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Edition 3
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## Documentation History

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

Edition 1 . . . . . September 1989
Edition 2 . . . . . March 1993
Edition 3 . . . . . December 1995

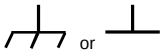
## Safety Symbols



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



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



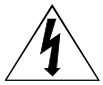

Frame or chassis ground terminal—typically connects to the equipment's metal frame.



Alternating current (AC).



Direct current (DC).



Indicates hazardous voltages.

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

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

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

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

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

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

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

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

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



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

**declares, that the product:**

**Product Name:** RF Multiplexer

**Model Number:** HP E1366A/E1367A

**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): 4kV CD, 8kV AD
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 (inclusive 93/68/EEC) and carries the "CE" mark accordingly.

Tested in a typical HP B-size mainframe.



**December 5, 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 +49-7031-143143).



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| • The documentation is clearly written. | O | O | O | O | O |
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# Chapter 1
# Getting Started with the HP E1366A/E1367A RF Multiplexers

## Using This Chapter

This chapter includes an RF multiplexer's description, addressing guidelines, and an example to check initial operation. Chapter contents are:


- Multiplexer Module Description . . . . . Page 11
- Programming the Multiplexer Module . . . . . Page 13
- Initial Operation . . . . . Page 15


## Multiplexer Module Description

The HP E1366A 50Ω RF Multiplexer (2 x 4:1) and the HP E1367A 75Ω RF Multiplexer (2 x 4:1) are VXIbus and VMEbus B-size register-based products which provide bidirectional switching and scanning for user inputs and outputs. The multiplexers can operate in a B-size VXIbus or VMEbus mainframe or (with an adapter) in a C-size VXIbus mainframe.

For the RF multiplexers, switching consists of connecting a channel to its common terminal. Scanning consists of connecting a series of channels (one at a time) to the appropriate common terminal.

### Basic Operation

The multiplexers consist of two banks of channels (bank 0 and bank 1) to form two 4:1 multiplexers. Bank 0 includes channels 00 through 03 and com 00. Bank 1 includes channels 10 through 13 and com 10. Sèe Figure 1-1 for a simplified switching diagram.

Each channel is switched (connected to its common) by closing the appropriate (nonlatching) relays. Channels 00 through 03 can be switched to com 00, and channels 10 through 13 can be switched to com 10. Only one channel in each bank can be connected to its common at a time.

User inputs and outputs to each channel are made through BNC connectors. When open (disconnected from common), each channel is terminated in its characteristic impedance (50Ω for the E1366A, 75Ω for the E1367A).

A termination resistor (50Ω for the HP E1366A or 75Ω for the HP E1367A) is mounted on each channel, but can be removed as desired. At power-on or reset, all channels are open and terminated in their characteristic impedance, and both commons are open.



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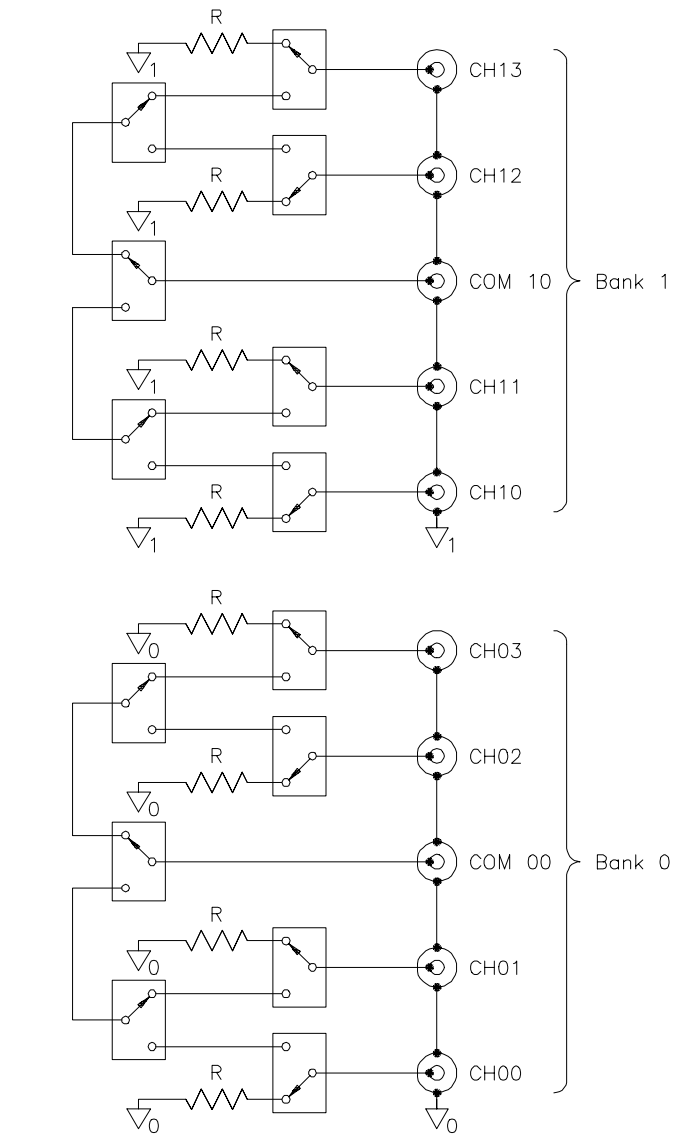



**Figure 1-1. Multiplexers Switching Diagram**



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### Typical Configuration

The multiplexer relays are configured in a " tree" structure which provides high isolation and low VSWR (voltage standing wave ratio). Each channel can switch user inputs up to 42 Vdc or 42 Vac peak. User input frequencies to the multiplexers can be from dc to 1.3 GHz.

The multiplexers can be configured for several arrangements, such as standard, tree, or matrix. You can use single scanning, multiple scanning, or continuous scanning for any configuration.

For a SCPI (Standard Commands for Programmable Instruments) environment, one or more multiplexers can be defined as a *switchbox* instrument. For a switchbox instrument, all multiplexer channels within the instrument can be addressed using a single interface address.

## Programming the Multiplexer Module

To program the RF multiplexers using SCPI, you must select the controller language, interface address, and SCPI commands to be used. Guidelines to select SCPI commands for the RF multiplexers follow. See the appropriate HP B-size or C-size configuration guide for interface addressing and controller language information.

---

**Note** This discussion applies to SCPI programming. See Appendix B, RF Multiplexers Registers, for information on multiplexer registers.

---

### Specifying SCPI Commands

To address specific channels within an RF multiplexer, you must specify the SCPI command and multiplexer channel address. For the RF multiplexers, use CLOSe <*channel_list*> to switch (close) channels and use OPEN<*channel_list*> to disconnect channels. Use SCAN <*channel_list*> to scan (sequentially close) multiplexer channels.

### Multiplexer Channel Address

For the RF multiplexers, 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 multiplexer card number (01-99) and "nn" is the channel numbers (00-03 and 10-13).



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## Multiplexer Card Numbers

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

For a multiple-module switchbox, the card numbers are 01, 02,...,n. The switch module with the lowest logical address is always card number 01. The card number with the next successive logical address is card number 02, and so on. See the HP B-size configuration guide for a definition of logical addresses.

### Example: Multiple-Module Switchbox Card Numbers

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

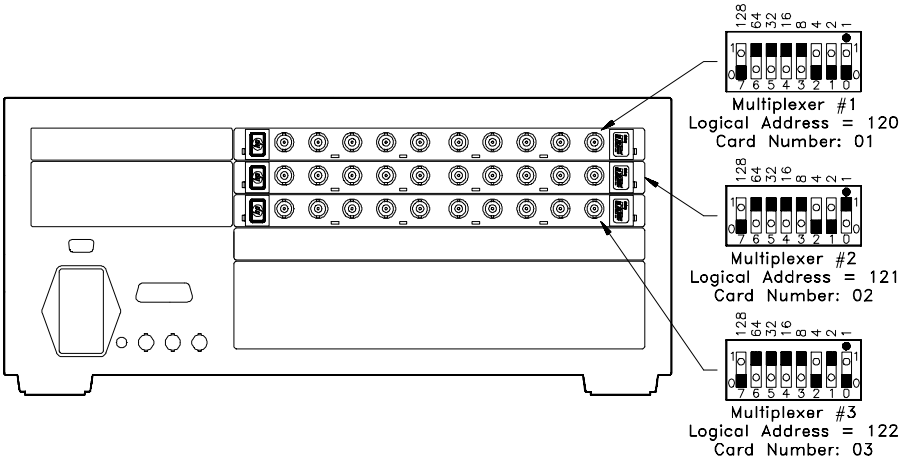



**Figure 1-2. Multiple-Multiplexer Switchbox Instrument**

## Multiplexer Channel Numbers

RF multiplexer channel numbers are 00 through 03 and 10 through 13. The channels can be addressed using channel numbers or channel ranges. For a single-module switchbox, channel ranges can span across the two channel banks. For multiple-module switchboxes, channel ranges can span across the channels of all modules.



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Use commas (**,**) to form a channel list or use a colon (**:**) to form a channel range. Only valid channels can be accessed in a channel list or channel range. Also, the channel list or channel range must be from a lower channel number to a higher channel number. For example, SCAN (@100:213) is acceptable, but SCAN (@213:100) generates an error.

### Example: RF Multiplexer Channel Lists/Ranges

Channel Lists:

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

Channel Ranges:

```
OPEN  (@100:113)        !Open all channels on card 01
SCAN  (@100:213)        !Scan all channels on cards 01 and 02
```

# Initial Operation

An example program follows which uses Hewlett-Packard BASIC and SCPI language to get you started using the RF multiplexers. The computer used in the example is an HP 9000 Series 200/300 (or equivalent) controller with HP BASIC as the program language. The computer interfaces to the mainframe using the Hewlett-Packard Interface Bus (HP-IB)*.

This program closes channel 02 of an RF multiplexer at logical address 120 (secondary address = 120/8 = 15) and queries the channel closure state. The result is returned to the controller and displayed (1 = channel closed, 0 = channel open). See the HP B-size configuration guide for information on addressing.

