STATe] <state>
    [:STATe]?
```

[:STATe]

OUTPut[:STATe] <*state*> enables or disables the "Trig Out" port on the rear panel of the HP E1300A/E1301A Mainframe. OUTPut[:STATe] ON | 1 enables the port and OUTPut[:STATe] OFF | 0 disables the port.

Parameters

Parameter Name	Parameter Type	Range of Values
state	boolean	ON | OFF | 1 | 0

Comments

- **Enabling Trig Out Port:** When enabled, a pulse is output from the "Trig Out" port after each scanned switchbox channel is closed. If disabled, a pulse is not output from the port after channel closures. The output pulse is a +5 V negative-going pulse.
- **Trig Out Port Shared by Switchboxes:** When enabled, the "Trig Out" port is pulsed by any switchbox each time a scanned channel is closed. To disable the output for a specific switchbox, send the OUTPut[:STATe] OFF or OUTPut[:STATe] 0 command for that switchbox.
- **Related Commands:** [ROUTe:]SCAN, TRIGger:SOURce
- ***RST Condition:** OUTPut[:STATe] OFF (port disabled)

Example

```
OUTP:STAT ON          Enable "Trig Out" port to output pulse
```

[:STATe]?

OUTPut[:STATe]? queries the present state of the "Trig Out" port. The command returns 1 if the port is enabled or 0 if the port is disabled.

Example **Query Trig Out Port Enable State**

This example enables the "Trig Out" Port and queries the enable state. The OUTPut[:STATe]? command returns 1 since the port is enabled.

```
OUTP:STAT ON          Enable "Trig Out" port
OUTP:STAT?            Query port enable state
```

The [ROUTe:] command subsystem controls switching and scanning operations for relay matrix modules in a switchbox.

Subsystem Syntax

```
[ROUTe:]
    CLOSe <channel_list>
    CLOSe? <channel_list>
    OPEN <channel_list>
    OPEN? <channel_list>
    SCAN <channel_list>
        :MODE NONE | VOLT
        :MODE?
```

CLOSe

[ROUTe:]CLOSe *<channel_list>* closes the relay matrix channels specified by *channel_list*. *channel_list* has the form (@nnrc) where nn = matrix card number (01-99), r = matrix row number (0-3), and c = matrix column number (0-3).

Parameters

Parameter Name	Parameter Type	Range of Values
channel_list	numeric	nn00-nn03, nn10-nn13, nn20-nn23, nn30-nn33

Comments

- **Closing Channels:**
  - To close a single channel, use [ROUTe:]CLOSe (@nnrc);
  - for multiple channels use [ROUTe:]CLOSe (@nnrc,nnrc,...);
  - for sequential channels, use [ROUTe:]CLOSe (@nnrc:nnrc);
  - for groups of sequential channels, use [ROUTe:]CLOSe (@nnrc:nnrc,nnrc:nnrc);
  - or any combination.

  Closure order for multiple channels with a single command is not guaranteed.

- **Related Commands:** [ROUTe:]OPEN, [ROUTe:]CLOSe?
- ***RST Condition:** All channels open

Example

Closing Matrix Channels

This example closes channels 100 and 213 of a two-module switchbox (card numbers 01 and 02).

