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Notes

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HP E1442A 64-Channel Form C Switch Module User's Manual
Edition 2

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.

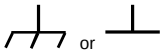
Edition 1 . . . . . July 1994

Edition 2 . . . . . March 1996

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.

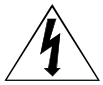
Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.



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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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.

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according to ISO/IEC Guide 22 and EN 45014

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: 64-Channel Form C GP Switch Module

Model Number: HP E1442A

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
IEC 801-3:1984/EN50082-1 (1992): 3 V/m
IEC 801-4:1988/EN50082-1 (1992): 1kV Power Line, .5kV Signal Lines
IEC 801-5:1992(DRAFT) 3kV Low Energy, 1kV High Energy

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

Tested in a typical configuration in an HP C-size VXI mainframe.

July 28, 1994 **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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HP E1442A 64-Channel Form C Switch Module User's Manual
Edition 2

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• Examples are clear and useful.	O	O	O	O	O
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Please write any comments or suggestions below--be specific.

Chapter 1
HP E1442A Module Setup

Using This Chapter

This chapter provides one page of general module information followed by the tasks you must perform to set up your module. It also provides information to verify that your installation was successful. Chapter contents include:

General Information

The terms "Form C switch" and "switch" are both used in this manual to refer to the HP E1442A 64-Channel Form C Switch Module which is a VXIbus C-size register-based slave device that can operate in a C-size VXIbus mainframe or a VMEbus mainframe.

The switch "instrument" is the firmware running in the E1405/E1406 Command Module. This firmware is the instrument driver providing SCPI (Standard Commands for Programmable Instruments) programming capability. The term "switchbox" is used to refer to a switch instrument made up of one or more switch modules.

Programming the HP E1442A can be done through the command module using the Standard Commands for Programmable Instruments (SCPI - see Chapter 3), or via direct register access (register-based programming - see Appendix B).

Graphical Overview

Figure 1-1 is a simplified schematic illustrating the 64-channel Form C switch module with internal bus and all available terminal modules.

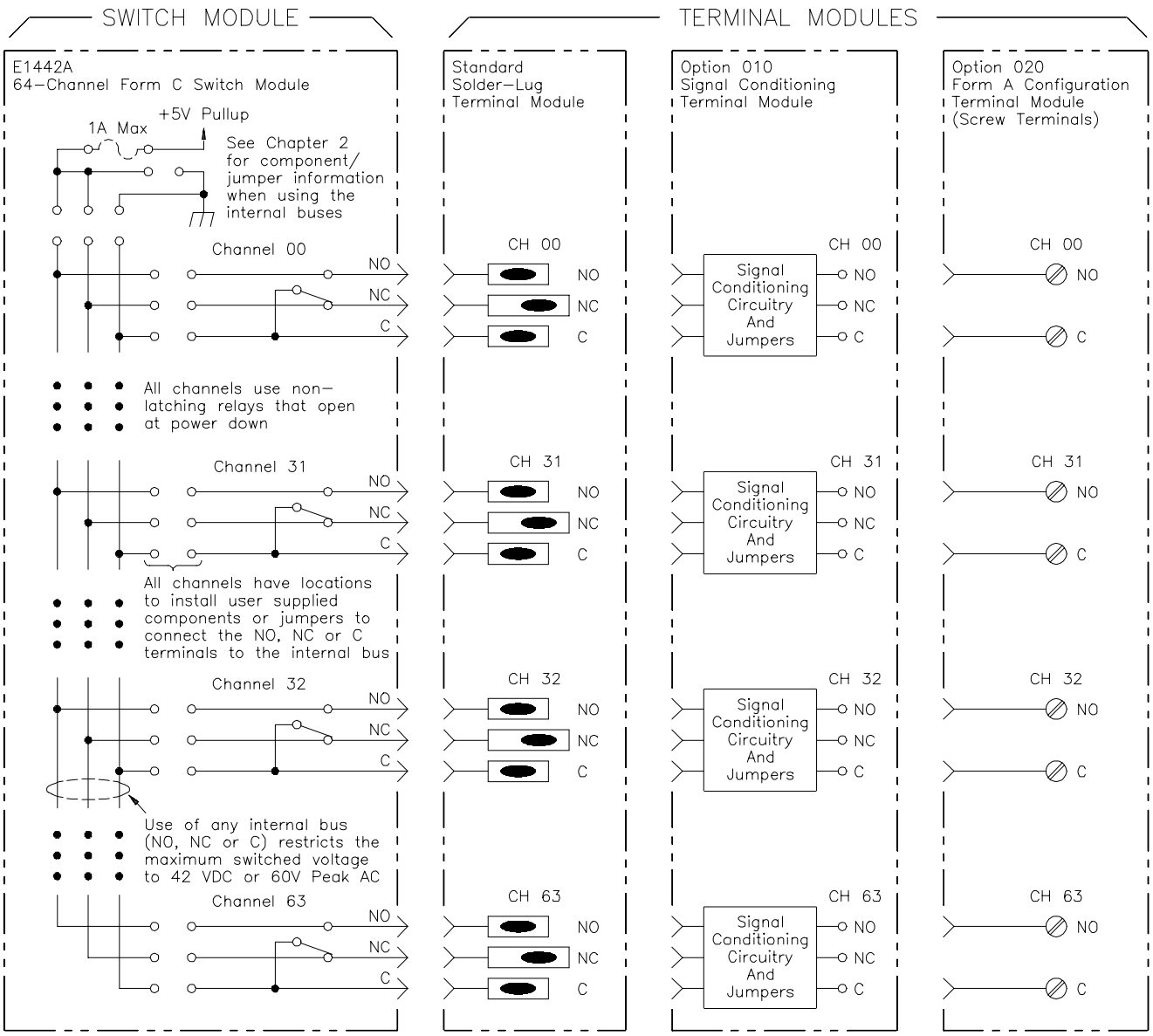


Figure 1-1. Form C Switch Simplified Schematic

HP E1442A Terminal Module Summary

- Standard Solder-Lug Terminals
- Option 010: Signal Conditioning Circuitry/Solder Eyes
- Option 020: Screw Terminal Form A Configuration Terminals (NOTE: Option 020 has no connection to the NC relay contact.)

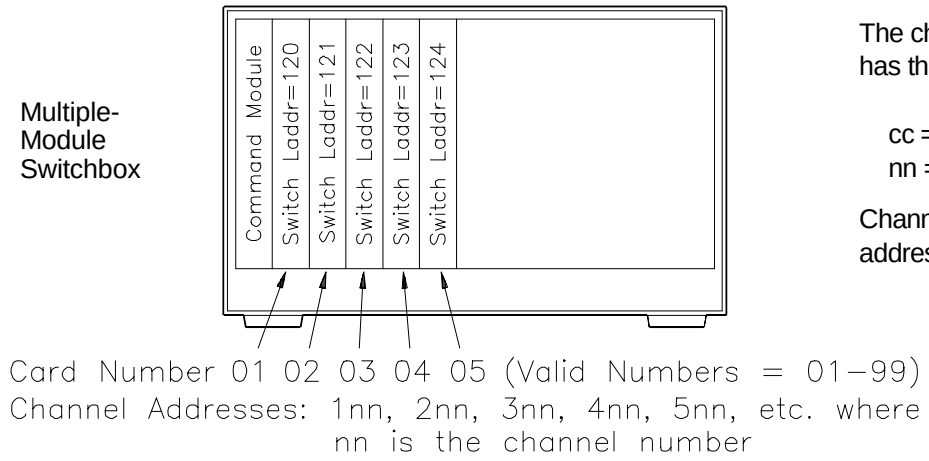
Module Use and Address Selection

You can use the switch module as a switchbox in two ways:

- As one module in a group of switch modules called a switchbox. The first module must be addressed so it can be recognized as an instrument and the other modules in the group have addresses sequentially following the first module e.g., 120, 121, 122 ....
- As a single-switchbox switch module. The module must be addressed so it can be recognized as an instrument.

NOTE Addressing channels on a switch module depends on how you use the module. Figure 1-2 on card numbers (module numbers) and channel addresses describes how your choice of using the module determines how you access a particular channel on the switch card (module).

Multiple-Module Switchbox

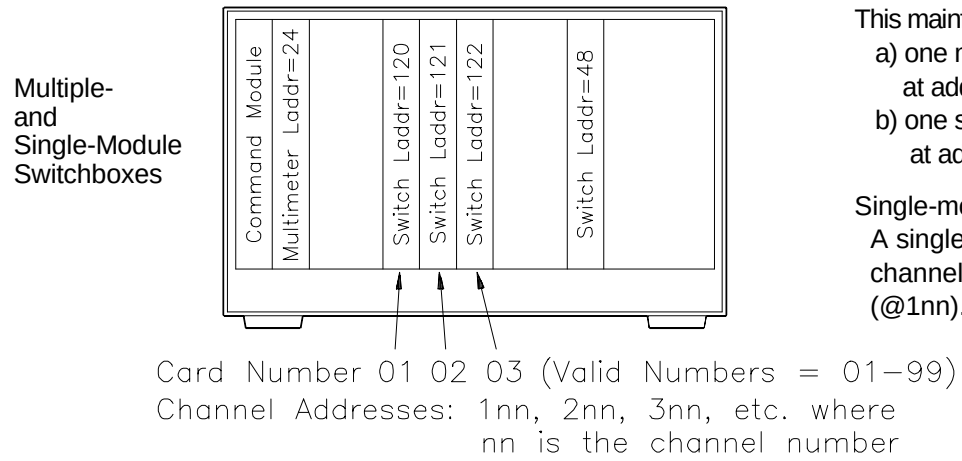


The channel address (*channel_list*) has the form (@ccnn) where:

cc = card number
nn = channel number.

Channel 45 on card number 02 is addressed by (@245).

Multiple- and Single-Module Switchboxes



This mainframe has two switchboxes:
a) one multiple-module switchbox at address 120, and
b) one single-module switchbox at address 48.

Single-module channel addressing: A single-module switchbox has channel addresses of the form (@1nn). It is card number 1.

Figure 1-2. Logical Address, Card (Module) Number and Channel Address

Setting the Module Address Switch

The logical address switch (LADDR) factory setting is 120. Valid addresses are from 1 to 254. The Form C switch module can be configured as a single instrument, or as a switchbox. Refer to the *C-Size VXIbus Systems Configuration Guide* for addressing information. Refer to Figure 1-3 for switch position information.

Note When using an HP E1405A/B or E1406A, the address switch value must be a multiple of 8 if the module is the first module in a switchbox used with a VXIbus command module using SCPI commands.

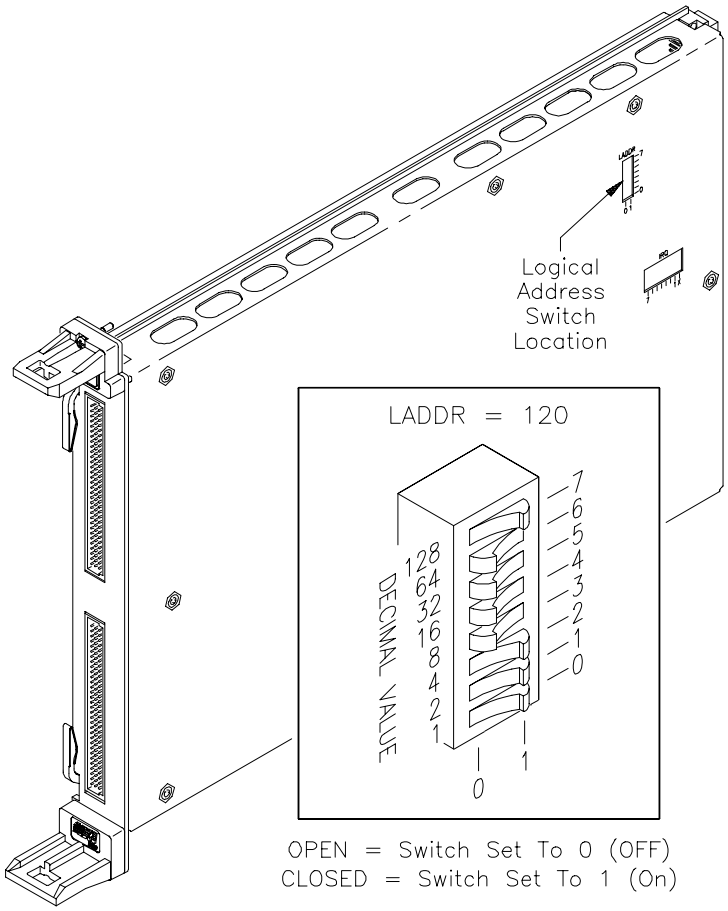


Figure 1-3. Setting the Logical Address

Setting Interrupt Priority

Interrupts are enabled at power-up, after a SYSRESET, or after resetting the module via the control register. An interrupt is generated after any channel enable register is accessed when interrupts are enabled. The interrupt is generated approximately 13 ms after one of the registers is accessed. The interrupt priority jumper selects which priority level will be asserted. The interrupt priority jumper is set in position 1 as shipped from the factory. For most applications this priority level should not have to be changed. The interrupts are disabled when set to level X. The interrupt priority jumpers are identified on the sheet metal shield. A hole has been cut into it for access. Interrupts can also be disabled using the Control Register.

To change the setting, simply remove the jumper or jumpers from their current position and place on the level you desire. If the card uses two 2-pin jumpers, both jumpers must be placed in the same row for proper operation.

Note Consult your mainframe manual to make sure backplane jumpers are configured correctly. If you are using the HP E1401A/B Mainframe, these jumpers are automatically set when the card is installed.

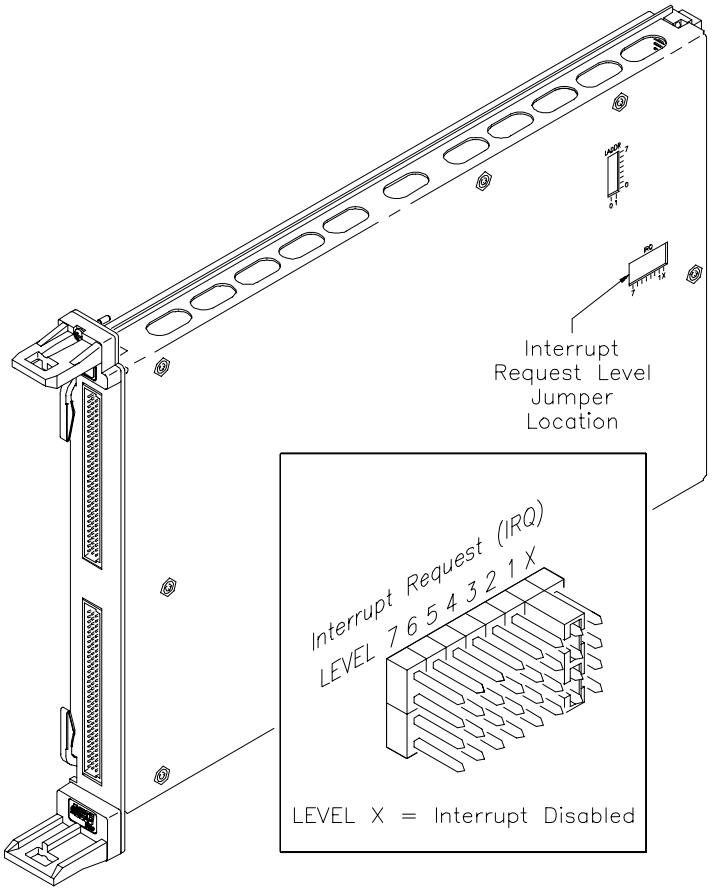


Figure 1-4. Setting Interrupt Request (IRQ) Priority

Connecting User Inputs

The Form C switch consists of a component module and a terminal module. The user connects inputs to the Form C switch NO (Normally Open), NC (Normally Closed), and C (Common) terminal connections on one of the three available terminal modules. Figure 1-1 earlier in this chapter shows the switch module and the three terminal modules. Figure 1-5 below shows the module front panel and the module's connector pin-out which mate to the terminal module.

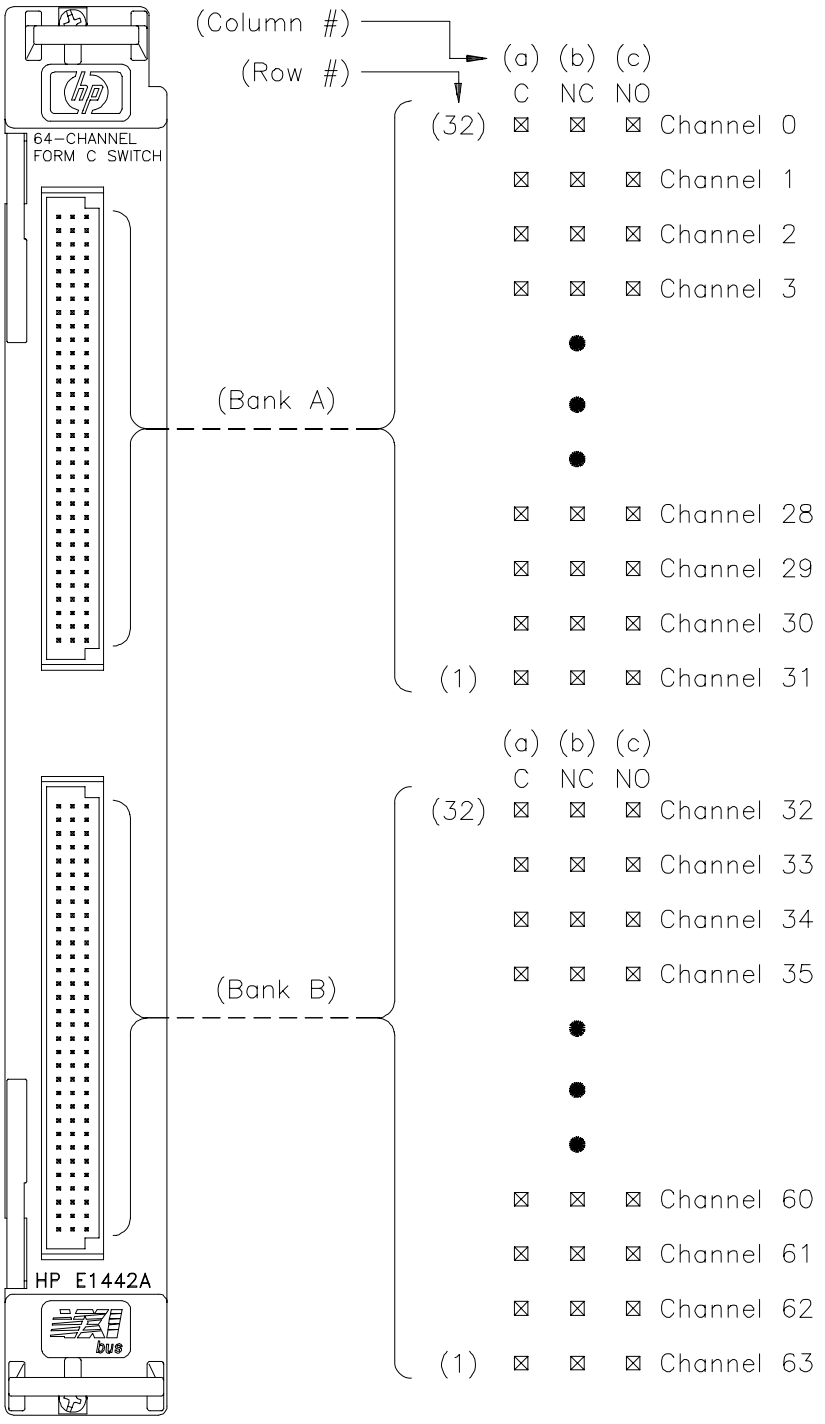
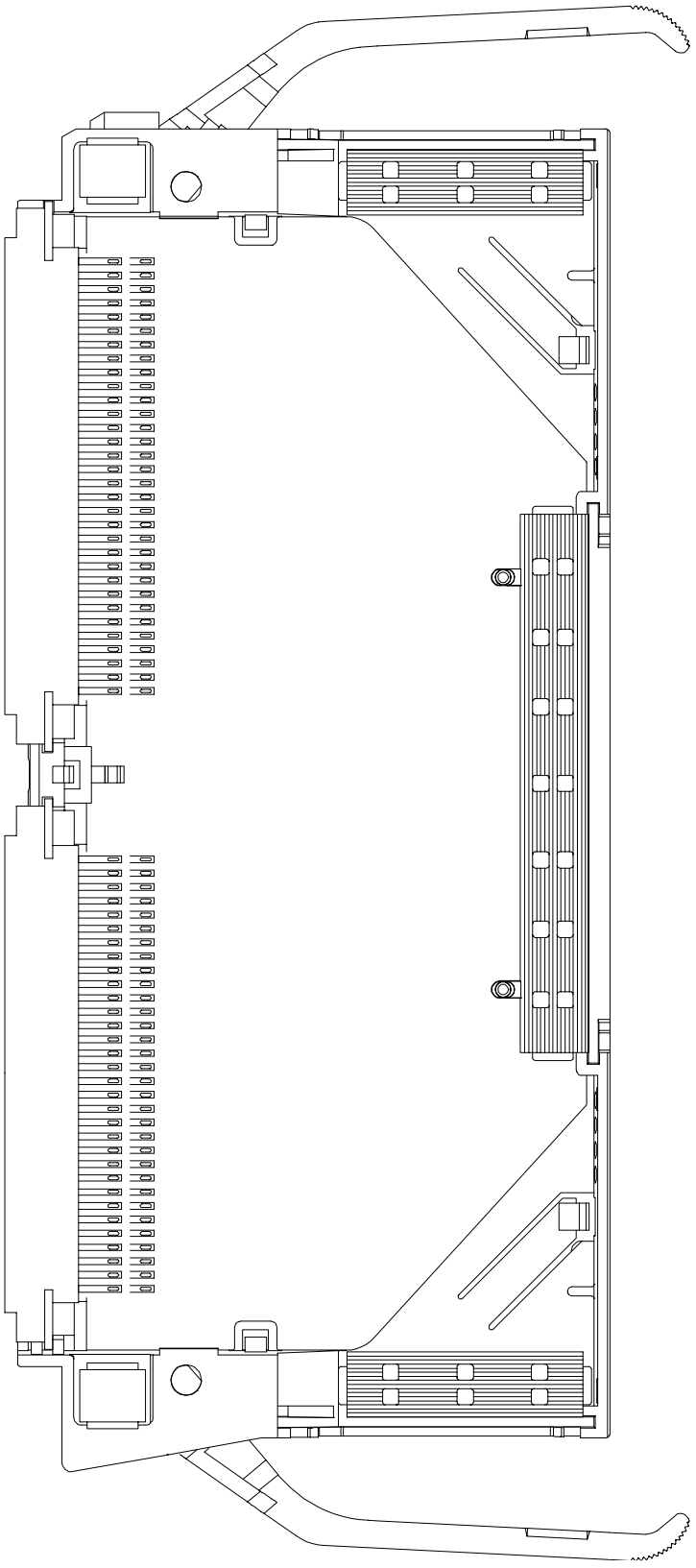


