HP 3499A/B
Switch/Control System

User’s Manual

Manual Part Number: 03499-90001
Printed in P.R.C. E0999

Legal and Safety Information

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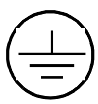
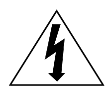
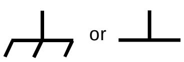
HP 3499A/B Switch/Control System User's Manual
Edition 1

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 (03499-90001) . . . . September 1999

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.		Alternating current (AC)
			Direct current (DC).
	Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.		Indicates hazardous voltages.
		WARNING	Calls attention to a procedure, practice, or condition that could cause bodily injury or death.
	Frame or chassis ground terminal—typically connects to the equipment's metal frame.	**CAUTION**	Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

WARNINGS

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

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

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

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

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

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

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

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.

Operating Location: Sheltered location where air temperature and humidity are controlled within this product’s specifications and the product is protected against direct exposure to climatic conditions such as direct sunlight, wind, rain, snow, sleet, and icing, water spray or splash, hoarfrost or dew. (Typically, indoor.) Pollution environment for which this product may be operated is IEC 664 Pollution degree 2.

WARNINGS (Cont.)

The HP 3499A/B can have modules that are capable of switching voltages up to 250V maximum. Voltage levels above the levels specified for accessible connectors or cable ends could cause bodily injury or death to an operator. Special precautions must be adhered to (discussed below) when applying voltages in excess of 60 Vdc, 30 Vac rms or 42.4 Vac peak.

Module connectors and test signal cables connected to them cannot be operator accessible. Cables and connectors are considered inaccessible if a tool (e.g., screwdriver, wrench, socket, etc.) or a key (equipment in a locked cabinet) is required to gain access to them. Additionally, the operator cannot have access to a conductive surface connected to any cable conductor (High, Low or Guard).

Assure the equipment under test has adequate insulation between the cable connections and any operator-accessible parts (doors, covers, panels, shields, cases, cabinets, etc.). Verify there are multiple and sufficient protective means (rated for the voltages you are applying) to assure the operator will NOT come into contact with any energized conductor even if one of the protective means fails to work as intended. For example, the inner side of a case, cabinet, door, cover or panel can be covered with an insulating material as well as routing the test cables to the module's front panel connectors through non-conductive, flexible conduit such as that used in electrical power distribution.

This ISM device complies with Canadian CES-001
Cet appareil ISM est conforme à la norme NMB-001 du Canada

CLEANING INFORMATION

The instrument should only be cleaned by wiping it with a soft damp cloth.

BATTERY DISPOSAL

This product contains a nickel-cadmium battery. Please recycle or dispose of in accordance with all applicable Federal, State and Local laws

DUTCH BATTERY DISPOSAL WARNING

Declaration of Conformity

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company
China Test & Measurement Operation

Manufacturer's Address: #4 Hua Yuan Road, Haidian District
Beijing 100088, PRC

Declares, that the product:

Product Name: Switch/Control System

Model Number: HP 3499A/B

Product Options: All

Conforms to the following product specifications:

Safety: IEC 61010-1 (1990)+A1:1992+A2:1995/EN61010-1:1993+A2:1995
CSA C22.2 #1010.1:1993
UL 3111-1

EMC: IEC61326-1+A1:1998/EN61326-1+A1:1998
Canada ICES-001
Australia AS/NZS/2064
Russia GOST 23450-79
Czech Republic CSN EN55011
Hungary MSZ EN55011

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.

September, 1999

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Weiren Wang, QA Manager

For Compliance Information ONLY, contact:

Australia Contact: Product Regulations Manager, Hewlett-Packard, Australia Ltd., 31-41 Joseph Street, Blackburn, Victoria 3130, Australia

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

USA Contact: Product Regulations Manager, Hewlett-Packard, P.O. Box 301, Mail Stop BU212, Loveland, CO 80537

How to Use This Manual

Manual Overview

This manual shows how to configure, operate, and program an HP 3499A/B Switch/Control System. For service information, refer to the *HP 3499A/B Switch/Control System Service Manual*.

Manual Content

Nine chapters and one appendix are included in this manual.

- **Chapter 1** provides a typical configuration of the test system using HP 3499A/B as switching/control, followed by the general information of the HP 3499A/B mainframes and the plug-in modules.
- **Chapter 2** shows the process to install a plug-in module into an HP 3499A/B mainframe and the way to mount an HP 3499A/B onto a rack. This chapter also provides the basic operations to program the instrument.
- **Chapter 3** and **Chapter 4** show you how to use the instrument in different system modes: SCPI mode and HP 3488A mode, either from the front panel or over the remote interface.
- **Chapter 5** shows the detailed front panel operations to use the instrument.
- **Chapter 6** and **Chapter 7** list all the SCPI commands and HP 3488A commands, respectively.
- **Chapter 8** provides the necessary information for each plug-in modules. Including in this chapter are the modules' general descriptions, the wiring information, the specifications, and so on.
- **Chapter 9** shows the examples to program the instrument with Visual BASIC, Visual C/C++ and HP BASIC.
- **Appendix A** lists the errors that may occur during the instrument power-on or operation.

Suggested Sequence to Use This Manual

HP 3499A/B can be operated in different system modes: SCPI mode & HP 3488A mode. In either mode, the related chapters are listed in the Table below.

	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8	Chapter 9	Appendix A
SCPI Mode	X	X	X		X	X		X	X	X
HP 3488A Mode	X	X		X	X		X	X	X	X

Contents

HP 3499A/B Switch/Control System User's Manual

Edition 1

Chapter 1
System Overview

About This Chapter

The HP 3499 Switch/Control System is composed of two mainframes and a set of plug-in modules. This chapter provides a typical configuration of the test system using HP 3499A/B as switching/control, followed by a description of the HP 3499A/B mainframes and all the plug-in modules. The following sections are included in this chapter:

HP 3499 Switch/Control System

The system switching performance is critical to the overall performance of a test system. The flexibility and scale of switching configurations available determine the efficiency of the final switching design, including the amount and complexity of wiring at the time of system integration.

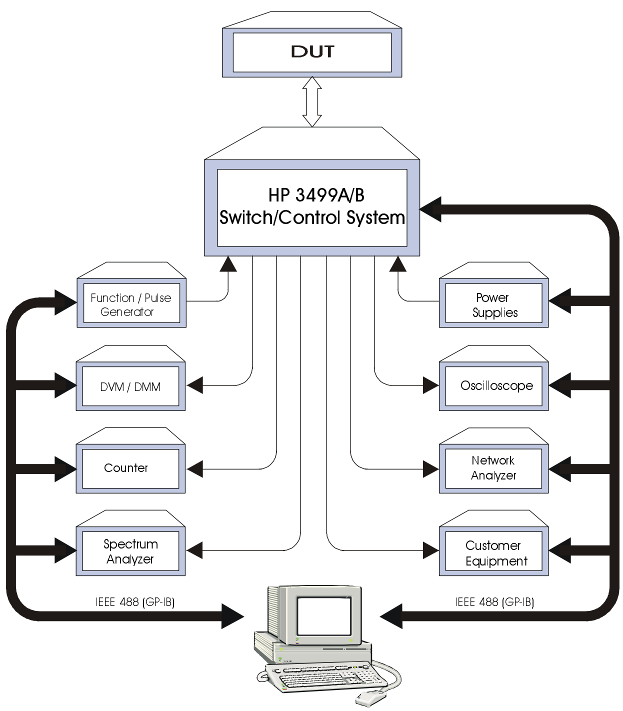


Figure 1-1. A Typical Test System

The HP 3499 Switch/Control System provides high density and high speed switching for routing test signals to and from your DUTs (devices under test) and test instruments such as external DMMs, scopes, counters, power supplies, etc. Whether you are involved in a large production test system or a small R&D bench top system, the HP 3499 Switch/Control System provides an ideal combination of price/performance solution. With a wide variety of available modules, you can configure your test system much more easily and flexibly. Figure 1-1 on Page 1 shows the typical configuration of a test system, using HP 3499A/B system as switching and control.

HP 3499A/B Mainframes Introduction

Two mainframes are available, the 5-slot full-rack-width HP 3499A and the 2-slot half-rack-width HP 3499B. Both the HP 3499A and the HP 3499B can be either operated from the front panel or programed over a remote interface.

The HP 3499A/B can be operated in either of the two system modes, SCPI mode and HP 3488A mode. The SCPI mode allows the full realization of performance potentials and advanced features, such as parallel operation of multiple relays on multiple modules. Inclusion of the HP 3488A mode is for backward compatibility with the HP 3488A.

HP 3499A/B Features

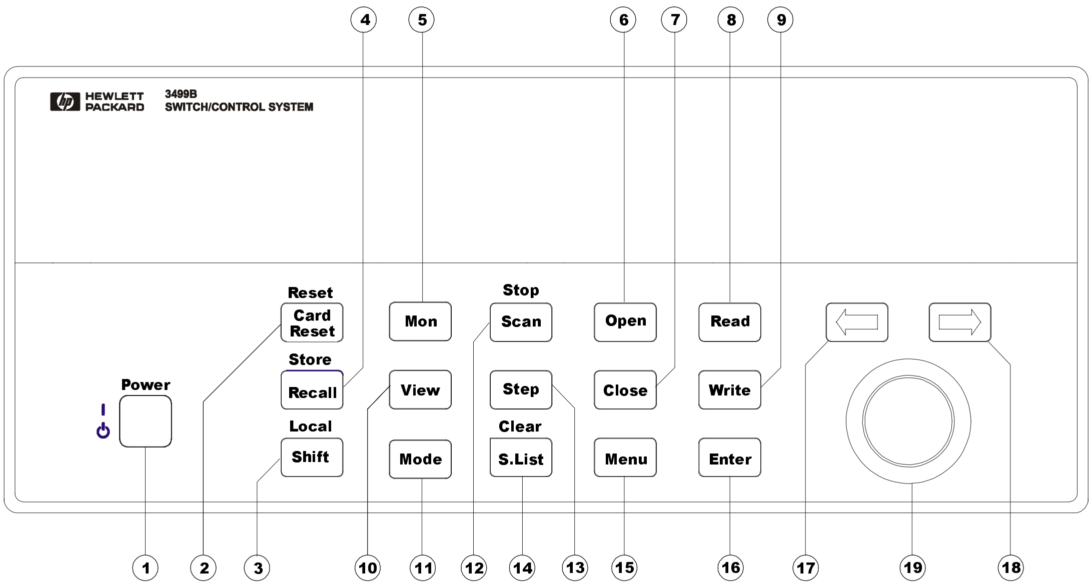
The HP 3499A/B mainframes provide a convenient mechanical and programming environment for the plug-in modules. The HP 3499A/B can:

- Support both the existing HP 3488A modules and the new HP 3499 modules;
- Support dual command sets: SCPI command set and HP 3488A command set;
- Support downloadable firmware-upgrade;
- Provide an intuitive and easy-to-use user interface;
- Provide both GPIB (IEEE-488) and RS-232 interface control[1];
- Provide built-in external triggering capability;
- Provide a built-in 4-bit digital I/O port;
- Store/recall up to 10 customized instrument setups[2];
- Provide relay cycle count information for preventive maintenance of the test system[3].

[1]. RS-232 interface CANNOT be used in HP 3488A mode.
[2]. HP 3499A/B mainframes can store/recall up to 40 customized instrument setups in HP 3488A mode.
[3]. Relay cycle count information is available only from the new switching modules, such as the HP N2260A, N2261A, N2262A, N2264A, and N2265A.

Front Panel at a Glance

Figure 1-2 shows the front panel of HP 3499B. The front panel of HP 3499A is same as that of HP 3499B.



Note: 1. The keys labled with 10, 11, 14, and 15 guide you through menus to configure various parameters of the instrument. See Chapter 5 for details on these menus operation.

2. The keys labled with 2, 3, 4, 12 and 14 are double-function keys decribed with “a” and “b” respectively. The function printed above the key (function “b”) is implemented by pressing **Shift** key then the key. See Chapter 5 for details of their operation.

1. Power on/standby
2. **a.** Reset a module
b. Reset instrument
3. Shift/Local key
4. **a.** Recall instrument state
b. Store instrument state
5. Monitor a channel/port/module
6. Open relay channel
7. Close relay channel
8. Read from DIO port
9. Write to DIO port
10. Enable View menu to:
View errors
View scan list
View relay cycle counts
11. Enable Mode menu to:
Configure MUX module
Configure DIO module
12. **a.** Initiate scan
b. Stop scan
13. Step through scan list
14. **a.** Enable S.List menu to:
Create scan list
Select arm source
Select arm count
Select trigger source
Set channel delay time
b. Clear scan list
15. Enable Menu menu to:
Pair two modules together
Enable/disable trigger out pulse
Set instrument power-on state
Configure GPIB/RS-232 interface
Perform self-test
Select SCPI/3488A mode
Query firmware revision
Query serial number
16. Confirm the selection
17. Left arrow key
18. Right arrow key
19. Knob

Figure 1-2. The Front Panel of HP 3499B

Rear Panel at a Glance

Figure 1-3 shows the rear panel of HP 3499B. The rear panel of HP 3499A is similar to that of HP 3499B except that five slots are available for the plug-in modules.

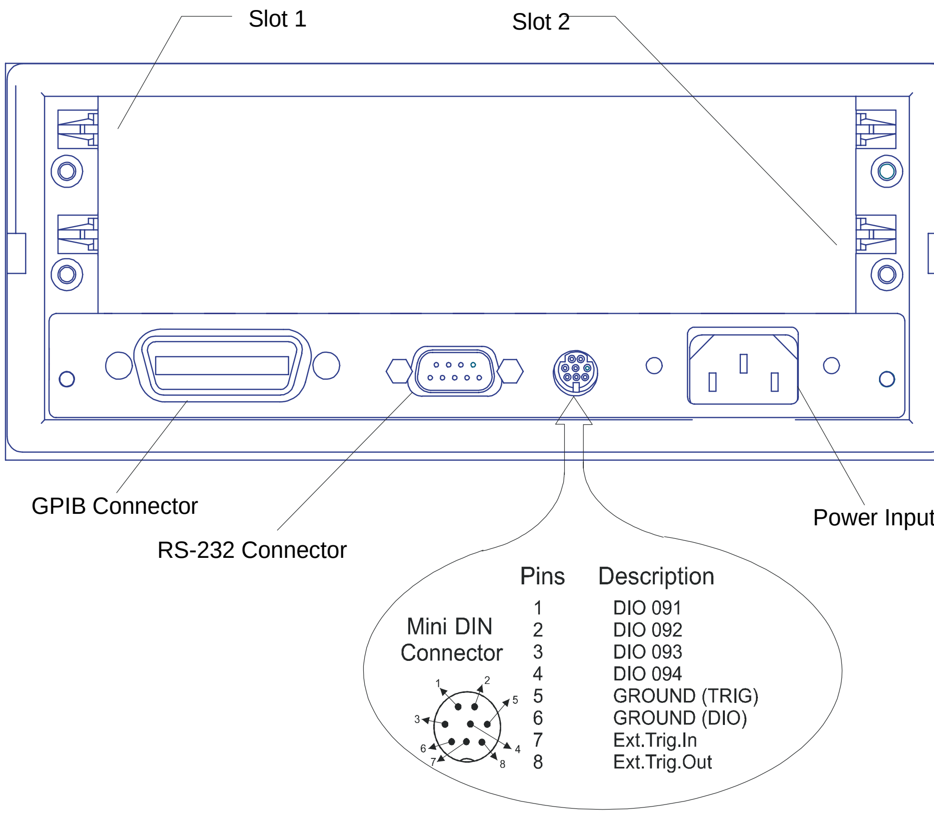


Figure 1-3. The Rear Panel of HP 3499B

Note The HP N2289A cable can be ordered to accommodate connection from the rear panel Mini DIN connector to an external device.

Plug-in Modules Overview

The HP 3499A/B mainframes support multiple plug-in modules, including all the existing HP 3488A modules, as well as several new ones. Based on their functions, the modules can be divided into five classes:

- Multiplexer (MUX) modules
- General Purpose Relay (GP) modules
- Matrix modules
- Digital I/O (DIO) modules
- Multifunction modules

Note Refer to Chapter 8 “Plug-in Modules” starting from Page 173, for the details of the individual plug-in modules.

MUX Modules

A MUX (multiplexer) module switches one signal to multiple DUTs (devices under test), or multiple signals to one device, one at a time. Example applications include capacitor leakage, connector/switch contact, and insulation resistance test systems. To expand switching capacity or build special configurations, the multiplexer switching modules can also be used with matrix or other modules. Figure 1-4 shows a simple 1 x 4 MUX.

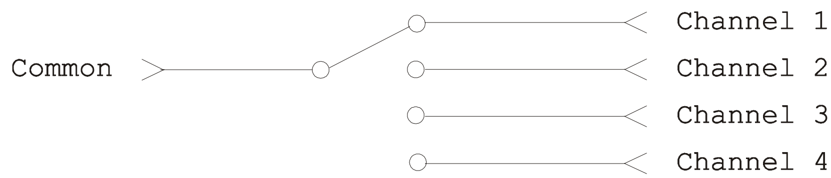


Figure 1-4. A Simple MUX Switching

Multiplexers are available in several types:

- *One-Wire (Single-Ended) Multiplexer* for common LO measurements
- *Two-Wire Multiplexer* for floating measurements
- *Four-Wire Multiplexer* for resistance and RTD measurements
- *Very High Frequency (VHF) / Microwave Multiplexer* for switching frequencies up to microwave (26.5 GHz).

Table 1-1 lists the MUX modules available with the HP 3499A/B.

Table 1-1. Multiplexer Modules

Model Number	Module Name	Descriptions
HP 44470A/D	10/20-Channel MUX Module	The 10/20 DPST (Double-pole Single-throw) relays switch both HI and LO inputs up to 250V, 2A with low differential offsets for accurate measurements.
HP 44472A	Dual 4-Channel VHF Switch Module	The two independent groups of bidirectional 1x4 switches with 50Ω characteristic impedance can be used for signals from DC to 300 MHz.
HP 44478A/B	50Ω/75Ω 1.3GHz Multiplexer	The two independent groups of bidirectional 1x4 switches with 50Ω/75Ω characteristic impedance can be used for signals from DC to 1.3 GHz.
HP N2260A	40-Channel MUX Module	Primarily a 40-channel 2-wire multiplexer, switches both HI and LO inputs (200 V, 1 A) with DPST relays. It can be easily configured as 80 1-wire channels, dual independent 20 2-wire channels, or 20 4-wire channels.

GP Modules

The GP (General Purpose) relay modules often consist of independent latching or non-latching relays. It is useful for creating additional isolation between circuits, providing safety interlock, actuating other relays or circuits, or building special topologies such as binary ladders and tree structures. A simple 4-channel SPST (Single-pole Single-throw) GP switching is shown in Figure 1-5 on Page 6.

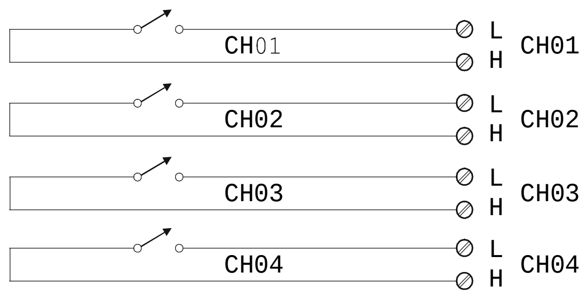


Figure 1-5. A Simple GP Switching

Table 1-2 lists the GP relay modules available with the HP 3499A/B.

Table 1-2. GP Relay Modules

Model Number	Module Name	Descriptions
HP 44471A	10-Channel GP Relay Module	The 10 independent SPST (Single-pole Single-throw) relays provide quality connections for low level signals, and can also switch signals up to 250V, 2A.
HP 44471D	20-Channel GP Relay Module	The 20 independent SPST (Single-pole Single-throw) relays provide quality connections for low level signals, and can also switch signals up to 250V, 1A.
HP 44475A	Breadboard Module	Use the breadboard for custom circuits and special purpose functions in your test system.
HP 44476A	3-Channel 18GHz Switch Module	The 3 independent 50Ω SPDT (Single-pole Double-throw) coaxial switches with SMA connectors provide high isolation, low insertion loss, and low VSWR for switching signals up to 18GHz.
HP 44476B	2-Channel Microwave Switch Module	Similar to the HP 44476A but does not have the coaxial switches installed. A variety of HP coaxial switches can be mounted onto the module to provide 3-, 4-, or 5-port switching up to 26.5GHz.
HP 44477A	7-Channel Form-C Relay Module	The 7 independent, break-before-make, SPDT Form-C relays provide for general purpose switching and control of external devices up to 250V, 2A.
HP N2261A	40-Channel GP Relay Module	The 40 independent SPST relays provide quality connections for low level signals, and can also switch signals up to 200V, 1A.

Matrix Modules

A matrix switch is the most versatile type of system switching. Any input can be connected to any output, singly or in combination. This helps minimize the need for complex wiring, and can simplify the DUT interface. In addition, a matrix module can be used in conjunction with other modules to provide a wide variety of switching combinations. A matrix is arranged in rows and columns and a simple 4 x 4 matrix switching is shown in Figure 1-6 on Page 7.

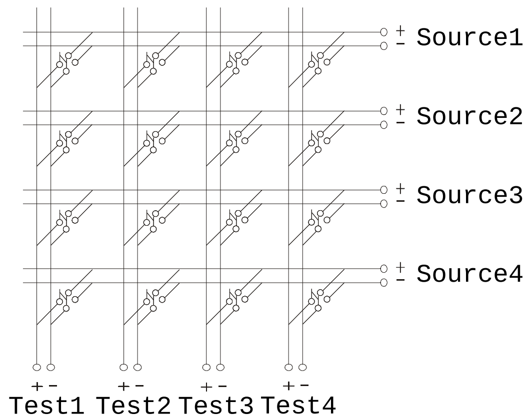


Figure 1-6. Matrix Switching

Table 1-3 lists the matrix modules available with the HP 3499A/B.

Table 1-3. Matrix Modules

Model Number	Module Name	Descriptions
HP 44473A	4 x 4 Matrix Module	Each crosspoint or node of the 4 x 4 matrix module uses a DPST (Double-pole Single-throw) relay to switch two wires (Hi & Lo) for signals up to 250V, 2A.
HP N2262A	4 x 8 Matrix Module	Each crosspoint or node of the 4 x 8 matrix module uses a DPST (Double-pole Single-throw) relay to switch two wires (Hi & Lo) for signals up to 200V, 1A.

Digital I/O Modules

The digital I/O modules provide high-density digital input/output capabilities in an easy-to-control form. The independent TTL-compatible inputs and outputs make it well-suited for monitoring and controlling devices compactly and cost-effectively. Typically, the digital outputs are used to provide drive for relatively high current devices such as solenoids, relays and small motors. The digital inputs are used to monitor devices such as micro-switches. A simplified schematic of digital input and output is shown in Figure 1-7.

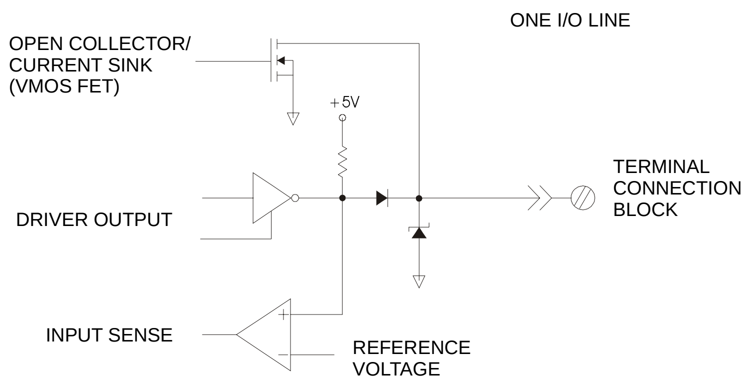


Figure 1-7. A simple DIO Circuit

Table 1-4 lists the digital I/O modules available with the HP 3499A/B.

Table 1-4. Digital I/O Modules

Model Number	Module Name	Descriptions
HP 44474A	16-Bit Digital I/O Module	The module offers 16-bidirectional I/O lines and four handshake lines for sensing and control of external devices up to 30 V, 125 mA. All lines are TTL-compatible.
HP N2263A	32-Bit Digital I/O Module	The module offers 32-bidirectional I/O lines and three handshake lines for sensing and control of external devices up to 42 V, 600 mA. All lines are TTL-compatible.

Multifunction Modules

A multifunction module combines two or more functions such as MUX, GP, Matrix, or Digital I/O onto a single module, making it possible to implement a complicated switching application with fewer modules. Therefore, the cost is reduced by minimizing the number of mainframes and modules required.

Each separate function on a multifunction module can be operated independently. For example, an HP N2265A can be used as both a 4 x 4 matrix module and a 16-bit digital I/O module.

Table 1-5 lists the multifunction modules available with the HP 3499A/B.

Table 1-5. Multifunction Modules

Model Number	Module Name	Descriptions
HP N2264A[1]	12-Channel GP + 3-Channel High-current GP Relay + 16-Bit Digital I/O Module	The module provides 12-channel SPST (Single Pole Single Throw) GP relays for signals up to 200 V, 1 A, 3-channel high-current GP relays for signals up to 125 V, 5 A, and 16-bit digital I/O for sensing and control of external devices up to 42 V, 600 mA.
HP N2265A	4 x 4 Matrix + 16-Bit Digital I/O Module	The module provides 4 x 4 2-wire matrix for signals up to 200V, 1A, and 16-bit digital I/O for sensing and control of external devices up to 42 V, 600 mA.

[1]. The 12 SPST GP relays and the 3 high-current GP relays on this module are non-latching relays.

HP 3499A/B Mainframes Specification

Table 1-6 lists the specifications of the HP 3499A/B mainframes.

Table 1-6. HP 3499A/B Mainframes Specification

Items	Specifications
General	
Power Supply	100 to 240 VAC universal input; 47 Hz to 440 Hz; 40 VA maximum.
Operating Environment	0 to 55^{o}C (32 to 130^{o}F); < 80% RH, 0 to 40^{o}C (32 to 104^{o}F).
Storage Environment[1]	-40 to +75^{o}C (-40 to 165^{o}F)
Net Weight	HP 3499A: 3.8 kg (8.4 bs); HP 3499B: 2.5 kg (5.5 bs).
Dimensions	HP 3499A: H 89mm, W 426mm, L 348mm (H 3.5”,W 16.8”,L 13.7”); HP 3499B: H 89mm, W 213mm, L 348mm (H 3.5”,W 8.4”,L 13.7”).
Safety	Conforms to CSA, UL-1244, IEC 1010 Cat I.
RFI and ESD	CISPR 11, IEC 801/2/3/4.
System	
Capacity	HP 3499A: 5 slots; HP 3499B: 2 slots.
Display	Vacuum fluorescent, 13 characters can be displayed simultaneously.
Rear Panel Connectors	GPIB (IEEE-488); RS-232; 8-pin Mini DIN connector (4-bit Digital I/O, external triggers).
Memory	Battery backed, 4-year typical life (below 40^{o}C)[1]; Capable of storing 10 instrument setups and 10 errors in SCPI mode or 40 instrument setups and 1 error in HP 3488A mode.
Switch Setting Time	Automatically selected by the mainframe for individual modules; Additional time from 0 to 99999.999 seconds can be added in 1 ms steps.
Arm Source	External trigger (from the rear panel Mini DIN connector); IEEE-488 bus (GET, *TRG, or pressing **Step** from the front-panel); Software (TRIGger:IMM); Internal timer (programmable as 0 to 99999.999 seconds in 1 ms steps).
Trigger Source	External trigger (from the rear panel Mini DIN connector); IEEE-488 bus (GET, *TRG, or pressing **Step** from the front-panel); Software (Trigger:IMM); Internal timer (programmable as 0 to 99999.999 seconds in 1 ms steps).
External Trigger Input	Level: TTL compatible; Minimum trigger pulse width: 2 µs; Maximum external trigger delay[2]: 2 ms.
External Trigger Output	Level: Normally pull up to 5 V; Sink current: 10 mA @ V_o(Low) $\leq$ 0.4V; 80 mA @ V_o(Low) $\leq$ 0.8V; Low going pulse width: 10 µs typical.

