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Documentation History

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

Edition 1 . . . . . September, 1989
Update 1 . . . . . September, 1990
Edition 2 . . . . . December, 1992
Edition 3 . . . . . November, 1993
Edition 4 . . . . . April, 1995

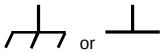
Safety Symbols



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



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



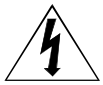
Frame or chassis ground terminal—typically connects to the equipment's metal frame.



Alternating current (AC).



Direct current (DC).



Indicates hazardous voltages.

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

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

WARNINGS

The following general safety precautions must be observed during all phases of operation, service, and repair of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

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

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

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

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

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

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

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

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

declares, that the product:

Product Name: 48 Channel Single-Ended Relay Multiplexer Module

Model Number: E1346A

Product Options: All

conforms to the following Product Specifications:

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

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

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

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



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

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

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• Instructions are easy to understand.	O	O	O	O	O
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• Examples are clear and useful.	O	O	O	O	O
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Chapter 1
Getting Started with the HP E1346A

Using This Chapter

This chapter describes the HP E1346A 48-Channel Single Ended Relay Multiplexer Module, and shows how to program the module using SCPI (Standard Commands for Programmable Instruments) commands. This chapter contains the following sections:

- Multiplexer Module Description . . . . . Page 11
- Programming the Multiplexer Module . . . . . Page 13
- Initial Operation . . . . . Page 16

Instrument Definition

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

Multiplexer Module Description

Refer to Figure 1-1 for the following explanations of the 48-Channel Single Ended Relay Multiplexer Module.

General Description

The multiplexer module provides switching (multiplexing) of up to 48 channels (i.e., channels 00 to 47). Each channel switches only a High (H) connection. The Low (L) and Guard (G) connections are common for each channel. The multiplexer module can only close one channel at a time.

The multiplexer module consists of a component assembly and a terminal block. The channel relay switches are on the component assembly. The field wiring from user sources connect to the terminal block. The terminal block also provides connections for multimeters, voltmeters, counters, and other measuring devices.

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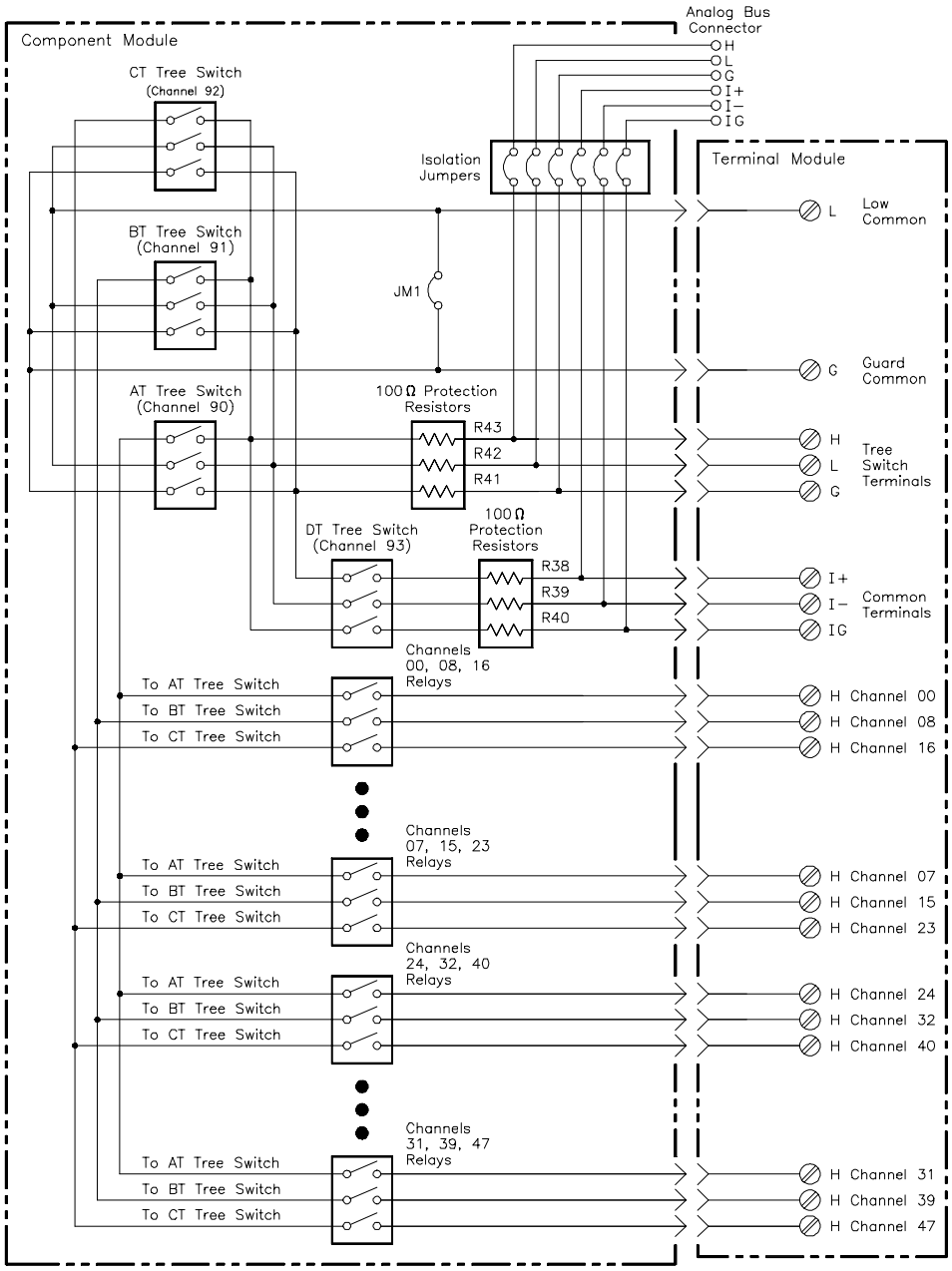


Figure 1-1. Multiplexer Module Block Diagram

Multiplexer Channel Descriptions and Connections

The channel switches connect, through the AT, BT, and CT Tree Switches, to the Common Terminals. Closing a channel using SCPI automatically closes the appropriate tree switch for connections. For example, a channel 00 closure automatically closes the AT Tree Switch. To close the tree switches using register programming, use channel number 90, 91, or 92 for the AT, BT, or CT Tree Switches, respectively.

The multiplexer also has an additional tree switch called the DT Tree Switch. It connects the DT Tree Switch Terminals, when closed, to any channel. Use this tree switch for ohms measurements. This connects the ohms current source to the channels inside the module. Use channel number 93 to select this tree switch.

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The Common Terminals also connect to the H, L, and G connections on the Analog Bus Connector. The DT Tree Switch Terminals also connect to the I+, I-, and IG connections on the Analog Bus Connector. The Analog Bus Connector provides direct channel connections between multiple multiplexer modules, and connections between a multiplexer module and the HP E1326/
E1411 Multimeter. Cables make the necessary connections without the need to externally wire the multimeter/multiplexer module to the terminal module.

Each Common and DT Tree Switch lines have a 100 Ω resistor in series with each line. The resistors provide relay protection and are located on the component module. The Analog Bus lines have jumpers in series that you may remove to isolate the analog bus from the multiplexer module. The Low (L) and Guard (G) commons are normally connected to each other through isolation jumper JM1 (see Chapter 2). Remove the jumper to minimize errors caused by lead resistance in the low lines. The jumper is located on the component assembly.

Programming the Multiplexer Module

The multiplexer module is programmed either in a switchbox or scanning voltmeter configuration. To program the multiplexer module using Standard Commands for Programmable Instruments (SCPI), you must select the controller language, interface address, and SCPI commands to be used. See the "HP 75000 Series B Installation and Getting Started Guide" or the "HP E1405/E1406 Command Module Manual" for interface addressing and controller language information of multiplexer modules in a switchbox or scanning voltmeter configuration.

Note *This discussion applies to SCPI programming. See Appendix B (48-Channel Relay Multiplexer Registers) for details on multiplexer module registers.*

Selecting Channels

To address specific channels within a multiplexer module in a switchbox or scanning voltmeter configuration, you must:

- send the appropriate SCPI command string to the switchbox or scanning voltmeter (e.g., CLOSe, OPEN, etc.)
- specify the card number
- specify the channel number

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Multiplexer Card Numbers

The card number identifies the module within a switchbox or scanning voltmeter configuration. The switch module with the lowest logical address is always card number 01. The card number with the next successive logical address is 02, and so on. Figure 1-2 illustrates the card number and logical address of a typical single module switchbox. Figure 1-3 illustrates the card numbers and logical addresses of a typical multiple module switchbox. Figure 1-4 illustrates the card numbers of a typical multiple module scanning voltmeter.

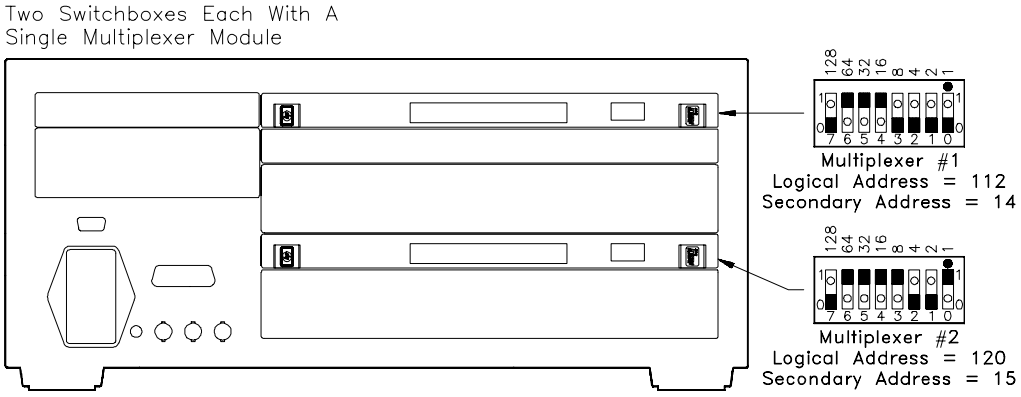


Figure 1-2. Card Numbers for Single Module Switchboxes

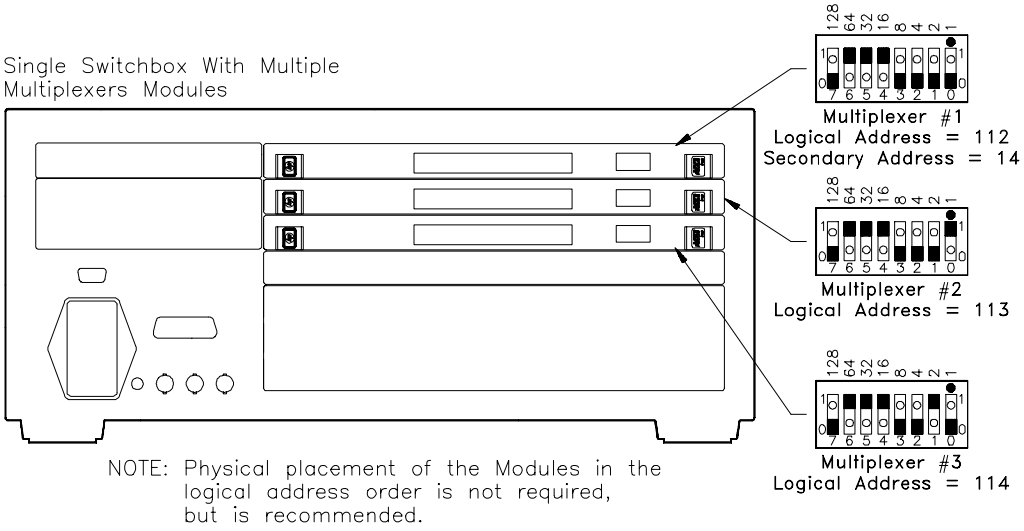


Figure 1-3. Card Numbers for Multiple Module Switchboxes

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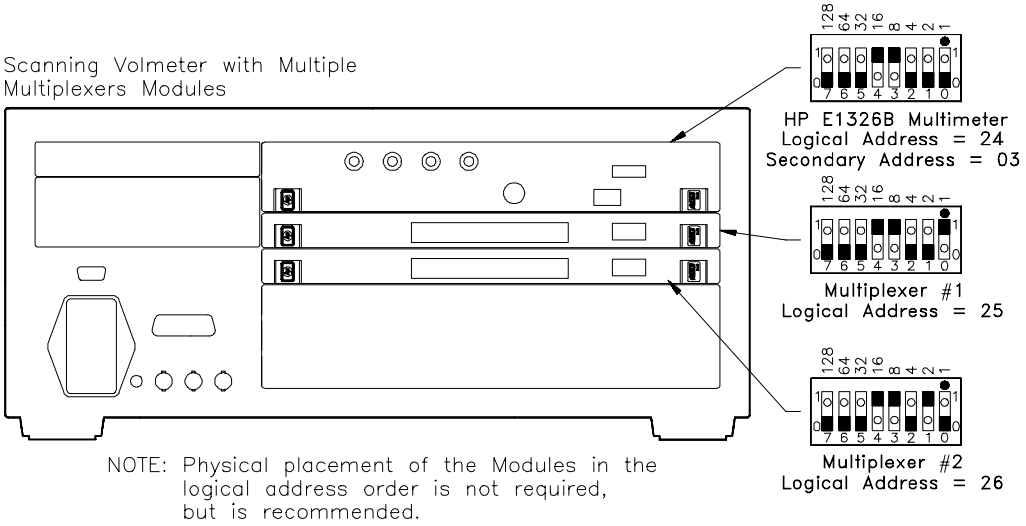


Figure 1-4. Card Numbers for Multiple Module Scanning Voltmeter

The logical addresses noted in Figures 1-2, 1-3, and 1-4 apply to modules installed in an HP 75000 Series B Mainframe (HP Model Number E1300/E1301) or in a mainframe with an HP E1405/E1406 Command Module. See the "HP 75000 Series B Installation and Getting Started Guide" or the "HP E1406 Command Module Manual" for more information on switchboxes and scanning voltmeter configurations, and logical addressing. For uses in other systems or mainframes, see the appropriate manuals.