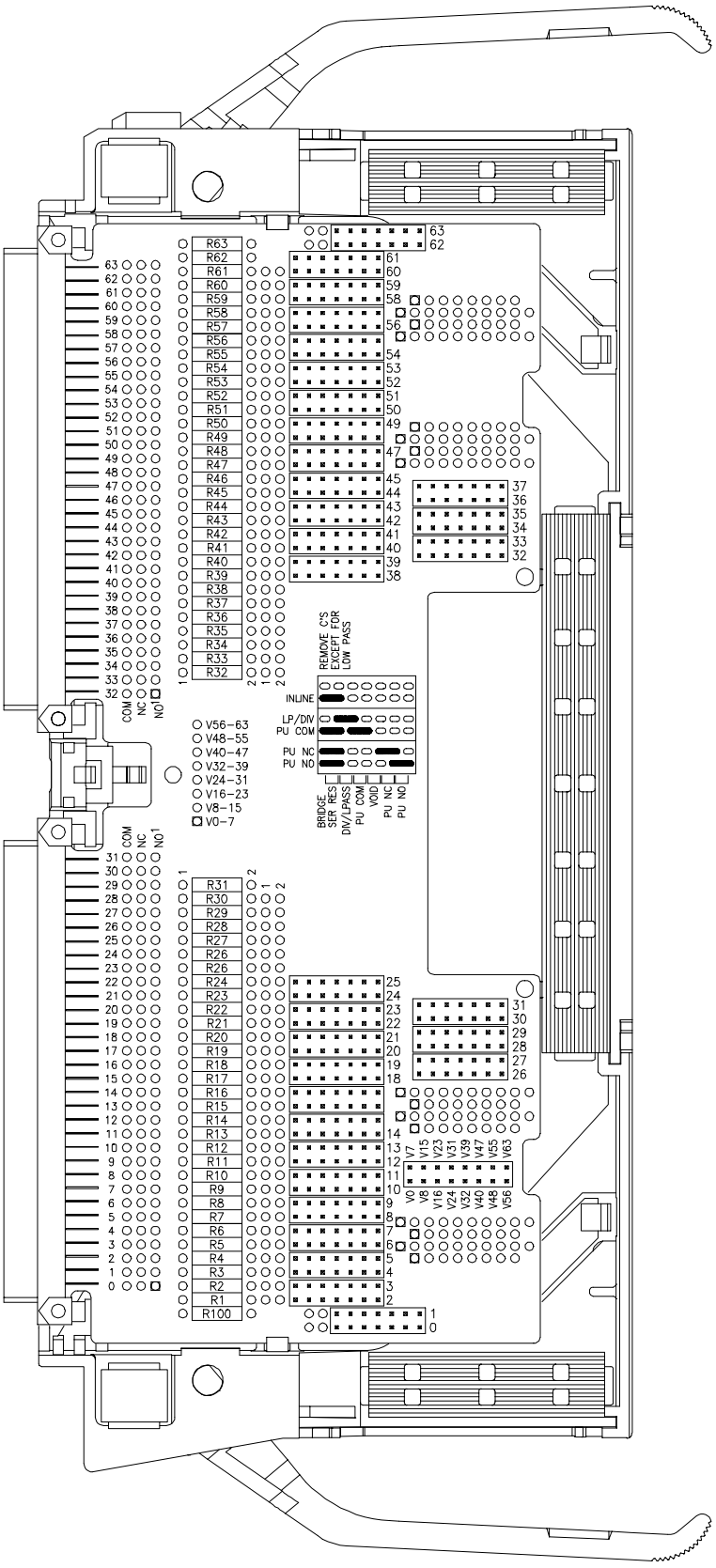
Figure 1-5. 64-Channel Form C Switch Front Panel

Standard Form C Configuration



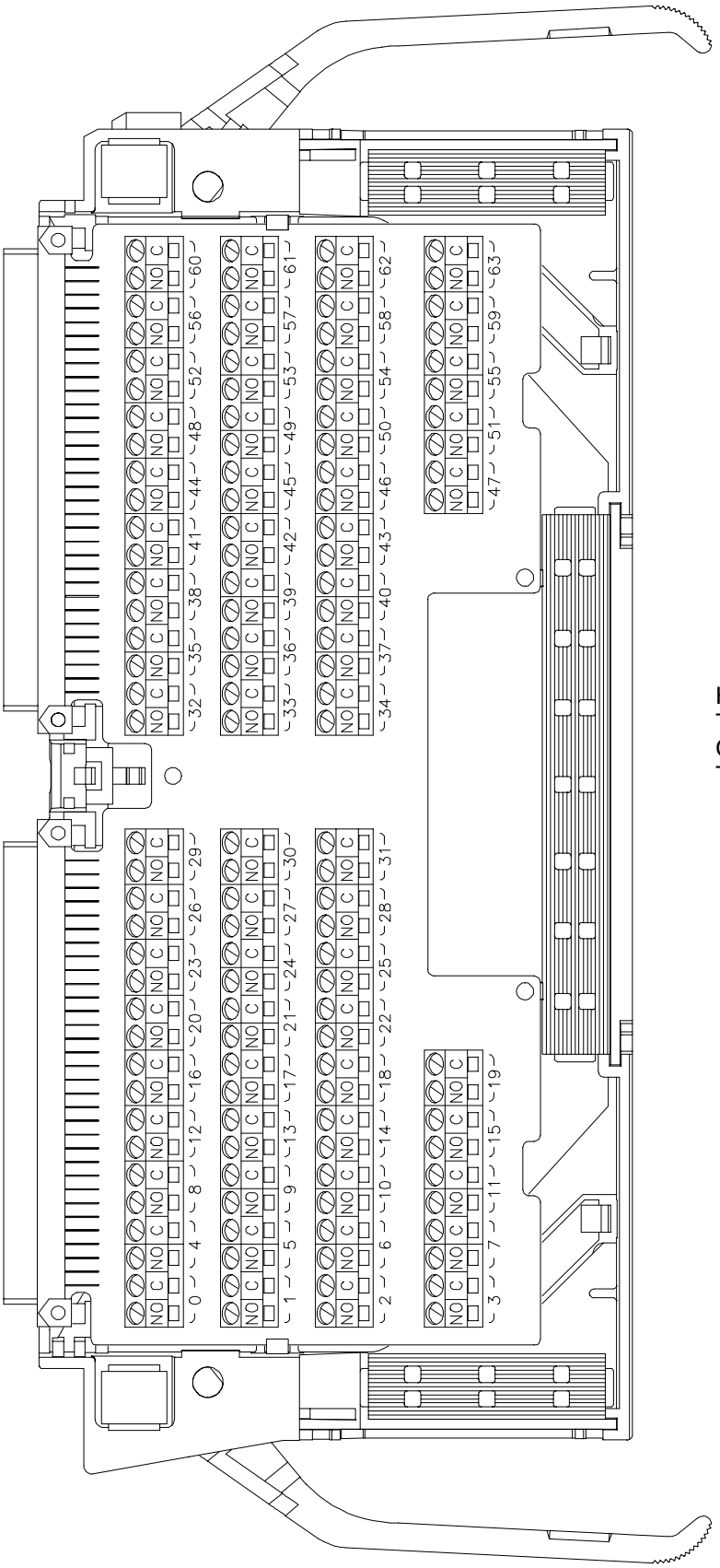
HP E1442A Standard Terminal Module Form C Configuration with Solder Lugs

Option 010 Form C Configuration



HP E1442A Option 010 Terminal Module Form C Configuration with Signal Conditioning Circuitry

Option 020 Form A Configuration



HP E1442A Option 020 Terminal Module Form A Configuration with Screw Terminals

	Terminal Module Type		
	Standard Solder-lug	Option 010 Signal Conditioning	Option 020 Form A Screw Terminal
RELAY OPEN	LOAD 1	LOAD 1	NO CONNECTION
RELAY CLOSED	LOAD 2	LOAD 2	LOAD 2

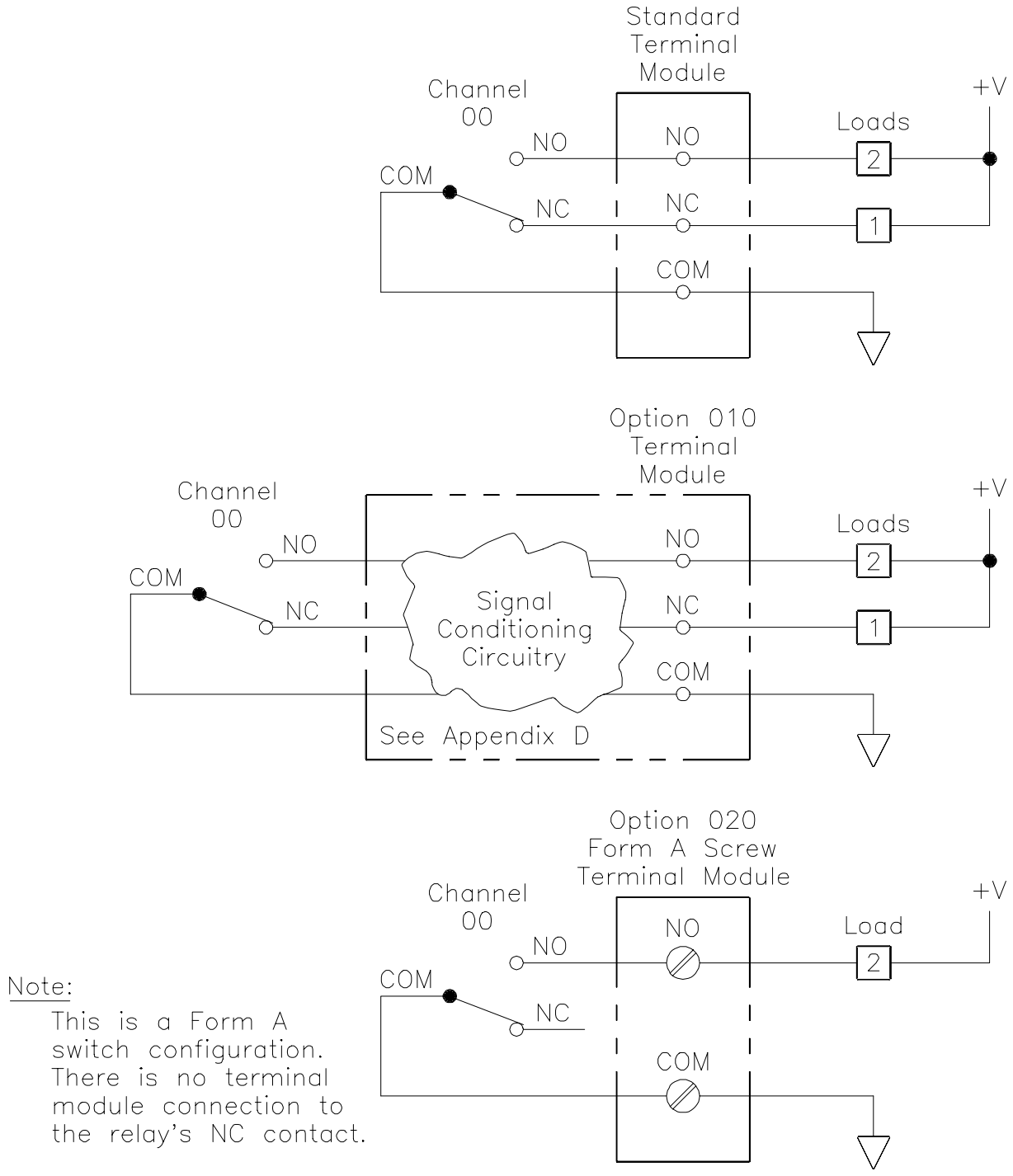


Figure 1-6. Terminal Module Differences

Using the Internal Buses

The HP E1442A 64-Channel Form C Switch Module contains internal buses that you can connect any channel contact to. Figure 1-7 below shows channels 0 and 63 and the internal bus structure. There is a bus for the common, the normally closed (NC), and the normally open (NO) contacts. Other jumpers provide the means to connect the NC and NO contacts to a fused +5V pull-up voltage, or to be connected as pull-downs to ground. The common can be connected to ground. Figure 1-8 shows where you can find the component/jumper locations on the module.

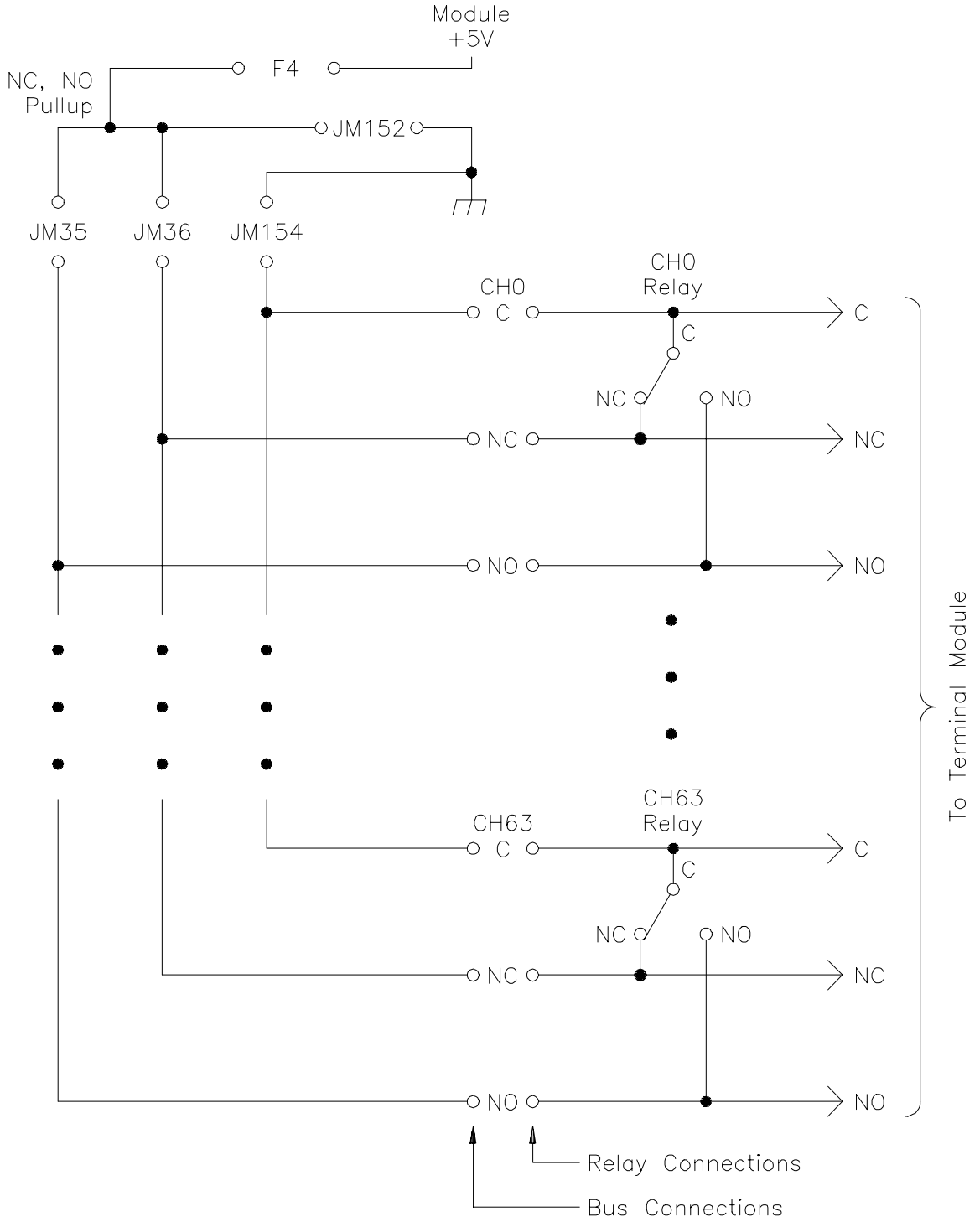
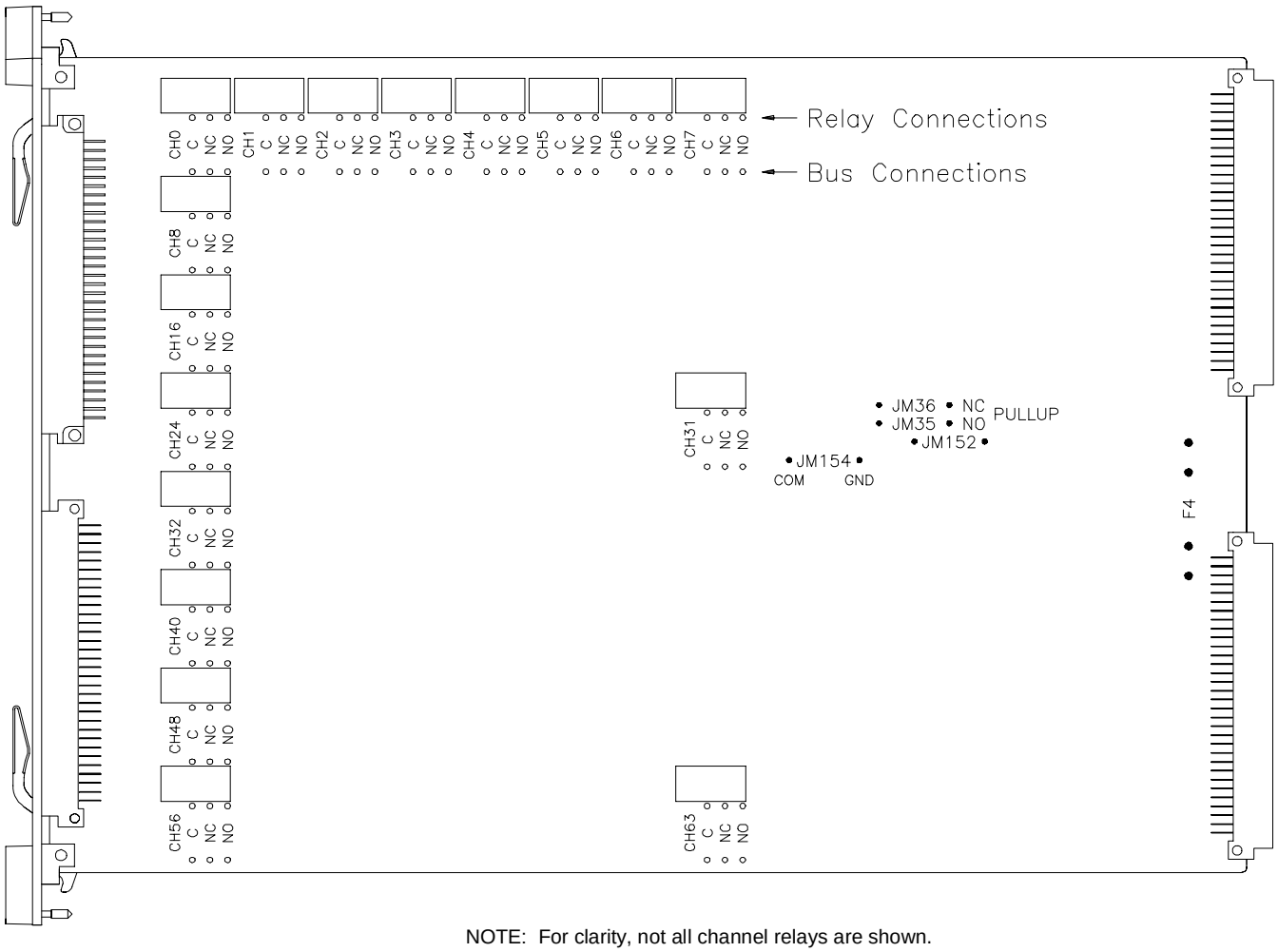


Figure 1-7. HP E1442A Internal Bus Structure



NOTE: For clarity, not all channel relays are shown.

"Relay Connection" and "Bus Connection" nodes are identified on the previous diagram.

Figure 1-8. HP E1442A Internal Bus Component/Jumper Locations

⚠ WARNINGS and CAUTIONS

WARNING **SHOCK HAZARD. Only qualified, service-trained personnel aware of the hazards involved should install, configure, or remove the module. Disconnect all power sources from the mainframe, the terminal module and installed modules before installing or removing a module.**

WARNING **SHOCK HAZARD. When handling user wiring connected to the terminal module, consider the highest voltage present accessible on any terminal.**

WARNING **SHOCK HAZARD. Use wire with an insulation rating greater than the highest voltage which will be present on the terminal module. Do not touch any circuit element connected to the terminal module if any other connector to the terminal module is energized to more than 30 VAC RMS or 60 VDC.**

CAUTION **MAXIMUM VOLTAGE/CURRENT. Maximum allowable voltage per channel terminal-to-terminal or terminal-to-chassis for the switch module is 150 Vdc or 150 Vac RMS (210 Vac peak). Maximum current per channel is 1 Adc or 1 Aac RMS (non-inductive). Maximum transient voltage is 1300V peak. Maximum power input is 40 Wdc or 40 VA per channel, 320 Wdc or 320 VA per module. Exceeding any limit or use outside the parameters specified in Appendix A and by these warnings and cautions may damage the switch module and impair the protection provided by the module.**

CAUTION **WIRING TERMINAL MODULE: When wiring to the terminal connectors on the E1442A terminal module, be sure not to exceed a 5mm strip back of insulation to prevent the possibility of shorting to other wiring on adjacent terminals.**

CAUTION **STATIC-SENSITIVE DEVICE. Use anti-static procedures when removing, configuring, cleaning and installing a module. The switch module is susceptible to static discharges; do not install the module without its metal shield attached.**

CAUTION **CLEANING the Front Panel: Disconnect power from the mainframe and remove the module to be cleaned. Clean the front panel with a soft cloth dampened either in clean water or in water containing a mild detergent. Do not use abrasive cleaners. Do not use an excessively wet cloth or allow excessive water to migrate inside the module. Let the panel dry thoroughly before reinstalling the module.**

Installing the Switch Module in a Mainframe

The HP E1442A 64-Channel Form C Switch Module may be installed in any slot (except slot 0) in a C-size mainframe. Refer to Figure 1-9 to install the module in a mainframe.

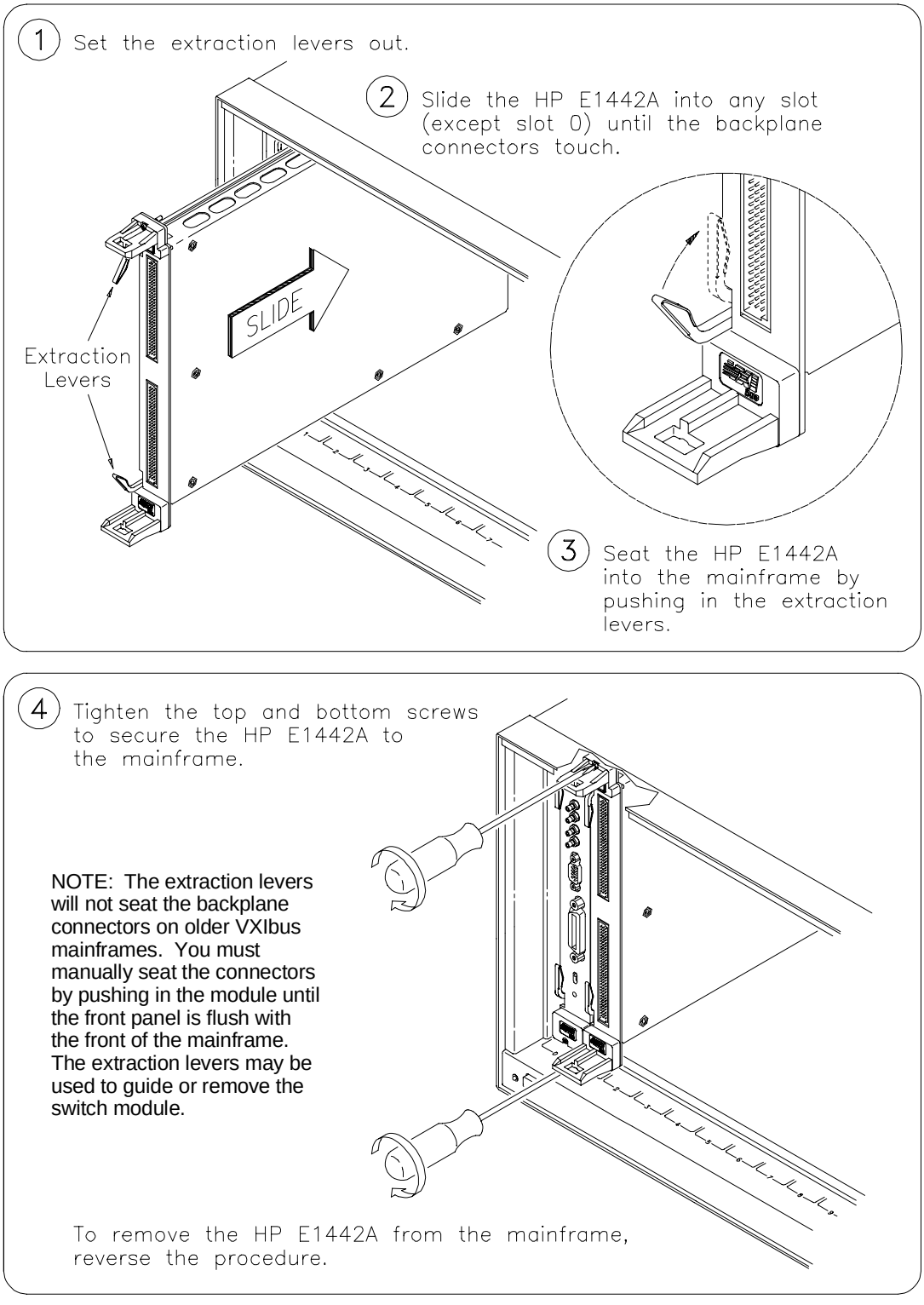


Figure 1-9. Installing the Switch Module in a Mainframe

Wiring the Terminal Module

Figures 1-10 and 1-11 show the rudiments of the terminal module assembly. Maximum terminal wire size is No. 16 AWG. Wire ends should be stripped 5mm (0.2 in.) and tinned. When wiring all channels, use a smaller gauge wire (No. 20-22 AWG).

