

Chapter 6

44470A

Relay Multiplexer

Introduction

-hp- Model 44470A (3488A Option 010) Relay Multiplexer provides 10 channels of 2 wires each to switch analog signals to a common bus. The relays exhibit low thermal offset characteristics making them ideal for precision low level measurements*.

The individual relays on this option are rated at 250 Volts @ 2 Amps and can be operated in either a BBM mode (break before make) or in a mode where multiple channels may be closed together. This multiplexer option offers many possible uses including multiplexing signals directly to a measuring instrument or as an Input/Output multiplexer with the 44473A Matrix option. A removable terminal block assembly is provided for convenience in wiring and also provides strain relief for cables.

This chapter is designed to serve as a reference guide for using the 44470A Relay Multiplexer. As such, it contains programming information, installation and configuration information, and application examples.

WARNING

The 3488A Option 010, 44470A Multiplexer Assembly uses latching relays. The state of these relays can only be altered under program control. This is an advantage in the sense that, under most conditions of failure, the relays will remain in whatever state your program has set them. However, in case of power or equipment failure, any application requiring a failsafe method of insuring that the circuits under control are in a known state must be provided by the installer.

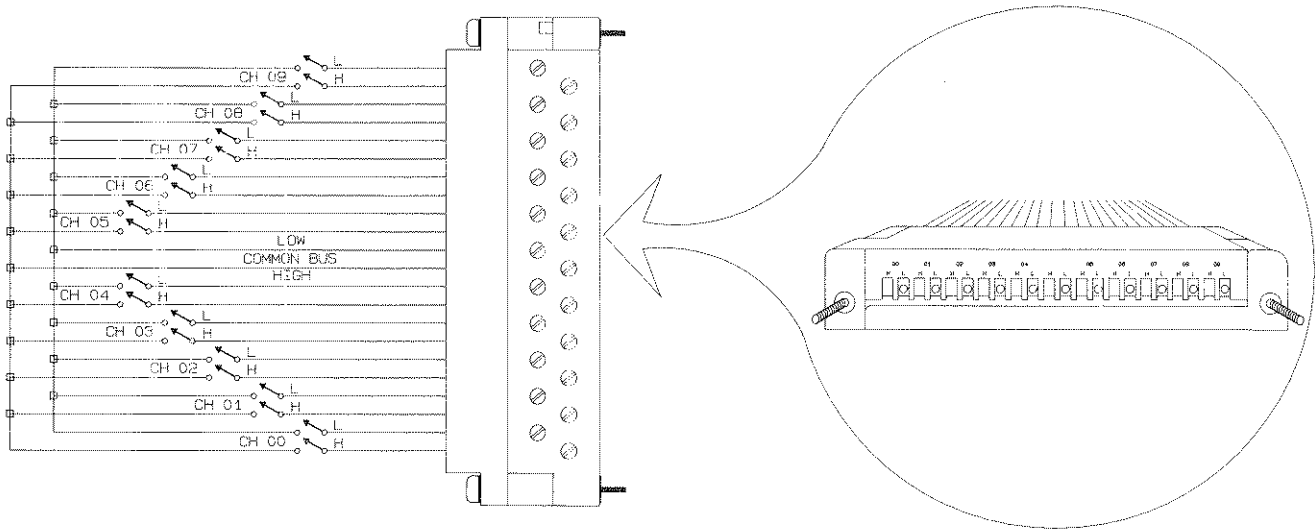
Operation

As shown in Figure 6-1, the 44470A Relay Multiplexer assembly consists of ten 2-wire relays connected to a common analog bus. Two modes of operation are possible: single channel, break-before-make or multiple channels closed together. Basically, there are two different ways the 44470A may be used: inputs from 10 different sources may be switched to the one common bus or one input (common bus) may be switched to 10 different places.

* Although the 44470 Multiplexer can be used to switch thermocouples, there is no offset compensation built-in and errors may occur.

An example of the first case would be when measuring up to 10 different voltage sources. Each channel connects to one voltage source and the common bus would connect to a digital voltmeter. As each relay is closed, the voltmeter measures that voltage. In this case only one relay would be closed at any one time.

To illustrate the second case, consider a dc voltage source being switched to several different loads. More than one relay might be closed at any one time.



3488-1-1

Figure 6-1. 44470A Simplified Schematic

At turn on or reset (either from the front panel RESET key or the HP-IB CLEAR command), all channels on the 44470A will be opened.

Channels

A channel, as described in Chapter 2, refers to an individual relay, in this case a relay on the 44470A assembly. Therefore, when speaking of closing a channel, we are referring to closing a particular relay. Channel numbers are two digit numbers 00 through 09 and are repeated on each 44470A assembly. This can be seen by the numbering on the Terminal Block Edge Connector.

Channel addresses, on the other hand, are determined by which slot the 44470A assembly is mounted in. Channel addresses are a three digit number where the first digit specifies the particular slot where the 44470A option is installed. The last two digits are the channel number. For example, channel address 102 means slot number 1, channel 02.

The following table shows the channel addressing scheme for the five different slots.

Table 6-1. Channel Addressing Scheme

Channel number as shown on the terminal block	Channel address if 44470A assembly is in slot number:				
	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5
00	100	200	300	400	500
01	101	201	301	401	501
02	102	202	302	402	502
03	103	203	303	403	503
04	104	204	304	404	504
05	105	205	305	405	505
06	106	206	306	406	506
07	107	207	307	407	507
08	108	208	308	408	508
09	109	209	309	409	509

Commands

Most of the 3488A commands can be used in controlling the 44470A option. In addition to the standard 3488A commands, two HP-IB interface commands directly effect the 44470A. All of these commands are described using a simple format of explanation.

In the following summary of command descriptions, square brackets ([]) indicate optional parameters, whereas items in < > brackets are mandatory. For further explanation of the command code mnemonics, refer to Chapters 2 and 3.

CLOSE a channel

Command Format: CLOSE <ch. address>[,<ch. address>,<ch. address>,...]

Description

The CLOSE command is used to simply close one or more channels on the 44470A. Note that the CLOSE command does not open any channels that were previously closed. Several channels can be closed with one CLOSE command by separating the channel addresses with a comma. If more than one channel is specified with the command, they are closed in the order listed.

Examples

OUTPUT 709;"CLOSE 102,103,105" ! Closes channels 2, 3, and 5 in slot number 1

OUTPUT 709;"CLOSE 104,305" ! Closes channel number 4 in slot 1 and channel number 5 in slot 3.

OPEN a channel

Command Format: OPEN <ch. address>[,<ch. address>,<ch.address>...]

Description

OPEN is used to open individual channels on the 44470A assembly. If more than one channel is specified in the OPEN list, they are opened in the order listed. Use the CARD RESET command to open all channels on an assembly. It is easier than listing each channel individually.