Table 1-6. HP 3499A/B Mainframes Specification

Items	Specifications
Built-in 4-bit Digital I/O	Input: TTL compatible; Output: V_o(high) $\geq$ 2.4V @ I_o = 1 mA; V_o(Low) $\leq$ 0.8V @ I_o = –100 mA; Maximum V_o = 42V, with external pull-up.
System Speed	
Scan Speed	80 ch/s (N2260A)
Parser Time[3]	Open (@100) 3 ms Close (@100) 3 ms Open (@100:139) 4 ms
Switching Speed	Channels Time (ms) Open/Close 1 8.3 (N2260A) Open/Close 10 18.8 (N2260A, in the same group) Open/Close 40 42.0 (N2260A) *SAV/*RCL 200 76.0 (N2260A)
Digital I/O Block Transfer Rate	20K bytes/sec (long word)

[1]. Storage at temperature above 40 ^{0}C will decrease battery life.
[2]. Maximum time from activation of external trigger pulse to start of switch open or close.
[3]. Measured from the time at which the command terminator is taken from the bus to the time at which the relay begins to open or close.

Chapter 2
Quick Start

About This Chapter

This chapter describes the procedure to install the plug-in modules into a mainframe and mount the mainframe onto a system rack, followed by the basic operations of an HP 3499 Switch/Control System. The chapter contents include:

Prepare the Instrument for Use

Unpacking and Inspection

Verify that you have received the following items with your HP 3499A or HP 3499B mainframe:

-- One power cord;
-- This *User's Guide*;
-- One *Quick Reference*;
-- One Tie Down Clip 03499-21002 (for HP 3499B only);
-- Any plug-in modules you ordered, which will be delivered in separate shipping containers.

Power on the Instrument

Verify that the instrument is in proper working order by

1. Connect the instrument to an AC power source with the supplied power cord.
2. Push the **Power** switch on the lower left side of the front panel to power on the instrument.
3. On power-up, every segment in the display should light up briefly, including all annunciators. Following this "starburst" display, the internal self-test will begin.
4. If the self-test passes[1], the default system mode and the GPIB address are displayed, together with a "beep" sound. Then the display shows the instrument model number.

[1]. If the self-test failed, the reason of the failure will be displayed on the front panel. For details of all self-test errors, refer to Table 9-1 on Page 275.

SCPI GPIB 9

HP 3499	0

Note When shipped from the factory, the SCPI mode and the GPIB interface with the address of “9” are used. Slot 0 refers to the controller board of the mainframe.

If the Instrument Does Not Turn On

1. Verify that the power cord is firmly plugged into the power receptacle on the rear panel of the instrument.
2. Make sure that the power source the instrument is plugged into is energized.
3. Verify that the instrument is turned on.

Note If the instrument DOES NOT turn on after you perform the above procedure, contact your nearest Hewlett-Packard sales office.

Module Installation

WARNING **Only qualified personnel should install or remove the plug-in modules into or from an HP 3499A/B mainframe. Make sure to disconnect the power cord from the back of the mainframe prior to installing or removing any modules.**

Caution **Use anti-static procedures when configuring, installing or removing any plug-in modules. To prevent contamination to the modules that could degrade performance, handle the modules by the side edges or shields only. Do not touch the board surfaces or components.**

Module Installation

Upon receipt of an HP 3499A/B mainframe, the plug-in modules you ordered were not installed in the mainframe. In addition, the terminal block(s) and/or the cables ordered for wiring external test circuits are also separated from your modules.

Figure 2-1 on Page 13 shows the procedure on how to install a plug-in module into the mainframe, as well as how to attach a screw terminal block onto the module. For more details about screw terminal blocks, crimp-and-insert terminal blocks and/or DIN-to-D cables wiring, see “Plug-In Modules Wiring Information” on Page 254.

STEP 1

1. Face the mainframe rear panel towards you;
2. Select a slot in which the module is to be installed.

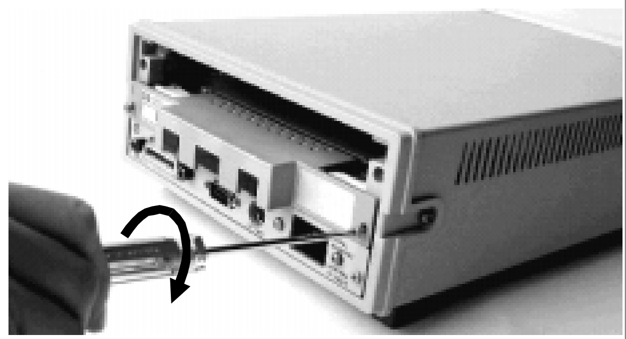
STEP 2

1. Hold the sides of the module, component side down, by the metal shields;
2. Insert the module into the slot guides and slide the module towards the front of the instrument;
3. Push firmly until the module “snaps” into place.
4. Push both plastic levers inward to lock the module.

STEP 3 (Optional)

1. Wire the screw terminal block (module dependent, refer to Chapter 8 for details);
2. Attach the screw terminal block onto the plug-in module.

STEP 4 (Optional)



1. Push firmly until the terminal block “snaps” into place;
2. Lock the screw terminal block with the two screws (Torque < 8 in-lbs).

Figure 2-1. Module installation

Module Removal

To remove a plug-in module from the HP 3499A/B mainframe, reverse the procedures above.

Rack Mount the HP 3499A/B Mainframes

You can mount the HP 3499A/B mainframes on a standard 19-inch rack cabinet with the optional rack-mounting kits. The instructions and mounting hardware are included with each rack-mounting kit.

Mount HP 3499A

To rack mount an HP 3499A, the full-rack-width mainframe, order an adapter kit 5183-7171.

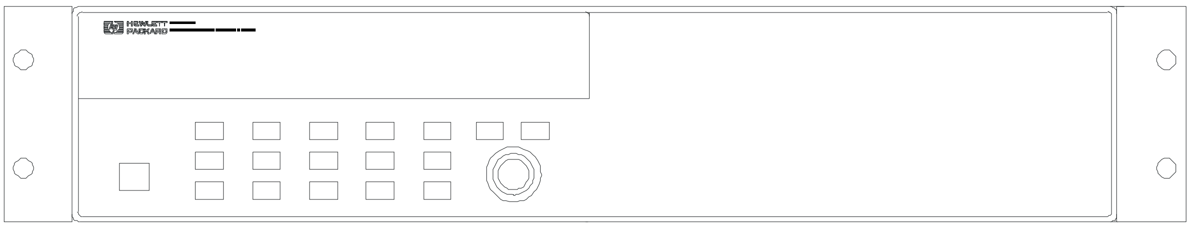


Figure 2-2. Rack Mount an HP 3499A

Mount HP 3499B

To rack mount a single HP 3499B, the half-rack-width mainframe, order an adapter kit 5183-7172 (see Figure 2-3), or an HP Support Shelf 5063-9255, a slide kit 1494-0015 and a filler panel 5002-3999 (see Figure 2-4).

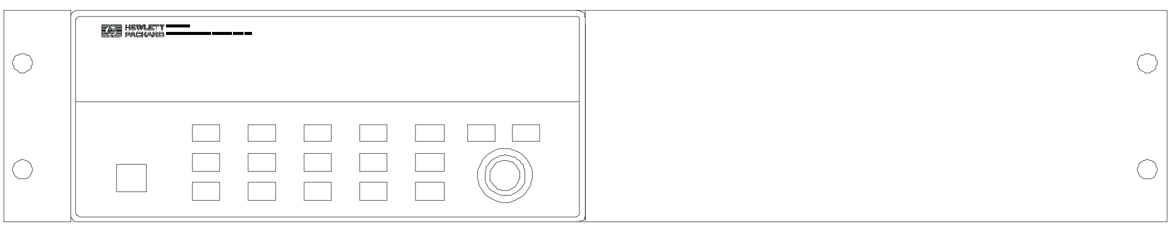


Figure 2-3. Rack Mount a Single HP 3499B - I

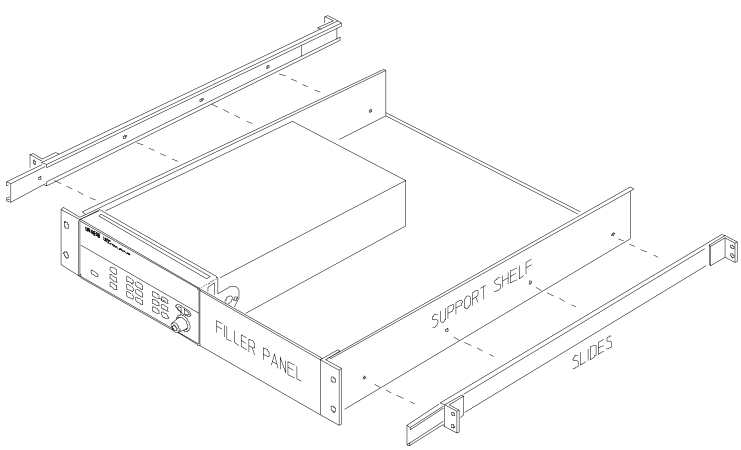


Figure 2-4. Rack Mount a Single HP 3499B - II

To rack mount two HP 3499B's side-by-side or any HP System II instrument side-by-side with an HP 3499B, order an HP Support Shelf 5063-9255, and a slide kit 1494-0015 (see Figure 2-5).

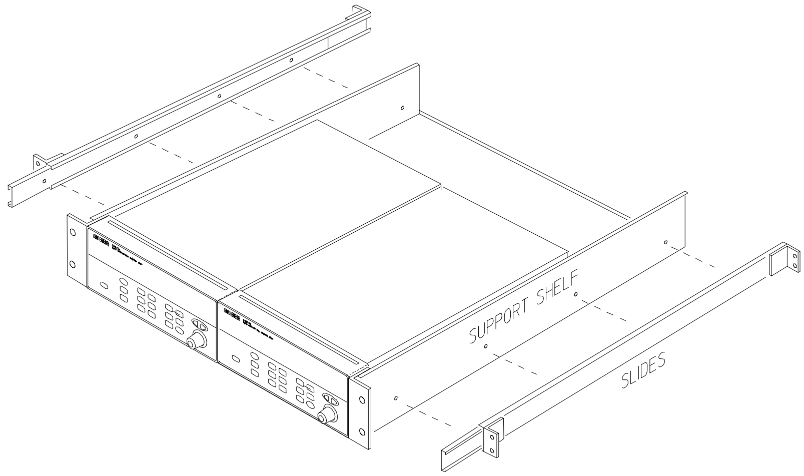


Figure 2-5. Rack Mount Two HP 3499B's Side-by-side

Note To rack mount an HP 3499B with an HP Support Shelf 5063-9255, a Tie Down Clip (P/N 03499-21002) provided with an HP 3499B must be used to fix the HP 3499B onto the shelf.

Operating the Instrument

An HP 3499 Switch/Control System can be easily operated from the front-panel, or programmed with SCPI or HP 3488A commands over the remote interface.

The following sections are only intended to show the basic front-panel operation and remote programming. For detailed front-panel operation, refer to Chapter 5 "Front-Panel Operation" starting from Page 49. For more information about the SCPI and HP 3488A commands, refer to Chapter 6 "SCPI Command Reference" starting from Page 79 and Chapter 7 "HP 3488A Command Reference" starting from Page 139, respectively.

Channel Addressing

In HP 3499 Switch/Control System, a channel refers to an individual relay on a switching module, or an individual bit/port on a digital I/O module. The channel address is in the form of *snn*, where *s* represents slot number (slot 0 refers to the mainframe controller board, slot 1 and 2 to plug-in modules in an HP 3499B, slot 1 through 5 to plug-in modules in an HP 3499A) and *nn* represents channel number (module type dependent). For more information about channel addresses of individual plug-in modules, refer to Table 6-1 on Page 82, and/or Table 7-1 on Page 140.

Basic Front-Panel Operation

This example shows how to close or open channels on an HP N2260A module from the front panel. Assuming that an HP N2260A module is installed in slot 1 of the HP 3499A and configured as a 40-channel 2-wire MUX (default setting), the channels on the HP N2260A can be addressed as 100 through 139.

Step 1: Select a Channel

Continuously turn the knob until the desired channel (i.e. 102) is shown on the channel display area.

```
MUX          OPEN    102
```

Step 2: Close/Open a Channel

Press **Close** to close the selected channel, or press **Open** to open the selected channel.

Repeat step 1 and 2 to close or open other channels.

Note To open all channels on a module, press **Card Reset**. To open all channels on all modules installed in the instrument, press **Shift**, then **Card Reset,** or cycle power the instrument. In these cases, it is easier than to repeatedly press **Open**.

Note For step-by-step instructions on front-panel operation, refer to Chapter 5 starting from Page 49.

A Sample Program with SCPI Commands

Almost all the front-panel operations can also be performed by sending SCPI or HP 3488A commands over the remote interface. Prior to performing any operation (close/open/scan channels, etc.) with either SCPI commands or HP 3488A commands, you must connect the HP 3499A/B mainframe to a computer first. The HP 3499A/B mainframe can be connected to a computer directly via the RS-232 interface. But the connection via GPIB interface requires an IEEE-488 interface card to be installed in the computer.

Note Only one interface can be used at a time. The remote interface selection and configuration can be performed from the front-panel only. Refer to “Configure Remote Interface” starting from Page 74 for more details.

The following example is programmed in HP BASIC language using SCPI commands. Assuming the selection code of the GPIB interface is 7 and the address of the HP 3499A/B mainframe is set to 9 (factory default setting), an HP N2260A module is installed in slot 1 and configured as a 40-channel 2-wire MUX. The program will close channels 3, 4, 5, 6, 7 and 10, then query which channels are closed.

```
10  OUTPUT 709; "*RST"                ! Reset the instrument, all
                                      channels in the instrument will
                                      be opened.
20  OUTPUT 709; "CLOS (@103:107,110)  ! Close the specified channels.
30  OUTPUT 709; "CLOS:STAT?"          ! Return the closed channel
                                      numbers.
40  ENTER 709; A$
50  PRINT A$
```

Note For more information about SCPI commands, refer to Chapter 6 starting from Page 79.

A Sample Program with HP 3488A Commands

The following example is programmed in HP BASIC language using HP 3488A commands. Same as the previous example, the selection code of GPIB interface is 7 and the address of the HP 3499A/B mainframe is set to 9. An HP N2260A module is installed in slot 1 and configured as a 40-channel 2-wire MUX. Closing channels 3, 4, 5, 6, 7 and 10, then querying for the closed channels can be achieved by the following program.

```
10  OUTPUT 709; "RESET"               ! Reset the instrument, all
                                      channels in the instrument will
                                      be opened.
20  OUTPUT 709; "CLOSE 103-107,110"   ! Close the specified channels.
30  OUTPUT 709; "CMON 1"              ! Display the closed channel
                                      numbers on the front panel.
40  OUTPUT 709; "VIEW 105"            ! Query the state of a particular
                                      Channel 105.
50  ENTER 709; A$                     ! Input the response from HP
                                      3499A/B.
60  DISP A$                           ! "CLOSED 0" is returned.
```

Note For more information about HP 3488A commands, refer to Chapter 7 starting from Page 139.

Chapter 3

Using the Instrument in SCPI Mode

About This Chapter

The HP 3499 Switch/Control System can be operated in either SCPI mode or HP 3488A mode. This chapter provides a brief description on how to use the instrument in SCPI mode[1]. For step-by-step instructions of the front-panel operation, refer to Chapter 5 “Front-Panel Operation” starting from Page 49. For more details about SCPI commands, refer to Chapter 6 “SCPI Command Reference” starting from Page 79. The following sections are included in this chapter:

Throughout this manual, the following conventions are used for SCPI command syntax for remote interface programming.

- Square brackets (**[ ]**) indicate optional keywords or parameters.
- Angle brackets (< >) enclose parameters for which you must specify a value.
- A vertical bar (|) separates multiple parameters.

The following conventions are used for the front-panel operation.

- All keys on the front-panel keyboard are expressed in bold font and normally associated with a “press”. For example, press **Mon**.
- All the front panel display annunciators are expressed in bold font followed by an “annunciator”. For example, **MON** annunciator.

---

[1]. Make sure the instrument is in SCPI mode prior to performing any operation described in this chapter. This can be done either by sending SYSMODE SCPI (or SYSMODE 0) command over GPIB or RS-232 interface, or by performing the following procedure from the front panel:
a. Press **Menu**, then turn the knob until “SYSTEM MODE” is displayed and press **Enter**.
b. If “SCPI MODE” is displayed, the instrument is currently in SCPI mode. Otherwise, turn the knob until “SCPI MODE” is displayed, then press **Enter**, the instrument will change to SCPI mode.

- The information shown on the front panel display is enclosed within a pair of quotation marks.
- **Shift + Recall**[1] indicates the sequential operation: first press **Shift**, then press **Recall**.

Monitoring a Channel or a Slot

In a switch/control system, it is necessary to acquire, confirm and continuously monitor the current status of a particular switching channel, a digital I/O port, or an entire plug-in module. HP 3499A/B provides you the ability to achieve the above.

- To monitor a channel or a port, specify the channel or port number[2]. To monitor a plug-in module, specify its slot number. Moreover, the displayed information is module type dependent as shown in Table 5-2 on Page 55.
- *Front-Panel Operation:*

  Select a channel, a digital I/O port, or a slot, press **Mon**. The **MON** annunciator lights up. Press **Mon** again to exit this state.

MUX OPEN 101	*Monitor a switching channel 101;*
DIN 255 400	*Monitor a DIO Port 400;*
1:0, , , , , ,6, , ,9, 2	*Monitor a MUX or GP module;*
00: H255 L254. 4	*Monitor a DIO module.*

- *SCPI Commands*:

```
DIAGnostic:MONitor 103     ! Monitor Channel 103;
DIAGnostic:MONitor 400     ! Monitor a DIO Port 400;
DIAGnostic:MONitor 2       ! Monitor the module in slot 2.
```

Note If only part of the information about the monitored module is displayed, press **Enter** to display the next part. Repeat this process when necessary.

[1]. Also applicable to keys **Card Reset**, **Scan**, and **S.List**.

[2]. For detailed channel/port definition of each module, refer to Table 6-1 on Page 82. And the built-in digital I/O bits/port can be operated either as a 4-bit port (numbered *090*), or as four independent bit channels (numbered *091* through *094*).

Switching a Relay Channel

Switch modules can be used to route signals to and from your test system. This is achieved by closing or opening the relay channels on these modules.

- From the front panel, you can open/close one relay channel at a time. However, over the remote interface, multiple relay channels can be operated by a single command if a channel list is specified. In addition, these open/closed states can be stored, and a stored channel setup can be included in a scan list.

- Whenever a switch module is reset, all the closed relay channels on the module will be opened.

- Whenever the instrument is powered up[1] or reset, all the closed relay channels in the instrument will be opened.

- *Front-Panel Operation:*

  Select a channel, press **Open** or **Close**.

  Select a slot, press and hold **Card Reset** down to open all channels on the selected module.

  Press **Shift**, then press and hold **Card Reset** down to open all channels in the instrument.

- *SCPI Commands*:

```
[ROUTe]:OPEN (@101, 103:107, 207)   ! Open multiple channels;
SYSTem:CPON 1                       ! Open all channels on the
                                    module in slot 1;
[ROUTe]:CLOSe (@101,103:107,207)    ! Close multiple channels.
```

Note When the HP N2260A is working in 1-wire mode, only one relay channel on it can be in a closed state at any time.

Configuring a MUX Module

A newer multiplexer module, such as the HP N2260A, can be flexibly configured.

- With the help of two tree relays (*s98* & *s99*, where *s* refers to the slot number), an HP N2260A can be easily configured as an 80-channel 1-wire, a 40-channel 2-wire, a dual 20-channel 2-wire, or a 20-channel 4-wire MUX module.

[1]. Throughout this chapter, the instrument will power-on to its reset state unless otherwise specified.

- When the instrument is powered up or reset, an HP N2260A module will act as a 40-channel 2-wire MUX module (default setting).

- When working in 1-wire mode, only one relay channel on the HP N2260A can be in a closed state at any time.

- *Front-Panel Operation:*

  Select the slot in which an HP N2260A is installed, press **Mode** (the **CONFIG** annunciator lights up)**,** then select the desired function mode (i.e. 1-wire mode).

CONFIG MUX 1	→	WIRE1 1

- *SCPI Commands*:

  [ROUTe]:FUNCtion 1, WIRE1 *! Configure the module in slot 1 to be 1-wire mode.*

Note For more details of the HP N2260A module, refer to “HP N2260A 40-Channel MUX Module” on Page 174.

Digital I/O Operation

The digital input/output is well-suited for monitoring and controlling external devices. In addition to the built-in digital I/O bits/port in the mainframe (see Figure 1-3 on Page 4), several digital I/O modules and multifunction modules with a DIO function are also available. In the following context, multifunction modules refer to those with such a DIO function.

- The built-in digital I/O in the mainframe consists of four bits which can be operated either independently as four bit channels (numbered *091* through *094*) or as one 4-bit port (numbered *090*).

- The plug-in digital I/O modules and multifunction modules usually consist of several 8-, 16-, and/or 32-bit ports. These ports can be operated independently, which means one port can be used for output operation, while others can be used for input. However, all bits within a same 8-bit port are dependent, if one bit of a port is used for input or output operation, then all other bits of the same port can only be used for the same operation.

Note For more information about the specific digital I/O module, refer to Chapter 8 “Plug-in Modules” starting from Page 173.

Digital I/O Configuration

- Parameters such as flow control mode, control line polarity, flag line polarity, and I/O direction line polarity, are all configurable for the plug-in digital I/O modules and multifunction modules. However, these DO NOT apply to the 4-bit built-in digital I/O bits/port.

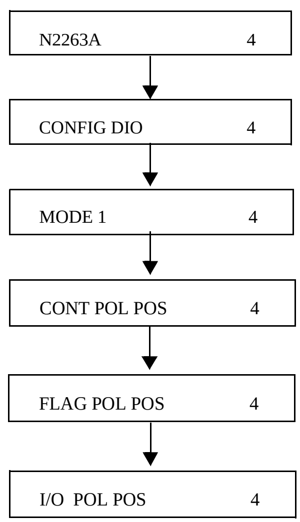
- In addition, from the front panel, the data line polarity of any 8-bit port can be configured, as well as the 4-bit built-in digital I/O port (numbered *090*) on the mainframe control board. However, over the remote interface, the data line polarity of any 8-/16-/32-bit ports and 4-bit built-in digital I/O port can be configured.

- Data display format of any 8-bit port, binary or decimal (default), can only be specified from the front panel. Once specified, the format applies to all input and output operations on the same port.

- When the instrument is powered up or reset, the flow control mode is set to Mode #1 and the polarities of all configurable lines are positive.

- *Front-Panel Operation:*

  Select a digital I/O module, then press **Mode,** the **CONFIG** annunciator lights up. Select a flow control mode (i.e. MODE 1), then the control line polarity, and so on.



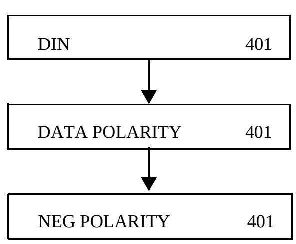
Select flow control mode;

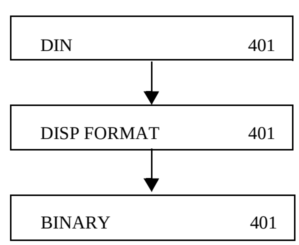
Select the control line polarity;

Select the flag line polarity;

Select the I/O direction line polarity.

Select a digital I/O port, then press **Mode,** the **CONFIG** annunciator lights up. Select "DATA POLARITY" to set data line polarity and select "DISP FORMAT" to set data display format for the port.





• *SCPI Commands*:

SOURce:DIGital:MODE 4,1	*! Set the flow control mode to Mode 1;*
SOURce:DIGital:CONTrol:POLarity 4,1	*! Set the control line polarity to negative;*
SOURce:DIGital:FLAG:POLarity 4,0	*! Set the flag line polarity to positive;*
SOURce:DIGital:IO:POLarity 4,1	*! Set the I/O line polarity to negative;*
SOURce:DIGital:DATA:BYTE:POLarity 400, POS	*! Set the data lines polarity of 8-bit Port 400 to positive.*

Digital Input Operation

• From the front panel, you can read data from the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a digital I/O module or multifunction module.

• From the remote interface, you can read data from the individual bit channels and 8-/16-/32-bit ports on a digital I/O module or multifunction module, as well as from the built-in digital I/O bits/port (numbered *090* through *094*).

• Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a SYST:CPON command will set all ports on the specified module as input ports (ports on other modules are not affected).

• *Front-Panel Operation:*

Select an 8-bit digital I/O port, press **Read** to read the data from the port.

• *SCPI Commands*:

SENSe:DIGital:DATA:BIT? 406	*! Read the bit channel 406;*
SENSe:DIGital:DATA:WORD:VALue? 400	*! Read the 16-bit Port 400.*

Digital Output Operation

• From the front panel, you can write data to the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a digital I/O module or multifunction module.

• From the remote interface, you can write data to individual bit channels and 8-/16-/32-bit ports on a digital I/O module or multifunction module, as well as to the built-in digital I/O bits/port (numbered *090* through *094*).

• Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a SYST:CPON command will set all ports on the specified module as input ports (ports on other modules are not affected).

- *Front-Panel Operation:*

  Select an 8-bit port, press **Write**, the data from the last operation (read or write) will be displayed. Edit the data and press **Enter** to write the data to the specified port. To cancel the write operation, press **Write** again instead of **Enter**.

- *SCPI Commands*:

```
SOURce:DIGital:DATA:BIT 409,1          ! Write 1 to bit channel 409;
SOURce:DIGital:DATA:WORD 400, 219
                                       ! Write 219 to 16-bit Port 400.
```

Scanning

The HP 3499 Switch/Control System can scan switching channels, digital I/O bit channels, and even the stored channel setups in a scan list. Scanning in SCPI mode offers more features than in HP 3488A mode, allowing the operator to control the scan in more ways by configuring the arm source, trigger source, arm count, etc.

Rules for Scanning

- A scan list must be specified before initiating a scan. One or more switching channels, digital I/O bit channels, and/or previously stored channel setups can be included in a scan list. The order of the channels in the scan list determines the order of the channels to be scanned.

- If any plug-in module is installed or removed while the instrument is operating, the instrument will automatically perform a reset and the current scan list is cleared as a consequence.

- If a scan list contains a non-existing channel, the scan cannot be performed and an error will occur.

- If a scan list contains a channel on a digital I/O module that does not work in Mode #1 or Mode #2, the scan cannot be performed and an error will occur.

- A scan cannot be performed and an error will occur if a mismatch between a stored channel setup in the scan list and the current hardware configuration is found.

- When a scan is aborted, the channel last scanned before the interruption will remain closed. Aborting a scan does not affect the present scan configuration. A scan cannot resume from where it is interrupted. To initiate a new scan, the channels in the scan list will be scanned from the beginning.

Scan Process

Figure 3-1 on Page 26 shows the scan process in SCPI mode, which will give you a better understanding on the scanning operation.

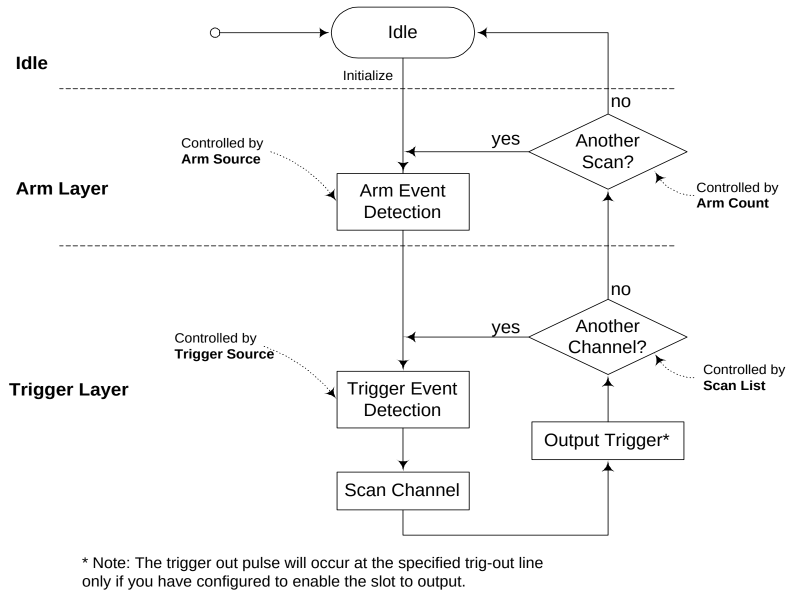


Figure 3-1. The Process of a Scan Operation

As shown, the scan operation consists of two layers: Arm Layer and Trigger Layer. The instrument is considered to be in the Idle state whenever it is not operating within any one of the layers. When a scan is initiated, the instrument is taken out of the idle state and proceeds into the Arm Layer. When an arm source is detected, the instrument leaves the Arm Layer and proceeds to the Trigger Layer. In Trigger Layer, when detecting a trigger source, it advances one step following the scan list. After scanning through all the channels/bits in the scan list, and reaching the arm count, the scan is terminated and the instrument returns to the idle state.

