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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

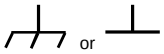
Safety Symbols



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.



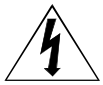
Frame or chassis ground terminal—typically connects to the equipment's metal frame.



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.

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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.

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Manufacturer's Name: Hewlett-Packard Company
Loveland Manufacturing Center

Manufacturer's Address: 815 14th Street S.W.
Loveland, Colorado 80537

declares, that the product:

Product Name: 16-Channel Form C Switch Module

Model Number: E1364A

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).

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Edition 2

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Chapter 1
Getting Started with the HP E1364A

Using This Chapter

This chapter includes a Form C Switch description, addressing guidelines, and an example program to check initial operation. Chapter contents are:

- Instrument Definition . . . . . Page 11
- Programming the Switch . . . . . 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 or multiple plug-in modules (for a Switchbox or Scanning Voltmeter Instrument).

Switch Description

The HP E1364A 16-Channel Form C Switch Module is a B-Size VXIbus and VMEbus register-based product which can be used for switching/scanning, control, and digital output applications. The switch can operate in a B-Size VXIbus or VMEbus mainframe or (with an adapter) in a C-Size VXIbus mainframe. The module has 16 channels of Form C relays. Each channel includes a relay with common (C), normally open (NO), and normally closed (NC) contacts.

For the Form C Switch, switching consists of opening or closing a channel relay to provide alternate connections to user devices. Scanning consists of closing a set of relays, one at a time. By adding jumpers and pullup/pulldown resistors, the switch can be used to control external user devices or as a digital output device.

Basic Operation

As shown in Figure 1-1, the Form C Switch consists of 16 channels (channels 00 through 15). Each channel uses a latching relay. As required, jumpers can be added to connect +5 V or +12 V for control or digital output applications. Also, pullup resistors can be added for digital output applications.

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Each channel is switched by opening or closing the appropriate channel relay. Since the relays are latching, the relay remains in the last state during power-up or power-down. When a reset occurs, all channel commons (C) are connected to the corresponding normally closed (NC) contacts. User inputs/outputs to each channel are via the NO, NC, and C terminal connectors on the terminal module.

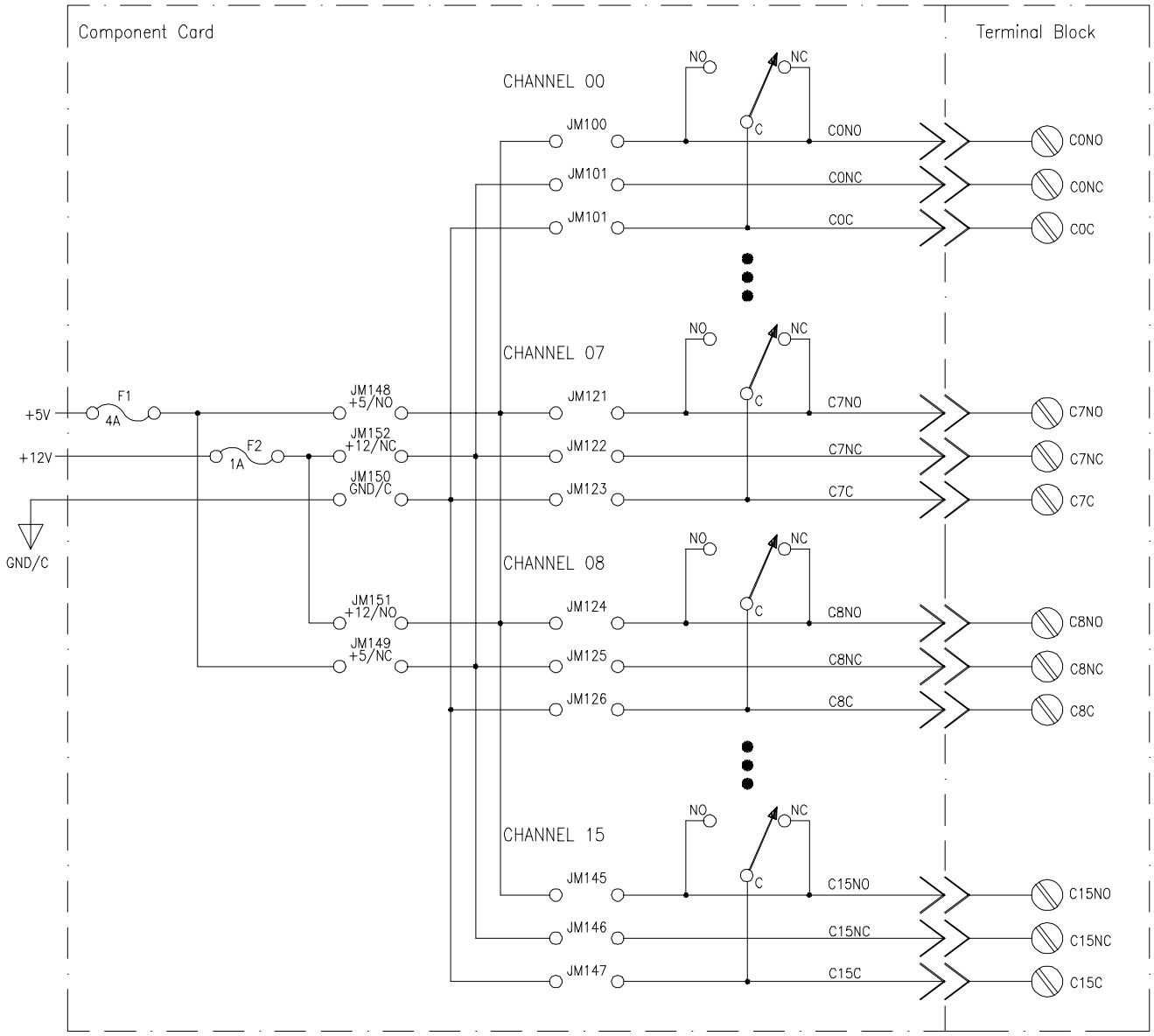


Figure 1-1. Form C Switch Simplified Diagram

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Typical Configuration

The Form C Switch accepts user inputs up to 250 V dc or 250 V ac peak (177 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 the maximum scan rate is about 50 Hz.

As noted, the switch may be configured for general purpose switching/scanning, control, or digital output applications. For general purpose switching or scanning, no additional configuration is required. To configure the switch for control applications, install jumpers to connect a + 5V or + 12V source and GND. To configure the switch for digital output applications, connect jumpers and install pullup/pulldown resistors as required. See Chapter 2 for configuration details.

For a SCPI (Standard Commands for Programmable Instruments) environment, multiple Form C Switches can be configured as a switchbox instrument. For a switchbox instrument, all switch channels within the instrument can be addressed using a single interface address. Single, multiple, or continuous scanning of specified switch channels is available for any switchbox configuration.

Programming the Switch

To program the Form C Switch using SCPI, you must know the module's logical address, module number, and the SCPI commands to be used. Guidelines to select SCPI commands for the Form C Switch 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, *Form C Switch Registers*, for information on Form C Switch registers.

Specifying SCPI Commands

To address specific channels within a Form C Switch, you must specify the SCPI command and switch channel address. For the Form C Switch, use CLOSe <*channel_list*> to connect the normally open (NO) terminal to the common (C) terminal for the channels specified. Use OPEN <*channel_list*> to connect the normally closed (NC) terminal to the common (C) terminal for the channels specified. Use SCAN <*channel_list*> to close the set of channels specified, one channel at a time.

Switch Channel Addresses

For the Form C Switch, the channel address (<*channel_list*>) has the form (@ccnn) where cc = switch card number (01-99) and nn = channel numbers (00-15).

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

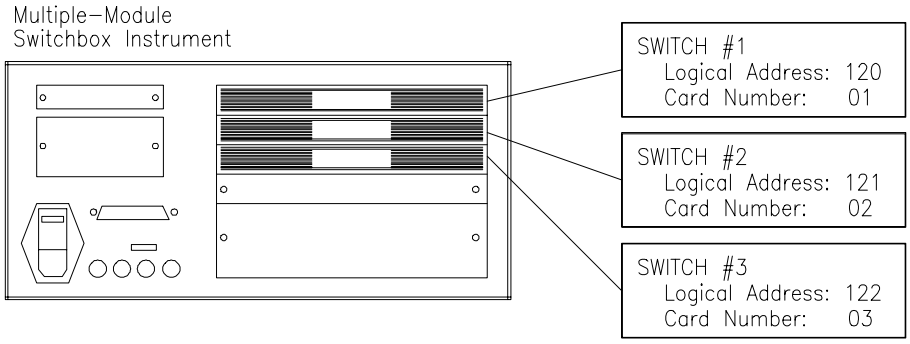
Switch Card Numbers

The switch card number depends on the switchbox configuration (single-module or multiple-module) set for the switches. (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 *HP 75000 Series B Installation and Getting Started Guide* for a definition of logical addresses.)

Example: Multiple-Module Switchbox Card Numbers

Assume the three Form C Switches in the following figure form a switchbox instrument with switch logical addresses of 120,121, and 122. Since card number 01 is assigned to the module with the lowest logical address, etc., the card numbers are as shown.



Switch Channel Numbers

Form C Switch channel numbers are 00 through 15. The channels can be addressed using channel numbers or channel ranges. For a single-module switchbox, channel ranges can span across the channels. For multiple-module switchboxes, channel ranges can span across the channels of all modules.

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 (@100:215) is acceptable, but CLOS (@215:100) generates an error.