```
CLOS (@100,213)
```

Close channels 100 and 213. 100 closes channel 00 of card #1 and 213 closes channel 13 of card #2.

CLOSe?

[ROUTe:]CLOSe? <*channel_list*> returns the current state of the channel(s) queried. *channel_list* has the form (@nnrc) (see [ROUTe:]CLOSe for definition). The command returns 1 if channel(s) are closed or returns 0 if channel(s) are open.

Comments

- **Query is Software Readback:** The [ROUTe:]CLOSe? command returns the current software state of the channel(s) specified. It does not account for relay hardware failures. A maximum of 127 channels at a time can be queried for a multi-module switchbox.

Example

Query Channel Closure

This example closes channels 100 and 213 of a two-module switchbox and queries channel closure. Since the channels are programmed to be closed 1,1 is returned as a string.

CLOS (@100,213)	*Close channels 100 and 213*
CLOS? (@100,213)	*Query channels 100 and 213 state*

OPEN

[ROUTe:]OPEN <*channel_list*> opens the relay matrix channels specified by *channel_list*. *channel_list* has the form (@nnrc) where nn = matrix card number (01-99), r = matrix row number (0-3), and c = matrix column number (0-3).

Parameters

Parameter Name	Parameter Type	Range of Values
channel_list	numeric	nn00-nn03, nn10-nn13, nn20-nn23, nn30-nn33

Comments

- **Opening Channels:**
  - To open a single channel, use [ROUTe:]OPEN (@nnrc);
  - for multiple channels use [ROUTe:]OPEN (@nnrc,nnrc,...);
  - for sequential channels, use [ROUTe:]OPEN (@nnrc:nnrc);
  - for groups of sequential channels, use [ROUTe:]OPEN (@nnrc:nnrc,nnrc:nnrc);
  - or any combination.

  Opening order for multiple channels with a single command is not guaranteed.
- **Related Commands:** [ROUTe:]CLOSe, [ROUTe:]OPEN?
- ***RST Condition:** All channels open.

Example

Opening Channels

This example opens channels 100 and 213 of a two-module switchbox (card numbers 01 and 02).

OPEN (@100,213)	*Open channels 100 and 213. 100 opens channel 00 of #1 and 213 opens channel 13 of card #2.*

OPEN?

[ROUTe:]OPEN? <*channel_list*> returns the current state of the channel(s) queried. *channel_list* has the form (@nnrc) (see [ROUTe:]OPEN for definition). The command returns 1 if channel(s) are open or returns 0 if channel(s) are closed.

Comments

- **Query is Software Readback:** The ROUTe:OPEN? command returns the current software state of the channels specified. It does not account for relay hardware failures. A maximum of 127 channels at a time can be queried for a multi-module switchbox.

Example

Query Channel Open State

This example opens channels 100 and 213 of a two-module switchbox and queries channel 213 state. Since channel 213 is programmed to be open, 1 is returned.

```
OPEN (@100,213)          Open channels 100 and 213
OPEN? (@213)             Query channel 213 state
```

SCAN

[ROUTe:]SCAN <*channel_list*> defines the channels to be scanned. *channel_list* has the form (@nnrc) where nn = matrix card number (01-99), r = matrix row number (0- 3), and c = matrix column number (0-3).

Parameters

Parameter Name	Parameter Type	Range of Values
channel_list	numeric	nn00-nn03, nn10-nn13, nn20-nn23, nn30-nn33

Comments

- **Defining Scan List:** When [ROUTe:]SCAN is executed, the channel list is checked for valid card and channel numbers. An error is generated for an invalid channel list.

- **Scanning Channels:**
  - You can scan single channels (@nnrc);
  - multiple channels (@nnrc,nnrc,...);
  - sequential channels (@nnrc:nnrc);
  - groups of sequential channels (@nnrc:nnrc,nnrc:nnrc);
  - or any combination.

- **Scanning Operation:** When a valid channel list is defined, INITiate[:IMMediate] begins the scan and closes the first channel in the channel list. Successive triggers from the source specified by TRIGger:SOURce advance the scan through the channel list.

- **Stopping Scan:** See ABORt.

- **Related Commands:** TRIGger, TRIGger:SOURce

- ***RST Condition:** All channels open.

Example Scanning Using External Device

See Chapter 4, “Example: Scanning with External Device” or “Example: Scanning Using Trig Out and Event In Ports” for example scanning programs using external instruments.

SCAN:MODE

[ROUTe:]SCAN:MODE NONE | VOLT can be used for the relay matrix. Both NONE and VOLT set the mode for "no measurements". This command has no effect on relay matrix operation.

SCAN:MODE?

[ROUTe:]SCAN:MODE? can be used to query the scanning mode (NONE or VOLT) for the relay matrix.

The STATus subsystem reports the bit values of a Standard Operation Status Register. Enables the Status Register to set a bit after a bit is set to 1 by the Standard Operation Register.

Subsystem Syntax

```
STATus
    :OPERation
        :ENABle <number>
        [:EVENt]?
```

:OPERation:ENABle

STATus:OPERation:ENABle <*number*> enables the Operation Status Register to set a bit in the Status Register. Setting bit 8 in the Operation Status Register to 1 sets bit 7 in the Status Register to 1, when enabled.

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1-32767

Comments

- **Setting Bit 7 of the Status Register:** STATus:OPERation:ENABle 256 sets bit 7 of the Status Register to 1 after bit 8 of the Operation Status Register is set to 1.
- **Related Commands:** [ROUTe:]SCAN

Example

Enabling Status Register Bit 7