Idle

The instrument is considered to be in the Idle state whenever it is not operating within any one of the layers. When the instrument is taken out of the Idle state, the **SCAN** annunciator lights up and operation proceeds to the Arm Layer.

Arm Layer

The instrument requires an arm source to allow operation to proceed into the Trigger Layer. One of the following arm sources can be selected:

- **TIMER:** with timer arm source selected, the instrument will not proceed to the trigger layer unless the specified time interval is elapsed.
- **IMM:** with IMM (default) arm source selected, operation immediately proceeds to the trigger layer as soon as the instrument is taken out of the idle state.
- **BUS:** with bus arm source selected, the instrument will not proceed to the trigger layer unless a GET or a *TRG command is received, or **Step** on the front panel is pressed.

- **EXT:** with external (EXT) arm source selected, the instrument will not proceed to the trigger layer unless an external trigger is received from the specified trigger-in line.
- **MIX:** with mix arm source selected, the instrument will not proceed to the trigger layer unless a BUS event or EXTernal event occurs.
- **HOLD:** with hold arm source selected, the instrument will wait for a TRIGger[:IMMediate] command before proceeding further.

Trigger Layer

In Trigger Layer, the instrument requires a trigger source to open the previous channel and then close the next one listed in the scan list. One of the following trigger sources can be selected:

- **TIMER:** with timer trigger source selected, the next channel is not scanned unless the specified time interval is elapsed.
- **IMM:** with IMM (default) trigger source selected, the next channel will be closed as soon as the previous channel is opened.
- **BUS:** with bus trigger source selected, the next channel is not scanned unless a GET or a *TRG command is received, or **Step** on the front panel is pressed.
- **EXT:** with external (EXT) trigger source selected, the next channel is not scanned unless an external trigger is received from the specified trigger-in line.
- **MIX:** with mix trigger source selected, the next channel is not scanned unless a BUS event or EXTernal event occurs.
- **HOLD:** with hold trigger source selected, the next channel is not scanned unless a TRIGger[:IMMediate] command is received.

Creating Scan List

Before initiating a scan, a scan list must be set up. The instrument scans the specified channels automatically in the same order of the scan list.

- The scan list is automatically cleared whenever the instrument is turned off or reset. You can also clear the scan list by pressing **Shift+S.List**.

- *Front-Panel Operation:*

  Press **S.List**, the **CONFIG** annunciator will light up. Select “ADD TO SCAN” to add the desired switching channels, digital bit channels, or stored instrument setups.

ADD TO SCAN	→	SELECT 101

- *SCPI Commands*:

[ROUTe]:SCAN (@100,104:109, 411,1)	*!Create scan list to include channel 100, channel 104 through 109, bit channel 411, and stored state 1.*

Configuring Scan

The scan procedure is controlled by specifying an arm source, a trigger source, and the number of sweeps (a sweep is one pass through the scan list).

- You can select any one of the six arm sources to control the onset of each sweep. IMM is the default arm source. If TIMER arm source is selected, the elapsed time can be set between 0 and 99999.999 seconds, with a 1 ms resolution.

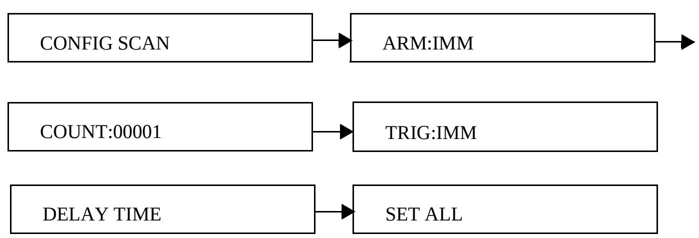
- You can select any one of the six trigger sources to notify the HP 3499A/B to advance to the next channel in the scan list. IMM is the default trigger source. If TIMer trigger source is selected, the elapsed time can be set between 0 and 99999.999 seconds, with a 1 ms resolution.

- You can specify the number of times (between 1 and 99999) the instrument is to sweep through the scan list. When the specified number is reached, the scan stops.

- You can also specify a delay time (between 0 and 99999.999 seconds, with 1 ms resolution) after which HP 3499A/B may send a *trigger out pulse*[1] when a channel is closed. The delay time for all channels can be set individually or simultaneously.

- *Front-Panel Operation:*

  Press **S.List**, the **CONFIG** annunciator will light up. Select "CONFIG SCAN" to set an arm source, then the arm count and the trigger source. Select "DELAY TIME" to set the delay time for all channels, either individually or simultaneously. Press **S.List** again to exit the scan configuration.



- *SCPI Commands*:

ARM:SOURce IMMediate	*! Set arm source to IMM;*
ARM:COUNt 10	*! Set arm count to 10 times;*
TRIGger:SOURce IMMediate	*! Set trigger source to IMM;*
ROUTe:CHANnel:DELAY 2,(@101)	*! Add 2 seconds time delay for channel 101.*

[1]. The trigger out pulse can be send out only if you have configured to enable the instrument to output either from the built-in external trigger-out line (see Figure 1-3 on Page 4) or from the CC (channel closed) control lines on the HP 44474A module (if installed). Refer to "External Scanning" on Page 29 for more details.

Performing Scan

After the scan configuration, the actual scan can be performed.

- Pressing **Scan** or sending an INITiate command, the **SCAN** annunciator lights up. The instrument will continue scanning as configured or until it is stopped by pressing **Shift+Scan** or an ABORt command.

- A much simpler scanning can also be done. Once a scan list exists, simply press **Step** repeatedly to start and step through the channels in the list. In this case, the **SCAN** annunciator will not light up, and the configured arm source, trigger source, and arm count are ignored.

- *Front-Panel Operation:*

  Pressing **Scan** to initiate the scan operation, pressing **Shift**+**Scan** to stop.

  OR

  Pressing **Step** to start and step through the channels in the scan list.

- *SCPI Commands*:

INITiate	*!Initiate the scan;*
ABORt	*!Stop the scan.*

Note If a scan list contains a non-existing channel, the scan cannot be performed and an error will occur.

Note If a scan list contains a channel on a digital I/O module that does not work in Mode #1 or Mode #2, the scan cannot be performed and an error will occur.

Note If a stored channel setup in the scan list does not match the current hardware configuration, the scan cannot be performed and an error will occur.

External Scanning

To control scanning with an external instrument (such as a DMM), external connections through a pair of control lines are required to synchronize the scan sequence between the HP 3499A/B and the external instrument. Figure 3-2 on Page 30 shows an example connection. The HP 3499A/B can be configured to output a trigger pulse to notify the external instrument whenever a relay is closed. In response, the arm source or trigger source must be configured as either EXT or MIX so that the HP 3499A/B can receive the notification from the external instrument to advance to the next channel in the scan list.

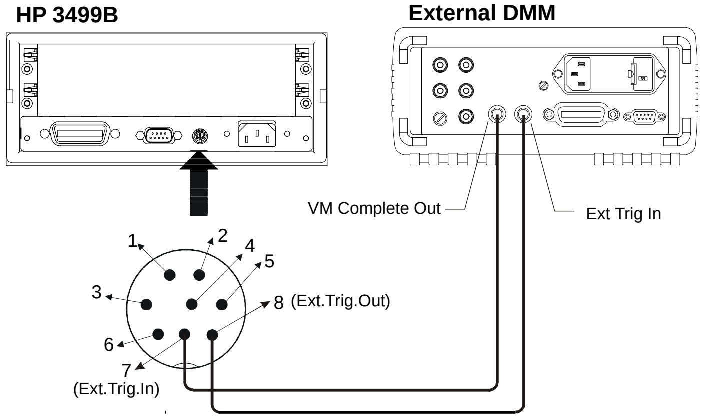


Figure 3-2. Connections for External Scanning

- In addition to the Ext.Trig.In and Ext.Trig.Out pair provided on the rear panel of the mainframe (see Figure 1-3 on Page 4), the EI (external increment) and CC (channel closed) pair on an HP 44474A module[1] can also be used as an alternative. Specifying Slot 0 or the slot in which an HP 44474A module is installed to indicate which pair is to be employed.

- Once a new pair of control lines is selected, the newly selected trigger-in line is immediately ready to accept the trigger signal from the external instrument. Enabling or disabling the newly selected pair will decide whether a trigger out pulse can be sent through the trigger-out line to the external instrument.

- *Front-Panel Operation:*

  Press **Menu**, select “CONF EXT TRIG”. Select either slot 0 (HP 3499A/B mainframes) or the slot in which an HP 44474A is installed, then enable/disable the pair of trigger lines.

  Press **S.List**, select “CONFIG SCAN” to configure the arm source or trigger source as either EXT or MIX.

- *SCPI Commands*:

```
CONFigure:EXTernal:TRIGger:SOURce 0 ! Select to use the built-in
                                      ext.trig.in and ext.trig.out lines;
CONFigure:EXTernal:TRIGger:OUTPut 1 ! Enable to output a trigger
                                      pulse on the Ext.Trig.Out line.
ARM:SOURce EXT                      ! Set arm source to EXT;
TRIGger:SOURce EXT                  ! Set trigger source to EXT.
```

[1]. Refer to “HP 44474A 16-Bit Digital I/O Module” on Page 230 for more details about the CC and EI lines.

System-Related Operations

This section provides information on system-related topics such as storing instrument setups, reading errors, running a self-test, turning on/off front-panel display, as well as reading the relay cycle counts.

State Storage

The current instrument setup can be stored for future use. The stored setups can be recalled directly, or included in a scan list.

- An instrument setup stored in SCPI mode includes the channel configuration (the status of relay channels, and/or the static digital I/O state), module configuration (card pair, function mode, etc.), as well as scanning setups (scan list, arm count, arm source, etc.).

- Up to 10 instrument setups can be stored in non-volatile memory locations numbered 01 through 10. The recalled setup must be one of the previously stored instrument setups.

- Before recalling a stored setup, the instrument verifies that all module type and slot assignment match the setup. If a mismatch is detected, an error will occur.

- An instrument power-on or reset does not affect the stored instrument setup information. Once a setup is stored, it remains until overwritten or specially deleted with SYSTem:STATe:DELete command.

- Whenever the system mode is changed, all stored setups will be cleared automatically.

- *Front-Panel Operation:*

  To store an instrument setup, press **Shift** + **Recall**, then select a memory location and press **Enter**. To cancel the store operation, press **Recall** again instead of **Enter**.

  To recall a stored setup, press **Recall**, then select the memory location to be recalled and press **Enter**. To cancel the recall operation, press **Recall** again instead of **Enter**.

- *SCPI Commands*:

*SAV <1-10>	*! Store an instrument setup.*
*RCL <1-10>	*! Recall a previously stored setup.*

Error Conditions

When the **ERROR** annunciator on the front-panel lights up, one or more command syntax or hardware errors have been detected.

- Up to 10 errors can be stored in the instrument error queue. Errors are retrieved in a first-in-first-out (FIFO) manner, which means the first error returned is the first error that was stored.

- If more than 10 errors have occurred, the last error stored in the queue (the most recent error) is replaced with "-350 QUEUE OVERFLOW". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with "NO ERROR".

- The error queue will be cleared automatically once you read the queue, change the system mode, send the *CLS command, or cycle power the instrument. However, a module reset or an instrument reset will not clear the error queue.

- *Front-Panel Operation:*

  Press **View** and select "ERROR", the first error recorded is returned. Use the arrow key (=>) to scroll through the whole error message, then turn the knob to proceed to view other errors in the error queue.

- *SCPI Commands*:

  `SYSTem:ERRor?` *! Query the error queue.*

Note For more information about errors, refer to Appendix A on Page 271.

Self-Test

The HP 3499A/B can do a self-test to verify that it is in proper operation.

- If the self-test is successful, "PASSED" will be displayed on the front panel. Otherwise, the reason of the failure will be displayed. For details of all self-test failures, refer to Table 9-1 on Page 275.

- *Front-Panel Operation:*

  Press **Menu**, select "SELFTEST" to perform a self-test.

- *SCPI Commands*:

  `*TST?` *! Returns zero if the test is successful, or non-zero if it fails.*

Display Control

For some reasons (such as security, processing speed, etc.), it is sometimes necessary to turn off the front-panel display. You can also write a message of up to 13 characters to display on the front-panel.

The display cannot be turned off from the front panel.

- When the display is turned off, the entire front-panel display goes blank except for the **ADRS** and **RMT** annunciators (the **ERROR** annunciator will also be on if there are errors), and all keys except **Local** are locked.

- If the display is turned off, pressing **Local** causes the instrument to return to local operation, the display will be turned back on.

- The display is automatically turned on when power is cycled, or after a *RST command.

- When the display is on, you can send a message (up to 13 characters) to display on the front panel over the remote interface. If you attempt to send more than 13 characters, only the first 13 characters can be displayed. The characters can be letters (A-Z), numbers (0-9), and special characters like “space”, “*”, “+”, etc., refer to Page 91 for a complete list.

- *SCPI Commands*:

DIAGnostic:DISPlay:STATe 0|OFF	*! Turn off the display.*
DIAGnostic:DISPlay:STATe 1|ON	*! Turn on the display.*
DIAGnostic:DISPlay “Scan finished”	*! Display the message on the front panel.*

Relay Cycle Counts

The HP 3499A/B can read the relay cycle counts on the newer plug-in modules.

- This feature is supported by HP N2260A, N2261A, N2262A, N2264A and N2265A modules.

- The cycle counts of the tree relays (*s98 & s99*) on HP N2260A can also be queried.

- *Front-Panel Operation:*

  Press **View**, select “RELAY CYCLES”, then select a relay channel to read its cycle count.

- *SCPI Commands*:

DIAGnostic:RELay:CYCLes? (@101)	*! Query relay cycle count of Channel 101.*

Remote Interface Configuration

The instrument is shipped with both a GPIB (IEEE 488) interface and an RS-232 interface for remote communication. But only one interface can be used at a time.

The remote interface can be configured from the front panel only.

GPIB Interface

Each device on the GPIB interface must have a unique address.

- When shipped from the factory, the GPIB interface is selected and its address is set to “9”. The GPIB address of the instrument can be set to any value between 0 and 30.
- The GPIB address is stored in non-volatile memory, and does not change when the instrument is turned off or reset.
- Switching between SCPI mode and HP 3488A mode causes the HP 3499A/B to select the GPIB interface and its address setting.
- *Front-Panel Operation:*

  Press **Menu**, select “INTERFACE”. Select “GPIB/488”, then set its address and enable/disable Power-on SRQ.

RS-232 Interface

RS-232 interface can be selected and its baud rate, parity, and flow control mode can be configured from the front-panel.

- **Baud Rate:** The baud rate can be set to one of the following: 2400, 4800, 9600, 19200, 38400, or 57600. The factory default setting is 9600.
- **Parity** and **Data Bits:** The parity and data bits can be set to one of the following: None, 8 bits; Even, 7 bits; or Odd, 7 bits. The factory default setting is None, 8 bits.
- **Flow Control:** The flow control can be set to one of the following: None (factory default setting), XON/XOFF, DTR/DSR, RTS/CTS.

  -- **None:** In this mode, data is sent and received over the interface without any flow control. When using this method, use a slower baud rate (< 9600 baud) and avoid sending more than 128 characters without stopping or reading a response.

  -- **XON/XOFF:** This mode uses special characters embedded in the data stream to control the flow. If the instrument is addressed to send data, it continues sending data until the “XOFF” (13_h) character is received. When the “XON” character (11_h) is received, the instrument resumes sending data.

-- **DTR/DSR:** In this mode, the instrument monitors the state of the DSR (data set ready) line on the RS-232 connector. When the line goes true, the instrument sends data over the interface. When the line goes false, the instrument stops sending information (typically within six characters). The instrument sets the DTR line false when the input buffer is almost full (approximately 100 characters) and releases the line when space is available again.

-- **RTS/CTS:** This mode operates the same as the DTR/DSR mode but uses the RTS (request to send) and CTS (clear to send) lines on the RS-232 connector instead. When the CTS line goes true, the instrument sends data over the interface. When the line goes false, the instrument stops sending information (typically within six characters). The instrument sets the RTS line false when the input buffer is almost full (approximately 100 characters) and releases the line when space is available again.

- Switching the instrument system mode causes the instrument to select the GPIB interface and its address setting.

- *Front-Panel Operation:*

  Press **Menu**, select “INTERFACE”. Select “RS-232” interface, then set the baud rate, parity, and flow control.

Factory Default State and Reset State

Table 3-1 on Page 36 shows the settings of the instrument after a reset in SCPI mode, as well as the default settings when the instrument is shipped from the factory.

- Resetting the instrument can be performed either by pressing **Shift + Card Reset** from the front-panel, or with a *RST command over the remote interface.

- The instrument will automatically perform a reset if any plug-in module is installed or removed while the instrument is on.

Table 3-1. Factory Default State and Reset State

Item		Factory Default	Reset
Interface	GPIB/488	GPIB (Address 9)	Keep current setting[1]
	RS-232		Keep current setting[1]
System Mode	SCPI Mode	SCPI Mode	Keep current setting
	HP 3488A Mode		Keep current setting
	Display State	On	On
	Stored State	Empty	Keep current setting
	Error Queue	Empty	Not cleared
Module-Related	Switching Channels	Open	Open
	Digital I/O Ports	Input	Input
	Card Pair	None	None
Scan-Related	Scanning	None	Stop scan in progress
	Scan List	Empty	Empty
	ARM SOURce	IMMediate	IMMediate
	ARM TIMer (seconds)	0	0
	Arm Count	1	1
	TRIGger SOURce	IMMediate	IMMediate
	TRIGger TIMer (seconds)	0	0
	Channel Delay (seconds)	0	0
	Trigger Out Pulse	Disabled	Disabled

[1]. Current setting includes the selection of an interface, as well as the settings for the interface.

Chapter 4
Using the Instrument in HP 3488A Mode

About This Chapter

The HP 3499 Switch/Control System can be operated in either SCPI mode or HP 3488A mode. This chapter provides a brief description on how to use the instrument in HP 3488A mode[1]. For step-by-step instructions of the front-panel operation, refer to Chapter 5 “Front-Panel Operation” starting from Page 49. For more details about HP 3488A commands, refer to Chapter 7 “HP 3488A Command Reference” starting from Page 139. The following sections are included in this chapter:

The following conventions are used for the front-panel operation.

- All keys on the front-panel keyboard are expressed in bold font and normally associated with a “press”. For example, press **Mon**.
- All the front panel display annunciators are expressed in bold font followed by an “annunciator”. For example, **MON** annunciator.
- The information shown on the front panel display is enclosed within a pair of quotation marks.
- **Shift + Recall**[2] indicates the sequential operation: first press **Shift**, then press **Recall**.

Note In HP 3488A mode, RS-232 interface CANNOT be used.

[1]. Make sure the instrument is in HP 3488A mode prior to performing any operation described in this chapter. This can be done either by sending SYSMODE HP3488A (or SYSMODE 1) command over GPIB interface or by performing the following procedure from the front panel:
a. Press **Menu**, then turn the knob until “SYSTEM MODE” is displayed and press **Enter**.
b. If “HP 3488A MODE” is displayed, the instrument is currently in HP 3488A mode. Otherwise, turn the knob until “HP 3488A MODE” is displayed, then press **Enter**, the instrument will change to HP 3488A mode.
[2]. Also applicable to keys **Card Reset**, **Scan**, and **S.List**.

Monitoring a Channel or a Slot

In a switch/control system, it is necessary to acquire, confirm and continuously monitor the current status of a particular switching channel, a digital I/O port, or an entire plug-in module. HP 3499A/B provides you the means to achieve the above.

- To monitor a channel or a port, specify the channel or port number[1]. To monitor a plug-in module, specify its slot number. Moreover, the displayed information is module type dependent as shown in Table 5-2 on Page 55.

- *Front-Panel Operation:*

  Select a channel, a digital I/O port, or a slot, press **Mon**. The **MON** annunciator lights up. Press **Mon** again to exit this state.

`MUX        OPEN   101`	*Monitor a switching channel 101;*
`DIN         255   400`	*Monitor a DIO Port 400;*
`1:0, , , , , ,6, , ,9,      2`	*Monitor a MUX or GP module;*
`00: H:255   L254.    4`	*Monitor a DIO module.*

- *HP 3488A Commands:*

OUTPUT 709; "VIEW 103"	*! Query the state of a relay channel 103;*
OUTPUT 709; "VIEW 431"	*! Query the state of a bit channel 431;*
OUTPUT 709; "CMON 2"	*! Monitor the module in slot 2.*

Note If only part of the information about the monitored module is displayed, press **Enter** to display the next part. Repeat this process when necessary.

Switching a Relay Channel

Switch modules can be used to route signals to and from your test system. This is achieved by closing or opening the relay channels on these modules.

- From the front panel, you can open/close one relay channel at a time.

[1]. For detailed channel/port definition of each module, refer to Table 7-1 on Page 140. And the built-in digital I/O bits/port can be operated either as a 4-bit port (numbered *090*), or as four independent bit channels (numbered *091* through *094*).

However, over the GPIB interface, multiple relay/bit channels can be operated by a single command if a channel list is specified. In addition, these open/closed states can be stored, and the stored channel setups can be included in a scan list.

- Whenever a switch module is reset, all the closed relay channels on the module will be opened.
- Whenever the instrument is powered up[1] or reset, all the closed relay channels in the instrument will be opened.
- *Front-Panel Operation:*

  Select a channel, press **Open** or **Close**.

  Select a slot, press and hold **Card Reset** down to open all channels on the selected module.

  Press **Shift**, then press and hold **Card Reset** down to open all channels in the instrument.

- *HP 3488A Commands:*

```
OUTPUT 709; "OPEN 101,102, 207"     ! Open multiple channels;
OUTPUT 709; "CRESET 1"              ! Open all channels on the
                                    module in slot 1;
OUTPUT 709; "CLOSE 101,102, 207"    ! Close multiple channels.
```

Note The bit channels on Digital I/O modules or Multifunction modules can be closed or opened by CLOSE or OPEN command only when they are in either Mode #1 or Mode #2.

Digital I/O Operation

The digital input/output is well-suited for monitoring and controlling external devices. In addition to the built-in digital I/O bits/port in the mainframe (see Figure 1-3 on Page 4), several digital I/O modules and multifunction modules with a DIO function are also available. In the following context, multifunction modules refer to those with such a DIO function.

- The built-in digital I/O in the mainframe consists of four bits which can be operated either independently as four bit channels (numbered *091* through *094*) or as one 4-bit port (numbered *090*).
- The plug-in digital I/O modules and multifunction modules usually consist of several 8-, 16-, and/or 32-bit ports. These ports can be operated independently, which means one port can be used for output

[1]. Throughout this chapter, the instrument will power-on to its reset state unless otherwise specified.

operation, while others can be used for input. However, all bits within a same 8-bit port are dependent, if one bit of a port is used for input or output operation, then all other bits of the same port can only be used for the same operation.

Note For more information about the specific digital I/O module, refer to Chapter 8 “Plug-in Modules” starting from Page 173.

Digital I/O Configuration

- Parameters such as flow control mode, control line polarity, flag line polarity, and I/O direction line polarity, are all configurable for the plug-in digital I/O modules and multifunction modules. However, these DO NOT apply to the 4-bit built-in digital I/O bits/port.

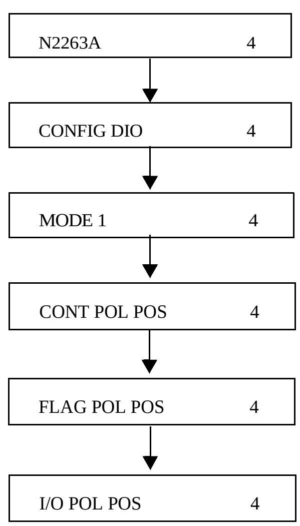
- In addition, from the front panel, the data line polarity of any 8-bit port can be configured, as well as the 4-bit built-in digital I/O port (numbered *090*) on the mainframe control board. However, over the remote interface, the data line polarity of any 8-/16-/32-bit ports and 4-bit built-in digital I/O port (numbered *090*) can be configured.

- Data display format of any 8-bit port, binary or decimal (default), can be specified from the front panel only. Once specified, the format applies to all input and output operations on the same port.

- When the instrument is powered up or reset, the flow control mode is set to Mode #1 and the polarities of all configurable lines are positive.

- *Front-Panel Operation:*

  Select a digital I/O module, then press **Mode** (the **CONFIG** annunciator lights up). Select a flow control mode (i.e. MODE 1), then the control line polarity, and so on.



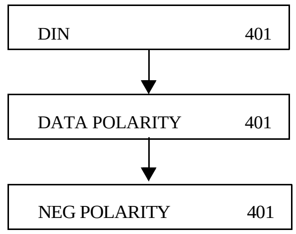
Select flow control mode;

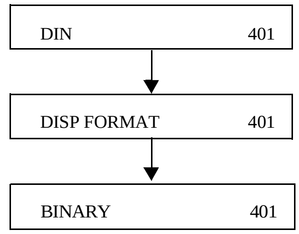
Select the control line polarity;

Select the flag line polarity;

Select the I/O direction line polarity.

Select a digital I/O port, then press **Mode,** the **CONFIG** annunciator lights up. Select “DATA POLARITY” to set data line polarity and select “DISP FORMAT” to set data display format for the port.





- *HP 3488A Commands:*

OUTPUT 709; “DMODE 4,1,0,1”	*! Set the flow control to Mode #1 and the polarity of all lines to default values.*

Digital Input Operation

- From the front panel, you can read data from the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a digital I/O module or multifunction module.
- From the remote interface, you can read data from the built-in digital I/O port (numbered *090*) and the 8-/16-/32-bit ports on a plug-in digital I/O module or multifunction module. The built-in digital I/O bit channels (numbered *091* through *094*) or the individual bit channels on plug-in modules can be queried with VIEW command to determine whether it is open or closed.
- Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a SYST:CPON command will set all ports on the specified module as input ports (ports on other modules are not affected).
- *Front-Panel Operation:*

  Select an 8-bit digital I/O port, press **Read** to read the data from the port.

- *HP 3488A Commands:*

OUTPUT 709; “DREAD 402”	*! Read data from Port 402;*
OUTPUT 709; “VIEW 403”	*! View a bit channel 403.*

Digital Output Operation

- From the front panel, you can write data to the built-in digital I/O bits/port (numbered *090* through *094*) or any one of the 8-bit ports on a Digital I/O module or multifunction module.
- From the remote interface, you can write data to the built-in digital I/O

port (numbered *090*) and the 8-/16-/32-bit ports on a plug-in digital I/O module or multifunction module. The built-in digital I/O bit channels (numbered *091* through *094*) or the individual bit channels on a plug-in module (in either Mode #1 or Mode #2) can be opened or closed with an OPEN or CLOSE command.

- Instrument reset will set all digital I/O ports in the instrument as input ports. Pressing **Card Reset** or issuing a SYST:CPON command will set all ports on the specified module as input ports (ports on other modules are not affected).

- *Front-Panel Operation:*

  Select an 8-bit port, press **Write**, the data from the last operation (read or write) will be displayed. Edit the data and press **Enter** to write the data to the specified port. To cancel the write operation, press **Write** again instead of **Enter**.

- *HP 3488A Commands:*

OUTPUT 709; "DWRITE 400, 219"	*! Write 219 to 16-bit Port 404;*
OUTPUT 709; "CLOSE 401, 407, 411"	*! Close bit channels 401, 407, and 411;*
OUTPUT 709; "OPEN 403, 405, 407"	*! Open bit channels 403, 405, and 407.*

Scanning

HP 3499 Switch/Control System can scan switching channels, digital I/O bit channels, and stored channel setups in a scan list.

- A scan list must be specified before scanning. One or more switching channels, digital I/O bit channels, and/or previously stored channel setups can be included in a scan list. The order of the channels in the scan list determines the order of the channels to be scanned.

- The scan list is automatically cleared whenever the instrument is turned off or reset. You can also clear the scan list by pressing **Shift+S.List**.

- If the instrument system mode is changed, or any plug-in module is installed or removed while the instrument is operating, the instrument will automatically perform a reset and the current scan list is cleared as a consequence.

- When pressing **Step** or using a STEP command to initiate a scan, the **SCAN** annunciator will not light up and the first channel in the scan list will be closed. Each subsequent stepping causes the most recently closed channel to open, and the next channel in the scan list to close. Stepping beyond the last channel in the scan list causes a wraparound to the first channel.

- When stepping to a channel on a digital I/O module that does not work in either Mode #1 or Mode #2, an error will occur.

- If a stored setup does not match the current hardware configuration, stepping to that setup will not cause the mainframe to recall the setup, and an error will occur.