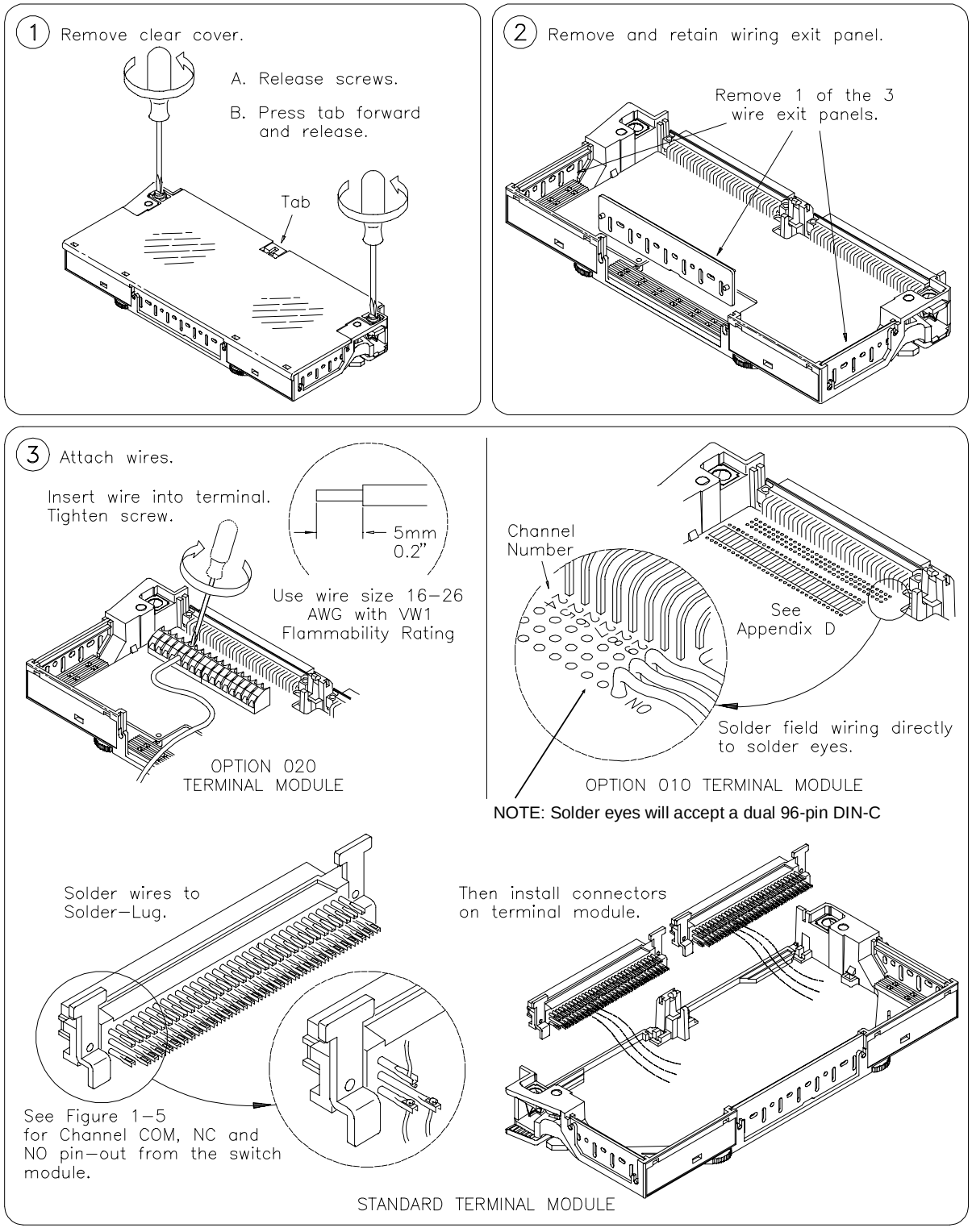


Figure 1-10. Wiring the Terminal Module (continued on next page)

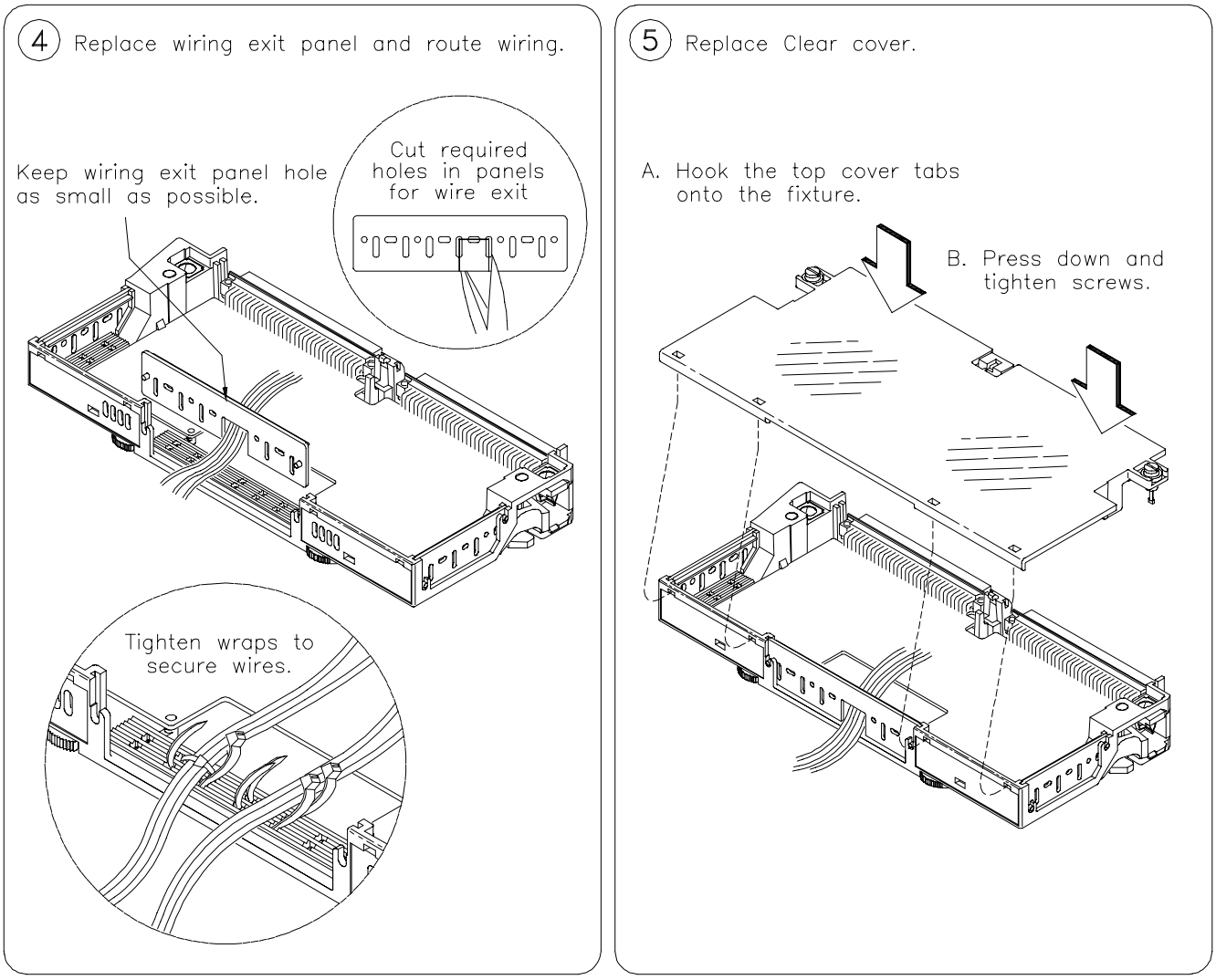


Figure 1-11. Wiring the Terminal Module (continued from previous page)

Attaching the Terminal Module to the Switch Module

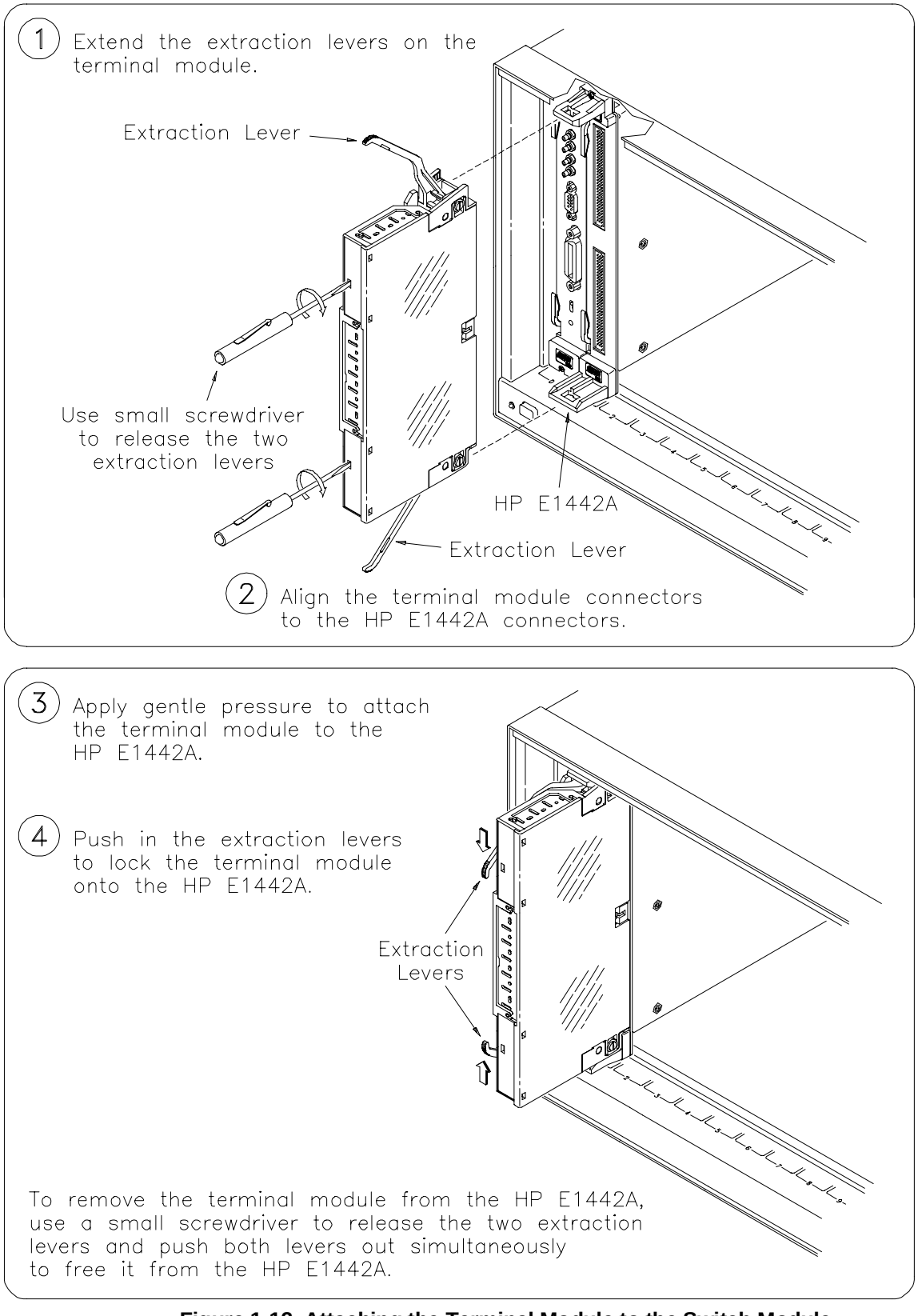


Figure 1-12. Attaching the Terminal Module to the Switch Module

Initial Operation

The following program uses Hewlett-Packard BASIC and SCPI (Standard Commands for Programmable Instruments) 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.)

The Normally Open (NO) contact of each Form C relay is "open" and the Normally Closed (NC) contact of each Form C relay is "closed" when the switch is deactivated (the Common terminal (C) is connected to NC at power-on, after reset or after an open command).

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 *C-Size VXI bus Systems Configuration Guide* for information on addressing.

Example: Close Form C Switch Channel

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

Programming the Switch

To program the Form C switch using SCPI, you must select the computer language, interface address, and SCPI commands to be used. Guidelines to select SCPI commands for the Form C switch follow. See the *C-Size VXIbus Systems Configuration Guide* for interface addressing and computer language information.

Note This discussion applies only to SCPI programming using the HP switchbox driver version provided with this module. See Appendix B, "Form C Switch Register Programming & Definitions", 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 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.

Channel Addresses

Channel addresses (*channel_list*) have the form (@ccnn) where cc = switch card number (01-99) and nn = channel numbers (00-63).

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.

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 *C-Size VXIbus Systems Configuration Guide* for a definition of logical addresses.)

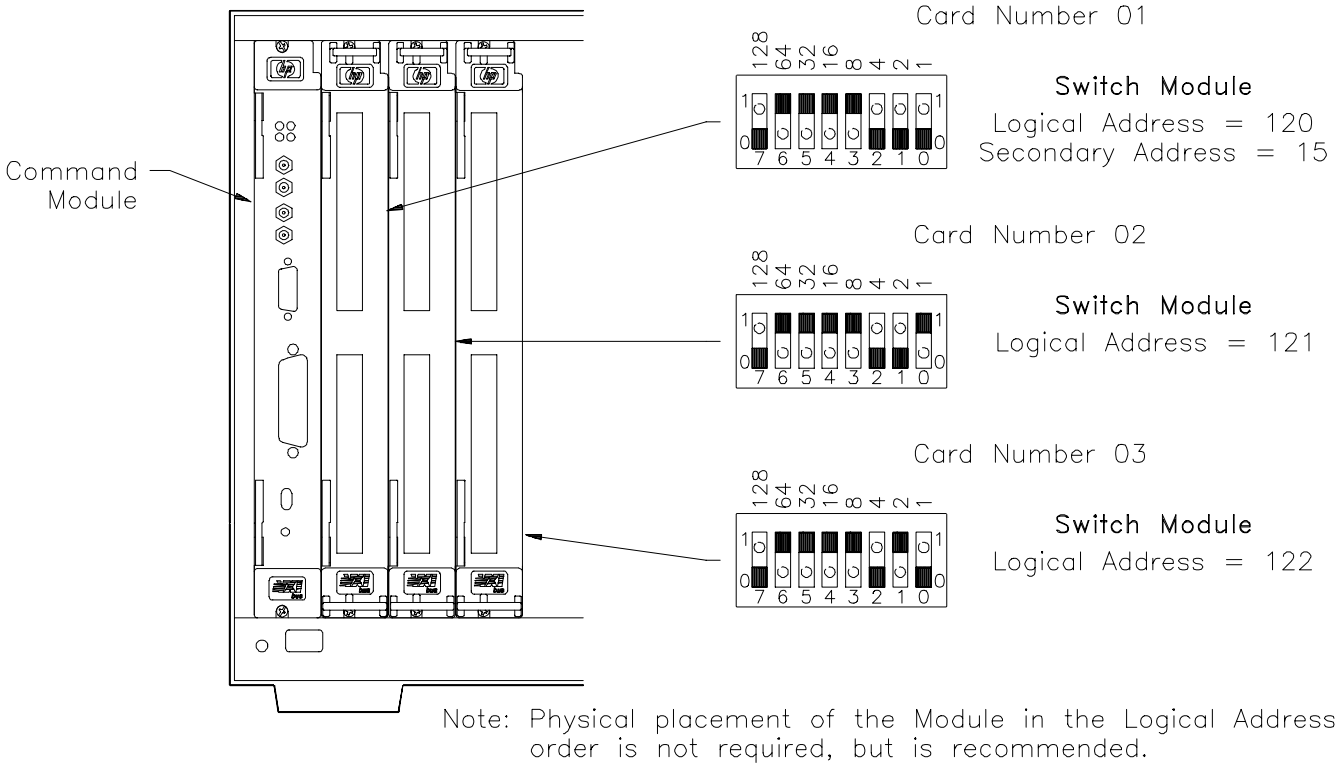


Figure 1-13. Multiple-Module Switchbox Card Numbers

Assume that three Form C switches are configured to form a switchbox instrument with logical addresses of 120, 121, and 122. Since card number 01 is assigned to the module with the lowest logical address, card number 01 is assigned to the card at logical address 120. Card number 02 is assigned to the card at address 121 and card number 03 is assigned to the card at address 122.

Channel Numbers, Channel Lists, Channel Ranges

Form C switch channel numbers are 00 through 63. 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.

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 (@100:163)          ! Open all channels on card 01.
SCAN (@100:163)          ! Scan all channels on card 01.
SCAN (@100:199)          ! Scan all channels on card 01.
```

Chapter 2
HP E1442A Switchbox Application Examples

Using This Chapter

This chapter provides application information and examples for using the HP E1442A 64-Channel Form C Switch Module in a "switchbox". The switchbox can consist of a single-switch module or multiple-switch modules. It can also include other HP switch modules which are controlled by the same "SWITCH" device driver.

This chapter contains:

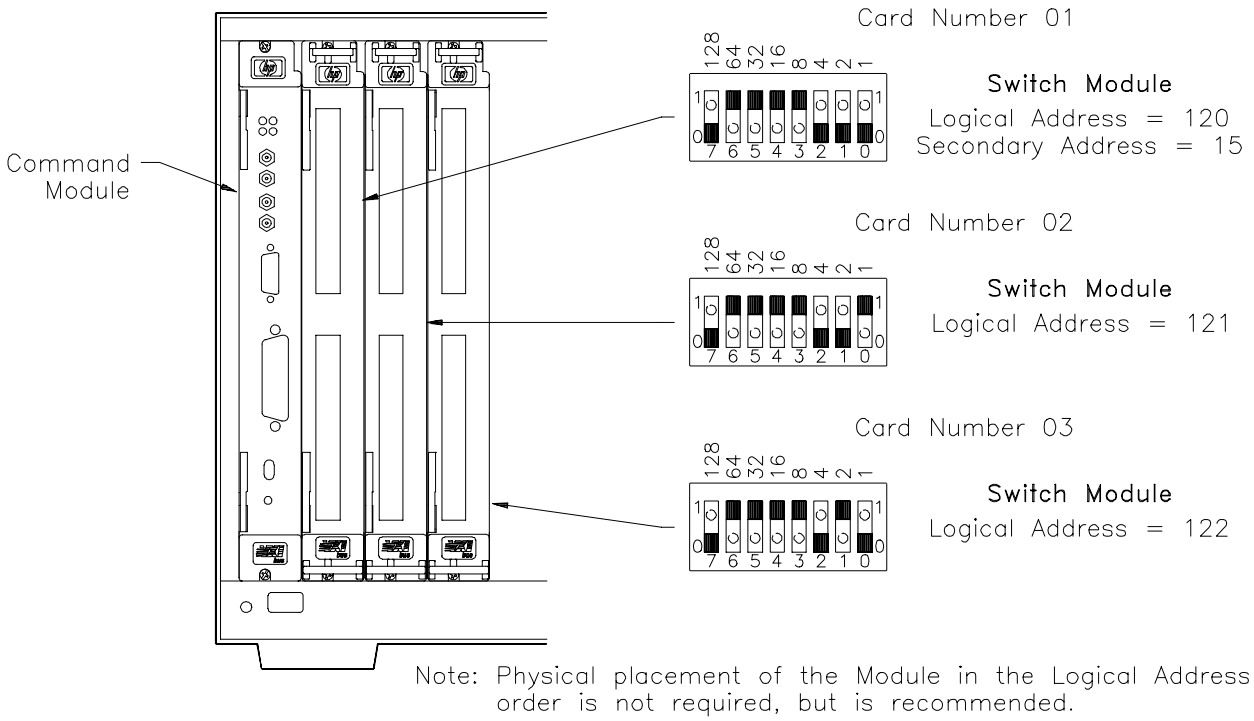


Figure 2-1. Switchbox Configuration

How to Scan

Scanning Form C switch channels consists of closing a set of channels (connecting NO to C) one channel at a time. Single scan, multiple (ARM:COUNt 2 to 32767) scans, or continuous (INIT:CONT) scanning modes are available. See the command reference in Chapter 3 for more information on these commands.

A number of SCPI commands relate to scanning; most of them are optional.

- ARM:COUNt sets the number of scanning cycles per INIT (optional).
- TRIGger:SOURce sets the trigger source for scan advance (optional).
- OUTPut:STATe enables/disables Trig Out signal (optional).
- OUTPut[:EXTernal][:STATe] ON selects Trig Out port (optional).
- INIT:CONTinuous ON selects continuous scanning (optional).
- SCAN defines channels to be scanned (required).
- INIT begins scanning (required).
- TRIG advances to next channel in scan list (required if using HOLD or BUS trigger sources).

Reset Conditions

At power-on or following the reset of the module (*RST command), all 64 channels are open (common connected to the normally closed terminal). In addition, after a *RST command the current scan channel list is invalidated. Table 2-1 lists the parameters and default values following power-on or reset.

Table 2-1. Power-on and Reset Default Values.

Parameter	Default	Description
ARM:COUNt	1	Number of scanning cycles is one.
TRIGger:SOURce	IMM	Will advance scanning cycles automatically.
INITiate:CONTinuous	OFF	Number of scanning cycles is set by ARM:COUNt.
OUTPut:[:STATe]	OFF	Trigger output from EXT, TTL or ECL sources is disabled.
Channel state	All 64 channels are open (channels 00 - 63).	
Channel list from SCAN command (after *RST)	Current channel list is invalidated following a reset of the module with the *RST command.	

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 E1405A/B or E1406A Trig Out port. See the examples that follow.

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.

Example: Scanning with External Device

This example uses the command module's 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 E1405A/B or E1406A Trig Out port is connected to the instrument External Trigger In port. For this example, the mainframe and instrument are connected via HP-IB with mainframe at address 709 and the measurement instrument at address 722. The Form C switch is at logical address 120 (secondary address 15 and therefore address through the mainframe at address 70915). 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. 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
```

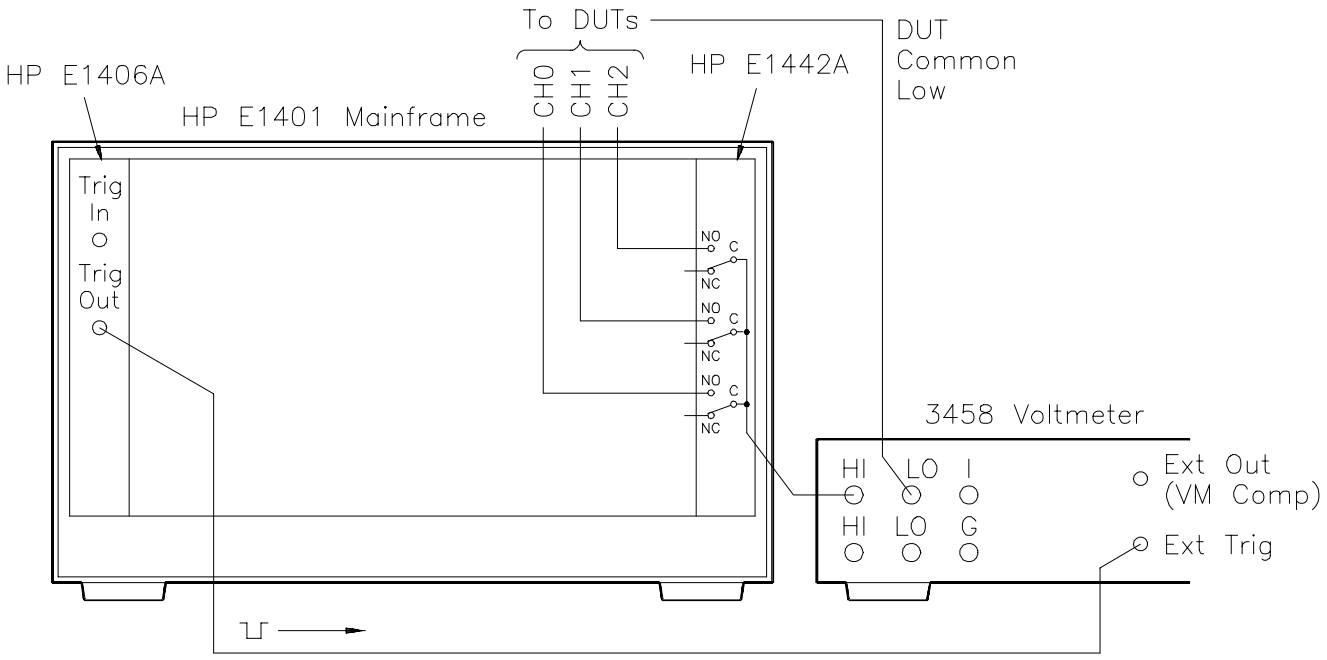


Figure 2-2. Scanning with an External Device

Example: Scanning Using Trig Out and Trig In Ports

This example uses the command module's Trig Out and Trig 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 measurement instrument are connected via HP-IB with mainframe at address 709 and the measurement instrument at address 722. The Form C switch logical address is 120 (secondary address = 120/8= 15 and therefore addressed through the mainframe at 70915).

