HP 3488A Switch/Control Unit

HP 44478A/B
1.3 GHz Multiplexer Modules

Operating, Programming, and
Configuration Manual

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Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät/System _____ HP 44478A/B _____
in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und
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Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten
verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter
Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's declaration

This is to certify that the equipment _____ HP 44478A/B _____
is in accordance with the Radio Interference Requirements of Directive FTZ 1046/84. The German
Bundespost was notified that this equipment was put into circulation, the right to check
the series for compliance with the requirements was granted.

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If Test- and Measurement Equipment is operated with unscreened cables and/or used for
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Interference Limits are still met at the border of his premises.

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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the National Institute of Standards and Technologies, to the extent allowed by the the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in materials and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period]. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Duration and conditions of warranty for this instrument may be superceded when the instrument is integrated into (becomes a part of) other -hp- instrument products.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

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Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

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 INSTRUMENT

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

DO NOT OPERATE A DAMAGED INSTRUMENT

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

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

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Operating and Safety Symbols

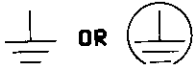**Symbols Used On Products And In Manuals**

~ LINE — AC line voltage input receptacle.

Instruction manual symbol affixed to product. Warns and cautions the user to refer to respective instruction manual procedures to avoid personal injury or possible damage to the product.

Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.

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

Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.
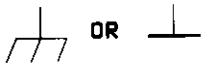
OR — Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.

ATTENTION
Static Sensitive
Devices

Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

NOTE

NOTE

Calls attention to a procedure, practice, or condition that requires special attention by the reader.

CAUTION

CAUTION

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

WARNING

WARNING

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

Contents

HP 44478A/B 1.3 GHz Multiplexer Modules

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HP 44478A/B
1.3 GHz Multiplexer Modules

Introduction

This manual contains information needed to configure, install, and program the HP 44478A 50 Ohm and the HP 44478B 75 Ohm 1.3 GHz Multiplexer modules. In this manual, the terms "1.3 GHz multiplexers", "the modules", and "HP 44478" are used to refer to the HP 44478A and the HP 44478B. All information applies equally to both modules unless stated otherwise. The manual is divided into six sections:

- **Module Description** is an overall description of the modules.

- **Installing the HP 44478A/B** describes the use of the module's SMB and BNC connectors.

- **Using the HP 44478A/B** is a tutorial showing how to operate the modules.

- **Command Summary** summarizes the commands referenced in the manual.

- **Specifications** lists the specifications for the modules.

- **Typical AC Performance** shows the module's typical performance characteristics versus frequency.

Module Description

The modules consist of two 4-to-1 multiplexers (group 00 and group 10) that provide bidirectional switching. The module relays are configured in a "tree" structure providing high isolation and low VSWR (voltage standing wave ratio). Each channel can switch up to 42V DC+AC peak at frequencies up to 1.3 GHz.

CAUTION

The maximum voltage that can be applied between any HP 44478A/B center conductor or shield to any other center conductor, shield or chassis ground is 42V DC+AC peak.

The maximum current per channel or common is 1A DC or 1A AC RMS. The maximum switching power is 24W or 24 VA per channel or common. The maximum power per resistive termination is 0.25W or 0.25 VA. Exceeding any of these limits may damage the module.

Each channel's center conductor may momentarily short to the shield when that channel is opened or closed. Only resistive (e.g., 50Ω or 75Ω) or current-limited (< 1 Amp) inputs with less than 0.1 µF total capacitance should be used.

User connections for the channels are through BNC connectors. Each channel has an SMB connector which allows you to connect resistive terminations and terminate unused channels. Refer to "Installing the

HP 44478A/B", later in this manual, for more information. Figure 1 is a simplified switching schematic for the modules.

TYPICAL CHANNEL RESISTIVE TERMINATIONS

FOR HP 44478A, R=50Ω (OR 75Ω)
FOR HP 44478B, R=75Ω

44478: A78. F. 1
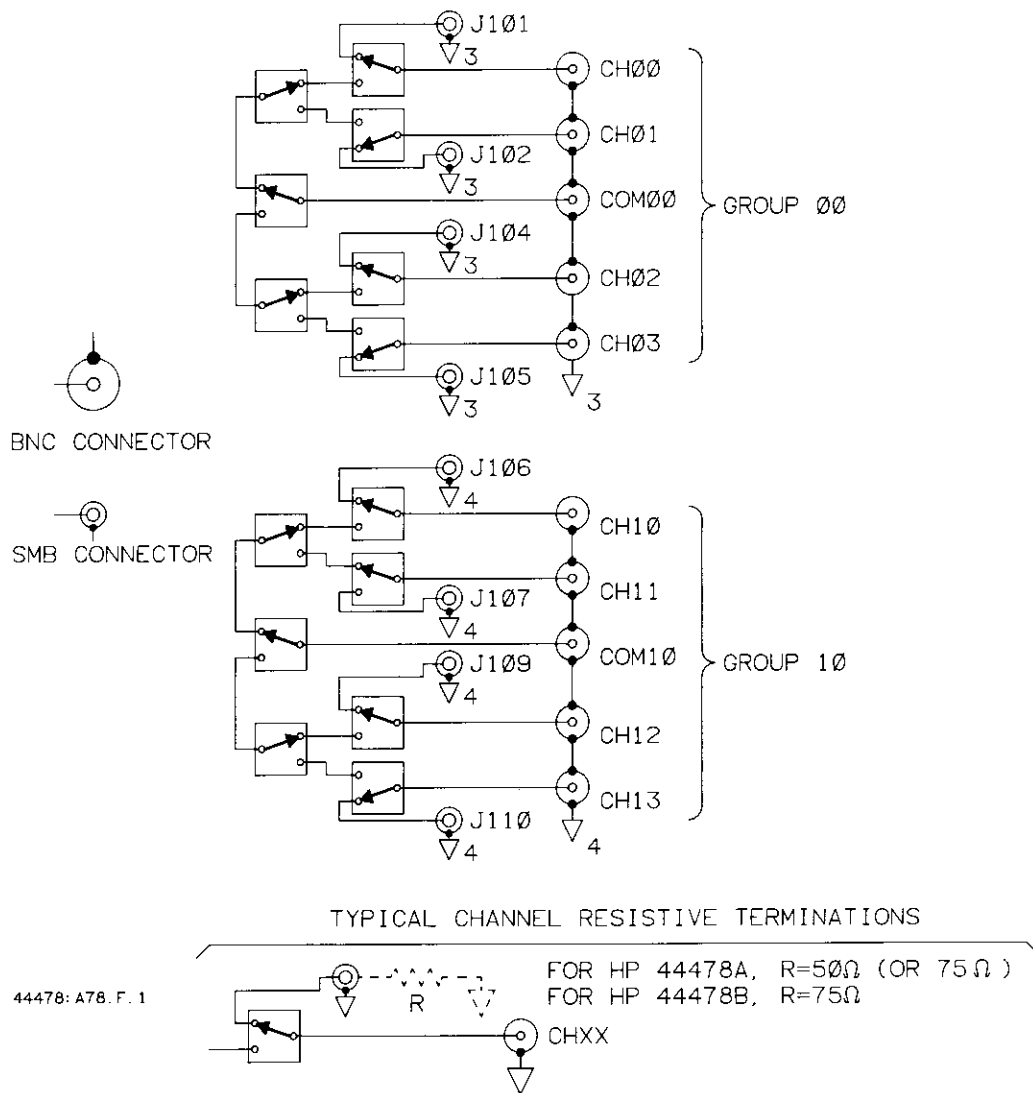
Figure 1. HP 44478A/B Simplified Switching Schematic

Channels

A channel refers to an individual set of relays on the HP 44478 assembly. When a channel is closed, a particular set of relays close connecting the common BNC to one of the four BNC inputs.