Example

```
OUTPUT 709;"OPEN 103,105,107"    ! 1 Relays 3, 5, and 7 are opened in slot
                                   number 1
```

VIEW a channel

Command Format: VIEW <ch. address>

Description

The VIEW command is used to look at the state (either open or closed) of a particular channel. The 3488A responds with the string "OPEN 1" if the specified channel is open. If the specified channel is closed, the 3488A responds with the string "CLOSED 0". In the 3488A display, the channel address is displayed followed by a colon and the appropriate string.

Example

```
10 OUTPUT 709;"VIEW 105"    ! VIEWs channel 5 on slot number 1
20 ENTER 709;A$             ! input the response from the 3488A
30 DISP A$                  ! A$ will either be "OPEN 1" or "CLOSED 0"
```

OR

```
20 ENTER 709; A
30 DISP A                    ! "A" will either be 1 or 0 (open or closed,
                               respectively)
```

CARD TYPE

Command Format: CTYPE <slot>

Description

This command causes the 3488A to respond with a description of what type of option card is located in the specified slot. The description includes the name of the card as well as the option number. In the display, the description is preceded by the specified slot number.

Card Type	Description
Slot is empty	NO CARD 00000
10 Channel Multiplexer	RELAY MUX 44470
General Purpose Card	GP RELAY 44471
High Frequency Scanner	VHF SW 44472
Matrix Card	MATRIX SW 44473
Digital I/O Card	DIGITAL IO 44474
Breadboard Card	BREADBOARD 44475

Example

```
10 OUTPUT 709;"CTYPE 3"    ! look for the card in slot 3
20 ENTER 709;A$
30 DISP A$                 ! Card description will be displayed
```

CARD RESET

Command Format: CRESET <slot>[, <slot>, ...]

Description

CRESET is used to reset all channels on the 44470A assembly to their open state. Only cards in the slots specified are affected.

Example

```
OUTPUT 709;"CRESET 2"    ! resets the option assembly in slot 2
```

CARD PAIR

Command Format: CPAIR <slot>, <slot>

Description

Card PAIR is used to pair up two option assemblies of the same type, e.g., 44470A's. This operation will effectively assign both options to both slot numbers so that closing or opening a channel on either option will perform the same operation on the respective channel on the other option. This feature is especially useful when doing 4-wire scanning.

Commands used with the Card PAIR function are: CLOSE, OPEN, CRESET, CHAN and STEP. Of course, paired slots can be used as part of a scan list.

Executing a CPAIR command cancels any previous CPAIR command that involved either of the two options. It is possible, however, to have two sets of card pairs, e.g. slots 1 paired with 2 and 3 paired with 4.

Example

OUTPUT 709; "CPAIR 1,3" ! sets the options in slots 1 and 3 as pairs

OUTPUT 709; "CLOSE 105" ! closes channels 105 and 305 simultaneously

Executing the CPAIR command without specifying slot numbers allows you to determine which, if any, slots are paired together. Four numbers are returned separated by commas. The first two numbers specify slots in the first pair, the second two numbers specify the second pair. An inactive card pair is denoted by 0,0.

Example

OUTPUT 709; "CPAIR"

ENTER 709; A\$

DISP A\$

String variable A\$ will have the four slot numbers.
Note, you may have to dimension A\$ to 30.

At the back of this chapter is a section on applications. One of the application examples demonstrates the use of the CPAIR mode with 4-wire resistance measurements.

SCAN LIST

Command Format: SLIST [<ch. address>(, or -)<ch.address> . . . <ch. address>]

Description

Scan List allows you to specify a sequence of channels to be scanned. The sequence is specified as a list of up to 85 channel addresses (relay or digital I/O lines) and/or stored setups separated by commas. Contiguous channels may be specified by entering the first channel address and the last channel address separated by a hyphen. STEP is used to sequentially close channels in the list.

Example

```
10 OUTPUT 709; "SLIST 104,205,300-309,410,0"  
20 FOR I=1 TO 14  
30 OUTPUT 709; "STEP"  
40 NEXT I
```

In this example, the scan would start with channel 104, followed by channel 205, followed by channels 300, 301, 302, . . . 309 and finally channel 410. The 0 channel specified at the end of the list is a stop channel and opens the last channel closed (channel 410) but does not close any other channel.

Notes

1. Channels may be scanned in any sequence, i.e., 309-300.
2. Stepping beyond the last channel specified in the Scan List causes a wrap-around to the first channel in the list. The number 0 can be used as a stop channel.
3. Refer to the Advanced Operations section in this chapter for information on using the External Increment and Channel Closed features.
4. The commands OPEN, CLOSE, CRESET, or RECALL will have no effect on the Scan List even though the state of individual channels may change.
5. Stored setups may be recalled as part of the Scan List simply by specifying the register number. For example: SLIST 104,105,106,25,200,201. Here, register 25 has the stored setup.

STEPping Through the Scan List

Command Format: STEP

Description

STEP is used to open the the last channel closed and close the next channel in the Scan List. If STEP is executed and no Scan List exists, the 3488A will generate an execution error.

The 3488A uses a pointer to keep track of which channel in the Scan List is currently closed. When STEP is executed, that channel is opened and the next item in the list is checked. If the next item in the list is a relay or Digital I/O line, that channel is closed. If the next item in the list is a stored setup, that setup is recalled. Channels that are closed by a setup will remain closed, that is, they are not opened by the next execution of the STEP command.

For additional information see the Advanced Operation section of this chapter for Channel Closed and External Increment.

Example

```
10 OUTPUT 709;"SLIST 100 – 109;CMON 1"  
20 FOR I= 1 TO 10  
30 OUTPUT 709;"STEP"  
40 NEXT I
```

CHANnel command

Command Format: CHAN [<ch. address>]

Description

CHAN is used to open the last channel closed by either STEP or CHAN and close the specified channel. If no channel is specified with CHAN, the 3488A will respond with the number of the last channel closed by either STEP or CHAN. If no channel has been closed since the last reset, then CHAN returns the number 0.

If a Scan List is in effect when CHAN is executed, the 3488A will search through the list and position the Scan List pointer to the channel specified by CHAN. If CHAN specifies a channel that is not in the Scan List, and then STEP is executed, the 3488A will open the channel closed by CHAN and go to the beginning of the Scan List.

Example

OUTPUT 709; "CHAN 203" ! Closes channel 203

OUTPUT 709; "CHAN"

ENTER 709; A

DISP A

! Variable A will contain the last channel closed, i.e.,
203

CARD MONITOR mode

Command Format: CMON <slot>

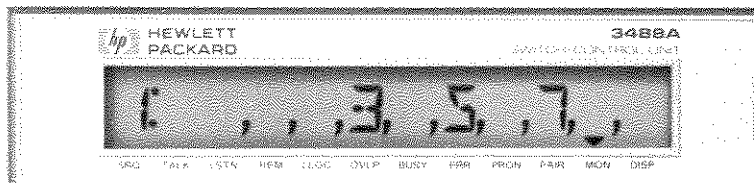
Description

Card Monitor is used to look at the state of the individual option assemblies in the specified slot (1-5). Specifying 0 as the slot will cause the monitor mode to be cancelled. If a negative number is used for the slot, the 3488A will go to its monitor tracking mode.