```
STAT:OPER:ENAB 256          Enables bit 7 of Status Register
```

:OPERation[:EVENt]?

STATus:OPERation[:EVENt]? returns the bit value of the Operation Status Register (only bit 8 is used by the matrix modules).

Comments

- **Setting Bit 8 of the Operation Status Register:** Bit 8 (Scan Complete) is set to 1 after a scanning cycle completes. Bit 8 returns to 0 after sending the STATus:OPERation[:EVENt]? command.
- **Returned Data After Sending the STATus:OPERation[:EVENt]? command:** The command returns +256 if bit 8 of the Operation Status Register is set to 1 or it returns +0 if bit 8 of the Operation Status Register is set to 0.
- **Related Commands:** [ROUTe:]SCAN

Example **Reading the Operation Status Register After a Scanning Cycle**

STAT:OPER?	*Returns bit values of the Standard Operation Status Register. Returns +256 if bit 8 is set to 1 or returns +0 if bit 8 is set to 0.*

The SYSTem subsystem returns the error numbers and error messages in the error queue of a switchbox, and returns the types and descriptions of modules (cards) in a switchbox.

Subsystem Syntax

```
SYSTem
    :CDEScription? <number>
    :CPON <number | ALL>
    :CTYPe? <number>
    :ERRor?
```

:CDEScription?

SYSTem:CDEScription? <*number*> returns the description of a selected module (card) in a switchbox.

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1-99

Comments

- **4 X 4 Relay Matrix Module Description:**
  The SYSTem:CDEScription? <*number*> command returns:

```
4 X 4 Relay Matrix
```

Example **Reading the Description of a Card#1 Module**

```
SYST:CDES? 1                    Return the description
```

:CPON

SYSTem:CPON <*number* | ALL> sets the selected module (card) in a switchbox to its power-on state.

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1-99

Comments

- **Matrix Module Power-On State:** The power-on state is all channels (relays) open. Note that *RST opens all channels of all modules in a switchbox, while SYSTem:CPON <*number*> opens the channels in only the module (card) specified in the command.

Example **Setting Card #1 Module to its Power-On State**

```
SYST:CPON 1                     Sets module #1 to power-on state
```

:CTYPe?

SYSTem:CTYPe? <*number*> returns the module (card) type of a selected module in a switchbox.

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1-99

Comments

- **4 X 4 Relay Matrix Module Model Number:** The SYSTem:CTYPe? <*number*> command returns:

```
HEWLETT-PACKARD,E1361A,0,A.01.00
```

  where the 0 after E1361A is the module serial number (always 0) and A.01.00 is an example of the module revision code number.

Example

Reading the Model Number of a Card#1 Module

```
SYST:CTYP? 1                    Return the model number
```

ERRor?

SYSTem:ERRor? returns the error numbers and corresponding error messages in the error queue of a switchbox. See Appendix C for a listing of some switchbox error numbers and messages.

Comments

- **Error Numbers/Messages in the Error Queue:** Each error generated by a switchbox stores an error number and corresponding error message in the error queue. The error message can be up to 255 characters long.

- **Clearing the Error Queue:** An error number/message is removed from the queue each time the SYSTem:ERRor? command is sent. The errors are cleared first-in, first-out. When the queue is empty, each following SYSTem:ERRor? command returns 0, "No error". To clear all error numbers/messages in the queue, execute the *CLS command.

- **Maximum Error Numbers/Messages in the Error Queue:** The queue holds a maximum of 30 error numbers/messages for each switchbox. If the queue overflows, the last error number/message in the queue is replaced by -350, "Too many errors". The least recent error numbers/messages remain in the queue and the most recent are discarded.

Example

Reading the Error Queue

```
SYST:ERR?                       Query the error queue
```

The TRIGger command subsystem controls the triggering operation of relay matrix modules in a switchbox.

Subsystem Syntax

```
TRIGger
    [:IMMediate]
    :SOURce BUS | EXTernal | HOLD | IMMediate
    :SOURce?
```

[:IMMediate]

TRIGger[:IMMediate] causes a trigger event to occur when the defined trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD.

Comments

- **Executing the TRIGger[:IMMediate] Command:** A *channel list* must be defined with [ROUTe:]SCAN <*channel_list*> and an INITiate[:IMMediate] command must be executed before TRIGger[:IMMediate] will execute.
- **BUS or HOLD Source Remains:** If selected, the TRIGger:SOURce BUS or TRIGger:SOURce HOLD commands remain in effect after triggering a switchbox with the TRIGger[:IMMediate] command.
- **Related Commands:** INITiate, [ROUTe:]SCAN

Example

Advancing Scan Using TRIGger Command

This example uses the TRIGger command to advance the scan of a single-module switchbox from channel 00 through 03. Since TRIGger:SOURce HOLD is set, the scan is advanced one channel each time TRIGger is executed.