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 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 automatically repeated for channels 101-102.

```
10 OUTPUT 722;"TRIG EXT; .... "          ! Configure voltmeter.
20 OUTPUT 70915;"OUTP ON"                ! Enable Trig Out port.
30 OUTPUT 70915;"TRIG:SOUR EXT"          ! Event In triggering.
40 OUTPUT 70915;"SCAN (@l00:102)"        ! Scan channels 00-02.
50 OUTPUT 70915;"INIT"                   ! Enable scan.
60 FOR Chan = 1 to 3
70     PRINT "Channel", Chan, Result
80 NEXT Chan
90 OUTPUT 70915;"*RST"                   ! Resets module; opens last switch
                                           closed.
100 END
```

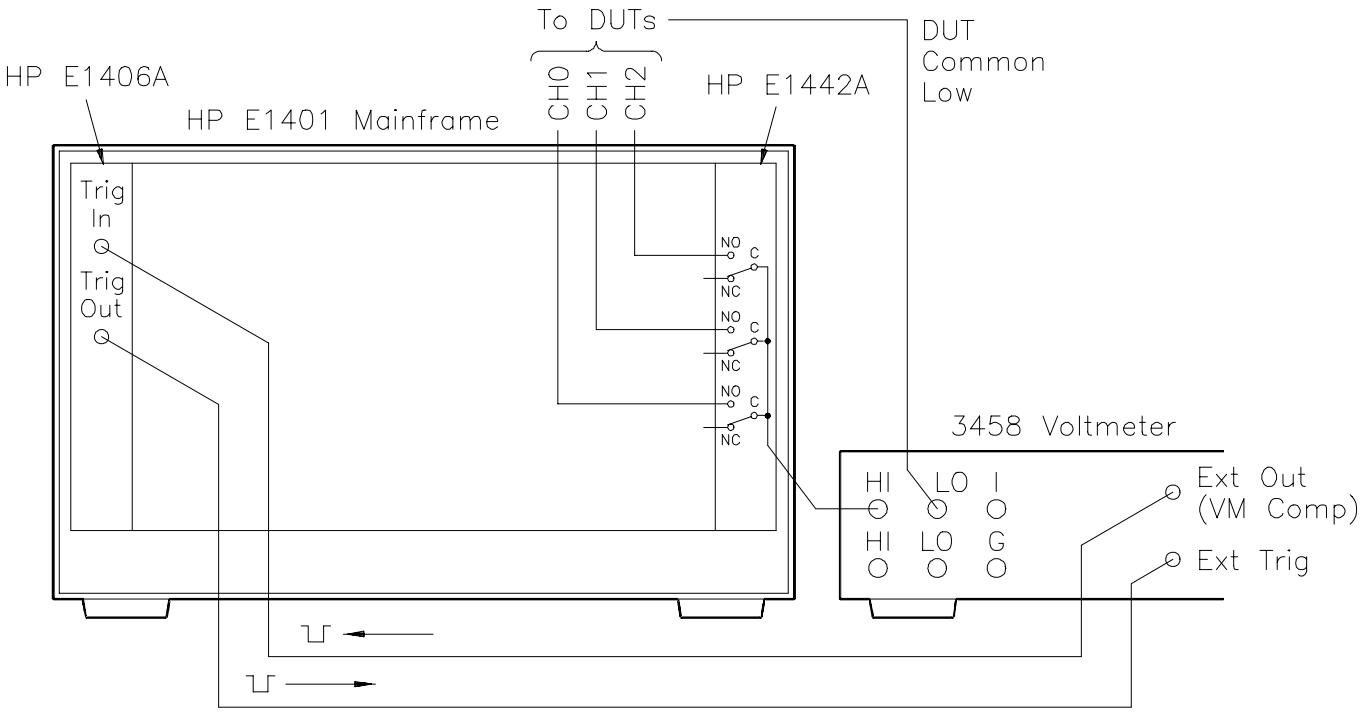


Figure 2-3. Scanning Using Trig Out and Trig In

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 STATe:OPERational[:EVENt]? command in the Command Reference 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 E1400A/E1401A Mainframe or an HP E1405/E1406 Command Module 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 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.
```

Saving and Recalling States

This section contains information about saving and recalling a switch module state. The switchbox driver can store up to 10 states.

Saving States

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

- Channel Relay State (channels 00 through 63 open or closed)
- ARM:COUNt
- TRIGger:SOURce
- OUTPut[:STATe]
- INITiate:CONTinuous

Recalling States

The *RCL <*numeric_state*> command recalls a previously saved state. Enter the number (0-9) in the state parameter of the desired saved state. If *SAV was not previously executed using the selected number, the switch module will configure to the reset values (see Table 2-1).

NOTE Scan lists are not saved when a state is saved. You must re-enter your scan list after recalling a state.

Detecting Error Conditions

There are two general approaches to error checking. The simplest, but most time consuming, is to ask the instrument whether there are errors at every step of the switching process. This is called "polling" and is illustrated in the example shown below.

```
10  DIM  Err$[256]
20  OUTPUT 70915;"CLOS  (@101)"      ! Close channel 1 switch.
30  OUTPUT 70915;"SYST:ERR?"         ! Query for error.
40  ENTER 70915;Err$                 ! Read response.
50  IF VAL (Err$) > 0 THEN           ! If an error is found (Err$ not 0).
60    PRINT "Error";Err$             ! Print the error.
70    STOP                           ! Quit if error encountered.
80  END IF
90  ... (PROGRAM CONTINUES)
```

Using Interrupts with Error Checking

The second approach involves the use of interrupts. The following program is a method of checking for errors using interrupts as you program the switch module. The program monitors the switch's Standard Event Status Register for an error condition. If no errors occur, the switch module functions as programmed. If errors do occur, the switch module interrupts the computer, and the error codes and messages are read from the error queue.

This HP BASIC programming example has a single switch module at address 70915.

```
 10
 20
 30
 40 ON INTR 7 CALL Errmsg              ! Call to print out error message.
 50 ENABLE INTR7:2
 60
 70
 80
 90
100 OUTPUT 70915;"*SRE  32"            ! Enables the standard event summary bit SRE.
110 OUTPUT 70915;"*ESE  60"            ! Enables all parser generated errors.
115                                    ! See STATus command figure.
120
130
140
 .
 .
 .
190 END
200 !
210
220
230
240
250 SUB Errmsg                         ! Define interrupt service routine.
260   DIM A$[256]                      ! Declare response string.
270   CLEAR 70915                      ! Clear the switch module.
280   B = SPOLL(70915)                 ! Fetch status byte.
290   REPEAT                           ! Repeat.
300         OUTPUT 70915;"SYST:ERR?"! Query for error.
310         ENTER 70915;Code,A$        ! Read response.
320         PRINT Code,A$              ! Print error.
330  UNTIL Code=0                      ! Keep querying for an error until
                                       error code = 0.
340   OUTPUT 70915;"*CLS"              ! Clears status registers and error queue.
350   STOP
360 SUBEND
```

Synchronizing the Form C Switch

This section discusses synchronizing the switch to other instruments when making measurements. The following example uses the switch module to switch a signal to be measured by a multimeter. The program verifies that the switching is complete before the multimeter begins a measurement.

Measurement Set-Up

- Digital Multimeter has an HP-IB select code = 7, primary address = 09 and secondary address = 03 (it is addressed as 70903).
- HP E1442A has an HP-IB select code = 7, primary address = 09 and secondary address = 15 (it is addressed as 70915).
- Controller is an HP Series 200/300/400 computer with HP BASIC.

```
10  OUTPUT 70915;"CLOS  (@100)"      ! Close channel 100.
20  OUTPUT 70915;"*OPC?"             ! Wait for completion of close
                                     command.
30  ENTER 70915;Opc_value           ! Read response to *OPC?
                                     command.
31  !
32  ! Channel is closed and measurement can be made.
33  !
40  OUTPUT 70903;"MEAS:VOLT:DC?"     ! Make VM measurement.
50  ENTER 70903;Meas_value           ! Read the measurement.
60  PRINT Meas_value                 ! Print the measurement.
70 END
```

Chapter 3
HP E1442A Switchbox Command Reference

Using This Chapter

This chapter describes Standard Commands for Programmable Instruments (SCPI) and summarizes IEEE 488.2 Common (*) commands applicable to the HP E1442A 64-Channel Form C Switch Module. This chapter contains the following sections:

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

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 with parameters, 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 lowercase letters. The uppercase 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 lowercase 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 [ROUTe:] subsystem shown below:

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

The root command [ROUTe:] is an implied command (indicated by square brackets [ ]). To close relays in a channel list, you can send either of the following command statements:

```
[ROUTe:]CLOSe (@100:107, 201, 225)   or   CLOSe (@100:107, 201, 225)
```

These commands function the same closing channels 00 through 07 on card 1 and channels 01 and 25 on card 2.

Parameters

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

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 number of values. These parameters use mnemonics to represent each valid setting. An example is the TRIGger:SOURce<*source*> command 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 setting 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;*TRG
```

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 HP E1442A 64-Channel Form C Switch Module. Commands are listed alphabetically by subsystem and within each subsystem.

There are two methods to send commands to the instrument. The method most often used is from a controller over the HP-IB interface; this method will be referred to as the "HP-IB interface" in the following command reference. The second method of sending commands is from a terminal connected to the HP E1405/1406 Command Module (RS-232). Commands sent this way will be referred to as "from the terminal" in the following command reference.

ABORt

The ABORt command stops a scan in progress when the trigger sources are either TRIGger:SOURce BUS or TRIGger:SOURce HOLD. See the comments below for how to get out of a scan if trigger source is not BUS or HOLD.

Subsystem Syntax ABORt

Comments

- **Channel Status After an ABORt:** ABORting a scan will leave the last channel that it closed in the closed position.
- **Effect on Scan Complete Status Bit:** ABORting a scan will not set the "scan complete" status bit.
- **Stopping Scans Enabled from HP-IB Interface:** When a scan is enabled from the HP-IB interface, and the trigger source is not HOLD or BUS, you can clear the interface to stop the scan (in the BASIC programming language, this is done by executing the CLEAR command for your interface, e.g. CLEAR 7).

  When the scan is enabled from the HP-IB interface and the trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD, send the ABORt command over the HP-IB bus.

NOTE Clearing the HP-IB interface during a scan leaves the last channel the scan closed in the closed position and does not set the "scan complete" status bit.

- **Stopping Scans by Using the RS-232 Terminal:** You may use a terminal connected to the HP E1405/1406 Command Module to stop any scan.

  If the scan was started from the terminal, and the trigger source is HOLD or BUS, send the ABORt command to halt the scan. If the scan was started from the terminal and some other trigger source is being used, a "Ctrl-c" will send an interface CLEAR to the instrument and abort the scan. Sending "Ctrl-r" also sends an interface CLEAR to the instrument and additionally performs a reset (*RST) on the instrument. (See the Command Reference in the command module's user's manual for details on the terminal interface.)

  If the scan was started from the HP-IB interface but you wish to stop it by using the terminal, first make sure that the correct instrument (e.g.,SWITCH at desired logical address) is selected by using the terminal soft keys. Then send a "Ctrl-r". This will send an interface CLEAR to the HP-IB task, but will not place the instrument in the reset state with respect to the HP-IB task. These actions will occur regardless of the trigger source setting.

NOTE Clearing the interface using a "Ctrl-c" from the terminal during a scan leaves the last channel it closed in the closed position and does not set the Scan Complete status bit.

- **Related Commands:** ARM, INITiate:CONTinuous, [ROUTe:]SCAN, TRIGger

Example **Stopping a Scan with** ABORt

```
TRIG:SOUR BUS                    ! Bus is trigger source.
INIT:CONT ON                     ! Sets continuous scanning.
SCAN   (@100:115)                ! Sets channel list.
INIT                             ! Starts scanning cycle.
  .
  .
ABOR                             ! Aborts scan in progress.
```

ARM

The ARM subsystem allows a scan list to be scanned multiple times (1 through 32767) with one INITiate command.

Subsystem Syntax

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

:COUNt

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

Parameters

Parameter Name	Parameter Type	Range of Values
<number>	numeric	1 thru 32767 | MIN | MAX

Comments

- **Number of Scans:** Use only values between 1 (MIN) to 32767 (MAX) for the number of scanning cycles (default is MIN = 1).
- **Related Commands:** ABORt, INITiate:IMMediate, INITiate:CONTinuous
- ***RST Condition:** ARM:COUNt 1

Example

Setting Ten Scanning Cycles

```
ARM:COUN 10                 ! Sets 10 scanning cycles.
SCAN  (@100:115)            ! Sets channel list.
INIT                        ! Starts scanning cycle.
```

:COUNt?

ARM:COUNt? [MIN | MAX] returns the current number of scanning cycles set by ARM:COUNt. If a value between MIN and MAX is set, that value for ARM:COUNt is returned. The optional parameters MIN and MAX allow you to query the module for the these values instead of looking them up in the command reference. A 1 is returned for the MIN parameter; 32767 is returned for the MAX parameter regardless of the ARM:COUNt value set.

Parameters

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

Comments

- **Related Commands:** INITiate:IMMediate

Example

Query Number of Scanning Cycles

```
ARM:COUN 55          ! Set 10 scanning cycles.
ARM :COUN?           ! Query number of scanning
                     cycles; returned value is 55.
```

DISPlay

The DISPlay subsystem monitors the channel state of a selected module (or card) in a switchbox. The DISPlay command subsystem only operates with an RS-232 terminal connected to the HP E1405/1406 Command Module's RS-232 port. These commands control the display on the terminal, and would in most cases be typed directly from the terminal keyboard. It is possible, however, to send these commands over the HP-IB interface and control the terminal's display. In this case, care must be taken that the instrument receiving the DISPlay command is the same one that is currently selected on the terminal, otherwise the HP-IB command will have no visible effect.

Subsystem Syntax

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

:MONitor:CARD

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

NOTE You must use DISP:MON:STAT ON to actually display the monitored module state to the RS-232 terminal.

Parameters

Parameter Name	Parameter Type	Range of Values
<*number*>|AUTO	numeric	1 thru 99

Comments

- **Selecting a Specific Module to be Monitored:** Send the card number in a switchbox with the DISPlay:MONitor:CARD command.
- **Selecting the Present Module to be Monitored (AUTO):** Use the DISPlay:MONitor 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:CARD?

DISPlay:MONitor:CARD? queries the setting of the :MONitor:CARD command and returns the module in a switchbox to be monitored.

:MONitor[:STATe]

DISPlay:MONitor[:STATe] <***mode***> turns the monitor mode on or off. When monitor mode is on, the RS-232 terminal display presents an array of values indicating the open/close state of every switch on the module. This display is dynamically updated each time a switch is opened or closed.

Parameters

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

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.

- Typing in another command on the terminal will cause the DISPlay:MONitor[:STATe] to be automatically set to OFF (0). NOTE: Use of the OFF parameter is useful only if the command is issued across the HP-IB interface.

- **Selecting the Module to be Monitored:** Use the DISPlay:MONitor:CARD <*number*>|AUTO command to select the module.

- **Monitor Mode on an HP E1405/1406 Command Module Display:** A typical display for the HP E1442A 64-Channel Form C Switch with all channels (i.e. all relays) closed follows. The "#H" indicates data is in hexadecimal format. Each channel is represented as a bit in the hex value.

  The channels are grouped into four blocks of 16 channels each.

  ```
  15-0 #HFFFF 31-16 #HFFFF 47-32 #HFFFF 63-48 #HFFFF
  ```

  Closing only channel 3 would appear as `15-0: #H0008.`

- ***RST Condition:** DISPlay:MONitor[:STATe] OFF | 0
  An *RST also opens all switches on the card. A DISP:MON ON command following a *RST will display the following:

  ```
  15-0 #H0000 31-16 #H0000 47-32 #H0000 63-48 #H0000
  ```

Example

Enabling the Monitor Mode

```
DISP:MON:CARD 2          ! Selects module #2 in a switchbox.
DISP:MON 1               ! Turns the monitor mode on.
```

:MONitor[:STATe]?

DISPlay:MONitor[:STATe]? queries the monitor mode. The command returns a `1` if monitor mode is on or a `0` if monitor mode is off.

INITiate

The INITiate 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. The setting of this command determines whether or not a subsequent INIT[:IMMediate] command will cause a continuous scan to occur.

Parameters

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

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 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. A trigger at the end of the channel list opens the last channel in the list and the scanning cycle stops.
- The INITiate:CONTinuous command does not start a scanning cycle (see INIT:IMM).
- **Stopping Continuous Scans:** See the ABORt command.
- **Related Commands:** ABORt, ARM:COUNt, INITiate[:IMMediate], TRIGger, TRIGger:SOURce
- ***RST Condition:** INITiate:CONTinuous OFF

Example

Enabling Continuous Scans

```
INIT:CONT ON          ! Enables continuous scanning.
SCAN  (@100:163)      ! Sets channel list.
INIT                  ! Starts scanning cycle.
```

: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

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

[:IMMediate]

INITiate[:IMMediate] starts the scanning cycle and closes the first channel in the channel list. Successive triggers from the source specified 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. A trigger advances the scan through the channel list. An invalid channel list generates an error (see [ROUTe:]SCAN command).
- **Stopping Scanning Cycles:** See the ABORt command.
- **Related Commands:** ABORt, ARM:COUNt, INITiate:CONTinuous, TRIGger, TRIGger:SOURce
- ***RST Condition:** None

Example

Starting a Single Scan

```
SCAN  (@100:163)      ! Sets channel list.
INIT                  ! Starts scanning cycle by closing
                      channel 00 and proceeding.
```

OUTPut

The OUTPut subsystem enables one trigger line of the HP E1405A/B or E1406A Command Module. It also can disable the active line.

Subsystem Syntax

```
OUTPut
    :ECLTrgn
        [:STATe] <mode>
        [:STATe]?
    [:EXTernal]
        [:STATe] <mode>
        [:STATe]?
    :TTLTrgn
        [:STATe] <mode>
        [:STATe]?
```

:ECLTrg*n*[:STATe]

OUTPut:ECLTrg*n*[:STATe] <*mode*> enables (ON or 1) or disables (OFF or 0) the ECL trigger bus pulse on the VXI bus line specified by *n*. There are two ECL trigger lines on the VXI bus allowing valid values for *n* to be 0 and 1.

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

Comments

- When OUTPut:ECLTrg*n*[:STATe] ON is set, a trigger pulse occurs each time a channel is closed during a scan.

:ECLTrg*n*[:STATe]?

OUTPut:ECLTrg*n*[:STATe]? queries the state of the ECL trigger bus line specified by *n*. A `1` is returned if the line is enabled; a `0` is returned if it is disabled. Valid values for *n* are 0 and 1.

Parameter Name	Parameter Type	Range of Values
n	numeric	0 or 1

[:EXTernal][:STATe]

OUTPut[:EXTernal][:STATe] <*mode*> enables or disables the Trig Out port on the HP E1405A/B or E1406A Command Module. OUTPut[:EXTernal][:STATe] ON | 1 enables the port and OUTPut[:EXTernal][:STATe] OFF | 0 disables the port.

Parameters

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

Comments

- **Abbreviated Syntax:** OUTPut subsystem commands [:EXTernal] and [:STATe] are optional subcommands. The OUTPut command can be abbreviated by simply executing OUTPut ON or OUTPut OFF.
- **Enabling Trig Out Port:** When enabled, the Trig Out port is pulsed each time a channel is closed during scanning. When disabled, the Trig Out port is not pulsed.
- **Output Pulse:** The pulse is a +5 V negative going pulse.
- **Trig Out Port Shared by Switchboxes:** Once enabled, the Trig Out port may be pulsed by the switchbox each time a channel is closed in a switchbox during scanning. To disable the output for a specific switchbox, send the OUTPut[:EXTernal] [:STATe] OFF or OUTPut[:EXTernal][:STATe] 0 command for that switchbox. The OUTP OFF command must be executed following use of this port to allow other instrument drivers to control the Trig Out port.
- **Related Commands:** [ROUTE:]SCAN, TRIGger:SOURce
- ***RST Condition:** OUTPut[:EXTernal][:STATe] OFF (port disabled)

Example

Enabling Trig Out Port

```
OUTP ON                    ! Enables Trig Out port for pulse
                           output.
```

[:EXTernal][:STATe]?

OUTPut:[:EXTernal][STATe]? queries the present state of the Trig Out port on the HP E1405/E1406 Command Module. The command returns `1` if the port is enabled, or `0` if disabled.