When used to monitor the 44470A assembly, the display shows the slot number (extreme left) and those channels that are closed, separated by commas. The MONitor annunciator also comes on:

Example

OUTPUT 709;"CLOSE 103,105,107; CMON 1"



The format of the display can be summarized as:

s: n,n,n,n,n,n,n,n,n

where s represents the slot number being monitored and n is a one digit channel number.

Advanced Operations

Advanced Operations provide you with more capabilities when using the 3488A. It may be important, for example, to tell the system voltmeter when a channel has been closed and thus take a measurement. Or maybe you need to close the next channel in a scan list when some external event has taken place, perhaps as soon as the voltmeter has completed its reading. Most operations can be performed with only the basic commands, but for those times when you need something more, the advanced operations should meet your switching needs.

External Increment and Channel Closed

External Increment (EI) provides a method of sequencing through a scan list without system computer intervention. Typically, EI is connected to the Voltmeter Complete* output on a system voltmeter. Thus, when the voltmeter has completed its measurement, it signals the 3488A to step to the next channel in the list. The EI input is rising-edge triggered and TTL compatible.

Channel Closed (CC) provides a 15 μ S TTL pulse for signaling when a channel has been closed in the 3488A. This signal can be tied to the External Trigger input of a voltmeter to trigger it when a channel is closed. Together, EI and CC can be used with a system voltmeter to sequence through a scan list without any intervention by the system computer. Later in this chapter, examples number 2 and 3 will show how this can be done.

Using the External Increment and Channel closed features requires the use of a 44474A Digital I/O option. This also means that the Digital I/O option cannot be configured in Handshake Mode #5 when it is used for scanning (it can be used statically, however). The DMODE command is used to specify the handshake mode, Polarity, and External Increment (EI). Only one Digital I/O option can be configured for EI at a time. If one option is configured to accept EI and another is subsequently enabled, the first card will be disabled.

Even though the only specifier we are interested in is EI, the mode and polarity specifiers must be included. The format for specifying DMODE is as follows:

```
DMODE <slot>[, <mode>][, <polarity>][, <EI>]
```

* Voltmeter Complete is a feature on most Hewlett-Packard digital voltmeters to signal the completion of a measurement by means of a TTL compatible pulse.

The MODE specifier is as follows:

Definition	Value
Static Mode	1
Static mode for read back	2
R/W and Strobe	3
Rd & Wrt Strobe	4
Handshake (no EI)	5

Any of the modes may be specified for use with External Increment except the Handshake mode (value 5).

The Polarity specifier is the sum of weighted values and is defined as follows:

Definition	Value
Lower 8-bits polarity	1 = Low true
Upper 8-bits polarity	2 = Low true
PCTL Polarity	4 = Low busy
PFLG Polarity	8 = Low busy
I/O Direction line polarity	16 = Low input mode

EI is enabled by specifying 1. It is disabled with a specifier of 0.

Refer to Chapter 10 for more information on setting up the 44474A Digital I/O option for External Increment and Channel Closed.

Delay

Command Format: DELAY [<time in mS>]

Description

The DELAY command is used to insert a time delay between the time that a channel is closed and the time that the next command can be executed and the Channel Closed pulse is output. The delay time may be specified from 0 to 32,767 mS (32 seconds) in 1 mS increments. The delay time does not become effective until either CHAN or STEP is executed.

If any command is sent to the 3488A during the delay time, the command will be executed as soon as the delay time is complete. If there is not a time value sent with the DELAY command, the 3488A will respond with the current value of the delay time.

Remember that the Channel Closed pulse will be output from whichever 44474A assembly has External Increment enabled.

Examples

OUTPUT 709; "DELAY 2000; CHAN 101" ! The delay time is 2000 mS = 2 seconds

OUTPUT 709; "DELAY"

ENTER 709; A

DISP A

! Display the delay time

HP-IB Interface Commands

Only two interface commands affect the state of the 44470A channels: TRIGGER (Group Execute Trigger) and CLEAR (Device Clear or Selected Device Clear). TRIGGER performs the same function as the 3488A STEP command. In other words, the two commands:

TRIGGER 7 (or TRIGGER 709)

and

OUTPUT 709; "STEP"

perform the same function as far as the 44470A assembly is concerned.

CLEAR, whether a Device Clear or Selected Device Clear, simply resets the 3488A and hence all relays will go to their open state.

44470A Assembly Installation

This portion of the chapter is written specifically for the service trained technician. It provides the necessary information for a person trained in electronic circuitry to configure and install the option assembly. Carefully read through this section and adhere to all cautions and warnings.

WARNING

Only qualified service trained personnel should remove, configure, or install the 3488A option assemblies. Disconnect the 3488A power cord from the back of the instrument prior to installing the option assemblies.

WARNING

The 3488A Option 010,44470A Relay Multiplexer, uses latching relays. The state of these relays can only be altered under program control. This is an advantage in the sense that, under most conditions of failure, the relays will remain in whatever state your program has set them. However, in case of power or equipment failure, any application requiring a failsafe method of insuring that the circuits under control are in a known state must be provided by the installer.

In case of component failure or programming error, any voltage input to an option card may be present on any other terminal on the same option card.

When you initially received your 3488A, the option assemblies were not installed in the mainframe. Each option assembly was packaged separately along with a terminal block edge connector and a two piece strain relief housing. In addition, two labels were provided for option identification.

CAUTION

Use clean handling and anti-static procedures when removing, configuring and installing the option assemblies. The circuit boards must be kept clean to ensure compliance with impedance specifications. The option assemblies as well as the 3488A mainframe contains CMOS devices which are susceptible to static discharges.

A few simple steps are required to install the 44470A assembly. Carefully observe the orientation of the assembly and terminal block as you install them.

1. Pre-installation
 - a. Remove the ac power cord from the 3488A before installing any option assembly.
 - b. Position the 3488A with the rear panel towards you.
 - c. Select a slot. Refer to Figure 6-2, the 3488A has five slots for installing option assemblies. The 44470A can be used in any of the five slots.