Multiplexer Channel Address

For the 48-Channel Multiplexer, the channel address (*channel_list*) is in the form:

- (@ccnn) for a single channel
- (@ccnn,ccnn) for multiple channels
- (@ccnn:ccnn) for sequential channels
- (@ccnn:ccnn,ccnn:ccnn) for groups of sequential channels
- or any combination of the above

where "cc" is the card number and "nn" is the channel number.

For example, the command string to close channel 02 of card number 1 is:

```
CLOSe (@0102)
```

Since "cc" (the card number) must be sent, it becomes part of the channel number. Also, you can ignore leading zeros in the card numbers. Thus, to close channel 02, send "102" instead of "0102". To close the above channel, execute:

```
CLOSe (@102)
```


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SCPI Command Format Used in This Manual

You can send SCPI commands in either a short or long form. A long form example is:

```
CLOSe (@102)
```

The same command shown without the lower case letters is the short form. The command then becomes:

```
CLOS (@102)
```

Some commands in this manual are shown with brackets ([ ]). These are implied or optional commands that you do not have to execute. For example, the ROUT command is an implied command and is shown in this manual as:

```
[ROUT:]CLOS (@102)
```

Thus, to execute these commands, simply enter:

```
CLOS (@102)
```

See Chapter 5 for more explanation about SCPI commands and how to send them.

Initial Operation

Use the following program example to verify initial multiplexer operation by closing a channel and querying channel closure. The example first resets the switchbox and then closes channel 02 of a single multiplexer module (card number 1) in the switchbox. The program next queries the channel closure state. A returned "1" shows that the command to close the channel has been sent to the switchbox. A returned "0" shows that the command to close the channel has not been sent to the switchbox.

The computer used in the example is an HP Series 200/300 computer with HP BASIC as the program language. The computer interfaces to the mainframe using the Hewlett-Packard Interface Bus (HP-IB)*. The HP-IB interface select code is 7, the HP-IB primary address is 09, and the HP-IB secondary address is 14. Refer to the "HP 75000 Series B Installation and Getting Started Guide" for addressing information.

Example: Reset the switchbox and close channel 02

```
10 OUTPUT 70914;"*RST"                 Opens all channels
20 OUTPUT 70914;"CLOS (@102)"          Close channel 02
30 OUTPUT 70914;"CLOS? (@102)"         Query channel 02 state
40 ENTER 70914;Value                   Enter results into Value
50 PRINT Value                         Display result
60 END
```

* HP-IB is Hewlett-Packard's implementation of IEEE Std 488.1-1984

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Chapter 2
Configuring the HP E1346A Multiplexer Module

Using This Chapter

This chapter shows how to connect external wiring to the 48-Channel Single Ended Relay Multiplexer Module, and how to configure the module. This chapter contains the following sections:

- Warnings and Cautions . . . . . Page 17
- Connecting Field (user) Wiring . . . . . Page 18
- Wiring a Terminal Block . . . . . Page 19
- Connecting the Analog Bus . . . . . Page 21
- Setting the Address Switch . . . . . Page 21
- Removing the Low-to-Guard Isolation Jumper. . . . . Page 21
- Selecting the Interrupt Priority . . . . . Page 23

Warnings and Cautions

Warning

SHOCK HAZARD. Only service-trained personnel who are aware of the hazards involved should install, remove, or configure the multiplexer module. Before you install any module, disconnect AC power from the mainframe and from user wiring. To prevent electrical shock, all wires to the channel connections must be insulated to at least 120 V rms (170 V peak).

Caution

MAXIMUM VOLTAGE/CURRENT. The maximum voltage that may be applied between High (H), Low (L), and Guard (G) terminals is 170 V dc or 120 V rms (170 V peak). The maximum current is 50 mA (non-conductive) per channel.

STATIC ELECTRICITY. Static electricity is a major cause of component failure. To prevent damage to the electrical components in the multiplexer module, observe anti-static techniques whenever removing a module from the mainframe or whenever working on a module.

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Connecting Field Wiring

Figure 2-1 shows the terminal block for the 48-Channel Single Ended Relay Multiplexer Module (HP E1346A). Use the following guidelines for wire connections.

Wiring Guidelines

- If possible, use shielded cables with the shields connected to the Guard (G) terminals and to the low connection near the measurement point.
- Be sure the wires make good connections on the screw terminals.

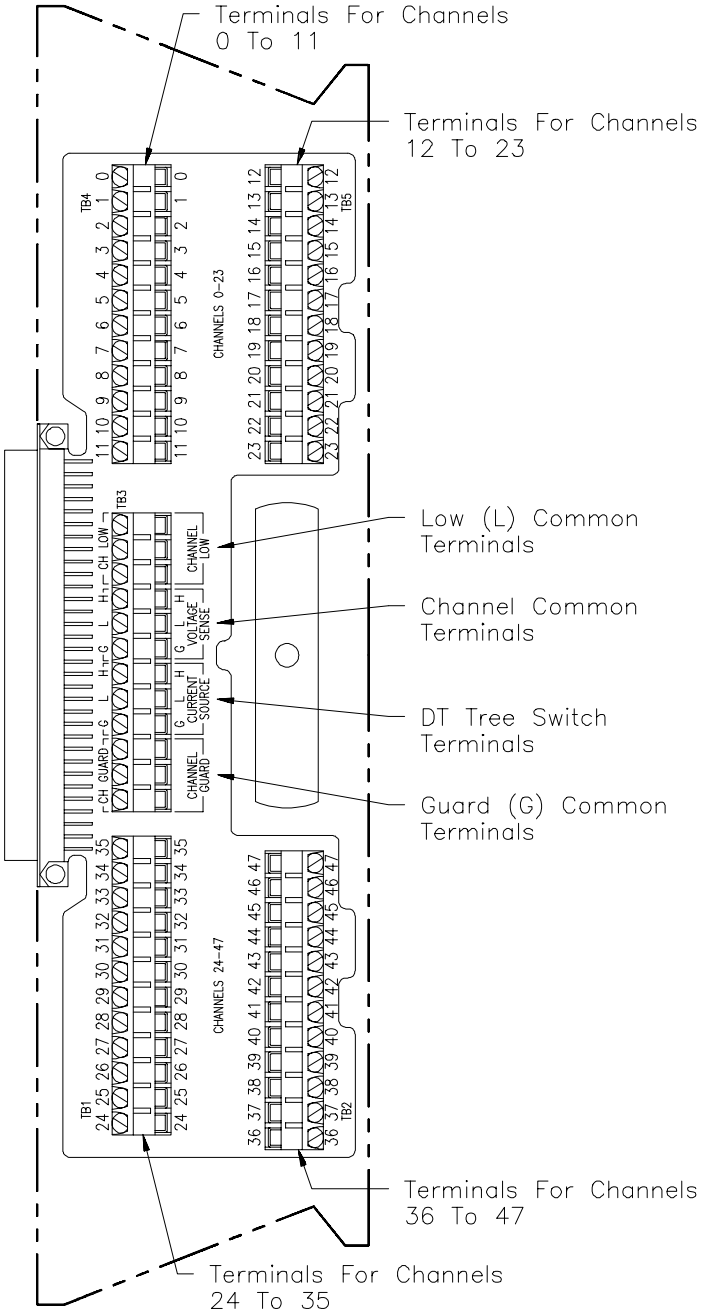
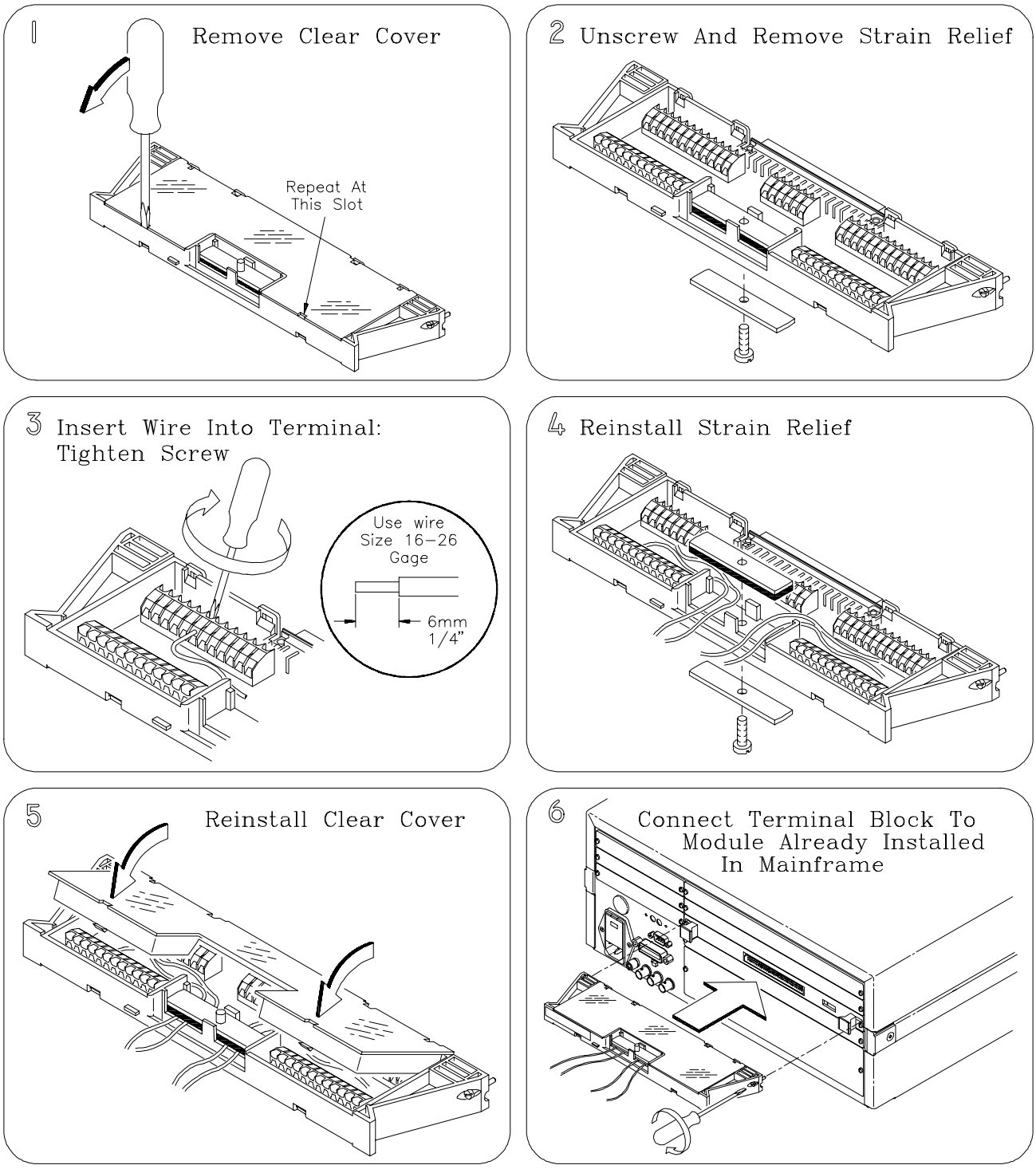


Figure 2-1. Multiplexer Module Terminal Block

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Wiring a Terminal Block



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Connecting User Inputs

The HP E1346A consists of a relay modules and a terminal module. Normally you will use the terminal block supplied with the module. However, you may want to configure your own terminal block. Figure 2-2 shows the module front panel and the module's connector pin-out.