You switch a channel by using a complete channel address. The channel address is determined by which slot the HP 44478 is installed in. Channel addresses are three digit numbers of the form *snn* where the first number "*s*" specifies the particular slot (1 through 5) of the HP 3488A where the HP 44478 is installed. The last two digits "*nn*" are the channel number. For example, channel address 102 means slot 1, channel 02.

The following table shows all possible channel addresses.

Channel number as shown above connector	Channel address if HP 44478 module is in slot number:				
	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5
Group 00					
00	100	200	300	400	500
01	101	201	301	401	501
02	102	202	302	402	502
03	103	203	303	403	503
Group 10					
10	110	210	310	410	510
11	111	211	311	411	511
12	112	212	312	412	512
13	113	213	313	413	513

Table 1. Possible Channel Addresses.

Installing the HP 44478

This section gives you information on how to install the HP 44478.

WARNING

SHOCK HAZARD. Only qualified service-trained personnel should remove, configure, or install the HP 44478A/B modules. Disconnect the HP 3488A power cord from the back of the instrument prior to installing a module.

⚠₂ **WARNING** 42 VOLTS MAX

POSSIBLE OPERATOR INJURY. *The HP 44478A (HP 3488A Option 019) and the HP 44478B (HP 3488A Option 020) contain latching relays which connect the "COMMON" BNC to the "GROUP" BNC connectors. The state of the relays can only be altered by program control. In case of a power or equipment failure, the relays will remain in whatever state they were last programmed to. Any application requiring a failsafe method of insuring that the COMMON connector is connected to a known GROUP connector after a power or equipment failure, must be provided for by the installer. When power is reinstated, relays go to the power-on state.*

CAUTION

Use anti-static procedures when removing, configuring, and installing a module. The module, as well as the HP 3488A, contains CMOS devices which are susceptible to static discharges. Do not install a module without its metal covers attached.

To install an HP 44478 1.3 GHz Multiplexer Module in the HP 3488A, you perform the following steps.

1. Remove the ac power cord from the HP 3488A before installing the module.

2. Face the HP 3488A rear panel toward you.

3. Determine the slot in which you will install the module. Figure 2 illustrates the five slots that are available for installing modules. You can install the HP 44478 in any one of the five slots.

4. Hold the module by the metal shields, component side down. Insert the module into the slot guides and slide the module toward the front of the instrument. Push firmly until the assembly "snaps" into place. Secure the module in the slot by tightening the panel's two side screws.
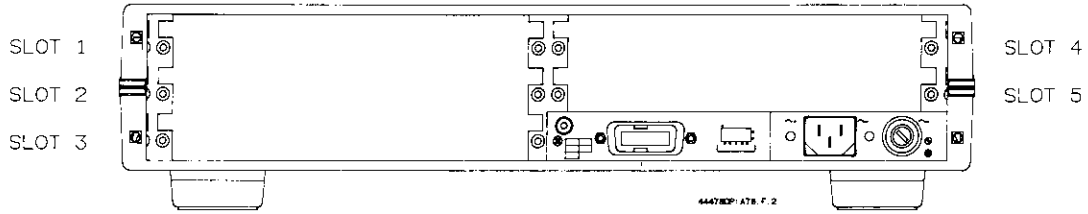
Figure 2. HP 3488A Rear Panel; Available Module Slots.

| **NOTE** |

To remove the module, simply loosen the screws at each end of the panel. Then pull the module out of the mainframe by holding on to the BNC connectors.

BNC Connectors

Figure 3 shows the modules' female BNC connectors and the channel and group numbers. The BNC connectors accept user-supplied male BNC connectors.
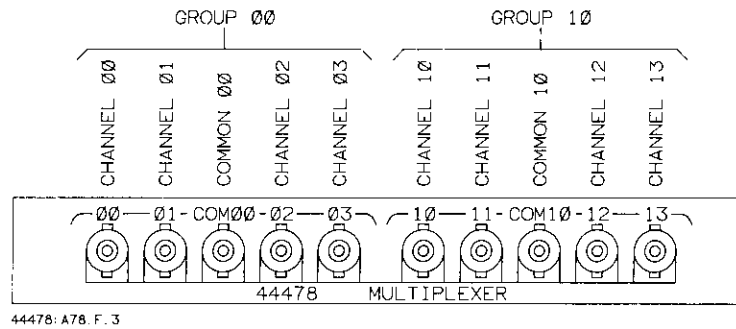
Figure 3. HP 44478A/B BNC Connectors.

SMB Connectors

Figure 4 shows the modules' SMB connectors, their "J" numbers, and their corresponding channels (SMB connectors are shown schematically in Figure 1). The SMB connectors allow you to connect SMB resistive terminations to unused channels. SMB resistive terminations are available from Hewlett-Packard under the following accessory numbers:

HP 34585A (set of four 50Ω terminations for the HP 44478A)
HP 34586A (set of four 75Ω terminations for the HP 44478B)

All SMB connectors on the HP 44478 are 50Ω connectors. The HP 34586A SMB kit shown above contains 75Ω terminations which fit onto 50Ω male SMB connectors. When using the SMBs only for channel terminations, the HP 44478B specifications are not significantly degraded. However, using the HP 44478B's SMB connectors for any other purpose is not recommended.

SMB CONNECTORS (8)
FOR RESISTIVE TERMINATIONS
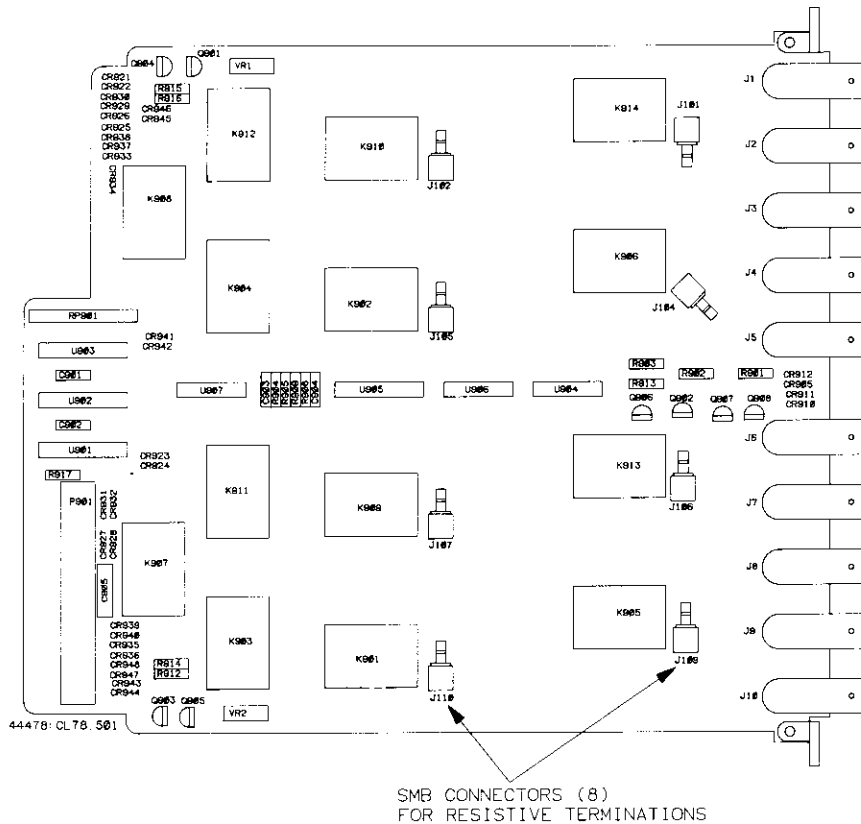
Figure 4. HP 44478A/B SMB Connectors