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Example: Form C Switch Channel Lists/Ranges

Channel Lists:

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

Channel Ranges:

```
OPEN (@100:115)          Open all channels on card 01
SCAN (@100:115)          Scan all channels on card 01
```

Initial Operation

An example program follows which uses Hewlett-Packard BASIC and the SCPI language to get you started using the Form C Switch. The example assumes an HP 9000 Series 200/300 (or equivalent) computer and a Hewlett-Packard Interface Bus (HP-IB). (HP-IB is the Hewlett-Packard implementation of the IEEE 488.2-1987 standard.)

This program closes channel 02 of a Form C Switch at logical address 120 (secondary address = 120/8 = 15) and queries the channel closure state. The result is returned to the computer and displayed (1 = channel closed, 0 = channel open). See the *HP 75000 Series B Installation and Getting Started Guide* for information on addressing.

Example: Close Form C Switch Channel

```
10 OUTPUT 70915;"CLOS (@102)"        ! Close channel 02
20 OUTPUT 7091 5;"CLOS? (@102)"      ! Query channel 02 state
30 ENTER 70915;Value                 ! Enter result into Value
40 PRINT Value                       ! Display result
50 END
```


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Chapter 2
Configuring the HP E1364A Form C Switch

Using This Chapter

This chapter shows how to make user connections to the Form C Switch and how to configure the switch module. Chapter contents are:

- Warnings and Cautions . . . . . Page 17
- Connecting User Inputs . . . . . Page 18
- Typical Switch Configurations . . . . . Page 20
- Changing Form C Switch Components . . . . . Page 23
- Module Front Panel Connections . . . . . Page 24

Warnings and Cautions

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

Caution MAXIMUM VOLTAGE/CURRENT. Maximum allowable voltage per channel for the module is 250 Vdc or 250 Vac RMS (350 V ac peak). Maximum current per channel is 1 Adc or 1 Aac RMS (non-inductive). Maximum power input is 40 W (dc) or 40 VA (ac) per channel or 320 W (dc) or 320 VA (ac) per module. Exceeding any limit may damage the module.

Caution CONNECTING + 5V + 12V: On the module, the backplane + 5V line is fused at 4 A and the + 12V line at 1 A. When connecting + 5V or + 12V to the Form C Switch, install appropriate pullup resistors to prevent shorting the power supplies. Also, the total current drawn by all circuits connected to the Form C Switch must not exceed the fuse rating for the supplies used.

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

Connecting User Inputs

The Form C Switch consists of a component module and a connector block. User inputs to the Form C Switch are to the NO, NC, and C terminal connectors on the terminal block. Figure 2-1 shows the connector block and associated channel numbers. Figure 2-2 shows how to connect user (field) wiring to the connector block.

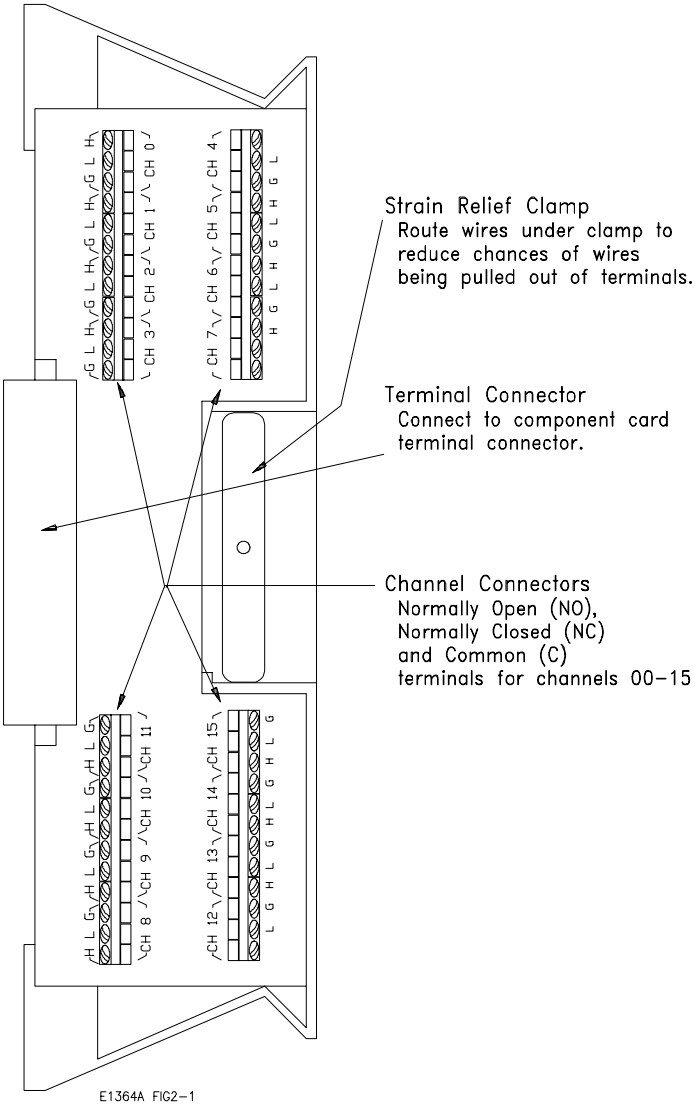


Figure 2-1. Form C Switch Terminal Block

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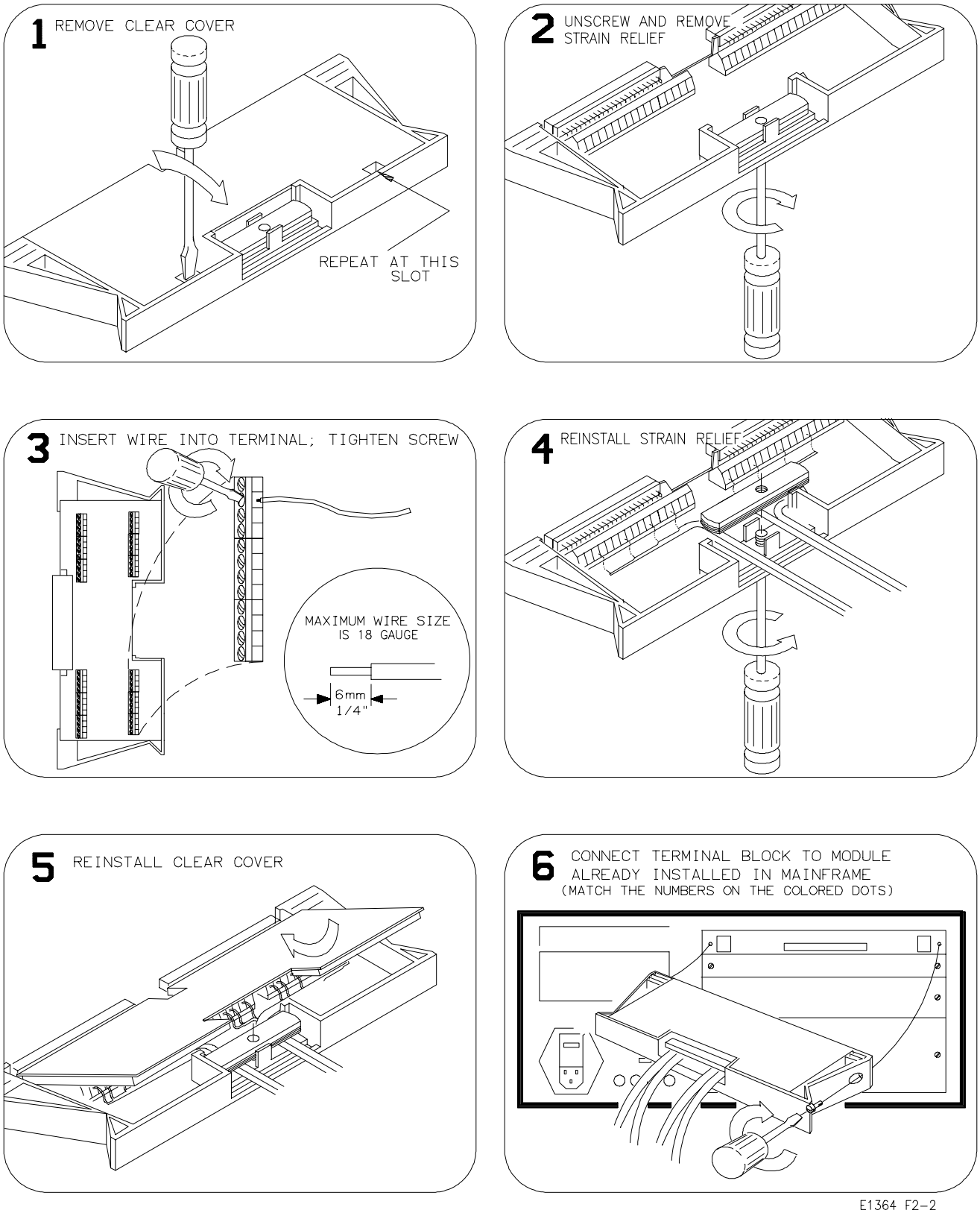


Figure 2-2. Wiring the Form C Switch Terminal Block

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Typical Switch Configurations

Typical Form C Switch configurations are:

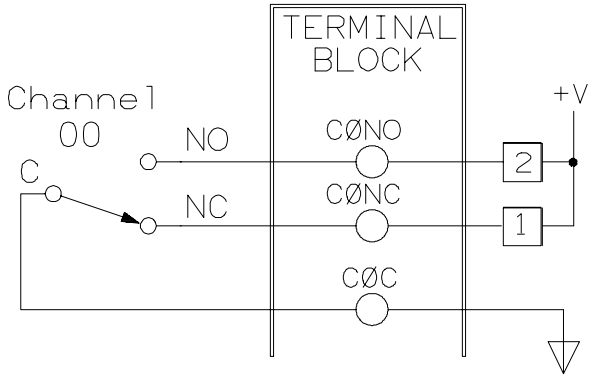
- General purpose relay
- Relay control
- Digital output

General Purpose Relay Configuration

As factory configured, the Form C Switch is set for general purpose relay configuration. For this configuration, you can switch channels by opening or closing channel relays or you can scan a set of channels.