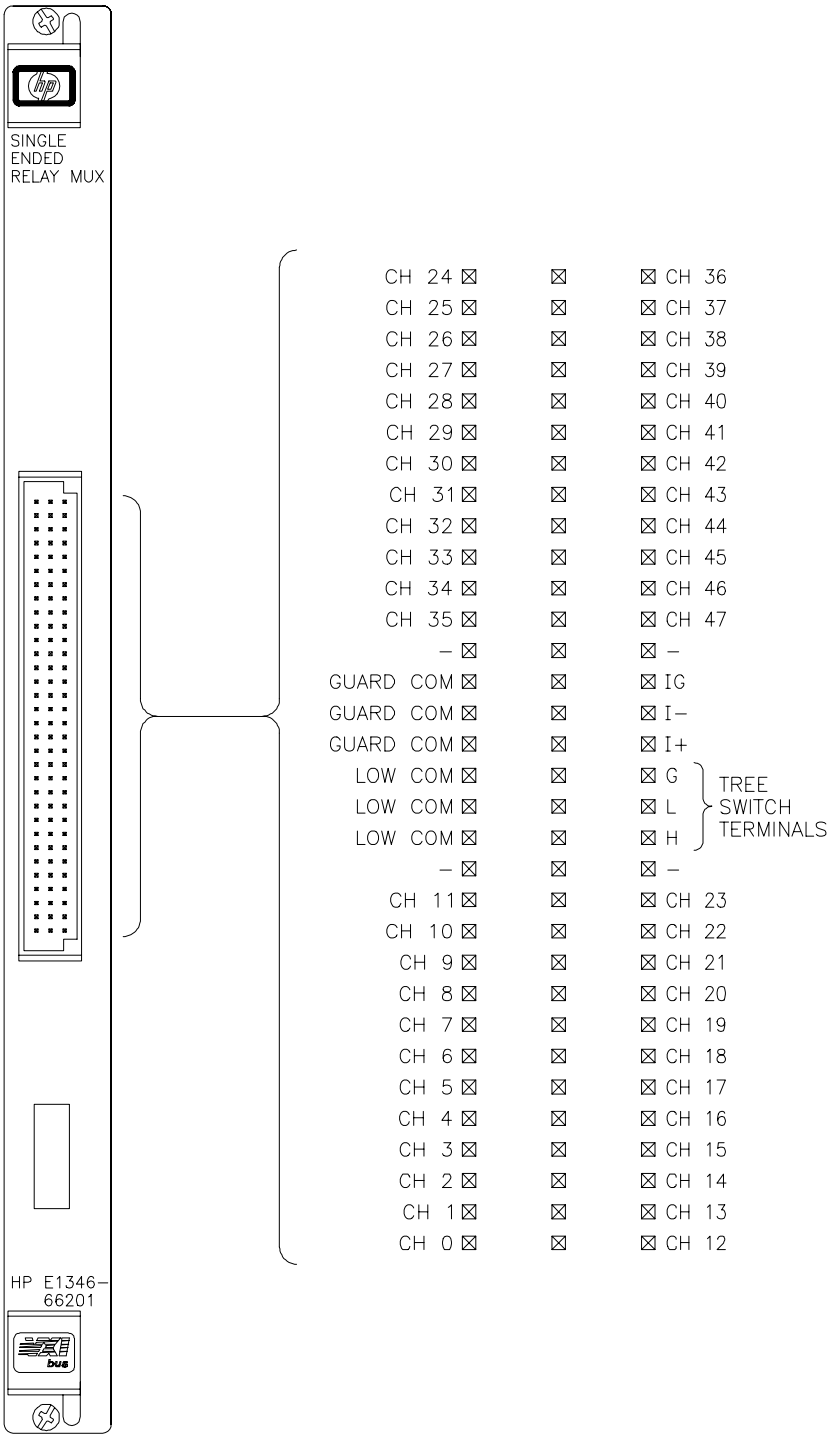


Figure 2-2. HP E1346A Front Panel and Connector Pin-out

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Connecting the Analog Bus

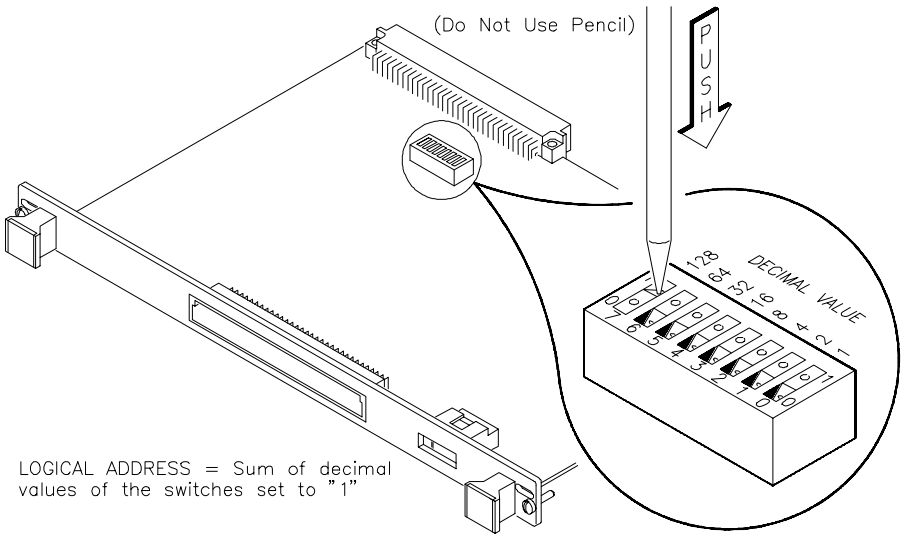
Figure 2-3 shows how to connect the analog bus between multiple multiplexer modules and to the HP E1326A Multimeter. Use the cables shipped with the multiplexer modules to connect the analog bus of the multiplexer modules. Use the cable shipped with the HP E1326A Multimeter to connect the analog bus of the multiplexer module to the Multimeter input.

These cables are needed to connect the multiplexer when mounted in the E1403 Module Carrier to the E1411A/B DMM in a C-size cardcage. They must be ordered separately.

- Connecting E1411 to RELAY MUX's: use E1326-61611 (long analog bus cable).
- Connecting RELAY to RELAY or RELAY to FET MUX: use E1400-61605.

Setting the Address Switch

The address switch (LADDR) factory setting is 112. You may have changed the setting during module installation. Valid address values are from 0 to 255. Refer to the "HP 75000 Series B System Installation and Getting Started Guide" or the "HP E1406 Command Module Manual" for addressing information. Otherwise, to change the setting, use the following:



Removing the Low-to-Guard Isolation Jumper

Isolation jumper JM1 connect the Low (L) and Guard (G) commons to each other. To minimize errors caused by lead resistance in the low lines, you may wish to remove the jumper. Use Figure 2-4 to locate jumper.

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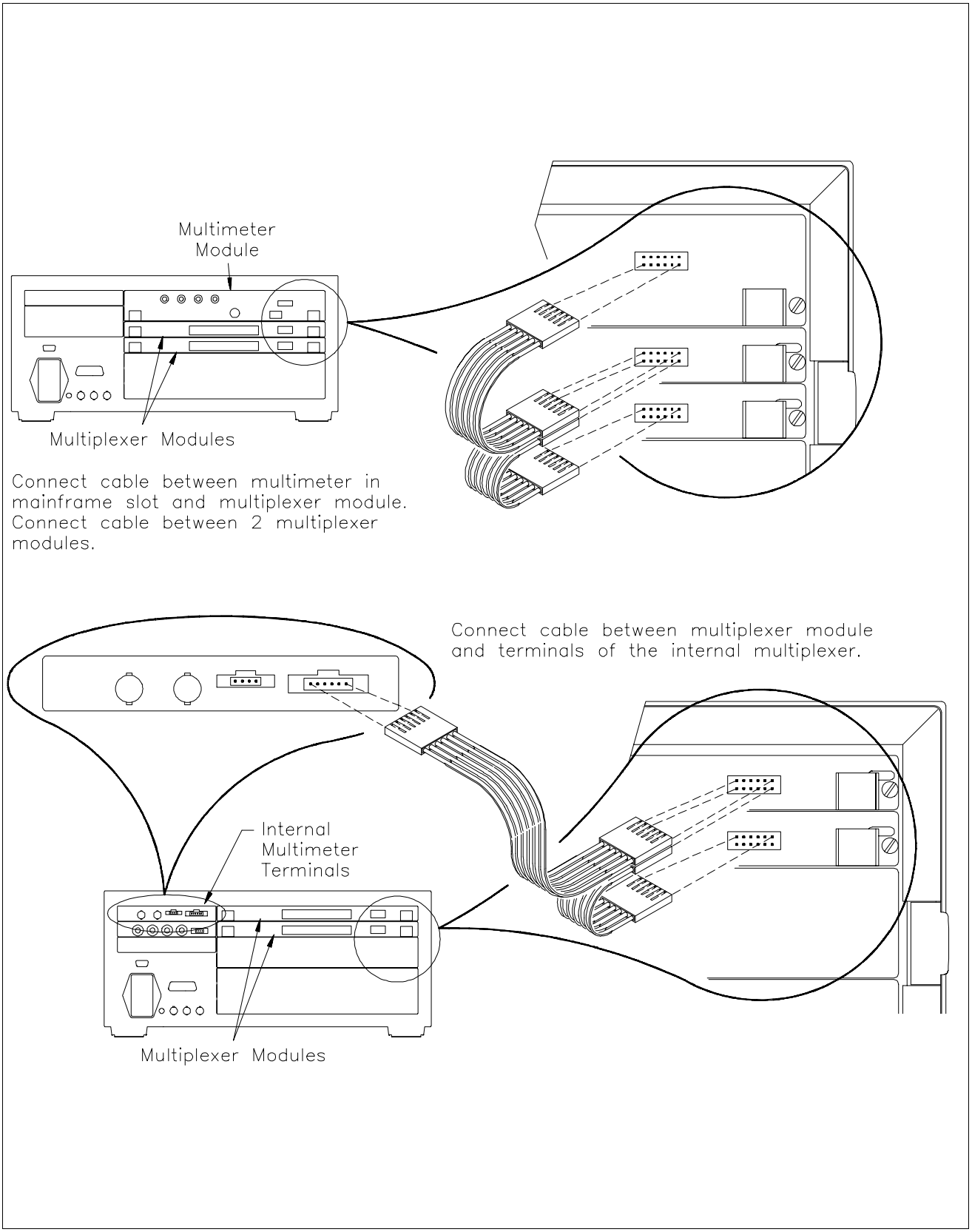


Figure 2-3. Analog Bus Connections between Multiplexer/Multimeter Modules

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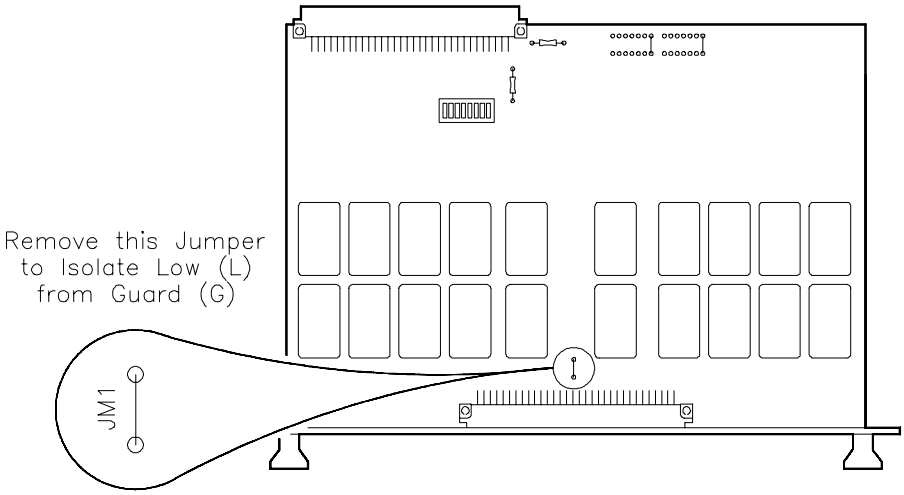


Figure 2-4. Removing the Isolation Jumper

Selecting the Interrupt Priority

The multiplexer module generates a backplane interrupt after a channel relay closing or opening completes. You can select seven different interrupt priority levels for this interrupt. Level 1 is the lowest priority and Level 7 is the highest priority. The multiplexer module's factory setting is Level 1.

Refer to Figure 2-5 to change the interrupt priority. To change, clip and remove two jumpers from the old priority location. Install and solder two new jumpers in the new priority location (Figure 2-4 shows a priority change from 1 to 7). Set the interrupt priority level to the interrupt handler level of the module's commander. The E1300/E1301 commander always handles all interrupt levels. The E1405/E1406 and the E1499A commander's default is to handle interrupt level 1, however, they may be configured to handle any combination of interrupt levels.

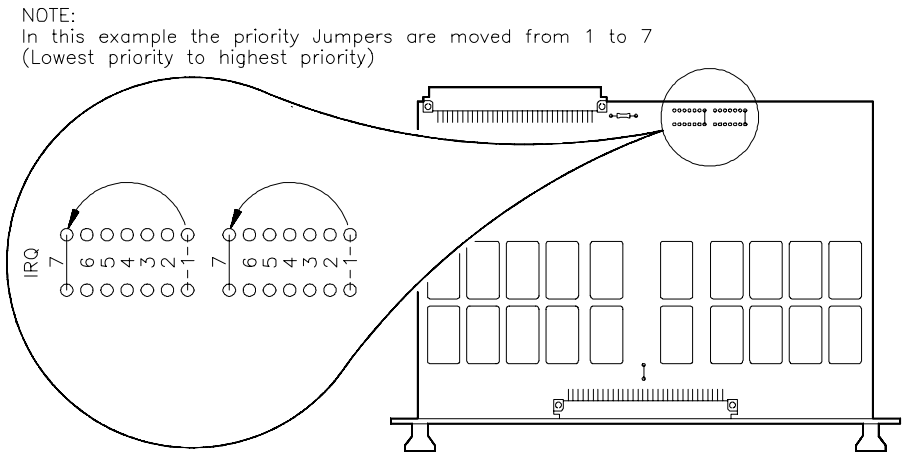


Figure 2-5. Changing the Interrupt Priority Level Jumpers

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Chapter 3
Using the HP E1346A Multiplexer Module

Using This Chapter

This chapter uses typical examples to show how to use the 48-Channel Relay Multiplexer Module. Refer to Chapter 4 (Understanding the 48-Channel Multiplexer Module) for more information. This chapter contains the following sections:

- Multiplexer Commands . . . . . Page 25
- Connecting Channels to Common for Making Measurements . . . . . Page 26
- Scanning a Range of Switchbox Channels . . . . . Page 29

Multiplexer Commands

Table 3-1. Multiplexer Commands in Chapter 3

Command	Description
ARM:COUN<*number*>	Selects multiple scanning cycles
INIT[:IMM]	Starts scanning process; use the [ROUT:]SCAN command to select channels for scanning
INIT:CONT 1 |0 |ON |OFF	Enables/disables continuous scanning cycles
[ROUT:]CLOS<*channel_list*>	Closes all channels in channel list
[ROUT:]CLOS?<*channel_list*>	Queries mainframe for channel closure
[ROUT:]OPEN<*channel_list*>	Opens all channels in channel list
[ROUT:]SCAN<*channel_list*>	Closes all channels in channel list one at a time; previous channel opens before next channel closes
[ROUT:]SCAN:MODE RES	Automatically closes the DT Tree Switch for 2-wire ohms measurements while scanning
NOTE: The commands with brackets ([ ]) are implied and are not shown in this chapter	

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Connecting Channels to Common for Making Measurements

- Closing any channel on the multiplexer module connects the channel's High (H) terminal to the Channels H Common Terminal and the H terminal of the Analog Bus connector.
- Closing the DT Tree Switch connects any channel on the multiplexer module to the DT Tree Switch terminals.
- Closing the DT Tree Switch connects any channel on the multiplexer module to the I+ I- , and IG terminals of the Analog Bus connector.
- All channels are referenced to one Low (L) and one Guard (G) Common that are normally connected to each other. To isolate the Low and Guard Commons, remove jumper J01.