- *Front-Panel Operation:*

  Press **S.List**, the **CONFIG** annunciator lights up. Select “ADD TO SCAN” to add switching channels, digital bit channels, or stored instrument setups. Select “DELAY TIME” to set the delay time for all channels.

ADD TO SCAN	→	SELECT 101 101
DELAY TIME	→	00001.000 SECS

  OR

  Press **Step** to initiate and close the first channel in the scan list. Then press **Step** repeatedly to scan the subsequent channels in the scan list. Stepping beyond the last channel in the scan list causes a wraparound to the first channel.

- *HP 3488A Commands:*

```
10  OUTPUT 709; “SLIST 100-109          ! Create a scan list;
20  FOR I = 1 to 10
30  OUTPUT 709; “STEP”                  ! Step through the scan list;
40  OUTPUT 709; “DELAY 20”              ! Add 20 ms time delay.
50  Next I
```

External Scanning

To control scanning with an external instrument (such as a DMM), external connections through a pair of control lines are required to synchronize the scan sequence between the HP 3499A/B and the external instrument. Figure 4-1 on Page 44 shows an example connection. The HP 3499A/B can be configured to output a trigger pulse to notify the external instrument whenever a relay is closed. In response, the external instrument will notify the HP 3499A/B when it is ready to advance to the next channel in the scan list.

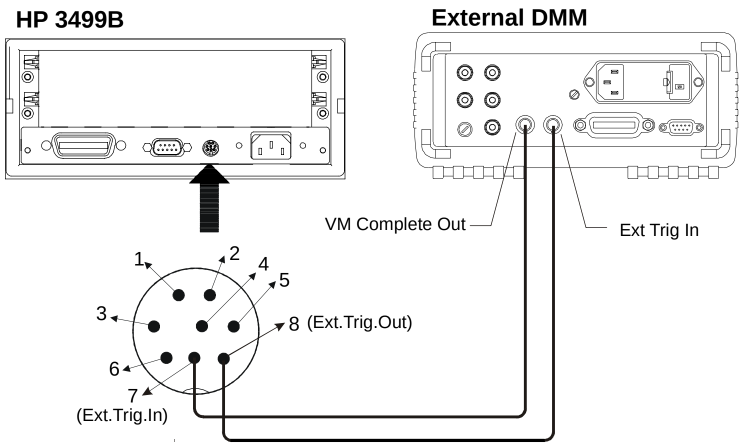


Figure 4-1. Connections for External Scanning

- In addition to the Ext.Trig.In and Ext.Trig.Out pair provided on the rear panel of the mainframe (see Figure 1-3 on Page 4), the EI (external increment) and CC (channel closed) pair on an HP 44474A module[1] can also be used as an alternative. Specifying Slot 0 or the slot in which an HP 44474A module is installed to indicate which pair is to be employed.

- Either pair of the trigger lines can be selected. When a pair is enabled, the previously enabled pair will be disabled automatically; otherwise, the previously enabled pair is still in effect.

- *Front-Panel Operation:*

  Press **Menu**, select “CONF EXT TRIG”. Select either Slot 0 (HP 3499A/B mainframes) or the slot in which an HP 44474A is installed, then enable/disable the pair of trigger lines.

- *HP 3488A Commands:*

OUTPUT 709; “DMODE 0, 1, 0, 1”	*! Allow output a trigger pulse on the rear panel Mini DIN connector.*

System-Related Operations

This section provides information on system-related topics such as storing instrument setups, reading errors, running a self-test, turning on/off front-panel display, as well as reading the relay cycle counts.

[1]. Refer to “HP 44474A 16-Bit Digital I/O Module” on Page 230 for more details about the CC and EI lines.

State Storage

The current instrument setup can be stored for future use. The stored setups can be recalled directly, or included in a scan list.

- Up to 40 instrument setups (the status of relay channels, and/or the static digital input/output state) can be stored in non-volatile memory locations numbered 01 through 40. The recalled setup must be one of the previously stored instrument setups.

- Before recalling a stored setup, the instrument verifies that all module type and slot assignment match the setup. If a mismatch is detected, an error will occur.

- An instrument power-on or reset does not affect the stored instrument setup information. Once a setup is stored, it remains unless it is overwritten.

- Whenever the system mode is changed, all stored setups will be cleared automatically.

- *Front-Panel Operation:*

  To store an instrument setup, press **Shift** + **Recall**, then select a memory location and press **Enter**. To cancel the store operation, press **Recall** again instead of **Enter**.

  To recall a stored setup, press **Recall,** then select the memory location to be recalled and press **Enter**. To cancel the recall operation, press **Recall** again instead of **Enter**.

- *HP 3488A Commands:*

OUTPUT 709; “STORE <1-40>”	*! Store an instrument setup;*
OUTPUT 709; “RECALL <1-40>”	*! Recall the previously stored channel setup.*

Error Conditions

When the **ERROR** annunciator on the front-panel lights up, one or more command syntax or hardware errors have been detected.

- In HP 3488A mode, only the sum of the values of the possible error conditions, as defined in Table 9-2 on Page 276, is recorded in the error queue. For example, the returned value of “0003” means that both “Syntax Error” and “Execution Error” occur. You can read it either from the front-panel, or with an HP 3488A command over the GPIB interface.

- The error queue will be cleared automatically once you read the queue, change the system mode, reset or cycle power the instrument.

- *Front-Panel Operation:*

Press **View** and select “ERROR”. The displayed value is the sum of the values of the possible error conditions.

- *HP 3488A Commands:*

ERROR	*! Query the error register.*

Note For more information about errors, refer to Appendix A on Page 271.

Self-Test

The HP 3499A/B can do a self-test to verify that it is in proper operation.

- If the self-test is successful, “PASSED” will be displayed on the front panel. Otherwise, the reason of the failure will be displayed on the front panel. For details of all self-test failures, refer to Table 9-3 on Page 276.

- *Front-Panel Operation:*

  Press **Menu** and select “SELFTEST” to perform a self-test.

- *HP 3488A Commands:*

TEST	*! Returns zero if the test is successful, or non-zero if it fails.*

Display Control

For some reasons (such as security, processing speed, etc.), it is sometimes necessary to turn off the front-panel display. You can also write a message of up to 13 characters to display on the front-panel.

The display cannot be turned off from the front panel.

- When the display is turned off, the entire front-panel display goes blank except for the **ADRS** and **RMT** annunciators (the **ERROR** annunciator will also be on if there are errors), and all keys except **Local** are locked.

- If the display is turned off, pressing **Local** causes the instrument to return to local operation, the display will be turned back on.

- The display is automatically turned on when power is cycled, or after a RESET command.

- When the display is on, you can send a message (up to 13 characters) to display on the front panel over the remote interface. If you attempt to send more than 13 characters, only the first 13 characters can be displayed. The characters can be letters (A-Z), numbers (0-9), and special characters like “space”, “*”, “+”, etc., refer to Page 91 for a complete list.

- *HP 3488A Commands:*

OUTPUT 709; “DOFF”	*! Turn off the display;*
OUTPUT 709; “DON”	*! Turn on the display;*
OUTPUT 709; “DISP Scan finished.”	*! Display the message on the front panel.*

Relay Cycle Counts

The HP 3499A/B can read the relay cycle counts on the newer plug-in modules.

In HP 3488A mode, the relay cycle counts can be queried from the front-panel only.

- This feature is supported by HP N2260A, N2261A, N2262A, N2264A and N2265A modules.
- The cycle counts of the tree relays (*s98 & s99*) on HP N2260A can also be queried.
- *Front-Panel Operation:*

  Press **View**, select “RELAY CYCLES”, then select a relay channel to read its cycle count.

Remote Interface Configuration

The instrument is shipped with both a GPIB (IEEE 488) interface and an RS-232 interface for remote communication. However, only the GPIB interface can be used in HP 3488A mode.

The GPIB interface can be configured from the front panel only.

- Each device on the GPIB interface must have a unique address. When shipped from the factory, the GPIB interface is selected and its address is set to “9”. The GPIB address of the instrument can be set to any value between 0 and 30.
- The GPIB address is stored in non-volatile memory, and does not change when the instrument is turned off or reset.
- Switching between SCPI mode and HP 3488A mode causes the HP 3499A/B to select the GPIB interface and its address setting.
- *Front-Panel Operation:*

  Press **Menu** and select “INTERFACE”. Select “GPIB/488”, then set the address and enable/disable Power-on SRQ.

Note The RS-232 interface cannot be used in HP 3488A mode.

Factory Default State and Reset State

Table 4-1 shows the settings of the instrument after a reset in HP 3488A mode, as well as the default settings when the instrument is shipped from the factory.

- The instrument can be reset either by pressing **Shift + Card Reset**, or with a RESET command over the GPIB interface.

- The instrument will automatically perform a reset if any plug-in module is installed or removed while the instrument is on.

Table 4-1. Factory Default State and Reset State

Item		Factory Default	Reset
Interface	GPIB/488	GPIB (Address 9)	Keep current setting[1]
	RS-232[2]		Keep current setting
System Mode	SCPI Mode	SCPI Mode	Keep current setting
	HP 3488A Mode		Keep current setting
System-Related	Display State	On	On
	Stored State	Empty	Keep current setting
	Error Queue	Empty	Cleared
Module-Related	Switching Channels	Open	Open
	Digital I/O Ports	Input	Input
	Card Pair	None	None
Scan-Related	Scanning	None	Stop scan in progress
	Scan List	Empty	Empty
	Channel Delay (seconds)	0	0
	Trigger Out Pulse	Disabled	Disabled

[1]. Current setting includes the selection of the GPIB interface and its address setting.
[2]. RS-232 interface CANNOT be used in HP 3488A mode.

Chapter 5
Front-Panel Operation

About This Chapter

The HP 3499A mainframe front panel operation is identical to that of the HP 3499B. This chapter covers all aspects of front-panel operation. Chapter contents include:

The following conventions are used for the front-panel operation.

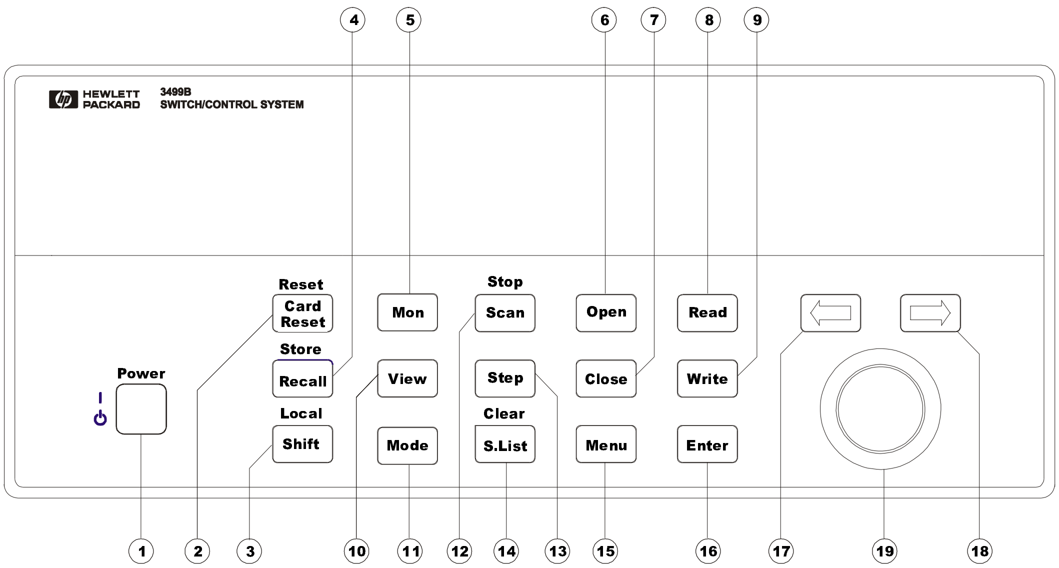
- All keys on the front-panel keyboard are expressed in bold font and normally associated with a “press”. For example, press **Mon**.
- All the front panel display annunciators are expressed in bold font followed by an “annunciator”. For example, **MON** annunciator.
- The information shown on the front panel display is enclosed within a pair of quotation marks.
- **Shift + Recall**[1] indicates the sequential operation: first press **Shift**, then press **Recall**.

[1]. Also applicable to keys **Card Reset**, **Scan**, and **S.List**.

Front-Panel Overview

The HP 3499A/B can be operated in either SCPI mode or HP 3488A mode. Differences between these two modes will be detailed later in this chapter. Unless specifically indicated, all the operations demonstrated in this chapter apply to both modes.

Note Switching between SCPI mode and HP 3488A mode will reset the instrument to the factory default settings, except the GPIB address which will retain its last setting.



Note: 1. The keys labled with 10, 11, 14, and 15 guide you through menus to configure various parameters of the instrument. The details on these menus operation are demonstrated later in this chapter..

2. The keys labled with 2, 3, 4, 12 and 14 are double-function keys. See the next page for the rules of their operation.

1. Power on/standby
2. **a.** Reset a module
b. Reset instrument
3. Shift/Local key
4. **a.** Recall instrument state
b. Store instrument state
5. Monitor a channel/port/module
6. Open relay channel
7. Close relay channel
8. Read from DIO port
9. Write to DIO port
10. Enable View menu to:
View errors
View scan list
View relay cycle counts
11. Enable Mode menu to:
Configure MUX module
Configure DIO module
12. **a.** Initiate scan
b. Stop scan
13. Step through scan list
14. **a.** Enable S.List menu to:
Create scan list
Select arm source
Select arm count
Select trigger source
Set channel delay time
b. Clear scan list
15. Enable Menu menu to:
Pair two modules together
Enable/disable trigger out pulse
Set instrument power-on state
Configure GPIB/RS-232 interface
Perform self-test
Select SCPI/3488A mode
Query firmware revision
Query serial number
16. Confirm the selection
17. Left arrow key
18. Right arrow key
19. Knob

Figure 5-1. HP 3499B Front Panel

Keyboard

As shown in Figure 5-1 on Page 50, the keyboard is composed of 15 function keys arranged in a 3 by 5 matrix on the left side, and a knob with 2 arrow keys on the right side.

Simple-control Keys

Some keys are used for frequent operations, such as **Open, Close, Read, Write**, etc. Simply press the specific key to perform the desired operation.

Double-function Keys

Some keys have double functions, one printed on the key and the other printed in blue above the key. To perform the function printed on the key, simply press the key. To perform the function printed above the key, firstly press **Shift** (the **SHIFT** annunciator lights up), then the key within 5 seconds. For example, to perform **Store** operation, press **Shift**, then press **Recall** (We will use **Shift+Recall** to represent the above sequential operations throughout this manual).

Note If no key is pressed within 5 seconds or an invalid key is pressed, the **SHIFT** annunciator will turn off and the previously pressed **Shift** key becomes invalid. To turn off the **SHIFT** annunciator, just press **Shift** again.

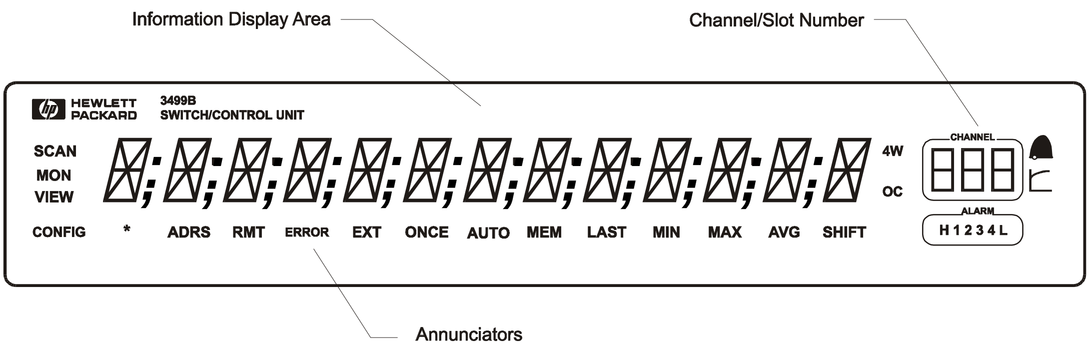
Configuration Keys

Menu, Mode, and **S.List** are configuration keys, designed to automatically guide you to configure the parameters required for a particular function or operation through the menus. Details about the specific configuration key operations are discussed later in this chapter. The following rules apply to these menus operation.

- Press an appropriate configuration key, you are automatically guided to the first level of the menu.
- Rotate the knob to view other items at the same level of the menu, press **Enter** to accept the selection and proceed to the next level or return to the first level of the menu if no further levels exist.
- To edit the value of parameters (i.e. arm count, etc.), use the arrow keys (**<=** or **=>)** to select the to-be-edited bit (in dim), rotate the knob to modify the value of that bit, press **Enter** to accept the value and proceed to the next level or return to the first level if no further levels exist.
- At any level of any menu, except the first level, pressing the same configuration key will make the instrument return to the first level.
- At the first level of any menu, pressing the same configuration key will make the instrument exit the current menu operation.

Note During a menu operation, if no key is pressed within 30 seconds or an invalid key is pressed, the instrument will exit the menu.

Display



As shown in above figure, the display is divided into several function areas. Channel number is always displayed in the channel area on the upper right corner of the display. The main area, which is in the center of the display, is primarily used to display channel status (open or closed), or other information messages, such as menu items, prompt information, error messages, etc. Around the display are annunciators to indicate various states of the operation. The indications of the annunciators are summarized in Table 5-1.

Table 5-1. Annunciators Summary

Annunciator	Indication
SCAN	Scan is initiated.
MON	Instrument is in monitor mode.
VIEW	Scan list, errors or relay cycle counts are being viewed.
CONFIG	Any configuration key has been pressed.
*	Instrument is advancing a scan step.
ADRS	Instrument is addressed to listen or talk over the remote interface.
RMT	Instrument is in remote mode.
ERROR	Error queue is not empty.
EXT	Scan is waiting for external trigger source.
SHIFT	Shift key has been pressed.

Channel/Slot Addressing

Many of the front-panel operations require you specify one or more channels. A channel refers to an individual relay on a switching module, or an individual bit/port on a digital I/O module. The channel address is in the form of *snn*, where *s* represents slot number (slot 0 refers to the mainframe controller board, slot 1 and 2 to plug-in modules in an HP 3499B, slot 1 through 5 to plug-in modules in an HP 3499A) and *nn* represents channel number (module type dependent). For example, the channel addresses of a 40-channel HP N2261A in Slot 2 are numbered as channels 200 through 239. For more information about channel addresses of individual plug-in modules, refer to Table 6-1 on Page 82, and/or Table 7-1 on Page 140.

Channel/Slot Selection

The two arrow keys (<= and =>) together with the knob are used to select slots and channels. The following procedure shows you how to do that.

1. **Select a slot.** Press <= or => to directly jump to a desired slot, or turn the knob until the desired slot number appears.

   For example, the display below indicates that an HP N2260A module is installed in Slot 1.

N2260A	1

2. **Select a channel**. Continuously turn the knob until the desired channel number (3 digital number) is displayed on the channel display area.

   As shown below, the top display indicates the current channel 101 is a multiplexer channel and in OPEN state, and the lower display indicates that the current channel 401 is a digital input port.

MUX	OPEN	101

DIN	401

Note

Open, **Close**, **Read** and **Write** keys are invalid if a slot, instead of a channel, is selected.

To demonstrate the following operations more easily and clearly, we assume that modules have been installed in an HP 3499A mainframe and the configuration is:

Slot 1	HP N2260A Multiplexer module
Slot 2	HP N2261A GP Relay module
Slot 3	HP N2262A Matrix module
Slot 4	HP N2263A Digital I/O module
Slot 5	HP N2260A Multiplexer module

Local/Remote Control

When power-up, the instrument is in local mode. All keys on the front panel are fully functional. When receiving any command from the remote interface, the instrument automatically switches to remote mode (**ADRS** and **RMT** annunciators light up), all front-panel keys are locked, except **Local, Mon, View, Enter,** the arrow keys (<= & =>) and the knob.

Local and **Shift** use the same key. While in local mode, the key is used as **Shift** key. While in remote mode (the **RMT** annunciator is on), the key is used as **Local** key which provides a convenient method of restoring front panel operation. Simply press the key, the **RMT** annunciator turns off and the instrument returns to local mode.

Note All keys will be locked if a SYSTem:RWLock command is received through the RS-232 interface or a LOCAL LOCKOUT command through the GPIB interface. In this case, the front panel operation can be restored by sending a SYSTem:LOCal command over the RS-232 interface, or a LOCAL command over GPIB interface, or cycling power the instrument.

Monitor a Channel or a Slot

In a switch/control system, it is necessary to acquire, confirm and continuously monitor the current status of a particular switching channel, a digital I/O port, or an entire plug-in module. HP 3499A/B provides you the ability to achieve the above.

1. Press **Mon**, the **MON** annunciator lights up to indicate the instrument is in the monitoring state.
2. Select the slot or the channel/port to be monitored. Note that the displayed information depends on the selected module type as shown in Table 5-2.
3. (Optional) If only part of the channel status on the module can be displayed at one time, press **Enter** to display the next part.
4. (Optional) Repeat step 2 & 3 if other slots or channels/ports are to be monitored.

5. Press **Mon** again to exit the monitoring state, the **MON** annunciator turns off.

Note The built-in digital I/O bits/port can be monitored either individually as bit channels (numbered *091* through *094*) or as a 4-bit port (numbered *090*). However, the individual bit channels on a digital I/O or multifunction module (with a DIO function) cannot be monitored this way.

Note For multiplexer modules and GP Relay modules, 10 channels can be displayed at one time; for matrix modules, one ROW or one Column can be displayed at one time; for digital I/O modules, two 8-bit ports can be displayed at one time. For multifunction modules, the first function on the module is displayed, then the next.

Table 5-2. Display on Monitoring Mode

Display	Description
1:0, , , , , ,6, , ,9, 2	The display for a multiplexer or a GP relay module. This display indicates that the monitored module is in Slot 2 and channels 10, 16, and 19 are closed.
ROW 3: ,1, ,3, , ,6,7 3 0; , ,3,COL 3, 3	The display for a matrix module. The top is the row information, indicating that the relays on Row 3, Columns 1, 3, 6 and 7 of the module (in Slot 3) are closed. The lower display is the column information, indicating that relays on column 3, row 0 and 3 are closed.
00:H255 L254. 4	The display for a digital I/O module. The first 2 digits on the left (“00” in this case) represents the “L” 8-bit port address. Adding one to this value, the “H” 8-bit port address is obtained. Data with a trailing decimal point indicates that the last operation on that port was a WRITE, data without a trailing decimal point indicates that the last operation on that port was a READ. This display shows that the data last read from Port 401 is 255 and the data last written to Port 400 is 254.
DIO 12 090 DOUT 0 091	The top display is for the built-in digital I/O Port *090* and the data from the last operation. The lower display indicates that data last written to the bit channel 091 is 0.
ROW 0: ,1, ,3, 5 00:H255 L254. 5	For a multifunction module, the first function on the module is displayed, then the next. This display is an example of a multifunction module with matrix and DIO functions.

Close or Open Channels

You can close or open individual relay channels on a switch or multifunction module (with a switch function), by following the procedure below:

1. Select the channel to be opened or closed.

2. Press **Close** to close the selected channel, or press **Open** to open the selected channel.

3. Repeat steps 1 & 2 if operation on other channels is desired.

Read from a Digital I/O Port

You can read data from the built-in digital I/O port/bits (numbered *090* through *094*), or any one of the 8-bit ports on a digital I/O or multifunction module (with a DIO function). Perform the following procedure to read from a port:

1. Select a digital I/O port.
2. Press **Read**, the data read from the selected port will be displayed.

   For example, the display below shows the data read from Port 401.

Display	Format
DIN 255 401	Decimal format
DIN 11111111 401	Binary format

Note Data display format of individual 8-bit ports can be specified either in binary or decimal, refer to the procedure on Page 63. Once specified, the format applies to all input and output operations on the same port.

Write to a Digital I/O Port

You can write data to the built-in digital I/O port/bits (numbered *090* through *094*), or any one of the 8-bit ports on a digital I/O or multifunction module (with a DIO function). Perform the following procedure to write to a port.

1. Select a digital I/O port to be written to (“DIN” indicates that the last operation on the port is a READ, and “DOUT”, a WRITE).

DIN 401

2. Press **Write**, the data from the last operation (READ or WRITE) on the selected port will be displayed and "DOUT" is displayed to indicate the port is now an output port.

```
DOUT            255  401
```

3. Edit the value. Press the arrow keys (<= or =>) to select the to-be-edited bit (in dim), turn the knob to modify the value.

```
DOUT            254  401
```

4. Press **Enter** to output the data to the selected port, or press **Write** again to cancel the current write operation.

Note Data display format of individual 8-bit ports can be specified either in binary or decimal, refer to the procedure on Page 63. Once specified, the format applies to all input and output operations on the same port.

Store an Instrument State

The current instrument setup can be stored for future use. The stored setups can be recalled directly, or included in a scan list. Also, the instrument can be set to power on to the stored state, see "Configure Power-on State" on Page 73 for details. However, the stored information in SCPI mode is different from that in HP 3488A mode. Table 5-3 lists the differences.

Table 5-3. The Differences Between Two Modes

SCPI Mode	HP 3488A Mode
Stored information: 1. Status of relay channels (open/close); 2. Status of digital I/O ports (input/output) on digital I/O modules in either static Mode #1 or Mode #2; 3. Module configurations: card pair, 1/2/4-wire function mode, baud rate, flow control, etc; 4. Scanning setups: scan list, arm count, arm source, etc.	Stored information: 1. Status of relay channels (open/close); 2. Status of digital I/O ports (input/output) on digital I/O modules in either static mode1 or mode2.
Up to10 instrument states can be stored in any memory locations numbered 01 through 10.	Up to 40 instrument states can be stored in any of memory locations numbered as 01 through 40.

Assume that the current instrument setup is what you desired. Perform the following procedure to store it in a memory location.

1. Press **Shift**, the **SHIFT** annunciator lights up, then press **Recall,** the **SHIFT** annunciator turns off and the display would be:

```
STORE 01
```

2. Turn the knob to change the memory location number to your desired value (i.e. 05).

STORE 05

3. Press **Enter** to store the current instrument state at the specified memory location 05, or press **Recall** again to cancel the store operation.

Note An instrument power-on or reset does not affect the stored instrument setup information. Once a setup is stored, it remains until overwritten or specially deleted with SYSTem:STATe:DELete command.

Note Whenever the system mode is changed, all stored setups will be cleared automatically.

Recall an Instrument State

You can recall a previously stored instrument setup. Before recalling a stored setup, the instrument verifies that all module type and slot assignment match the setup. If a mismatch is detected, the recall operation will stop and an error “RECALL FAILED” will be returned. Perform the following procedure to recall a stored setup.

1. Press **Recall,** then turn the knob to select a previously stored setup (i.e. 05).

RECALL 05

2. Press **Enter** to recall the setup (i.e. 05), or press **Recall** again to cancel the current recall operation.

View Key Operation

The instrument can store up to 10 errors[1] in the error queue, up to 200 channels in the scan list, as well as the relay cycle counts on the newer plug-in modules. The **View** key provides you an intuitive way to query these information. Table 5-4 lists the **View** key structure (named as View menu), followed by the procedure of the View menu operation in SCPI mode.

[1]. In HP 3488A mode, only the sum of the values of the possible error conditions, as defined in Table 9-2 on Page 276, is recorded in the error queue and shown on the front panel.

Table 5-4. View Key Structure

1st level Items	Description
ERROR	Query the errors recorded in the error queue.
SCAN LIST	Query the channels included in the scan list.
RELAY CYCLES	Query the relay cycle counts on some modules.

View Error

Perform the following procedure to view errors recorded in the error queue.

1. Press **View**, the **VIEW** annunciator lights up. When "ERROR" is displayed, then press **Enter**.

ERROR	108

2. If no error is in the error queue (the **ERROR** annunciator is off), the display shows "NO ERROR" and then automatically returns to the first level of the View menu.

NO ERROR	108

If there are errors (the **ERROR** annunciator is on), the first error in the error queue is displayed. Press => key to scroll the display to show the whole error message.

01:ERR -109

MISSING PARAMETER

3. (Optional) Turn the knob to view other errors in the error queue, or press **Enter** to return to the first level of the View menu, the **ERROR** annunciator turns off.
4. Press **View** again to exit the View menu operation, the **VIEW** annunciator turns off.

Note See Appendix A on Page 271 for a complete list of error messages.

Note All errors are cleared once the error queue is viewed, and the **ERROR** annunciator turns off.

View Scan List

Perform the following procedure to view the channels included in a scan list. Assuming that channels 103 through 107 are included in the scan list.

1. Press **View**, the **VIEW** annunciator lights up. Turn the knob until "SCAN LIST" is displayed, then press **Enter**.