Example: General Purpose Relay Configuration

Figure 2-3 shows a typical general purpose relay configuration for channel 00. When the relay is open, the NC terminal is connected to the C terminal and Load 1 is connected. When the relay is closed, the NO terminal is connected to the C terminal and Load 2 is connected.



RELAY	LOAD
OPEN	1
CLOSED	2

E1364A F2-3

Figure 2-3. Example: General Purpose Relay Configuration

Relay Control Configuration

By connecting jumpers, you can use the Form C Switch to drive (control) external relays. The source can be +5V/NO, +5V/NC, +12V/NO, or +12V/NC depending on the jumpers connected on the switch. (See Figure 1-1 in Chapter 1 for jumper numbers and see Figure 2-6 for jumper locations.)

Note

When connecting the +5V or +12V backplane sources, the total current draw should not exceed 1 A per Form C Switch for the +5V supply or 0.5 A per Form C Switch for the +12V supply. You should fuse all external equipment to ensure excess current is not drawn.

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Example: Relay Control Configuration

Figure 2-4 shows one way to control external relays using the +5V/NO source. For this example, channel 15 is dedicated to provide the +5V source to external relays 1 and 2. When the Form C Switch channel 00 relay is open, external relay 1 is connected to ground and +5V is applied to external relay 2. When the Form C Switch channel 00 is closed, external relay 2 is connected to ground and +5V is applied to external relay 2.

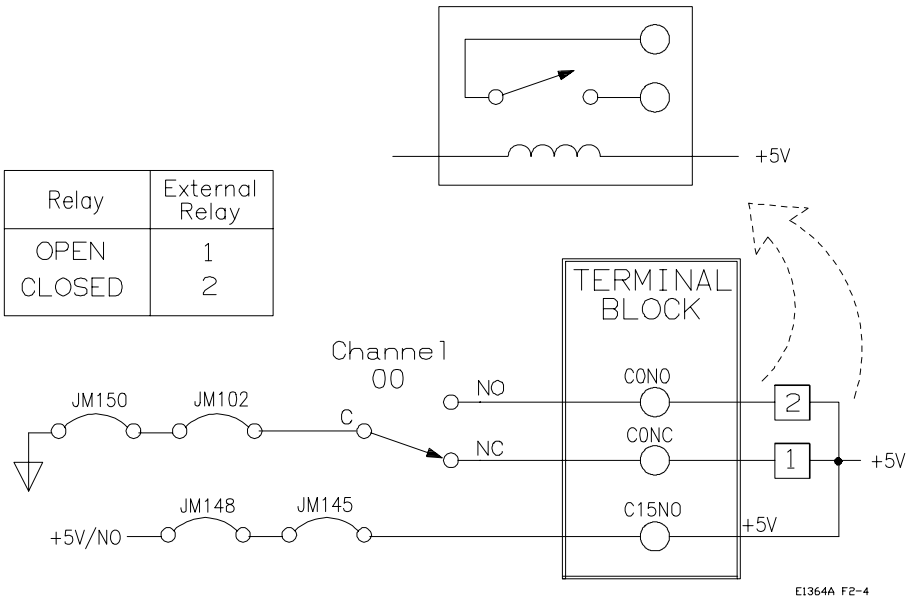


Figure 2-4. Example: Relay Control Configuration

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Digital Output Configuration

By connecting jumpers and installing pullup/pulldown resistors, you can configure the switch as a digital output device.

Note

When connecting the + 5V or + 12V backplane sources for digital output operation, you must install pullup resistors on the Form C Switch for the supplies used. Also, the total current drawn by user circuits should not exceed 1 A per Form C Switch for the + 5V supply or 0.5 A per Form C Switch for the + 12V supply. You should fuse all external equipment to ensure excess current is not drawn.

Example: Digital Output Configuration

Figure 2-5 shows channel 00 configured for digital output operation. When the channel 00 relay is open (NC connected to C), point A is at + 5V. When the channel 00 relay is closed (NO connected to C), point A is at 0V.

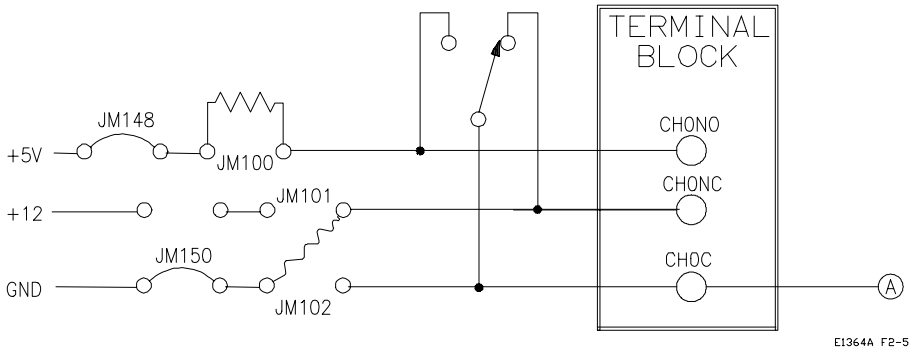


Figure 2-5. Example: Digital Output Configuration

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Changing Form C Switch Components

As required, you can:

- Change the Logical Address switch setting
- Change interrupt priority jumper positions
- Replace fuses on the switch component module

See Figure 2-6 for component locations.

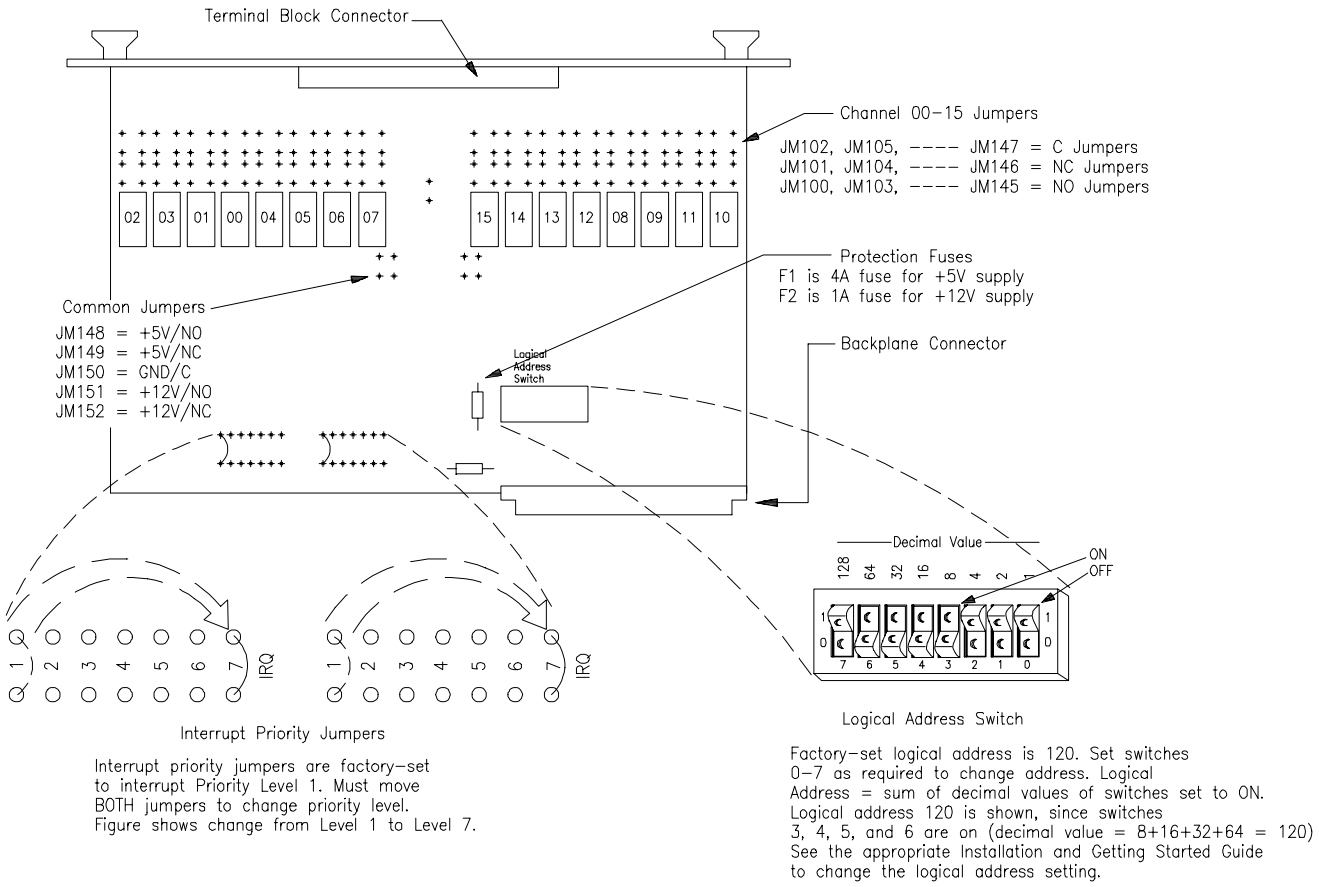


Figure 2-6. Form C Switch Component Locations

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Module Front Panel Connections

If you choose not to use the supplied connector block, Figure 2-7 shows the E1364A front panel and the connection diagram for wiring your own terminal connector.