```
TRIG:SOUR HOLD          Sets trigger source to HOLD
SCAN (@100:103)         Defines channel list
INIT                    Begin scan, close channel 00
loop statement          Start count loop
TRIG                    Advance scan to next channel
increment loop          Increment loop count
```

TRIGger:SOURce BUS | EXTernal | HOLD | IMMediate specifies the trigger source to advance the *channel list* during scanning.

Parameters

Parameter Name	Parameter Type	Range of Values
BUS	discrete	*TRG or GET command
EXTernal	discrete	"Event In" port
HOLD	discrete	Hold triggering
IMMediate	discrete	Immediate triggering

Comments

- **Enabling the Trigger Source:** The TRIGger:SOURce command only selects the trigger source. The INITiate[:IMMediate] command enables the trigger source.
- **Using the TRIG Command:** You can use TRIGger[:IMMediate] to advance the scan when TRIGger:SOURce BUS or TRIGger:SOURce HOLD is selected.
- **Using External Trigger Inputs:** With TRIGger:SOURce EXTernal selected, only one switchbox at a time can use the external trigger input at the HP E1300A/E1301A Mainframe "Event In" port. The trigger input is assigned to the first switchbox that requested the external trigger source (with a TRIGger:SOURce EXTernal command).
- **Assigning External Trigger:** A switchbox assigned with TRIGger:SOURce EXTernal remains assigned to that source until the switchbox trigger source is changed to BUS, HOLD, or IMMediate. When the source is changed, the external trigger source is available to the next switchbox which requests it (with a TRIGger:SOURce EXTernal command). If a switchbox requests an external trigger input already assigned to another switchbox an error is generated.
- **Using Bus Triggers:** To trigger the switchbox with TRIGger:SOURce BUS selected, use the IEEE 488.2 common command *TRG or the HP-IB Group Execute Trigger (GET) command.
- **Trig Out Port Shared by Switchboxes:** See the OUTPut command.
- **Related Commands:** ABORt, [ROUTe:]SCAN, TRIGger
- ***RST Condition:** TRIGger:SOURce IMMediate

Examples Scanning Using External Triggers

This example uses external triggering (TRIG:SOUR EXT) to scan channels 00 through 03 of a single-module switchbox. The trigger source to advance the scan is the input to the "Event In" on an HP E1300A/E1301A mainframe. When INIT is executed, the scan is started and channel 00 is closed. Then each trigger received at the "Event In" advances the scan to the next channel.

```
TRIG:SOUR EXT                 Select external triggering
SCAN (@100:103)               Scan channels 00 through 03
INIT                          Begin scan, close channel 00
trigger externally            Advance scan to next channel
```

Scanning Using Bus Triggers

This example uses bus triggering (TRIG:SOUR BUS) to scan channels 00 through 03 of a single-module switchbox. The trigger source to advance the scan is the *TRG command (as set with TRIGger:SOURce BUS). When INIT is executed, the scan is started and channel 00 is closed. Then, each *TRG command advances the scan to the next channel.

```
TRIG:SOUR BUS                 Select interface (bus) triggering
SCAN (@100:103)               Scan channels 00 through 03
INIT                          Start scan, close channel 00
loop statement                Loop to scan all channels
*TRG                          Advance scan using bus triggering
increment loop                Increment loop count
```

:SOURce?

TRIGger:SOURce? returns the current trigger source for the switchbox. Command returns BUS, EXT, HOLD, or IMM for sources BUS, EXTernal, HOLD, or IMMediate, respectively.

Example Query Trigger Source

This example sets external triggering and queries the trigger source. Since external triggering is set, TRIG:SOUR? returns EXT.