### Example: Close Multiplexer Channel

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

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



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# Chapter 2
# Configuring the HP E1366A/E1367A RF Multiplexers

## Using This Chapter

This chapter shows how to make user connections to the RF multiplexers and how to configure the multiplexer modules. Chapter contents are:


- Warnings and Cautions . . . . . Page 17
- Connecting User Inputs . . . . . Page 18
- Typical Multiplexer Configurations . . . . . Page 20
- Changing Multiplexer Components. . . . . Page 23


## Warnings and Cautions

**Warning** **SHOCK HAZARD. Only qualified, service-trained personnel who are aware of the hazards involved should install, configure, or remove the RF multiplexers. Remove all power sources from the mainframe and installed modules before installing or removing a module.**

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

**Caution** **MAXIMUM VOLTAGE/CURRENT. Maximum voltage between any RF multiplexer center conductor or shield to any other center conductor, shield, or chassis ground is 42 Vdc or 42 Vac peak. Maximum current per channel or common is 1 A dc or 1 A ac RMS. Maximum switching power is 24 W or 24 VA per channel or common. Maximum power per resistive termination is 1 W or 1 VA. Exceeding any limit may damage the module.**



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**Caution** **CENTER CONDUCTOR MAY SHORT TO SHIELD. Each channel's center conductor may momentarily short to the shield when the channel is opened or closed. Use only resistive (50Ω or 75Ω) or current-limited (<1 A) inputs with less than 0.1 μF total capacitance.**

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

# Connecting User Inputs

User inputs to the RF multiplexers are made through user-supplied male BNC connectors to the female BNC connectors on the modules. Figure 2-1 shows the multiplexer female BNC connectors and associated channel numbers.

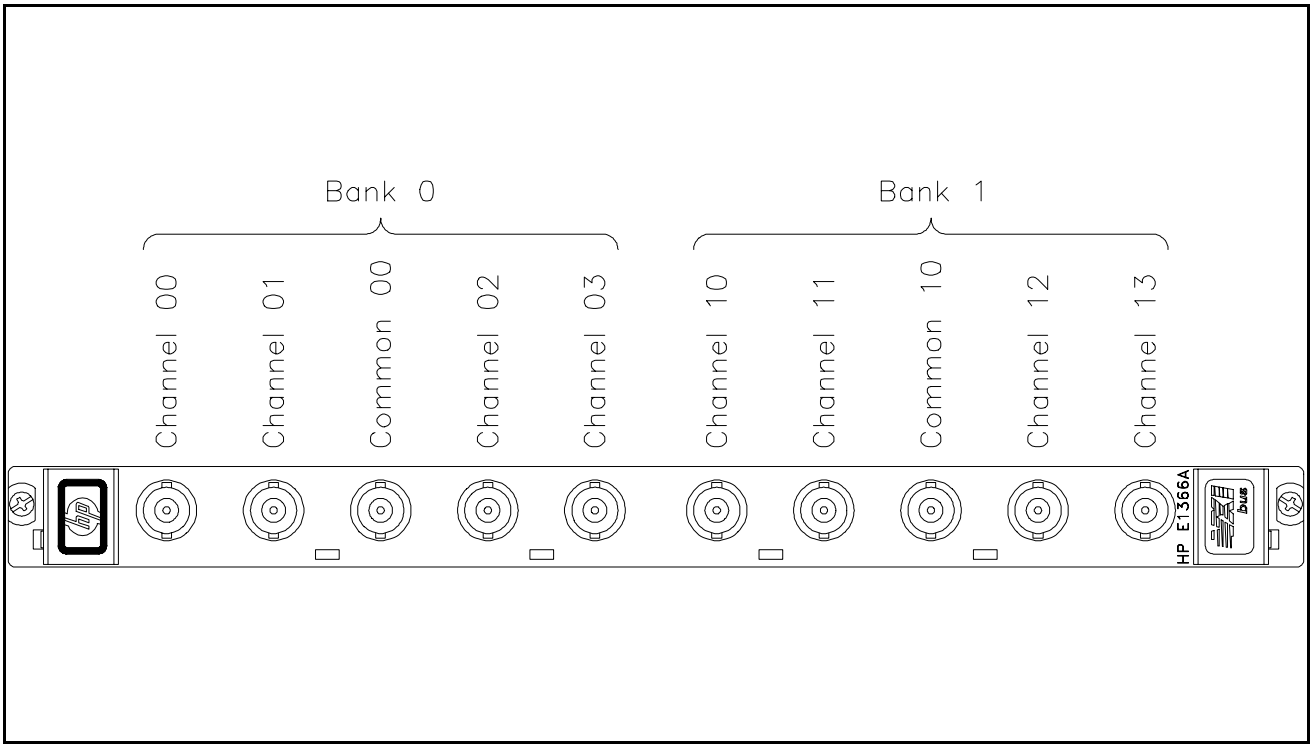



**Figure 2-1. BNC Connector Locations**



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Some guidelines for user input cabling are:

- For best high-frequency performance, user cabling should have at least two braided shields or one braid and a foil wrap.
- Always use shielded coaxial cables with the characteristic impedance of the multiplexer used (50Ω or 75Ω). Keep cables as short as possible, especially in high-frequency circuits or pulse circuits where a rise/fall time of <50 nsec is critical.
- Long cables can add delay time which can cause timing problems. All test equipment, such as counters, spectrum analyzers, and oscilloscopes, must be terminated in the characteristic impedance to minimize reflection loss.
- To maintain low dc offset voltages, cables should have copper center conductors, not copper-clad steel. RG-233/U cable is recommended. Table 2-1 lists Hewlett-Packard BNCcables which meet these guidelines.

**Table 2-1. Hewlett-Packard BNC Cables**

| Type | Length | Part Number |
|---|---|---|
| 50 Ω coaxial | 30 cm (12 in)<br>61 cm (24 in)<br>122 cm (48 in) | 8120-1838<br>8120-1839<br>8120-1840 |
| 75 Ω coaxial | 30 cm (12 in)<br>61 cm (24 in) | 5062-6452<br>5063-0061 |



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# Typical Multiplexer Configurations

Typical RF multiplexer configurations are:

- Standard configuration (2 x 4:1 multiplexer)
- Tree configuration (1 x 12:1 multiplexer)
- Matrix-type configuration (4:1 to 4:1 multiplexer)

## Standard Configuration

Figure 2-2 shows the standard configuration (2 x 4:1) for the RF multiplexers. With this configuration, you can switch channels 00-03 to com 00 and switch channels 10-13 to com 10. One channel per bank can be connected to its common at a time.

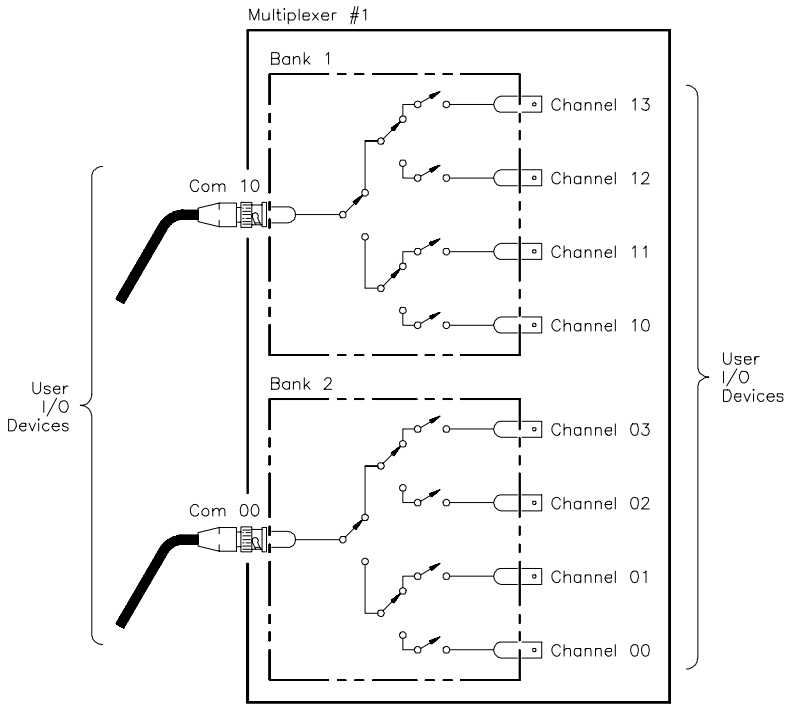



**Figure 2-2. Typical Standard Configuration**



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## Tree Configuration

Figure 2-3 shows a typical tree configuration which uses two RF multiplexers to provide a 1 x 12:1 multiplexer. This configuration provides isolation of test points while maintaining characteristic impedance. With tree configuration, signal delay time is more than doubled since the signal must pass through two channel banks plus extra cabling. Keep cables as short as possible, especially between channel banks, to minimize delay.

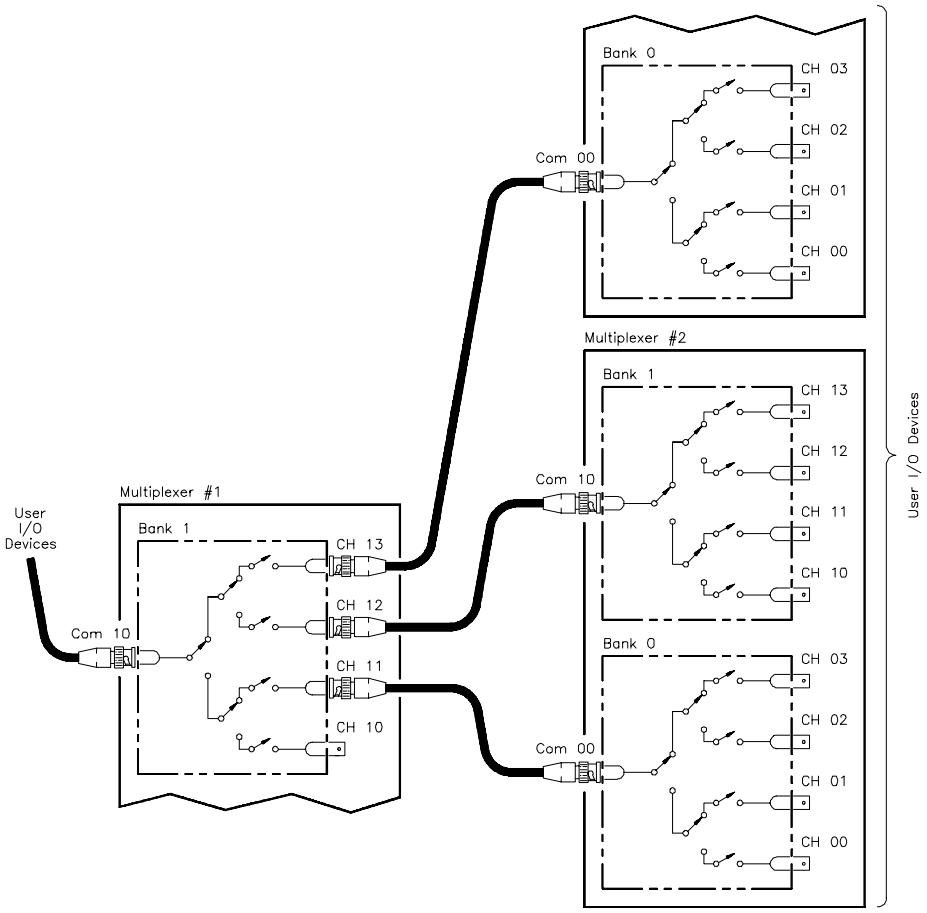



**Figure 2-3. Typical Tree Configuration**



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## Matrix-Type Configuration

Figure 2-4 shows the two banks of an RF multiplexer connected to form a matrix-type arrangement. This configuration provides a way to connect multiple devices under test (DUTs) to multiple test instruments. With this configuration, only one channel in bank 0 (one "row") can be connected to one channel in bank 1 (one "column") at a time.