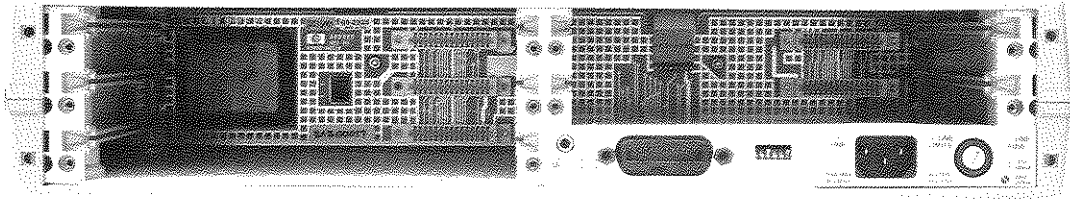


Figure 6-2. Rear Panel View Of The 3488A

2. Option assembly installation

- a. Hold the option assembly, component side down, by the metal shields. Insert the circuit card into the slot guides and slide toward the front of the instrument. Push firmly until the assembly 'snaps' into place. Fold the plastic levers toward the assembly. These levers lock the option into the mainframe.

NOTE

To remove the option assembly, simply unfold the plastic tab levers. This will release the locking mechanism and pull the option out of the mainframe connector.

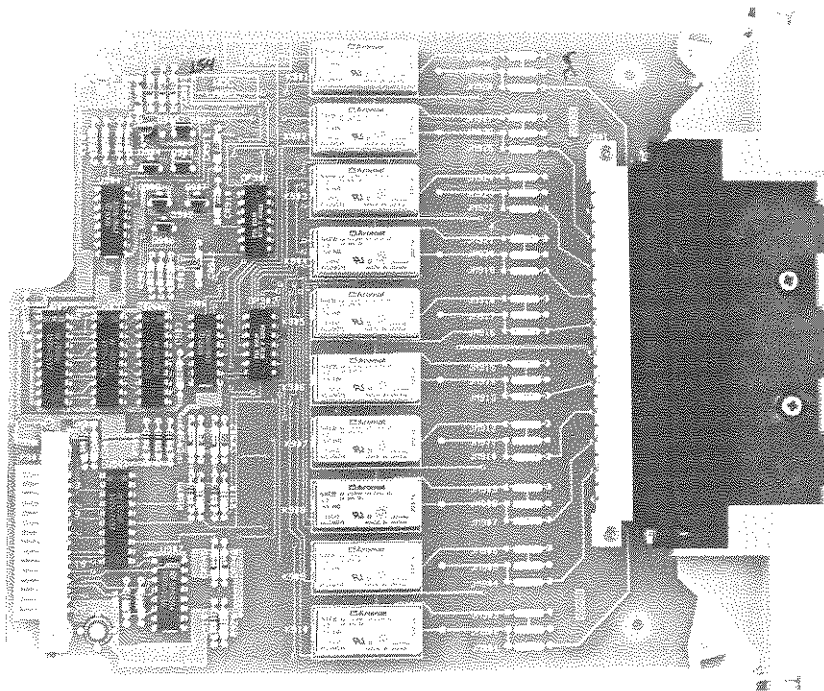


Figure 6-3. Option Card

3. Terminal Block Wiring

a. Wire the Terminal Block Edge Connector. The following photograph shows the channel connection sequence for the 44470A Terminal Block Edge Connector. This terminal block is keyed to fit only the 44470A assembly. Extra terminal blocks are available under the -hp- part number 44480A. This terminal block was designed to accept wires in the range of 18 to 26 AWG.



Figure 6-4. Terminal Block

4. Strain Relief

a. Secure the terminal block to the strain relief housing with the captive screws on the terminal block. Make certain that the screws used to tighten the connector wires to the terminal block are accessible through the strain relief housing.

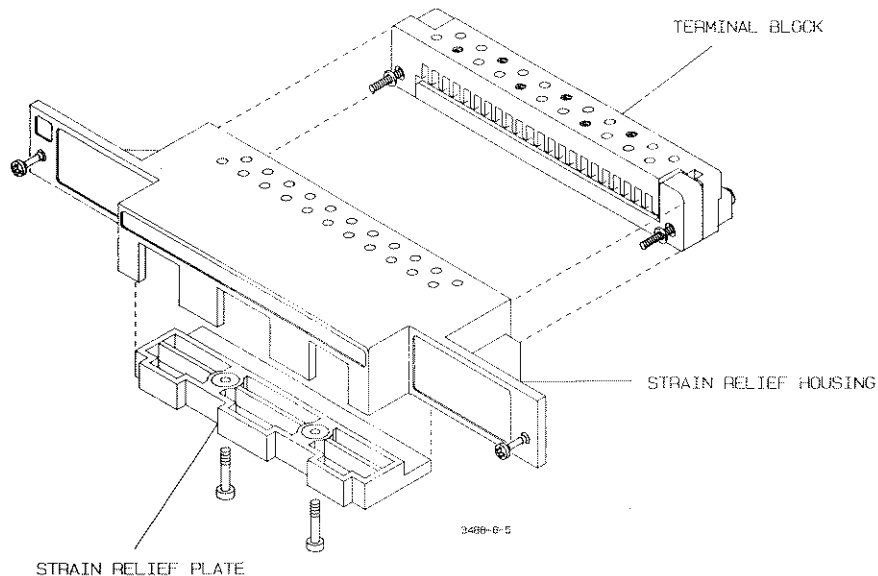


Figure 6-5. Strain Relief Housing

b. Route the wires evenly through the three strain relief cutouts. This will ensure a uniform amount of strain relief. If only a few wires are used, they should go through the middle cutout.

c. To protect wires smaller than 22AWG it is recommended that these wires be bundled together starting no more than 4" from the back of the 3488A. Failure to do so may cause wires to break at the strain relief. To illustrate the need for this, a 26AWG wire can survive about 7 to 8 pounds of tension before breaking. A bundle of 10, however, could survive up to 70 pounds of tension.

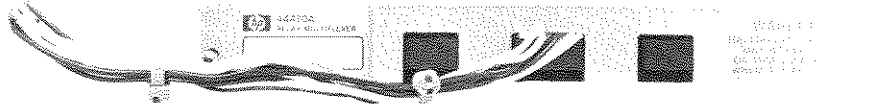


Figure 6-6. Cable Routing

d. Secure the strain relief plate to the strain relief housing (ribbed side toward housing). Do not over tighten the screws.

e. Push the terminal block with strain relief housing onto the option assembly connector. Tighten the two screws on either end of the housing.