```
TRIG:SOUR EXT                 Set external trigger source
TRIG:SOUR?                    Query trigger source
```

The following table lists the IEEE 488.2 Common (*) Commands that apply to the relay matrix module. The operation of some of these commands is described in Chapter 4 of this manual. For more information on Common Commands, refer to the *HP 75000 Series B Mainframe* (HP Model Number E1300/E1301) *User's Manual* or the ANSI/IEEE Standard 488.2-1987.

Command	Title	Description
*IDN?	Identification	Returns identification string of the switchbox.
*RST	Reset	Opens all channels, and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF.
*TST?	Self-Test	Always returns 0.
*OPC	Operation Complete	See note below
*OPC?	Operation Complete Query	See note below
*WAI	Wait to Complete	See note below
*CLS	Clear status	Clears all status registers (see STATus:OPERation[:EVENt]?)
*ESE	Event status enable	See note below
*ESE?	Event status enable query	See note below
*ESR?	Event status register query	See note below
*SRE	Service request enable	Enables status register bits (see Chapter 4 for operation)
*SRE?	Service request enable query	See note below
*STB?	Read status byte query	See note below
*TRG	Trigger	Triggers the switchbox to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS
*RCL	Recall instrument state	See note below
*SAV	Store instrument state	See note below

Note: These commands apply to many instruments and are not documented in detail here. See the *HP 75000 Series B E1300/E1301 Mainframe User's Manual*, the *HP E1405A Command Module Manual* or the ANSI/IEEE Standard 488.2-1987 for more information.

The following tables summarize SCPI and IEEE 488.2 Common (*) Commands for relay matrix modules used in a switchbox.

SCPI Commands Quick Reference

Command		Description
ABORt		Abort a scan in progress.
ARM	:COUNt <*number*> MIN | MAX :COUNt? [MIN | MAX]	Multiple scans per INIT command. Query number of scans.
DISPlay	:MONitor:CARD <*number* | AUTO> *:MONitor[:STATe] <boolean>*	Selects module to be monitored. Selects monitor mode.
INITiate	:CONTinuous <*mode*> :CONTinuous? [:IMMediate]	Enables/disables continuous scanning. Query continuous scan state. Starts a scanning cycle.
OUTPut	[:STATe] <*state*> [STATe]?	Enables/disables "Trig Out" pulse. Query port enable state.
[ROUTe:]	CLOSe <*channel _list*> CLOSe? <*channel _list*> OPEN <*channel_list*> OPEN? <*channel _list*> SCAN <*channel_list*> SCAN:MODE NONE | VOLT	Close channel(s). Query channel(s) closed. Open channel(s). Query channel(s) opened. Define channels for scanning. Sets scan mode.
STATus	:OPERation:ENABle :OPERation[:EVENt]?	Enables the Operation Status Register to set a bit in the Status Register. Returns status of Operation Status Register.
SYSTem	:CDEScription? <*number*> :CPON <*number* | ALL> :CTYPe? <*number*> :ERRor?	Returns description of module in a switchbox. Sets specified module to its power-on state. Returns the module type. Returns error number/message in a switchbox Error Queue.
TRIGger	[:IMMediate] :SOURce BUS :SOURce EXTernal :SOURce HOLD :SOURce IMMediate :SOURce?	Causes a trigger to occur. Trigger source is *TRG. Trigger source is "Event In". Hold off triggering. Continuous (internal) triggers. Query scan trigger source.

IEEE 488.2 Common Commands Quick Reference

Command	Title	Description
*RST	Reset	Opens all channels, and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF
*TRG	Bus Trigger	When scan is enabled and trigger source is TRIG:SOUR BUS, use the *TRG command to trigger the switchbox to advance the scan.
*TST?	Self-Test	Always returns 0.

Appendix A
HP E1361A Relay Matrix Specifications

Maximum Input Voltage:

Hi to Lo	Any term. to chassis
250VDC	250 VDC
250VAC rms	250VAC rms
354VACpeak	354VACpeak

Maximum Current:
Per Channel: 40WDC or 40VA ACrms

Maximum Power:
Per Channel: 40WDC or 40VA AC
Per Module: 320WDC or 320VA AC

Thermal Offset:
<14 μV differential per path

Closed Channel Resistance:
<1.5Ω/contact (typical)
<3.5Ω at end of relay life

Insulation Resistance:
$>10^7$Ω at ≥40ºC, 65% RH
$>10^8$Ω at ≥25ºC, 40% RH

Bandwidth: -3dB at 10 MHz
(50Ω source and load)

Crosstalk, Channel to Channel (typical):
≤100kHz: ≤80dB
≤10Mhz: ≤30dB

Capacitance:

H to L:	<150pF*
H to H:	<20pF
L to L:	<20pF
H or L to Chassis:	<150pF

*all contacts closed

Net Weight: 0.7 kg

Insertion Loss:
≤100kHz: <0.1dB
≤10MHz: <3.0dB

Relay Life (typical):
No Load: $>10^6$ operations
Max. Load: $>10^5$ operations

Terminals: Screw type, removable. Max. Wire Size, 16AWG