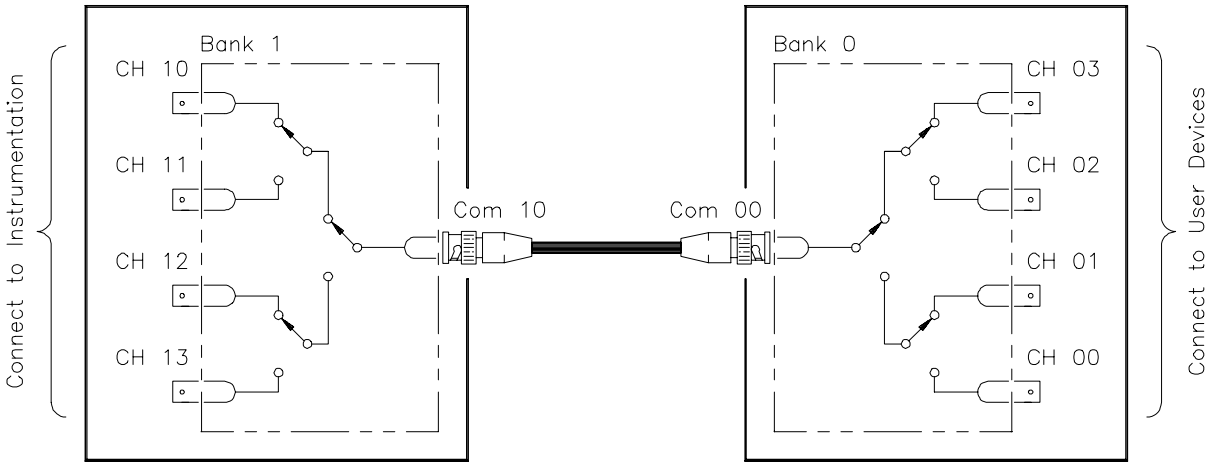



**Figure 2-4. Typical Matrix-Type Configuration**



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# Changing Multiplexer Components

As required, you can change the logical address switch setting, replace the protection fuses, change the interrupt priority jumper setting, or remove channel termination resistors. See Figure 2-5 for locations.

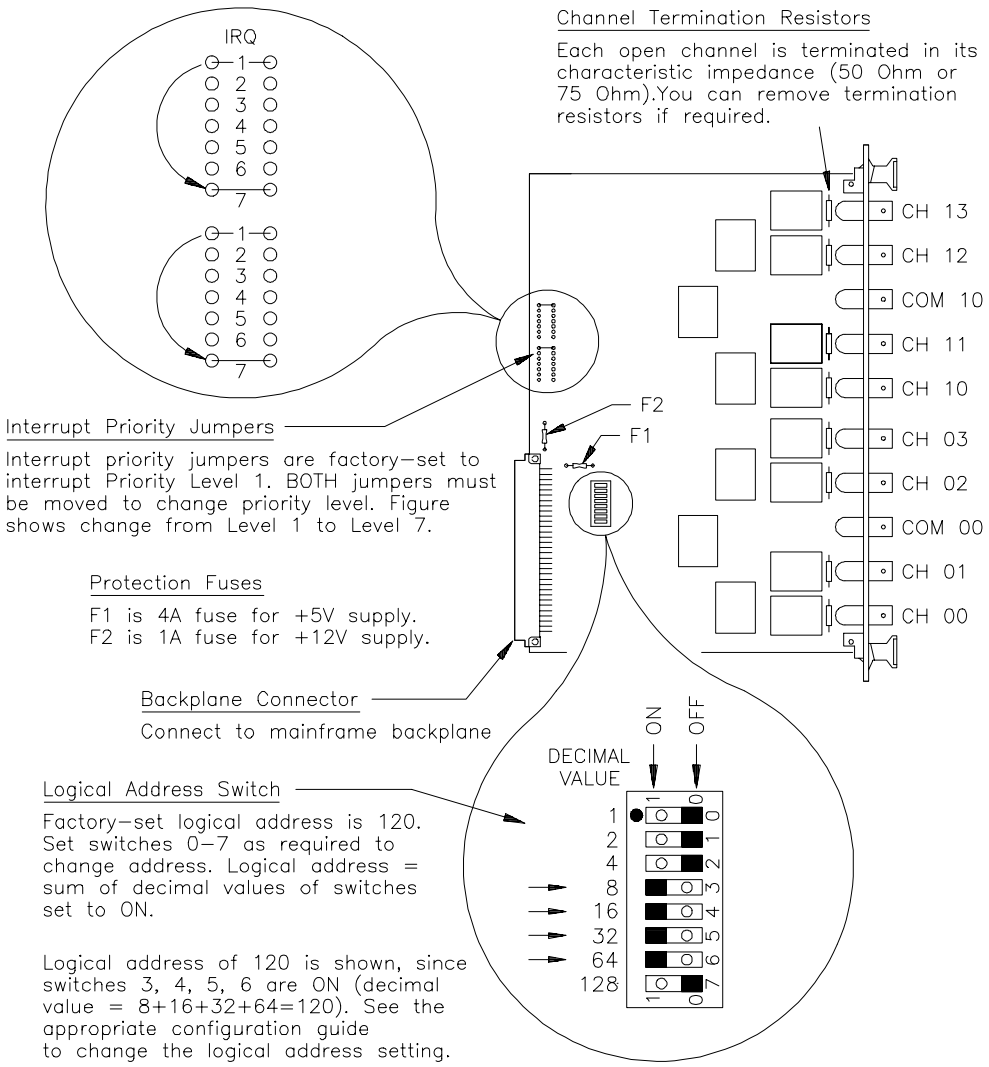



**Figure 2-5. RF Multiplexer Component Locations**



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# Chapter 3
# Using the HP E1366A/E1367A RF Multiplexer Module

## Using This Chapter

This chapter provides examples to switch multiplexer channels and to scan multiplexer channels. As required see Chapter 4, Understanding the RF Multiplexers, to modify the examples for your application. Also, see Chapter 5, RF Multiplexers Command Reference, for command information. Chapter contents are:


- Multiplexer Commands . . . . . Page 25
- Switching Channels . . . . . Page 25
- Scanning Channels . . . . . Page 29


## Multiplexer Commands

**Table 3-1. RF Multiplexer Commands Used in Chapter 3**

| Command | Description |
|---|---|
| CLOS <*channel_list*><br>OPEN <*channel_list*> | Close channels<br>Open channels |
| TRIG:SOUR BUS \|EXT \|HOLD \|IMM<br>SCAN <*channel_list*><br>INIT | Set scanning trigger source<br>Define channels to be scanned<br>Start scan, close first channel |

## Switching Channels

- Switching channels consists of closing or opening a channel. Close channels 00-03 by connecting a channel to com 00 or close channels 10-13 by connecting a channel to com 10. Only one channel per bank can be closed at a time.

- Use CLOSe <*channel_list*> to close channels use OPEN <*channel_list*> to open channels. *channel_list* has the form (@ccnn) for a single channel, (@ccnn,ccnn,...) for two or more channels, or (@ccnn:ccnn) for a set of channels where cc = card number, nn = channel number.

- Switching configurations include standard, matrix, and tree. See Chapter 2 for configuration details.



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## Example: Standard Switching

This example connects channel 02 to com 00 of an RF multiplexer in standard configuration. The multiplexer is defined as a single-multiplexer switchbox instrument. See the following figure for typical user connections. To connect channel 02 to com 00, execute:

```
CLOS (@102)          ! Connect channel 02 to com 00.
                     ! 1 is the card number and 02 is the
                     ! channel number.
```

To open the channel, use OPEN (@102).

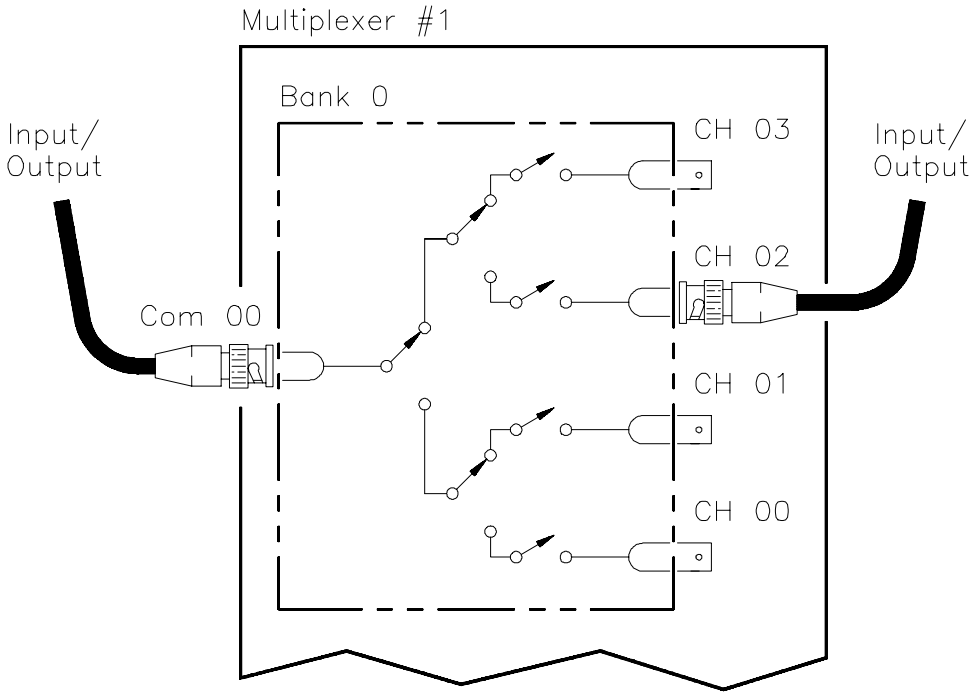



**Figure 3-1. Standard Switching**



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## Example: Tree Switching

This example uses two RF multiplexers in a tree configuration to connect com 10 of multiplexer #1 with channel 12 of multiplexer #2. The two multiplexers form a multiple-multiplexer switchbox instrument with multiplexer #1 as card 01 and multiplexer #2 as card 02. See the following figure for typical user connections. To make this connection, execute:

```
CLOS (@112,212)          ! Connect com 10 of multiplexer #1
                         ! to channel 12 of multiplexer #2.
```

To open the channels, use OPEN (@112,212).