SCAN LIST	101

2. The first channel in the scan list is displayed on the channel area. Continuously turn the knob to view other channels in the scan list.

001 OF 005	103

3. Press **Enter** to return to the first level of the View menu.

SCAN LIST	107

4. Press **View** again to exit the View menu operation, the **VIEW** annunciator turns off.

View Relay Cycles

Perform the following procedure to view the relay cycle counts.

1. Press **View**, the **VIEW** annunciator lights up. Turn the knob until "RELAY CYCLES" is displayed, then press **Enter**.

RELAY CYCLES	400

2. If no module with the relay cycle count feature[1] is present, "N/A" will be displayed, then the display automatically returns to the first level of the View menu.

N/A	400

If the selected channel is a relay without the cycle counts feature, the instrument will display the cycle counts of the first relay with the feature.

7383	100

If the selected channel (i.e. 109) is a relay with the cycle counts feature, the cycle counts of the relay will be displayed.

10132	109

[1]. Relay cycle count feature is supported by HP N2260A, HP N2261A, HP N2262A, HP N2264A, and HP N2265A modules.

3. Turn the knob to select other relay channels to read their cycle counts or press **Enter** to return to the first level of the View menu.

RELAY CYCLES	108

4. Press **View** again to exit the View menu operation, the **VIEW** annunciator turns off.

Mode Key Operation

Sometimes, you may need to configure a multiplexer module or a module with a DIO function to work in the way you desire. The **Mode** key will guide you to do that through its menus (named as Mode menu).

- Multiplexer modules can be configured only in SCPI mode. Table 5-5 shows the relevant **Mode** key structure.
- The digital I/O modules and multifunction modules with a DIO function can be configured in either SCPI mode or HP 3488A mode. Table 5-6 shows the relevant **Mode** key structure.
- In addition, some configurations for digital I/O modules or multifunction modules apply to individual ports instead of the entire module. In this case, the **Mode** key shows a completely different structure as summarized in Table 5-7 on Page 62.

Table 5-5. Mode Key Structure - I[1]

1st level Items	2nd Level Items	Description
CONFIG MUX	WIRE1 WIRE2 WIRE4 DUAL WIRE2	Configure HP N2260A Multiplexer module to work as: 80-channel 1-wire, 40-channel 2-wire, 20-channel 4-wire, or two independent groups of 20-channel 2-wire module.

[1]. In SCPI mode, when a slot with an HP N2260A module is selected, this Mode menu is displayed.

Table 5-6. Mode Key Structure - II[1]

1st level Items	2nd Level Items	3rd Level Items	4th Level Items	5th Level Items	Description
CONFIG DIO	MODE 1 MODE 2 MODE 3 MODE 4 MODE 5	CONT POL POS CONT POL NEG	FLAG POL POS FLAG POL NEG	I/O POL POS I/O POL NEG	Configure DIO module, including the handshake mode, the control line and flag line polarities, and the polarity of the I/O direction line.

[1]. When a slot with a Digital I/O or Multifunction module (with a DIO function) is selected, this Mode menu is displayed.

Table 5-7. Mode Key Structure - III[1]

1st Level Items	2nd Level Items	Description
DATA POLARITY	POS POLARITY NEG POLARITY	Set the polarity of the data lines for the port.
DISP FORMAT	DECIMAL BINARY	Set data display format for the port.

[1]. When a digital I/O port is selected, this Mode menu is displayed.

Note For the built-in digital I/O port (numbered *090*), only the data line polarity and the data display format can be configured.

Note Only in SCPI mode, the newer multiplexer module, such as the HP N2260A, can be flexibly configured. For more information on individual modules, refer to Chapter 8 starting from Page 173.

Configure MUX Module

Perform the following procedure to configure an HP N2260A multiplexer module.

1. Select a slot in which an HP N2260A module is installed.

N2260A	1

2. Press **Mode**, the **CONFIG** annunciator lights up and "CONFIG MUX" is displayed.

CONFIG MUX	1

3. Press **Enter**, then turn the knob until the desired mode (i.e. WIRE1) is displayed.

WIRE1	1

4. Press **Enter** to return to the first level of the Mode menu.

CONFIG MUX	1

5. Press **Mode** again to exit the multiplexer module configuration, the **CONFIG** annunciator turns off.

Configure DIO Module

Perform the following procedure to configure the plug-in digital I/O modules and multifunction modules (with a DIO function), such as flow control mode, control line polarity, flag line polarity, and I/O direction line polarity.

1. Select a slot in which a digital I/O or multifunction module is installed.

N2263A	4

2. Press **Mode**, the **CONFIG** annunciator lights up and the first item in the first level of the Mode menu is displayed, then press **Enter**.

CONFIG DIO	4

3. Turn the knob until the desired flow control mode (i.e. MODE 2) is displayed, then press **Enter**. Refer to Table 7-3 on Page 151 for more details of the five modes.

MODE 2	4

4. Turn the knob until the desired control line polarity (i.e. CONT POL POS) is displayed, then press **Enter**.

CONT POL POS	4

5. Turn the knob until the desired flag line polarity (i.e. FLAG POL POS) is displayed, then press **Enter**.

FLAG POL POS	4

6. Turn the knob until the desired I/O line polarity (i.e. I/O POL POS) is displayed, then press **Enter**. The instrument returns to the first level of the Mode menu.

I/O POL POS	4

7. Press **Mode** again to exit the current configuration, the **CONFIG** annunciator turns off.

Configure DIO Ports

Perform the following procedure to configure the data line polarity and data display format of individual digital I/O ports.

1. Select a digital I/O port (i.e. Port 401).

DIN	401

2. Press **Mode**, the **CONFIG** annunciator lights up and the display would be:

DATA POLARITY	401

3. **To set the data line polarity of the port:**

   a. When "DATA POLARITY" is displayed, press **Enter**.

DATA POLARITY	401

   b. Turn the knob until the desired polarity (i.e. NEG POLARITY) is displayed.

NEG POLARITY	401

   c. Press **Enter** to return to the first level of the Mode menu.

DATA POLARITY	401

To set data display format of the port:

   a. Turn the knob until "DISP FORMAT" is displayed, then press **Enter.**

DISP FORMAT	401

   b. Turn the knob until the desired data display format (i.e. BINARY) is displayed.

BINARY	401

   c. Press **Enter** to return to the first level of the Mode menu.

DISP FORMAT	401

4. Press **Mode** again to exit the current configuration, the **CONFIG** annunciator turns off.
5. (Optional) Repeat step 1 through 4 to configure the data line polarity and data display format of other digital I/O ports.

Note Once you have selected the data display format for a port, it applies to all input and output operations on that port.

Scanning Operation

The scan operation in SCPI mode is very different from that in HP 3488A mode, as can be seen from Page 25 of Chapter 3 and Page 42 of Chapter 4, respectively. In HP 3488A mode, you only need to create a scan list, then step through the scan list by repeatedly pressing **Step**. However, scanning in SCPI mode has more features. Additional scan control can be achieved by configuring the arm source, trigger source, arm count, etc. Since SCPI mode can do whatever HP 3488A mode can, only the scanning operation in SCPI mode will be demonstrated. Figure 5-2 shows the scan process in SCPI mode, which will give you a better understanding on the scanning operation.

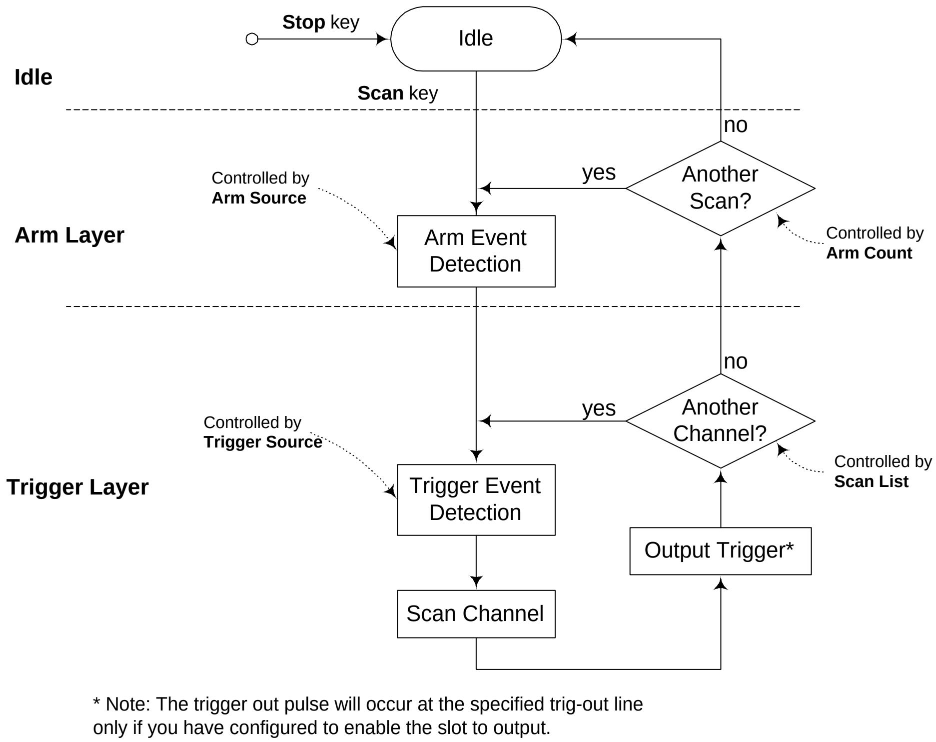


Figure 5-2. The Process of Scanning Operation in SCPI mode

Overview

Before initiating a scan, a scan list must be set up. You can also specify an arm source, a trigger source, and the number of sweeps (a sweep is one pass through the scan list) to control the scan process. All these can be done from the **S.List** key. The **S.List** key structure (named as S.List menu) in SCPI mode is different from that in HP 3488A mode, as shown and summarized in Table 5-8 and Table 5-9 on Page 66, respectively.

Table 5-8. S.List Key Structure in SCPI Mode

1st Level Items	2nd Level Items	3rd Level Items	4th Level Items	Description
ADD TO SCAN	**SELECT** nnn			Create a scan list to include all the desired switch channels, DIO bit channels, and/or the previously stored setups.
CONFIG SCAN	**ARM: TIMER** **ARM: IMM** **ARM: BUS** **ARM: EXT** **ARM: MIX** **ARM: HOLD**	**COUNT:** 00001	**TRIG: TIMER** **TRIG: IMM** **TRIG: BUS** **TRIG: EXT** **TRIG: MIX** **TRIG: HOLD**	Configure the scan operation, such as an arm source, an arm count, and a trigger source.
DELAY TIME	**SET ALL**	nnnnn.nnn **SECS**		Set delay time for all channels or for individual channels.
	SET CH	**SELECT** nnn	nnnnn.nnn **SECS**	

Table 5-9. S.List Key Structure in HP 3488A Mode[1]

1st Level Items	2nd Level Items	Description
ADD TO SCAN	**SELECT** nnn	Create a scan list to include all the desired switch channels, DIO bit channels, and/or the previously stored setups.
DELAY TIME[2]	nnnnn.nnn **SECS**	Set a delay time for all scanned channels.

[1]. Unlike SCPI mode, HP 3488A mode does not support the arm source, arm count, and trigger source configuration.

[2]. In HP 3488A mode, only one delay time value can be set for all channels. However, you can set different delay time values for individual channels in SCPI mode.

Create Scan List

1. Press **S.List**, the **CONFIG** annunciator lights up and the first item at the first level of the S.List menu is displayed.

   ADD TO SCAN 101

2. Add the desired switch channels, digital I/O bit channels, and/or previously stored setups into the scan list.

   a. When “ADD TO SCAN” is displayed, press **Enter**.

   SELECT 101

b. Turn the knob to select the desired channel (i.e. 103).

SELECT	103

c. Press **Enter** to add the channel into the scan list.

SELECT	*	103

d. (Optional) Repeat Step b & c if other switch channels, digital I/O bit channels, and/or previously stored setups need to be added. (Note that 001 through 010 shown on the channel number area refer to the previously stored setups that can be included into the scan list.)

3. Press **S.List** again to return to the first level of the S.List menu.

ADD TO SCAN	107

4. Press **S.List** again to exit the S.List menu, the **CONFIG** annunciator turns off.

Note To view which channels are currently included in the scan list, refer to the procedure on Page 59 of this manual. To clear the scan list, simply press **Shift+S.List**.

Select Arm Source, Arm Count, and Trigger Source

1. Press **S.List**, the **CONFIG** annunciator lights up. Turn the knob until "CONFIG SCAN" is displayed, then press **Enter**.

CONFIG SCAN

2. Select an arm source (default is ARM:IMM). Turn the knob until the desired arm source (i.e. ARM:BUS) is displayed, then press **Enter** to proceed to step 3.

ARM: BUS

If "ARM:TIMER" is displayed, press **Enter**, then set the time interval (default is 0). Press <= or => to select the to-be-edited bit (in dim) and turn the knob to modify the value. When the time interval (ranging from 0 to 99999.999s) is set to the desired value, press **Enter**.

00002.000 SECS

3. Set the arm count (default is 1). Press <= or => key to select the to-be-edited bit and turn the knob to modify the value. When the arm count is set to the desired value, press **Enter**.

COUNT: 00003

4. Select a trigger source (default is TRIG:IMM). Turn the knob until the desired trigger source (i.e. TRIG:MIX) is displayed, then press **Enter** to return to the first level of the S.List menu.

TRIG: MIX

If “TRIG:TIMER” is selected, press **Enter,** then set the time interval (default is 0). Press <= or => key to select the to-be-edited bit (in dim) and turn the knob to modify the value. When the time interval (ranging from 0 to 99999.999s) is set to the desired value, press **Enter** to return to the first level of the S.List menu.

00000.200 SECS

5. Press **S.List** again to exit the S.List menu, the **CONFIG** annunciator turns off.

Set Delay Time

1. Press **S.List**, the **CONFIG** annunciator lights up. Turn the knob until “DELAY TIME” is displayed, press **Enter**.

DELAY TIME

2. To set a uniform delay time for all channels: When “SET ALL” is displayed, press **Enter**. Press <= or => key to select the to-be-edited bit (in dim) and turn the knob to modify the value (between 0 and 99999.999s). When the value is set to the desired one, press **Enter** to return to the first level of the S.List menu.

SET ALL

00000.002 SECS

DELAY TIME

To set different delay time interval for individual channels: Turn the knob until “SET CH” is displayed, then press E**nter**. Turn the knob to select the channel to be set (i.e. 103), then press **Enter** to set its delay time. Press <= or => key to select the to-be-edited bit (in dim) and turn the knob to modify the value. When the value is set to the desired one, press **Enter** to return to "SET CH" item. Repeat the above if other channels need to be set or press **S.List** again to return to the first level of the S.List menu.

SET CH	107

SELECT CH	103

00000.005 SECS	103

SELECT CH	103

DELAY TIME	103

3. Press **S.List** again to exit the S.List menu, the **CONFIG** annunciator turns off.

Note If only few channels have a different delay time, you can select "SET ALL" to set the delay time for all channels first, then select "SET CH" to change for the few channels one by one.

Perform Scan

After the scan configuration, the actual scan can be performed[1].

1. Press **Scan** to take the instrument out of the idle state, the **SCAN** annunciator lights up.
2. Once out of the idle state, the instrument will continue scanning according to the configuration. The arm source is used to control the onset of each scan sweep (a sweep is one pass through the scan list). The trigger source is used to advance one channel in the scan list (open the previous channel, then close the next channel in the list, and the ***** annunciator lights up).
3. When the scanning is finished, the instrument returns to the idle state and the **SCAN** annunciator turns off. You can also stop the scanning in progress at any time by pressing **Shift+Scan**.

[1]. The scan cannot be performed and "CANNOT INIT" will be displayed if any of the following conditions occurs:
a. The scan list contains a non-existing channel, such as N2260A module changes from WIRE1 to WIRE2.
b. The scan list contains a channel on a digital I/O module that does not work in Mode #1 or Mode #2.
c. A stored channel setup in the scan list does not match the current hardware configuration.

Note A scan can also be conducted in a much simpler manner. Once a scan list exists, simply press **Step** repeatedly to start and step through the scan list. However, in this case, the **SCAN** and the ***** annunciators do not light up and the configured arm source, trigger source, and arm count are ignored.

Note Card Pair is functional during a scan, which means that both the channels included in the scan list and the paired channels will be scanned.

Menu Key Operation

Configuring system-related instrument parameters can be done from the **Menu** key. However, the **Menu** key structure (named as Menu menu) in HP 3488A mode is different from that in SCPI mode. They are summarized and shown in Table 5-10 and Table 5-11 on Page 71, respectively. Since SCPI mode can do whatever HP 3488A mode can, only the **Menu** key operation in SCPI mode will be demonstrated.

Table 5-10. Menu Key Structure in HP 3488A Mode[1]

1st Level Items	2nd Level Items	3rd Level Items	4th Level Items	Description
CARD PAIR	**FIRST SLOT** 1	**SECOND SLOT** -		Select the paired cards.
CONF EXT TRIG	**TRIG OF SLOT** 0	**ENABLE** **DISABLE**		Select a pair of external trigger lines and enable/disable HP 3499 to output a trigger pulse.
INTERFACE	**GPIB/488**	**ADDRESS** 09	**SRQ ON** **SRQ OFF**	Set GPIB interface, then set its address (0-30) and enable/disable Power-on SRQ.
SELFTEST				Perform a selftest.
SYSTEM MODE	**SCPI MODE**			Select a system mode for the instrument.
	HP 3488A MODE			
REVISION INFO				Query the current firmware revision.
SERIAL NO				Query HP 3499A/B serial number.

[1].Configuring RS-232 interface and setting instrument power-on state cannot be done in HP 3488A mode.

Table 5-11. Menu Key Structure in SCPI Mode

1st Level Items	2nd Level Items	3rd level Items	4th level Items	Description
CARD PAIR	**FIRST SLOT** 1	**SECOND SLOT** -		Select the cards to be paired together.
CONF EXT TRIG	**TRIG SLOT** 0	**ENABLE** **DISABLE**		Select a pair of external trigger lines and enable/disable HP 3499 to output a trigger pulse.
POWER ON SET	**PWR ON RESET**			Set instrument power-on to the reset state or a state stored in memory location nn.
	USER SET UP	**POWER ON** nn		
INTERFACE	**GPIB/488**	**ADDRESS** 09	**SRQ ON** **SRQ OFF**	Select GPIB interface, then set its address (0-30) and enable/disable Power-on SRQ.
	RS-232	**2400 BAUD** **4800 BAUD** **9600 BAUD** **19200 BAUD** **38400 BAUD** **57600 BAUD**		Select RS-232 interface and configure its baud rate, data bits, parity, and flow control mode. The defaults are 9600 BAUD, NONE, 8 BITS, and FLOW NONE.
		ODD, 7 BITS **EVEN, 7 BITS** **NONE, 8 BITS**		
		FLOW NONE **FLOW XON/XOFF** **FLOW DTR/DSR** **FLOW RTS/CTS**		
SELFTEST				Perform a selftest.
SYSTEM MODE	**SCPI MODE**			Select a system mode for operation.
	HP 3488A MODE			
REVISION INFO				Query the current firmware revision.
SERIAL NO				Query HP 3499A/B serial number.

Press **Menu** to enter the Menu menu, the **CONFIG** annunciator lights up. The following operation can be done from the Menu menu in SCPI mode:

- Pair two modules together.
- Enable/disable trigger out pulse.
- Set instrument power-on state.
- Configure remote interface (GPIB or RS-232).
- Perform a self-test.
- Set instrument system mode (SCPI mode or HP 3488A mode).
- Query HP 3499A/B firmware revision.
- Query HP 3499A/B serial number.

Note HP 3488A mode does not support configuring RS-232 interface and setting the instrument power-on state.

Card Pair

The two modules to be paired must be identical. When two modules are paired together, any operation on a channel of one module will be duplicated on the corresponding channel of the other module.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "CARD PAIR" is displayed, press **Enter**.

CARD PAIR

2. When "FIRST SLOT 1" is displayed, turn the knob to select the first paired slot (i.e. Slot 1), then press **Enter**[1].

FIRST SLOT 1

3. When "SECOND SLOT **-**" is displayed, turn the knob to select the second slot (i.e. 5) to be paired with the first.

SECOND SLOT 5

4. Press **Enter** to return to the first level of the Menu menu.

CARD PAIR

5. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Configure External Trigger

In addition to the mainframe rear panel TRIG IN and TRIG OUT pair that can be used for externally-controlled scanning, the EI (External Increment) and the CC (Channel Closed) pair on the HP 44474 module can also be used as an alternative. However, only one pair can be used at a time. You can specify which pair to use and whether a trigger out pulse can be sent out when a relay is closed during scanning. Refer to "External Scanning" on Page 29 for more details.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "CONF EXT TRIG" is displayed, then press **Enter**.

CONF EXT TRIG

2. Select either Slot 0 (HP 3499A/B mainframes) or the slot in which an HP 44474A is installed, then press **Enter**.

TRIG SLOT 0

[1]. In case there are no matching cards installed in the mainframe, the display will show "NO MATCH", then automatically returns to the first level of the Menu menu.

3. When “ENABLE” is displayed, press **Enter** to enable a trigger pulse output from the selected line. Alternatively, turn the knob until “DISABLE” is displayed, press **Enter** to disable this function, the instrument returns to the first level of the Menu menu.

ENABLE

4. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Note In the SCPI mode, once a new pair of control lines is selected, the newly selected trigger-in line is immediately ready to accept the trigger signal from an external instrument. However, in the HP 3488A mode, only after the newly selected pair is enabled, will the previously enabled pair be disabled. Otherwise, the previously enabled pair is still in effect.

Configure Power-on State

The instrument can be set to power-on to the reset state (see Table 3-1 on Page 36 or Table 4-1 on page 63), or to a state stored at a specified memory location. The instrument will return to the specified state the next time it is turned on.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until “POWER ON SET” is displayed, then press **Enter**.

POWER ON SET

2. To set the instrument power-on to the reset state: When “PWR ON RESET” is displayed, press **Enter**, the instrument will return to the first level of the Menu menu.

PWR ON RESET

To set the instrument power-on to a stored state: Turn the knob until “USER SET UP” is displayed, then press **Enter**[1]. Select the desired memory location (i.e. 05) by turning the knob, then press **Enter** to return to the first level of the Menu menu.

USER SET UP

POWER ON 05

3. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

[1]. “NO DATA” will be displayed if no state had ever been stored, then the instrument automatically returns to the first level of the Menu menu.

Note If the instrument is set to power on to a previously stored setup that is no longer valid, it will automatically power on to the reset state and “RECALL FAILED” will be displayed.

Configure Remote Interface

The instrument can communicate with a computer over GPIB or RS-232 interface. Perform the following procedure to configure the interface.

Note Only one interface can be used at a time. When shipped from the factory, the GPIB interface is selected and its address is set to “9”.

Note RS-232 interface can be configured and used only in SCPI mode.

GPIB Interface

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until “INTERFACE” is displayed, then press **Enter**.

    INTERFACE

2. Turn the knob until “GPIB/488” is displayed, then press **Enter**.

    GPIB/488

3. Turn the knob to set GPIB address (between 0 and 30), then press **Enter**.

    ADDRESS 09

4. When “ON” is displayed, press **Enter**, the HP 3499A/B will interrupt the system computer when powered up. To disable this feature, select “OFF”. Then the instrument returns to the first level of the Menu menu.

    ON

5. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

RS-232 Interface

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until “INTERFACE” is displayed, then press **Enter**.

    INTERFACE

2. Turn the knob until “RS-232” is displayed, then press **Enter**.

RS-232

3. Turn the knob until the desired baud rate (default: 9600) is displayed, then press **Enter**.

9600 BAUD

4. Turn the knob until the desired parity and data bits (default: NONE, 8 BITS) is displayed, then press **Enter**.

NONE; 8 BITS

5. Turn the knob until the desired mode (default: FLOW NONE) is displayed, then press **Enter** to return to the first level of the Menu menu.

FLOW NONE

6. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Perform Self-test

The self-test feature of the instrument provides you with a method of verifying proper instrument operation. The self-test can be executed at any time.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until “SELFTEST” is displayed, then press **Enter**.

SELFTEST

2. If the self-test is successful, “PASSED” will be displayed. Otherwise, the reason of the failure will be displayed. For details on self-test failures, refer to Table 9-1 on Page 275.

PASSED

3. Press **Enter** to return to the first level of the Menu menu.

SELFTEST

4. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Select a System Mode

The instrument can be operated in either SCPI mode or HP 3488A mode. When shipped from the factory, the instrument is set to the SCPI mode. Perform the following procedure to select the desired system mode for the instrument before any operation.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "SYSTEM MODE" is displayed, then press **Enter**.

SYSTEM MODE

2. Turn the knob until the desired system mode (i.e. HP 3488A MODE) is displayed, then press **Enter**.

HP 3488A MODE

3. The instrument will change to the selected system mode and the display will be:

HP 3499	0

Note Switching between SCPI mode and HP 3488A mode will reset the instrument to the factory default settings, except the GPIB address which will retain its last setting.

Firmware Revision Query

Perform the following procedure to query HP 3499A/B firmware revision.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "REVISION INFO" is displayed, then press **Enter**.

REVISION INFO

2. The system firmware revision number will be displayed.

REVISION 1.0

3. Press **Enter** to return to the first level of the Menu menu.

REVISION INFO

4. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Serial Number Query

Perform the following procedure to query HP 3499A/B serial number.

1. Press **Menu**, the **CONFIG** annunciator lights up. Turn the knob until "SERIAL NO" is displayed.

SERIAL NO

2. Press **Enter,** HP 3499A/B serial number is displayed.

CN12345678

3. Press **Enter** again to return to the first level of the Menu menu.

SERIAL NO

4. Press **Menu** again to exit the Menu menu, the **CONFIG** annunciator turns off.

Reset a Module

To reset a plug-in module, perform the following procedure.

1. Turn the knob to select the slot to be reset (i.e. HP N2260A module in Slot 1).

N2260A	1

2. Hold down **Card Reset**, the display would be:

HOLD TO RESET	1

3. Hold the key for a while until the display changes, then release the key.

RESET CARD	1

4. The display returns to the previous display.

N2260A	1

Note For a switch relay module, **Card Reset** will open all channels on the selected module. For a digital I/O module, **Card Reset** will make all ports on the selected module as input ports.

Reset the Instrument

At any time while you are using the instrument, you can reset it by performing the following procedure.

1. Assume that the current display is shown as below:

MUX CLOSED 101

2. Press **Shift,** then hold down **Card Reset**, the display would be:

HOLD TO RESET

3. Hold the key for a while until the display turns to the below, then release the key.

RESET. . .

4. When the instrument finishes resetting, the default display appears.

MUX OPEN 101

Note The instrument will automatically perform a reset if any plug-in module is installed or removed while the instrument is on.

Note The instrument reset state in SCPI mode and HP 3488A mode is listed in Table 3-1 on Page 36 and Table 4-1 on Page 48, respectively.

Power on the Instrument

To turn on the instrument, press **Power** switch on the lower-left side of the front-panel. If the instrument is powered up for the first time, the instrument will power-on to the factory default settings as shown in Table 3-1 on Page 36. Otherwise, the instrument will power-on to the state as specified. Refer to “Configure Power-on State” on Page 73 for more details.

Chapter 6
SCPI Command Reference

Using This Chapter

This chapter describes Standard Commands for Programmable Instruments (SCPI)[1] and summarizes IEEE 488.2 Common (*) commands applicable to the HP 3499A/B Switch/Control Unit. The chapter contains the following sections.