Module Size/Device Type:
VXI B-Size, Register-based

Connectors used: P1

No. Slots: 1

VXIbus Interface Capability:
Interrupter, D16

Interrupt Level: 1-7 selectable

Power Requirements:

Voltage:	+5	+12
Peak module current, IPM (A):	0.10	0.24
Dynamic module current, IDM (A)	0.01	0.01

Watts/slot: 1.0

Cooling/slot:
0.02 mm H_2O @ 0.10 liters/sec

Humidity: 65% 0 to 40ºC

Operating Temperature: 0 to 55 ºC

Storage Temperature: -40 to +75ºC

EMC, RFI Safety: meets FTZ 1046/1984, CSA 556B, IEC 348, UL 1244

Relay Life

Electromechanical relays are subject to normal wear-out. Relay life depends on several factors. The effects of loading and switching frequency are briefly discussed below:

Relay Load. In general, higher power switching reduces relay life. In addition, capacitive/inductive loads and high inrush currents (for example, turning on a lamp or starting a motor) reduces relay life. *Exceeding specified maximum inputs can cause catastrophic failure.*

Switching Frequency. Relay contacts heat up when switched. As the switching frequency increases, the contacts have less time to dissipate heat. The resulting increase in contact temperature also reduces relay life.

End-of-Life Detection

A preventive maintenance routine can prevent problems caused by unexpected relay failure. The end of the life of the relay can be determined by using one or more of the three methods described below. The best method (or combination of methods), as well as the failure criteria, depends on the application in which the relay is used.

Contact Resistance. As the relay begins to wear out, its contact resistance increases. When the resistance exceeds a predetermined value, the relay should be replaced.

Stability of Contact Resistance. The stability of the contact resistance decreases with age. Using this method, the contact resistance is measured several (5-10) times, and the variance of the measurements is determined. An increase in the variance indicates deteriorating performance.

Number of Operations. Relays can be replaced after a predetermined number of contact closures. However, this method requires knowledge of the applied load and life specifications for the applied load.

Replacement Strategy

The replacement strategy depends on the application. If some relays are used more often, or at a higher load, than the others, the relays can be individually replaced as needed. If all the relays see similar loads and switching frequencies, the entire circuit board can be replaced when the end of relay life approaches. The sensitivity of the application should be weighed against the cost of replacing relays with some useful life remaining.

Note Relays that wear out normally or fail due to misuse should not be considered defective and are not covered by the product's warranty.

Appendix B
HP E1361A Relay Matrix Registers

Register Definitions

The HP E1361A 4 X 4 Relay Matrix is a register-based slave device. See Figure B-1 for register definitions.

ID Register

b+00$_{16}$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined								Undefined							
Read*	RegBas		A16		Manufacturer ID											

* Returns FFFF$_{16}$ = Hewlett-Packard A16 only Register-based

Device Type Register

b+02$_{16}$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined															
Read*	1 (A16 only)						Module ID Code									

*Returns FF24$_{16}$

Status/Control Register

b+04$_{16}$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Undefined															R
Read**	FF$_{16}$								B	7F$_{16}$						

* R is matrix reset (all channels open); ** Status "busy"is low true in bit #7 (FF7F$_{16}$)

Channel Enable Register

b+08$_{16}$	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	33	23	13	03	32	22	12	02	31	21	11	01	30	20	10	00
Read	Always returns FFFF$_{16}$															

* Write "1" to close channel, "0" to open channel. First number in Write is row, second is column (e.g., for bit #11, 3 = row 3 and 2 = column 2). All combinations are allowed (all rows and columns can be connected).

Figure B-1. Relay Matrix - Register Definitions

Addressing the Registers

To read or write to specific registers, you must use the register address. Since the addresses for HP 75000 Series B or Series C plug-in modules are A00 through A15, use the VME A16 mnemonic for the address space. The address space within the mainframe/command module memory map depends on the mainframe/command module used. For example, the address of the HP E1300A/E1301A Mainframe starts at $1F0000_{16}$.