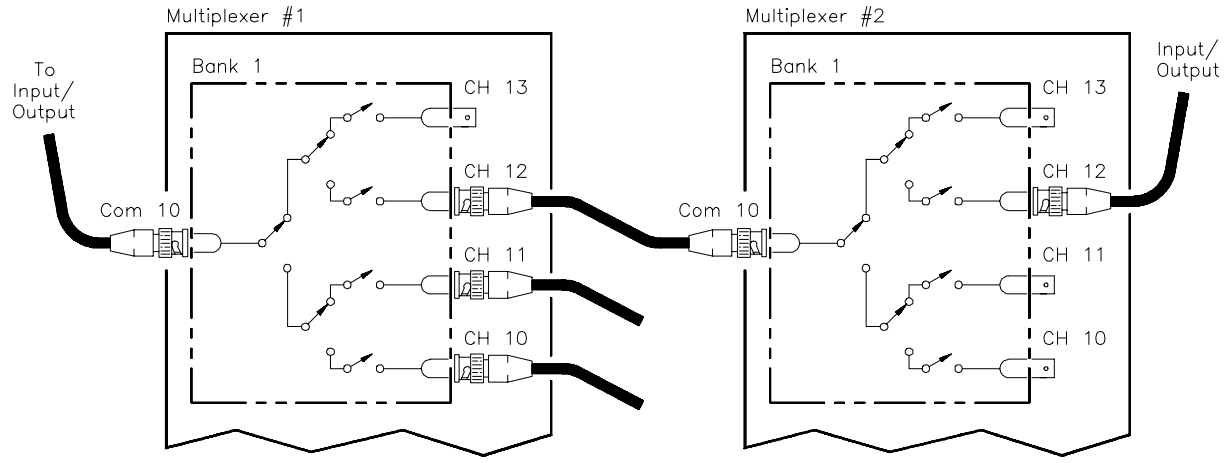



**Figure 3-2. Tree Switching**



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## Example: Matrix-Type Switching

This example connects channel 13 to channel 01 of an RF multiplexer in matrix-type configuration. The multiplexer is defined as a single-module switchbox instrument. See the following figure for typical user connections.

To connect channel 13 to channel 01, execute:

```
CLOS  (@101,113)          ! Connect channel 01 to channel 13.
                          ! 1 is the card number and 01, 13
                          ! are channel numbers.
```

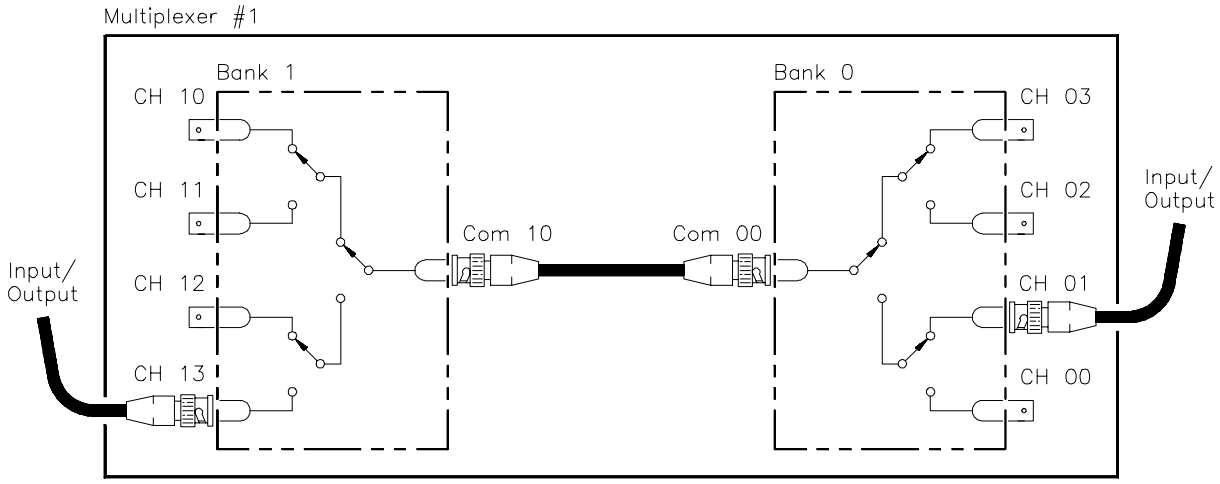



**Figure 3-3. Matrix-Type Switching**

To open the channels, use OPEN (@101,113).

## Switching Channels Comments

**Query Channel States.** Use CLOSe? <*channel_list*> or OPEN? <*channel_list*> to query the channel states (open/closed). CLOSe? returns a 1 for channels closed, 0 for channels open. OPEN? returns a 0 for channels closed, 1 for channels open. (Commands do not account for relay hardware failures.)

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



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# Scanning Channels

- Scanning channels consists of closing a set of channels, one channel at a time. You can scan any combination of channels for a single-multiplexer or multiple-multiplexer switchbox.
- Single, multiple, or continuous scanning modes are available. Any switching configuration can be used for scanning. See Chapter 4.

## Example: Scanning Using Trig Out Port

This example shows one way to synchronize instrument measurements of DUTs with RF multiplexer channel closures. For measurement synchronization, the HP E1300A/E1301A Trig Out BNC port is connected to the instrument External Trigger In port. See the following figure for typical user connections.

For this example, the mainframe and instrument are connected via HP-IB with mainframe address of 709 and instrument address of 722. The RF multiplexer is at logical address 120 (secondary address 15). (You must add required instrument commands to line 10.)

```
10  OUTPUT 722;"TRIG EXT;...."          ! Ext triggering
20  OUTPUT 70915;"OUTP ON"              ! Enable Trig Out
30  OUTPUT 70915;"TRIG:SOUR BUS"        ! Bus triggering
40  OUTPUT 70915;"SCAN (@100:103)"      ! Scan channels
50  OUTPUT 70915;"INIT"                 ! Enable scan
60  FOR I=1 TO 4                        ! Start loop
70  ENTER 722;A                         ! Enter result
80  PRINT A                             ! Display result
90  TRIGGER 70915                       ! Advance scan
100 NEXT I                              ! Increment count
110 END
```

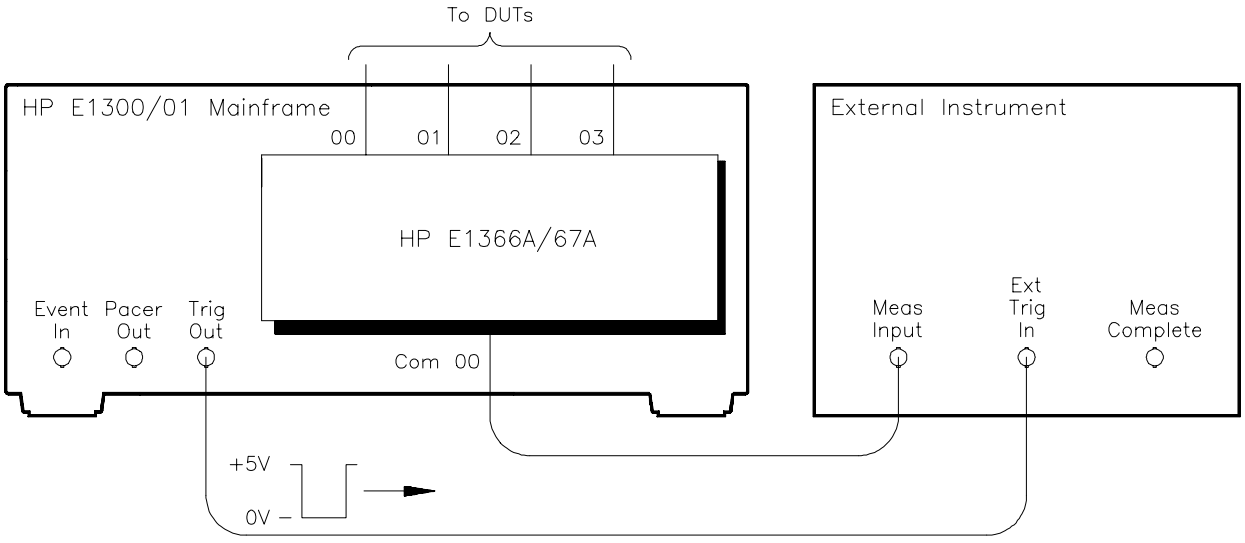



**Figure 3-4. Scanning Using Trig Out Port**



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## Scanning Channels Comments

**Scan List Can Extend Across Boundaries.** For multiple-multiplexer switchbox instruments, the scan list can extend across multiplexer boundaries. For example, for a two-multiplexer switchbox instrument, SCAN (@100:213) will scan all channels in both multiplexers.

**Setting Multiple/Continuous Scans.** Use ARM:COUN <*number*> to set from 1 to 32767 scans through the scan list. Use INIT:CONT ON to set continuous scanning. See Chapter 4.



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# Chapter 4
# Understanding the HP E1366A/E1367A RF Multiplexers

## Using This Chapter

This chapter explains techniques to scan RF multiplexer channels and shows how to use the Scan Complete bit. The chapter contents are:


- Scanning Channels Commands . . . . . Page 31
- Using Scanning Trigger Sources . . . . . Page 31
- Scanning with External Instruments. . . . . Page 31
- Using the Scan Complete Bit . . . . . Page 36


## Scanning Channels Commands

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

## Using Scanning Trigger Sources

The TRIG:SOUR command specifies the source to advance the scan. You can use the TRIG command to advance the scan when TRIG:SOUR BUS or TRIG:SOUR HOLD is set. The OUTP command can be used to enable the HP E1300A/E1301A Trig Out or the HP E1405A/E1406A port. Figure 4-2 shows scanning trigger sources.

## Scanning with External Instruments

Scanning RF multiplexer channels has the same effect as executing multiple CLOSe commands. Thus, scanning is useful when the outputs 7from a number of DUTs are to be measured with an instrument. Two examples using HP BASIC programming language follow.