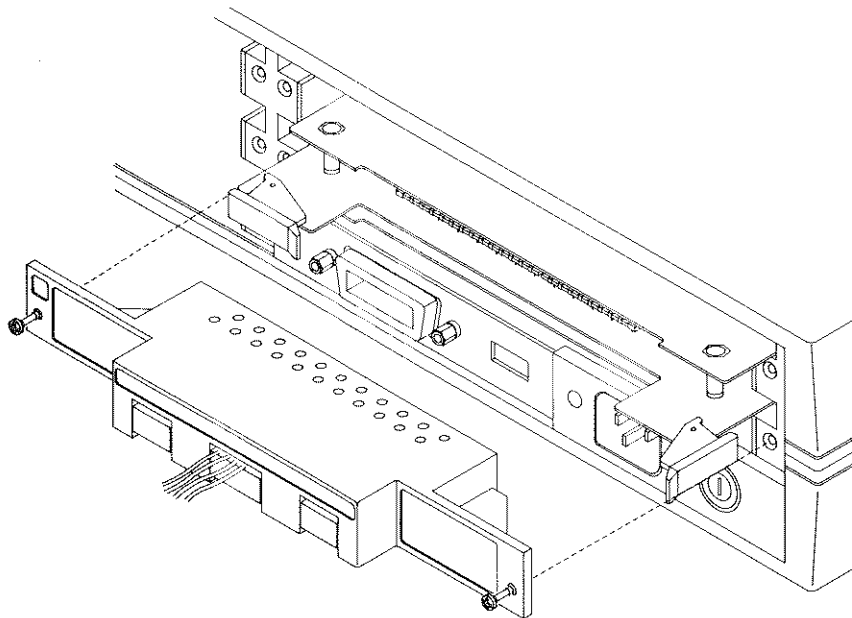


Figure 6-7. Attaching the Terminal Block

5. Labels

- a. Two labels were provided with the option assembly. One identifies the assembly as a 44470A Relay Multiplexer. There is space on the bottom of this label to type or write in a description of where this particular option is being used.
- b. Second, a series of numbered labels (1 to 5) is provided to help you identify the slot where the assembly is located. Select the appropriate number and place it in the upper left hand corner of the strain relief housing.

Configuration

Provisions have been made on the 44470A circuit board for installing simple attenuators or filter networks. An attenuator is composed of two resistors that act as a voltage divider. Three jumper locations are provided for installing components in the signal High lead, Low lead and as a shunt from High to Low. Consider the following diagram:

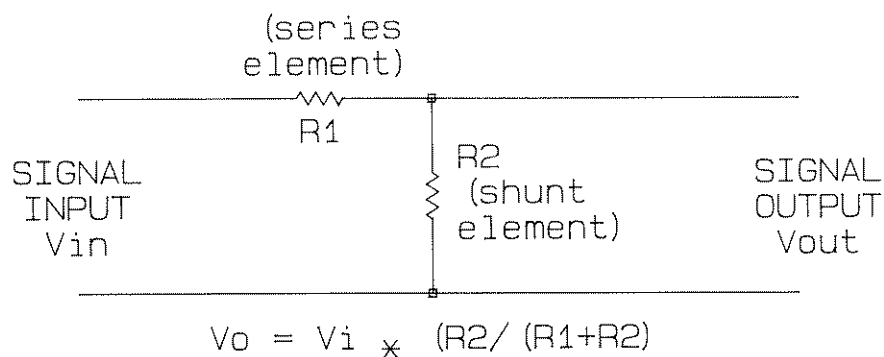


Figure 6-8. Diagram of Simple Attenuator

In order to install attenuators on the 44470A circuit board, the circuit board must be removed from the protective shields. Use caution as the 44470A assembly uses CMOS device which are susceptible to static discharge. Figure 6-9 shows the 44470A circuit board with the locations of where attenuators are to be installed.

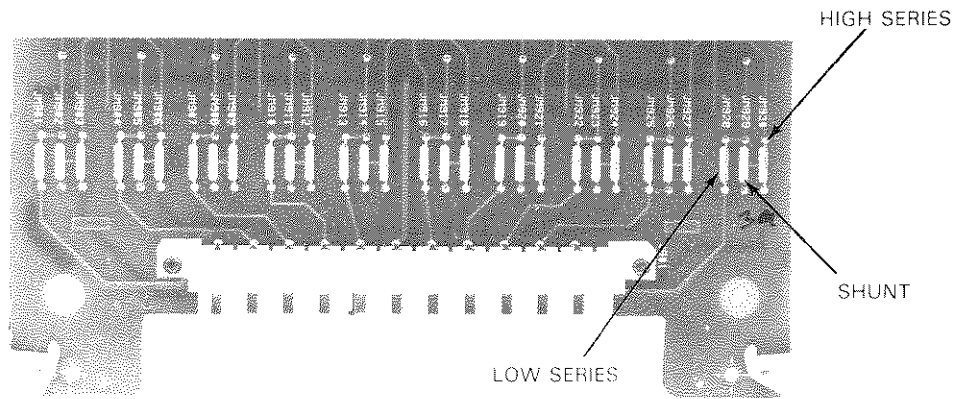


Figure 6-9. Attenuator Board Locations

One typical use for the shunt component is with 4–20 mA transducers. A 50 Ω , $\pm 1\%$, 0.5 watt resistor (-hp- part number 0699-0064) can be installed in the shunt location. The resultant voltage drop (transducer current through the resistor) can be measured by a system voltmeter. Thus, the 50 Ω resistor converts the 4–20 mA current to an 0.2 – 1 volt signal.

Accessories

-hp- part number 44480A provides an extra Screw Terminal Connector Block for the 44470A assembly.

Specifications

The specifications at the end of this chapter apply to only the 44470A assembly. These specifications are the performance standards or limits against which the assembly is tested. Do not exceed or surpass the specified limits.

Any changes in specification due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement.

Applications

The following four application examples demonstrate various uses of the 44470A Multiplexer option. Consideration should be given to your particular application before deciding which option assembly to use. The 44470A option is designed for use in measurements where noise bandwidth is not important, with a voltmeter for example. If your application requires higher isolation for noise rejection, such as with a spectrum analyzer, the 44472A VHF switch should be used.