Command Types

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

Common Command Format

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

```
*RST     *ESE 32     *STB?
```

SCPI Command Format

The SCPI commands perform functions like closing/opening switches, making measurements, 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 <scan_list>
        :SIZE?
```

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

Command Separator

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

[1]. Make sure that the HP 3499A/B is in SCPI mode prior to sending a SCPI command to the instrument. Otherwise an error will occur.

ROUTe:SCAN:SIZE?

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

Abbreviated Commands

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

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

Implied Commands

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

```
[ROUTe:]CLOSe  <channel_list>
    CLOSe?  <channel_list>
    SCAN  <scan_list>
        [:LIST]
        :SIZE?
```

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

ROUT:CLOS (@100:107, 201, 205)   ***or***   CLOS (@100:107, 201, 205)

These commands function the same: closing Channels 0 through 7 in Slot 1 and Channels 1 and 5 in Slot 2.

Parameters

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

Parameter Type	Explanations and Examples
Numeric	Accepts all commonly used decimal representations of number including optional signs, decimal points, and scientific notation. 123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MINimum, MAXimum, and DEFault.
Boolean	Represents a single binary condition that is either true or false. ON, OFF, 1, 0
Discrete	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is the TRIGger:SOURce <*source*> command where *source* can be BUS, EXT, HOLD, or IMM.

Optional Parameters. Parameters shown within square brackets ([ ]) are optional. (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 uses the default value. For example, consider the ARM:COUNt?[<MIN | MAX>] command. If you send the command without specifying a parameter, the present ARM:COUNt setting is returned. If you send the MIN parameter, the command returns the minimum count available. If you send the MAX parameter, the command returns the maximum count available. Be sure to place a space between the command and the parameter.

Linking Commands

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

*RST;CONF:EXT:OUTP ON *or* TRIG:SOUR HOLD;*TRG

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

ARM:COUN 1;:TRIG:SOUR EXT

Channel Addressing

Before the actual programming, the slot number and channel number need to be defined.

Slot Number

HP 3499A is a full-rack-width mainframe with six programmable slots, numbered as Slots 0 through 5. Slot 0 refers to the mainframe control board where the 4-bit built-in digital I/O resides in, whereas Slots 1 through 5 are available for the plug-in modules.

HP 3499B is a half-rack-width mainframe with only three programmable slots. Slot 0 refers to the mainframe control board where the 4-bit built-in digital I/O resides in, whereas Slots 1 through 2 are available for the plug-in modules.

The slot numbers are labelled on the rear panel of an HP 3499A/B.

Channel Number

Channels or bit numbers of the HP 3499A/B plug-in modules are defined according to their densities. Normally the channels or bit numbers start at 00.

The channels or bits of the available plug-in modules, including the MUX, GP relay, Matrix, Digital I/O and the multifunction modules, are numbered in different ways. Table 6-1 on Page 82 lists the channel/bit numbers for these modules.

Note Pay special attention to the 4-bit built-in digital I/O in Slot 0. The 4-bit port number is 090 (the first 0 refers to Slot 0), and the four independent bits are numbered as 091 through 094.

Channel Address

A *Channel_list* refers to a list of channels or bits, separated by commas (,) on the plug-in modules in a mainframe. Each channel is denoted as ***snn***, where ***s = Slot Number*** (0-5 for HP 3499A, 0-2 for HP 3499B; 0 is reserved for the mainframe control board or Slot 0, the others are for the plug-in modules), and ***nn = Channel***

Number (plug-in modules dependent). Table 5-1 lists the channel/bit address of existing modules.

Table 6-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules

HP P/N (Descriptions)	**Channel Addressing** (*snn*, *s* = Slot Number; *nn* = Channel Number)	**Slot Number**	
		HP 3499A	**HP 3499B**
HP 44470A 10-Channel MUX Module	*s00, s01, s02, s03... s08, s09*	1, 2, 3, 4, 5	1, 2
HP 44470D 20-Channel MUX Module	*s00, s01, s02, s03... s18, s19*	1, 2, 3, 4, 5	1, 2
HP 44471A 10-Channel GP Relay Module	*s00, s01, s02, s03... s08, s09*	1, 2, 3, 4, 5	1, 2
HP 44471D 20-Channel GP Relay Module	*s00, s01, s02, s03... s18, s19*	1, 2, 3, 4, 5	1, 2
HP 44472A Dual 4-Channel VHF Module	Group 0: *s00, s01, s02, s03*; Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP 44473A 4X4 Matrix Module	Row: 0, 1, 2, 3; Column: 0, 1, 2, 3 (*s00, s01, s02, s03; s10, s11, s12, s13;* *s20, s21, s22, s23; s30, s31, s32, s33)*[1]	1, 2, 3, 4, 5	1, 2
HP 44474A 16-Bit Digital I/O Module	Individual Bits: *s00, s01, s02... s14, s15* 8-Bit Ports: *s00, s01* 16-Bit Port: *s00*	1, 2, 3, 4, 5	1, 2
HP 44475A Breadboard Module	N/A	1, 2, 3, 4, 5	1, 2
HP 44476A 3-Channel 13 GHz Microwave Switch Module	*s00, s01, s02*	1, 2, 3, 4, 5	1, 2
HP 44476B 2-Channel 26 GHz Microwave Switch Module	*s00, s01*	1, 2, 3, 4, 5	1, 2
HP 44477A 7-Channel Form-C Relay Module	*s00, s01, s02, s03, s04, s05, s06*	1, 2, 3, 4, 5	1, 2
HP 44478A 50 Ω 1.3 GHz MUX Module	Group 0: *s00, s01, s02, s03* Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP 44478B 75 Ω 1.3 GHz MUX Module	Group 0: *s00, s01, s02, s03* Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP N2260A 40-Channel MUX Module[2]	1-Wire Mode: *s00, s01... s78, s79*[3] 2-Wire Mode: *s00, s01...s38, s39* Dual 2-Wire Mode: *s00, s01...s38, s39* 4-Wire Mode: *s00, s01...s18, s19*[4]	1, 2, 3, 4, 5	1, 2
HP N2261A 40-Channel GP Relay Module	*s00, s01, s02, s03... s37, s38, s39*	1, 2, 3, 4, 5	1, 2

Table 6-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules

HP P/N (Descriptions)	Channel Addressing (*snn*, *s* = Slot Number; *nn* = Channel Number)	Slot Number	
		HP 3499A	HP 3499B
HP N2262A 4X8 Matrix Module	Row 0, 1, 2, 3; Column 0, 1, 2, 3... 6, 7 *(s00, s01, s02... s07; s10, s11, s12... s17;* *s20, s21, s22... s27; s30, s31, s32... s37)*	1, 2, 3, 4, 5	1, 2
HP N2263A 32-Bit Digital I/O Module	Individual Bits: *s00, s01, s02... s30, s31;* 8-Bit Ports: *s00, s01, s02, s03;* 16-Bit Ports: *s00, s02;* 32-Bit Port: *s00.*	1, 2, 3, 4, 5	1, 2
HP N2264A 12-Channel GP Relay + 3-Channel High-current GP Relay + 16-Bit Digital I/O Module	12 GP Relays: *s00, s01, s02... s10, s11;* 3 High-current GP Relays: *s20, s21, s22;* **16-Bit Digital I/O:** Individual Bits: *s30, s31, s32... s44, s45;* 8-Bit Ports: *s30, s31;* 16-Bit Port: *s30.*	1, 2, 3, 4, 5	1, 2
HP N2265A 4X4 Matrix + 16-Bit Digital I/O Module	4X4 Matrix: Row 0, 1, 2, 3; Column 0, 1, 2, 3 *(s00, s01, s02, s03; s10, s11, s12, s13;* *s20, s21, s22, s23; s30, s31, s32, s33)* **16-Bit Digital I/O:** Individual Bits: *s40, s41, s42... s54, s55;* 8-Bit Ports: *s40, s41;* 16-Bit Port: *s40.*	1, 2, 3, 4, 5	1, 2
4-Bit Built-in Digital I/O	Individual Bits: *091, 092, 093, 094;* 4-Bit Port: *090.*	0	0

[1]. A channel number on a matrix module is formed in Slot-Row-Column format, i.e., channel address s23 means row 2, column 3 in Slot s.

[2]. HP N2260A can be used as an 80-channel 1-wire MUX module, a 40-channel 2-wire MUX module, two 20-channel 2-wire MUX modules, or a 20-channel 4-wire MUX module in SCPI mode.

[3]. The Low (L) terminals of the 40 2-wire channels form the first 40 1-wire channels (Channels 00-39), and the High (H) terminals of the 40 2-wire channels form the second 40 1-wire channels (Channels 40-79).

[4]. The first channels (CH00 & CH20) of either banks (BANK 0 and BANK 1) form Channel 00, the second channels (CH01 & CH21) of either banks form Channel 01, and so on.

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI) commands for the HP 3499A/B Switch/Control Systems. Commands are listed alphabetically by subsystem and within each subsystem.

ABORt

The **ABORt** command stops a scan in progress regardless of the trigger sources.

Subsystem Syntax

ABORt

Comments

- **Scan Configurations:** Aborting a scan only stops a scan, but DOES NOT change the scan configuration. This command has no effect to the scan list, the scan trigger source, the scan interval and the channel trigger source, etc.

Note The interface clear command (CLEAR 7) can also stop a scan.

- ***RST Conditions:** A scan will also stop whenever the instrument is powered up or reset (*RST command). The difference is that all the scan configurations will be reset to its default state in this case. Refer to Table 3-1 on Page 36 for more information.

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

Example Stopping a Scan with ABORt

```
*RST                  ! Reset the instrument.
TRIG:SOUR  BUS        ! Bus is trigger source.
SCAN  (@100:115)      ! Set a sequence of channels to be
                        scanned.
INIT                  ! Start a scanning cycle.
.
.
ABOR                  ! Abort (Stop) a scan in progress.
```

The **ARM** subsystem sets the event control source, allows a scan list to be scanned multiple times (1 through 99,999) with one INITiate command, and sets timer for sweep-to-sweep interval.

Subsystem Syntax

ARM:SOURce BUS|EXTernal|IMMediate|TIMer|MIX|HOLD
ARM:SOURce?
ARM:COUNt *<number>*|MIN|MAX|INFinity
ARM:COUNt? [<MIN|MAX|INFinity>]
ARM:TIMer *<seconds>*|MIN|MAX
ARM:TIMer?

ARM:SOURce

ARM:SOURce BUS|EXTernal|IMMediate|TIMer|MIX|HOLD specifies the event control source for the arm layer.

Parameters

Name	Type	Range of Values	Default Value
<*source*>	Discrete	BUS|EXT|IMM|TIM|MIX|HOLD	IMM

Comments

- With BUS selected, a sweep of scan[1] will start after a *TRG or GET is received. With EXTernal selected, a sweep of scan will start after an external trigger is received.
- With IMMediate selected, a sweep of scan will start immediately after INITiate, or end of a sweep.
- With TIMer selected, a sweep of scan will start after the timer is time-out. With MIX selected, the scan will continue after a BUS event or an EXTernal event occurred. With HOLD selected, a sweep of scan will start after a TRIGger[:IMMediate] is received.
- ***RST Condition:** Whenever the instrument is powered on or reset, the default event control source for the instrument will be IMMediate. Executing a *CLS command has no effect to it.

Example

*RST	*! Reset the instrument.*
ARM:SOUR IMM	*! Specify the ARM source.*
SCAN (@100:115, 210:219)	*! Set a range of channels to be scanned.*
INIT	*! Start a sweep of scan.*

[1]. A sweep of scan refers to one cycle to scan through all the channels/bits listed in the *scan_list*. A scan may include multiple sweeps of scan specified with the command ARM:COUNt.

ARM:SOURce?

ARM:SOURce? queries the event control source for the arm layer. One of BUS|EXTernal|IMMediate|TIMer|MIX|HOLD returns to indicate the event control source.

Example

*RST	*! Reset the instrument.*
ARM:SOUR EXT	*! Set the External trigger as the trigger source.*
SCAN (@200:319)	*! Set a range of channels to be scanned.*
INIT	*! Start a sweep of scan.*
...	
ARM:SOUR?	*! Query the ARM source.*

ARM:COUNt

ARM:COUNt *<number>*|MIN|MAX|INFinity allows scanning cycles to occur a multiple of times (1 to 99,999) with an INITiate command. MIN specifies a single sweep, MAX specifies 99,999 sweeps, and INF, an infinite number of sweeps.

Parameters

Name	Type	Range of Values	Default Value
<*number*>	numeric	<1 - 99,999>|MIN|MAX|INF	1

Comments

- **Number of Scans:** Use only numbers between 1 (MIN) and 99,999 (MAX) for scanning cycles.
- With **INFinity**, the scanning will be continuing until a command **ABORt** is executed, or the instrument is powered on/reset.
- **Related Commands:** ABORt, INITiate[:IMMediate].
- ***RST or Power on Condition:** ARM:COUNt 1.

Example

Setting 10 Scanning Cycles

ARM:COUN 10	*! Set 10 scanning cycles.*

ARM:COUNt?

ARM:COUNt? [<MIN|MAX|INFinity>] returns the current number of scanning cycles set by ARM:COUNt. If a value between MIN and MAX is set, that number will be returned. The optional parameters MIN and MAX allow you to query the module for these values instead of looking them up in the command reference. "1" is returned for MIN; "99999" is returned for MAX; and "-1" is returned for INFinity.

Parameters

Name	Type	Range of Values	Default Value
<MIN|MAX|INFinity>	numeric	MIN = 1, MAX = 99,999 and INF = -1	current cycles

Comments

- The returned number of scanning cycles is “1” whenever the instrument is powered on or reset.
- **Related Commands:** INITiate[:IMMediate]

Example

Query the Number of Scanning Cycles

ARM:COUN 10	*! Set 10 scanning cycles.*
ARM:COUN?	*! Query the number of scanning cycles. The returned value is 10.*

ARM:TIMer

ARM:TIMer *<seconds>*|MINimum|MAXimum sets the sweep-to-sweep interval in arm layer. This timer is valid only if the TIMer is selected in ARM:SOURce command.

Parameters

Name	Type	Range of Values	Default Value
<seconds>	numeric	0 - 99999.999 (seconds) MIN = 0, MAX = 99999.999	0

Comments

- **Difference between TRIGger:TIMer and ARM:TIMer:** The command TRIGger:TIMer is used to set the channel-to-channel interval in trigger layer. Instead, the command ARM:TIMer is used to set the sweep-to-sweep interval in arm layer.
- **Valid Timer:** This timer would not be valid unless the TIMer has been specified as the arm source in the command ARM:SOURce TIMer.
- **Valid Value:** The valid value of *<seconds>* can be a number between 0.000 and 99999.999 (seconds), in increment of 0.001.
- ***RST Condition:** The default value is 0 whenever the instrument is powered on or reset.

Example

ARM:SOUR TIM	*! Set the TIMer as the event control source for the ARM layer.*
ARM:TIM 10	*! Set 10 seconds as the sweep-to-sweep interval.*
SCAN (@200:415)	*! Set a range of channels to be scanned.*
INIT	*! Start the sequence of scanning according to the specific setup.*

ARM:TIMer?

ARM:TIMer [MINimum|MAXimum]? queries the sweep-to-sweep interval in arm layer. Only after the TIMer is selected in ARM:SOURce command can the returned value be valid. The returned value is a value between 0 and 99999.999 (seconds) indicates the sweep-to-sweep interval set by the command ARM:TIMer.

Example

ARM:SOUR TIM	*! Set the timer as the event control source.*
ARM:TIM 10	*! Set the sweep-to-sweep interval to 10 seconds.*
...	
ARM:TIM?	*! Query the sweep-to-sweep interval. The returned value will be "10" indicates the interval is 10 seconds.*

The **CONFigure** subsystem selects one of the two external trigger sources to be used in the system: the EI/CC lines on an HP 44474A DIO module, or the Trigger In/Out lines of the mainframe. It also determines if a pulse should be outputted after a channel is closed during a scanning.

Subsystem Syntax

```
CONFigure
    :EXTernal[:TRIGger]
        :SOURce <number>
        :SOURce?
        [:OUTput] <0|1|OFF|ON>
        [:OUTput]?
```

CONFigure:EXTernal[:TRIGger]:SOURce

CONFigure:EXTernal[:TRIGger]:SOURce *<number>* selects one of the two external trigger sources to be used in the system.

Parameters

Name	Type	Range of Values	Default Value
<number>	numeric	int. 0 - 5	0

Comments

- **The Range of <*Number*>** is 0-5. “0” selects the external trigger lines (Trigger In/Out) on the HP 3499A/B mainframe. Any other value (1-5) specifies the external trigger lines (EI and CC) on an HP 44474A in the specified slot, the HP 44474A should not be in Mode #5.
- If there is no HP 44474A installed in the mainframe, <*number*> is automatically set to “0”.
- **Trigger In/Out:** both pulses are TTL-compatible.
- ***RST Condition:** <*number*> is “0” whenever the instrument is powered on or reset. *CLS has no effect to the value.

Example

CONF:EXT:SOUR 2	*! Select EI/CC of HP 44474A in Slot 2 as the external trigger source.*

CONFigure:EXTernal[:TRIGger]:SOURce?

CONFigure:EXTernal[:TRIGger]:SOURce? queries the external trigger source. Returned value will be between 0-5. “0” means the trigger source is the external trigger lines (Trigger In/Out) on the HP 3499A/B mainframe. 1-5 means the trigger sources are EI/CC on the HP 44474A in the specified slot, i.e. returned value “4” means the trigger source is EI/CC on the HP 44474A in Slot 4.

Example CONF:EXT:SOUR 2 *! Set EI/CC on the HP 44474A in slot 2 as the external trigger source.*

CONF:EXT:SOUR? *! Query the external trigger source used in the system. Returned value is "2".*

*RST *! Reset the instrument.*
CONF:EXT:SOUR? *! Query the external trigger source again. Returned value "0" indicates the external trigger source is Trigger In/Out on the mainframe.*

CONFigure:EXTernal[:TRIGger][:OUTPut]

CONFigure:EXTernal[:TRIGger][:OUTPut] ***<0|1|OFF|ON>*** determines if a pulse should be outputted after a channel is closed during a scanning.

Parameters

Name	Type	Range of Values	Default Value
<value>	boolean	0|1|OFF|ON	0|OFF

Comments

- Setting the value to 0/OFF disables the pulse output. Setting the value to 1/ON enables the pulse output. In this case, the HP 3499A/B will output a pulse after closing a channel. This pulse can be used to trigger other instruments.
- ***RST Condition:** An instrument power-on or reset will disable the pulse output. Executing the command *CLS has no effect on this setting.

Example CONF:EXT:OUTP 1 *! Enable the pulse output.*

CONFigure:EXTernal[:TRIGger][:OUTPut]?

CONFigure:EXTernal[:TRIGger][:OUTPut]? queries if a pulse will be outputted after a channel is closed during a scanning. Returned value will be either "0" or "1". "0" indicates that the pulse output is disabled, "1" indicates the pulse output is enabled.

Example CONF:EXT:OUTP 1 *! Enable the pulse output.*
CONG:EXT? *! Query the pulse output state. Returned value "1" indicates that the pulse output is enabled.*

The **DIAGnostic** subsystem controls the HP 3499A/B's display. It can be used to enable/disable the display, display a message, monitor a specified slot or a channel/bit, or query/reset the specified channel relay cycles. It can be also used to read from or write to a register specified for the existing HP 3488A modules.

Subsystem Syntax