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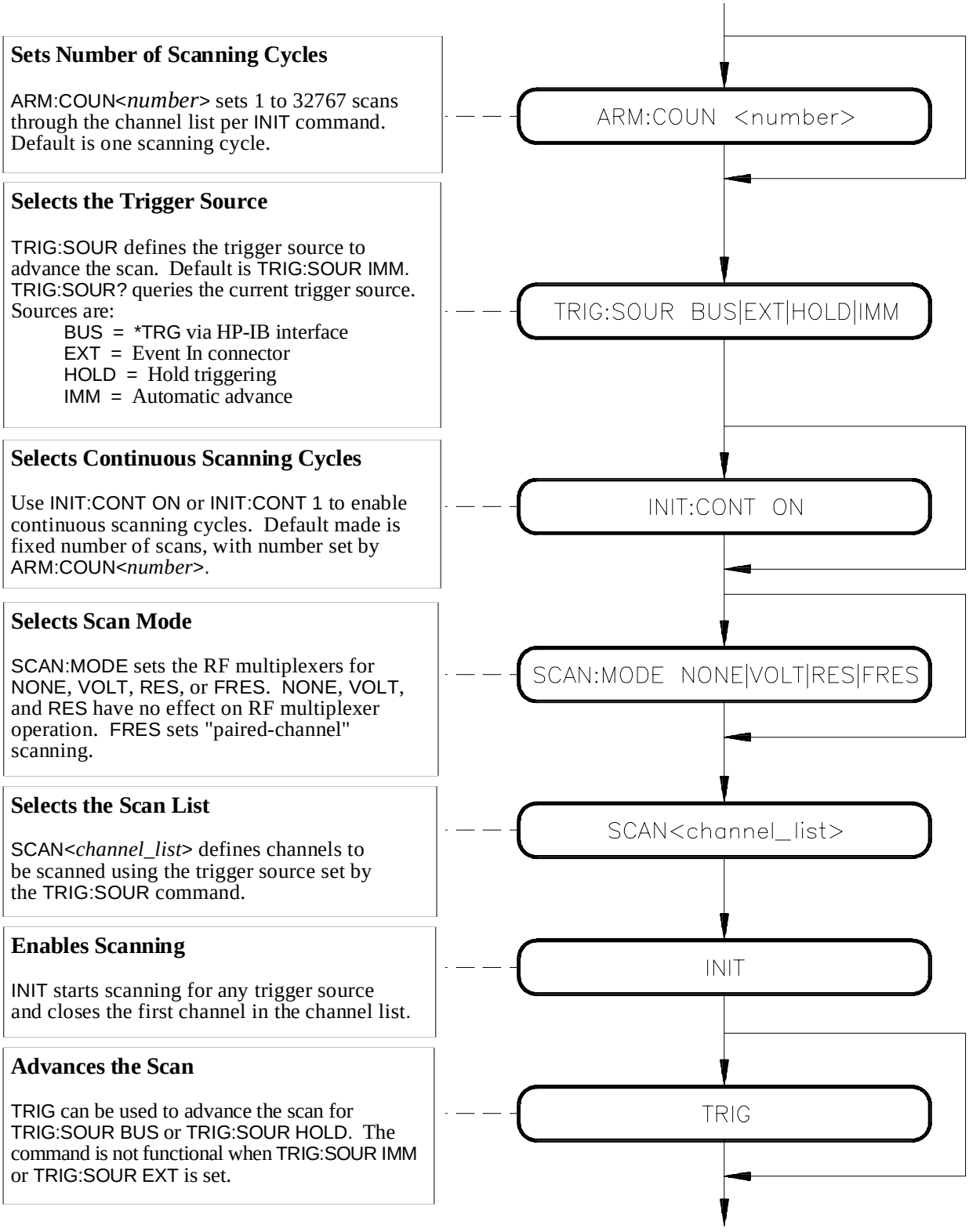



**Figure 4-1. Scanning Channels Commands**



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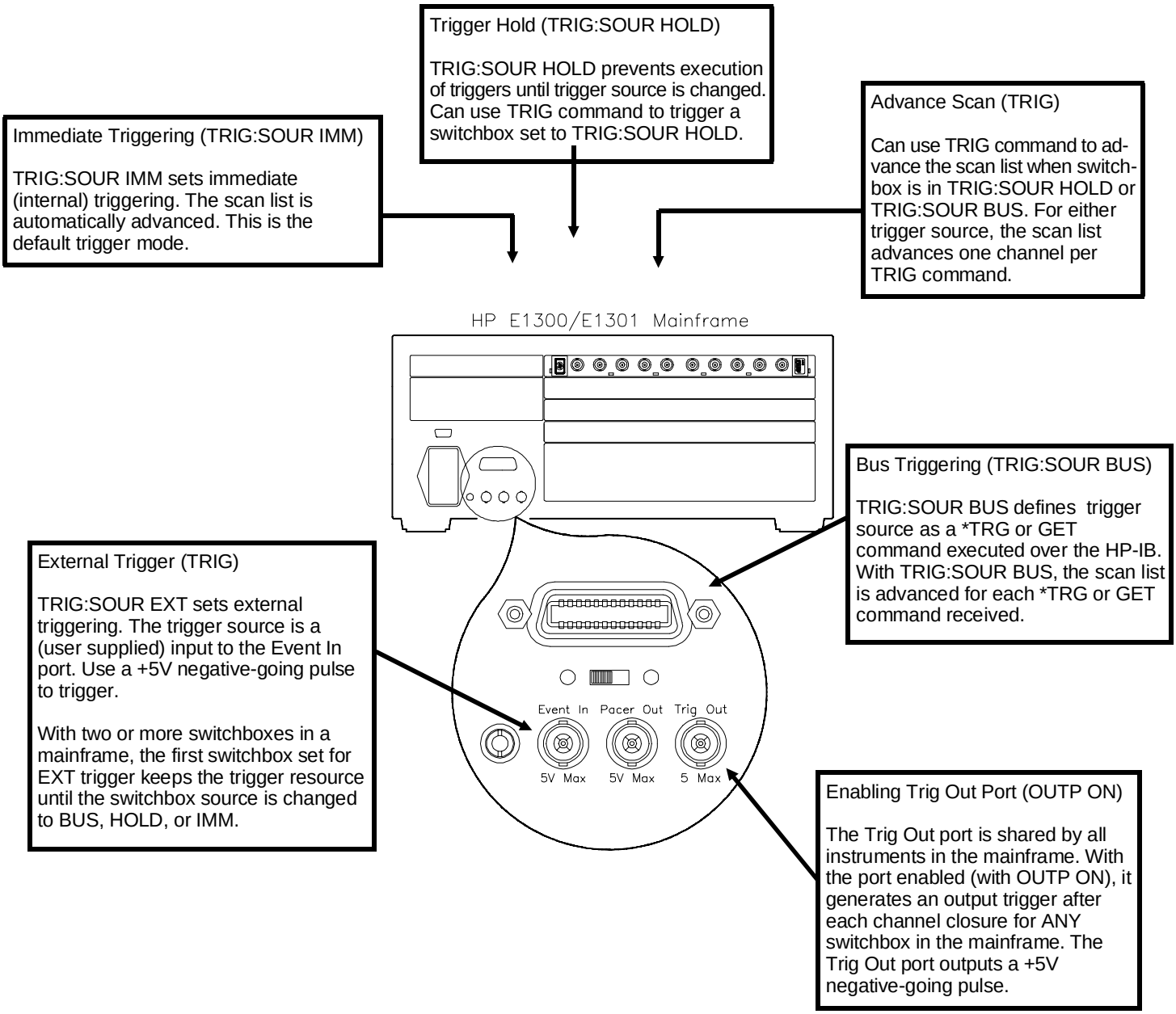



**Figure 4-2. Scanning Trigger Sources**



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## Example: Scanning with External Device

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

For this example, the HP E1300A/E1301A and the instrument are connected via HP-IB with HP E1300A/E1301A address of 709 and instrument address of 722. The RF multiplexer logical address is 120 (secondary address =120/8 =15). The measurements are transferred directly to the computer. (Appropriate instrument commands must be added to line 10.) The sequence of operation is:

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

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

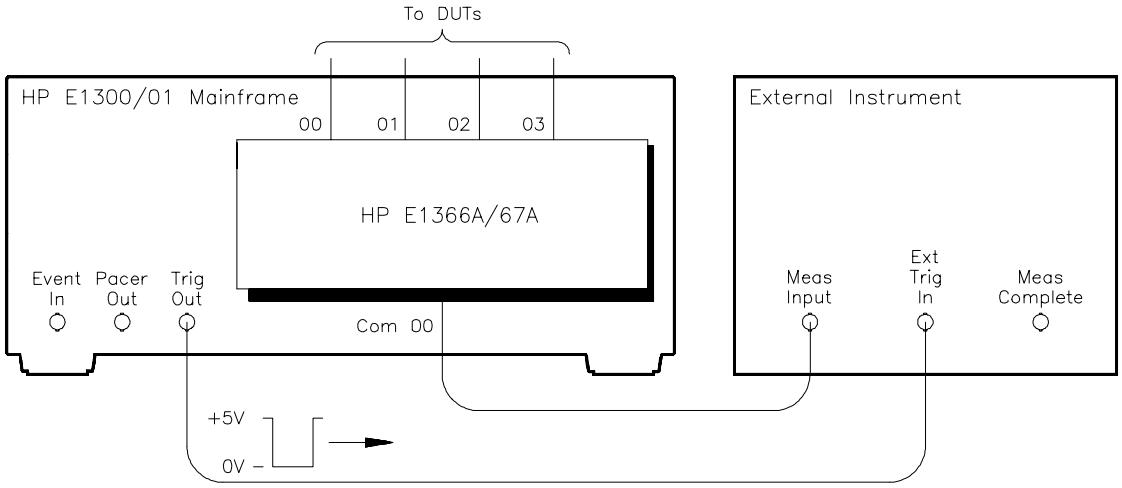



**Figure 4-3. Scanning with External Device**



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

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

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

1. INIT (line 50) closes channel 100.
2. The channel closure causes a trigger output from the "Trig Out" port.
3. Trigger to Ext Trig In starts channel 100 measurement.
4. Channel 100 measurement result is stored in instrument.
5. Trigger is then output from multimeter's "MEASUREMENT COMPLETE" port.
6. Trigger to "Event In" port advances scan to channel 101.
7. Steps 2-6 are repeated for channels 101 through 102.