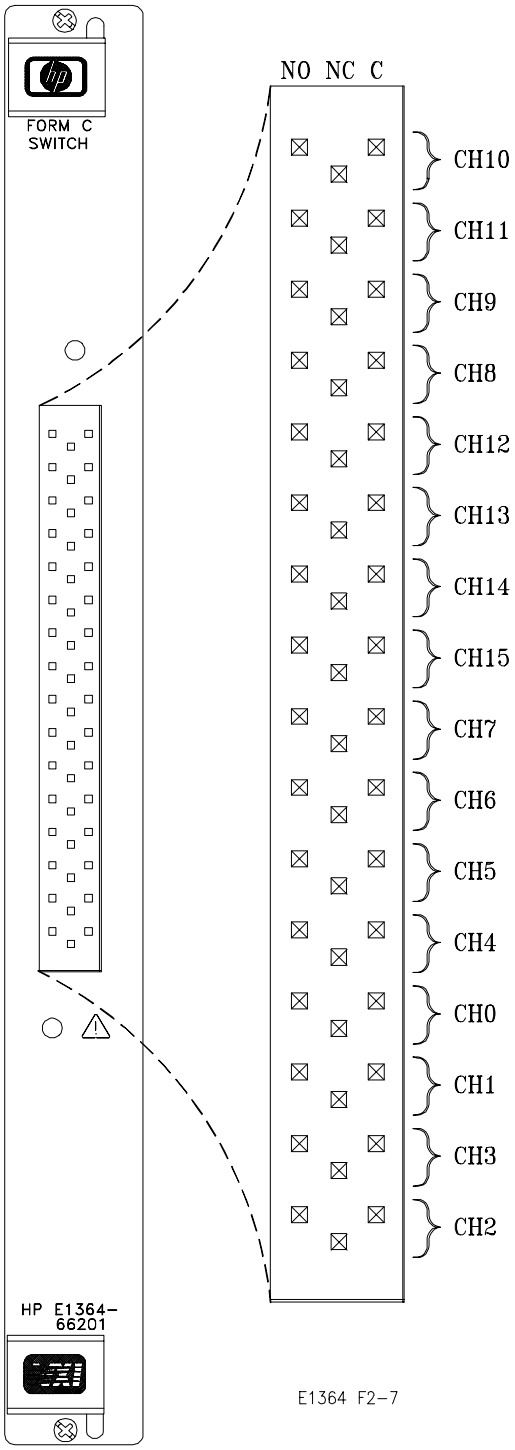


Figure 2-7. E1364A Front Panel and Wiring Diagram

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Chapter 3
Using the HP E1364A Form C Switch

Using This Chapter

This chapter provides examples to use the Form C Switch for switching channels and scanning channels. As required see Chapter 4, Understanding the Form C Switch, for further information on scanning channels. See Chapter 5, Form C Switch Command Reference, for command information. Chapter contents are:

- Form C Switch Commands . . . . . Page 25
- Switching Channels . . . . . Page 26
- Scanning Channels . . . . . Page 31

Form C Switch Commands

Table 3-1. Form C Switch Commands in Chapter 3

Command	Description
INIT[:IMM]	Starts the scan sequence and closes the first channel in the channel list.
OUTP[:STAT] ON	Enables the HP E1300A/E1301A Trig Out port to output pulses.
[ROUT:]CLOS <*channel_list*>	Closes the channels in the channel list.
[ROUT:]CLOS? <*channel_list*>	Queries the state of the channels in the channel list.
[ROUT:]OPEN <*channel_list*>	Opens the channels in the channel list.
[ROUT:]SCAN <*channel_list*>	Closes the channels in the channel list, one channel at a time.
TRIG:SOUR BUS I EXT I HOLD I IMM	Selects the trigger source to advance the scan.

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Switching Channels

For general purpose relay operation, you can connect or disconnect a load by opening or closing specified channel relays. By adding jumpers and/or pullup/pulldown resistors, the switch can be configured for relay control or digital output operations.

Use CLOS <*channel_list*> to connect a channel's normally open (NO) terminal to its common (C) terminal or use OPEN <*channel_list*> to connect a channel's normally closed (NC) contact to its common (C) terminal. <*channel_list*> has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-15).

Example: Voltage Switching

This example closes channel 00 of a Form C Switch to switch the load voltage (E) from Load 1 to Load 2. When the channel relay is open, the load voltage is applied to Load 1. When the relay is closed, the voltage is applied to Load 2. See Figure 3-1 for typical user connections. To close channel 00, execute:

```
CLOS (@100)
```

Close channel 00 relay (connect NO to C). 1 is the card number and 00 is the channel number.

To open channel 00, use OPEN (@100).

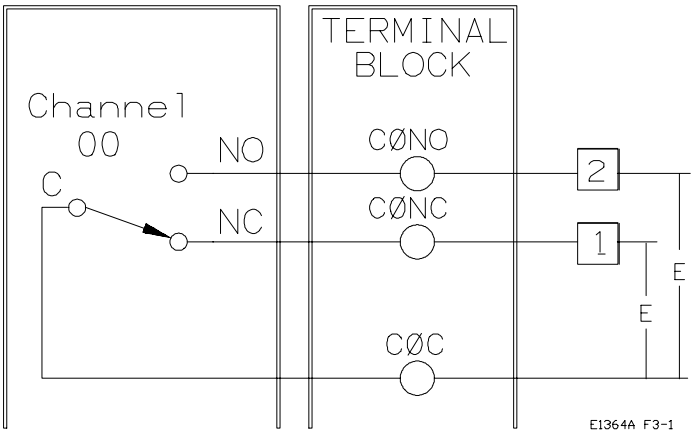


Figure 3-1. Example: Voltage Switching

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Example: Controlling Microwave Relays

This example shows one way that the Form C Switch can be used to control an (external) microwave relay. Figure 3-2 shows an HP 33311B Microwave Relay connected to channel 00 of a Form C Switch. The + 5V source for the microwave relay is provided via channel 15 of the Form C Switch (via JM148, JM145, and the channel 15NO terminal).

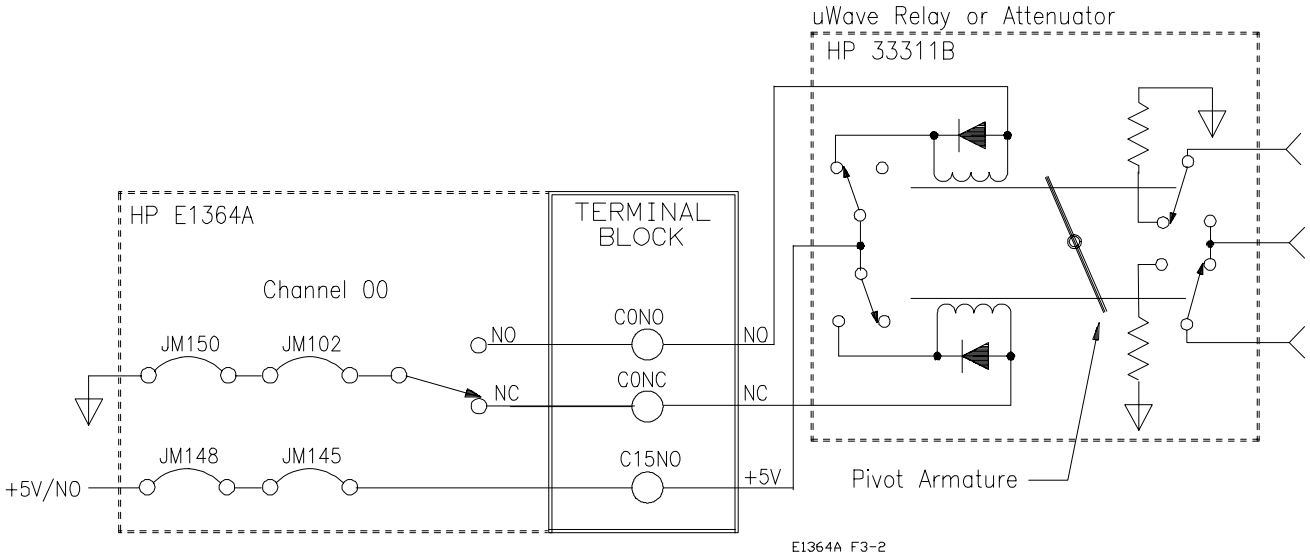
With this configuration, the Form C Switch provides a ground path for the coil current of the microwave relay. For example, with the Form C Switch channel 00 relay open (NC connected to C), a ground path (via the channel 0NC terminal, the channel 00 relay, JM102, and JM150) is provided for the NC side of the microwave relay.

When the microwave relay NC contact is closed, + 5V is applied to the microwave NC coil and the coil is energized. The same actions occur for the NO side of the microwave relay if the Form C Switch channel 00 relay is closed (NO connected to C). To close channel 00, execute:

```
CLOSE (@100)
```

Close channel 00 relay (connect NO to C). 1 is the card number and 00 is the channel number.

To open channel 00, use OPEN (@100).



NOTES:

1. Channel 15 is dedicated to supplying + 5V to the microwave relay. The + 5V supply can be used to supply other external relays connected to the channel 15NO terminal.