Example

Query Trig Out Port State

```
OUTP ON                    ! Enable Trig Out port for pulse
                           output.
OUTP:STAT?                 ! Query port enable state.
```

:TTLTrg*n*[:STATe]

OUTPut:TTLTrg*n*[:STATe] <***mode***> enables (ON or 1) or disables (OFF or 0) the TTL trigger bus pulse on the VXI bus line specified by *n*. There are eight TTL trigger lines on the VXI bus (n = 0 through 7).

Parameter Name	Parameter Type	Range of Values
n	numeric	0 thru 7
<*mode*>	boolean	0 | 1 | ON | OFF

Comments

- When OUTPut:TTLTrg*n*[:STATe] ON is set, a trigger pulse occurs each time a channel is closed during a scan.

:TTLTrg*n*[:STATe]?

OUTPut:TTLTrg*n*[:STATe]? queries the state of the TTL trigger bus line specified by *n*. A `1` is returned if the line is enabled; a `0` is returned if it is disabled. Valid values for *n* are 0 through 7.

Parameter Name	Parameter Type	Range of Values
n	numeric	0 thru 7

[ROUTe:]

The [ROUTe] subsystem controls switching and scanning operations for the 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 <mode>
        :MODE?
```

CLOSe

[ROUTe:]CLOSe <*channel_list*> activates the Form C switch relay for the channels specified in the *channel_list*. The relay's Common (C) terminal is connected to the Normally Open (NO) terminal (see diagram below). The *channel_list* is in the form (@ccnn), (@ccnn,ccnn), or (@ccnn:ccnn) where cc = card number (00-99) and nn = channel number (00-63).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00-cc63

Comments

- **Special Case of Using Upper Range 99 in the Channel List:** Specifying the last channel as 99 e.g., (@100:199) automatically closes all channels on the card number specified by cc.
- **Closing Channels (card and channel syntax; ccnn):**
  - [ROUTe:]CLOSe (@ccnn) to close a single channel.
  - [ROUTe:]CLOSe (@ccnn,ccnn) to close multiple channels.
  - [ROUTe:]CLOSe (@ccnn:ccnn) to close sequential channels.
  - [ROUTe:]CLOSe (@ccnn:ccnn,ccnn:ccnn) to close a group of sequential channels.
- **Closure Order:** A list of channels will not all close simultaneously. The order channels close when specified from a single command is not guaranteed. Use sequential CLOSe commands if needed.

- **Related Commands:** [ROUTe:]OPEN, [ROUTe:]CLOSe?
- ***RST Condition:** All Form C switch channels are open.

Example Closing Form C Switch Channels

This example closes channel 00 of card number 1 Form C switch module and channel 15 of card number 2 Form C switch module in a single switchbox.

```
CLOS   (@100,215)          ! 100 closes channel 00 of Form C
                           switch #1; 215 closes channel 15
                           of Form C switch #2.
```

CLOSe?

[ROUTe:]CLOSe? <***channel_list***> returns the current state of the channel(s) queried. The *channel_list* is in the form (@ccnn). The command returns `1` if the channel is in the NO state (C connected to NO) or returns `0` if the channel is in the NC state (C connected to NC). If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list.

Comments

- **Query is Software Readback:** The [ROUTe:]CLOSe? command returns the current state of the hardware controlling the specified channel. It does not account for a failed switch element or a relay closed by direct register access (see Appendix B).

Example Query Form C Switch Channel Closure

```
CLOS   (@100,215)          ! 100 closes channel 00 of Form C
                           switch #1; 215 closes channel 15
                           of Form C switch #2.
CLOS?  (@215)              ! Query channel 215.
```

OPEN

[ROUTe:]OPEN <*channel_list*> de-energizes the relays for the channels specified in the *channel_list* connecting the Common (C) terminal to the Normally Closed (NC) terminal (see diagram below). The *channel_list* is in the form (@ccnn), (@ccnn,ccnn), or (@ccnn:ccnn) where cc = card number (00-99) and nn = channel number (00- 63).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00-cc63

Comments

- **Using Upper Range 99 in the Channel List:** Specifying the last channel as 99 e.g., (@100:199) automatically opens all channels on the card number specified by cc.

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

- **Opening Order:** A list of channels will not all open simultaneously. The order channels open when specified from a single command is not guaranteed. Use sequential OPEN commands if needed.

- **Related Commands:** [ROUTe:]CLOSe, [ROUTe:]OPEN?

- ***RST Condition:** All Form C switch channels are open.

Example

Opening Form C Switch Channels

This example opens channel 00 of a card number 1 Form C switch module and channel 63 of a card number 2 Form C switch module in a single switchbox.

```
OPEN (@100,263)          ! 100 opens channel 00 of Form C switch #1; 263 opens channel 63 of Form C switch #2.
```

OPEN?

[ROUTe:]OPEN? <***channel_list***> returns the current state of the channel queried. The *channel_list* is in the form (@ccnn). The command returns `1` if the channel is in the NC state (C connected to NC) or returns `0` if the channel is in the NO state (C connected to NO). If a list of channels is queried, a comma delineated list of 0 or 1 values is returned in the same order of the channel list.

Comments

- **Query is Software Readback:** The [ROUTe:]OPEN? command returns the current state of the hardware controlling the specified channel. It does not account for a failed switch element.

Example

Query Form C Switch Channel Open State

```
OPEN   (@100,263)          ! 100 opens channel 00 of Form C
                           switch #1; 263 opens channel 63 of
                           Form C switch #2.
OPEN?  (@263)              ! Query channel 263.
```

SCAN

[ROUTe:]SCAN <*channel_list*> defines the channels to be scanned. The *channel_list* is in the form (@ccnn), (@ccnn,ccnn), or (@ccnn:ccnn) where cc = card number (00-99) and nn = channel number (00-63 and 99). See the first bullet comment for explanation of using the special case of 99 in the channel list.

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00-cc63 (or cc99)

Comments

- **Special Case of Using Upper Range 99 in the Channel List:** Specifying the last channel as 99, e.g. (@100:199) automatically scans all channels on the card number specified by cc.
- **Defining the Channel List:** When executing [ROUTe:]SCAN, the channel list is checked for valid card and channel numbers. An error is generated for an invalid channel list.
- **Scanning Operation:** With a valid channel list, INITiate[:IMMediate] starts the scanning cycle 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 the ABORt command.
- **Related Commands:** CLOSe, OPEN, SCAN:MODE, TRIGger, TRIGger:SOURce
- ***RST Condition:** All channels open.

Example

Scanning Using External Device

See Chapter 2, "Example: Scanning with External Device" or "Example: Scanning Using Trig Out and Trig In Ports" for example scanning programs using external instruments.

Example Scanning Using External Devices

The following example shows how to scan channels using the HP E1405/1406 Command Module via HP-IB and an HP 3457A Digital Multimeter. This example uses the command module's Trig Out port to synchronize the switch module in a switchbox to the multimeter. The trigger pulse from the Trig Out port triggers the multimeter for a measurement. See Chapter 2 for typical user connections to the Form C switch module.

The computer used in the example is an HP Series 200/300 with HP BASIC as the program language. The computer interfaces with the mainframe over HP-IB. Assumed is an HP-IB select code of 7, an HP-IB primary address of 09 and 22 for the HP E1405/E1406 Command Module and HP 3457A Multimeter, respectively, and an HP-IB secondary address of 15 for the switchbox.

```
10  OUTPUT 722;"TRIG EXT;DCV"          ! Sets multimeter to external
                                       trigger and to measure dc volts.
20  OUTPUT 70915;"OUTP ON"             ! Enables Trig Out port on
                                       command module.
30  OUTPUT 70915;"TRIG:SOUR BUS"       ! Sets switchbox to receive bus
                                       triggers.
40  OUTPUT 70915;"SCAN:MODE VOLT"      ! Sets switchbox to measure
                                       voltage during scanning.
50  OUTPUT 70915;"SCAN   (@100:163)"   ! Selects the channel list.
60  OUTPUT 70915;"INIT"                ! Starts scanning cycle.
70  FOR I=1 TO 64                      ! Starts count loop.
80          ENTER 722;A                ! Enters voltmeter reading into
                                       variable A.
90        PRINT A                      ! Prints reading in variable A.
100       TRIGGER 70915                ! Triggers the switchbox to
                                       advance the channel list.
110 NEXT I                             ! Increments count.
120 END
```

SCAN:MODE

[ROUTe:]SCAN:MODE <*mode*> sets the Form C switch channels defined by the [ROUTe:]SCAN <*channel_list*> command for "no measurements".

The SWITCH device driver for the E1442A also supports Form C switches which use this command to close appropriate tree relays for a specific kind of measurement (e.g., 2-wire and 4-wire ohms require different tree relay closures). For compatibility in use with the switchbox device driver, the E1442A accepts the SCAN:MODE command but it has no effect on Form C operation. It's important to note that the command erases the current SCAN list when executed.

NOTE This command erases the current SCAN channel list; SCAN:MODE must be followed by a [ROUTe:]SCAN command to re-establish a scan channel list.

Parameters

Parameter Name	Parameter Type	Range of Values
<*mode*>	discrete	NONE | VOLT

Comments

- **Order of Command Execution:** If used, [ROUTe:]SCAN:MODE must be executed before [ROUTe:]SCAN <*channel_list*> because SCAN:MODE erases the current SCAN list. Note: The SCAN:MODE command is not needed for Form C Switch operation.
- **Related Commands:** SCAN
- *RST **Condition:** [ROUTe:]SCAN:MODE NONE

SCAN:MODE?

[ROUTe:]SCAN:MODE? returns the current state of the scan mode. The command returns NONE or VOLT to indicate which mode the scan is set.

STATus

The STATus subsystem reports the bit values of the Operation Status Register (in the command module). It also allows you to unmask the bits you want reported from the Standard Event Register and to read the summary bits from the Status Byte Register.

Subsystem Syntax

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

Comments

The STATus system contains four software registers (that is, they reside in a SCPI driver, not in the hardware), two of which are under IEEE 488.2 control: the Standard Event Status Register (*ESE?) and the Status Byte Register (*STB?). The Operational Status bit (OPR), Service Request bit (RSQ), Standard Event summary bit (ESB), Message Available bit (MAV) and Questionable Data bit (QUE) in the Status Byte Register (bits 7, 6, 5, 4 and 3 respectively) can be queried with the *STB? command. Use the *ESE? command to query the *unmask* value for the Standard Event Status Register (the bits you want logically OR'd into the summary bit). The registers are queried using decimal weighted bit values. The decimal equivalents for bits 0 through 15 are shown below.

Bit #	15 (MSB)	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 (LSB)
Decimal Value	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

A numeric value of 256 executed in a STATus:OPERation:ENABle <*unmask*> command allows only bit 8 to generate a summary bit. The decimal value for bit 8 is 256.

The decimal values are also used in the inverse manner to determine which bits are set from the total value returned by an EVENt or CONDition query. The SWITCH driver exploits only bit 8 of Operation Status Register. This bit is called the Scan Complete bit which is set whenever a scan operation completes. Since completion of a scan operation is an event in time, you will find that bit 8 will never appear set when STAT:OPER:COND? is queried. However, you can find bit 8 set with the STAT:OPER:EVENt? query command.

:OPER:CONDition?

STATus:OPERation:CONDition? returns the state of the Condition Register in the Operation Status Group. The state represents conditions which are part of the instrument's operation. The SWITCH driver does not set bit 8 in this register (see STAT:OPER:EVENt?).

:OPERation:ENABle

STATus:OPERation:ENABle <*number*> sets an enable mask to allow events recorded in the Event Register to send a summary bit to the Status Byte Register (bit 7). For Form C switch modules, when bit 8 in the Operation Status Register is set to 1 and that bit is enabled by the OPER:ENABle command, bit 7 in the Status Register is set to 1.

Parameters

Parameter Name	Parameter Type	Range of Values
<*number*>	numeric	1 through 65535

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

Enable the Status Register

```
STAT:OPER:ENAB 256          ! Enables bit 8 of the Operation Status Register to be reported to bit OPR in the Status Register.
```

:OPERation:ENABle?

STATus:OPERation:ENABle? returns which bits in the Event Register (Operation Status Group) are unmasked.

:OPERation[:EVENt]?

STATus:OPERation[:EVENt]? returns which bits in the Event Register (Operation Status Group) are set. The Event Register indicates when there has been a time-related instrument event.

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. The command returns `+0` if bit 8 of the Operation Status Register is set to 0.
- **Event Register Cleared:** Reading the STATus:OPERation:EVENt register with the STATus:OPERation:EVENt? command clears it.
- **ABORting a Scan:** ABORting a scan will leave bit 8 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.
read the register value     ! +256 shows bit 8 is set to 1; +0 shows bit 8 is set to 0.
```

:PRESet

STATus:PRESet affects only the enable register by setting all enable register bits to 0. It does not affect either the "status byte" or the "standard event status". PRESet does not clear any of the event registers.

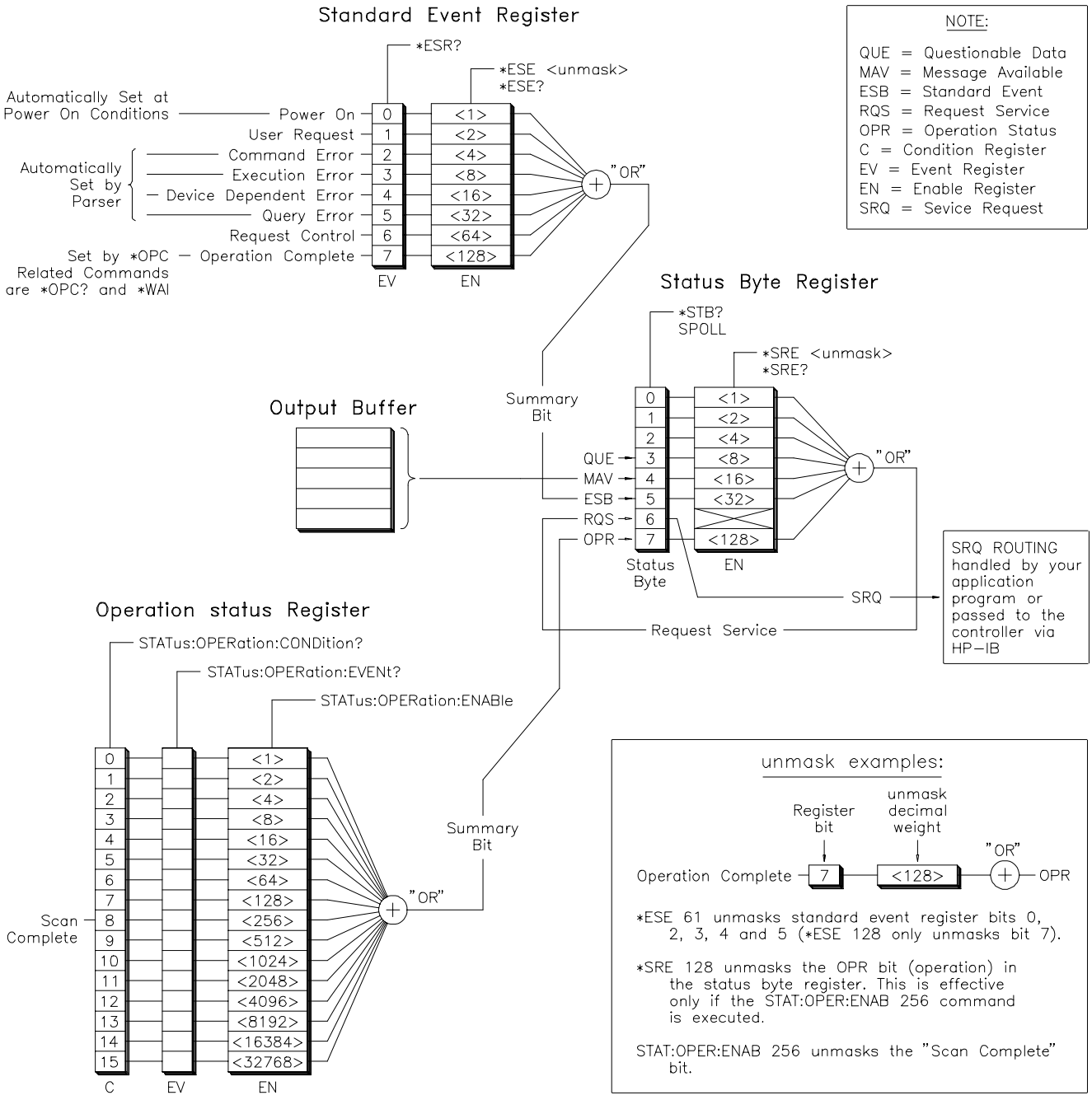


Figure 3-1. HP E1442A Status System Register Diagram

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
    :CDEScription? <number>
    :CTYPe? <number>
    :CPON <number>| ALL
    :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 through 99

Comments

- **Form C Switch Module Description:**
  The SYSTem:CDEScription?<*number*> command returns:

  ```
  64 Channel General Purpose Switch
  ```

  for the HP E1442A.

Example

Reading the Description of a Card #1 Module

```
SYST:CDES? 1                    ! Determine the description.
```

:CPON

SYSTem:CPON <*number*>|ALL opens all channels of a selected or all modules (cards) in a switchbox to their power-on state.

Parameters

Parameter Name	Parameter Type	Range of Values
<*number*>	numeric	1 through 99

Comments

- **Differences Between *RST and CPON:** SYSTem:CPON only opens all channels of a selected module or all modules in a switchbox. *RST opens all channels of all modules in a switchbox and also sets all other settings to their power-on states.

Example

Set All Channels on Module #1 to Power-on State

```
SYST:CPON 1                     ! Sets module #1 channels to
                                ! power-on state (open).
```

: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 through 99

Comments

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

  ```
  HEWLETT-PACKARD,E1442A,0,A.08.00
  ```

  Note: The four fields of the response are, 1) manufacturer, 2) model number, 3) serial number (always 0), and 4) SWITCH firmware revision.

Example

Reading the Model Number of a Card #1 Module

```
SYST:CTYP? 1                    ! Determine 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 the 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. Each error message can be up to 255 characters long but typically is much shorter.

- **Clearing the Error Queue:** An error number/message is removed from the queue each time the SYSTem:ERRor? query command is sent. The errors are cleared first-in, first-out. When the queue is empty, each following SYSTem:ERRor? query 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.
```

TRIGger

The TRIGger subsystem commands controls the triggering operation of the Form C switch modules in a switchbox.

Subsystem Syntax

```
TRIGger
    [:IMMediate]
    :SOURce <source>
    :SOURce?
```

[:IMMediate]

TRIGger[:IMMediate] causes a trigger to occur when the defined trigger source is TRIGger:SOURce HOLD or TRIGger:SOURce BUS. This can be used to trigger a suspended scan operation.

Comments

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

Example

Advancing Scan Using the TRIGger Command

```
TRIG:SOUR HOLD          ! Sets trigger source to hold.
SCAN   (@100:163)       ! Sets channel list.
INIT                    ! Starts scanning cycle.
loop statement          ! Starts count loop.
TRIG                    ! Advances channel list to next
                        channel.
increment loop          ! Increments count loop.
```

:SOURce

TRIGger:SOURce <*source*> specifies the trigger source to advance the scanning channel list.

Parameters

Parameter Name	Parameter Type	Description or Range of Values
BUS	discrete	*TRG command
EXTernal	discrete	Trig In port
HOLD	discrete	Hold triggering
ECLTrg*n*	numeric	*n* = 0 or 1
TTLTrg*n*	numeric	*n* = 0 thru 7
IMMediate	discrete	Immediate triggering

Comments

- **Enabling the Trigger Source:** The TRIGger:SOURce command only selects the trigger source. The INIT[:IMMediate] command enables the trigger source. The trigger source must be selected using the TRIGger:SOURce command before executing the INIT command.
- **One Trigger Input Selected at a Time:** Only one input (ECLTrg 0 or 1; TTLTrg 0, 1, 2, 3, 4, 5, 6 or 7; or EXTernal) can be selected at one time. Enabling a different trigger source will automatically disable the active input. For example, if TTLTrg1 is the active input, and TTLTrg4 is enabled, TTLTrg1 will become disabled and TTLTrg4 will become the active input.
- **Using the TRIG command:** You can use the TRIGger[:IMMediate] command 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 E1405/E1406 Command Module Trig In port.
- **Using TTL or ECL Trigger Bus Inputs:** These triggers are from the VXI backplane trigger lines ECL[0,1] and TTL[0-7]. These may be used to trigger the SWITCH driver from other VXI instruments.
- **Using EXTernal | TTLTrg*n* | ECLTrg*n* Trigger Inputs:** After using TRIGger:SOURce EXT | TTLT*n*| ECLT*n*, the selected trigger source remains assigned to the SWITCH driver until it is relinquished through use of the TRIG:SOUR BUS|HOLD command. While the trigger is in use by the SWITCH driver, no other drivers operating on the E1405/E1406 Command Module will have access to that particular trigger source. Likewise, other drivers may consume trigger resources which may deny access to a particular trigger by the SWITCH driver. You should always release custody of trigger sources after completion of an activity by setting the trigger source to BUS or HOLD (i.e. TRIG:SOUR BUS|HOLD).

- **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:** [ROUTe:]SCAN, TRIGger, ABORt
- ***RST Condition:** TRIGger:SOURce IMMediate

Example Scanning Using External Triggers

In the following example, the trigger input is applied to the HP E1405/E1406 Command Module Trig In port.

```
TRIG:SOUR EXT          ! Sets trigger source to external.
SCAN   (@100:163)      ! Sets channel list.
INIT                   ! Starts scanning cycle.
(trigger externally)   ! Advances channel list to next
                       channel.
```

Scanning Using Bus Triggers

```
TRIG:SOUR BUS          ! Sets trigger source to bus.
SCAN   (@100:163)      ! Sets channel list.
INIT                   ! Starts scanning cycle.
*TRG                   ! Advances channel list to next
                       channel.
```

:SOURce?

TRIGger:SOURce? returns the current trigger source for the switchbox. Command returns either BUS, EXT, HOLD, TTLT0-7, ECLT0-1 or IMM for trigger sources BUS, EXTernal, HOLD, TTL Trigger, ECL Trigger or IMMediate, respectively.

Example Query Trigger Source

```
TRIG:SOUR EXT          ! Sets trigger source to external.
TRIG:SOUR?             ! Queries trigger source; returns
                       EXT.
```

SCPI Command Quick Reference

The following table summarizes the SCPI commands for the HP E1442A 64-Channel Form C Switch Module used in a switchbox.