Example: Connect Channel 02 to Common for Voltage Measurement

Figure 3-1 shows how to connect channel 02 of a single module switchbox to the Common Terminals for a voltage measurement. Execute:

```
CLOS   (@102)
```

102 closes channel 02; the first number (1) is the card number

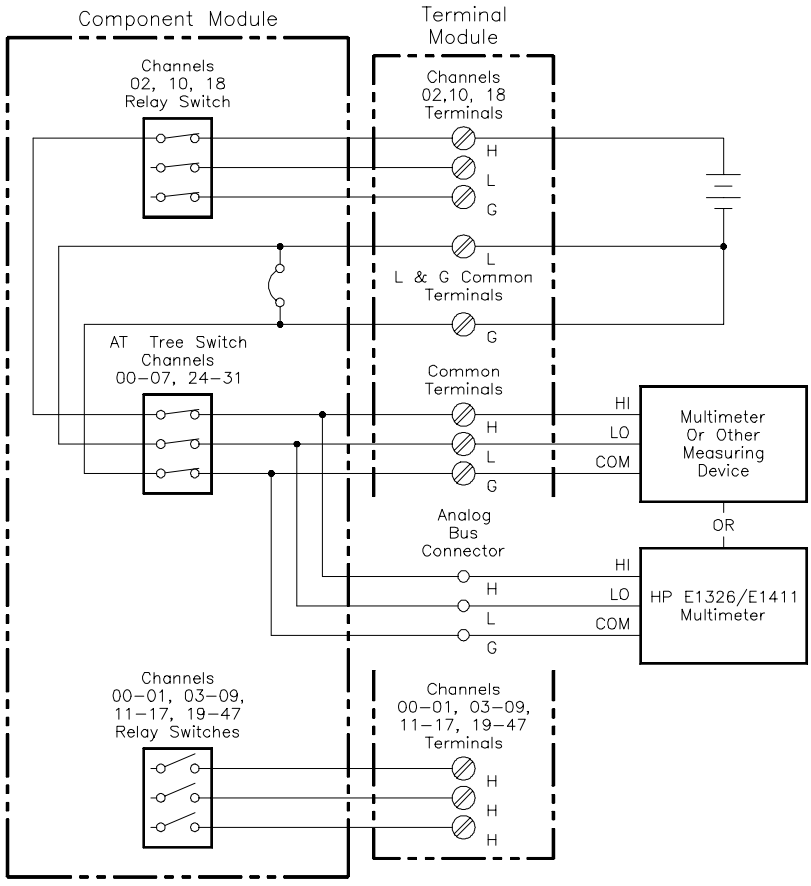


Figure 3-1. Connecting Channel 02 for a Voltage Measurement

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Example: Connect Channel 02 to the DT Tree Switch Terminals for an Ohms Measurement

Figure 3-2 shows how to connect channel 02 of a single module switchbox to the Common and DT Tree Switch Terminals for an ohms measurement. Execute:

```
CLOS   (@102,193)
```

102 closes channel 02; 193 closes the DT tree switch

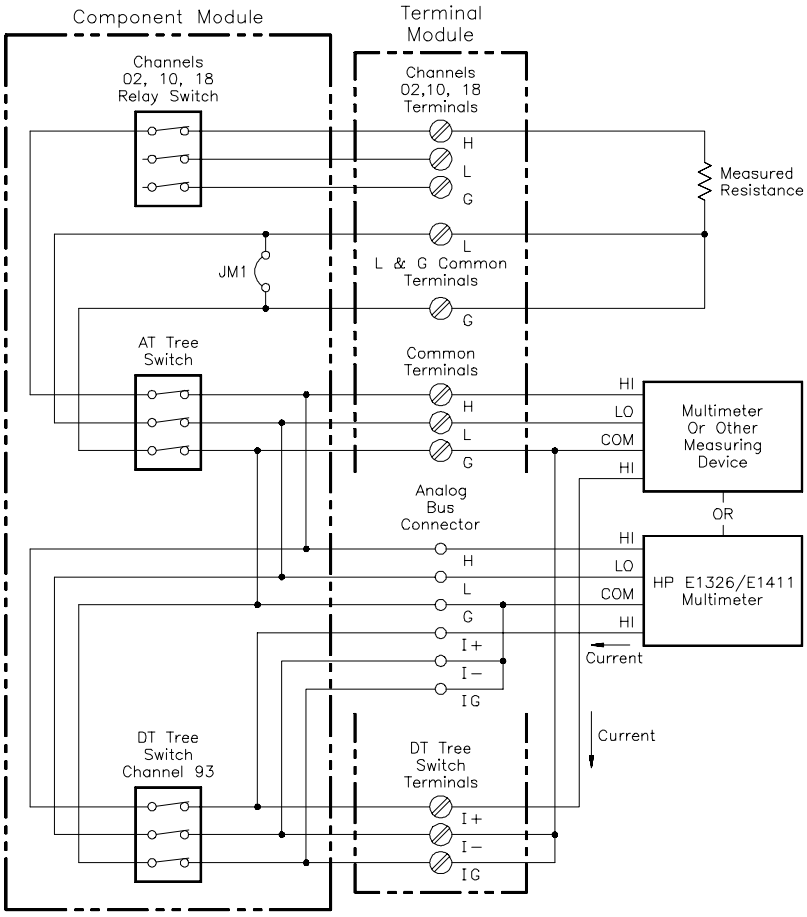


Figure 3-2. Connecting Channel 02 to the DT Terminals for an Ohms Measurement

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Comments

Opening Channels. Use the OPEN <*channel_list*>command to open channels. For example, to open channel 02 and the DT Tree Switch, execute:

```
OPEN   (@102,193)
```

Query Open/Closed Channels. The CLOS? <*channel_list*>and OPEN? <*channel_list*> commands determine if the channel in the channel list is open or closed, respectively. (The query command does not determine if, in the event of a hardware failure, the channel remains open/closed.) For example, to determine if channel 02 is closed, execute:

```
CLOS?   (@102)
```

and enter the response into a variable.

A response of 1 indicates that the channel is closed; a response of 0 indicates that the channel is open. The reverse is true for the OPEN? <*channel_list*> command. The correct responses for both the OPEN? and CLOS? commands are:

CLOS? 1 = Closed
0 = Open

OPEN? 1 = Open
0 = Closed

Note You must read the query response after sending a query command or the switchbox will generate an error.

Measuring with the HP E1326/E1411 Multimeters. The HP E1326/E1411 Multimeters can directly measure channels of single or multiple multiplexer modules in a scanning voltmeter configuration. The multimeters, when correctly programmed, automatically close the appropriate Tree Switches. For more information, see the HP E1326/E1411 User's manual.

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Scanning a Range of Switchbox Channels

- You can scan a range of channels of a switchbox consisting of single or multiple multiplexer modules (see Comments section for scanning requirements of a switchbox).
- Scanning involves sequentially closing each channel on a range of specified channels.
- During scanning, the relay which was previously closed opens before the next relay closes.

Example: Making Voltage Measurements by Scanning

Figures 3-3 and 3-4, and the following commands, show how to make voltage measurements by performing a single scanning cycle of all channels on two multiplexer modules in a single switchbox. In the example, the:

- Common Terminals of each terminal module connect to each other and to the multimeter in Figure 3-5. To connect the terminals to each other, use either the Analog Bus Cable (shown in Figure 2-2) or wire the terminals together between each terminal modules
- HP E1300/E1301 Mainframe's "Trig Out" pulse synchronizes the switchbox with the multimeter
- HP-IB Bus trigger command advances the switchbox channel list
- multimeter HP-IB select code is 7 and primary address is 22
- switchbox HP-IB select code is 7, the HP-IB primary address is 09, and the HP-IB secondary address is 14
- computer is an HP Series 200/300 Computer with HP BASIC using HP-IB

Enter and Execute:

```
10  OUTPUT 722;"TRIG EXT;DC 10"          Sets multimeter to external triggers and to measure dc volts
20  OUTPUT 70914;"OUTP ON"               Enables "Trig Out" port
30  OUTPUT 70914;"TRIG:SOUR BUS"         Sets switchbox to receive Bus triggers
40  OUTPUT 70914;"SCAN  (@100:247)"      Selects the channel list. 100 selects the first channel of module #1; 247 selects the last channel of module #2
50  OUTPUT 70914;"INIT"                  Starts scanning cycle
60  FOR I=1 TO 96                        Start count loop
70  ENTER 722;A                          Enter reading into variable A
80  PRINT A                              Print reading in variable A
90  TRIGGER 70914                        Trigger the switchbox to advance the scan list
100 NEXT I                               Increment count
110 END
```


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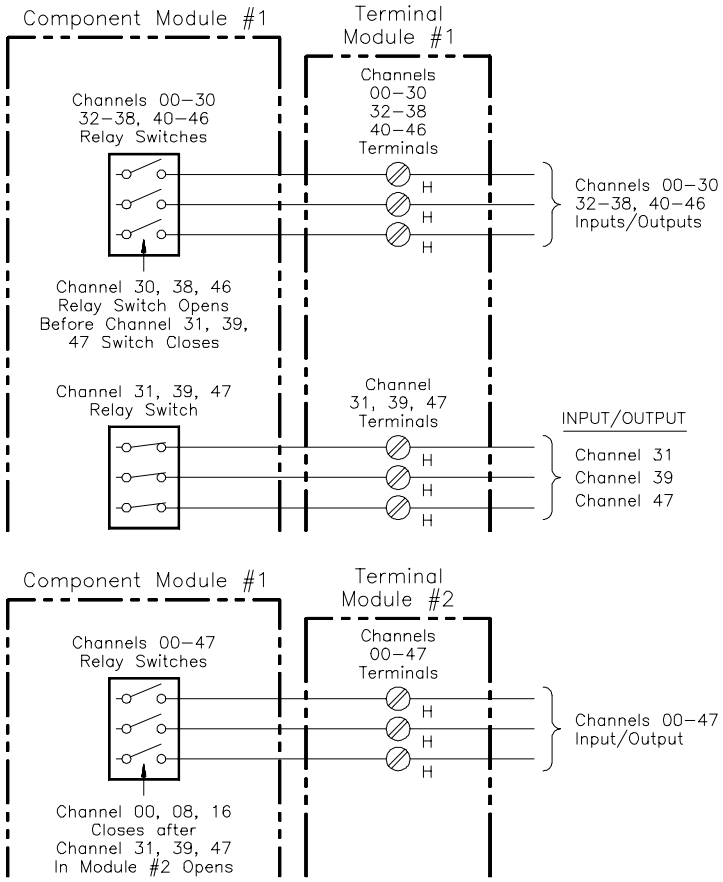


Figure 3-3. Scanning Channels 100 to 247 of a Two Module Switchbox

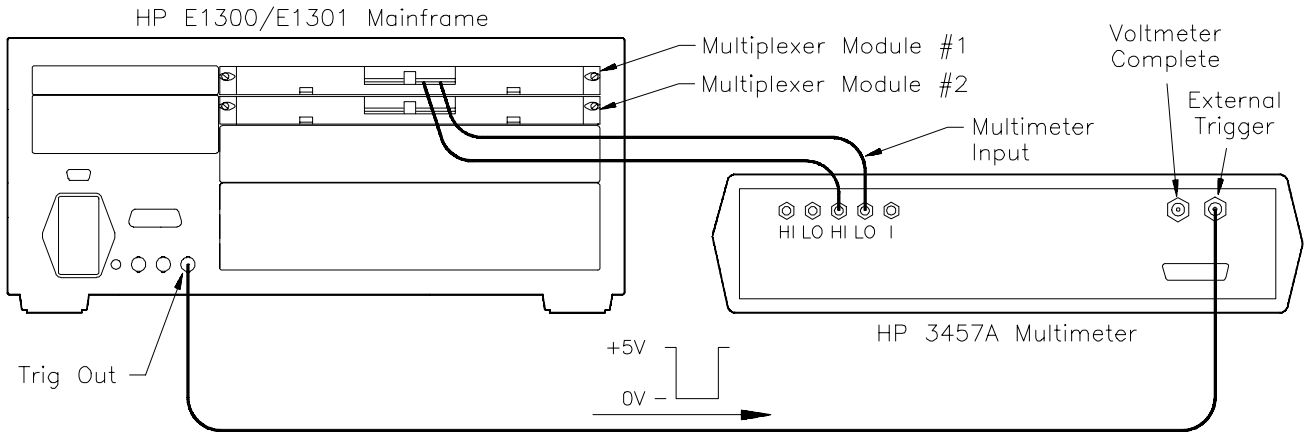


Figure 3-4. Mainframe to Multimeter Connections for Synchronization

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Example: Making 2-Wire Ohms Measurements by Scanning

Use the same setup shown in the first program example in this section, except change the command in line 10 and add the following command before the SCAN <*channel_list*> command in line 40, as follows:

```
10  OUTPUT 722;"TRIG EXT;OHMF"      Changes multimeter to 4-wire ohms
    OUTPUT 70914;"SCAN:MODE RES"    Closes the appropriate channel
                                    switches and DT Tree Switch
```

This command automatically closes the channels defined in the channel list and the DT Tree Switch during scanning.

Note

The Analog Bus cable automatically connects the I-, IG, and G terminals to the HP E1326/E1411 multimeters. These connections are not necessary with an external multimeter such as the HP 3457A.

Example: Making Multiple Scans

The ARM:COUN <*number*> command selects multiple scanning cycles. Add the command to the first program example in this section, as follows:

```
OUTPUT 70914;"ARM:COUN 10"      Enables 10 scanning cycles
OUTPUT 70914;"SCAN  (@100:247)" Sets scan list
```

Example: Making Continuous Scans

The INIT:CONT ON command selects continuous scanning cycles (INIT:CONT OFF disables continuous scanning cycles). Add the command to the first program example in this section, as follows:

```
OUTPUT 70914;"INIT:CONT ON"     Enables continuous scanning cycles
OUTPUT 70914;"SCAN  (@100:247)" Sets scan list
```

Comments

See Chapter 4 for more information on scanning.

Scanning Requirements of a Switchbox (in an HP Mainframe with an HP Command Module). To scan modules in a switchbox, you must:

- know the card numbers (see Chapter 1) of all the modules to be scanned
- sequentially address the modules (e.g., Logical Address 112, 113, 114, etc.)
- set lowest addressed module to a logical address that is a multiple of 8 (see the HP 75000 Series B Installation and Getting Started Guide, or other appropriate manual, for more information).