2. For this configuration, power to the external relays is limited to 4A maximum, 1A typical per Form C Switch. You can use separate, external power supplies to supply more than 4A or to supply voltages other than

Figure 3-2. Example: Controlling Microwave Relays

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Example: Controlling RF Switches/Step Attenuators

Figure 3-3 shows one way to drive HP 8761 SPDT RF Switches or HP 33300 Series Programmable Step Attenuators. (Figure 3-3 only shows control for the HP 33300 40 dB step. Additional drive relays are required for the 10 dB and 20 dB steps.) The HP 8761A and HP 33300A/C operate from a 12-15V coil voltage, while the HP 8761B and HP 33300B/D operate from a 24V-30V coil voltage. For example, to close channel 00, execute:

```
CLOS (@100)
```

Close channel 00 relay (connect NO to C). 1 is the card number and 00 is the channel number

To open channel 00, use OPEN (@100).

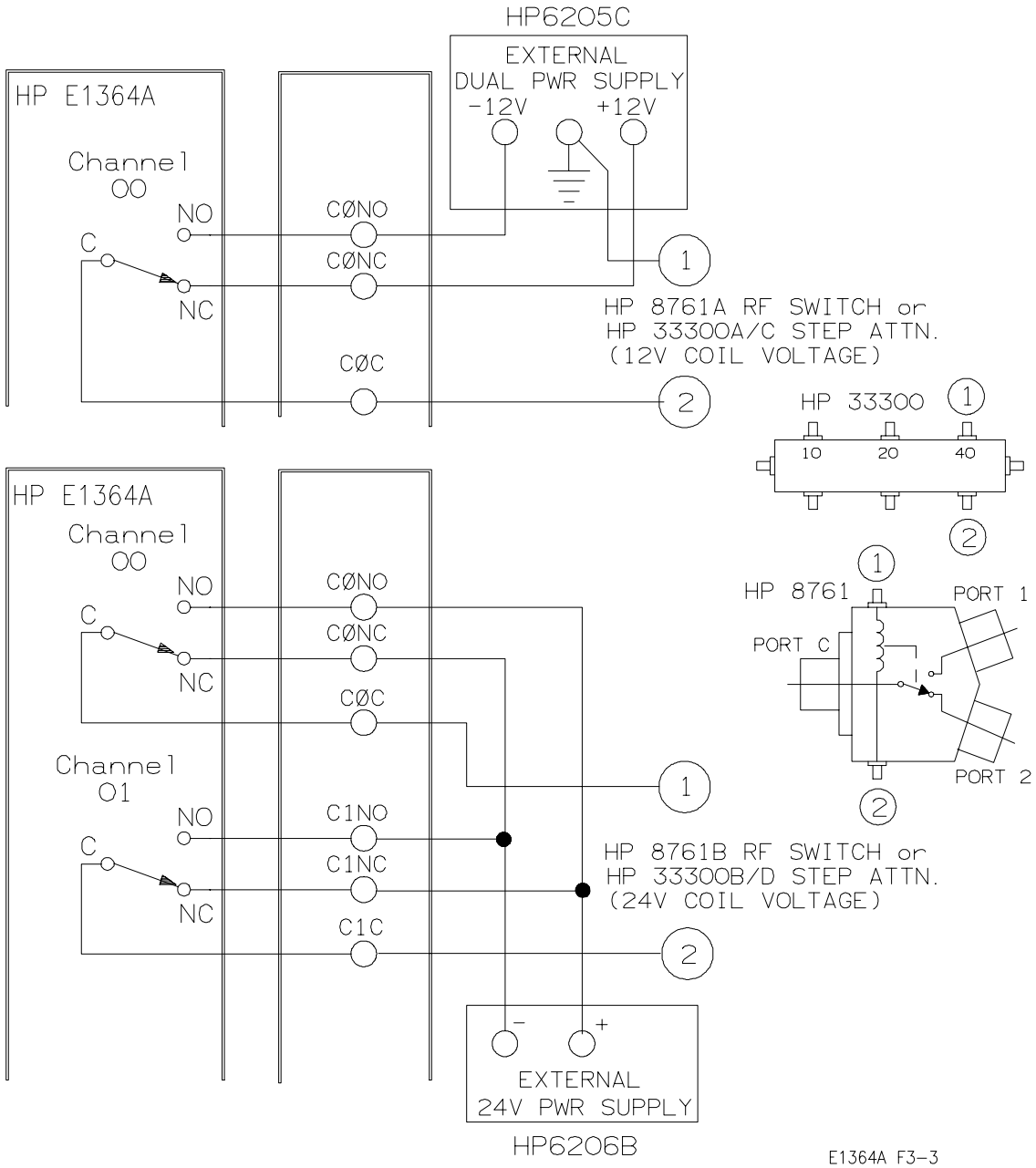


Figure 3-3. Example: Controlling RF Switches/Step Attenuators

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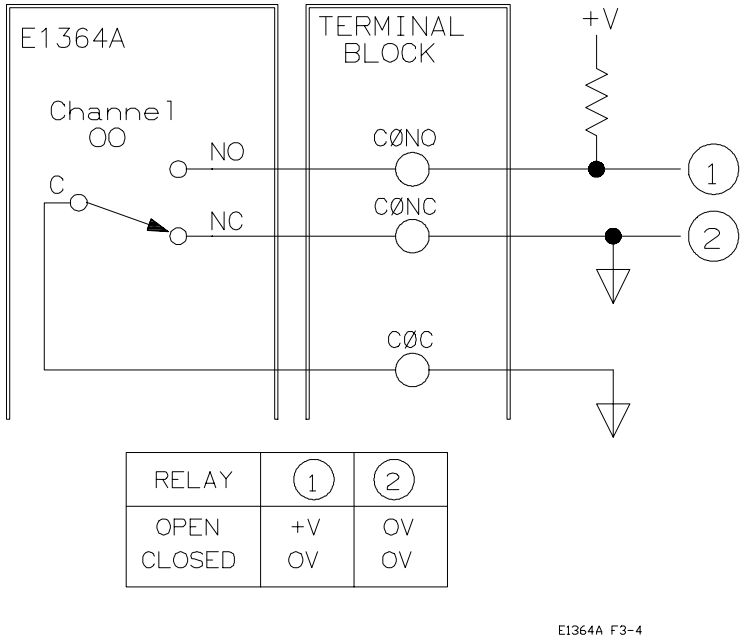
Example: Digital Output Configuration

Figure 3-4 shows channel 00 configured for digital output operation. When the channel 00 relay is open (NC connected to C), point 1 is at + V and point 2 is at 0 V. When the channel 00 relay is closed (NO connected to C), points 1 and 2 are both at 0 V. (This configuration is useful for 24V or 48V control logic, since this type of application cannot be met with the configuration shown in Chapter 2, Figure 2-5.) To close channel 00, execute:

```
CLOS (@100)
```

Close channel 00 relay (connect NO to C). 1 is the card number and 00 is the channel number.

To open channel 00, use OPEN (@100).



RELAY	1	2
OPEN	+V	OV
CLOSED	OV	OV

Figure 3-4. Example: Digital Output Configuration

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Example: Matrix Switching

The Form C Switch can be configured as a 4 x 4 single-wire matrix to connect any combination of up to four user sources (S0, S1, S2, and S3) to any combination of up to four user instruments (I0, I1, I2, and I3) at a time. Figure 3-5 shows a typical configuration. This example closes channel 02 to correct S2 to I0 and closes channel 13 to connect S1 to I3. To close channels 02 and 13, execute:

```
CLOS (@102,113)
```

Close channels 02 and 13. 1 is card number and 02,13 are channel numbers.

To open the channels, use OPEN (@102,113).

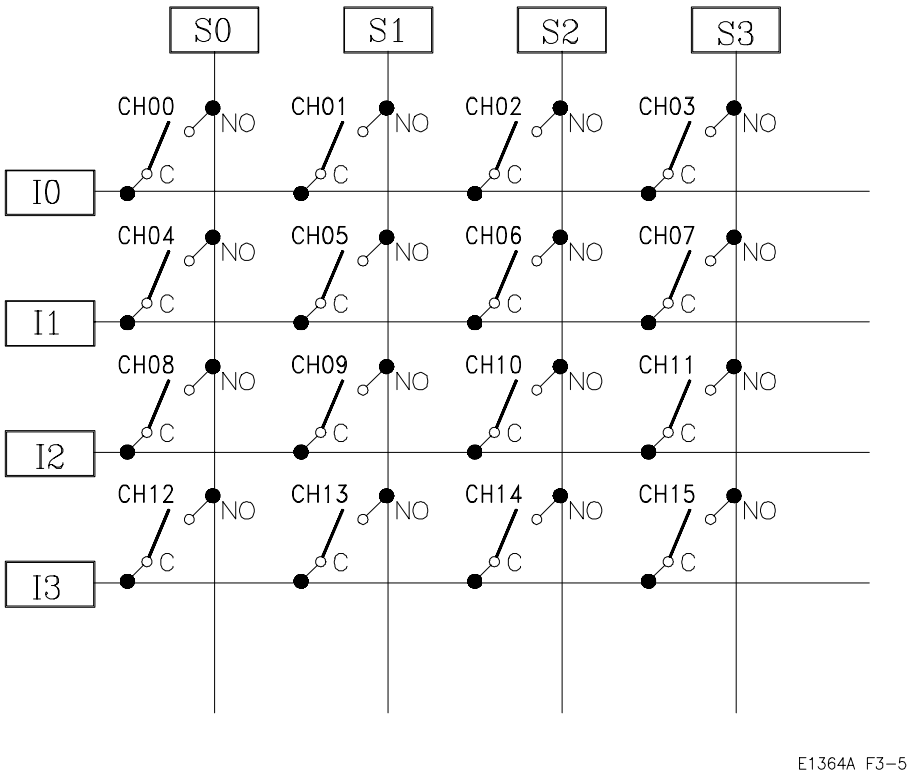


Figure 3-5. Example: Matrix Switching

Switching Channels Comments

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

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

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Scanning Channels

- For the Form C Switch, scanning channels consists of closing a specified set of channels, one channel at a time. You can scan any combination of channels for a single-module or a multiple-module switchbox.
- Single, multiple, or continuous scanning modes are available. See Chapter 4 for information on scanning Form C Switch channels.