Example 1. 4-Wire Ohms

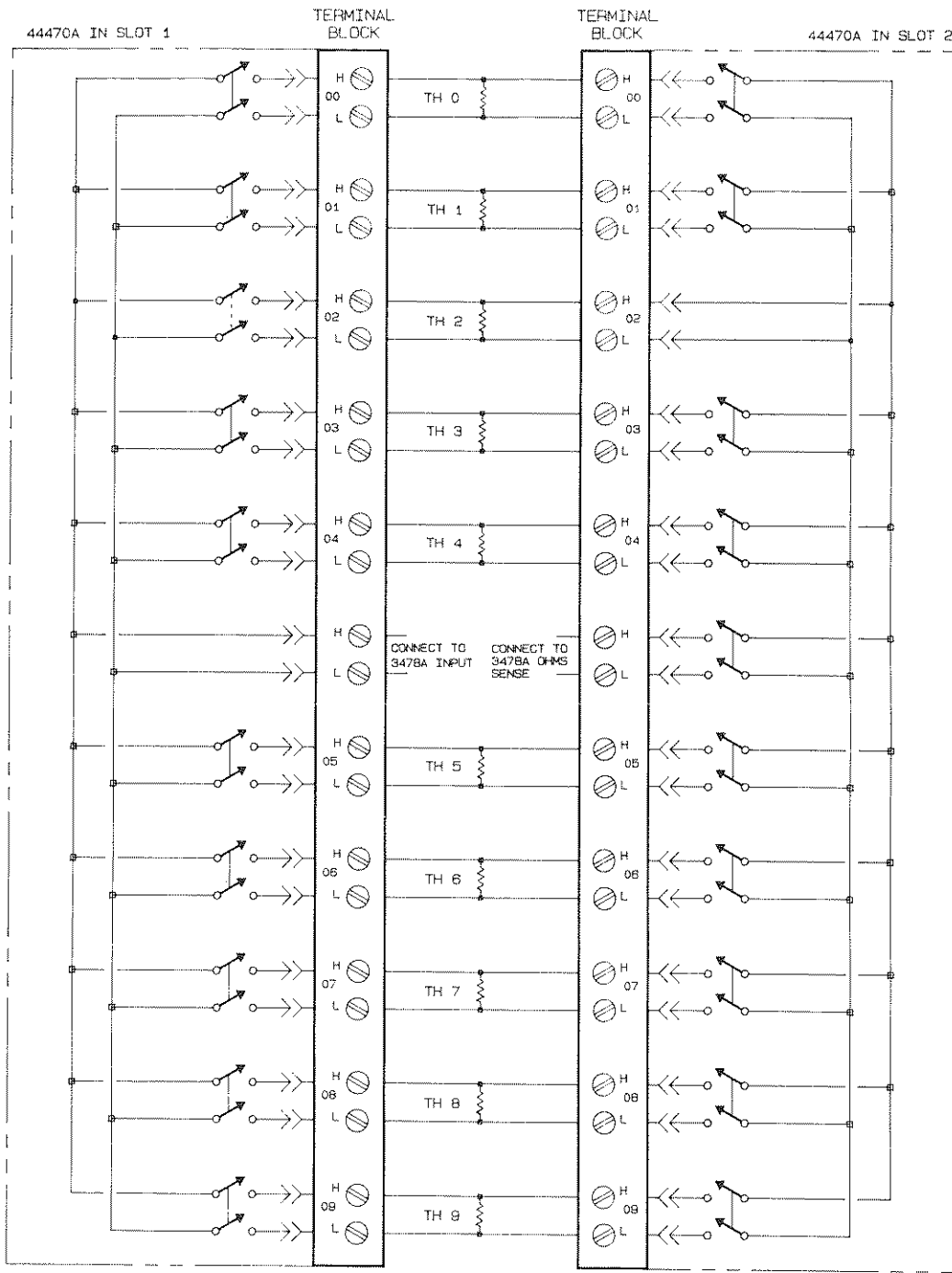
In this example, we want to show how channel pair scanning is useful when making 4-wire ohms measurements. Two 44470A assemblies are required. Slots 1 and 2 of the 3488A will be used for the 44470A assemblies. Let's use an -hp- 3478A to make the measurements on 10 thermistors. The resistance value of the thermistors can be converted to temperature by the computer.

Connect the Ω 's sense leads of the 3478A to the common bus of one of the 44470A assemblies. It doesn't matter which assembly, but for this example, let's use the one in slot 2. Now, connect the 3478A's voltmeter input terminal to the common bus of the 44470A assembly in slot 1.

Figure 6-10 shows the voltmeter connections and how the thermistors are connected to both 44470A assemblies

A program to scan through the channels and trigger the voltmeter for the measurements is shown below. This program was written for -hp- Series 80 computers. For clarity, the program does not show the resistance to temperature conversion routine.

10	!	4-Wire ohms example		
20	!	-HP- 85 version		
30	!	3488A at address 709, 3478		
		A at address 723	Line	Description
40		CLEAR 7		
50		OUTPUT 709 ; "CPAIR 1,2) SLIS	40	CLEAR resets the 3488A and 3478A.
		T 100-109"		
60		OUTPUT 723 ; "H4T4"		
70		FOR I=1 TO 10	50	Line 50 sets the 3488A to card pair slots
80		OUTPUT 709 ; "STEP"		1 and 2 (CPAIR1,2) and sets the scan list
90		TRIGGER 723		for channels 100-109.
100		ENTER 723 ; A(I)		
110		NEXT I		
120		!		
130		! Resistance to temperature	60	This line programs the 3478A for 4-wire
		conversion routine goes here		ohms measurements (H4) and trigger hold
140		!		(T4).
150		END		
			70-110	Lines 70 through 110 set up a loop to
				scan through the channel list. The
				readings are stored in array A(I).



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Figure 6-10. 4-Wire Ohms Measurements

Example 2. Scanning Using Channel Closed

Suppose we want to scan channels 100 through 209 (44470A options in slots 1 and 2) using Channel Closed. The 44474A Digital I/O option will be in slot 5. For this example, we will again use an -hp- 3478A Digital Voltmeter.

Remember to connect both 44470A's common bus to the input terminals of the 3478A. Also, connect the 3478A's External Trigger Input port to the 44474A's Channel Closed line.

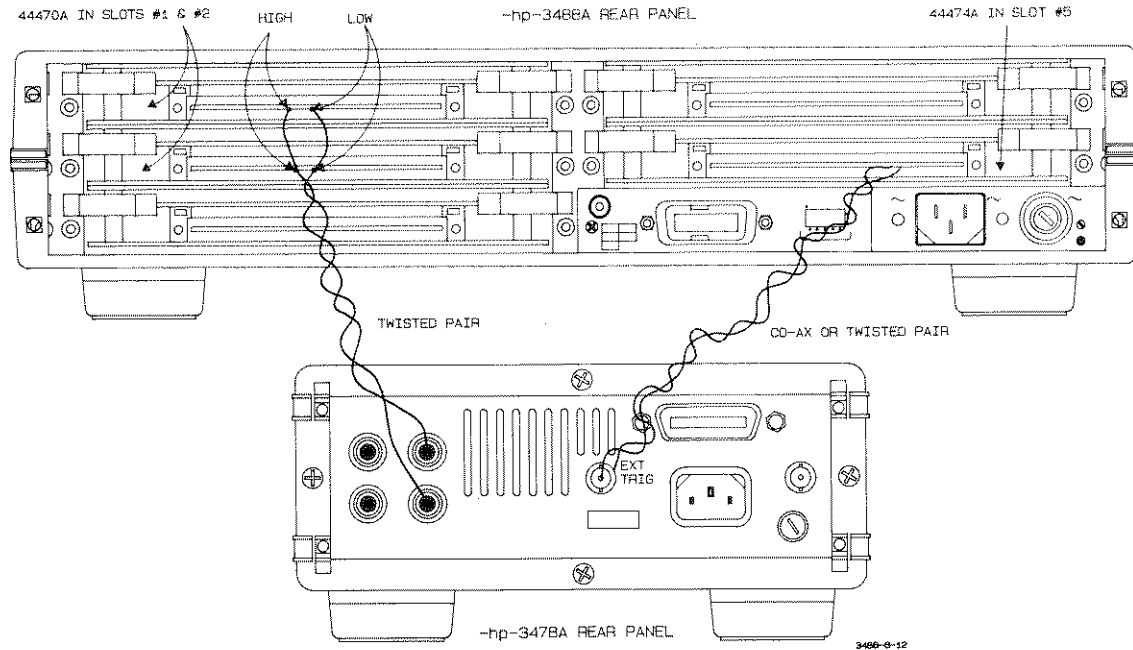


Figure 6-11. Channel Closed

The following program, written for an -hp- 85, shows the fundamental requirements for such a measurement system. Note the 3478A is triggered only by the Channel Closed pulse from the 44474A.