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

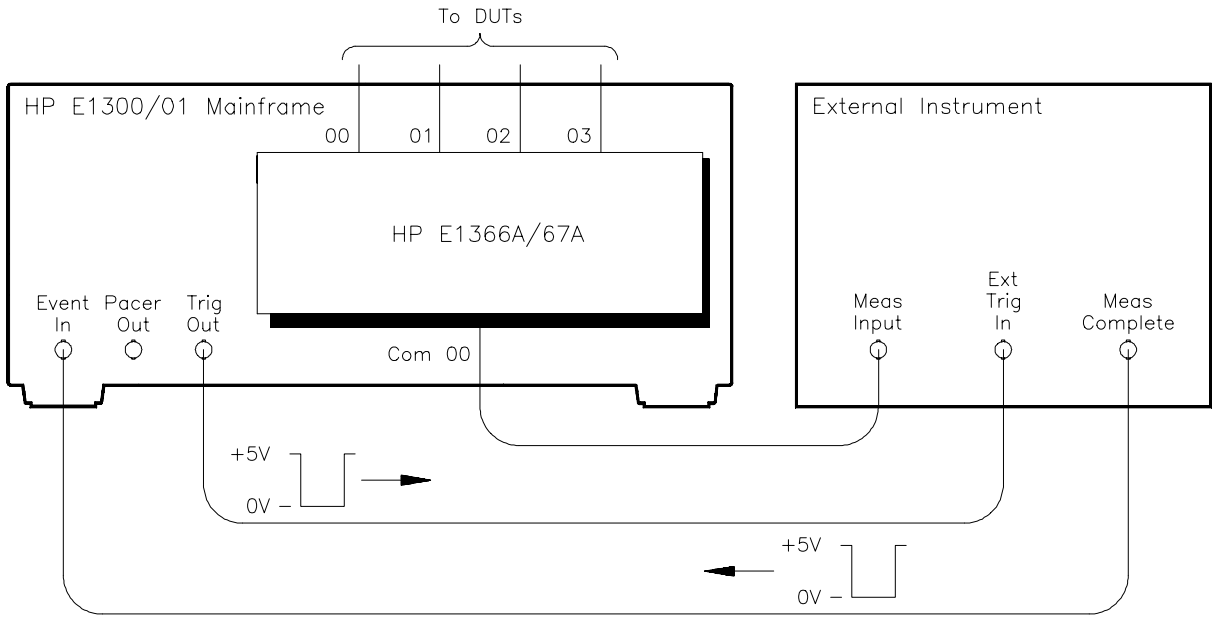



**Figure 4-4. Scan Using "Trig Out" and "Event In" Ports**



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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 STATus:OPERation[:EVENt]? command in Chapter 5 for an example.

When enabled by the STAT:OPER:ENAB 256 command, the Scan Complete Bit will be reported as bit 7 of the Status register. Use the HP-IB Serial Poll or the IEEE 488.2 Common Command *STB? to read the Status register. When bit 7 of the Status register is enabled by the *SRE 128 Common Command to assert an HP-IB Service Request (SRQ), you can interrupt the computer when the Scan Complete Bit is set, after a scanning cycle completes. This allows the 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 this example is an HP 9000 Series 200/300 used with HP BASIC as the programming language. The computer interfaces with an HP E1300A/E1301A mainframe over HP-IB. The HP-IB select code is 7, the HP-IB primary address is 09, and the HP-IB secondary address is 15.

## Example: Scan Complete Interrupt

```
10  OUTPUT 70915;"*CLS"                    ! Clear all switchbox status structure
20  OUTPUT 70915;"STAT:OPER:ENAB 256" ! Enable Scan Complete Bit to
                                           set bit 7 in Status register
30  OUTPUT 70915;"*SRE 128"                ! Enable bit 7 of Status register to
                                           assert SRQ
40  OUTPUT 70915;"TRIG:SOUR EXT"           ! External trigger mode
50  OUTPUT 70915;"SCAN  (@100:105)"        ! Select channels to be scanned
60  OUTPUT 70915;"INIT"                    ! Start scanning cycle
70  WHILE NOT BIT(SPOLL(70915),7)          ! 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  generated by a completed
                                   scanning cycle
110 END
```



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# Chapter 5
# HP E1366A/E1367A RF Multiplexers Command Reference

## Using This Chapter

This chapter describes Standard Commands for Programmable Instruments (SCPI) and summarizes IEEE 488.2 Common (*) commands applicable to both RF Multiplexer modules. See the appropriate HP B-size or C-size configuration guide for additional information on SCPI and Common commands. This chapter contains the following sections.


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


## Command Types

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

### Common Command Format

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

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

### SCPI Command Format

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

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

[ROUTe:] is the root command, CLOSe and SCAN are second-level commands with parameters, and :MODE? is a third-level command.



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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 lowercase letters. The uppercase letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated form or the entire command.

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

## Implied Commands

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

**Table 5-1. SCPI Parameter Types**

| Parameter Type | Explanations and Examples |
|---|---|
| Numeric | Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation.<br><br>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.<br><br>ON, OFF, 1, 0. |
| Discrete | Selects from a finite number of values. These parameters use mnemonics to represent each valid setting.<br><br>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;*RST
```

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

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



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# SCPI Command Reference

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

# 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 cycle 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 E1301A 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 E1301A front panel "Reset Instr" or "Clear Instr" key to stop the scan.
- **Stopping Scans Enabled from Front Panel:** When a scan is enabled from the HP E1301A front panel, execute *RST entered via the interface or the front panel "Reset Instr" or "Clear Instr" key to stop the scan.
- **Related Commands:** ARM, INITiate:CONTinuous, [ROUTe:]SCAN, TRIGger

## Example

**Stopping a Scan with ABORt**

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



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

## Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| <*number*> | numeric | 1 \|32767 \|MIN \|MAX |

## Comments

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

## Example

**Setting Ten Scanning Cycles**

This example sets an RF multiplexer for 10 scans of channels 00 through 03. When the scan sequence completes, channel 03 is closed.

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



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## :COUNt?

**ARM:COUNt? [MIN | MAX]** returns current number of scanning cycles set by ARM:COUNt. The current number of scan cycles is returned when MIN or MAX is not supplied. With MIN or MAX 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**

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

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



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# DISPlay

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

## 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 | ON \| OFF \| 1 \| 0 |

### 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 E1301A Mainframe Display:** A typical display for the HP E1366A or HP E1367A RF Multiplexer module follows, where channel 00 (in bank 0) and channel 13 (in bank 1) are closed.

  ```
  B0:0  B1:3
  ```

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

### Example

**Enabling the Monitor Mode**

```
DISP:MON:CARD 2          ! Selects module #2 in a switchbox
DISP:MON 1               ! Turns 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:** Use the DISPlay:MONitor:CARD command to send the module number for the switchbox to be monitored.
- **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 | ON \| OFF \| 1 \| 0 |

### Comments

- **Continuous Scanning Operation:** Continuous scanning is enabled with the INITiate:CONTinuous ON or INITiate:CONTinuous 1 command. Sending the INITiate[:IMMediate] command closes the first channel in the channel list.
- Each trigger from a trigger source selected by the TRIGger:SOURce command advances the scan through the channel list. A trigger at the end of the channel list closes the first channel in the channel list and the scan cycle repeats.
- **Non-Continuous Scanning Operation:** This is enabled with the INITiate:CONTinuous OFF or INIT:CONT 0 command. Sending the INIT:IMM command closes the first channel in the channel list.

  Each trigger from a trigger source selected by the TRIGger:SOURce command advances the scan through the channel list. At the end of the scanning cycle, all channels in the channel list are closed.
- **Stopping Continuous Scans:** See the ABORt command.
- **Related Commands:** ABORt, ARM:COUNt, TRIGger
- ***RST Condition:** INITiate:CONTinuous OFF

### Example

**Enabling Continuous Scans**

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

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



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## :CONTinuous?

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

### Example

**Query Continuous Scanning State**

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

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

## [:IMMediate]

**INITiate[:IMMediate]** starts the scanning cycle and closes the first channel in the channel list. Successive triggers from the source selected 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. Each trigger received advances the scan to the next channel in the channel list. An invalid channel list definition generates an error (see [ROUTe:]SCAN command).
- **Stopping Scanning Cycles:** See the ABORt command.

### Example

**Enabling a Single Scan**

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

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



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# OUTPut

The OUTPut subsystem enables or disables the "Trig Out" port of the HP E1300A/E1301A mainframe or the HP E1405A/E1406A module.

## Subsystem Syntax

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

## [:STATe]

**OUTPut[:STATe] ON | OFF | 1 | 0** enables/disables the "Trig Out" port on the rear panel of the HP E1300A/E1301A mainframe or the HP E1405A/E1406A module. 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 | ON \| OFF \| 1 \| 0 |

## Comments

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

## Example

**Enable "Trig Out" Port**

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

## [:STATe]?

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

## Example

**Query "Trig Out" Port Enable State**

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

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



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# [ROUTe:]

The ROUTe subsystem controls switching and scanning operations for RF 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 | FRES
        :MODE?
```

## CLOSe

**[ROUTe:]CLOSe *<channel_list>*** closes the RF multiplexer channels specified by *channel_list*. The *channel_list* has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-03 and 10-13).

### Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| <*channel_list*> | numeric | cc00-cc03, cc10-cc13 |

### 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)
  - groups of sequential channels, use [ROUTe:]CLOSe (@ccnn:ccnn,ccnn:ccnn)
  - or any combination.

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

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

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

### Example

**Closing Multiplexer Channels**

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

```
CLOS   (@100,213)          ! Close channels 100 and 213.
                           ! 100  closes channel 00 of card #1;
                           ! 213 closes channel 13 of card #2
```



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## CLOSe?

**[ROUTe:]CLOSe? *<channel_list>*** returns the current state of the channel(s) queried. The *channel_list* is in the form (@ccnn) (see [ROUTe:]CLOSe for definition). The command returns 1 for channel(s) closed or returns 0 for channel(s) opened.

### Comments

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

### Example

**Query Channel Closure**

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

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

## OPEN

**[ROUTe:]OPEN *<channel_list>*** opens the RF multiplexer channels specified by *channel_list*. The *channel_list* has the form (@ccnn) where cc = card number (00-99) and nn = channel number (00-03 and 10-13).

### Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| *<channel_list>* | numeric | cc00-cc03, cc10-cc13 |

### 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)
  - groups of sequential channels, use [ROUTe:]OPEN (@ccnn:ccnn,ccnn:ccnn)
  - or any combination.

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

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

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

### Example

**Opening Channels**

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

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



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## OPEN?

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

## Comments

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

## Example

**Query Channel Open State**

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

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



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## SCAN

**[ROUTe:]SCAN <*channel_list*>** defines the channels to be scanned. The *channel_list* has the form (@ccnn) where cc = card number (01-99) and nn = channel number (00-03 and 10-13).

### Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| <*channel_list*> | numeric | cc00-cc03, cc10-cc13 |

### Comments

- **Defining Scan 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 Channels:** You can scan single channels (@ccnn); multiple channels (@ccnn,ccnn,...); sequential channels (@ccnn:ccnn); groups of sequential channels (@ccnn:ccnn,ccnn:ccnn); or any combination.
- **Scanning Operation:** When a valid channel list is defined, INITiate[:IMMediate] begins the scan and closes the first channel in the channel list. Successive triggers from the source specified by TRIGger:SOURce advances the scan through the channel list.
- **Stopping Scan:** See the ABORt command.
- **Related Commands:** TRIGger, TRIGger:SOURce
- ***RST Condition:** All channels open.

### Example

**Scanning Using External Devices**

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



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## SCAN:MODE

**[ROUTe:]SCAN:MODE NONE | VOLT | RES | FRES** sets the scan mode for the RF multiplexers. NONE, VOLT, and RES have no effect on multiplexer operation. With FRES, the switch is set for "paired-channel" scanning. That is, when a channel in bank 0 is closed, the associated channel in bank 1 is simultaneously closed.

### Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| NONE \| VOLT \| RES \| FRES | discrete | NONE \| VOLT \| RES \| FRES |

### Comments

- **Order of Command Execution:** The [ROUTe:]SCAN:MODE command must be executed before the [ROUTe:]SCAN <*channel_list*> command.
- **FRES Mode Description:** With FRES, and channel closed in bank 0 automatically closes the paired channel in bank 1. For example, with FRES, closing channel 00 also simultaneously closes channel 10, closing channel 01 closes channel 11, etc. Use only channels 00-03 for the *channel_list*. Specifying channels 10-13 causes an error.
- ***RST Condition:** ROUT:SCAN:MODE NONE

### Example

**Selecting Paired-Channel Scanning**

```
TRIG:SOUR EXT                ! External trigger source
SCAN:MODE FRES               ! Paired-channel scanning mode
SCAN   (@100:103)            ! Select channels for scanning
INIT                         ! Start scanning, close channels
                             100 and 110
```

## SCAN:MODE?

**[ROUTe:]SCAN:MODE?** returns the current state of the scan mode. The command returns `"NONE"`, `"VOLT"`, `"RES"`, or `"FRES"` depending on the [ROUTE:]SCAN:MODE parameter setting.

### Example

**Query Scan Mode**

Since this example selects the FRES (paired-channel scanning), the query command returns "FRES".