```
DIAGnostic
    :DISPlay[:INFOrmation] <string>
    :DISPlay:STATe 0|1|OFF|ON
    :DISPlay:STATe?
    :MONitor <slot>|<channel_number>|-1
    :MONitor?
    [:RELay]:CYCLes <channel_list>
    [:RELay]:CYCLes:MAX? <slot>
    [:RELay]:CYCLes:CLEAR <channel_list>
    SPEEK? <slot>,<register>
    SPOKE <slot>,<register>,<data>
```

DIAGnostic:DISPlay[:INFOrmation]

DIAGnostic:DISPlay[:INFOrmation] *<string>* is used to write messages to be displayed in the display window on the HP 3499A/B.

Comments

- The <string> can contain up to 13 characters, as listed in the following table.

Type	Letters (Supported by HP 3499A/B)
Numeric	0-9
Alphabetic	A-Z
Symbolic	" ' (space) ( ) * + - , . : ; / \

- Lower case character inputs are acceptable, but the characters displayed are always in upper case.

- In addition, each character (except the 13th) can be trailed by any one of four special characters (, . : ;). A "trailer" special character will not be counted as one of the thirteen characters.

Example

Writing a module's identity to be displayed. Paired quotation marks (" ") or (' ') must be used to define the string.

DIAG:DISP "IT'S A DIO" *! The display will be "IT'S A DIO".*

DIAGnostic:DISPlay:STATe

DIAGnostic:DISPlay:STATe *<value>* is used to turn off/on the display of the instrument.

Parameters

Name	Type	Range of Values	Default Value
<value>	boolean	0|1|OFF|ON	1

Comments

- Set the value to "0|OFF" to turn off the instrument's display. Set the value to "1|ON" to turn on the display of the instrument.
- The ADRS & RMT annunciators may turn on when the front panel display is turned off. The ERROR annunciator turns on whenever an error occurs.
- After an instrument power-on or reset, the display will be turned on (default value is "1|ON"). Executing the command *CLS has no effect on the display status.

Example

DIAG:DISP:STAT 1|ON	*! Turn on the display of the instrument.*

DIAGnostic:DISPlay:STATe?

DIAGnostic:DISPlay:STATe? queries the display status of the instrument. Returned value is either a "0" or a "1", indicating the display is turned off or on, respectively.

Example

DIAG:DISP:STAT 0	*! Turn off the instrument's display.*
DIAG:DISP:STAT?	*! Query the display status. Returned value "0" indicates that the display is turned off.*
*RST	*! Reset the instrument.*
DIAG:DISP:STAT?	*! Query the display status again. Returned value "1" indicates that the display is turned on.*

DIAGnostic:MONitor

DIAGnostic:MONitor *<slot>\|<channel_number>\|<port>* is used to monitor a plug-in module, or a channel/port on the specified module.

DIAGnostic:MONitor *-1* is used to disable the monitor.

Comments

- **Slot Number:** the valid slot number is 0-5 for HP 3499A, 0-2 for HP 3499B.
- For 4-bit built-in DIO, the ports may be monitored include 090, 091-094. For the plug-in DIO modules, the ports only include the 8-bit ports.
- Specifying a "-1" will disable the monitor.

- **Channel Number:** only one slot or one channel/port can be monitored each time. Refer to "Table 6-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules" on Page 82 for more information.

- **HP N2260A:** The Tree Relays (s98, s99) on an HP N2260A cannot be monitored.

- ***RST Condition:** The monitor is disabled after an instrument power-on or reset.

Example

DIAG:MON 2	*! Monitor the module in Slot 2.*
DIAG:MON 308	*! Monitor channel 8 on the specified module (Slot 3).*

DIAGnostic:MONitor?

DIAGnostic:MONitor? queries the slot or channel/port being monitored. The returned value will be a valid slot number, or a channel address, or -1.

Comments

- The returned valid slot number is 0-5 for HP 3499A, 0-2 for HP 3499B. “0” means that the 4-bit built-in DIO is being monitored.

- Refer to "Table 6-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules" on Page 82 for the detailed channel information.

- Returned value “-1” indicates that the monitor is disabled.

Example

DIAG:MON 5	*! Monitor the module in Slot 5.*
DIAG:MON?	*! Returned value “5” indicates that the module in Slot 5 is being monitored.*
DIAG:MON 302	*! Monitor the channel 2 on the module plugged-into Slot 3.*
DIAG:MON?	*! Returned value “302” indicates that the specified channel is being monitored.*

DIAGnostic[:RELay]:CYCLes?

DIAGnostic[:RELay]:CYCLes? *<channel_list>* queries the open/close cycles each of the listed channel or tree relays has been operated. *Channel_list*, which can include the switching channels and tree relays, is in the form of (@snn), where s = slot number (1-5 for HP 3499A & 1-2 for HP 3499B) and nn = channel number. The returned values are the cycle counts of the relays queried.

Comments

- Only the relay cycles of the switching channels on the HP N2260A, N2261A, N2262A, N2264A and N2265A can be queried. “-1” will be returned if other channels are queried.

- **Tree Relays:** For HP N2260A, the tree relays (numbered as s98 and s99) can be includes in a *<channel_list>*.

- **Querying Channels:** To query:

  -- a single channel, use DIAG:CYCL? (@snn);
  -- multiple channels, use DIAG:CYCL? (@snn,snn);
  -- sequential channels, use DIAG:CYCL? (@snn:snn);
  -- a group of sequential channels, use DIAG:CYCL? (@snn:snn,snn:snn);
  -- or any combination.

- **Returned Value:** The returned values are a series of integers, separated by commas, in the order that the switching relays or tree relays were queried.

- **Maximum Channels Queried:** A maximum of 200 channels can be queried by a single DIAG:CYCL? command. Refer to Table 6-1 on Page 82 for the channel information.

Example

DIAG:CYCL? (@100,106,203)	*! Query the cycle counts of Channels 0, 6 in Slot 1 and Channel 3 in Slot 3.*
DIAG:CYCL? (@210:219,300:310)	*! Query the cycle counts of Channels 10-19 in Slot 2 and Channels 00-10 in Slot 3.*

DIAGnostic[:RELay]:CYCLes:MAX?

DIAGnostic[:RELay]:CYCLes:MAX? *<slot>* queries the maximum relay cycle count. The returned value is the maximum relay cycle count among all the relays on the specified module.

Comments

- This command is only applicable to these switching modules: HP N2260A, N2261A, N2262A, N2264A and N2265A. The valid slot number is 1-5 for HP 3499A and 1-2 for HP 3499B.

- **Only One Slot** can be queried with one command DIAG:CYCL:MAX? *<slot>*.

- **The Returned Value** is an integer to indicate the maximum relay cycle count, but not the respective relay channel.

Example

DIAG:REL:CYCL:MAX? 1	*! Query the maximum relay cycles of the module in Slot 1.*

DIAGnostic[:RELay]:CYCLes:CLEar

DIAGnostic[:RELay]:CYCLes:CLEar *<channel_list>* resets the relay cycle counter of the specified channel relay. *Channel_list* has the form of (@snn), where s = slot number (1-5 for HP 3499A, 1-2 for HP 3499B) and nn = channel number.

Comments

- This command will reset the relay cycle count back to zero. This should be done when replacing a relay with a new one.

- **Clearing Channels:** To clear:

  -- a single channel, use DIAG:CYCL:CLE (@snn);
  -- multiple channels, use DIAG:CYCL:CLE (@snn,snn);
  -- sequential channels, use DIAG:CYCL:CLE (@snn:snn);
  -- a group of sequential channels, use DIAG:CYCL:CLE (@snn:snn,snn:snn);
  -- or any combination.

- ***Channel_list:*** The number of channels listed in *channel_list* is limited to 200. Refer to Table 6-1 on Page 82 for the channel information.

Example

DIAG:CYCL:CLE (@100,105,109)	*! Clear the relay cycles of channels 0, 5 and 9 in Slot 1.*
DIAG:CYCL? (@105,109)	*! Returned values of "0,0" indicates that the relay cycles of the specified channel relays have been cleared.*

DIAGnostic:SPEEK?

DIAGnostic:SPEEK? *<slot>,<register>* is used to read a 8-bit data from the *<register>* specified. This command is only applicable for the existing HP 3488A modules.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 for HP 3499A 1-2 for HP 3499B	N/A
<register>	numeric	0-7	N/A

Comments

- This command is only for the existing HP 3488A modules[1], otherwise an error will occur.

- The data read back is in the form of a decimal number which is the sum of the binary weighted values of the bits that are high (< 5 volts).

Example

DIAG:SPEEK? 2,2	*! Read the specified register.*

[1]. The existing HP 3488A modules include HP 44470A/D, 44471A/D, 44472A, 44473A, 44474A, 44475A, 44476A/B, 44477A, 44478A/B.

DIAGnostic:SPOKE

DIAGnostic:SPOKE *<slot>,<register>,<data>* is used to write a 8-bit data to the *<register>* specified. This command is only applicable for the existing HP 3488A modules.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 for HP 3499A 1-2 for HP 3499B	N/A
<register>	numeric	0-7 (int.)	N/A
<data>	numeric	0-255 (int.)	N/A

Comments

- This command is only for the existing HP 3488A modules, otherwise an error will occur.
- The data write to is in the form of a decimal number which is the sum of the binary weighted values of the bits that are high (< 5 volts).

Example

DIAG:SPOKE 2,2,135	*! Write a 8-bit data (11100001$_h$)* to the specific register 2.
DIAG:SPEEK? 2,2	*! Read back the data from the register. The data read back is 135 (decimal).*

The **INITiate** command subsystem changes the scan state from idle to waiting-for-trigger.

Subsystem Syntax

INITiate

INITiate is used to change the scan state from idle to waiting for trigger state. If the ARM:SOURce is set to IMMediate, and the TRIGger:SOURce is also set to IMMediate, sending this command closes the first channel listed in the *scan_list*. Otherwise, the HP 3499A/B will wait for the arm source and the trigger source.

Example

SCAN (@100:109,210,311:319)	*! Set a scan list.*
ARM:SOUR IMM	*! Set the trigger source for the ARM layer.*
TRIG:SOUR IMM	*! Set the trigger source for the TRIGGER layer.*
INIT	*! Start a sweep of scan.*

The [ROUTe:] command subsystem controls switching and scanning operations of the HP 3499A/B plug-in modules. It can also be used to set the function mode for HP N2260A, to pair modules of the same type, and to set the delay time for the channels to be scanned.

Subsystem Syntax

[ROUTe:]
  [CHANnel:]DELay *<value>[,<channel_list>]*
  [CHANnel:]DELay? *<channel_list>*
  CLOSe *<channel_list>*
  CLOSe? *<channel_list>*
  CLOSe:STATe?
  CPAir *<slot>,<slot>*
  CPAir?
  FUNCtion *<slot>*,*<mode>*
  FUNCtion? *<slot>*
  OPEN *<channel_list>|ALL*
  OPEN? *<channel_list>*
  SCAN[:LIST] *<scan_list>*
  SCAN[:LIST]?
  SCAN CLEar
  SCAN:SIZE?

[ROUTe:][CHANnel:]DELay

[ROUTe:][CHANnel:]DELay *<value>, <channel_list>|ALL* inserts a delay between the moment a channel/bit is closed, or a recall operation and the moment the next operation begins, during a scan. If the external trigger output line is enabled by CONFigure:EXTernal ON, a pulse will not be outputted immediately after a channel is closed, until the delay time is time-out. The delay time can be specified from 0 through 99999.999 seconds. Figure 6-1 shows the relation between the delay time and the command TRIGger:TIMer.

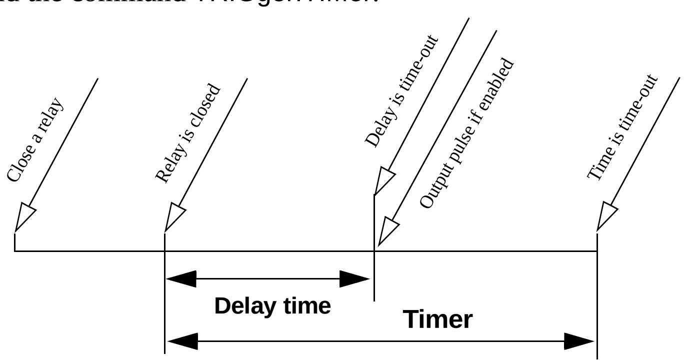


Figure 6-1. Relation between Delay and Timer

Parameters

Name	Type	Range of Values	Default Value
<value>	numeric	0 to 99999.999 (seconds)	0
<channel_list>	numeric	Refer to Table 6-1 on Page 82	N/A
ALL	N/A	All the channels/bits on the plug-in modules.	N/A

Comments

- **Delay Time:** The delay time is a value between 0 and 99999.999 (seconds), in 0.001 increments.
- This command can be used to set a delay time for the channels/bits specified in the *channel_list*, or set a delay time for all the channels present.
- ***Channel_list:*** The switching channels, DIO bits and the previously stored channel setups can be included in a *channel_list.* A stored channel setup is only referred to as a "channel", regardless of the channels/bits number included in this channel setup.
- The maximum number of channels listed in a *channel_list* is 200.
- ***RST Condition:** The default delay time is 0 after an instrument power-on or reset. The command *CLS has no effect on the delay time settings.

Example

DEL 10, (@100,102)

or

CHAN:DEL 10, (@100,102) *! Set 10 seconds of delay time for Channels 100 & 102.*

[ROUTe:][CHANnel:]DELay?

[ROUTe:][CHANnel:]DELay? *<channel_list>* queries the delay time for the channels/bits, or the stored channel setups specified in the *channel_list. Channel_list* is in the form of (@snn,mm), where s = slot number (1-5 for HP 3499A, 1-2 for HP 3499B), nn = channel number; mm is the stored channel setup.

Parameters

Name	Type	Range of Values
<channel_list>	numeric	Refer to Table 6-1 on Page 82

Comments

- ***Channel_list:*** The switching channels, DIO bits and the previously stored channel setups can be included in a *channel_list.* A stored channel setup is only referred to as a "channel", regardless of the channels/bits number included in this channel setup.
- The returned value is between 0 and 99999.999 (seconds), in 0.001 increments.
- **Querying Delay Time:** To query the delay time of

  -- a single channel, use DEL? (@snn);
  -- multiple channels, use DEL? (@snn,snn,mm...);
  -- sequential channels, use DEL? (@snn:snn,mm);
  -- groups of sequential channels, use DEL? (@snn:snn,mm,snn:snn);
  -- or any combination of the above.

- If a list of channels is queried, a comma delineated list of values is returned in the same order of the channel list.

- ***RST Condition:** The delay time set for all the channels is 0 after an instrument power-on or reset. The command *CLS has no effect on the delay time settings.

Example

*RST	*! Reset the instrument.*
DEL 10, (@219)	*! Set 10 seconds of delay time for the specified channel.*
DEL? (@100,219)	*! Query the delay time for the specified channels. The returned value is "0,10".*

[ROUTe:]CLOSe

[ROUTe:]CLOSe *<channel_list>* closes the switching channels specified in the *channel_list*. *Channel_list* is in the form of (@snn), where s = slot number (1-5 for HP 3499A, 1-2 for HP 3499B) and nn = channel number.

Parameters

Name	Type	Range of Values	Slot number
<channel_list>	numeric	Refer to Table 6-1 on Page 82.	1-5

Comments

- ***Channel_list:*** Only the switching channels on the plug-in modules can be included in a *channel_list*.

- **Tree Relays:** The two tree relays (s98 & s99) can not be switched with the commands OPEN or CLOSe.

- **Digital I/O Modules:** The bits on digital I/O modules can not be opened or closed with the commands [ROUTe:]OPEN and [ROUTe:]CLOSe.

Note To open or close a bit, use the command SOURce:DIGital:DATA:BIT.

- **HP N2260A:** This module can operate in any one of four function modes. The following table lists the channel number designation under different function modes.

Function Mode	Channel Number	Slot Number
One 80-channel 1-wire MUX	s00-s79	1-5 (3499A), 1-2 (3499B)
One 40-channel 2-wire MUX	s00-s39	
Two 20-channel 2-wire MUXs	s00-s39	
One 20-channel 4-wire MUX	s00-s19	

Note The function mode should be specified before closing/opening/scanning the channels on an HP N2260A, or the HP N2260A must be used as a 40-channel 2-wire MUX module (default function mode).

Note In 1-wire mode, only one channel can be closed at a time for an HP N2260A.

- **Closing Channels:** To close:

  -- a single channel, use CLOS (@snn);
  -- multiple channels, use CLOS (@snn,snn...);
  -- sequential channels, use CLOS (@snn:snn);
  -- groups of sequential channels, use CLOS (@snn:snn,snn:snn);
  -- or any combination of the above.

Note Channels in a *channel_list* may not close simultaneously. The order in which the channels close when operated by a single command is not guaranteed. Use sequential CLOSe commands if needed.

- **Parallel Switching[1]:** The switching modules specially designed for HP 3499A/B have the parallel switching feature, which makes the modules well suited for high speed switching applications.

Note Some switching modules CAN NOT perform the parallel switching. Refer to “Plug-in Modules” on Page 173 for more details.

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

- ***RST Condition:** All the channels on the plug-in modules are open.

Example Closing HP N2260A’s channels to perform 4-wire ohms measurements.

FUNC 2, WIRE4	*! Configure the module to 4-wire mode.*
CLOS (@200:219)	*! Close channel 00 through 19 on the MUX module.*

Make 4-wire ohms measurements.

OPEN ALL	*! Open all channels (00 through 19) after measurements.*

[ROUTe:]CLOSe?

[ROUTe:]CLOSe? *<channel_list>* returns the current state of the channel(s) queried. *Channel_list* is in the form of (@snn). The command returns a “1” if the channel is closed, or a “0” if the channel is open. If a list of channels is queried, a comma delineated list of 0’s and 1’s is returned in the same order of the channel list.

Comments

- **Query is Software Read back:** The ROUTe:CLOSe? command returns the current state of the specified channels. It does not account for a failed relay.

[1]. This feature is only applicable to HP N2260A/61A/62A/64A/65A. Refer to “Plug-in Modules” on Page 173 for more information about the parallel switching.

- If a list of channels is queried, a comma delineated list of values is returned in the same order of the channel list.

- ***Channel_list:*** See [ROUTe:]CLOSe for *channel_list* definition. The maximum number of channels returned is 200.

Example

CLOS (@100:103)	*! Close channels 0-3 in Slot 1.*
CLOS? (@100,103)	*! Returned value "1,1" indicates that the channels 0 & 3 are closed.*

[ROUTe:]CLOSe:STATe?

[ROUTe:]CLOSe:STATe? queries the closed state of the channel relays on the plug-in modules. The returned values will be a comma delineated list of the closed channel relays with the form of "snn,snn...". Where s = slot number (1-5 for HP 3499A, 1-2 for HP 3499B) and nn = channel number.

Comments

- **Query is Software Read back:** The ROUTe:STATe? command returns the closed state of the specified channels. It does not account for failed relays.

- Refer to Table 6-1 on Page 82 for more information about channel number.

Example

*RST	*! Reset the instrument. All the switching channels are set to the open state.*
CLOS (@100,109)	*! Close channels 0 & 9 on the specified module (in Slot 1).*
CLOS:STAT?	*! Returned value "100,109" indicates that the Channels 0 & 9 on the specified module are closed.*

[ROUTe:]CPAir

[ROUTe:]CPAir *<slot>,<slot>|-1* pairs two same (type) modules. The valid slot number is 1-5 for HP 3499A or 1-2 for HP 3499B. Slot 0 (the 4-bit built-in DIO) can not be paired with any slot. Specifying a "-1" (replacement for the second <*slot*>) will cancel the pair of the first <*slot*> involved.

Parameters

Name	Type	Range of Values
<slot>	numeric	1-5 (HP 3499A); 1-2 (HP 3499B)

Comments

- **Paired Modules:** Only two same (type) plug-in modules can be paired with a CPAir command. The modules include the switching modules (MUX, GP & Matrix), the digital I/O modules, and the multifunction modules.

- **HP N2260A:** This is a configurable MUX module. Only when both of the two HP N2260A are configured in the same function mode, can the two MUX modules described as of the same (type). Once paired, changing the function mode of one HP N2260A, the other HP N2260A in the pair will be set to the same function mode automatically.

- **Paired Switching Modules:** After two same (type) switching modules are paired, opening/closing/scanning one or more channels on either one of the paired modules will result in the same operation on the respective channels on the other module being performed at the same time.

- **Paired DIO Modules:** Two same (type) DIO modules used in Mode #1 or #2 can be paired[1]. Once paired, the source (DIO) operation[2] on either one of the paired modules will result in the same source operation on the other module being performed automatically at the same time.

- **Cancel a Pair:** Specifying a "-1" for the second <*slot*> will cancel the pair that the first <*slot*> involved.

- ***RST Condition:** There will be no paired cards after an instrument power-on or reset. The command *CLS has no effect on the paired modules status.

Example Assume that the modules in Slot 1 and Slot 3 are both HP 44470D 20-channel MUX modules. This example pairs the two HP 44470D modules, and then cancel this pair.

CPA 1,3	*! Paired modules in Slot 1 & Slot 3.*
CLOS (@100:119)	*! Close all channels on the module in Slot 1; the channels on the module in Slot 3 will be closed automatically.*
CPA 1,-1	*! Cancel the pair.*

[ROUTe:]CPAir?

[ROUTe:]CPAir? queries paired modules in the HP 3499A/B. The returned value will be a list of four numbers separated with commas, indicating the four slots in which two pairs of modules are plugged.

Comments

- **Returned Value:** The returned value is a list of four slot numbers separated with commas. The first two numbers specify the first pair of slots, the second two numbers specify the second pair. If there is only one pair, "0,0" will be returned for the last two numbers.

- **No Cards Paired:** The returned value will be 0,0,0,0 if no cards are paired.

- ***RST Condition:** There will be no cards paired after an instrument power-on or reset. The command *CLS has no effect on the card-pairing status.

Example

CPA 1,2	*! Pair the modules in Slots 1 & 2.*
CPA 3,5	*! Pair the modules in Slots 3 & 5.*
CPA?	*! Query the paired modules. Returned value "1,2,3,5" indicates that the first pair of modules is in Slots 1 & 2; the*

[1]. Two same (type) DIO modules can not be paired when used in Mode #3 or #4 or #5.

[2]. These source operations only include: SOURce:DIGital:DATA:BIT and SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>[:VALue]].

second pair is in Slots 3 & 5.

[ROUTe:]FUNCtion

[ROUTe:]FUNCtion *<slot>, <mode>* is used to configure an HP N2260A 40-channel MUX module. This module can be configured to any of the four function modes: an 80-channel 1-wire MUX, a 40-channel 2-wire MUX, two 20-channel 2-wire MUXs, or a 20-channel 4-wire MUX. After an instrument power on or reset, an HP N2260A will return to the default 40-channel 2-wire MUX mode. Changing function mode will open all the switching channels on an HP N2260A.

Parameters

Name	Type	Range of Values	Default Value
<slot> *<mode>*	numeric discrete	1-5 for HP 3499A, 1-2 for 3499B 1|2|3|4|WIRE1|WIRE2|BIWIRE2|WIRE4	N/A 2|WIRE2

Comments

- **1-Wire Mode (1|WIRE1):** This mode configures the HP N2260A as a 80-channel single-ended (1-wire) MUX module. The valid channel numbers are s00-s79. The 40 Low (L) terminals form Channels 00 through 39, the High (H) terminals, Channels 40 through 79.

Note For the HP N2260A, only one channel can be closed at a time when in 1-wire mode.

- **2-Wire Mode (2|WIRE2):** This mode configures the HP N2260A as a 40-channel 2-wire MUX module. The valid channel numbers are s00-s39. To close/open/scan one channel is actually to close/open/scan a 2-wire pair.
- **Dual 2-Wire Mode (3|BIWIRE2):** This mode configures the HP N2260A as two independent 20-channel 2-wire MUX modules. The valid channel numbers are again s00-s39 (s00-s19 for the first MUX and s20-s39 for the second).
- **4-Wire Mode (4 or WIRE4):** This mode configures the HP N2260A as a 20-channel 4-wire MUX module. Channels 20 through 39 (2-wire) are paired with Channels 00 through 19. The valid channel numbers are s00-s19. To close/open/scan a channel is actually closing/opening/scanning a 4-wire connection in this mode.
- **Paired HP N2260A:** If two HP N2260A are paired, changing the function mode on one module will result in the other module being changed to the same function mode automatically.
- Changing the function mode for HP N2260A will open all the switching channels on this module.

Note Two HP N2260A modules CANNOT be paired if they are configured in different function modes.

- ***RST Condition:** The HP N2260A is configured as a 40-channel 2-wire MUX module after an instrument power-on or reset. *CLS has no effect on the function mode settings.

Example This example configures HP N2260A in slot 1 to 4-wire function mode. Make sure an HP N2260A is installed in slot 1.

FUNC 1,4 (or WIRE4)	*! Configure the module in Slot 1 to 4-wire mode.*
CLOS (@100, 119)	*! Close 4-wire paired Channels 00 & 19, Channels 20 & 39 (in 2-wire mode) will be closed together.*

[ROUTe:]FUNCtion?

[ROUTe:]FUNCtion? <*slot*> queries the current function mode of the HP N2260A in the specified slot. The returned string will be one of WIRE1|WIRE2|BIWIRE2|WIRE4 to indicate the function mode of the module queried. The valid slot number is 1-5 for HP 3499A, 1-2 for HP 3499B.

Comments

- An HP N2260A must be installed in the specified slot, or an error will occur.

Example This example sets the module (in slot 1) to 2-wire mode and queries the function mode.

FUNC 1,2 (or WIRE2)	*! Configure the module in Slot1 to 2-wire function mode.*
FUNC? 1	*! Query function mode of the specified module. The returned value "WIRE2" indicates that the module is in 2-wire function mode.*

[ROUTe:]OPEN

[ROUTe:]OPEN *<channel_list>|ALL* opens the channels specified in the *channel_list*. You can also open all the channels present if *ALL* is specified. The *channel_list* is in the form of (*@snn)*, where s = slot number (1-5 for HP 3499A, 1-2 for HP 3499B) and nn = channel number.

Parameters

Name	Type	Range of Values
<channel_list>	numeric	Module dependent, Refer to Figure 6-1 on Page 82. Maximum number of channels is 200.

Comments

- ***Channel_list:*** Only the switching channels on the plug-in modules can be included in a *channel_list*.

- **Digital I/O Modules:** The bits on digital I/O modules can not be opened or closed with [ROUTe:]OPEN and [ROUTe:]CLOSe. Use the command SOURce:DIGital:DATA:BIT to open or close the specific bits on the digital I/O modules.

- **Tree Relays:** The two tree relays (s98 & s99) can not be switched with the commands OPEN or CLOSe.

- **HP N2260A:** This module can be configured as one of the four MUX modules. The following table lists the channel number designation under different function modes.

Function Mode	Channel Number	Slot Number
One 80-channel 1-wire MUX	s00-s79	1-5 (3499A), 1-2 (3499B)
One 40-channel 2-wire MUX	s00-s39	1-5 (3499A), 1-2 (3499B)
Two 20-channel 2-wire MUX	s00-s39	1-5 (3499A), 1-2 (3499B)
One 20-channel 4-wire MUX	s00-s19	1-5 (3499A), 1-2 (3499B)

- **Opening Channels:** To open:

  -- a single channel, use OPEN (@snn);
  -- multiple channels, use OPEN (@snn,snn,...);
  -- sequential channels, use OPEN (@snn:snn);
  -- groups of sequential channels, use OPEN (@snn:snn,snn:snn);
  -- or any combination of the above.

  -- To open all channels on the plug-in modules, use OPEN ALL.

Note Channels in a *Channel_list* may not open simultaneously. The order in which the channels open when operated by a single command is not guaranteed. Use sequential OPEN commands if needed.

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

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

Example OPEN (@100:109) *! Open the Channels 0-9 on the specified module.*

[ROUTe:]OPEN?

[ROUTe:]OPEN? *<channel_list>* returns the current state of the channel(s) queried. *Channel_list* is in the form of (@snn). The command returns a “1” if the channel is open, or a “0” if the channel is closed. If a list of channels is queried, a comma delineated list of 0’s and 1’s is returned in the same order of the channel list.

Comments

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

- ***Channel_list:*** See [ROUTe:]OPEN on Page 105 for *channel_list* definition. The maximum number of channels returned is 200.

Example Query Multiplexer Channel Open State

OPEN (@100,105)	*! Open Channels 0 & 5 on the specified module.*
OPEN? (@105)	*! Query open state of Channel 5 on the specified module. Returned value "1" indicates that the channel is open.*

[ROUTe:]SCAN[:LIST]

[ROUTe:]SCAN[:LIST] <*scan_list*> defines a sequence of channels/bits or channel setups to be scanned. *Scan_list* is in the form of (@snn,mm), (@snn,snn,mm), or (@snn:snn,mm) where s = slot number (0-5), nn = channel number (module dependent), mm = stored channel setups (1-10).

Parameters

Name	Type	Range of Values
<scan_list>	numeric	Module dependent, refer to Figure 6-1 on Page 82.

Comments

- ***Scan_List:*** The switching channels, DIO bits and the previously stored channels setups can be included in a *scan_list*.

- **DIO Lines:** The digital I/O lines included in *scan_list* must be in Static Mode #1 or #2.

- **Built-in DIO:** The bits on the 4-bit built-in digital I/O (091-094) can be included in a *scan_list*.

- **HP N2260A:** The function mode must be specified previous to defining the channels or channel range to be scanned, or the HP N2260A is used as a 40-channel 2-wire MUX.

- **Tree Relays:** The two tree relays (s98 & s99) can not be included in a *scan_list*.

- The maximum channel/bit number included in a *scan_list* is 200. One channel setup, regardless of its channel number, accounts for only one "channel" in a *scan_list*.

- **Scanning Operation:** When a valid *scan_list* is defined, and the arm source and the trigger source are selected with commands ARM:SOURce and TRIGger:SOURce, execution of INITiate begins the scan and closes the first channel specified in the *scan_list*. Successive triggers from the source specified by TRIGger:SOURce advance the scan through the *scan_list*. If a stored channel setup (1-10) is encountered, the HP 3499A/B will recall the stored channel setup, then proceed with the scanning.

- **Scanning Channels:** To scan:

  -- a single channel, use SCAN (@snn);
  -- multiple channels, use SCAN (@snn,snn,mm,snn...);
  -- sequential channels, use SCAN (@snn:snn,mm);

-- groups of sequential channels, use SCAN (@snn:snn,snn:snn,mm);
-- or any combination of the above.

- **Output Pulse:** A pulse will be outputted after each channel is closed if the trigger output pulse is enabled.

- **Stopping a Scan:** See the ABORt command on Page 84.

- ***RST Condition:** All channels are open and the *scan_list* will be cleared after an instrument power-on or reset. *CLS has no effect on the *scan_list*.

Example

*RST	*! Reset the instrument.*
SCAN (@100:119,5,200:209)	*! Set a sequence of channels specified to be scanned. The digital 5 represents the stored channel setup.*
INIT	*! Start a cycle of scan. The first channel closed is 0; then Channel 1 will be closed and Channel 0 opened; and so on.*

[ROUTe:]SCAN[:LIST]?

[ROUTe:]SCAN[:LIST]? queries the sequence of channels included in the *scan_list*. A comma delineated channel list will be returned, which is in the same order as in the scan_list and in the form of (*snn,snn,mm,...*), where *snn* is the channel number (module dependent), and *mm* = stored channel setup (1-10).

Example

*RST	*! Reset the instrument.*
SCAN (@100:109,5,200:203)	*! Set a sequence of channels & stored channel setup to be scanned.*
INIT	*! Start a cycle of scan.*
SCAN:LIST?	*! Query the scan list. A comma delineated channel list "100,101,102,103,104,105,106,107,108, 109,5,200,201,202,203" will be returned.*

[ROUTe:]SCAN:SIZE?

[ROUTe:]SCAN:SIZE? queries the number of channels in the *scan_list*. The returned value is an integer number between 0 and 200, including the stored channel setups.

Comments

- **Stored Channel Setup:** One stored channel setup accounts for only one "channel" in the *scan_list*, regardless of the channel numbers stored in that channel setup.

Example

SCAN (100:119,5,200:209)	*! Set a sequence of channels to be scanned. 5 is a stored channel setup.*
SCAN:SIZE?	*! Query the number of channels in the scan_list. The returned value is "31".*

[ROUTe:]SCAN CLEar

[ROUTe:]SCAN CLEar clears the scan list defined with the command [ROUTe:]SCAN[:LIST] *<scan_list>*. This command has no effect on the scan configurations except clearing all the channels/bits or the stored channel setups included in the *<scan_list>*.

Example

SCAN (100:119,5,200:209)	*! Set a sequence of channels to be scanned. 5 is a stored channel setup.*
SCAN:SIZE?	*! Query the number of channels in the scan_list. The returned value is "31".*
SCAN CLE	*! Clear the scan_list.*
SCAN:SIZE?	*! The returned value will be "0".*

Both the **SOURce** and **SENSe** commands are only applicable to the digital I/O modules. The **SOURce** command subsystem selects the digital I/O mode, and sets the polarity of the digital I/O ports. It can be used to write a 0 or 1 to a specific bit, or to write data or a block of data to specific 8/16/32-bit digital I/O ports. In addition, this subsystem can also define the size and name of the data block to be read or written, write a block of data in memory, or remove one/all blocks from the system memory.

Subsystem Syntax