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Chapter 4
Understanding the HP E1346A Multiplexer

Using This Chapter

This chapter explains techniques to scan the channels of the 48-Channel Single Ended Relay Multiplexer Module. This chapter contains the following sections:

- Commands for Scanning Switchbox Channels . . . . . Page 33
- Using Scanning Trigger Sources . . . . . Page 33
- Using the Scan Complete Bit. . . . . Page 38

Commands for Scanning Switchbox Channels

Scanning multiplexer channels consists of sequentially closing a set of channels. Available for the multiplexers are single, multiple (2 to 32767), or continuous scanning modes. See Figure 4-1 for the scanning commands.

Using Scanning Trigger Sources

The TRIG:SOUR command specifies the source to advance the channel list. Use the TRIG command to advance the channel list while in the TRIG:SOUR BUS or TRIG:SOUR HOLD trigger source. To enable the HP E1300/E1301 Mainframe "Trig Out" port, use the OUTP command. Figure 4-2 shows the trigger sources. The sources are also used in other HP VXIbus mainframes with HP command modules that have "Trig Out" ports.

Scanning with External Instruments

The examples on pages 4-4 and 4-5 show different ways to scan channels of a switchbox in an HP E1300/E1301 Mainframe. The operation is similar to other HP VXIbus mainframes with HP command modules that have "Trig Out" and "Event In" ports.

The computer used in the examples is an HP Series 200/300 used 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
- HP-IB primary address of 09 for the HP E1300/E1301 Mainframe
- HP-IB primary address of 22 for the HP 3457A Multimeter
- HP-IB secondary address of 14 for the multiplexer module

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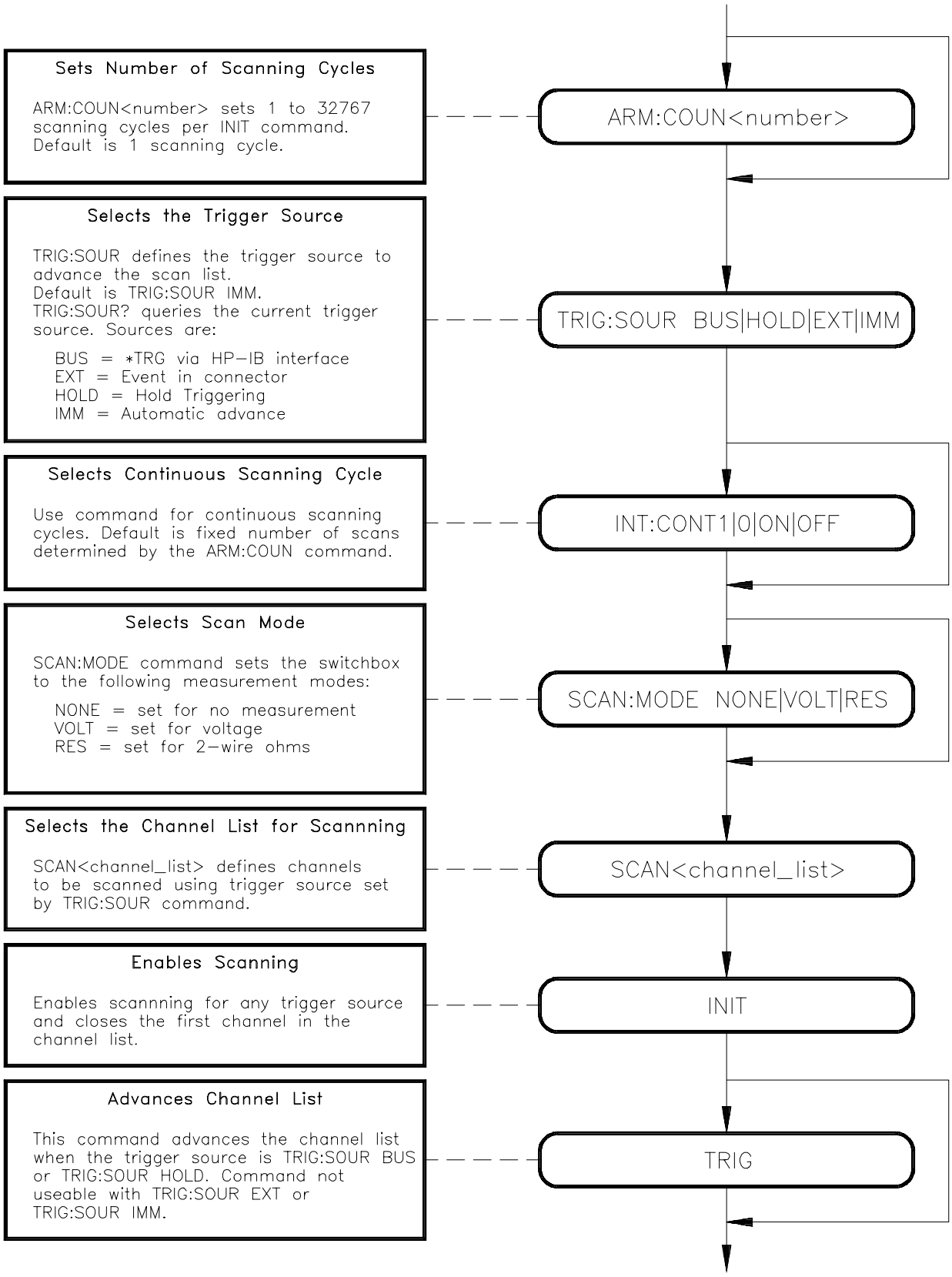


Figure 4-5. Scanning Commands

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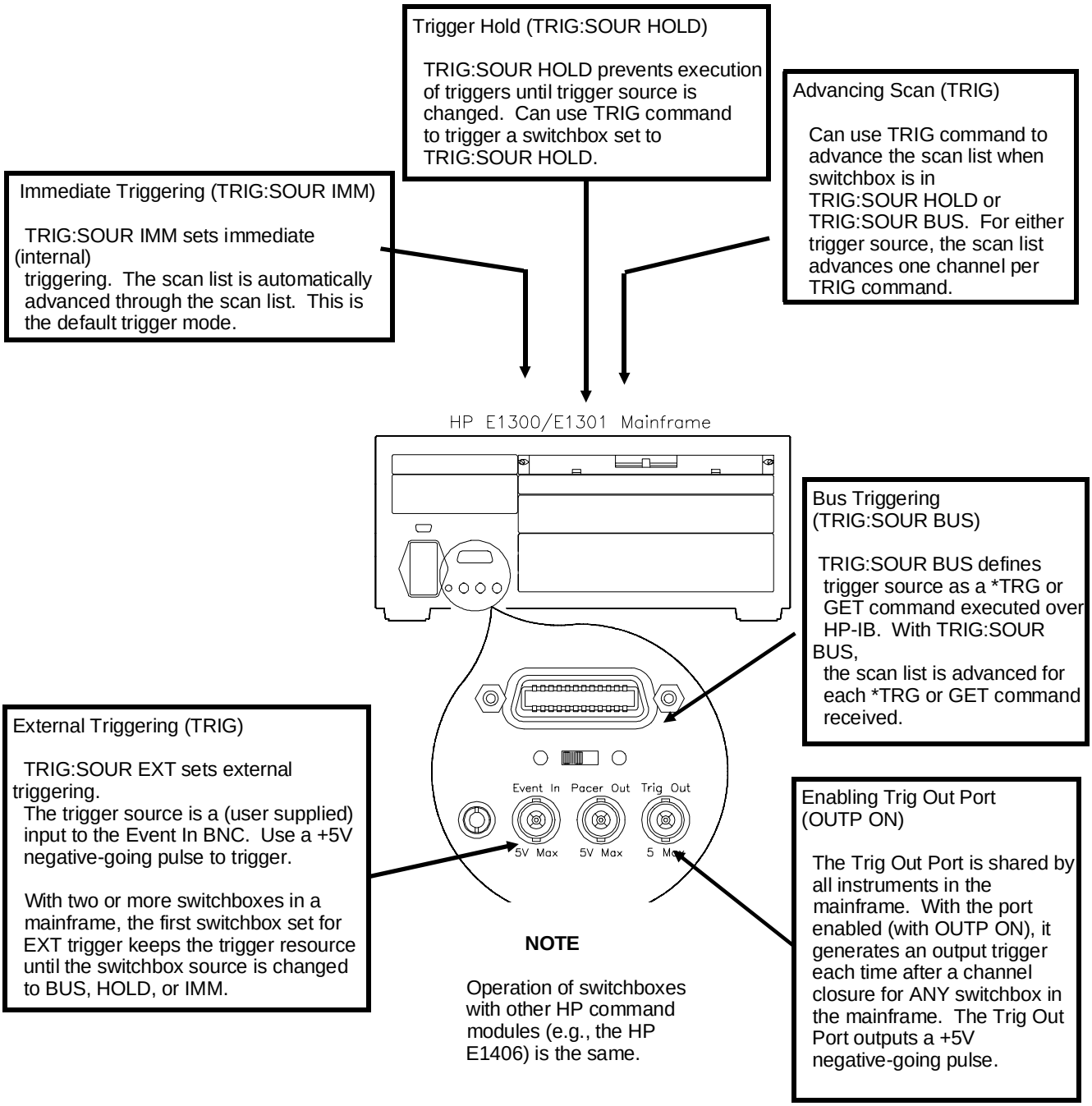


Figure 4-2. Trigger Sources for Scanning

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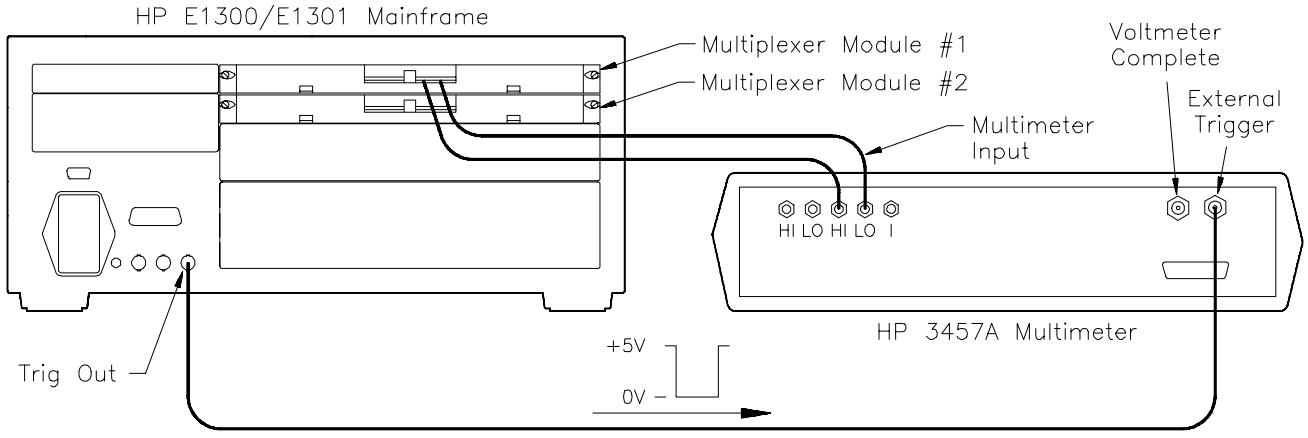
Example: Scanning With External Devices

This example uses the mainframe "Trig Out" port to synchronize the multiplexer to an HP 3457A Digital Multimeter. See the following figure for typical connections.

For this example, use the trigger output pulse of the mainframe "Trig Out" port to trigger the multimeter via its External Trigger port. The sequence of operation is:

1. INIT (line 70) closes channel number 100.
2. The channel closure causes a trigger output from the "Trig Out" port.
3. The trigger causes the multimeter to make a measurement.
4. Measurement result is sent to the computer (lines 80 to 100).
5. TRIGGER command (line 110) advances the channel list to the next channel.
6. Steps 2-5 are repeated for channels 101 through 115.

```
10  OUTPUT 722;"TRIG EXT;DCV"          ! Sets multimeter to external
                                       trigger and to measure dc volts
20  OUTPUT 70914;"OUTP ON"             ! Enables "Trig Out" port
30  OUTPUT 70914;"TRIG:SOUR BUS"       ! Sets switchbox to receive Bus
                                       triggers
40  OUTPUT 70914;"SCAN  (@100:247)"    ! Selects the channel list for
                                       scanning
50  OUTPUT 70914;"INIT"                ! Starts scanning cycle
60  FOR I=1 TO 96                      ! Start count loop
70  ENTER 722;A                        ! Enter reading into variable A
80  PRINT A                            ! Print reading in variable A
90  TRIGGER 70914                      ! Trigger the switchbox to advance
                                       the channel list
100 NEXT I                             ! Increment count
110 END
```



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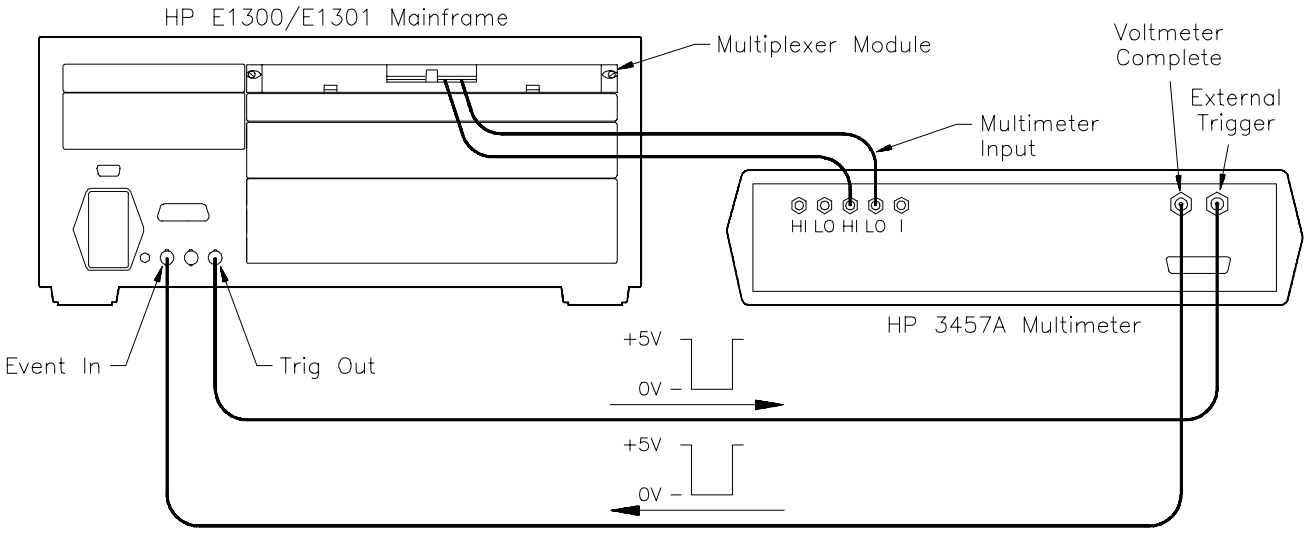
Example: Scanning Using "Trig Out" and "Event In" Ports

This example uses the mainframe "Trig Out" and "Event In" ports to synchronize the multiplexer to an HP 3457A Digital Multimeter. See the following figure for typical connections.