Example: Scanning Using Trig Out Port

This example shows one way to synchronize instrument measurements of devices under test (DUT) with Form C Switch channel closures. For measurement synchronization, the HP E1300A/E1301A Trig Out BNC port is connected to the instrument External Trigger In port. See Figure 3-6 for typical user connections.

For this example, the mainframe and instrument are connected via HP-IB to an HP E1300A/E1301A mainframe with an address of 709 and an external instrument (such as an HP 3457A Multimeter) with an address of 722. The Form C Switch is at logical address 120 (secondary address 15).

Note You must add required instrument commands to line 10. Also, you may need to add a WAIT statement as line 65, depending on the speed of the measurement.

```
10 OUTPUT 722; "TRIG EXT;..    "          ! Ext triggering
20 OUTPUT 70915; "OUTP ON"                ! Enable Trig Out Port
30 OUTPUT 70915; "TRIG:SOUR BUS"          ! 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 loop
70 ENTER 722:A                            ! Enter result
80 PRINT A                                ! Display result
90 TRIGGER 70915                          ! Advance scan
100 NEXT I                                ! Increment count
110 END
```


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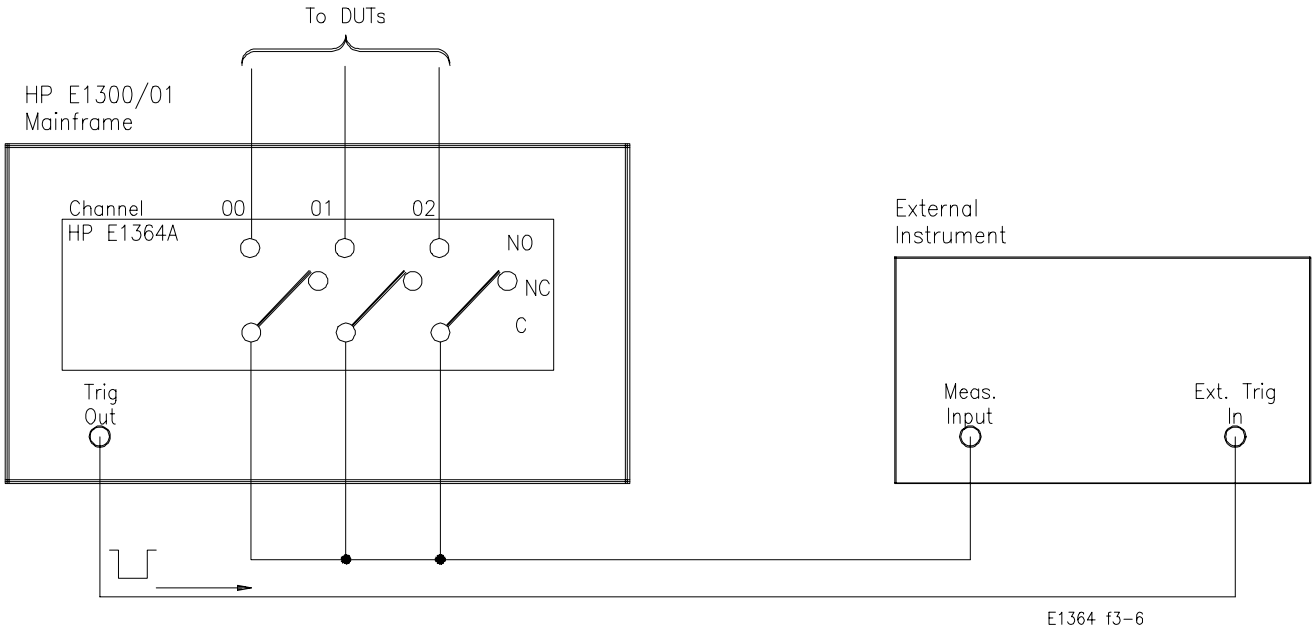


Figure 3-6. Example: Scanning Using Trig Out Port

Scanning Channels Comments

Channel List Can Extend Across Boundaries. For multiple-module switchbox instruments, the channels to be scanned can extend across switch modules. For example, for a two-module switchbox instrument, SCAN (@100:215) will scan all channels of both Form C Switches.

Setting Multiple/Continuous Scans. Use ARM:COUNt <*number*> to set from 1 to 32767 scans. Use INITiate:CONTinous ON to set continuous scanning. See Chapter 4 for details.

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Chapter 4
Understanding the HP E1364A Form C Switch

Using This Chapter

This chapter describes some techniques to scan Form C switch channels and to use the Scan Complete bit. In addition, this chapter describes how the instrument responds to special 488.2 commands and the SCPI query, SYStem:ERRor? The chapter contents are:

- Scanning Channels Commands . . . . . Page 33
- Using Scanning Trigger Sources . . . . . Page 33
- Scanning with External Instruments . . . . . Page 33
- Using the Scan Complete Bit. . . . . Page 38
- Special 488.2 Commands (*RCL,*RST,*SAV) . . . . . Page 39
- SCPI Error Responses . . . . . Page 40

Scanning Channels Commands

Scanning Form C Switch channels consists of closing a set of channels (connecting NO to C) one channel 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

TRIG:SOUR specifies the source to advance the scan. Use the TRIG command to advance the scan when TRIG:SOUR BUS or TRIG:SOUR HOLD is set. The OUTP command enables the HP E1300A/E130lA or HP E1405/E1406 Trig Out port. Figure 4-2 shows scanning trigger sources.

Scanning With External Instruments

Scanning Form C Switch 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 HP BASIC programming language follow.

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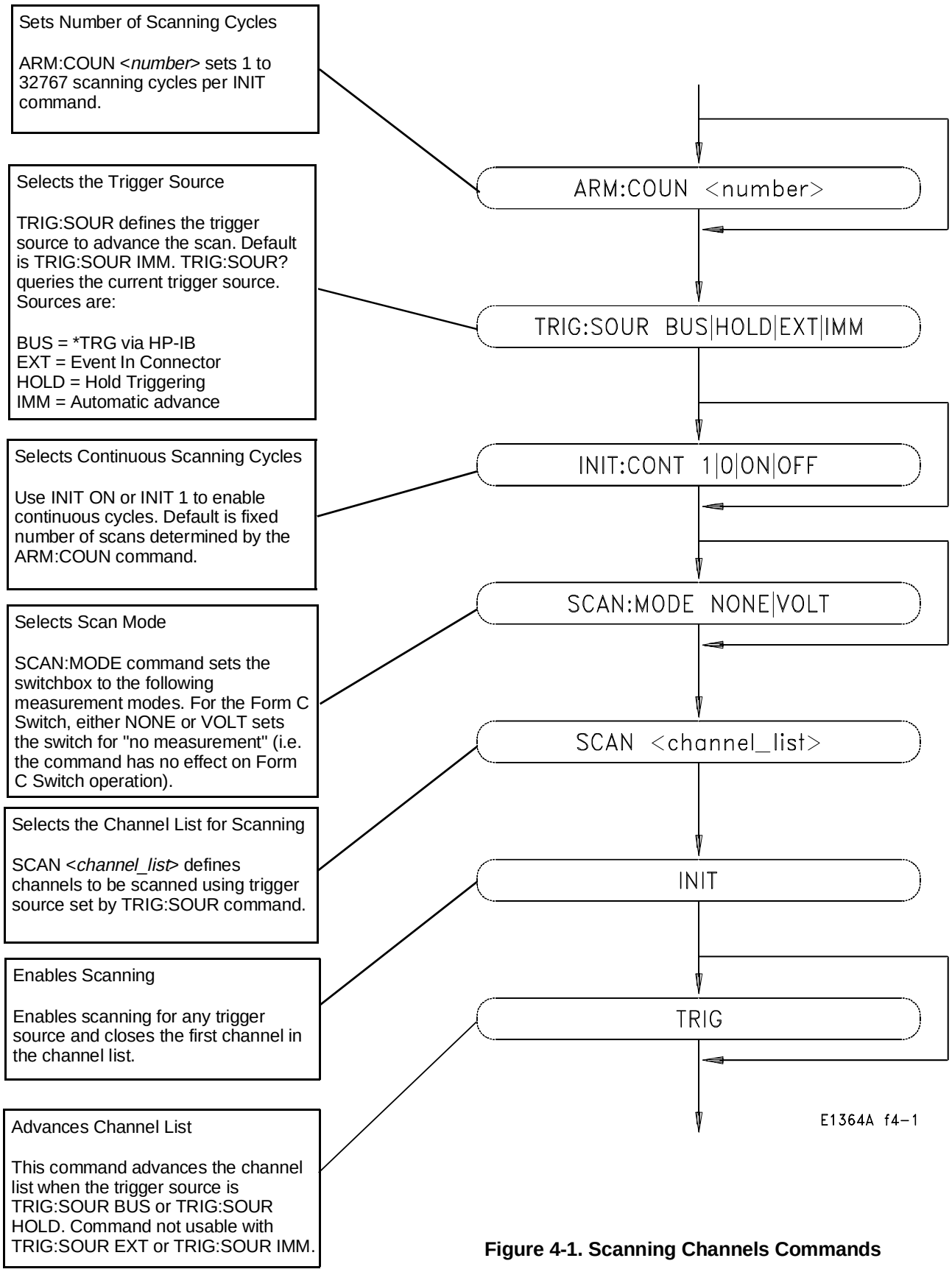