```
SCAN:MODE FRES               ! Selects paired-channel scanning
SCAN:MODE?                   ! Query scanning mode
```



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# STATus

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

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

## :OPERation:ENABle

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

### Parameters

| Parameter Name | Parameter Type | Range of Values |
|---|---|---|
| <*number*> | numeric | 1-32767 |

### Comments

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

### Example

**Enabling Status Register Bit 7**

```
STAT:OPER:ENAB 256          ! Enables bit 7 of Status register
```



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# SYSTem

The SYSTem subsystem returns error numbers/messages in the error queue of a switchbox, and returns module types and descriptions in a switchbox.

## Subsystem Syntax

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

## :ERRor?

**SYSTem:ERRor?** returns the error numbers/messages in the error queue of a switchbox. See Appendix C for error message information.

### 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 negative and the error message can be up to 255 characters long.
- **Clearing the Error Queue:** An error number/message is removed from the queue each time the SYSTem:ERRor? command is sent. The errors are cleared first-in, first-out. When the queue is empty, each following SYSTem:ERRor? command returns 0, "No error". To clear all error numbers/messages in the queue, execute *CLS.
- **Maximum Error Numbers/Messages in the Error Queue:** The queue holds a maximum of 30 error numbers/messages for each switchbox. If it overflows, the last error 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

- **RF Multiplexers Module Description:**
  The SYST:CDESciption? <*number*> command returns: "`50 Ohm RF Mux`" for the HP E1366A or "`75 Ohm RF Mux`" for the HP E1367A.

### Example

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

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

## :CTYPe?

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



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### Parameters

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

### Comments

- **RF Multiplexers Model Number:**
  The SYSTem:CTYPe? <*number*> command returns `"HEWLETT-PACKARD,E1366A,0,A.01.00"` (E1366A), or returns `"HEWLETT-PACKARD,E1367A,0,A.01.00"` (E1367A), where the `"0"` after `"E1366A"` or `"E1367A"` is the module serial number (always 0) and `"A.01.00"` is an example of the module revision code number.

### Example

**Reading the Model Number of a Card #1 Module**

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

## :CPON

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

### Parameters

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

### Comments

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

### Example

**Setting Card #1 Module to its Power-on State**

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



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# TRIGger

The TRIGger subsystem controls the triggering operation of RF 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 with [ROUTe:]SCAN <*channel_list*> and an INITiate[:IMMediate] command must be executed before TRIGger[:IMMediate] will be executed.
- **HOLD or BUS Source Remains:** The TRIGger:SOURce HOLD or TRIGger:SOURce BUS commands remain in effect, if selected, after triggering a switchbox with the TRIGger[:IMMediate] command.
- **Related Commands:** INITiate, [ROUTe:]SCAN

## Example

**Advancing Scan Using the TRIGger Command**

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

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



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## :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 or GET command |
| EXTernal | discrete | "Event In" BNC port |
| HOLD | discrete | Hold triggering |
| IMMediate | discrete | Immediate triggering |

### Comments

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



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### Example Scanning Using External Triggers

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

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

### Example Scanning Using Bus Triggers

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

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

## :SOURce?

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

### Example Query Trigger Source

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

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



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# IEEE 488.2 Common Commands

The following table lists the IEEE 488.2 Common (*) Commands that apply to the RF Multiplexer module. The operation of some of these commands is described in Chapter 4 of this manual. For information on Common Commands, refer to the HP B-size configuration guide or the *ANSI/IEEE Standard 488.2-1987*.

| Command | Title | Description |
|---|---|---|
| *IDN?<br>*RST | Identification<br>Reset | Returns identification string of the switchbox.<br>Opens all channels, and invalidates current channel list for Opens all channels, and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF. |
| *TST? | Self-Test | Always returns 0. |
| *OPC<br>*OPC?<br>*WAI | Operation Complete<br>Operation Complete Query<br>Wait to Complete | See note below.<br>See note below.<br>See note below. |
| *CLS<br>*ESE<br>*ESE?<br>*ESR?<br>*SRE<br>*SRE?<br>*STB? | Clear status<br>Event status enable<br>Event status enable query<br>Event status register query<br>Service request enable<br>Service request enable query<br>Read status byte query | Clears all status registers (see STATus:OPERation[:EVENt]?).<br>See note below.<br>See note below.<br>See note below.<br>Enables status register bits (see Chapter 4 for operation).<br>See note below.<br>See note below. |
| *TRG | Trigger | Triggers the switchbox to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS. |
| *RCL<br>*SAV | Recall instrument state<br>Store instrument state | See note below.<br>See note below. |
| Note: These commands apply to many instruments and are not documented in detail here. See the appropriate HP B-size or C-size configuration guide, 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 RF Multiplexer modules used in a switchbox.

**SCPI Commands Quick Reference**

| Command | | Description |
|---|---|---|
| ABORt | | Abort a scan in progress. |
| ARM | :COUNt <*number*><br>:COUNt? [MIN \|MAX] | Multiple scans per INIT command.<br>Query number of scans. |
| DISPlay | :MONitor[:STATe] <*boolean*><br>:MONitor:CARD <*number*>\|AUTO | Selects monitor mode.<br>Selects module to be monitored. |
| INITiate | :CONTinuous ON \|OFF<br>:CONTinuous?<br>[:IMMediate] | Enables/disables continuous scanning.<br>Query continuous scan state.<br>Starts a scanning cycle. |
| OUTPut | [:STATe] ON \|OFF<br>[:STATe]? | Enables/disables "Trig Out" pulse.<br>Query port enable state. |
| [ROUTe:] | CLOSe <*channel_list*><br>CLOSe? <*channel_list*><br>OPEN <*channel_list*><br>OPEN? <*channel_list*><br>SCAN <*channel_list*><br>SCAN:MODE NONE \|VOLT \|<br>RES \|FRES | Close channel(s).<br>Query channel(s) closed.<br>Open channel(s).<br>Query channel(s) opened.<br>Define channels for scanning.<br><br>Sets scan mode. |
| STATus | :OPERation[:EVENt]?<br>:OPERation:ENABle | Returns status of Operation Status register.<br>Enables the Operation Status register to set a bit in the Status register. |