Command		Description
ABORt		Aborts a scan in progress.
ARM	:COUNt <*number*> MIN |MAX :COUNt? [MIN|MAX]	Multiple scans per INIT command. Queries number of scans.
DISPlay	:MONitor:CARD <*number*>|AUTO :MONitor:CARD? :MONitor[:STATe] ON|OFF|1|0 :MONitor[:STATe]?	Selects module to be monitored. Queries the card number. Selects monitor mode. Queries the monitor mode.
INITiate	:CONTinuous ON|OFF :CONTinuous? [:IMMediate]	Enables/disables continuous scanning. Queries continuous scan state Starts a scanning cycle.
OUTPut	:ECLTrg*n*[:STATe] ON|OFF|1|0 :ECLTrg*n*[:STATe]? [:EXTernal][:STATe] ON|OFF|1|0 [:EXTernal][:STATe]? :TTLTrg*n*[:STATe] ON|OFF|1|0 :TTLTrg*n*[:STATe]?	Enables/disables the specified ECL trigger line. Queries the specified ECL trigger line. Enables/disables the Trig Out port on the HP E1405/E1406. Queries the external state. Enables/disables the specified TTL trigger line. Queries the specified TTL trigger line.
[ROUTe:]	CLOSe <*channel_list*> CLOSe? <*channel_list*> OPEN <*channel_list*> OPEN? <*channel_list*> SCAN <*channel_list*> SCAN:MODE NONE|VOLT SCAN:MODE?	Closes channel(s). Queries channel(s) closed. Opens channel(s). Queries channel(s) opened. Defines channels for scanning. Sets scan mode (has no effect on Form C operation). Queries the scan mode.
STATus	:OPERation:CONDition? :OPERation:ENABle :OPERation:ENABle? :OPERation[:EVENt]? :PRESet	Returns contents of the Operation Condition Register. Enables events in the Operation Event Register to be reported. Returns the mask value set by the :ENABle command. Returns the contents of the Operation Event Register. Sets Enable Register bits to 0.
SYSTem	:CDEScription? <*number*> :CTYPe? <*number*> :CPON <*number*>|ALL :ERRor?	Returns description of module in a switchbox. Returns the module type. Opens all channels on specified module(s). Returns error number/message in a switchbox Error Queue.
TRIGger	[:IMMediate] :SOURce BUS :SOURce EXTernal :SOURce HOLD :SOURce IMMediate :SOURce:ECLTrg*n* :SOURce:TTLTrg*n* :SOURce?	Causes a trigger to occur. Trigger source is *TRG. Trigger source is Trig In (on the HP E1405 or E1406). Holds off triggering. Trigger source is the internal triggers. Trigger is the VXIbus ECL trigger bus line *n*. Trigger is the VXIbus TTL trigger bus line *n*. Queries scan trigger source.

IEEE 488.2 Common Command Reference

The following table lists the IEEE 488.2 Common (*) commands accepted by the HP E1442A 64-Channel Form C Switch Module. The operation of some of these commands is described in Chapter 2 of this manual. For more information on Common commands, refer to the user's manual for your HP E1400/E1401 Mainframe, or the *ANSI/IEEE Standard 488.2-1987*.

Command	Command Description
*CLS	Clears all status registers (see STATus:OPERation[:EVENt]?) and clears the error queue.
*ESE<*unmask*>	Enable Standard Event.
*ESE?	Enable Standard Event Query.
*ESR?	Standard Event Register Query.
*IDN?	Instrument ID Query; returns identification string of the module.
*OPC	Operation Complete.
*OPC?	Operation Complete Query.
*RCL<*n*>	Recalls the instrument state saved by *SAV. You must reconfigure the scan list.
*RST	Resets the module. Opens all channels and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF.
*SAV<*n*>	Stores the instrument state **but does not** save the scan list.
*SRE<*unmask*>	Service request enable, enables status register bits.
*SRE?	Service request enable query.
*STB?	Read status byte query.
*TRG	Triggers the module to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS.
*TST?	Self-test. Executes an internal self-test and returns only the first error encountered. Does not return multiple errors. The following is a list of responses you can obtain where "cc" is the card number with the leading zero deleted. `+0` if self test passes. `+cc01` for firmware error. `+cc02` for bus error (problem communicating with the module). `+cc03` for incorrect ID information read back from the module's ID register. `+cc10` if an interrupt was expected but not received. `+cc11` if the busy bit was not held for a sufficient amount of time.
*WAI	Wait to Complete.

NOTE These commands apply to many instruments. See the user's manual for your HP E1400/E1401 Mainframe, or the *ANSI/IEEE Standard 488.2-1987* for more information about these commands. The common commands *RCL, *SAV and *TST? do specific actions with the HP E1442A and are described in the above table in "Command Description".

Appendix A
HP E1442A Form C Switch Specifications

Maximum Input Voltage:

High to Low	Any terminal to chassis
150VDC	150VDC
150VAC RMS	150VAC RMS
210VAC Peak	210VAC Peak

(Maximum with internal jumpers installed or use of option 010 terminal module):

High to Low	Any terminal to chassis
60VDC	60VDC
30VAC RMS	30VAC RMS
42VAC Peak	42VAC Peak

Maximum Current (per switch):
lA DC or lA AC RMS

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

Thermal Offset: <70 μV per channel

Closed Channel Resistance:
<1.5Ω typical
<3.5Ω at end of relay life

Insulation Resistance:
(between any two points):
$>10^7\Omega$ at 40°C, 65% RH
$>10^8\Omega$ at 25°C, 40% RH

Bandwidth: -3dB at 10 MHz

Crosstalk, Channel to Channel:
<100 kHz: <-70dB
<10 MHz: <-30dB

Capacitance:
Common to NO or NC: <40pF
Channel to Channel: <30pF

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

Power Up/Down States: All Open

Typical Time to Open/Close a Channel: 13mS

Module Size/Device Type: C, register based

Installation Category: IC 1

Connectors Used: Pl and P2

Number of Slots: 1

VXIbus Interface Capability: Interrupter, D16

Interrupt Level: 1-7, selectable

Power Requirements:

Peak Module Current		
Voltage:	+5V	+12V
IPM:	0.10A	0.24A
Dynamic Module Current		
Voltage:	+5V	+12V
IDM:	0.11A	0.01A

Watts/Slot: 1.0

Maximum Transient Voltage: 1300V

Operating Temperature: 0° to 55°C

Storage Temperature: -40° to 75°C

Operating Humidity: 40°C and`95% RH

Operating Location: Intended for indoor use only

IEC Pollution Degree 2 (Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected. See page 74.)

Definition of Terms:

Pollution: Any addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity.

Pollution Degree: For the purpose of evaluating CLEARANCES, Pollution Degree 1 and Pollution Degree 2 are recognized for use in the micro-environment.

Pollution Degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

Pollution Degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

Clearance: The shortest distance in air between two conductive parts.

Appendix B
HP E1442A Form C Switch Register Programming & Definitions

About This Appendix

This appendix contains the information you need for register-based programming. The contents include:

Register Programming vs. SCPI Programming

The HP E1442A 64-Channel Form C Switch Module is a register-based module which does not support the VXIbus word serial protocol. When a SCPI command is sent to the Form C switch, the HP E1406A Command Module parses the command and programs the switch at the register level.

NOTE If SCPI is used to control this module, then register programming is not recommended. The SCPI Driver maintains an image of the card state. The driver will be unaware of changes to the card state if you alter the card state by using register writes.

Register-based programming is a series of **reads** and **writes** directly to the Form C switch registers. This increases throughput speed since it eliminates command parsing and allows the use of an embedded controller. Also, if slot 0, the resource manager, and the computer (HP-IB) interface are provided by other devices, a C-size system can be downsized by removing the command module.

Addressing the Registers

Register addresses for register-based devices are located in the upper 25% of VXI A16 address space. Every VXI device (up to 256 devices) is allocated a 32-word (64-byte) block of addresses. With seven registers, the HP E1442A Form C Switch Module uses seven of the 64 addresses allocated.

The Base Address

When you are reading or writing to a switch register, a hexadecimal or decimal register address is specified. This address consists of a base address plus a register offset.

The base address used in register-based programming depends on whether the A16 address space is outside or inside the HP E1406A Command Module.

A16 Address Space Outside the Command Module

When the HP E1406A Command Module is not part of your VXIbus system (Figure B-1), the switch's base address is computed as:

$C000_{16} + (LADDR * 64)_{16}$ *or* $49{,}152 + (LADDR * 64)$

where $C000_{16}$ (49,152) is the starting location of the register addresses, LADDR is the switch's logical address, and 64 is the number of address bytes per VXI device. For example, the switch's factory-set logical address is 120 (78_{16}). If this address is not changed, the switch will have a base address of:

$C000_{16} + (120 * 64)_{16} = C000_{16} + 1E00_{16} =$ **$DE00_{16}$**

or (decimal)

$49{,}152 + (120 * 64) = 49{,}152 + 7680 =$ **56,832**

A16 Address Space Inside the Command Module or Mainframe

When the A16 address space is inside the HP E1406A Command Module (Figure B-2), the switch's base address is computed as:

$1FC000_{16} + (LADDR * 64)_{16}$ *or* $2{,}080{,}768 + (LADDR * 64)$

where $1FC000_{16}$ (2,080,768) is the starting location of the VXI A16 addresses, LADDR is the switch's logical address, and 64 is the number of address bytes per register-based device. Again, the switch's factory-set logical address is 120. If this address is not changed, the switch module will have a base address of:

$1FC000_{16} + (120 * 64)_{16} = 1FC000_{16} + 1E00_{16} =$ **$1FDE00_{16}$**

or

$2{,}080{,}768 + (120 * 64) = 2{,}080{,}768 + 7680 =$ **2,088,448**

Figure B-1 shows the register address location within A16 as it might be mapped by an embedded controller. Figure B-2 shows the location of A16 address space in the HP E1405A/B and E1406A Command Modules.

Register Offset

The register offset is the register's location in the block of 64 address bytes. For example, the switch's Status/Control Register has an offset of 04_{16}. When you write a command to this register, the offset is added to the base address to form the register address:

$DE00_{16} + 04_{16} =$ **$DE04_{16}$**
$1FDE00_{16} + 04_{16} =$ **$1FDE04_{16}$**

or

56,832 + 4 = **56,836**
2,088,448 + 4 = **2,088,452**

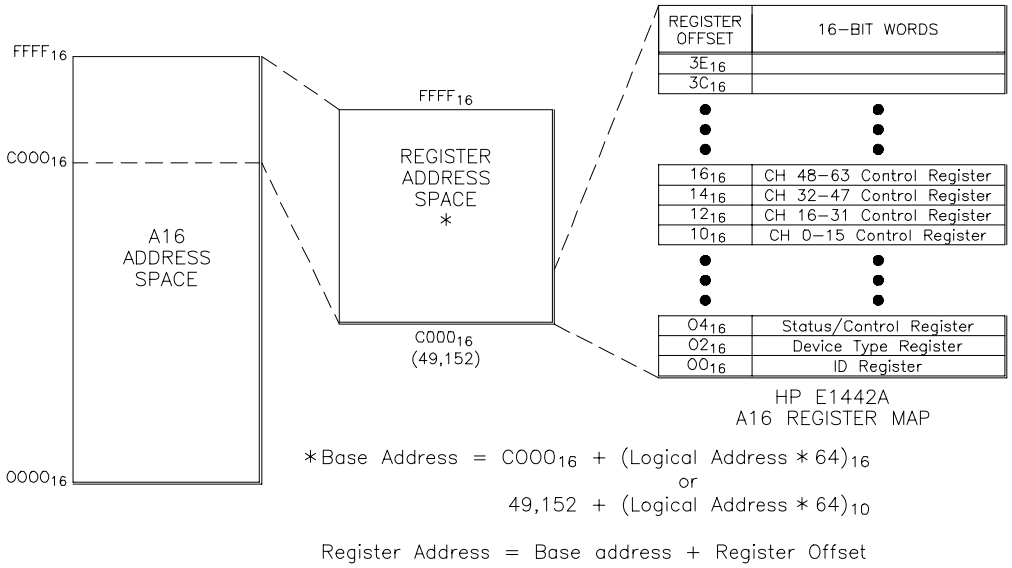


Figure B-1. Register within A16 Address Space

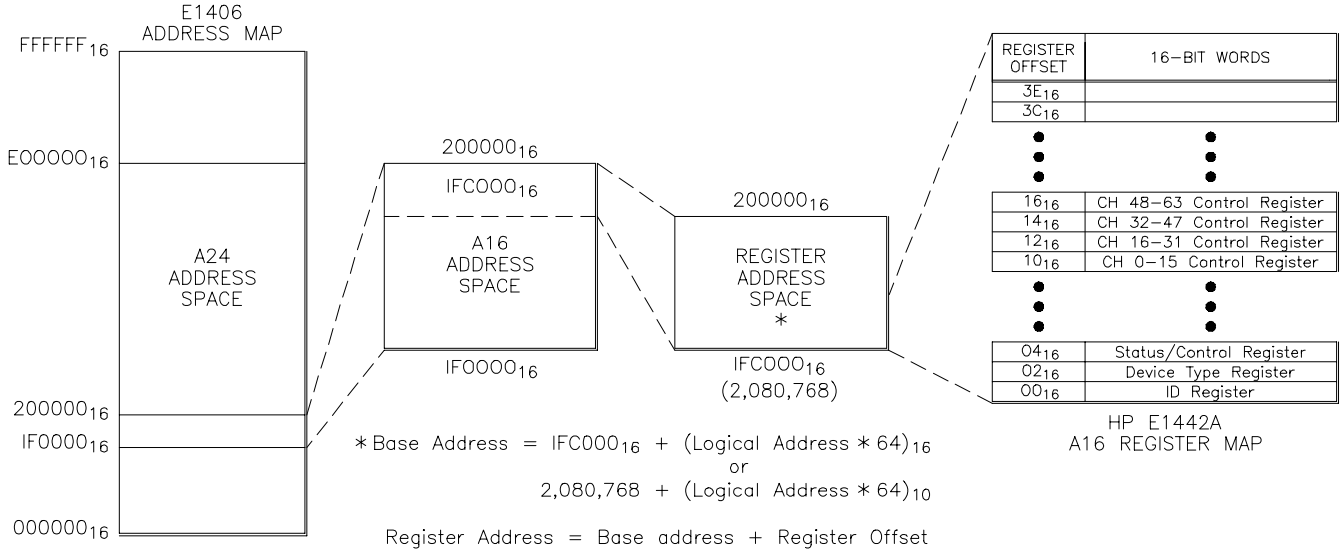


Figure B-2. Registers within the HP E1406 A16 Address Space

Register-Based Programming the HP E1442A

The HP E1442A Form C Switch Module is a register-based slave device. There are 64 independent switches on the card which are controlled using the Switch Control Registers. There are four register types on this module:

- ID Register - Identifies Hewlett-Packard as the manufacturer, and that the card is an A16 register-based device.
- Device Type Register - Identifies card as an HP E1442A.
- Status/Control Register - When read from, it is used to return device- specific status information. When written to, it is used to set control bits.
- Switch Enable Registers - These four registers control the state of the Form C switches on the module (e.g. close or open the switch).

The register definitions are listed later in this chapter.

Reading or Writing to HP E1442A Registers

To read or write to specific registers you must address a particular register within a module. The registers within a module are located using a fixed offset. The module address is based on the module's logical address. There are two basic ways of accessing registers. One method uses the logical address directly to access a particular card using VXI:READ and VXI:WRITE commands through a command module. The other method can be used with an embedded controller that locates A16 data space within its memory map. The memory mapping allows registers to be directly read or written with moves to/from memory.

The factory setting of the logical address switch is 120 (78_{16}). This value is used in the following examples.

Register Access with Logical Address (Command Module)

When using the HP El405 or E1406 Command Module to access registers via VXI:READ and VXI:WRITE commands, the logical address is used to determine which VXI module is being accessed.

Note Refer to the HP El405/E1406 Command Module documentation for use of the VXI:READ and VXI:WRITE commands and other related commands.

The following commands are sent to the HP El406 Command Module via the HP-IB. The example below shows a portion of an HP BASIC program. The controller could either be external or embedded in the VXI mainframe. This example shows the Status/Control Register being accessed.

```
! Writes FFFF hex to Control Register
OUTPUT 70900; "VXI:WRITE 120, 4, #HFFFF"

! Reads from Status Register
OUTPUT 70900;"VXI:READ 120,4 "
ENTER 70900; Status
```

Register Access with Memory Mapping (Embedded Controller)

When using an embedded controller, VXI A16 address space is usually mapped to some block of memory within the controller's addressable memory space.

Note

Refer to the manual for the specific embedded controller that you are using to determine where VXI Al6 is mapped. There may be other methods of accessing the VXI backplane. What is shown here is the method in which Al6 addresses are calculated for a module.

For example, for the HP 75000 Series C Mainframe with an HP El405/E1406 Command Module, VXI Al6 address space starts at $lF0000_{16}$. In the HP El405/E1406 Command Module, the Al6 space is divided so modules are addressed only at locations beginning with $C000_{16}$ within Al6. 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 on the module:

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

For the Form C switch, the factory-set logical address is 120 (78_{16}), so to address the Status/Control Register of a Form C switch using the HP El405 Command Module:

$$\text{base address} = (78_{16})*(40_{16}) + C000_{16} = DE00_{16}$$

$$\text{register address} = [\text{A16 location}]_{16} + [\text{base address}]_{16} + [\text{register offset}]_{16}$$
$$\text{register address} = 1F0000_{16} + DE00_{16} + 04_{16} = 1FDE04_{16}$$

Reading the HP E1442A 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})
- Switch Enable Register for channels 0 - 15 (base + 10_{16})
- Switch Enable Register for channels 16 - 31 (base + 12_{16})
- Switch Enable Register for channels 32 - 47 (base + 14_{16})
- Switch Enable Register for channels 48 - 63 (base + 16_{16})

ID Register

For the Form C switch, a read of the ID Register (base address + 00_{16}) returns $\texttt{FFFF}_{16}$ since the switches are manufactured by Hewlett-Packard and are A16 only, register-based devices. The Device Type Register (base + 02_{16}) returns $\texttt{0228}_{16}$.

Device Type Register

For the Form C switch, a read of the Device Type Register (base address + 02_{16}) returns $\texttt{0228}_{16}$. This indicates it is a model HP E1442A.

Status/Control Register

Each relay requires about 13 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 a `1` in bit 7 when the module is not busy or returns a `0` in bit 7 when the module is busy.

An interrupt is generated after any of the Switch Enable Registers are written. Bit 6 of the Status Register is used to enable/disable interrupts from the card. If bit 6 is returned as a `0`, interrupts are enabled. If bit 6 is returned as a `1`, interrupts are disabled.

Bit 14 is the MODID bit. When a `0` is returned in bit 14, the module has been selected with a high state on the P2 MODID line (this occurs during turn-on). If a `1` is returned, the module has not been selected.

Switch Enable Register

A read of any of the Switch Enable Registers always returns $\texttt{FFFF}_{16}$, regardless of the channel states.

Writing to HP E1442A Registers

You can write to the following Form C switch registers:

- Status/Control Register (base + 04_{16})
- Switch Enable Register for channels 0 - 15 (base + 10_{16})
- Switch Enable Register for channels 16 - 31 (base + 12_{16})
- Switch Enable Register for channels 32 - 47 (base + 14_{16})
- Switch Enable Register for channels 48 - 63 (base + 16_{16})

Status/Control Register

Writing a 1 to bit 0 of the Status/Control Register (base + 04_{16}) to reset the switch module (all channels open). Resetting the module enables interrupts.

Note

It is necessary to write a 0 to bit 0 after the reset has been performed before any other commands can be programmed and executed.

To disable the interrupt generated when channels are opened/closed, write a 1 to bit 6 of the Status/Control Register.

Note

Typically, interrupts are disabled when doing register-level access to a module. Refer to the operating manual of the command module or the embedded controller being used in order to handle interrupts. Interrupts are re-enabled after a reset.

Bit 12 provides status on fuse F4. This is a user-installed component required to provide the +5V pullup voltage to the module's internal bus for the NC and NO contacts. A 0 indicates the fuse is not installed (or the fuse is blown if installed); a 1 indicates you previously installed the fuse and it is good.

Switch Enable Registers

Writes to the Switch Enable Registers (base + 10_{16} through base + 16_{16}) enable you to open or close the desired channel. For example, write a 1 to bit 2 of the Switch Enable Register (base + 10_{16}) to close channel 02. Or, write a 0 to bit 15 of the register at base + 16_{16} to open channel 63.

Note

All relays are non-latching and will open during a power-down.

A switch is open when contact is made between the normally closed (NC) contact and common (C). It is closed when contact is made between the normally open (NO) contact and common (C). Any combination of open or closed states is allowed at one time for all channels on the module.

Write a "1" to the register bit to close the relay.

Write a "0" to the register bit to open the relay.

Register Definitions

Manufacturer ID Register (a read only register)

Address b + 00_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	Manufacturer ID; Returns FFFFh = Hewlett-Packard A16 only register-based device.															

Device Type Register (a read only register)

Address b + 02_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Read	Returns 0228_{16} for the E1442A module.															

Status/Control Register

Address b + 04_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Undefined									D	Undefined					R
Read**	Un-def	M	Un-def	S1	Undefined				B	D	Undefined					R

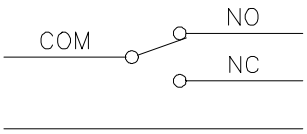
The following two tables describe Status/Control Register bits:

***WRITE BITS (Status/Control Register)**		
bit 0	R	Writing a 1 to this bit resets the switch to the power-on state (all channels open). To reset, you must keep this bit set to 1 for a minimum of 100 ms and then you must set bit 0 back to a logical 0 to allow switches to be closed.
bit 6	D	Disable interrupt by writing a 1 to this bit (this is set back to 0 with a reset).

****READ BITS (Status/Control Register)**		
bit 0	R	A 1 at this bit resets the switch to the power-on state (all channels open). You must set bit 0 back to a logical 0 to allow switches to be closed.
bit 6	D	Interrupt Status; 1 = disabled, 0 = enabled.
bit 7	B	Busy Status; 1 = not busy, 0 = busy.
bit 12	S1	Fuse F4 Status; 0 = fuse F4 not installed (factory shipped without fuse). (A 0 can indicate a blown fuse after installing fuse F4.) 1 = fuse F4 is installed (user must install fuse). Fuse F4 provides +5V pull-up voltage for the NC and NO switch contacts by use of the module's internal bus (see figures 1-7 and 1-8).
bit 14	M	MODID bit; if the bit is 0, module has been selected during turn-on. Normally this bit is 1 when not in the turn-on cycle.

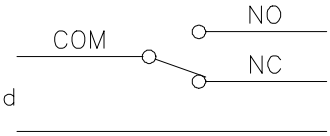
Switch Enable Registers

You write to the switch enable registers to close (or open) a channel.



Relay position after "CLOSE" command

Write a "1" to the register bit to close the relay.



Relay position after "OPEN" command

Write a "0" to the register bit to open the relay.