Figure 4-1. Scanning Channels Commands

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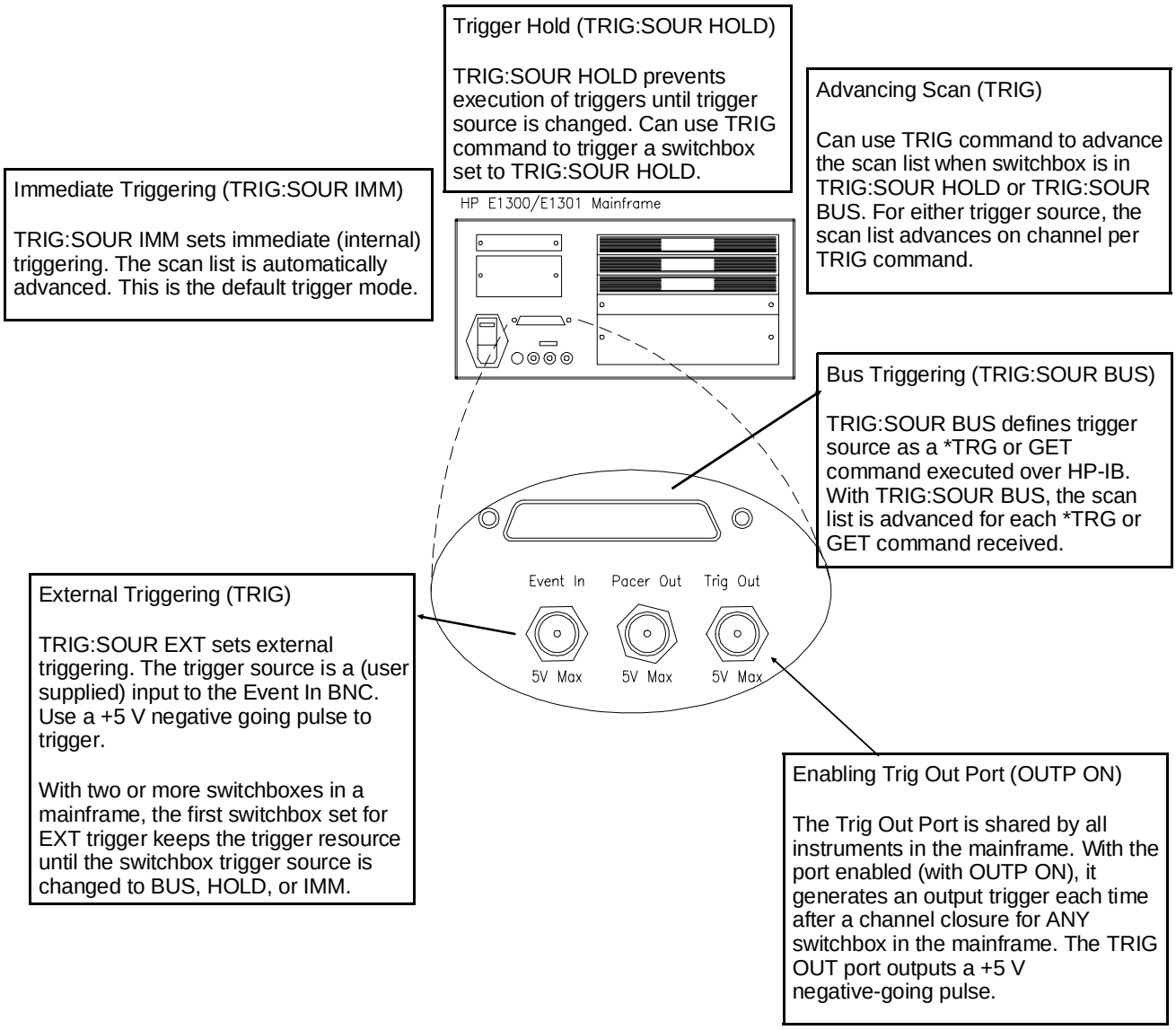


Figure 4-2. Scanning Trigger Sources

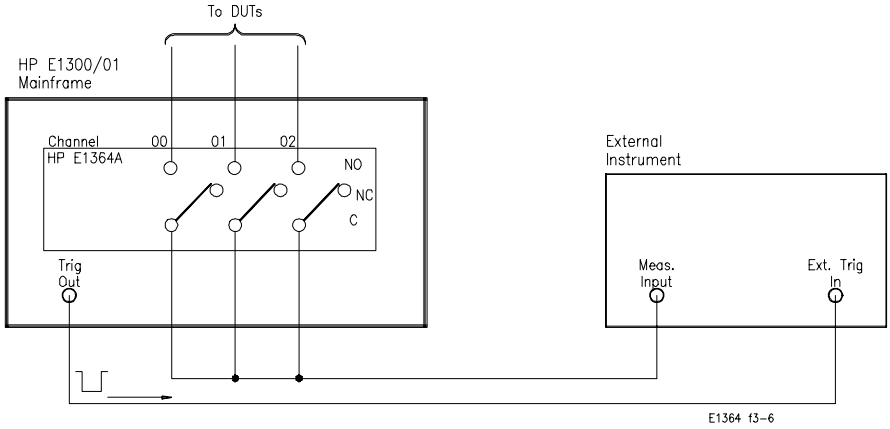
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Example: Scanning With External Devices

This example uses the mainframe Trig Out port to synchronize the Form C Switch 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 mainframe and instrument are connected via HP-IB with mainframe address of 709 and instrument address of 722. The Form C Switch is at logical address 120 (secondary address 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 as line 65 for long measurements.) The sequence of operation is:

1. INlT (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; "0UTP 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
```



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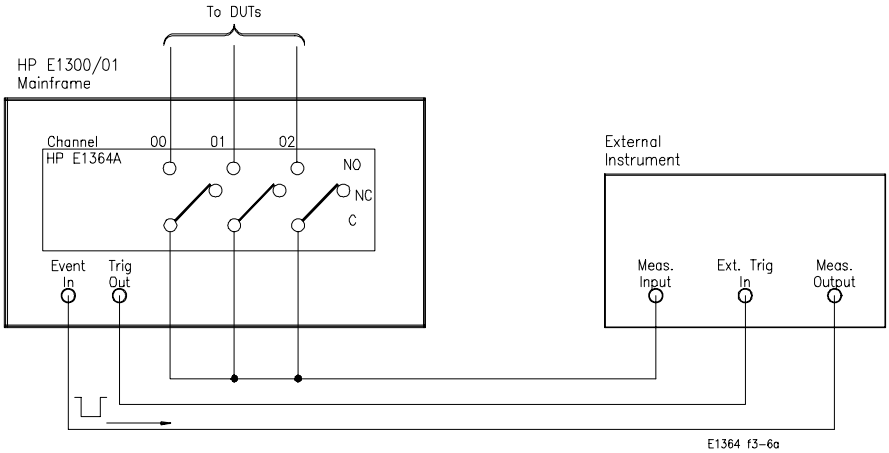
Example: Scanning Using Trig Out and Event In Ports

This example uses the mainframe Trig Out and Event In ports to synchronize Form C switch 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 Form C Switch 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 initiates 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; "0UTP 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
```



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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.

Example: Scan Complete Interrupt

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.

```
10 OUTPUT 70914; "*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 70915;"TRIG:SOUR EXT"            ! Set to external trigger mode
50 OUTPUT 70915;"SCAN(@100:147)"           ! Select channels to be scanned
60 OUTPUT 70915; "INIT"                    ! Start scanning cycle
70 WHILE NOT BIT(SPOLL(70915),7)           ! Waiting 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
```


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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.

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:STATe OFF
- SCAN:MODE NONE
- SCAN PORT NONE

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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 327671].

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.

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Chapter 5
HP E1364A Form C Switch Command Reference

Using This Chapter

This chapter summarizes Standard Commands for Programmable Instruments (SCPI) and IEEE 488.2 Common (*) commands. See the *HP 75000 Series B B-Size VXIbus Mainframe HP E1300A/E130lA 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 41
- SCPI Command Reference . . . . . Page 44
- Common Command Reference . . . . . Page 61
- Command Quick Reference . . . . . Page 62

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 key word 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

The SCPI commands perform functions like closing switches, making measurements, and querying instrument states or 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.

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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 MEAS and MEASURE are both acceptable forms. Other forms of MEASure, such as MEASU or MEASUR, will generate an error. You may use upper- or lower-case letters. Therefore, MEASURE, measure, and MeAsUrE are all 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?
:PERiod
:PERiod?

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**

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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

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SCPI Command Reference

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

ABORt

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 From Interface:** When a scan is enabled from an interface, an interface CLEAR command or the HP E130lA front panel "Reset Instr" or "Clear Instr" keys can be used to stop the scan. When the scan is enabled from the interface and TRIG:SOUR BUS or HOLD is set, use ABORt or the HP E130lA 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 through 03
INIT                          Start scan, close channel 00
   .
   .
ABOR                          Abort scan in progress
```


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ARM

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, MAX sets 32767 cycles.

Parameters

Parameter Name	Parameter Type	Range of Values
<*number*>	numeric	1-32767 I MIN I 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 Form C Switch 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
```


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: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
```


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DISPlay

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 E130lA).

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
```


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MONitor[:STATe]

DISPlay:MONitor[:STATe] <*mode*> turns the monitor mode on or off.