Cabling Considerations

For the best high-frequency performance, cables for user wiring should have at least two braided shields or one braid and a foil wrap. To maintain low DC offset voltages, cables should have copper center conductors, not copper-clad steel. RG-223/U cable is recommended. Ready-made cables (BNCs on both ends) are available from Hewlett-Packard with the following part numbers:

8120-1838: 30 cm (12 in.), 50Ω coaxial
8120-1839: 61 cm (24 in.), 50Ω coaxial
8120-1840: 122 cm (48 in.), 50Ω coaxial

11652-60012: 30 cm (12 in.), 75Ω coaxial
11652-60013: 61 cm (24 in.), 75Ω coaxial
11652-60014: 94 cm (37 in.), 75Ω coaxial

Always use shielded coaxial cables with the characteristic impedance of the module used (50 or 75 ohm). Keep cables as short as possible, especially in high frequency circuits or pulse circuits where a rise/fall time of <50 nS is critical. Long cables can add considerable delay time which can cause timing problems. All test equipment such as counters, spectrum analyzers, oscilloscopes, etc., must be terminated in the characteristic impedance to minimize reflection loss.

Configuration Examples

Figure 5 shows the two multiplexer groups of one HP 44478 module connected together in a "T" configuration. This circuit provides a 1-of-8 multiplexer. VSWR becomes an important consideration because the characteristic impedance of 50 or 75 ohms is lost. Considerable reflection may be present and could cause double triggering in counters, etc. This configuration should not be used with very narrow pulses or pulses with rise/fall times of 20 nS or less.
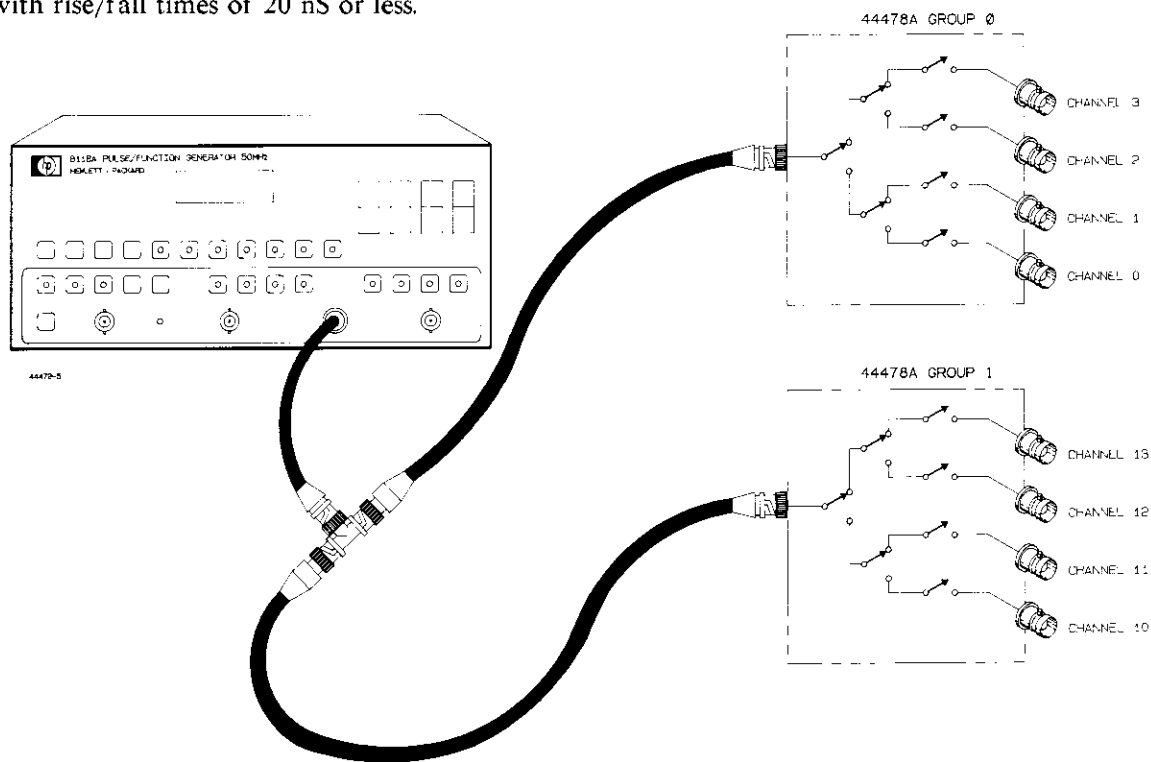
Figure 5. HP 44478 Group 00 and Group 10 in "T" Configuration.

The correct way to connect multiple 1-of-4 group multiplexers is shown in Figures 6 and 7. Never use BNC "T" connectors if full bandwidth performance is needed since VSWR will not be maintained in the test system.

Figure 6 shows two channel groups connected together to form a 1-of-4 to 1-of-4 matrix. This configuration provides an excellent method of connecting four devices under test to four different test instruments and maintains the characteristic impedance.
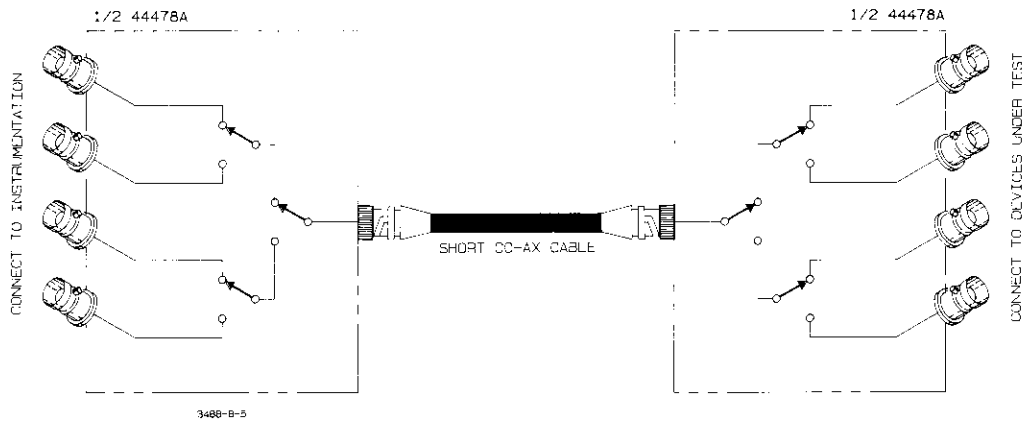
Figure 6. HP 44478 4X4 Matrix.