	Line	Description
10 ! Channel Closed example		
20 ! -HP- 85 version		
30 ! 3488A at address 709, 3478 A at address 723		
40 CLEAR 7	40	CLEAR resets the 3488A and 3478A.
50 OUTPUT 709 ;"SLIST 100-209,0 ; DMODE 5,1,1,1"	50	This line sets the 3488A for a scan list (SLIST) on channels 100 through 209. It also enables the 44474A Digital I/O option (slot 5, mode 1, polarity 1, EI enabled) for External Increment and Channel Closed.
60 OUTPUT 723 ;"H0T2"	60	The 3478A is set to its Home mode (DC Volts, Auto-range, Single trigger, 4½ digit resolution, auto-zero on) with H0 and the External Trigger mode with T2.
70 FOR I=1 TO 20	70-110	Lines 70 through 110 set up a loop to step through the scan list. Each reading is read into array A(I).
80 OUTPUT 709 ;"STEP"		
90 ENTER 723 ; A(I)		
100 DISP I;A(I)		
110 NEXT I		
120 END		

Example 3. Scanning Using External Increment and Channel Closed

Using a voltmeter with internal reading storage (such as the -hp- 3456A) makes the scanning even easier and faster. The main feature of this example is speed because as soon as the voltmeter completes one reading, the next channel is closed and a new reading initiated. Measurement speed is not dependent on the system computer.

Essentially, this program is the same as Example 2. Remember to connect the 44470A's common buss to the voltmeter input terminals and connect the voltmeter's External Trigger to the 3488A's Channel Closed line. Connect the 3456A's Voltmeter Complete to the 3488A's External Increment line.

The program sets the voltmeter for reading storage and then starts the scan sequence. As each reading is taken it is stored internally in the voltmeter and will be available to the computer later.

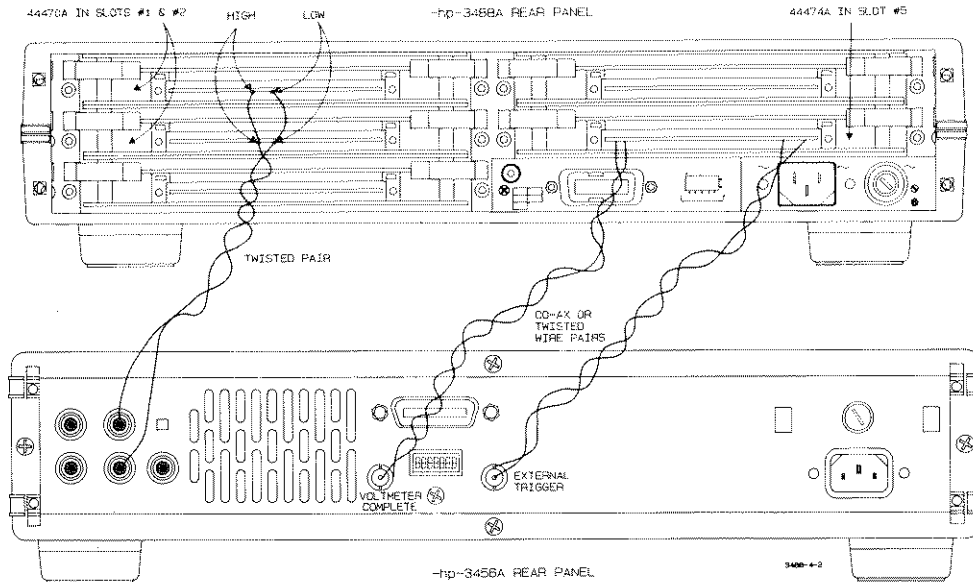


Figure 6-12. External Increment and Channel Closed

Refer to Chapter 10 for more information on setting up the Digital I/O option for External Increment and Channel Closed.

```

10 ! End of Scan sequence SRQ e
   example
20 ! -HP- 85 version
30 ! 3488a at address 709, 3456
   A at address 722
40 ON INTR 7 GOSUB 1000
50 ENABLE INTR 7;8
60 OUTPUT 709 ;"SLIST 100-209,0
   ; DMODE 5,1,0,1; MASK 1"
70 OUTPUT 722 ;"F1R1Z1T2RS1"
80 TRIGGER 709
90 GOTO 90 ! Mainline program e
   oes here
100 END
1000 P=SPOLL(709)
1010 IF BIT(P,0) THEN DISP "END
   OF SCAN REACHED"
1020 OUTPUT 722 ;"D020STR"
1030 FOR I=1 TO 20
1040 OUTPUT 722 ;"RER"
1050 ENTER 722 ; A(I)
1060 DISP A(I)
1070 NEXT I
1080 OUTPUT 722 ;"D1"
1090 STATUS 7,1 ; R
1100 OUTPUT 709 ;"STATUS"
1110 RETURN

```

Example 4. Single Ended Measurements

Using only 44470A Ten Channel Multiplexer options, a maximum of 50 channels (two wires) can be scanned for measurements. However, if you don't require the noise rejection of two wire measurements and the Lo side of all your signal sources can be connected together, you can use one 44471A and four 44470A options to provide up to 88 channels for single-ended measurements.

Figure 6-13 shows how these options are connected together in this example. Notice that all of the Hi terminals on the 44470A options connect to channel 0 on the 44471A. To measure any of the voltage sources connected to one of the Hi terminals, channel 0 on the 44471A must be closed. Furthermore, all the Lo terminals on the 44470A options connect to channel 1 on the 44471A. To measure any of

the voltage sources connected to the Lo terminals, Channel 0 must be opened and channel 1 closed. The remaining eight channels on the 44471A option can also be used for single ended measurements.