For this example, use the trigger output pulse of the mainframe "Trig Out" port to trigger the multimeter via its "EXTERNAL TRIGGER" port. Note that the pulse output from the multimeter's "VOLTMETER COMPLETE" port triggers the switchbox to advance the channel list. Use the multimeter's reading storage capability to store readings. The sequence of operation is:

1. INIT (line 50) closes channel number 100.
2. The channel closure causes a trigger output from the "Trig Out" port.
3. The trigger causes the multimeter to make a measurement.
4. Measurement result is stored into multimeter memory.
5. Trigger is output from multimeter's "VOLTMETER COMPLETE" port.
6. Trigger to "Event In" port advances the channel list to the next channel.
7. Steps 2-5 are repeated for channels 101 through 115.

```
10  OUTPUT 722;"TRIG EXT;DCV;MEM FIFO" ! Sets multimeter to external
                                       trigger; to measure dc volts, and
                                       store readings
20  OUTPUT 70914;"OUTP ON"             ! Enables "Trig Out" port
30  OUTPUT 70914;"TRIG:SOUR EXT"       ! Sets switchbox to receive external
                                       triggers
40  OUTPUT 70914;"SCAN  (@100:147)"    ! Selects the channel list (channels
                                       100 to 115)
50  OUTPUT 70914;"INIT"                ! Starts scanning cycle
60  END
```



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Using the Scan Complete Bit

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

When enabled by the STAT:OPER:ENAB 256 command, the Scan Complete Bit will be reported as bit 7 of the Status Register. Use the HP-IB Serial Poll or the IEEE 488.2 Common Command *STB? to read the Status Register. When bit 7 of the status Register is enabled by the *SRE 128 Common Command to assert an HP-IB Service Request (SRQ), you can interrupt the controller when the Scan Complete Bit is set, after a scanning cycle completes. This allows the controller 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 the example is an HP Series 200/300 used with HP BASIC as the program language. The computer interfaces with the mainframe over HP-IB. The HP-IB select code is 7, the HP-IB primary address is 09, and the HP-IB secondary address is 14.

Example: Scan Complete Interrupt

```
10  OUTPUT 70914;"*CLS"                          ! Clear all switchbox status structure
20  OUTPUT 70914;"STAT:OPER:ENAB 256" ! Enable Scan Complete Bit to set bit 7 in Status Register
30  OUTPUT 70914;"*SRE 128"                      ! Enable bit 7 of Status Register to assert SRQ
40  OUTPUT 70914;"TRIG:SOUR EXT"                 ! Set to external trigger mode
50  OUTPUT 70914;"SCAN  (@100:147)"              ! Select channels to be scanned
60   OUTPUT 70914;"INIT"                         ! Start scanning cycle
70  WHILE NOT BIT(SPOLL(70914),7)                ! Waiting for scan complete
80  PRINT "DO OTHER OPERATION HERE"              ! Enter program lines for computer to do other operations
90  END WHILE
100  PRINT "INTERRUPT GENERATED"                 ! Program goes to this line after interrupt is generated by a completed scanning cycle
110  END
```


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Chapter 5

HP E1346A Multiplexer Command Reference

Using This Chapter

This chapter describes Standard Commands for Programmable Instruments (SCPI) and summarizes IEEE 488.2 Common (*) commands applicable to the 48-Channel Single Ended Relay Multiplexer Module.

- Command Types . . . . . Page 39
- SCPI Command Reference . . . . . Page 41
- IEEE 488.2 Common Commands . . . . . Page 59
- Command Quick Reference . . . . . Page 60

Command Types

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

Common Command Format

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

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

SCPI Command Format

SCPI commands perform functions like closing switches, or 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.

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Command Separator

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

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

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

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated form or the entire command.

For example, if the command syntax shows MEASure, then MEAS and MEASURE are both acceptable forms. Other forms of MEASure, such as MEASU or MEASUR will generate an error. You may use upper or lower case letters. Therefore, MEASURE, measure, and MeAsUrE are all acceptable.

Implied Commands

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

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

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

```
SOUR:PULS:COUN 25    or    PULS:COUN 25
```


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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 value is returned. If you send the MIN parameter, the command returns the minimum count available. If you send the MAX parameter, the command returns the maximum count available. Be sure to place a space between the command and the parameter.

Linking Commands

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

```
*RST;OUTP ON      or      TRIG:SOUR HOLD;*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) for the multiplexer module. Commands are listed alphabetically by subsystem and also within each subsystem.

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ABORt

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

Subsystem Syntax

ABORt

Comments

- ABORt Operation invalidates the current channel list and sets ARM:COUNt 1 (one scanning cycles per INITiate command), sets INITiate CONTinuous OFF (no continuous scanning cycles), and sets TRIGger:SOURce IMMediate (continuous internal triggering).
- **Stopping Scans Enabled from Interface:** When a scan is enabled from the interface, use an interface CLEAR command or the HP E1301 front panel "Reset Instr" or "Clear Instr" key to stop the scan.

  When the scan is enabled from the interface and the trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD, use ABORt or the HP E1301 front panel "Reset Instr "or "Clear Instr" keys to stop the scan.
- **Stopping Scans Enabled from Front Panel:** When a scan is enabled from the HP E1301 front panel execute *RST over the interface or the front panel "Reset Instr" or "Clear Instr" keys to stop the scan.
- **Related Commands:** ARM, INITiate:CONTinuous, [ROUTe:]SCAN, TRIGger.

Example

Stopping a Scan with ABORt

```
TRIG:SOUR BUS                 Bus is trigger source
INIT:CONT ON                  Set continuous scanning
SCAN  (@100:147)              Sets channel list
INIT                          Starts scanning cycle
 .
ABOR                          Aborts scan in progress
```


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ARM

The ARM subsystem selects the number of scanning cycles (1 through 32767) for each 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 INIT command and INIT:CONT OFF is set.

Parameters

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

Comments

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

Example

Setting Ten Scanning Cycles

```
ARM:COUN 10                 Set 10 scanning cycles
SCAN  (@100:147)            Sets channel list
INIT                        Starts scanning cycle
```

:COUNt?

ARM:COUNt? [MIN |MAX] returns current number of scanning cycles set by ARM:COUNt. A value is supplied if no MIN or MAX parameter is sent. With MIN or MAX passed as parameters, MIN returns 1 and MAX returns 32767.

Parameters

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

Comments

- **Related Commands:** INITiate:IMMediate

Example

Query Number of Scanning Cycles

```
ARM:COUN 10                 Sets 10 scanning cycles
ARM COUN?                   Query number of scanning cycles;
                            returned value is 10
```


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DISPlay

The DISPlay subsystem monitors the channel state of a selected module (or card) in a switchbox. Only operates with mainframes that have a display, such as the HP 75000 Series B Mainframe (HP Model Number E1301).

Subsystem Syntax

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

MONitor[:STATe]

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

Parameters

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

Comments

- **Monitoring Switchbox Channels:** DISPlay[:STATe] ON or DISPlay[:STATe] 1 turns the monitor mode on to show the channel state of the selected module. DISPlay[:STATe] OFF or DISPlay[:STATe] 0 turns the monitor mode off.
- **Selecting the Module to be Monitored:** Use the DISPlay:MONitor:CARD <*number*>|AUTO command to select the module.
- **Monitor Mode on an HP 1301 Mainframe Display:** The following shows the monitor mode on the display of an HP E1301 Mainframe

  :Switch_112: Chan: 1 93

  The example shows that channels 01 and 93 (DT Tree Switch) are closed.
- ***RST Condition:** DISPlay:MONitor[:STATe] OFF |0

Example

Enabling the Monitor Mode

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


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MONitor:CARD

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

Parameters

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

Comments

- **Selecting a Specific Module to be Monitored:** Send the card number in a switchbox with the DISPlay:MONitor:CARD command.
- **Selecting the Present Module to be Monitored:** 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
```


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INITiate

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

Subsystem Syntax

```
INITiate
    :CONTinuous ON |OFF |1 |0
    :CONTinuous?
    [:IMMediate]
```

:CONTinuous

INITiate:CONTinuous ON |OFF |1 |0 enables or disables continuous scanning cycles for the switchbox.

Parameters

Parameter Name	Parameter Type	Range of Values
ON |OFF |1 |0	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.
- **Stopping Continuous Scans:** See the ABORt command.
- **Related Commands:** ABORt, ARM:COUNt, TRIGger, TRIGger:SOURce
- ***RST Condition:** INITiate:CONTinuous OFF

Example

Enabling Continuous Scans

```
INIT:CONT ON                 Enables continuous scanning
SCAN  (@100:147)             Sets channel list
INIT                         Starts scanning cycle
```


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:CONTinuous?

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

Example

Query Continuous Scanning State

```
INIT:CONT ON          Enables 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 advances 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 [ROUT:]SCAN command).
- **Stopping Scanning Cycles:** See the ABORt command.

Example

Enabling a Single Scan

```
SCAN  (@100:147)      Sets channel list
INIT                  Starts scanning cycle
```


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OUTPut

The OUTPut subsystem enables or disables the "Trig Out" BNC port of the HP E1300/E1301 Mainframe.

Subsystem Syntax

```
OUTPut
    [:STATe] ON |OFF |1 |0
    :STATe?
```

[:STATe]

OUTPut[:STATe] ON |OFF |1 |0 enables/disables the "Trig Out" BNC port on the HP E1300/E1301 Mainframe rear panel. OUTPut[:STATe] ON |1 enables the port and OUTPut[:STATe] OFF |0 disables the port.

Parameters

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

Comments

- **Enabling "Trig Out" Port:** When enabled, the "Trig Out" BNC is pulsed each time a channel is closed during scanning. When disabled, the "Trig Out" BNC is not pulsed.
- **Output Pulse:** The pulse is a -5 V negative going pulse.
- **"Trig Out" Port Shared by Switchboxes:** When enabled, the "Trig Out" BNC may be pulsed by any switchbox each time a channel is closed in a switchbox during scanning. To disable the output for a specific switchbox, send the OUTPut[:STATe] OFF or OUTPut[:STATe] 0 command for that switchbox.
- **Related Commands:** [ROUTE:]SCAN, TRIGger:SOURce.
- ***RST Condition:** OUTPut[:STATe] OFF (port disabled).

Example

Enabling "Trig Out" BNC Port

```
OUTP ON                    Enables "Trig Out" BNC for pulse output
```

:STATe?

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

Example

Query "Trig Out" BNC Port State

```
OUTP ON                    Enables "Trig Out" BNC for pulse output
OUTP:STAT?                 Query port enable state
```


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[ROUTe:]

The ROUTe subsystem controls switching and scanning operations for the multiplexer modules in a switchbox.

Subsystem Syntax

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

CLOSe

[ROUTe:]CLOSe *<channel_list>* closes multiplexer channels specified in the *channel_list*. The *channel_list* is in the form (@ccnn), (@ccnn,ccnn), or (@ccnn:ccnn) where cc = card number (00-99) and nn = channel number (00-47).

Parameters

Parameter Name	Parameter Type	Range of Values
<channel_list>	numeric	cc00 - cc47

Comments

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

  Closure order for multiple channels with a single command is not guaranteed.
- **Closing the DT Tree Switch:** Use channel number 93 to close the DT Tree Switch.
- **Related Commands:** [ROUTe:]OPEN, [ROUTe:]CLOSe?
- ***RST Condition:** All multiplexer channels are open.

Example

Closing Multiplexer Channels

This example closes channel 00 of a card number 1 multiplexer module and channel 47 of a card number 2 multiplexer module in a single switchbox.

```
CLOS (@100,247)
```

100 closes channel 00 of multiplexer #1; 247 closes channel 47 of multiplexer #2

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CLOSe?

[ROUTe:]CLOSe? <*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 closed or returns 0 if the channel is open.

Comments

- **Query is Software Readback:** The [ROUTe:]CLOSe? command returns the current software state of the channel specified. It does not account for relay hardware failures.

Example

Query Multiplexer Channel Closure

```
CLOS  (@100,247)
```

100 closes channel 00 of multiplexer #1; 247 closes channel 47 of multiplexer #2

```
CLOS?  (@247)
```

Query channel 247

OPEN

[ROUTe:]OPEN <*channel_list*> opens multiplexer channels specified in the *channel_list*. The *channel_list* is in the form (@ccnn), (@ccnn,ccnn), or (@ccnn:ccnn) where cc = card number (00-99) and nn = channel number (00-47).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00 - cc47

Comments

- **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 for multiple channels with a single command is not guaranteed.
- **Opening the DT Tree Switch:** Use channel numbers 93 to open the DT Tree Switch.
- **Related Commands:** [ROUTe:]CLOSe, [ROUTe:]OPEN?
- ***RST Condition:** All multiplexer channels are open.

Example

Opening Multiplexer Channels

This example opens channel 00 of a card number 1 multiplexer module and channel 47 of a card number 2 multiplexer module in a single switchbox.