A tree configuration, shown in Figure 7, provides complete isolation while maintaining the characteristic impedance. It also provides 16 channels for test points. Cable length should be kept as short as possible especially between channel groups. Signal delay time has doubled because the signal must pass through two channel groups.

Figure 7. HP 44478 Tree Configuration (2 modules; four groups).

Using the HP 44478

This section provides you information on how to close and open channels, how to set up a scan list and scan a sequence of channels, what the power-on state of the module is, and what the reset state of the module is. A full description of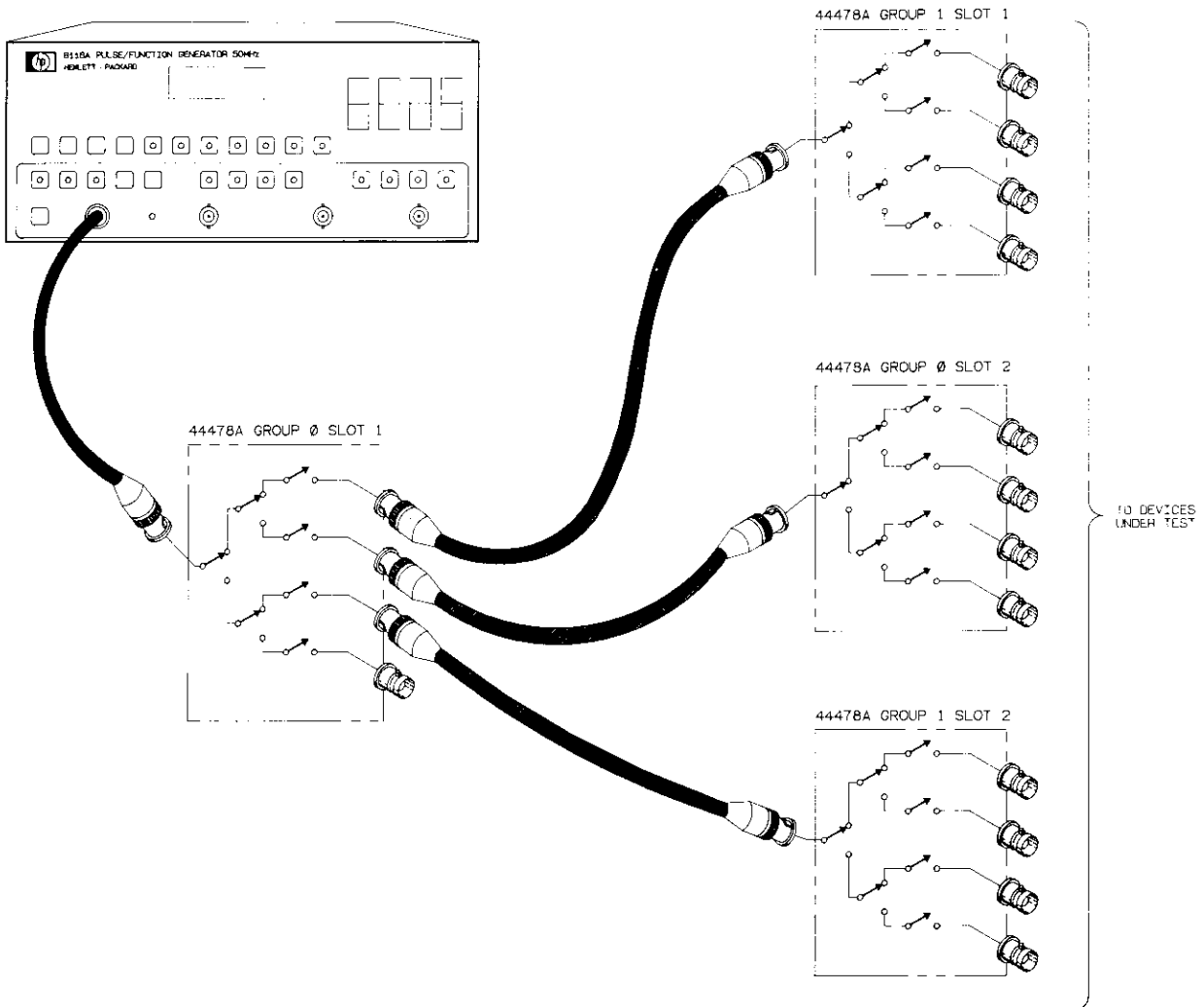 the commands used in this section can be found in the "Command Summary" section along with the syntax for each command.

⚠2 **WARNING**   42 VOLTS MAX

POSSIBLE OPERATOR INJURY. *The HP 44478A (HP 3488A Option 019) and the HP 44478B (HP 3488A Option 020) contain latching relays which connect the "COMMON" BNC to the "GROUP" BNC connectors. The state of the relays can only be altered by program control. In case of a power or equipment failure, the relays will remain in whatever state they were last programmed to. Any application requiring a failsafe method of insuring that the COMMON connector is connected to a known GROUP connector after a power or equipment failure, must be provided for by the installer. When power is reinstated, relays go to the power-on state.*

| NOTE |

The examples used in this manual are intended for Hewlett-Packard Series 80, Series 200, or Series 300 computers using HP BASIC language. They assume an HP-IB* interface select code of 7 and a device address of 09 (factory address setting) resulting in a combined HP-IB address of 709. We recommend you retain this address to simplify programming.

HP-IB Commands

Some HP 3488A commands are abbreviated when used as HP-IB commands. The "Command Summary" section of this manual lists the HP 3488A syntax for each command. For those commands where the HP-IB language syntax is different, a line labeled "HP-IB Syntax:" follows the HP 3488A syntax line showing the difference. Complete information is contained in the "Command Directory" section of the HP 3488A Operating, Programming, and Configuration Manual.

Power-On and Reset States

When you apply power to the HP 3488A, the relays on the HP 44478 are set to a state that disconnects the "COMMON" connector in each group from the four "CHANNEL" connectors in the group. This state is called the power-on state and can be reached by pressing the HP 3488A **RESET** button or giving a **CARD RESET** command to the slot in which you have the module installed (an HP-IB CLEAR command also restores the modules to the power-on state).

Power Failure State

If a power failure occurs, the latching relays retain the state they were last programmed to. See the **WARNING** which follows the heading "Using the HP 44478". When power is reinstated, the HP 3488A resets all modules. The relays on the HP 44478 are set to the power-on state.

Using Channels

The HP 44478 channels are controlled by the HP 3488A **CLOSE, OPEN, CARD RESET, CHAN,** and **STEP** commands. In the following paragraphs you will find example programs or program segments containing these commands. A description of the effect these commands have on "GROUP" connections is also given.