**Reading any Switch Enable Register will always return $FFFF_{16}$ regardless of the channel states.

Switch Enable Register (Channels 0 - 15)

Address b + 10_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Ch15	Ch14	Ch13	Ch12	Ch11	Ch10	Ch09	Ch08	Ch07	Ch06	Ch05	Ch04	Ch03	Ch02	Ch01	Ch00
Read**	Always returns $FFFF_{16}$															

Switch Enable Register (Channels 16 - 31)

Address b + 12_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Ch31	Ch30	Ch29	Ch28	Ch27	Ch26	Ch25	Ch24	Ch23	Ch22	Ch21	Ch20	Ch19	Ch18	Ch17	Ch16
Read**	Always returns $FFFF_{16}$															

Switch Enable Register (Channels 32 - 47)

Address b +14_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Ch47	Ch46	Ch45	Ch44	Ch43	Ch42	Ch41	Ch40	Ch39	Ch38	Ch37	Ch36	Ch35	Ch34	Ch33	Ch32
Read**	Always returns $FFFF_{16}$															

Switch Enable Register (Channels 48 - 63)

Address b +16_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Ch63	Ch62	Ch61	Ch60	Ch59	Ch58	Ch57	Ch56	Ch55	Ch54	Ch53	Ch52	Ch51	Ch50	Ch49	Ch48
Read**	Always returns $FFFF_{16}$															

Programming Examples

Beginning of Program

```
/* This program resets the HP E1442A, closes channels and reads the*/
/* switch's relay control registers, opens channels and scans all 64*/
/* channels on the module.                                          */

#include <sicl.h>
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <dos.h>

/* function prototypes */
void reset_sw(char *base_addr);
void delay (unsigned milliseconds);
```

Program Main

```
void main(void)
{
    double ldexp(double i, int exp);
    char *base_addr;
    int j, k;
    unsigned short chan_0_15_reg, chan_16_31_reg;     /* First 32 channels  */
    unsigned short chan_32_47_reg, chan_48_63_reg;    /* Second 32 channels */
    unsigned short id_reg, dt_reg;                    /* ID and device type */
    unsigned short stat_reg;                          /* Status Register */
    /* create and open a device session */
      INST e1442a;
      e1442a = iopen("vxi,120");

    /* map the E1442A registers into user memory space */
      base_addr = imap(e1442a, I_MAP_VXIDEV, 0, 1, NULL);

    /* clear the user screen */
      clrscr();

    /* reset the E1442A */
      reset_sw(base_addr);
```

Read ID and Device Type Registers

```
/********** read the switch's ID and Device Type registers **********/

      id_reg = iwpeek((unsigned short *)(base_addr + 0x00));
      dt_reg = iwpeek((unsigned short *)(base_addr + 0x02));
      printf("ID register = 0x%4X\nDevice Type register = 0x%4X\n",
      id_reg, dt_reg);
```

Read Status Register

```
/********** read the switch's Status Register *********/

   stat_reg = iwpeek((unsigned short *)(base_addr + 0x04));
   printf("Status register = 0x%4X\n", stat_reg);
```

Close and Open Channels

```
/********** close and open channels **********/

/* set all bits in register for channels 0-15 (offset 10) to 1 */
   iwpoke((unsigned short *)(base_addr + 0x10), 0xffff);

/* read the E1442A relay control registers and print their value*/
/* NOTE: relay control registers always return FFFF (hex)     */

   chan_0_15_reg = iwpeek((unsigned short *)(base_addr + 0x10));
   chan_16_31_reg = iwpeek((unsigned short *)(base_addr + 0x12));
   chan_32_47_reg = iwpeek((unsigned short *)(base_addr + 0x14));
   chan_48_63_reg = iwpeek((unsigned short *)(base_addr + 0x16));

   printf("Channels 00-15 register = 0x%4X\n", chan_0_15_reg);
   printf("Channels 16-31 register = 0x%4X\n", chan_16_31_reg);
   printf("Channels 32-47 register = 0x%4X\n", chan_32_47_reg);
   printf("Channels 48-63 register = 0x%4X\n", chan_48_63_reg);

   delay (100);    /* wait 100 milliseconds before resetting module */

 /* reset the E1442A to open all closed channels */
 /* NOTE: writing a 0 to the channels registers will also open channels */
   reset_sw(base_addr);
```

Scan Channels

```
/********** scanning channels **********/

/* scan channels 0-15 (register offset 10) */
   for (k=0; k15; k++)
   {
     iwpoke ((unsigned short *)(base_addr + 0x10), ldexp(1,k));
     delay (50);   /* delay to allow mechanical relays to close*/
   }
/* sets all bits to 0 to open last closed channel */
   iwpoke ((unsigned short *)(base_addr + 0x10), 0);

/* scan channels 16-31 (register offset 12) */
   for (k=0; k15; k++)
   {
   iwpoke ((unsigned short *)(base_addr + 0x12), ldexp(1,k));
   delay (50);
   }
/* sets all bits to 0 to open last closed channel */
   iwpoke ((unsigned short *)(base_addr + 0x12), 0);
```

```
    /* scan channels 32-47 (register offset 14) */
       for (k=0; k15; k++)
       {
         iwpoke ((unsigned short *)(base_addr + 0x14), ldexp(1,k));
         delay (50);
       }
    /* sets all bits to 0 to open last closed channel */
       iwpoke ((unsigned short *)(base_addr + 0x14), 0);

    /* scan channels 48-63 (register offset 16) */
       for (k=0; k15; k++)
       {
         iwpoke ((unsigned short *)(base_addr + 0x16), ldexp(1,k));
         delay (50);
       }
    /* sets all bits to 0 to open last closed channel */
       iwpoke ((unsigned short *)(base_addr + 0x16), 0);

    /* close session */
       iclose(e1442a);

}   /* end of main */
```

Reset Function

```
/*********************************************************/
void reset_sw(char *base_addr)
    /* reset the module; open all relays (write a 1 to status bit 0)  */
    /* delay 100 ms for reset then set bit to 0 to allow closing of  */
    /* switches                                                      */
 {
    /* this function resets the switch module */
       iwpoke((unsigned short *)(base_addr + 0x04), 1);
       delay (100);
       iwpoke((unsigned short *)(base_addr + 0x04), 0); }
 }
```

Appendix C
HP E1442A Form C Switch Error Messages

Error Types

Errors with negative values are governed by the SCPI standard and are categorized in the table below.

Categories of SCPI Errors

-199 to -100	Command Errors (syntax and parameter errors). See HP E1405/E1406 Command Module user's manual for description of these errors.
-299 to -200	Execution Errors (instrument driver detected errors). See following table for these values (also, see HP E1405/E1406 Command Module user's manual for further details).
-399 to -300	Device Specific Errors (instrument driver errors that are not command nor execution errors). See following table for these values (also, see HP E1405/E1406 Command Module user's manual for further details).
-499 to -400	Query Errors (problem in querying an instrument). See HP E1405/E1406 Command Module user's manual for description of these errors.

The table on the following page lists all the error messages that can be generated by the HP E1442A Form C Switch Module. Error numbers with positive values are not governed by the SCPI standard.

Form C Switch Error Messages

Code	Error Message	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.
-222	Data out of range	Parameter value is outside valid range.
-224	Illegal parameter value	Attempting to execute a command with a parameter not applicable to the command.
-240	Hardware error	Command failed due to hardware problem.
-310	System error	Internal driver error. This error can result if an excessively long parameter list is entered.
1500	External trigger source already allocate	Assigning an external trigger source to a switchbox when the trigger source has already been assigned to another switchbox.
1510	Trigger source non-existent	Selected trigger source is not available on this platform (e.g. some triggers are not available on the E1300/E1301 VXI B-size mainframes).
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.
2010	Scan mode not allowed on this card	The selected scanning mode is not allowed with this module or you have misspelled the mode parameter (see SCAN:MODE command).
2011	Empty channel list	No valid channels are specified in the <*channel_list*>.
2012	Invalid Channel Range	Invalid channel(s) specified in SCAN <*channel_list*> command. Attempting to begin scanning when no valid channel list is defined.
2017	Config error 17, Slot 0 functions disabled	Attempt to run a downloaded scan list with ARM:COUNt set to a value other than 1. Applies to HP FET switches only.
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.

About This Appendix

This appendix documents the HP E1442A Option 010 Terminal Module. With this terminal module the user can easily add components to configure a variety of passive signal conditioning circuits including pullups, pulldowns, and both single-ended and differential resistive dividers and filters. The user connects to the module by soldering wires or components to the terminal module PC board.

Figure D-1 is an overview of channels 0 and 1 and all associated component and voltage connections (resistors, capacitors, jumpers and voltages). Note the correlation of R0/C0 and R1/C1 with channels 0 and 1 respectively (also the associated voltage node V0-7 and user-supplied resistor SIP).

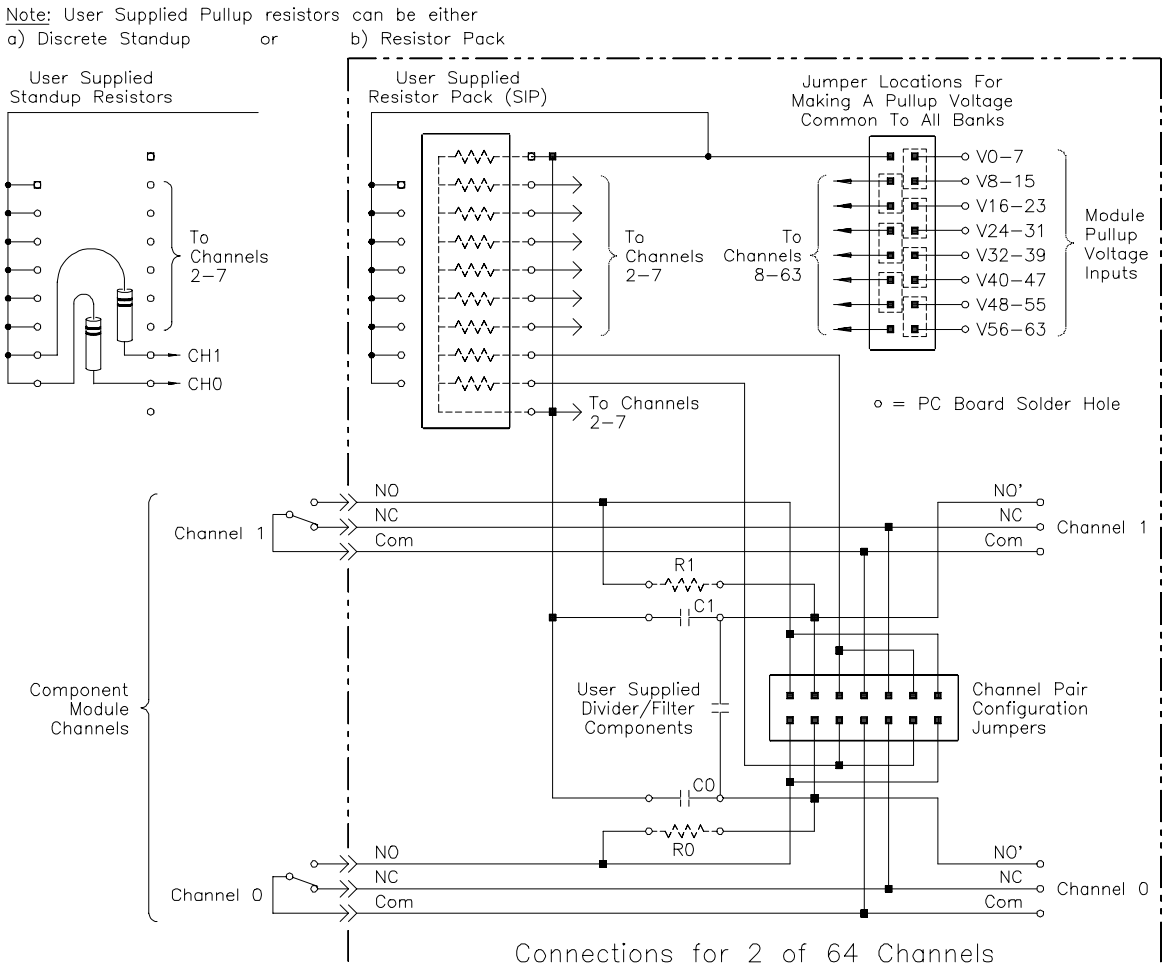
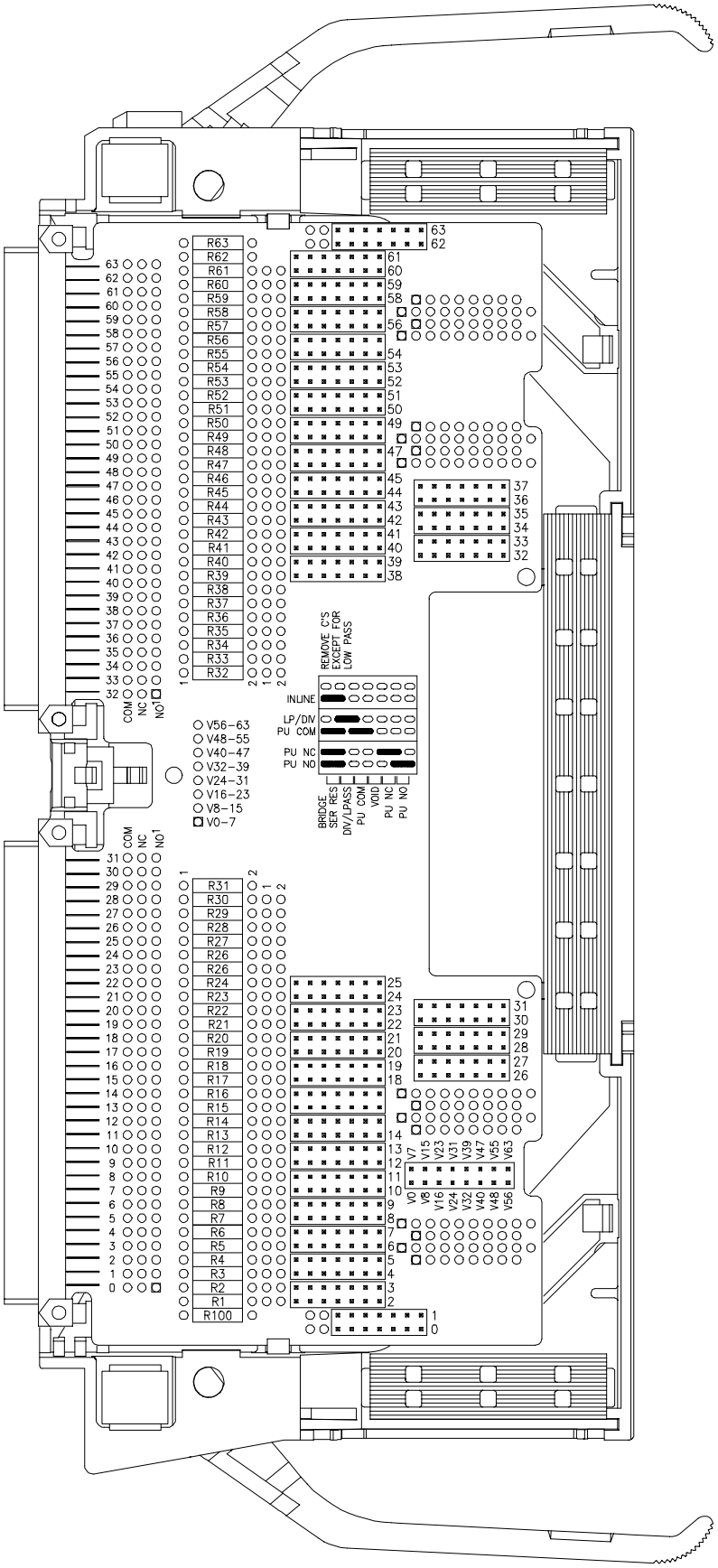


Figure D-1. Option 010 Terminal Module User Connections

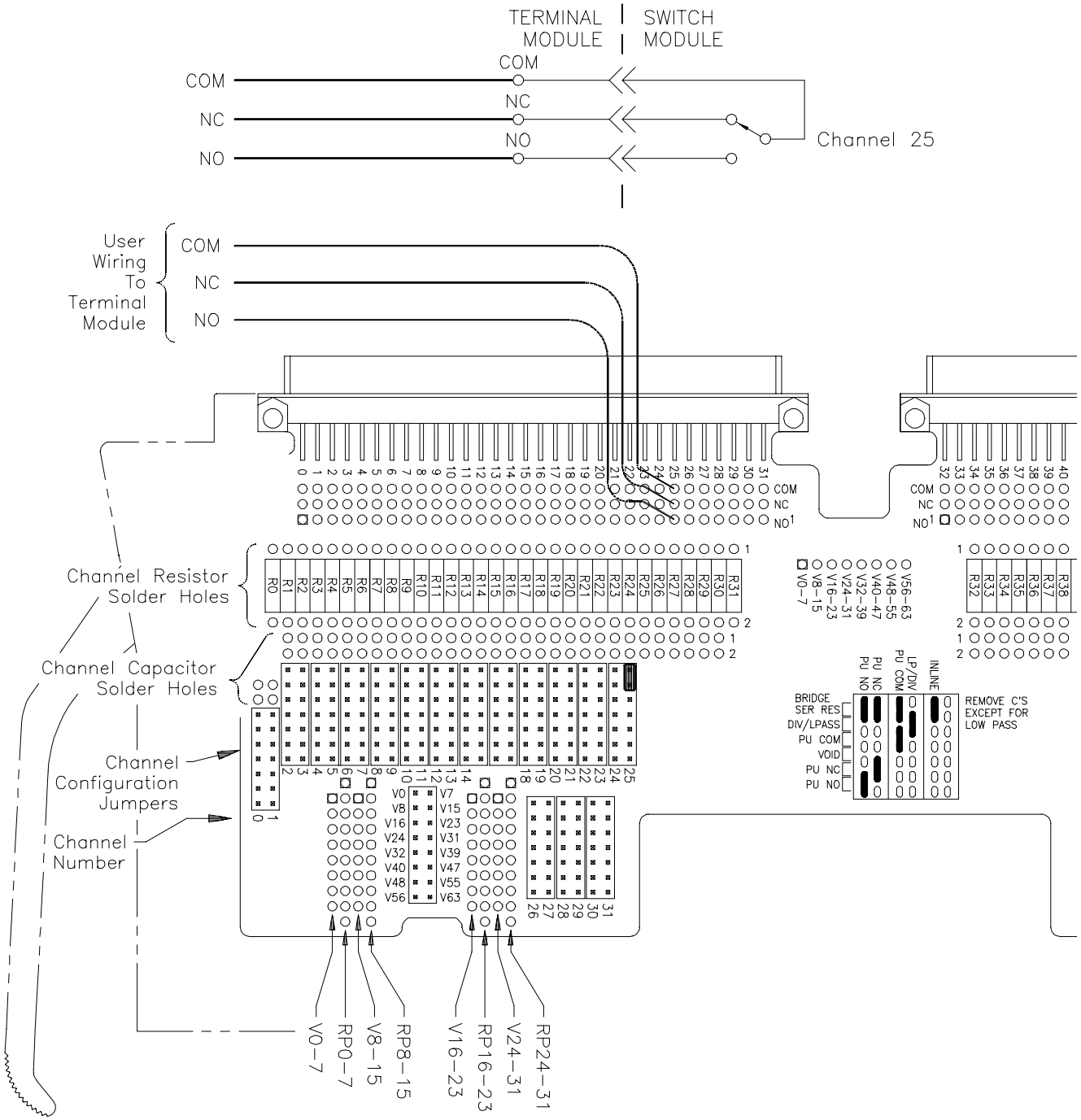
Figure D-2. HP E1442A Option 010 Terminal Module



Straight-Through Configuration Example

Any channel of the terminal module can be configured as a straight-through Form C relay. In this mode no resistors or capacitors are included. A two-position jumper is placed on the mode selection jumper.

Figure D-3. No components are added.
Set one configuration jumper as illustrated below (INLINE).

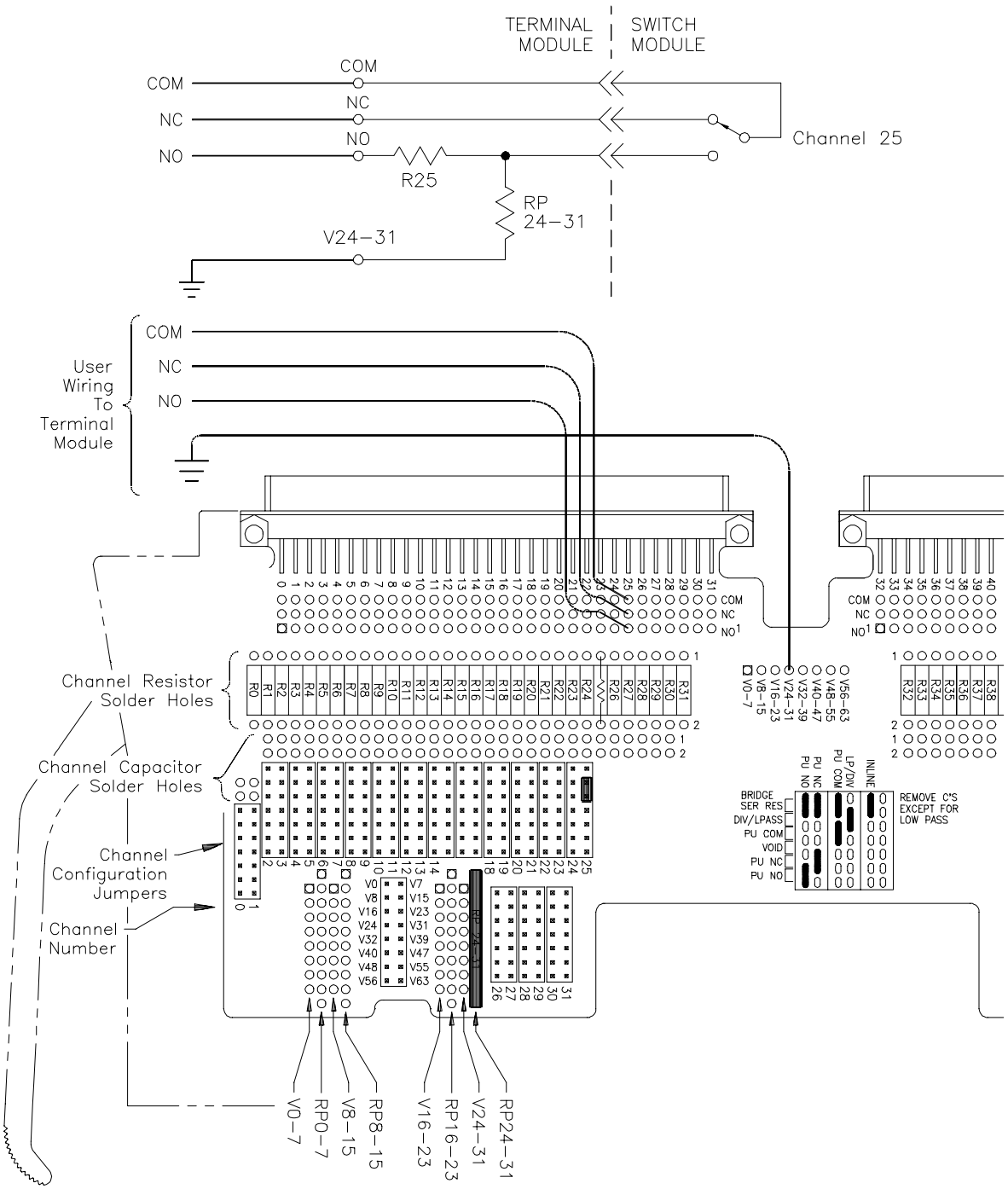


User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

Resistor Divider Configuration Example

Any channel can be configured as a resistor divider connected to the normally open contact of the Form C relay. The user-supplied SIP resistor can be replaced by a standing resistor with it inserted in the solder hole of the SIP and a solder hole directly across from it. The row of solder holes is connected to V24-31. The example below shows the voltage solder holes and identifies the voltage the row is connected to.

Figure D-4. Components to be added: Resistor R25 and SIP resistor pack RP24-31. Set one configuration jumper as illustrated below (LP/DIV).