```
OPEN  (@100,247)
```

100 opens channel 00 of multiplexer #1; 247 opens channel 47 of multiplexer #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 open or returns 0 if the channel is closed.

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Comments

- Query is Software Readback: The [ROUTe:]OPEN? command returns the current software state of the channel specified. It does not account for relay hardware failures.

Example

Query Multiplexer Channel Open State

```
OPEN  (@100,247)        100 opens channel 00 of multiplexer #1; 247 opens channel 47 of multiplexer #2
OPEN?  (@247)           Query channel 247
```

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 (00-47).

Parameters

Parameter Name	Parameter Type	Range of Values
<*channel_list*>	numeric	cc00 - cc47

Comments

- **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 advances the scan through the channel list.
- **Stopping Scan:** See the ABORt command.
- **Closing the DT Tree Switch:** See the [ROUTe:]SCAN:MODE RES command.
- **Related Commands:** TRIGger, TRIGger:SOURce.
- ***RST Condition:** All channels open.

Example

Scanning Using External Devices

The following example shows how to scan channels using the HP E1300/E1301 Mainframe via HP-IB and an HP 3457A Digital Multimeter. This example uses the mainframe "Trig Out" port to synchronize the multiplexer module in a switchbox to the multimeter. The trigger pulse form the port triggers the multimeter for a measurement. See chapter 3 for typical user connections to the multiplexer.

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 E1300/E1301 Mainframe and HP 3457A Multimeter, respectively, and an HP-IB secondary address of 14 for the switchbox.

```
10  OUTPUT 722;"TRIG EXT;DCV"     Sets multimeter to external trigger and to measure dc volts
20  OUTPUT 70914;"OUTP ON"        Enables "Trig Out" port
```


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```
30  OUTPUT 70914;"TRIG:SOUR BUS"      Sets switchbox to receive Bus triggers
40  OUTPUT 70914;"SCAN  (@100:147)"   Selects the channel list
50  OUTPUT 70914;"INIT"               Starts scanning cycle
60  FOR I=1 TO 48                     Start count loop
70  ENTER 722;A                       Enter reading into variable A
80  PRINT A                           Print reading in variable A
90  TRIGGER 70914                     Trigger the switchbox to advance the channel list
100 NEXT I                            Increment count
110 END
```

SCAN:MODE

[ROUTe:]SCAN:MODE NONE |VOLT |RES sets the multiplexer channels defined by the [ROUTe:]SCAN <*channel_list*> command for None, Volts, or 2-wire Ohms measurements.

Parameters

Parameter Name	Parameter Type	Range of Values
NONE |VOLT |RES	discrete	NONE |VOLT |RES

Comments

- **Order of Command Execution:** The [ROUTe:]SCAN:MODE command must be executed before the [ROUTe:]SCAN <***channel_list***>command.
- **NONE Mode Description:** Channel list is setup for a voltage measurement. This is the default setting of the multiplexer module and it is therefore not required to send this command for a voltage measurement.
- **VOLT Mode Description:** See the NONE Mode description above.
- **RES Mode Description:** Channel list is setup for 2-wire ohms measurements. Automatically closes the DT Tree Switch (channel 93) for ohms measurements.
- ***RST Condition:** [ROUTe:]SCAN:MODE NONE.

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Example Selecting the 2-Wire Ohms Mode

```
TRIG:SOUR EXT          Selects external trigger source
SCAN:MODE RES          Selects the 2-wire ohms scanning mode
SCAN  (@100:147)       Sets channel list
INIT                   Starts scanning cycle
```

SCAN:MODE?

[ROUTe:]SCAN:MODE? returns the current state of the scan mode. The command returns NONE, VOLT, or RES if the scan mode is in the NONE, VOLT, or RES mode, respectively.

Example Query Scan Mode

Since this example selects the RES (ohms) mode, the query command returns RES.

```
SCAN:MODE RES          Selects the 2-wire ohms scanning mode
SCAN:MODE?             Query the scanning mode
```


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STATus

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

Subsystem Syntax

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

:OPERation[:EVENt]?

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

Comments

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

Example Reading the Operation Status Register after a Scanning Cycles

```
STAT:OPER?                          Returns the bit values of the
                                    Standard Operation Status Register
read and print the register value   +256 shows bit 8 is set to 1;
                                    +0 shows bit 8 is set to 0
```

:OPERation:ENABle

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

Parameters

Parameter Name	Parameter Type	Range of Values
number	numeric	1 - 32768

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 7 of the Status Register
```


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SYSTem

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

Subsystem Syntax

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

:ERRor?

SYSTem:ERRor? returns the error numbers and corresponding error messages in the error queue of a switchbox. See Appendix C for a listing of 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. The error number is always a negative number. Each error message can be up to 255 characters long.
- *Clearing the Error Queue:* An error number/message is removed from the queue each time the SYSTem:ERRor? command is sent. The errors are cleared first-in, first-out. When the queue is empty, each following SYSTem:ERRor? command returns 0, "No error". To clear all error numbers/messages in the queue, execute the *CLS command.
- *Maximum Error Numbers/Messages in the Error Queue:* The queue holds a maximum of 30 error numbers/messages for each switchbox. If the queue overflows, the last error number/message in the queue is replaced by -350, "Too many errors". The least recent error numbers/messages remain in the queue and the most recent are discarded.

Example

Reading the Error Queue

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

:CDEScription?

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

Parameters

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

Comments

- **Multiplexer Module Description:** The SYSTem:CDESciption? <*number*>command returns:
  "48 Channel Single-Ended Relay Mux"

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Example Reading the Description of a Card #1 Module

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

:CTYPe?

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

Parameters

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

Comments

- **Multiplexer Module Model Number:** The SYSTem:CTYPe? <*number*>command returns:
  HEWLETT-PACKARD,E1346A,0,A.01.00

  Note: The first number after the E1346 model number is the serial number of the module (always 0); the module revision code follows the serial number.

Example Reading the Model Number of a Card #1 Module

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

:CPON

SYSTem:CPON<*number*>|ALL opens all channels of a selected or all modules (cards) in a switchbox.

Parameters

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

Comments

- **Differences between *RST and CPON:** SYSTem:CPON only opens all channels of a selected or all modules in a switchbox. *RST opens all channels of all modules in a switchbox and also sets the trigger, etc. modes to the power-on states.

Example Opening all Channels of a Card #1 Module

```
SYST:CPON 1                     Opens all channels of module #1
```


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TRIGger

The TRIGger subsystem commands controls the triggering operation of the multiplexer modules in a switchbox.

Subsystem Syntax

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

[:IMMediate]

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

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.

Example

Advancing Scan using the TRIGger Command

```
TRIG:SOUR HOLD          Sets trigger source to hold
SCAN  (@100:147)        Sets channel list
INIT                    Starts scanning cycle
loop statement          Start count loop
TRIG                    Advances channel list
increment loop          Increment count loop
```

:SOURce

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

Parameters

Parameter Name	Parameter Type	Range of Values
BUS	discrete	*TRG command
EXTernal	discrete	Event In BNC port
HOLD	discrete	Hold triggering
IMMediate	discrete	Continuous triggering

Comments

- **Enabling the Trigger Source:** The TRIGger:SOURce command only selects the trigger source. The INIT[:IMMediate] command enables the trigger source.
- **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.

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- **Using External Trigger Inputs:** With TRIGger:SOURce EXTernal selected, only one switchbox at a time can use the external trigger input at the HP E1300/E1301 Mainframe "Event In" BNC port. The trigger input is assigned to the first switchbox that requested the external trigger source.
- **Assigning External Trigger:** A switchbox assigned with TRIGger:SOURce EXTernal remains assigned at that source until it receives a command to change the source to BUS, HOLD, or IMMediate. When the source is changed, the external trigger source is available to another switchbox (with a TRIGger:SOURce EXTernal command). Another switchbox cannot receive an external trigger source if the source is already assigned, or an error is generated.
- **Using Bus Triggers:** To trigger the switchbox with TRIGger:SOURce BUS selected, use the IEEE 488.2 *TRG command or the HP-IB Group Execute Trigger (GET) command.
- **"Trig Out" Port Shared by Switchboxes:** See 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 E1300/E1301 Mainframe "Event In" BNC port.

```
TRIG:SOUR EXT          Sets trigger source to external
SCAN (@100:147)        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 external
SCAN  (@100:147)       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, or IMM for trigger sources BUS, EXTernal, HOLD, or IMMediate, respectively.

Example Query Trigger Source

```
TRIG:SOUR EXT          Sets trigger source to external
TRIG:SOUR?             Query trigger source; returns EXT
```


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IEEE 488.2 Common Commands

The following table lists the IEEE 488.2 Common (*) Commands that the HP E1346A 48-Channel Single Ended Relay Multiplexer Module accepts. The operation of some of these commands is described in Chapter 4 of this manual. For more information on Common Commands, refer to the HP 75000 Series B Mainframe (HP Model Number E1300/E1301) User's Manual or the ANSI/IEEE Standard 488.2-1987.

Command	Title	Description
*IDN? *RST *TST?	Identification Reset Self-Test	Returns identification string of the switchbox. Opens all channels, and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF. Always returns 0.
*OPC *OPC? *WAI	Operation Complete Operation Complete Query Wait to Complete	See note below. See note below. See note below.
*CLS *ESE *ESE? *ESR? *SRE *SRE? *STB?	Clear status Event status enable Event status enable query Event status register query Service request enable Service request enable query Read status byte query	Clears all status registers (see STATus:OPERation[:EVENt]?). See note below. See note below. See note below. Enables status register bits (see Chapter 4 for operation). See note below. See note below.
*TRG	Trigger	Triggers the switchbox to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS.
*RCL *SAV	Recall instrument state Store instrument state	See note below. See note below.
Note: These commands apply to many instruments and are not documented in detail here. See the HP 75000 Series B E1300/E1301 Mainframe User's Manual or the ANSI/IEEE Standard 488.2-1987 for more information.		

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Command Quick Reference

The following tables summarize SCPI and IEEE 488.2 Common (*) commands for the 48-Channel Single Ended Relay Multiplexer Module used in a switchbox.

SCPI Commands Quick Reference

Command		Description
ABORt		Abort a scan in progress.
ARM	:COUNt *<number>* :COUNt? [MIN |MAX]	Multiple scans per INIT command. Query number of scans.
INITiate	:CONTinuous ON |OFF [:IMMediate]	Enables/disables continuous scanning. Starts a scanning cycle.
DISPlay	:MONitor[:STATe] *<boolean>* :MONitor:CARD*<number>*|AUTO	Selects monitor mode. Selects module to be monitored.
OUTPut	[:STATe] ON |OFF	Enables/disable s "Trig Out" pulse.
[ROUTe:]	CLOSe *<channel _list>* CLOSe? *<channel _list>* OPEN *<channel_list>* OPEN? *<channel _list>* SCAN *<channel_list>* SCAN:MODE NONE |VOLT |RES	Close channel(s). Query channel(s) closed. Open channel(s). Query channel(s) opened. Define channels for scanning. Selects appropriate Channel Switches for Volts or 2-wire ohms measurements.
STATus	:OPERation[:EVENt]? :OPERation:ENABle	Returns status of Operation Status Register. Enables the Operation Status Register to set a bit in theStatus Register.
SYSTem	:ERRor? :CDEScriprion? *<number>* :CTYPe? *<number>* :CPON *<number>*|ALL	Returns error number/message in a switchbox Error Queue. Returns description of module in a switchbox. Returns the module type. Sets specified module to its power-on state.
TRIGger	[:IMMediate] :SOURce BUS :SOURce EXTernal :SOURce HOLD :SOURce IMMediate :SOURce?	Causes a trigger to occur. Trigger source is *TRG. Trigger source is "Event In" BNC. Hold off triggering. Continuous (internal) triggers. Query scan trigger source.

IEEE 488.2 Common Commands Quick Reference

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

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Appendix A
HP E1346A Multiplexer Specifications

Maximum Voltage:
Terminal to Terminal: 120 V DC or
AC RMS; 170 V Peak

Terminal to Chassis: 120 V DC or
AC RMS; 170 V Peak

Maximum Current per Channel:
50 mA (non-inductive)

Maximum Power per Channel: 1 VA

Thermal Offset per Channel:
< 50 µV (differential H-L)

Closed Channel Resistance:
100 Ω ±10% (the value of the protection resistors)

Insulation Resistance (Between any two points):
$>10^9$ Ω (at 40° C, 65% RH)

Relay Life:
@ No load: 10^8 Operations
@ Rated load: 10^7 Operations

Bandwidth (-3dB):
Z(source) =Z(load) =50 Ω
(Protection resistors shorted) ≥10 MHz

Channel-Channel Crosstalk

(Typical)	**(50 Ω Source & Load):**
1 kHz	-70 dB
10 kHz	-70 dB
100 kHz	-70 dB
1 MHz	-50 dB
10 MHz	-20 dB

Closed Channel Capacitance:
High-Low <150 pF
Low-Guard <150 pF
Guard-Chassis <2000 pF

Maximum Screw Term. Wire Size: 16 AWG

Module Size/Device Type: B, register-based

Connectors Used: P1

No. Slots: 1

VXIbus Interface Capability: Interrupter, D16

Interrupt Level: 1-7, selectable

Power Requirements:

Voltage	+5	+12
Peak module current, IPM (A):	0.20	0.13
Dynamic module current, IDM (A):	0.01	0.01

Watts/Slot: 1.0

Cooling/Slot: 0.02 mm H_2O @ 0.10 liter/sec

Humidity: 65% 0° to 40° C

Operating Temperature: 0° to 55° C

Storage Temperature: -40° to 75° C

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

Net Weight (kg): 0.9

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Relay Life

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

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

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

End-of-Life Detection

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

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

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

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

Replacement Strategy

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

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

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Appendix B
HP E1346A Multiplexer Registers

Register Definitions

The 48-Channel Relay Multiplexer Module is a register based device. See Figure B-1 for register definitions.