Closing Channels

The **CLOSE** command is used to close a channel on the HP 44478. The **CLOSE** command does not open any channels on other option assemblies that were previously closed. Only one channel per group on the HP 44478 can be closed at any time (two channels per assembly; one in group 00 and one in group 10). For example, the following statement connects "COM00" to "CH01" in GROUP 00 and "COM10" to "CH12" in GROUP 10 on a module in slot 5 of the HP 3488A:

```
OUTPUT 709; "CLOSE 501,512"
```

Opening Channels

You use an **OPEN** command to open a previously closed channel. This will disconnect the "CH" connector from the "COM" connector in the group. When more than one channel is specified in the **OPEN** command, channels are opened in the order listed. For example, the following statement opens channel 00 then channel 11 in slot 5.

```
OUTPUT 709; "OPEN 500,511"
```

If all channels on a module are to be opened, you can use the **CARD RESET** command instead of listing the channels in an **OPEN** command as shown in the above example.

Scanning Channels

You can declare a sequence of channels, called a scan list, and step through these channels break-before-make. 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 and last channel addresses separated by a hyphen. The **SCAN LIST** and **STEP** commands are used to establish and execute a scan through the channels in the order listed in the scan list. Refer to the next section "STEPping Through the Scan List" for a discussion of using the **STEP** command. When the last channel in the list is closed, the next **STEP** command begins scanning the scan list again. The following example scans twice the channels 500, 501, 502, and 511. The scan will be channels 500, 501, 502, 511, 500, 501, 502, 511 and channel 511 will remain closed after the scan. Refer to "Using a 'STOP' Channel in the Scan List" to open the last channel of a scan when the scan is complete.

```
10 OUTPUT 709; "SLIST 500-502,511"   !SLIST = SCAN LIST
20 FOR I = 1 TO 8
30 OUTPUT 709; "STEP"
40 NEXT I
50 END
```

STEPping Through the Scan List

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

The HP 3488A uses a pointer to keep track of which channel in the Scan List is currently closed. Whenever **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 as part of a stored setup will remain closed, that is, they are not opened by the next execution of the **STEP** command.

Refer to the example in the previous section titled "Scanning Channels" to see how **STEP** is used in conjunction with **SCAN LIST**.

Using a "STOP" Channel in the Scan List

You can open the last channel closed in a scan by specifying a "stop" channel at the end of the scan list (a "0" as the last channel of the list). The following example scans all eight channels on a module and opens the last channel closed in the scan by use of a "stop" channel. The scan starts with channel 500, proceeds through the "00" group of channels and then through the "10" group of channels. The 0 channel specified at the end of the list is the "stop" channel that opens the last channel closed (channel 513) but does not close any other channel.

```
10 OUTPUT 709; "SLIST 500-513,0; CMON 5"
20 FOR I = 1 TO 9
30 OUTPUT 709; "STEP"
40 NEXT I
50 END
```

Using CHAN to Close a Single Channel

You can use the **CHAN** command to open the last channel closed by a **STEP** command (or another **CHAN** command) before closing the channel specified in the **CHAN** statement. If no channel is specified in the **CHAN** command, the HP 3488A will respond with the last channel closed by either **STEP** or **CHAN**. If no channel has been closed since the last reset, then **CHAN** returns the number 000.

If a scan list is in effect and **CHAN** is executed specifying a channel within the list, the HP 3488A will search through the list and position the scan list pointer to the channel specified. The next **STEP** command will advance the scan from the channel specified by **CHAN**. If **CHAN** closes a channel that is not in the scan list and **STEP** is executed, the HP 3488A will open the channel closed by **CHAN** and then go to the beginning of the scan list.

Notes on Scanning Channels

1. Channels can be scanned in any sequence, i.e. 500-513 or 513-500 (500-513 scans in ascending order; 513-500 scans in descending order).

2. Stepping beyond the last channel specified in the Scan List causes a wrap-around to the first channel in the list.

3. If a list is to be scanned once, the number 0 can be used as the last channel in the list ("stop" channel), to open the last channel closed in the scan and not close any other channel.

4. The commands **OPEN, CLOSE, CRESET,** or **RECALL** will have no effect on the scan list even though the state of indiviual channels may change.

5. Stored setups may be recalled as part of a Scan List simply by specifying the register number. For example, SLIST 100,101,102,24,120,121,122 contains a stored setup in register 24.

6. Refer to the "Advanced Operations" section in this manual for information on using the External Increment and Channel Closed features. Also, this section describes how to insert a time delay between closing a channel and executing the next command.

Pairing Cards

You use the **CARD PAIR** to pair two HP 44478 modules together. Additionally, you can pair the HP 44478A and B modules with the HP 44471A General Purpose Relay Module, the HP 44472A VHF Switch Module, the HP 44476A/B Microwave Switch Modules, or the HP 44477A Form C Relay Module. Any combination of HP 44471A, 44472A, 44476A, 44476B, 44477A, 44478A, and 44478B can be paired. **NOTE:** When different module types are paired, you must be aware of which channels are present on each module because this command causes identically numbered channels in each module to operate together. Executing a command to close or open one channel causes the same channel on the paired module to close or open. Additionally, you can use paired slots in a scan list. Commands used with the **CARD PAIR** function are: **OPEN, CLOSE, CARD RESET, CHAN,** and **STEP.**

Executing a **CARD PAIR** command cancels a **CARD PAIR** command that previously paired one of the slots specified by the new **CARD PAIR** command. For example if slots 1 and 2 are paired, pairing slots 2 and 4 cancels the slot 1 and 2 pair. You can have more than one pair of slots; slot 1 paired with slot 2 and slot 3 paired with slot 4 establishes two pairs.

The following example closes a pair of channels.

```
10 OUTPUT 709; "CPAIR 1,3"    !Pairs slots 1 and 3. CPAIR = CARD PAIR
20 OUTPUT 709; "CLOSE 101"    !Closes channels 101 and 301 simultaneously
```

Executing the **CARD PAIR** command without specifying slot numbers allows you to determine if any slots are paired together. Four numbers are returned to the HP 3488A display separated by commas. The first two numbers specify the slots of the first pair; the last two numbers specify the slots of the last pair. A display of 0,0 indicates there is no pair established.

If the HP-IB **CPAIR** command is executed, the HP 3488A loads the response in the output buffer and the system controller must retrieve the information as shown in the following example.

```
10 OUTPUT 709; "CPAIR"
20 ENTER 709; A$
30 DISP A$              !Controller displays active pairs.
```

Other Commands

You can use three commands to query the HP 44478 to determine card type and to determine status of the channels. These commands are **CARD TYPE, VIEW,** and **CARD MON.**

CARD TYPE Command

This command causes the HP 3488A to display the slot number, module name, and model number of the module installed in the slot specified. The HP 44478 is an exception; it will not display "44478" but will respond with "VHF SW 44472" since the HP 44472 relay drive circuit is used in the HP 44478A/B. You must physically check the card installed in the slot specified to determine whether a "44472" or "44478" is installed.