Parameters

Parameter Name	Parameter Type	Range of Values
<*mode*>	boolean	ON l 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 E1364A Form C Switch module follows, where all channels (all relays) are closed.

  0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15

- ***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
```


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INITiate

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

Subsystem Syntax

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

:CONTinuous

INITiate:CONTinuous ON | OFF | 1 | 0 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 O 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
```


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: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
```

[: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[:IMMediat] 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).
```


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OUTPut

The OUTPut command subsystem enables or disables the "Trig Out" port of the HP E1300A/E130lA Mainframes or on the HP E1405/E1406 Command Modules.

Subsystem Syntax

OUTPut
[:STATe] <*mode*>
[:STATe]?

[:STATe]

OUTPut[:STATe] <*mode*> enables or disables the "Trig Out" BNC port on the rear panel of the HP E1300A/E1301A Mainframes or on the HP E1405/E1406 Command Modules. OUTPut[:STATe] ON | 1 enables the port and OUTPut[:STATe] OFF | 0 disables the port.

Parameters

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

Comments

- **Enabling Trig Out Port:** When enabled, a pulse is output from the "Trg 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 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

Enabling Trig Out Port:

```
OUTP:STAT ON          Enable "Trg Out"  port to output pulse after each scanned channel is closed
```

[: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
```


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[ROUTe:]

The ROUTe command subsystem controls switching and scanning operations for Form C Switch 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 Form C Switch channels specified by *channel_list*. *channel_list* has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-15).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00 - cc15

Comments

- **Closing Channels:** To close a single channel, use [ROUTe:]CLOSe (@ccnn); for multiple channels use [ROUTe:]CLOSe (@ccnn,ccnn,); for sequential channels, use [ROUTe:]CLOSe (@ccnn:ccnn); for groups of sequential channels, use [ROUTe:]CLOSe (@ccnn:ccnn,ccnn:ccnn); 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 Form C Switch 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.

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CLOSe?

[ROUTe:] CLOSe? <*channel_list*> returns the current state of the channel(s) queried. *channel_list* has the form (@ccnn) (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 l00 and 2l3
CLOS? (@100,213)         Query channels l00 and 2l3 state
```

OPEN

[ROUTe:]OPEN <*channel_list*> opens the Form C Switch channels specified by *channel_list*. *channel_list* has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-15).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00 - cc15

Comments

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


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OPEN?

[ROUTe:]OPEN? <*channel_list*> returns the current state of the channel(s) queried. *channel_list* has the form (@ccnn) (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 end 213
OPEN? (@213)             Query channel 213 state
```

SCAN

[ROUTe:]SCAN <*channel_list*> defines the channels to be scanned. *channel_list* has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-15).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00 - cc15

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 (@ccnn); multiple channels (@ccnn,ccnn,...); sequential channels (@ccnn:ccnn); groups of sequential channels (@ccnn:ccnn,ccnn:ccnn); 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 Devices" or "Example: Scanning Using Trig Out and Event In Ports" for example scanning programs using external instruments.

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SCAN:MODE

[ROUTe:]SCAN:MODE NONE | VOLT can be used for the Form C Switch. Both NONE and VOLT set the mode for "no measurements". This command has no effect on Form C Switch operation. [ROUTe:] SCAN:MODE? can be used to query the scanning mode (NONE or VOLT) for the Form C Switch.

STATus

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

Subsystem Syntax

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

:OPERation[:EVENt]?

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

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 STATus:OPERation[:EVENt]?:** The command returns + 256 if bit 8 of the Operation Status Register is set to 1. The command 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 the 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.

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:OPERation:ENABle

STATus:OPERation:ENABle <*number*> enables the Operation Status Register to set a bit in the Status Register. For the Form C Switch, when bit 8 in the Operation Status Register is set to 1, bit 7 in the Status Register is set to 1.

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
```

SYSTem

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
:ERRor?
:CDEScription? <*number*>
:CTYPe? <*number*>
:CPON <*number*> |ALL

: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.

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- **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
```

: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

- **Form C Switch Module Description:** The SYSTem:CDEScription? <*number*> command returns: "16 Channel General Purpose Relay"

Example Reading the Description of a Card#1 Module:

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

: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

- **Form C Switch Module Model Number:** The SYSTem:CTYPe? <*number*> command returns:

  HEWLETT-PACKARD,E1364A,0,A.01.00

  where the 0 after E1364A 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
```


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: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

- **Form C Switch 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
```

TRIGger

The TRIGger command subsystem controls the triggering operation of Form C Switch 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

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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 statements         Start count loop
TRIG                    Advance scan to next channel
increment loop          Increment loop count
```

:SOURce

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

Parameters

Parameter Name	Parameter Type	Parameter Description
BUS	discrete	*TRG or GET command
EXTernal	discrete	"Event In" BNC 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 E130OA/E1301A mainframe "Event In" BNC 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.

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- **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.
- ***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" BNC 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" BNC 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
```


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IEEE 488.2 Common Commands

The following table lists the IEEE 488.2 Common (*) Commands that apply to the Form C Switch 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* or the *ANSI/IEEE Standard 488.2-1987* for more information.

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Command Quick Reference

SCPI Commands Quick Reference

Command		Description
ABORt		Abort a scan in progress.
ARM	**:COUNt <*number*>** **:COUNt? [MIN | MAX]**	Multiple scans per INIT command. Query number of scans.
DISPlay	**:MONitor:CARD <*number*> | AUTO** **:MONitor[:STATe] <*mode*>**	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] <*mode*>** **[: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** **SCAN:MODE?**	Close channel(s). Query channel(s) closed. Open channel(s). Query channel(s) opened. Define channels for scanning. Sets scan mode. Query the 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" BNC. 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.

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Appendix A
HP E1364A Specifications

Maximum Input Voltage:

C to NC or NO:	Any term. to chassis:
250VDC	250VDC
250VAC RMS	250VAC RMS
354VAC Peak	354VAC Peak

Maximum Current:
Per switch: lA DC
lA AC RMS

Maximum Power:
Per switch: 40W DC
40VA AC
Per module: 320W DC
320VA AC

Thermal Offset: <7µV per chan.

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

Insulation Resistance: (between any two points)
$>10^7$Ω at ≤40ºC, 65% RH
$>10^8$Ω at ≤25ºC, 40% RH

Bandwidth: -3dB at 10 MHz (typical)

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

Power Available:
+5V @ lA
+12V @ 0.5 A

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

Capacitance:
C to NC or NO: <20pF
Chan. to Chan.: <20pF

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

Power Up/Down States: all open / left in last state

Terminals: screw type, max. wire size 16 AWG

Module Size/Device Type: B, register-based

Connectors Used: P1

No. Slots: 1

VXIbus Interface Capability: Interrupter, D16

Interupt 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_20 @ 0.10 liter/sec
Humidity: 65% to 40ºC
Operating Temperature: 0 to 55ºC
Storage Temperature: -40 to 75ºC
EMC, RFI, Safety: meets FTZ 1046/1984, CSA 556B, IEC 348, UL 1244
Net Weight (kg): 0.7

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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 (e.g., turning on a lamp or starting a motor) reduce 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 preventative maintenance routine can prevent problems caused by unexpected relay failure. The end of the life of the relay can be determined by using 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 should be replaced when the end of 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.

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Appendix B
HP E1364A Form C Switch Registers

Register Definitions

The HP E1364A Form C Switch is a register-based device. See Figure B-1.

ID Register

b + 00_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined								(Logical Address)							
Read*	Reg-Base		A16		Manufacturer ID											

* Returns FFF_{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: $FF20_{16}$ = 16-Channel Form C Switch

Status/Control Register

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

* R = Switch reset to power-on state (all switches open)
** B = Status "busy" is true low 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*	CH15	CH14	CH13	CH12	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0
Read	Always Returns $FFFF_{16}$															

Write "1" closes channel, write "0" opens channel
(close = connect NO to C, open = connect NC to C)

Figure B-1. Form C Switch - Register Definitions

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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 $lF0000_{16}$.

In 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:

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

For the Form C Switch, the factory-set logical address is 120 (78), so the base address = (78_{16})*(40_{16}) + C_{16} = $DE00_{16}$. Then, for example, to address the Status/Control register of a Form C Switch in an HP E1300A/E1301A, the register address = [A16 location]$_{16}$ + [base address]$_{16}$ + [register offset]$_{16}$ = $lF0000_{16}$ + $DE00_{16}$ + 04_{16} = $lFDE04_{16}$.

Reading the Registers

You can read the following Form C Switch 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 Form C Switch, a read of the ID register (base address + 00_{16}) returns $FFFF_{16}$ since the multiplexers are manufactured by Hewlett-Packard and are A16 only, register-based devices. The Device Type register (base + 02_{16}) returns $FF20_{16}$.

Status/Control Register

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

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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 Form C Switch registers:

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

The only write allowed to the Status/Control register (base + 04_{16}) is to bit 0. Writing a "1" to bit 0 resets the switch (all channels open) You must then write a "0" to bit 0 to complete the reset.

Note All relays are latching and will remain in the last state during power-down and power-up unless a reset occurs. A reset connects all channel common (C) terminals to the corresponding normally closed (NC) terminals. 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 02. Or, write a "0" to bit 14 of the register to open channel 14.

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Appendix C
HP E1364A Form C Switch Error Messages

Table C-l lists the error messages associated with the Form C Switch module programmed by SCPI. See the appropriate mainframe manual for a complete list of error messages.

Table C-1. Form C Switch 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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