Register Addressing

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 64 byte (32 word) block of addresses. The multiplexer uses six of the 64 addresses allocated.

Figure B-1 shows the register address location within A16. Figure B-2 shows the location of A16 address space in the HP E1300/01 mainframe and HP E1406 Command Module.

The Base Address

When you are reading or writing to a multiplexer register, a hexadecimal or decimal register address is specified. This address consists of a A16 base address plus a register offset or register number.

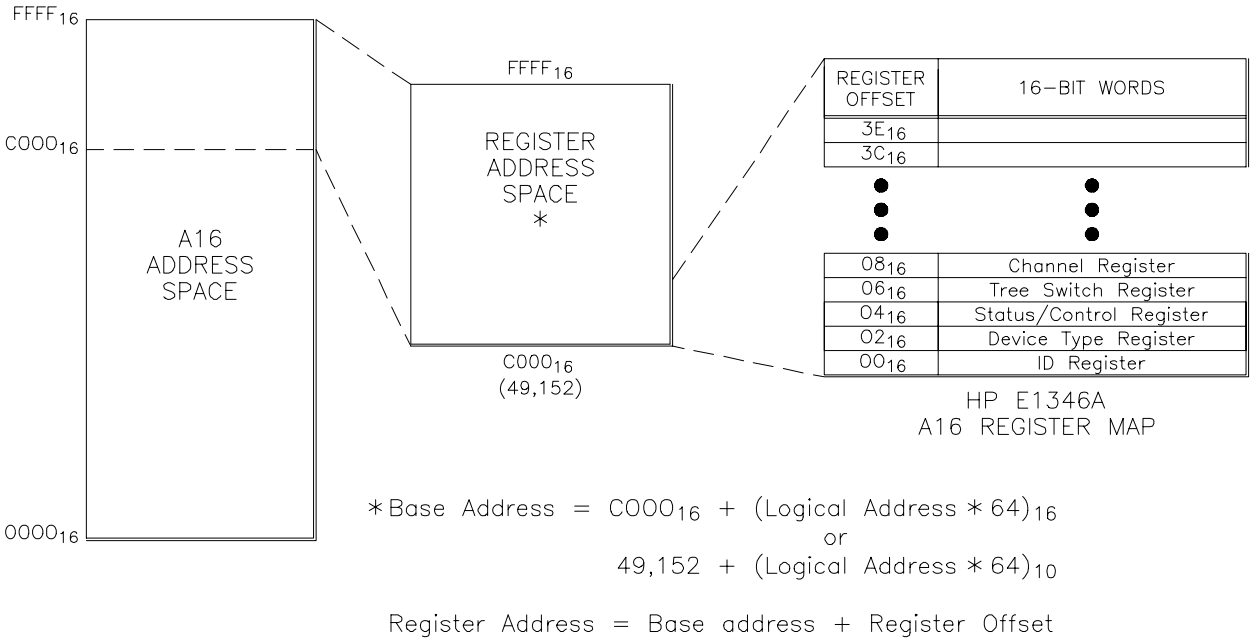


Figure B-1. HP E1346A Multiplexer Registers within A16 Address Space.

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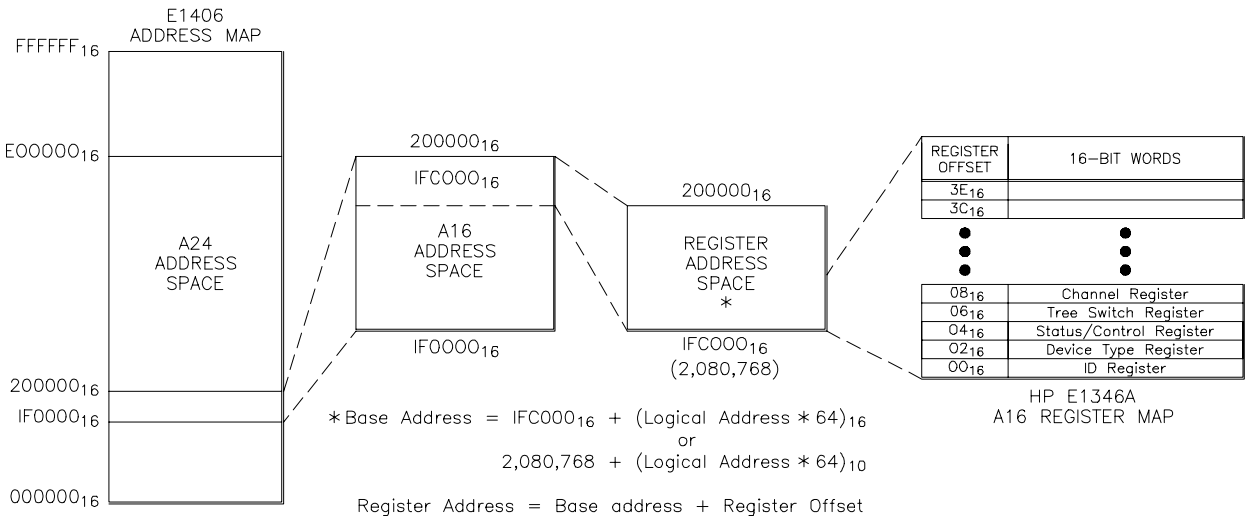


Figure B-2. Multiplexer Registers within HP E1300/E1406 A16 Address

The A16 base address used in register-based programming depends on whether the A16 address space is located inside the E1300(01) Mainframe/E1406 Command Module or elsewhere (e.g. embedded computer). Figures B-1, B-2, and Table B-1 enable you to determine the base address for the following computer configurations:

- E1300/E1301 Instrument BASIC (IBASIC)
- External Computer over HP-IB to E1300/E1301 Mainframe or E1406 Command Module
- V/382 Embedded Controller (C-Size system)

Computer Configurations

This section contains performance and functional information on the computer configurations that can be used with register-based programming.

Throughput Speed

Throughput speed is based on the amount of command parsing and whether the registers are accessed from the VXI backplane or from the HP-IB. The computer configurations which allow faster throughput relative to each other are summarized on page B-3.

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1. HP E1499A V/382 Controller with READIO and WRITEIO (register access is from VXI backplane).
2. E1300/01 IBASIC absolute addressing with READIO and WRITEIO (register access is from VXI backplane).
3. E1300/01 IBASIC select code 8 with READIO and WRITEIO (register access is from VXI backplane).
4. External Computer using DIAG:PEEK? and DIAG:POKE (register access is over HP-IB).
5. External Computer using VXI:READ? and VXI:WRITE (register access is over HP-IB).

Table B-1. Computer Configurations used with the HP E1346A.

Computer	Programming Method	Base Address
E1300/E1301 IBASIC (Absolute Addressing)	ReadIO (-9826, Base_addr +offset) WRITEIO -9826, Base_addr +offset: data (positive select code =byte read or write negative select code =word read or write)	Base_addr =$1FC000_{16}$ +$(LADDR *64)_{16}$ or =2,080,768 +(LADDR *64) offset =register offset (Figure B-1)
(Select Code 8)	READIO (8, Base_addr +reg number) WRITEIO 8, Base_addr +reg number; data	Base_addr =LADDR * 256 reg number =offset (Figure B-1)/2
External Computer (over HP-IB to E1300/1301 Mainframe or E1406 Command Module)	VXI:READ? logical_address, offset VXI:WRITE logical_address, offset, data DIAG:PEEK? Base_addr +offset, width DIAG:POKE Base_addr +offset, width, data	logical address setting (LADDR) offset =register offset (FIgure B-1) Base_addr =$1FC000_{16}$ +$(LADDR *64)_{16}$ or = 2,080,768 +(LADDR *64) offset =register offset (Figure B-1)
V/382 Embedded Computer (C-Size system)	READIO (-16, Base_addr +offset) WRITEIO -16, Base_addr +offset; data (positive select code =byte read or write negative select code =word read or write)	Base_addr =$C000_{16}$ +$(LADDR *64)_{16}$ or =49,152 +(LADDR *64) offset =register offset (Figure B-2)
LADDR : logical address. $(LADDR *64)_{16}$: multiply quantity, then convert to a hexadecimal number (e.g., 80 $*64)_{16}$ =1400_{16}. When using DIAG:PEEK? and DIAG:POKE, the width (number of bits) is 8 or 16.		

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Embedded Computer Programming (C-Size Systems)

If the E1346A multiplexer is part of a C-Size VXI system, the fastest throughput is achieved using an embedded computer. The embedded computer allows you to access the registers from the VXIbus backplane, and thus, there is no parsing of SCPI command headers.

IBASIC Programming

When the E1346A multiplexer is programmed using the E1300/E1301 Mainframe's Instrument BASIC (IBASIC), two methods of accessing the registers are through absolute addressing or using select code 8.

Absolute Addressing and Select Code 8

Absolute addressing is faster than select code 8 since the complete register address (including the A16 starting location $1FC000_{16}$) is specified. When select code 8 is used, the IBASIC processor must calculate the complete register address based on the logical address specified (Table B-1).

The Register Offset and Register Number

Depending on whether absolute addressing or select code 8 is used, either a register offset or register number is specified as part of the register address. Absolute addressing specifies a register offset, which is the register's location in the block of 64 address bytes. For example, the multiplexer's Channel Register has an offset of 08_{16}. When you write a command to this register, the offset is added to the base address to form the register address (using a logical address of 80):

register address =base address +register offset

$= 1FC000_{16} + (80 * 64)_{16} + 08_{16}$

$= 1FC000_{16} + 1400_{16} + 08_{16} =$ **$1FD408_{16}$**

or

$= 2{,}080{,}768 + (80 * 64) + 8$

$= 2{,}080{,}768 + 5120 + 8 =$ **2,085,896**

Using select code 8 requires that you specify a **register number**. The register number is the register offset/2. Referring to Figure B-1, the Channel register with an offset of 08, is register number 4.

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External Computer Programming

When the multiplexer is programmed by an external computer through the E1300/E1301 mainframe or E1406 Command Module, the registers are accessed using DIAG:PEEK? and DIAG:POKE, or VXI:READ? and VXI:WRITE.

DIAG:PEEK?/DIAG:POKE and VXI:READ?/VXI:WRITE

Throughput speed using DIAG:PEEK? and DIAG:POKE is faster than VXI:READ? and VXI:WRITE because the complete register address (including the A16 starting location $1FC000_{16}$) is specified. VXI:READ? and VXI:WRITE specify the device logical address and register offset only. Thus, the E1300/E1406 processor must calculate the complete register address which decreases throughput speed.

IBASIC programming using absolute addressing or select code 8 is faster than either DIAG:PEEK? and DIAG:POKE or VXI:READ? and VXI:WRITE because the registers are accessed from the VXIbus backplane rather than from the HP-IB. Also, READIO and WRITEIO are not parsed.

Reading the Registers

You can read the following multiplexer registers:

- ID Register (base $+00_h$)
- Device Type Register (base $+02_h$)
- Status Control Register (base $+04_h$)
- Tree Switch Registers (base $+06_h$)
- Channel Registers (base $+08_h$)

ID and Device Type Registers

ID Registers: Reading this register returns: $FFFF_h$. This shows Hewlett-Packard as the manufacturer and that the module is an A16 register based device.

Device Type Register: Reading this register returns:

48-Channel Relay Multiplexer: $FF08_h$.

Status Control Register

Each channel requires about 1 msec to close or open (2 msec for a close/open cycle). During this time, and also during a reset, the multiplexer is "busy". The status register returns the following:

"busy": $FFF7_h$
"not busy": $FFFF_h$

Tree Switch and Channel Registers

Always returns $FFFF_h$ regardless of channel/tree switch state.

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Writing to the Registers

You can write to the following multiplexer registers:

- Status Register (base $+04_h$)
- Tree Switch Registers (base $+06_h$)
- Channel Registers (base $+08_h$)

Status Control Register

Writing a "1" to bit 0 of this register resets the interface circuitry to its power-on state and opens all channels. This is the only allowable write to this register.

Bit 7 is the only bit that has meaning when reading this register. The busy bit will go true for about 1 msec after a write to either the Tree Switch Register or the Channel Registers. The transition of the busy bit from "busy" to "not busy" corresponds to a backplane interrupt occuring. A backplane interrupt always occurs after a channel write.

Tree Switches and Channel Registers

Writing a "1" to these registers closes the channel/tree switch and writing a "0" opens the channel/tree switch.

Resetting the Module

To reset the module:

1. Write a "1" to bit 0 of the Status Control Register
2. Wait 100 usec
3. Write a "0" to bit 0 of the Status Control Register

NOTE: The busy bit in this case doesn't indicate when the relays have settled.

Changing Channels

1. Write to the Tree Switch and Channel Registers.
2. Wait for busy to go to "1" or for a backplane interrupt.

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ID Register

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

* Returns $FFFF_h$ = Hewlett-Packard A16 only register-based

Device Type Register

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

* Returns: $FF08_h$ =48-Channel Single Ended Relay Multiplexer (E1346A)

Status/Control Register

b +04	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Undefined															R
Read**									B							

* R = Multiplexer reset to power-on state (all switches open) ** B = Status "busy" is true low in bit #7 ($FF7F_h$)

Tree Switch Register

b +06	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	Undefined												93	92	91	90
Read	Always returns $FFFF_h$															

* Write "1" closes switch, write "0" opens switch

Channel Register and Corresponding Tree Switch Bits

b +06	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*																90
b +08	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	CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00
b +06	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*															91	
b +08	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*	CH39	CH38	CH37	CH36	CH35	CH34	CH33	CH32	CH15	CH14	CH13	CH12	CH11	CH10	CH09	CH08
b +06	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write*														92		
b +08	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	CH23	CH22	CH21	CH20	CH19	CH18	CH17	CH16
Read	Always returns $FFFF_h$															

* Write "1" closes channel, write "0" opens channel

Figure B-3. Multiplexer Register Definitions

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Appendix C
HP E1346A Multiplexer Error Messages

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

Table C-1. 48-Channel Multiplexer Error Messages

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

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