VIEW Command

You use the **VIEW** command to look at the state (open or closed) of a particular channel. The HP 3488A responds with the string "OPEN 1" if the specified channel is open. If the specified channel is closed, the HP 3488A responds with the string "CLOSED 0". In the HP 3488A display, the channel address is displayed followed by a colon and the appropriate string. If **VIEW** is sent via the HP-IB, the controller must read the HP 3488A response ("1" or "0") as done for **CPAIR** using an ENTER and DISP program line.

CARD MON Command

The **CARD MON** command (card monitor) is used to display the state of all the channels on a module at once. You specify the slot (1-5) of the module you want to monitor. Specifying slot 0 in the command will cancel the card monitor function. Specifying a negative slot number causes the HP 3488A to go into the "MONITOR TRACKING" mode. In this mode, the HP 3488A display shows the slot of the negative slot number (ignoring the negative sign) but tracks to subsequent slots where channels are opened or closed. When used to monitor the HP 44478 modules, the display shows the slot number, a channel number that is closed, and commas that separate channel numbers. An open channel is represented by a blank. The two channel groups are separated by a semi colon. See Figure 8.
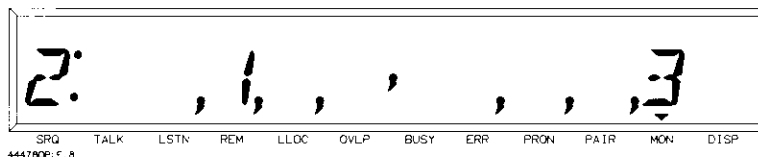

Figure 8. HP 44478 CARD MON Display.

The format of the display is


```
S: group 00 ; group 10   [a group has four channels (N,N,N,N)]
```

where S represents the slot number being monitored and N is a channel number. Whether **CARD MON** is executed from the HP 3488A front panel or via the HP-IB (**CMON**), the response is displayed on the HP 3488A front panel.

Advanced Operations

Advanced Operations provide you with information to perform more sophisticated test/measurment set ups. To perform these advanced operations, an HP 44474A Digital I/O module is required to have access to the External Increment (EI) input and Channel Closed (CC) output. The CC and EI lines do the following:

- Provide a signal (Channel Closed) to indicate when a channel has been closed (i.e. can tell a system voltmeter that a channel has been closed and is ready for a measurement to be taken)

- Receive a signal (External Increment) and close the next channel in the scan list upon receipt of the signal (i.e. after voltmeter completes a reading, it signals for a new channel).

Channel Closed (CC)

Channel Closed (CC) provides a 15μS TTL pulse for signaling when a channel has been closed in the HP 3488A. This signal can be tied to the External Trigger input of a voltmeter to trigger it when a channel is closed.

External Increment (EI)

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 HP 3488A to step to the next channel in the list. The EI input is rising-edge triggered and TTL compatible.

Using External Increment and Channel Closed

Using the External Increment and Channel Closed features requires the use of an HP 44474A Digital I/O module. This also means that the HP 44474A cannot be configured in handshake mode when it is used for scanning (it can be used statically, however). The DMODE command is used to specify the Handshake Mode, Polarity, and 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 specifer 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 found on most Hewlett Packard digital voltmeters to signal the completion of a measurement by means of a TTL compatible pulse.

The "mode" specifier is defined as follows:

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

Any of the MODES can 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.

Figure 9 illustrates a typical scanning application setup using an HP 44478 and the HP 44474A channel closed (CC) and external increment (EI) signals to control the scan with external measurement. More detailed information on use of CC and EI can be found in chapter 10 of the HP 3488A Operating, Programming, and Configuration Manual which decribes operation of the HP 44474A.
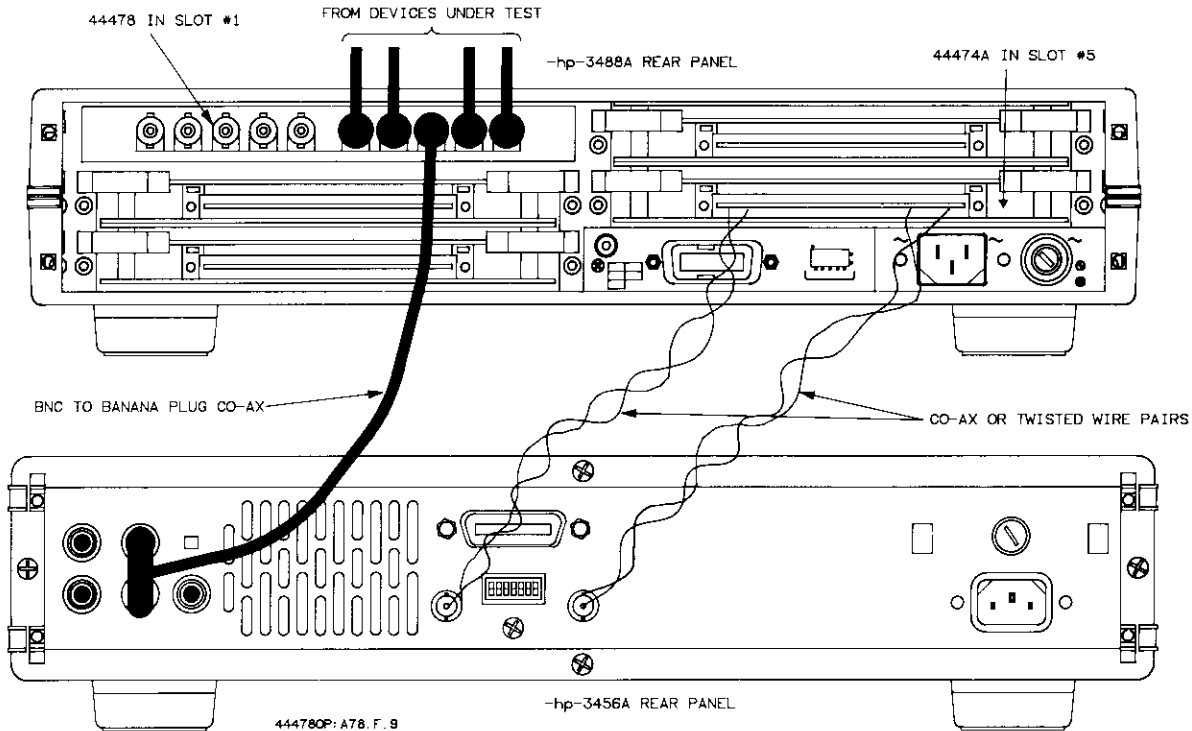

Figure 9. Typical Connections for Scanning With External Measurement Device.

DELAYing Command Execution

The **DELAY** command is used to insert a time delay between a channel closure with associated CC pulse output and execution of the next command. The CC pulse will be active on whichever HP 44474A module with External Increment enabled. The delay time can be specified from 0 to 32,767 mS (32.767 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 HP 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 specified with the **DELAY** command, the HP 3488A will respond with the current value of the delay time.

EXAMPLE: Set a delay of 45 mS.

```
OUTPUT 709;"DELAY 45"   !The delay time is 45 mS = .045 Sec.

OUTPUT 709;"DELAY"
OUTPUT 709;A
DISP A                  !Variable 'A' will show the current delay value.
```

HP-IB Interface Commands

Only two interface commands affect the state of the HP 44478A/B channels: TRIGGER (Group Execute Trigger) and CLEAR (Device Clear or Selected Device Clear).