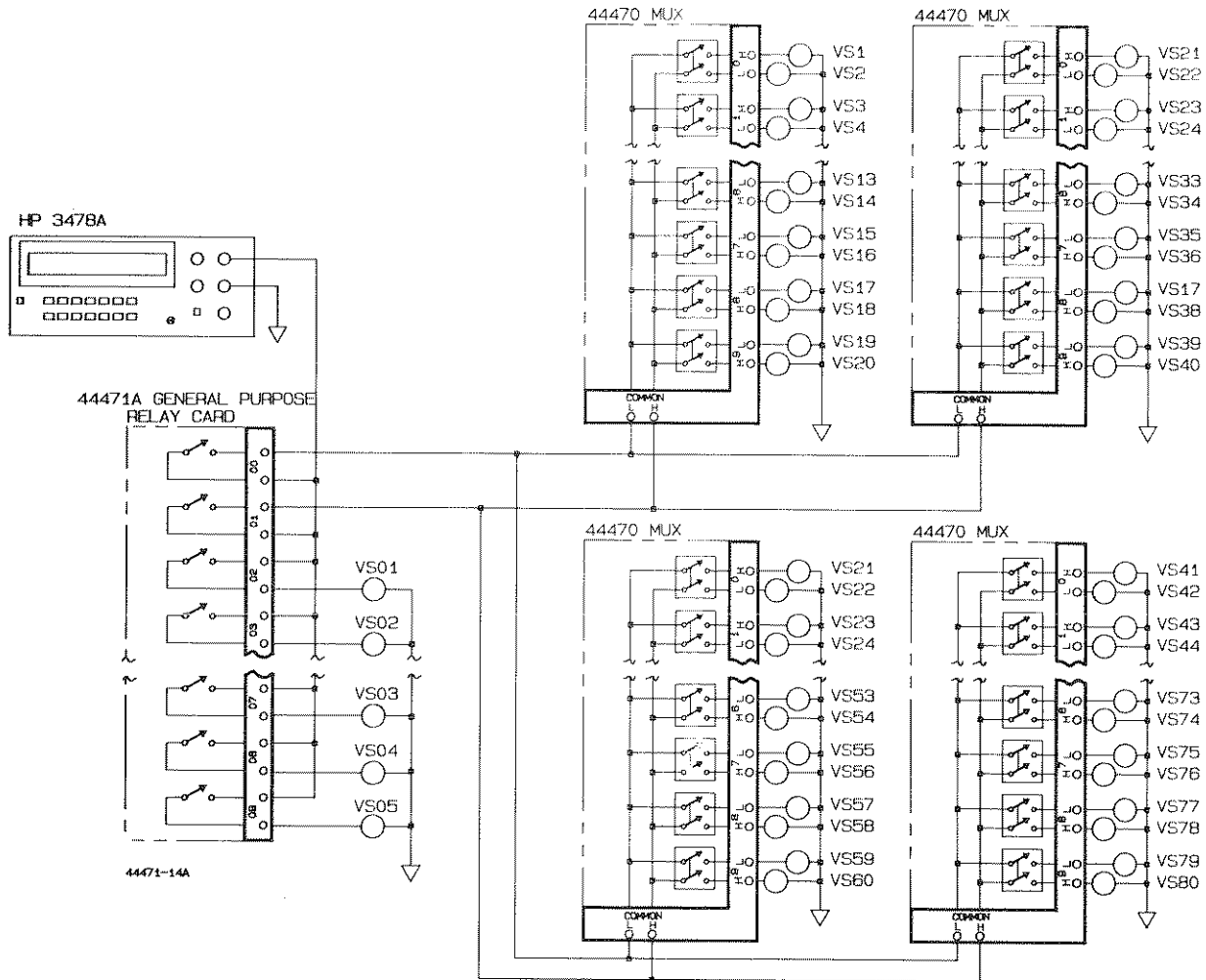


Figure 6-13. Single Ended Scanning

The associated program shows how to STEP through each of the 88 single ended channels. This program assumes that the 44471A option is mounted in slot 1 and the four 44470A's are installed in slots 2 through 5. The program uses an -hp- Model 3478A DVM for the measurements.

The program first sequences through the eight extra lines on the 44471A option (lines 50 - 90). Then, in lines 100 - 170, channel 100 is closed allowing measurements from the sources connected to the Hi terminals on the 44470A options. Finally, in lines 180 - 250, channel 100 is opened and channel 101 is closed permitting measurements from the Lo terminals on the 44470A options.


```

10 ! SINGLE ENDED SCANNING EXAMPLE
20 ! -HP- 85 VERSION WITH 3488A SWITCH AND 3478A DVM
30 ! 3488A AT ADDRESS 709, 3478A AT ADDRESS 723
40 OUTPUT 723 ;"T3"
50 OUTPUT 709 ;"SLIST 102-109,0; CMDN 1"
60 FOR I=2 TO 9 STEP 1
70 OUTPUT 709 ;"STEP"
80 TRIGGER 723
90 ENTER 723 ; A
100 PRINT "CHANNEL: ";I;"MEASUREMENT: ";A
110 NEXT I
120 ! MEASURE HI's
130 PRINT @ PRINT "HI CONNECTIONS MEASURED" @ PRINT
140 OUTPUT 709 ;"CLOSE 100; SLIST 200-509,0; CMDN -2"
150 FOR I=10 TO 50
160 OUTPUT 709 ;"STEP"
170 TRIGGER 723
180 ENTER 723 ; A
190 PRINT "CHANNEL: ";I;"MEASUREMENT: ";A
200 NEXT I
210 ! MEASURE LO's
220 PRINT @ PRINT "LO CONNECTIONS MEASURED" @ PRINT
230 OUTPUT 709 ;"OPEN 100;CLOSE101"
240 FOR I=51 TO 90
250 OUTPUT 709 ;"STEP"
260 TRIGGER 723
270 ENTER 723 ; A
280 PRINT "CHANNEL: ";I;"MEASUREMENT: ";A

```

Table 6-2. Option 010 44470A 10 Channel Relay Multiplexer Module Specifications

INPUT CHARACTERISTICS

Maximum Voltage (Terminal-terminal or terminal-chassis):
250 VDC, 250 VAC RMS, 350 VAC Peak

Maximum Current: (Per channel or module): 2 ADC, 2 AAC RMS

Maximum Power (Per channel or module): 60 W DC, 500 VA AC

Maximum power dissipated by user added components: 2 W

Thermal Offset: < 3 μ V differential or single ended

Closed Channel Resistance: < 2 Ω (end of relay life)

DC ISOLATION

	<(40°C,60% RH)	<(40°C,95% RH)
Open Channel, Channel-Channel*	> 10 ¹¹ Ω	> 10 ⁹ Ω
Hi-Lo*	> 10 ¹⁰ Ω	> 10 ⁸ Ω
Channel-Chassis*	> 10 ¹⁰ Ω	> 5x10 ⁸ Ω

(* with 1 channel closed)

AC ISOLATION/PERFORMANCE**

Capacitance:

Open Channel, Channel-Channel*	< 5 pF
Hi-Lo*	< 27 pF
Channel-Chassis*	< 80 pF

(* with 1 channel closed)

(50 Ω termination)	100 kHz	1 MHz	10 MHz
Insertion Loss (dB)	< 0.20	< 0.25	< 0.50
Crosstalk (dB)	< -73	< -53	< -33

**With chassis of all equipment connected, and with low of input lines connected to low of output lines (either directly or via 3488A switched channel).