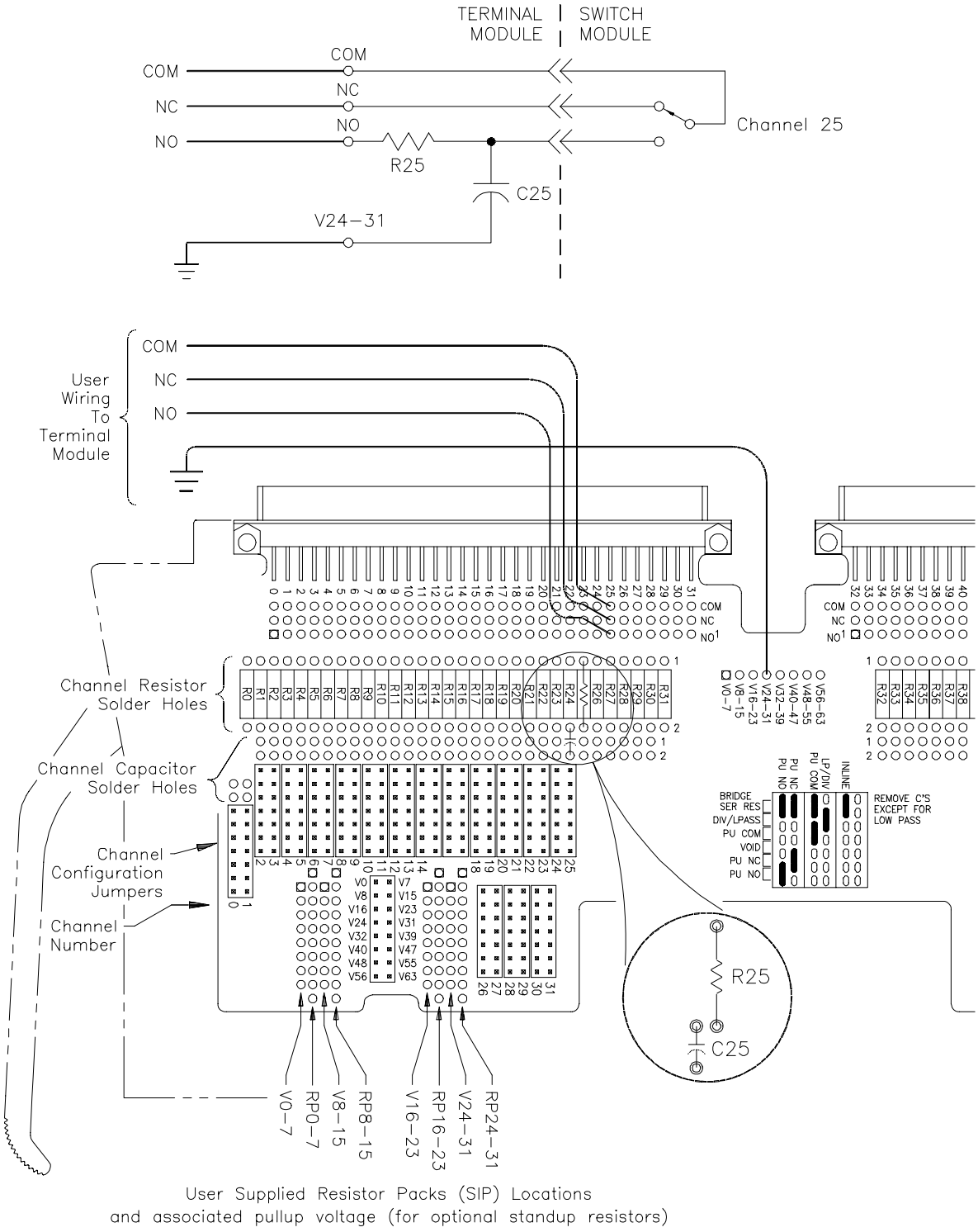


User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

Low-Pass Filter Configuration Example

Any channel can be configured as a low-pass filter connected to the normally open contact of the Form C relay.

Figure D-5. Components to be added: Resistor R25 and Capacitor C25. No configuration jumpers required.

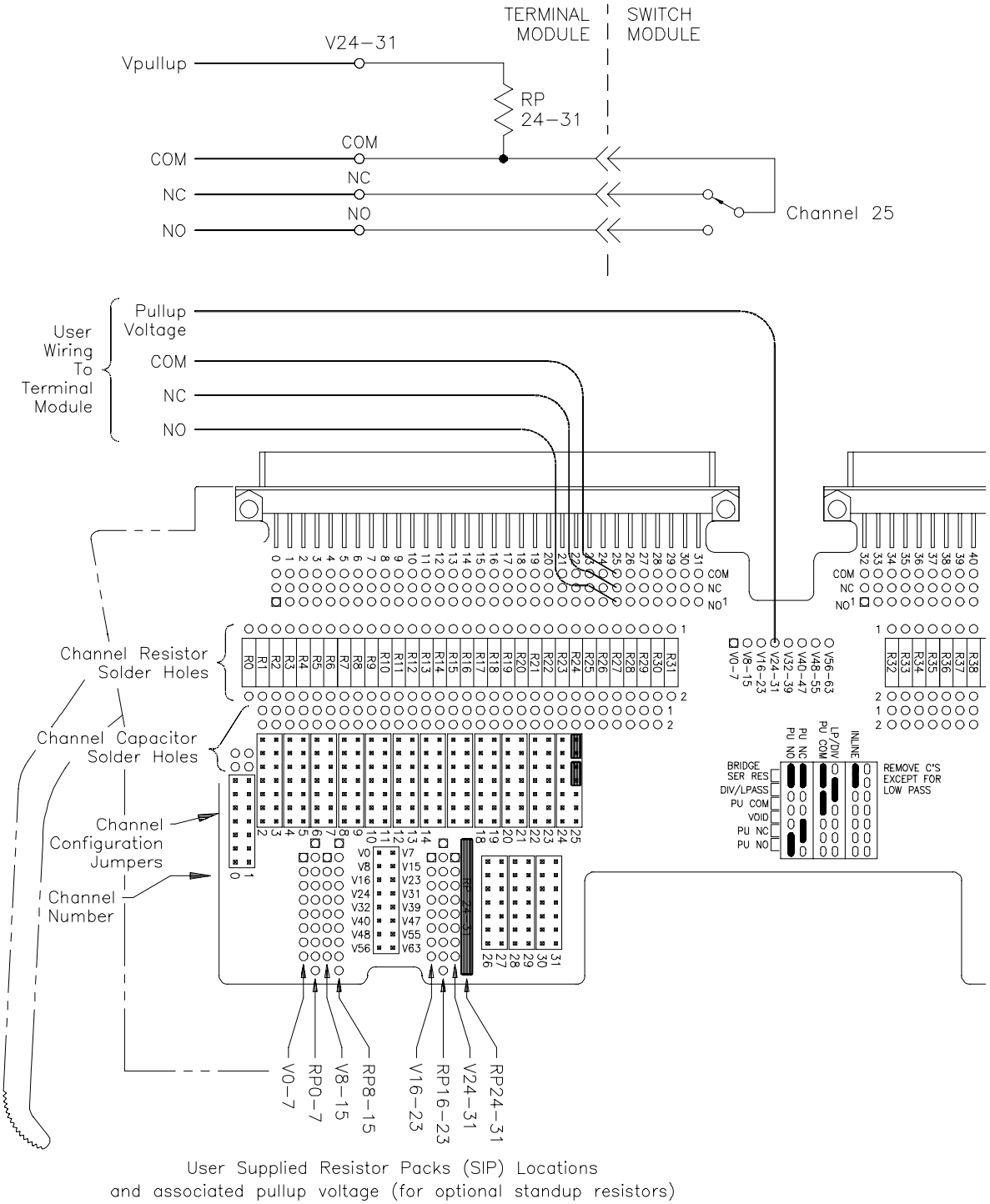


User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

Common Terminal Pullup Configuration Example

Any channel can be configured as a pullup (or pulldown) resistor connected to any of the contacts of the Form C relay. The figure below shows channel 25 with the pullup attached to the COM contact .

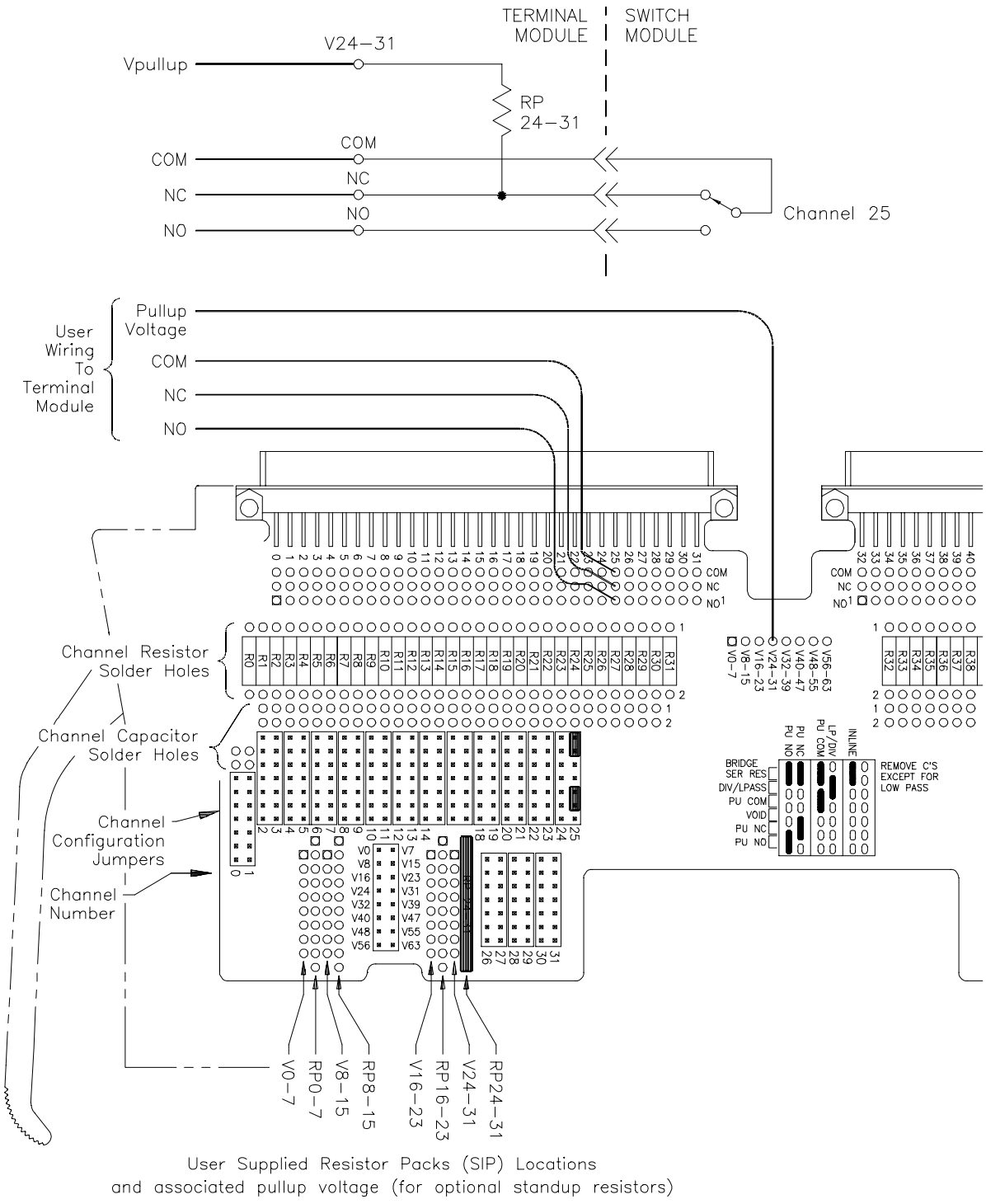
Figure D-6. Components to be added: SIP resistor pack RP24-31.
Set two configuration jumpers as illustrated below (PU COM).



Normally Closed Terminal Pullup Configuration Example

Any channel can be configured as a pullup (or pulldown) resistor connected to any of the contacts of the Form C relay. The figure below shows channel 25 with the pullup attached to the NC contact.

Figure D-7. Components to be added: SIP resistor pack RP24-31. Set two configuration jumpers as illustrated below (PU NC).

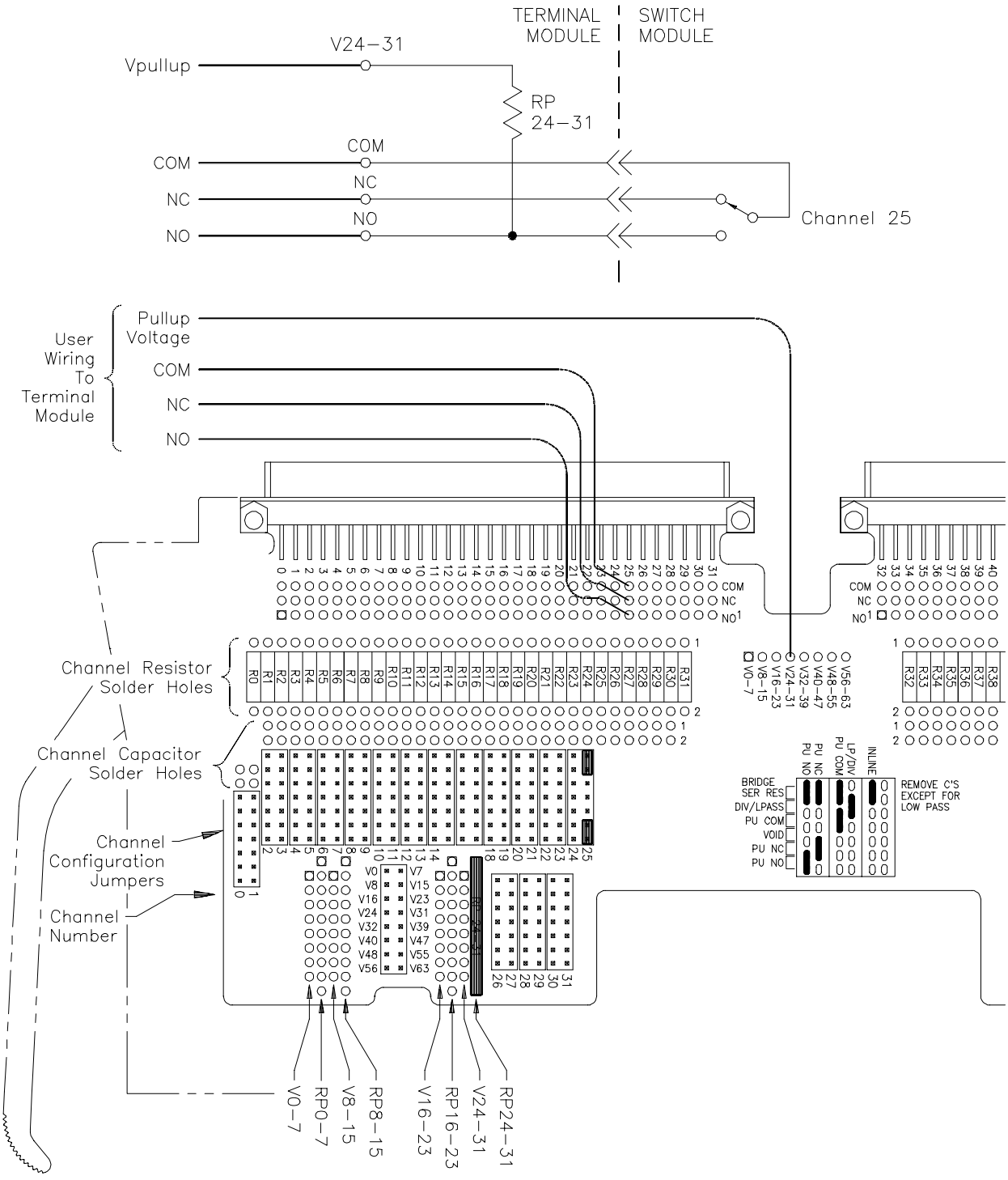


User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

Normally Open Terminal Pullup Configuration Example

Any channel can be configured as a pullup (or pulldown) resistor connected to any of the contacts of the Form C relay. The figure below shows channel 25 with the pullup attached to the NO contact.

Figure D-8. Components to be added: SIP resistor pack RP24-31. Set two configuration jumpers as illustrated below (PU NO).

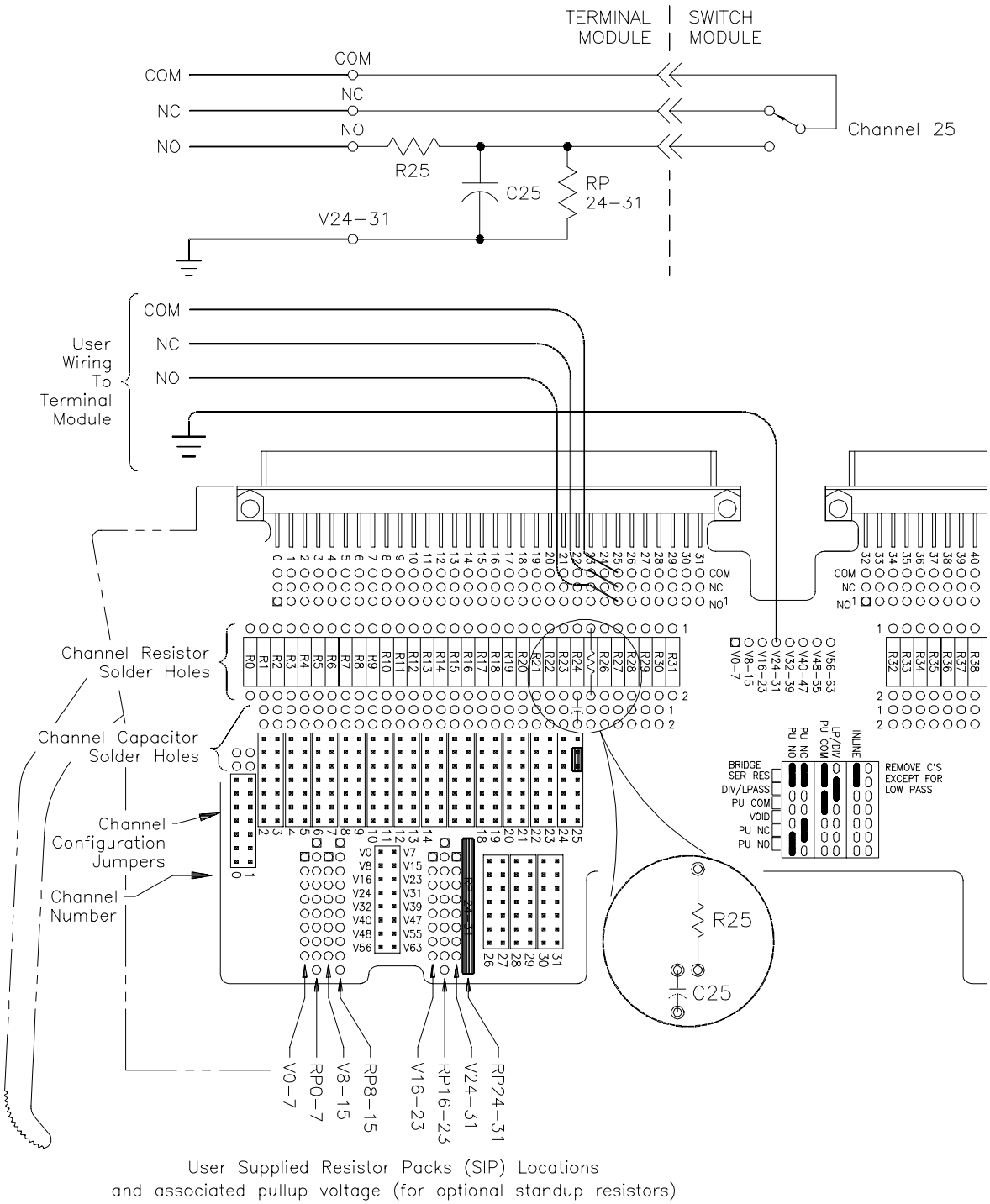


User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

Divider with Filter Configuration Example

Any channel can be configured as a resistor divider with a low-pass filter connected to the normally open contact of the Form C relay.

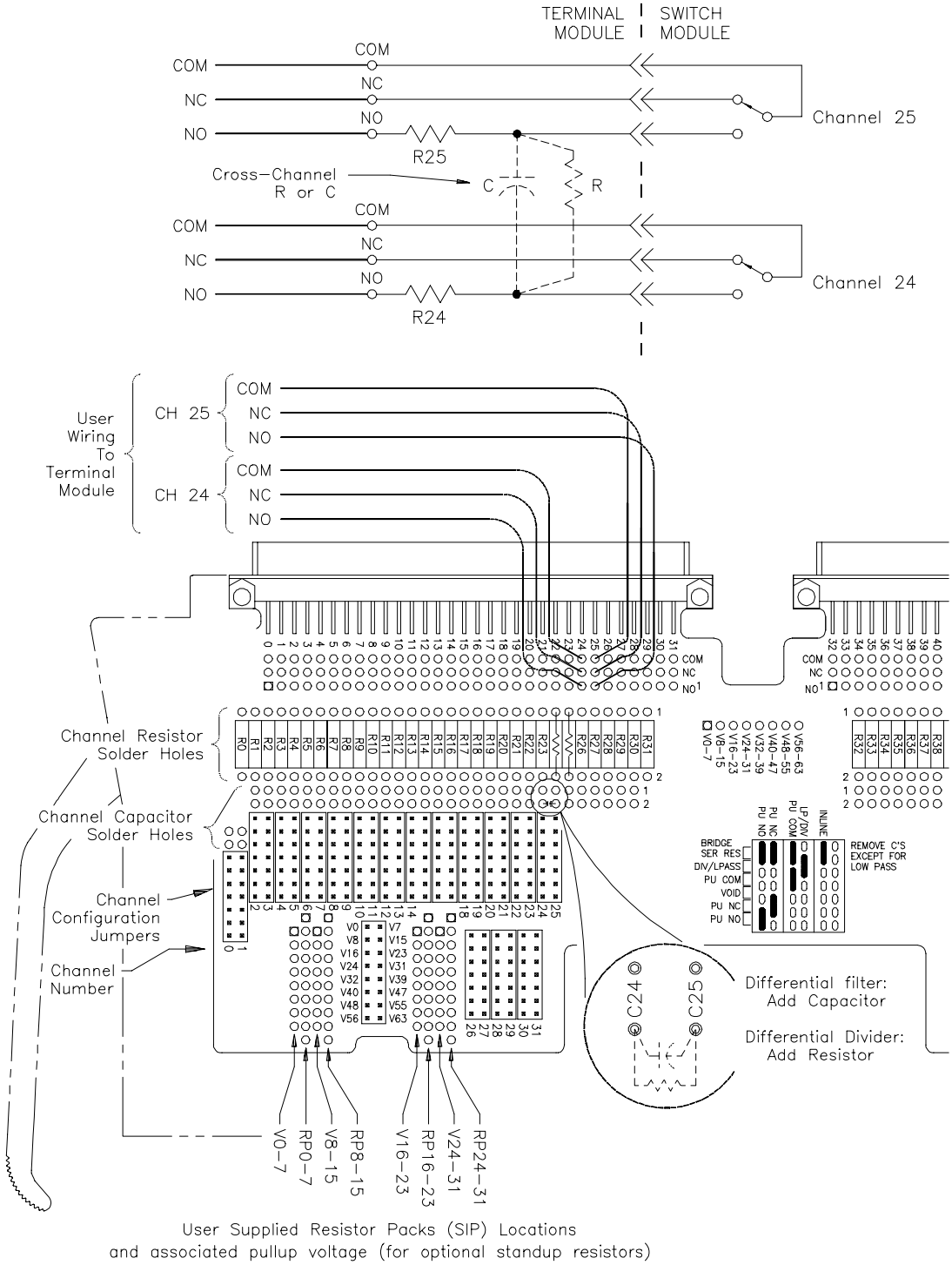
Figure D-9. Components to be added: Resistor R25, Capacitor C25 and SIP resistor pack R24-31. Set one configuration jumper as illustrated below (LP/DIV).



Differential Divider or Filter Configuration Example

Any channel can be configured as a differential divider (with optional filter) connected to the normally open contact of the Form C relay. The differential divider requires that two channels be used. The figure below shows channel 24 and 25 in this configuration with the optional filter.

Figure D-10. Components to be added: Resistors R24 and R25; add a cross-channel capacitor for a differential filter or add a cross-channel resistor for a differential divider. No configuration jumpers are required.



User Supplied Resistor Packs (SIP) Locations
and associated pullup voltage (for optional standup resistors)

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HP E1442A Switch Module User's Manual

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