| SYSTem | :ERRor?<br>:CDEScription? <*number*>.<br>:CTYPe? <*number*><br>:CPON <*number*>\|ALL | Returns error number/message in a switchbox Error Queue.<br>Returns description of module in a switchbox<br>Returns the module type.<br>Sets specified module to its power-on state. |
| TRIGger | [:IMMediate]<br>:SOURce BUS<br>:SOURce EXTernal<br>:SOURce HOLD<br>:SOURce IMMediate<br>:SOURce? | Causes a trigger to occur.<br>Trigger source is *TRG.<br>Trigger source is "Event In".<br>Hold off triggering.<br>Continuous (internal) triggers.<br>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 E1366A/E1367A RF Multiplexer Specifications

## Input Characteristics

**Maximum Voltage - any center or shield to any other center, shield, or chassis:** 42 V Peak

**Maximum Current per Channel or Common:** 1 Adc or $ac_{rms}$

**Maximum Power per Channel or Common:** 24 W or 24 VA

## General

Channels consist of non-latching armature relays**.**

**Typical Relay Life:**
With no load: $5 \times 10^6$ operations
With max. rated load: $10^5$ operations
***Note:*** *Relays are subject to normal wearout based on the number of operations.*

## DC Performance

**Thermal Offset:** <6µV

**Typical Closed Channel Resistance:** <1Ω

**End of Relay Life Closed Channel Resistance:** <3Ω

**Insulation Resistance (any terminal to any terminal):**
≤(40° C, 65% RH): $>10^8$Ω

## AC Performance

For ZL= ZS = 50Ω (E1366A)
For ZL= ZS = 75Ω (E1367A)

| | <10MHz | <100MHz | <500MHz | <1.3GHz |
|---|---|---|---|---|
| **Insertion Loss (dB)** | | | | |
| **≤(40°C, 65% RH)** | <0.3 | <0.7 | <1.5 | <3.0 |
| **Crosstalk(dB) (Channel-Channel*, or Channel-Common)**[1] | | | | |
| | <-90 | <-80 | <-60 | <-40 |
| **VSWR** | <1.2 | <1.25 | <1.35 | <1.55 |

* With one channel closed.
1 Specification assumes 50Ω or 75Ω termination. If all channels unterminated, derate specification by 6dB.

**Risetime:** <300psec
**Signal Delay:** <3nsec ± 50psec

**Capacitance:**
Center-shield <60pF
Chassis-shield <0.15µF

**Module Size/Device Type:** B, register-based

**Connectors Used:** P1

**Number of Slots:** 1

**VXIbus Interface Capability:**
Slave, Interrupter, A16, D16

**Interrupt Level:** 1-7, selectable

**Power Requirements:**

| | +5 | +12 |
|---|---|---|
| Voltage | | |
| Peak module current, IPM (A): | 0.10 | 0.18 |
| Dynamic module current, IDM (A): | 0.01 | 0.01 |

**Watts/Slot:** 3.0



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**Cooling/Slot:**
0.05 mm $H_2O$ @ 0.25 liter/sec

**Humidity:** 65% 0° to 40° C

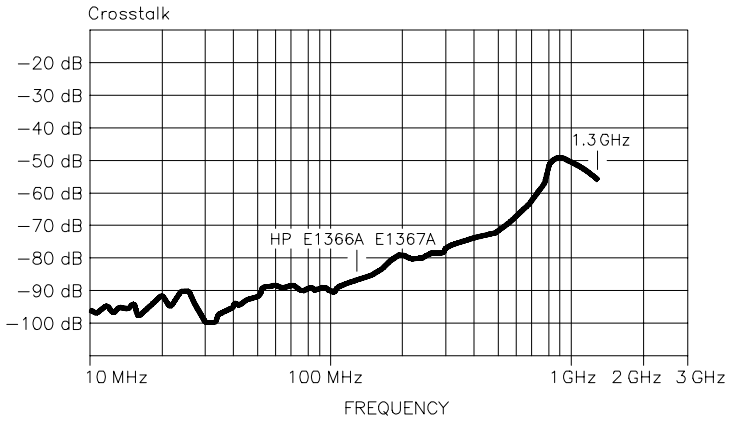
**Operating Temperature:** 0° to 55° C

**Storage Temperature:** - 40° to 75° C

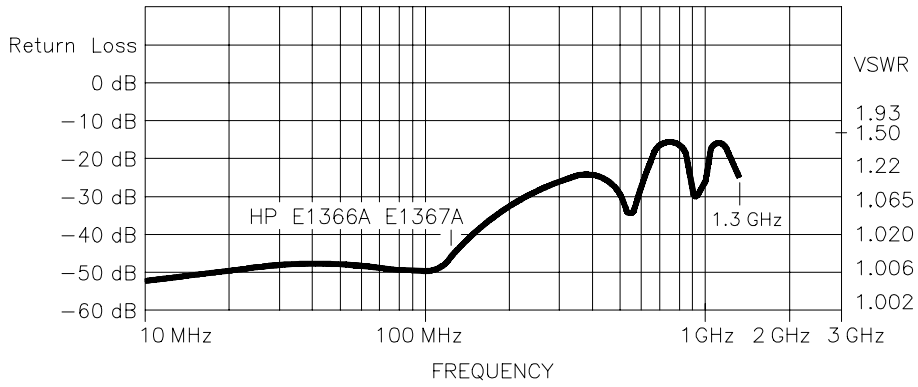
**EMC, RFI, Safety:**
meets FTZ1046/1984, CSA556B, IEC348, UL1244

**Net Weight (kg):** 0.7

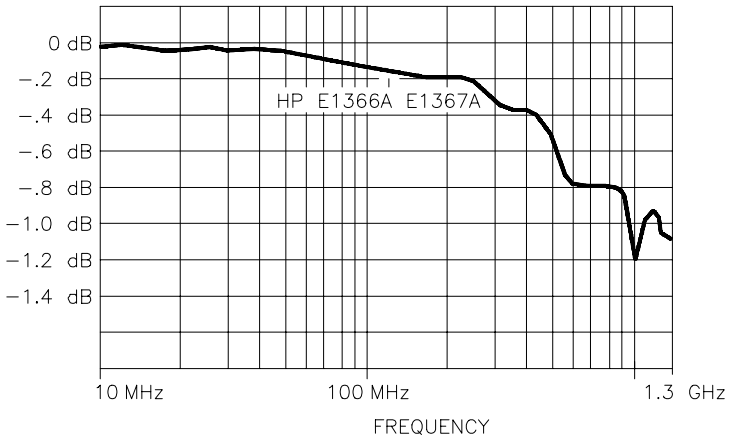
**Typical Crosstalk (channel-channel)**




**Typical Return/Loss VSVR**




**Typical Insertion Loss**






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

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

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

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

## Replacement Strategy

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

---

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

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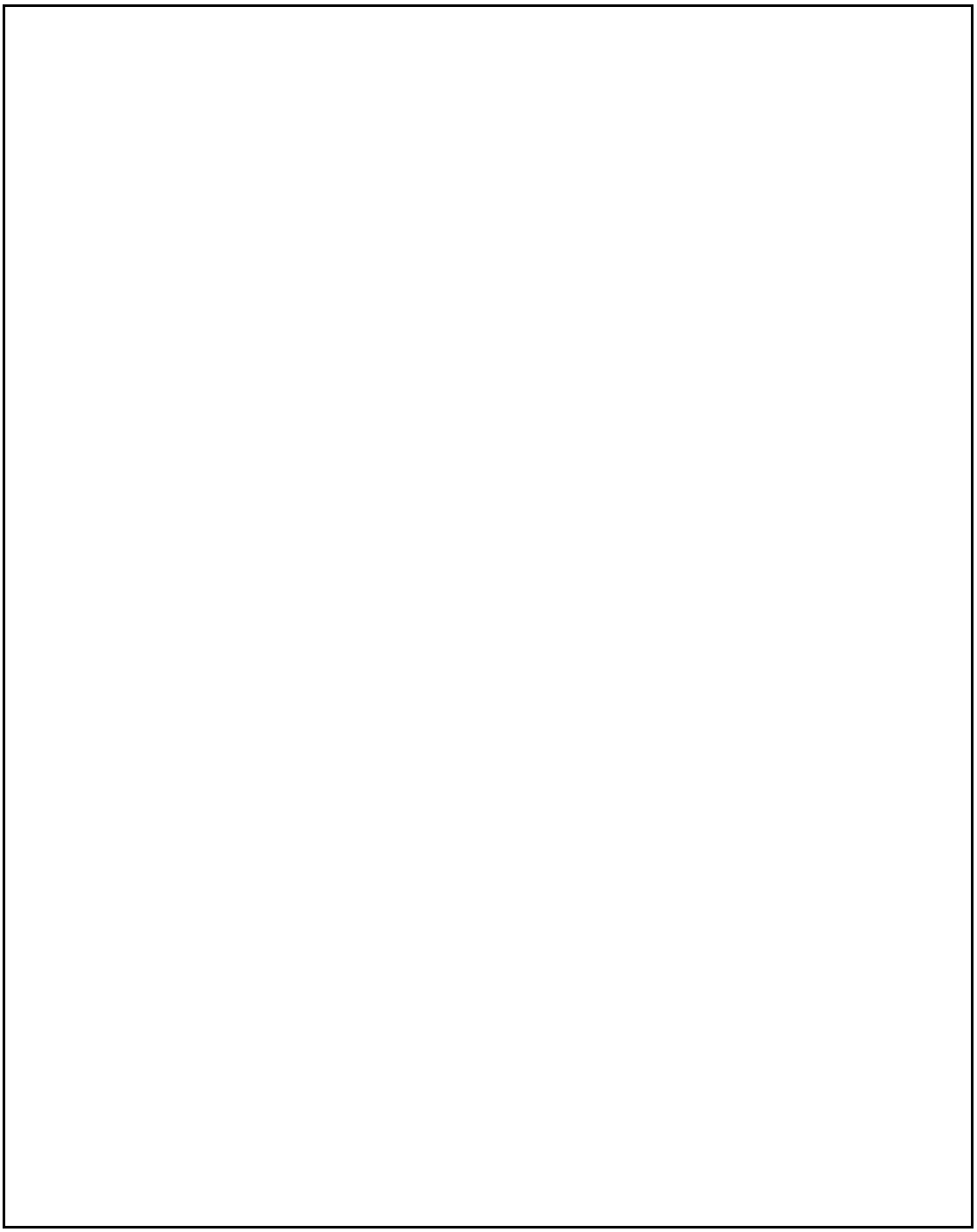
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# Appendix B
# HP E1366A/E1367A Multiplexer Registers

## Register Definitions

The HP E1366A and HP E1367A RF multiplexers are register-based slave devices. Register definitions are:

**ID Register**





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# Addressing the Registers

To read or write to specific registers, you must use the register address. Since the addresses for HP 75000 Series B or Series C plug-in modules are A00 through A15, use the VME A16 mnemonic for the address space. The address space within the mainframe/command module memory map depends on the mainframe/command module used. For example, the address of the HP E1300A/E1301A Mainframe starts at $1F0000_h$.

For the HP E1300/E1301, the A16 space is divided so modules are addressed only at locations beginning with $C000_h$ within A16. Each module is allocated 64 register addresses ($40_h$). The module base address is related to the logical address set by the logical address switch (LADDR) on the module:

**base address $(_h)$ = (logical address$_h$)*$40_h$ + $C000_h$**

For the RF multiplexers, the factory-set logical address is 120 ($78_h$), so the base address = $(78_h)*(40_h) + C000_h = DE00_h$. Then, for example, to address the Status/Control register of an RF multiplexer in an HP E1300A/E1301A, the register address = $[\text{A16 location}]_h + [\text{base address}]_h + [\text{register offset}]_h = 1F0000_h + DE00_h + 04_h = 1FDE04_h$.

# Reading the Registers

You can read the following RF multiplexer registers:

- ID register (base + $00_h$)
- Device Type register (base + $02_h$)
- Status/Control register (base + $04_h$)
- Bank 0 Channel Enable register (base + $08_h$)
- Bank 1 Channel Enable register (base + $A_h$)

## ID/Device Type Registers

For either RF multiplexer, a read of the ID register (address base + $00_h$) returns $FFFF_h$ since the multiplexers are manufactured by Hewlett-Packard and are A16 only, register-based devices. The Device Type register (base + $02_h$) returns $FF80_h$ for the HP E1366A (50Ω) multiplexer and returns $FF84_h$ for the HP E1367A (75Ω) multiplexer.

## Status/Control Register

Each relay requires about 15 msec execution time (close to open or open to close) during which time the RF multiplexers are "busy". A read of the Status/Control register (base + $04_h$) returns $FFFF_h$ when the module is not busy or returns $FF7F_h$ (bit 7 is low-true) when the module is busy.

## Channel Enable Registers

A read of either of the two Channel Enable registers (base + $08_h$ for bank 0 or base + $A_h$ for bank 1) always returns $FFFF_h$, regardless of the channel states.



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# Writing to the Registers

You can write to the following RF multiplexer registers:

- Status/Control register (base + $04_h$)
- Bank 0 Channel Enable register (base + $08_h$)
- Bank 1 Channel Enable register (base + $A_h$)

## Status/Control Register

The only write allowed to the Status/Control register (base + $04_h$) is to bit 0. Writing a "1" to bit 0 resets the multiplexer to its power-on state with all channels open and terminated and both commons open.

## Channel Enable Registers

Writes to the Channel Enable registers (base + $08_h$ and base + $A_h$) enabling you to open or close the desired channel (see Register Defintions at the beginning of this chapter). For example, write a "1" to bit 2 of the bank 0 Channel Enable register to close channel 02. Or, write a "1" to bit 3 of the Bank 1 Channel Enable register to close channel 13. Writing a "0" to bits 0 - 3 results in all channels open and terminated and the common open. Only one channel per bank can be closed at a time. Any bit pattern not shown in Register Defintions at the beginning of this chapter, results in the lowest-numbered channel being closed.



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# Appendix C
# HP E1366A/E1367A RF Multiplexer Error Messages

The table below lists the error messages associated with the multiplexer modules programmed by SCPI. See the appropriate mainframe manual for a complete list of 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 l t 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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