TRIGGER Command

TRIGGER performs the same function as the HP 3488A **STEP** command. The two commands illustrated below perform the same function:

```
TRIGGER 7 (or TRIGGER 709)
```

and

```
OUTPUT 709;"STEP"
```

CLEAR Command

CLEAR, whether a Device Clear or Selected Device Clear, simply resets the HP 3488A. This causes the HP 44478 to be set to the power-on state.

Command Summary

This section gives you a summary of the HP 3488A commands that control the HP 44478. Following each command is a description of the command and the command syntax. In addition to the HP 3488A commands, the HP-IB interface commands **TRIGGER** and **CLEAR** affect the HP 44478 and are discussed in this section. For more information on commands for these modules, refer to the Command Directory section in the HP 3488A Operating, Programming, and Configuration Manual.

CLOSE

The **CLOSE** command is used to close a channel (connect the "COM" connector to a group "CH" connector. The **CLOSE** command does not open any channels that were previously closed. You can close more than one channel with the same **CLOSE** command by separating the channel addresses with a comma; channels are closed in the order listed in the command.

Syntax: CLOSE <*ch. address*>[,<*ch. address*>,<*ch. address*>,...]

OPEN

You use the **OPEN** command to open a previously closed channel. If more than one channel is specified in the **OPEN** list, channels are opened in the order listed. Use the **CARD RESET** command to open all channels on a module.

Syntax: OPEN <*ch. address*>[,<*ch. address*>,<*ch. address*>,...]

SCAN LIST

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 or items (relays, Digital I/O lines, or stored setups) separated by commas. Contiguous channels may be specified by entering the first and last channel addresses separated by a hyphen. The **STEP** command is used to sequentially close channels in the list.

Syntax: SCAN LIST [<*ch. address*>(,or-)<*ch. address*> ...<*ch. address*>]

HP-IB Syntax: SLIST[<*ch. address*>(,or-)<*ch. address*> ...<*ch. address*>]

STEP

STEP is used to open the previously closed channel and close the next channel in the scan list. If **STEP** is executed and no scan list exists, the HP 3488A will generate an error.

The HP 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 as part of a stored setup will remain closed; that is, they are not opened by the next execution of the **STEP** command unless the next item is the recall of a stored setup.

Syntax: STEP

CHAN

You use **CHAN** to open the last channel closed by either **STEP** or **CHAN** (the most recent command) and close the specified channel. If no channel is specified with **CHAN**, the HP 3488A will respond with 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 HP 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 the **STEP** is executed, the HP 3488A will open the channel closed by **CHAN** and then go to the beginning of the scan list.

Syntax: CHAN [<*ch. address*>]

CARD RESET

CARD RESET is used to set all channels on the HP 44478A/B to their power on state. You specify the slot number for the card you want to reset.

Syntax: CARD RESET <*slot*>[,<*slot*>,...]

HP-IB Syntax: CRESET <*slot*>[,<*slot*>,...]

CARD TYPE

The **CARD TYPE** command is used to query an HP 3488A slot and determine what type of module is intalled in that slot. The HP 3488A responds to this command by displaying the slot number, module name, and module model number. The response must be read over the HP-IB if the HP-IB **CTYPE** command was given. Possible responses are shown in the table below. You use the ← key to shift the display and see the model number.

CARD TYPE	MODEL NO.	DISPLAY	
Slot is empty		NO CARD	00000
Relay Multiplexer Module	44470A	RELAY MUX	44470
General Purpose Relay Module	44471A	GP RELAY	44471 *
VHF Switch Module	44472A	VHF SW	44472 **
Matrix Module	44473A	MATRIX SW	44473
Digital I/O Module	44474A	DIGITAL IO	44474
Breadboard Module	44475A	BREADBOARD	44475
Microwave Switch Module	44476A/B	GP RELAY	44471 *
Form C Relay Module	44477A	GP RELAY	44471 *
1.3 GHz Multiplexer Module	44478A/B	VHF SW	44472 **

* The HP 44476A/B and the 44477A modules also display "GP RELAY 44471".

** The HP 44478A/B modules also display "VHF SW 44472". You must physically check the module to determine which module is present.

Syntax: CARD TYPE <*slot*>

HP-IB Syntax: CTYPE <*slot*>

CARD PAIR

You use the **CARD PAIR** command to pair two modules of the same type (e.g. two HP 44478As). You can pair HP 44478s with 44471s, 44472s, 44476s, and 44477s. This command assigns both modules to both slot numbers, and a command to close or open a channel on one module closes or opens the same channel on the other module.

Commands used with **CARD PAIR** are: **OPEN, CLOSE, CARD RESET, CHAN,** and **STEP.** You can also use paired channels in a **SCAN LIST.**

Executing a **CARD PAIR** command cancels any previous **CARD PAIR** command that involved either of the two slots listed. This allows you to have a maximum of two sets of card pairs at one time.

Syntax: **CARD PAIR** *<slot>,<slot>*

HP-IB Syntax: **CPAIR** *<slot>,<slot>*

CARD MON

The **CARD MON** command (card monitor) is used to look at the state of a module in the slot you specify. Specifying slot 0 will cause the monitor mode to be cancelled. If a negative number is used, the HP 3488A goes to the "MONITOR TRACKING" mode. First, the slot number (ignoring the negative sign) is monitored. The monitor will display the next slot having an open or close command executed and track any subsequent openings or closures. The format of the monitor mode display is

$$s: n,n,n,n ; n,n,n,n$$

where s represents the slot number being monitored and n is a channel number. A semicolon separates the two channel groups.

Syntax: **CARD MON** *<slot>*

HP-IB SYNTAX: **CMON** *<slot>*

HP-IB Interface Commands

Only two interface commands, other than those listed in the previous summary, affect the state of the HP 44478A/B channels: **TRIGGER** (Group Execute Trigger) and **CLEAR** (Device Clear or Selected Device Clear).

TRIGGER

TRIGGER performs the same function as the HP 3488A **STEP** command; it opens the last channel closed and closes the next channel in the scan list.

CLEAR

The **CLEAR** command (either a Device Clear or Selected Device Clear) resets the HP 3488A and all modules installed. The HP 44478A/B goes to its power-on state.

Specifications

The following specifications describe the modules' warranted performance over the temperature range 0°C to 55°C. Information marked by the *(Typ)●* designation is helpful in applying the modules but is non-warranted information.