For the HP E1300/E1301, the A16 space is divided so modules are addressed only at locations beginning with $C000_{16}$ within A16. Each module is allocated 64 register addresses (40_{16}). The module base address is related to the logical address set by the logical address switch (LADDR) on the module:

$$\text{base address}_{(16)} = (\text{logical address}_{16})*40_{16} + C000_{16}$$

For the relay matrix, the factory-set logical address is 120 (78_{16}), so the base address = $(78_{16})*(40_{16}) + C000_{16} = DE00_{16}$. Then, for example, to address the Status/Control Register of a relay matrix in an HP E1300A/E1301A, the register address = $[\text{A16 location}]_{16} + [\text{base address}]_{16} + [\text{register offset}]_{16} = 1F0000_{16} + DE00_{16} + 04_{16} = 1FDE04_{16}$.

Reading the Registers

You can read the following relay matrix registers:

- ID Register (base + 00_{16})
- Device Type Register (base + 02_{16})
- Status/Control Register (base + 04_{16})
- Channel Enable Register (base + 08_{16})

ID/Device Type Registers

For the relay matrix, a read of the ID Register (address base + 00_{16}) returns $FFFF_{16}$ since the matrix is manufactured by Hewlett-Packard and is an A16 only, register-based device. The Device Type Register (base + 02_{16}) returns $FF24_{16}$.

Status/Control Register

Each relay requires about 15 msec execution time (close to open or open to close) during which time the matrix is "busy". A read of the Status/Control Register (base + 04_{16}) returns $FFFF_{16}$ when the matrix is not busy or returns $FF7F_{16}$ (bit 7 is low-true) when the matrix is busy.

Channel Enable Register

A read of the Channel Enable Register (base + 08_{16}) always returns $FFFF_{16}$, regardless of the channel states.

Writing to the Registers

You can write to the following relay matrix registers:

- Status/Control Register (base + 04_{16})
- Channel Enable Register (base + 08_{16})

Status/Control Register

The only write allowed to the Status/Control Register (base + 04_{16}) is to bit 0. Writing a "1" to bit 0 resets the matrix (all channels open).

Note

All relays are latching and will remain in the last state during power down. At power-up or when the module is reset, all relays open. Any combination of channel open or closed states is allowed.

Channel Enable Register

Writes to the Channel Enable Register (base + 08_{16}) enable you to open or close the desired channel (see Figure B-1). For example, write a "1" to bit 2 of the Channel Enable Register to close channel 20 (row 2, column 0). Or, write a "0" to bit 14 of the register to open channel 23 (row 2, column 3).

Notes

Appendix C
HP E1361A Relay Matrix Error Messages

Table C-1 lists the error messages associated with the relay matrix modules programmed by SCPI. See the appropriate mainframe manual for a complete list of error messages.

Table C-1. 4 X 4 Relay Matrix Module Error Messages

No.	Title	Potential Cause(s)
-211	Trigger ignored	Trigger received when scan not enabled. Trigger received after scan complete. Trigger too fast.
-213	Init Ignored	Attempting to execute an INIT command when a scan is already in progress.
-224	Illegal parameter value	Attempting to execute a command with a parameter not applicable to the command.
1500	External trigger source already allocated	Assigning an external trigger source to a switchbox when the trigger source has already been assigned to another switchbox.
2000	Invalid card number	Addressing a module (card) in a switchbox that is not part of the switchbox.
2001	Invalid channel number	Attempting to address a channel of a module in a switchbox that is not supported by the module (e.g., channel 99 of a multiplexer module).
2006	Command not supported on this card	Sending a command to a module (card) in a switchbox that is unsupported by the module.
2008	Scan list not initialized	Executing a scan without the INIT command.
2009	Too many channels in channel list	Attempting to address more channels than available in the switchbox.
2012	Invalid Channel Range	Invalid channel(s) specified in SCAN <*channel_list*> command. Attempting to begin scanning when no valid channel list is defined.
2600	Function not supported on this card	Sending a command to a module (card) in a switchbox that is not supported by the module or switchbox.
2601	Channel list required	Sending a command requiring a channel list without the channel list.

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