HP 44478A
50 Ohm RF Multiplexer Module

Input Characteristics

MAXIMUM VOLTAGE:
Any center or shield to any other center, shield, or to the chassis: **42V DC+AC Peak**

MAXIMUM CURRENT per channel or common: **1A DC or AC RMS**

MAXIMUM POWER per channel or common: **24W, 24 VA or 44 dBm**
each resistive termination: **.25W, .25VA or 24 dBm**

AC Performance

For $Z_L = Z_S = 50\Omega$	≤10MHz	≤100MHz	≤500MHz	≤1.3GHz
INSERTION LOSS (dB):				
≤(40°C, 95% RH)	<0.3	<0.7	<1.5	<3.0
≤(25°C, 40% RH), (Typ.)●	<0.2	<0.5	<1.1	<1.9
CROSSTALK (dB) [1]				
Channel-Channel,* Channel-Common	<−90	<−80	<−65	<−55
Group-Group, Module-Module	<−90	<−80	<−70	<−60
VSWR	<1.2	<1.25	<1.35	<1.55

* With one channel closed

CAPACITANCE:
Center to center: <0.006pF
Center to shield: <60pF

RISETIME: <300ps

SIGNAL DELAY: <3ns; Channels matched to ±50ps

DC Performance

THERMAL OFFSET: <6μV, (<2μV, Typ.)●

CLOSED CHANNEL RESISTANCE:
(Typ.)●: <1Ω
End of Relay Life: <3Ω

INSULATION RESISTANCE any terminal to any terminal:
≤(40°C, 95% RH): >$10^8\Omega$
≤(25°C, 40% RH): >$10^{10}\Omega$ (Typ.)●

General

Channels consist of latching armature relays.

RELAY LIFE (Typ.)●:
With no load: 5×10^6 operations
At max. rated power: 10^5 operations

POWER-DOWN STATE is "Remain in Present State."

POWER-UP STATE is "All Open."

1 Specification assumes 50 Ω termination. If all channels unterminated, derate specification by 6dB.

(Typ)● - typical, but non-warranted parameter, intended to provide information useful in applying the instrument.

HP 44478B
75 Ohm RF Multiplexer Module

Input Characteristics

MAXIMUM VOLTAGE:
Any center or shield to any other center, shield, or to the chassis: **42V DC+AC Peak**

MAXIMUM CURRENT per channel or common: **1A DC or AC RMS**

MAXIMUM POWER per channel or common: **24W, 24 VA or 44 dBm**
each resistive termination: **.25W, .25VA or 24 dBm**

AC Performance

For $Z_L = Z_S = 75\Omega$	≤10MHz	≤100MHz	≤500MHz	≤1.3GHz
INSERTION LOSS (dB):				
≤(40°C, 95% RH)	<0.3	<0.7	<1.5	<3.0
≤(25°C, 40% RH), (Typ.)●	<0.2	<0.5	<1.1	<1.9
CROSSTALK (dB) [1]				
Channel-Channel,* Channel-Common	<−90	<−80	<−65	<−55
Group-Group, Module-Module	<−90	<−80	<−70	<−60
VSWR	<1.2	<1.25	<1.35	<1.55

* With one channel closed

CAPACITANCE:
Center to center: <0.006pF
Center to shield: <60pF

RISETIME: <300ps

SIGNAL DELAY: <3ns; Channels matched to ±50ps

DC Performance

THERMAL OFFSET: <6μV, (<2μV, Typ.)●

CLOSED CHANNEL RESISTANCE:
(Typ.)●: <1Ω
End of Relay Life: <3Ω

INSULATION RESISTANCE any terminal to any terminal:
≤(40°C, 95% RH): >$10^8\Omega$
≤(25°C, 40% RH): >$10^{10}\Omega$ (Typ.)●

General

Channels consist of latching armature relays.

RELAY LIFE (Typ.)●:
With no load: 5×10^6 operations
At max. rated power: 10^5 operations

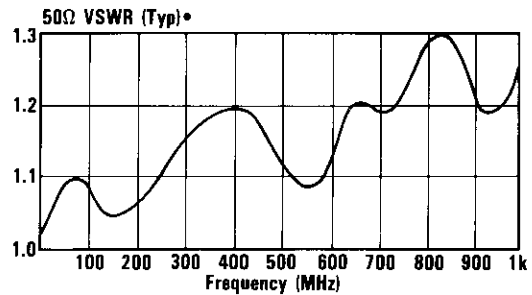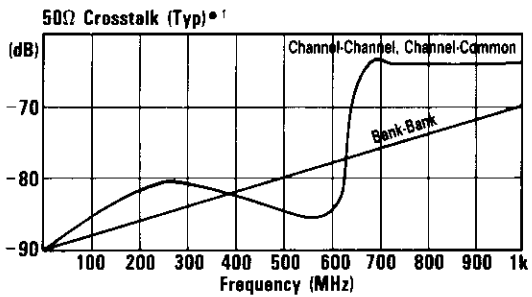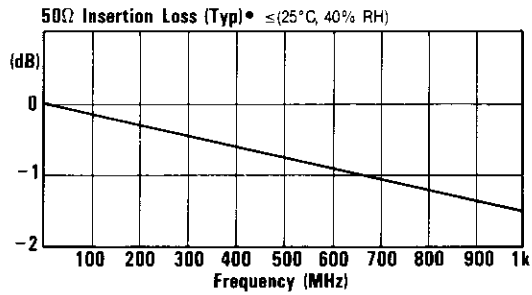POWER-DOWN STATE is "Remain in Present State."

POWER-UP STATE is "All Open."

1 Specification assumes 75 Ω termination. If all channels unterminated, derate specification by 6dB.

(Typ)● - typical, but non-warranted parameter, intended to provide information useful in applying the instrument.
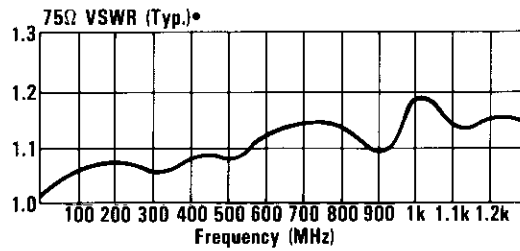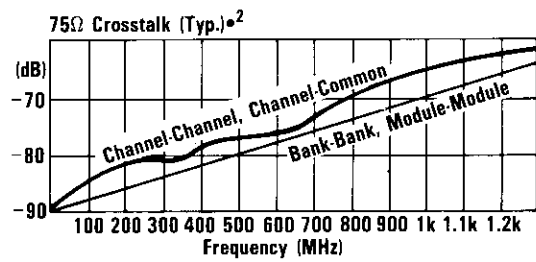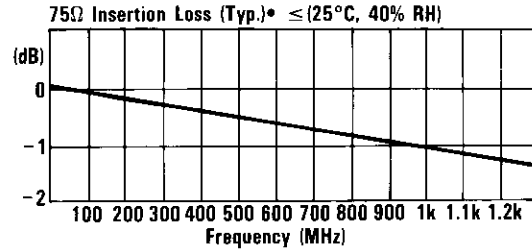
Typical AC Performance

HP 44478A
50 Ohm RF Multiplexer Module

50Ω Insertion Loss (Typ)• ≤(25°C, 40% RH)

50Ω Crosstalk (Typ.)•¹

50Ω VSWR (Typ)•

HP 44478B
75 Ohm RF Multiplexer Module

75Ω Insertion Loss (Typ.)• ≤(25°C, 40% RH)

75Ω Crosstalk (Typ.)•²

75Ω VSWR (Typ.)•

Digital Pulse, Input and Output Waveforms (Typ.)•

500ps/division