```
SOURce
    :DIGital
        :MODE <slot>,<mode>
        :MODE? <slot>
        :CONTrol:POLarity <slot>,<polarity>
        :CONTrol:POLarity? <slot>
        :FLAG:POLarity <slot>,<polarity>
        :FLAG:POLarity? <slot>
        :IO:POLarity <slot>,<polarity>
        :IO:POLarity? <slot>
        :DATA[:<BYTE|WORD|LWORD>]:POLarity <port>,<0|1|POS|NEG>
        :DATA[:<BYTE|WORD|LWORD>]:POLarity? <port>
        :DATA:BIT <bit_port>,<0|1>
        :DATA[:<BYTE|WORD|LWORD>[:VALue]] <port>,<data>
        :DATA[:<BYTE|WORD|LWORD>]:BLOCK <port>,<block_data>
        :DATA:[<BYTE|WORD|LWORD>:]TRACE <port>,<sys_mem_name>
        :TRACe:DEFine <sys_mem_name>,<size>[,<fill>]
        :TRACe:DEFine? <sys_mem_name>
        :TRACe:CATalog?
        :TRACe[:DATA] <sys_mem_name>,<block_data>
        :TRACe:DELete[:NAME] <sys_mem_name>
        :TRACe:DELete:ALL
```

SOURce:DIGital:MODE

SOURce:DIGital:MODE *<slot>,<mode>* sets the digital I/O mode. The valid slot number is 1 - 5 for HP 3499A and 1-2 for HP 3499B, and <*mode*> = 1-5.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 (3499A), 1-2 (3499B)	N/A
<mode>	numeric	1-5 (int)	1

Comments

- **Mode Definition:** Refer to “Digital MODE Command” on Page 151 for more information.

Note

Only the first port (including the first bit, i.e. Port s00 on an HP N2263A; Port s30 on an HP N2264A and Port s40 on an HP N2265A, etc.) on a digital I/O can be set in Mode #3, #4 or #5, and the three control lines are valid for this port. The other ports can be in Static Mode #1 or #2, and the three control lines are invalid.

- **4-Bit Built-in DIO:** This command has no effect on the built-in digital I/O in Slot 0.

- ***RST Condition:** The plug-in DIO modules will be in the default Static Mode #1 after an instrument power-on or reset. *CLS has no effect on the DIO mode.

Example SOUR:DIG:MODE 1,1 *! Set the DIO module in the specified slot in Static Mode #1.*

SOURce:DIGital:MODE?

SOURce:DIGital:MODE? *<slot>* queries the digital I/O mode. The returned number is 1-5, referring to the five modes, respectively. A slot number (1-5 for HP 3499A, 1-2 for HP 3499B) must be specified when querying the DIO mode.

Example

SOUR:DIG:MODE 1,3	*! Set the DIO mode for the specified DIO module.*
SOUR:DIG:MODE? 1	*! Query the DIO mode. Returned value "3" indicates that the DIO mode in Slot 1 is in Mode #3.*

SOURce:DIGital:CONTrol:POLarity

SOURce:DIGital:CONTrol:POLarity *<slot>,<polarity>* sets the polarity of PCTL lines. Once the polarity of the control lines is changed, the digital I/O module will immediately change the states of the affected lines.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 for HP 3499A 1-2 for HP 3499B	N/A
<polarity>	Boolean	0|1|POSitive|NEGative	0|POS

Comments

- **Built-in DIO in Slot 0:** This command is not supported by the 4-bit built-in digital I/O in Slot 0.

- ***RST Condition:** The default value will be 0|POS after an instrument power-on or reset. *CLS has no effect on this value.

Example SOUR:DIG:CONT:POL 1,1 *! Set the polarity of the control line.*

SOURce:DIGital:CONTrol:POLarity?

SOURce:DIGital:CONTrol:POLarity? *<slot>* returns the polarity of the PCTL line. The returned value is either a POS or a NEG. The valid slot number is 1 - 5 for HP 3499A and 1-2 for HP 3499B. Slot number must be specified in the command.

Example SOUR:DIG:CONT:POL 1,1 *! Set the polarity of the control line for the*

	DIO module in Slot 1.
SOUR:DIG:CONT:POL? 1	*! Query the polarity. Returned "NEG" indicates the polarity of the control line.*

SOURce:DIGital:FLAG:POLarity

SOURce:DIGital:FLAG:POLarity *<slot>,<polarity>* sets the polarity of PFLG lines. Once the polarity of the control lines is changed, the digital I/O module will immediately change the states of the affected lines.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 for HP 3499A 1-2 for HP 3499B	N/A
<polarity>	boolean	0|1|POSitive|NEGative	0|POS

Comments

- **Built-in DIO in Slot 0:** This command is not supported by the 4-bit built-in digital I/O in Slot 0.
- ***RST Condition:** The default value is 0|POS. *CLS has no effect on the value.

Example

SOUR:DIG:FLAG:POL 1,1	*! Set the polarity of the FLAG line for the DIO module in Slot 1.*

SOURce:DIGital:FLAG:POLarity?

SOURce:DIGital:FLAG:POLarity? *<slot>* returns the polarity of the FLAG line. The returned value is either a POS or a NEG. The valid slot number is 1-5 for HP 3499A and 1-2 for HP 3499B. Slot number must be specified in the command.

Example

SOUR:DIG:FLAG:POL 1,1	*! Set the polarity of the PFLG line for the DIO module in Slot 1.*
SOUR:DIG:FLAG:POL? 1	*! Query the polarity. Returned "NEG" indicates the polarity of the PFLG line NEG.*

SOURce:DIGital:IO:POLarity

SOURce:DIGital:IO:POLarity *<slot>,<polarity>* sets the polarity of IO lines. Once the polarity of the control lines is changed, the digital I/O module will immediately change the states of the affected lines.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1-5 for HP 3499A 1-2 for HP 3499B	N/A
<polarity>	boolean	0|1|POSitive|NEGative	0|POS

Comments

- **Built-in DIO in Slot 0:** This command is not supported by the 4-bit built-in digital I/O in Slot 0.
- ***RST Condition:** The default value will be 0|POS after an instrument power-on or reset. *CLS has no effect on the value.

Example

SOUR:DIG:IO:POL 1,1	*! Set the polarity of the IO line for the DIO module in Slot 1.*

SOURce:DIGital:IO:POLarity?

SOURce:DIGital:FLAG:POLarity? *<slot>* returns the polarity of the IO line. The returned value is either a POS or a NEG. The valid slot number is 1-5 for HP 3499A and 1-2 for HP 3499B. Slot number must be specified in the command.

Example

SOUR:DIG:IO:POL 1,1	*! Set the polarity of the IO line for the DIO module in Slot 1.*
SOUR:DIG:IO:POL? 1	*! Query the polarity. Returned "NEG" indicates the polarity of the IO line is NEG.*

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>]:POLarity

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>]:POLarity *<port>,<0|1|POS|NEG>* sets the polarity for a specified 8/16/32-bit digital I/O port.

Parameters

- **Port Definition:** Refer to Table 6-2.

Table 6-2. Port Definition

Port Type	Bits	Port Number
BIT	00 - 31	s00 - s31, 091 - 094
BYTE (default)	00 - 07 08 - 15 15 - 23 24 - 31	s00, 090 s01 s02 s03
WORD	00 - 15 16 - 31	s00 s02
LWORD	00 - 31	s00

Comments

- **BYTE|WORD|LWORD:** any one of the three types can be specified. The default is BYTE port.
- **0|1|POS|NEG:** The selectable polarity is either 0|POSitive (high true) or 1|NEGative (low true).
- **Data Lines State:** The current state of the data lines is not changed immediately, but the new polarity is to be used in subsequent operations.

- **Mode #3, #4, #5:** Only the first port (including the first bit on the DIO, i.e. Port 00, etc.) can be set in Mode #3, #4 or #5. The other ports will be in Static Mode #1 when the first port is in Mode #3, #4 or #5.
- ***RST Condition:** The DIO ports will be set to POS (high true) state after an instrument power-on or reset. *CLS has no effect on the state.

Example SOUR:DIG:DATA:BYTE:POL 100,NEG — *! Set the polarity to NEG (low true) for the specified 8-bit DIO port 100.*

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>]:POLarity?

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>]:POLarity? *<port>* queries the polarity of the specified 8/16/32-bit digital I/O port. A string of either POS or NEG will be returned, describing the polarity of the specified 8/16/32-bit digital I/O port.

Example

SOUR:DIG:DATA:POL 100,NEG	*! Set the polarity to NEG (low true) for the specified 8-bit DIO port 100.*
SOUR:DIG:DATA:POL? 100	*! Query the polarity of the specified port. "NEG" will be returned.*

SOURce:DIGital:DATA:BIT

SOURce:DIGital:DATA:BIT *<bit_port>,<0|1>* writes a 0 or a 1 to the specified digital I/O *bit_port*. *Bit_port* is in the form of snn, where s = slot number (0-5 for HP 3499A, 0-2 for HP 3499B). Slot 0 is reserved for the 4-bit built-in digital I/O. nn is the bit number (DIO module dependent).

Parameters

Name	Type	Range of Values	Default Value
<bit_port>	numeric	Built-in DIO: 091-094; 16-Bit DIO: s00-s15; 32-Bit DIO: s00-s31.	N/A

Comments

- **Bit_port:** A bit_port is actually a DIO bit and is module dependent. Refer to Table 6-1 on Page 82 for more information.
- **Built-in DIO in Slot 0:** The bit_port 091-094 is for the 4-bit built-in digital I/O module.
- **Writing 0/1 to a Bit:** Bits can be written one at a time. To write multiple bits, use this command repeatedly, or use the command SOURce:DIGital:DATA:[<BYTE|WORD|LWORD>[:VALue]].

Example SOUR:DIG:DATA:BIT 200,1 — *! Write a 1 to bit_port 200.*

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>[:VALue]]

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>[:VALue]] ***<port>,<data>*** writes data to the specified 8/16/32-bit digital I/O port.

Parameters

Port Type	Bit #	Port #	Data
BYTE	00-07 08-15 16-23 24-31	s00, 090 s01 s02 s03	0 to 255 *(decimal) or* 00_h to FF_h *(Hex)*
WORD	00-15 16-31	s00 s02	-2^{15} to $+(2^{15}-1)$ or (-32768 to +32767 or) -8000_h to $7FFF_h$
LWORD	00-31	s00	-2^{31} to $+(2^{31}-1)$ or (-2147483648 to +2147483647 or) -80000000_h to $+7FFFFFFF_h$

Comments

- **BYTE|WORD|LWORD:** One of the three operation states need to be specified in this command. If unspecified, the default operation state will be BYTE. The digital I/O ports will be used as 8-bit ports.

- **BYTE Port:** When BYTE is specified, bits on 16/32-bit DIO modules will be used as two or four 8-bit ports. An integer data between 0 and 255 (00_h and FF_h) can be written to the specified BYTE port.

Note An integer data ranged from 0 through 15 can be written to the 4-bit built-in DIO Port 090.

- **WORD Port:** When WORD is specified, bits on 16/32-bit DIO modules will be used as one or two 16-bit ports. An integer data between -32768 and +32767 (-8000_h and $+7FFF_h$) can be written to the specified WORD port.

- **LWORD Port:** LWORD can be specified only for the 32-bit DIO module. The 32 bits will form a 32-bit port. An integer data between -2^{31} and $+(2^{31}-1)$ (-80000000_h and $7FFFFFFF_h$) can be written to this LWORD port.

- **2's Complement Form:** Pay special attention to the data size when writing to a WORD or LWORD port. Any decimal number greater than +32767 (WORD port) or $+(2^{31}-1)$ (LWORD port) must be expressed in 2's complement form and as a negative number.

Note Refer to "WRITE to a Digital I/O" on Page 158 for more information about the 2's complement form.

Example

SOUR:DIG:DATA:WORD:VAL 100,4678 *! Write 1246_h to the WORD port 100.*

SOURce:DIGital:DATA[:<BYTE|WORD|LWORD>]:BLOCK

SOURce:DIGital:DATA:<BYTE|WORD|LWORD>:BLOCK *<port>,<block_data>* writes a block of data to the specified 8/16/32-bit digital I/O port directly.

Parameters

Name	Type	Range of Values	Default
<port>	numeric	BYTE: 090; s00, s01, s02, s03 WORD: s00, s02 LWORD: s00 (s = slot number)	BYTE
<block_data>	string	numeric header and ASCII block data	None

Comments

- **Port 090:** Port 090 is the Slot 0 4-bit digital I/O port. You can write a block of data to this port directly in BYTE state.
- ***<Block_Data>*** is in the form of *<#digits><length><block>*, where:
  <#digits> decides how many decimal digits are used to define *<length>*;
  <length> decides how many bytes are to be transferred in *<block>*;
  <block> contains the actual data to be transferred.
- The range of the *<block>* is 1-2048 bytes.

Example

This example sends a block of data “ABCDEFGHIJ” to a 16-bit port 100. Since the ASCII character A, B have decimal values of 65 and 66, the equivalent of 65 and 66 are written to the word port 100 first, A is in the High 8 bits and B in the Low 8 bits; then the C and D are written, and so on.

```
SOUR:DIG:DATA:WORD:BLOCK 100,#210ABCDEFGHIJ
```

SOURce:DIGital:DATA:[<BYTE|WORD|LWORD>:]TRACE

SOURce:DIGital:DATA:[<BYTE|WORD|LWORD>:]TRACE
<port>,<sys_mem_name> writes the block of data in memory to the specified 8/16/32-bit digital I/O port. The data block should have been defined in the system memory before sending this command.

Parameters

Name	Type	Range of Values	Default
<port>	numeric	BYTE: 090; s00, s01, s02, s03 WORD: s00, s02 LWORD: s00 (s = slot number)	(BYTE)
<sys_mem_name>	string	name of user memory block (maximum 12 characters)	None

Comments

- **<Sys_mem_name>** must have been previously defined by command SOUR:DIG:TRAC:DEF. The maximum length is 12 characters.

- The data block in the memory can be also written to the 4-bit built-in digital I/O port (port 090).

Example

SOUR:DIG:TRAC:DEF first_block,10	*! Define a 10-byte data block named as "first_block".*
SOUR:DIG:TRAC first_block,#210abcdefghij	*! Set the data block (abcdefghij).*
SOUR:DIG:WORD:TRACE 100,first_block	*! Write the block of data in "first_block" to a 16-bit port 100.*

SOURce:DIGital:TRACe:DEFine

SOURce:DIGital:TRACe:DEFine *<sys_mem_name>,<size>[,<fill>]* defines the size and name of the data block to be read or written. This will allocate memory block in the system memory space, with a maximum size of 32768 bytes.

Parameters

Name	Type	Range of Values	Default
<size>	numeric	1-32768 (bytes)	None
<fill>	numeric	0-FF_h	None
<sys_mem_name>	string	name of user memory block (maximum 12 characters)	None

Comments

- **Maximum Memory Size** is 32768 bytes.
- If *<fill>* is added, the bytes in the defined memory will be filled, i.e. if a 1024-byte memory is defined in <size>, those 1024 bytes will be filled.
- **Maximum Blocks:** A maximum of two blocks can be defined, and the total space occupied by the two blocks must be limited to 32768 bytes.
- ***<Sys_mem_name>:*** Users can define their own system memory name, with a maximum size of 12 characters.
- ***RST Condition:** The *<sys_mem_name>* and *<size>* will be cleared after an instrument power-on or reset. *CLS has no effect on the name.

Example

SOUR:DIG:TRAC:DEF first_block,20	*! Define a 20-byte data block named as "first_block".*

SOURce:DIGital:TRACe:DEFine?

SOURce:DIGital:TRACe:DEFine? *<sys_mem_name>* queries the size of the data block to be read or written. The returned value will be a decimal integer value between 0 and 32768, indicating the size of the block data in the system memory.

Example

SOUR:DIG:TRAC:DEF first_block,20	*! Define a 20 byte data block.*

SOUR:DIG:TRAC:DEF? first_block	*! Query the size of "first_block". Returned value "20" indicates that the data block contains 20 bytes.*

SOURce:DIGital:TRACe:CATalog?

SOURce:DIGital:TRACe:CATalog? queries the names of the defined system memory. The returned string is the block name. If two blocks are defined, the returned string will list the two block names separated by a comma.

Example

SOUR:DIG:TRAC:DEF first_block,156	*! Define a 156-byte data block named as "first_block".*
SOUR:DIG:TRAC:DEF second_block,156	*! Define another 156-byte data block named as "second_block".*
SOUR:DIG:TRAC:CAT?	*! Returned string "first_block, second_block" lists the names of the two blocks in the system memory.*

SOURce:DIGital:TRACe[:DATA]

SOURce:DIGital:TRACe[:DATA] *<sys_mem_name>,<block_data>* transfers the data block to the memory block previously defined with the command SOURce:DIGital:TRACe:DEFine.

Parameters

Name	Type	Range of Values	Default
<sys_mem_name>	string	name of user memory block (maximum 12 characters)	None
<block_data>	numeric	numeric herder and ASCII block data	None

Comments

- ***<Sys_mem_name>*** is the system memory name defined with the command SOURce:DIGital:TRACe:DEFine, its length should not exceed 12 characters.
- ***<Block_Data>*** is in the form of *<#digits><length><block>*, where: *<#digits>* decides how many decimal digits are used to define *<length>*; *<length>* decides how many bytes are to be transferred in *<block>*; *<block>* contains the actual data to be transferred.
- The range of the *<block>* is 1-2048 bytes.
- ***RST Condition:** The system memory will be reset (cleared) after an instrument power-on or reset. *CLS has no effect on the name and the data block.

Example

SOUR:DIG:TRAC se_block,#210abcdefghij	*! Set a data block.*

SOURce:DIGital:TRACe:DELete<[:NAME]|:ALL>

SOURce:DIGital:TRACe:DELete[:NAME] ***<sys_mem_name>*** removes one data block from the system memory. Refer to the commands above for the *<sys_mem_name>* definition.

SOURce:DIGital:TRACe:DELete:ALL removes all data blocks (maximum two blocks) from the system memory.

Both the **SENSe** and **SOURce** commands are only applicable to the digital I/O modules. The **SENSe** command subsystem reads a bit from the specified bit-port, or a datum from the specified digital I/O port. It can also be used to read a block of data from the specified 8/16/32-bit digital I/O port and store these data into the previously defined buffer in the system memory.

Subsystem Syntax

SENSe
:DIGital
:DATA:BIT? *<bit_port>*
:DATA[:<BYTE|WORD|LWORD>][:VALue]? *<port>*
:DATA[:<BYTE|WORD|LWORD>]:BLOCK? *<port>*
:DATA[:<BYTE|WORD|LWORD>]:TRACE *<port>,<sys_mem_name>*
:TRACe[:DATA]? *<sys_mem_name>*

SENSe:DIGital:DATA:BIT?

SENSe:DIGital:DATA:BIT? *<bit_port>* reads a bit from the specified digital I/O *bit_port*. *Bit_port* is in the form of snn, where s is the slot number (0-5 for HP 3499A & 0-2 for HP 3499B) and nn is the bit number. Slot 0 is reserved for the 4-bit built-in digital I/O.

Parameters

Name	Type	Range of Values	Default Value
<bit_port>	numeric	Built-in DIO: 091-094 16-Bit DIO: s00-s15 HP N2264A: s30-s45 HP N2265A: s40-s55 32-Bit DIO: s00-s31[1] (s = slot number)	N/A

[1]. Refer to Table 6-1 on Page 82 for more detail.

Comments

- **Returned Value:** Either a “0” or a “1” will be returned, indicating a open or closed state of the specified digital I/O *bit_port*.
- **Bit Port:** A *bit_port* is actually a DIO bit, and is module dependent.
- For the built-in digital I/O, the *bit_port* is 091 through 094.
- **Related Command:** SOUR:DIG:DATA:BIT.

Example

SENS:DIG:DATA:BIT? 106 *! Read the bit_port 106.*

SENSe:DIGital:DATA[:<BYTE|WORD|LWORD>][:VALue]?

SENSe:DIGital:DATA[:<BYTE|WORD|LWORD>][:VALue]? *<port>* reads data from the specified 8/16/32-bit digital I/O port. A decimal integer will be read back.

Parameters

Operation	Bit #	Port #	Data Range
BYTE	091-094 s00-s07 s08-s15 s16-s23 s24-s31	090 s00 s01 s02 s03	0 to 255 *(decimal) or* 00_h to FF_h *(Hex)*
WORD	s00-s15 s16-s31	s00 s02	-2^{15} to + (2^{15}-1) or (-32768 to +32767 or) -8000_h to $7FFF_h$
LWORD	s00-s31	s00	-2^{31} to + (2^{31}-1) or (-2147483648 to +2147483647 or) -80000000_h to $+7FFFFFFF_h$

Comments

- **BYTE|WORD|LWORD:** The operation states need to be specified in this command. If not specified, the default operation state is BYTE.
- **BYTE Port:** When BYTE is specified, an integer data between 0 and 255 (00_h and FF_h) will be read from the BYTE port.
- **WORD Port:** When WORD is specified, an integer data between -32768 and +32767 (-8000_h and $+7FFF_h$) will be read from the WORD port.
- **LWORD Port:** When LWORD is specified, an integer data between -2^{31} and $+(2^{31}-1)$ (-80000000_h and $7FFFFFFF_h$) will be read from the LWORD port.

Note For detailed information on the bit # and port # on the plug-in DIO modules, refer to Table 6-1 on Page 82.

- **2's Complement Form:** Numbers greater than +32767 (WORD port) and $+(2^{31}-1)$ (LWORD port) will be stored as negative numbers. When the returned data is negative, the inverse procedure must be used to calculate the actual bit state from the 2's complement form.

Note Refer to "WRITE to a Digital I/O" on Page 158 for more information about the 2's complement form.

- **Related Command:** SOUR:DIG:DATA.

Example

```
SOUR:DIG:DATA:WORD:VAL 100,+4678    ! Write 1246h to the WORD port 100.
SENS:DIG:DATA:WORD:VAL? 100         ! Read the WORD port 100. Returned
                                    data will be "+4678".
```

SENSe:DIGital:DATA[:<BYTE|WORD|LWORD>]:BLOCK?

SENSe:DIGital:DATA[:<BYTE|WORD|LWORD>]:BLOCK? *<port>,<size>* reads a block of data from the specified 8/16/32-bit digital I/O port directly. The returned data block has a header with the bytes specified in *<size>*.

Parameters

Name	Type	Range of Values	Default
<port>	numeric	BYTE: 090; s00, s01, s02, s03 WORD: s00, s02 LWORD: s00 (s = slot number)	BYTE
<size>	numeric	1-2048 (bytes)	None

Comments

- The *<size>* must be specified in this command. The returned data block has the length (bytes) specified in *<size>*. The header returned with the actual data will also indicate the length of the data block. The maximum size of *<size>* is 2048 bytes.

- **Port Number:** The port number is the same as in the command SOURce:DIGital:DATA:<BYTE|WORD|LWORD>:BLOCK.

- **Related Commands:** SOUR:DIG:DATA:<BYTE|WORD|LWORD>:BLOCK.

Example

SOUR:DIG:DATA:BYTE:BLOCK 100,#16ABCDEF
! Write a data block "ABCDEF" to BYTE port 100.

SENS:DIG:DATA:BYTE:BLOCK 100,6
! Read 6 bytes of data block from the BYTE port 100.

SENSe:DIGital:DATA:[<BYTE|WORD|LWORD>:]TRACE

SENSe:DIGital:DATA:[<BYTE|WORD|LWORD>:]TRACE *<port>,<sys_mem_name>* reads a block of data from the specified 8/16/32-bit digital I/O port and stores these data into the previously defined buffer in system memory.

Parameters

Name	Type	Range of Values	Default
<port>	numeric	BYTE: 090; s00, s01, s02, s03 WORD: s00, s02 LWORD: s00 (s = slot number)	(BYTE)
<sys_mem_name>	string	name of user memory block (maximum 12 characters)	None

Comments

- <**Sys_mem_name**> must be previously defined by command SOUR:DIG:TRAC:DEF. The maximum length is 12 characters.

- The data block can also be read from the built-in digital I/O port (Port 090).

- **Related Commands:** SOUR:DIG:TRAC:DEF, SOUR:DIG:DATA:TRACE.

Example

SOUR:DIG:TRAC:DEF buffer_block,10	*! Define a 10-byte data block buffer named as "buffer_block".*
SENS:DIG:DATA:TRACE 100,buffer_block	*! Read a block of data from the BYTE port 100 and store the data in the previously defined buffer (buffer_block).*

SENSe:DIGital:TRACe[:DATA]?

SENSe:DIGital:TRACe[:DATA]? *<sys_mem_name>* gets the data block read by the previous command SENSe:DIGital:DATA[:<BYTE|WORD|LWORD>]:TRACE. A block of data with a header will be returned.

Parameters

Name	Type	Range of Values	Default
<sys_mem_name>	string	name of user memory block (maximum 12 characters)	None

Example

SOUR:DIG:TRAC:DEF data_block,10	*! Define a 10-byte data bock "data_block".*
SOUR:DIG:TRAC data_block,#210abcdefghij	*! Transfer the data block "abcdefghij" to data_block.*
SOUR:DIG:DATA:TRACE 100,data_block	*! Write the data block in "data_block" to the BYTE port 100.*
SOUR:DIG:TRAC:DEF buffer_block,10	*! Define another 10-byte data block "buffer_block".*
SENS:DIG:DATA:TRACE 100,buffer_block	*! Read a block of data from BYTE port 100 and store the data block in the system memory "buffer_block".*
SENS:DIG:TRAC:DATA? buffer_block	*! Get a block of data from the system memory "buffer_block".*

The **STATus** subsystem reports the bit values of the Operation Status Register. It is also used to unmask the Standard Event Register bits, and to read the Status Byte Register summary bits.

Subsystem Syntax

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

The STATus system contains several registers (that is, they reside in a SCPI driver, not in the hardware), two of which are under IEEE 488.2 control: the Standard Event Status Register (*ESE?) and the Status Byte Register (*STB?). The operational status bit (OPR), service request bit (RQS), standard event summary bit (ESB) and message available bit (MAV) in the Status Byte Register (Bits 7, 6, 5 and 4 respectively) can be queried with the *STB? command. The *ESE? command is used to query the "unmask" value for the Standard Event Status Register (the bits you want logically OR'd into the summary bit). The registers are queried using decimal weighted bit values. The decimal equivalents for Bits 0 through 15 are included in "Figure 6-2. HP 3499A/B Status System Register Diagram" on Page 126.

A numeric value of 16, executed in a STAT:OPER:ENABle *<unmask>* command, allows only Bit 4 to generate a summary bit. The decimal value for Bit 4 is 16.

The decimal values are also used in the inverse manner to determine which bits are set from the total value returned by an EVENt or CONDition query. The HP 3499A/B exploits only Bit 4 of Operation Status Register. This bit is called the Scan Start Bit which is set whenever a scan operation starts. Since starting a scan operation is an event in time, you will find that Bit 4 will never appear set when STAT:OPER:COND? is queried. However, you can find Bit 4 set with the STAT:OPER:EVEN? query command.

STATus:OPERation:CONDition?

STATus:OPERation:CONDition? returns the state of the Condition Register in the Operation Status Group. The state represents conditions which are part of the instrument's operation. The HP 3499A/B does not set Bit 4 in this register (see STATus:OPERation[:EVENt]?).

STATus:OPERation:ENABle

STATus:OPERation:ENABle *<unmask>* sets an enable mask to allow events recorded in the Event Register to send a summary bit to the Status Byte Register (Bit 7). For Multiplexer modules, when Bit 4 in the Operation Status Register is set to 1 and that bit is enabled by the STATus:OPERation:ENABle command, Bit 7 in the Status Register will be set to 1.

Parameters

Name	Type	Range of Values	Default Value
<unmask>	numeric	0 through 65,535	N/A

Comments

- **Related Commands:** [ROUTe:]SCAN

Example Enabling Operation Status Register Bit 4

STAT:OPER:ENAB 16 *! Enable Bit 4 of the Operation Status Register to be reported to Bit 7 (OPR) in the Status Byte Register.*

STATus:OPERation:ENABle?

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

Comments

- **Output Format:** Returns a decimal weighted value between 0 and 65,535, indicating which bits are set to true.
- **Maximum Value Returned:** The value returned is the value set by the STAT:OPER:ENAB *<unmask>* command. However, the maximum decimal weighted value used in this module is 256 (Bit 8 set to true).

Example **Query the Operation Status Enable Register**

STAT:OPER:ENAB? *! Query the Operation Status Enable Register.*

STATus:OPERation[:EVENt]?

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

Comments

- **Setting Bit 4 of the Operation Status Register:** Bit 4 (scan start) is set to 1 after a scanning cycle starts. Bit 4 returns to 0 (zero) after the STATus:OPERation[:EVENt]? command is sent.
- **Setting Bit 0 & Bit 1:** Bit 0 (waiting in Trigger layer) is set to 0 (default), when it is set to 1, the next trigger signal is available in Trigger layer. Bit 1 (waiting in Arm layer) is also set to 0 (default), when it is set to 1, the next trigger signal is available in Arm layer.
- **Returned Data after sending the STATus:OPERation[:EVENt]? Command:** The command returns “+16” if Bit 4 of the Operation Status Register is set to 1. The command returns “+0” if Bit 4 of the Operation Status Register is set to 0.

- **Event Register Cleared:** Reading the Event Register with the STATus:OPERation:EVENt? command clears the register.

- **Related Commands:** [ROUTe:]SCAN

Example Reading the Operation Status Register After a Scanning Cycle

STAT:OPER?	*! Return the bit values of the Operation Status Register.*
read the register value	*! +16 shows Bit 4 is set to 1;+0 shows Bit 4 is set to 0.*

STATus:PRESet

STATus:PRESet affects only the Operation Enable Register by setting all Enable Register bits to 0. It affects neither the “status byte” nor the “standard event status”. PRESet does not clear any of the Event Registers.

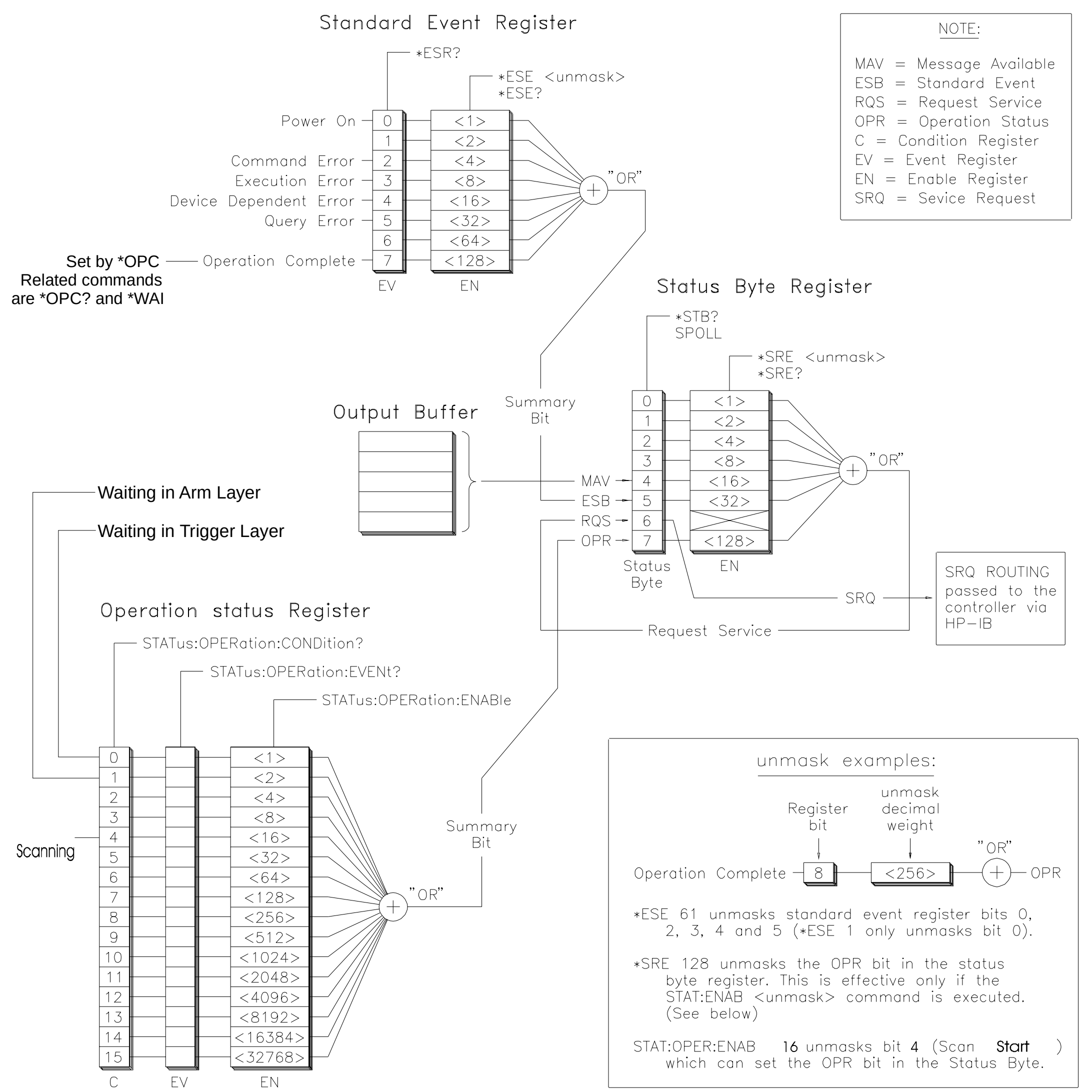


Figure 6-2. HP 3499A/B Status System Register Diagram

HP 3499A/B Switch/Control System can be operated in either one of the two system modes: SCPI mode and HP 3488A mode. This subsystem specifies and queries the instrument's system mode.

Subsystem Syntax

SYSMODE *<mode>*
SYSMODE?

SYSMODE

SYSMODE *<mode>* specifies a system mode for the HP 3499A/B Switch/Control system.

Parameters

Name	Type	Range of Values	Default Value
<mode>	discrete	0|1|SCPI|HP3488A	0|SCPI

Comments

- **System Mode:** The HP 3499A/B can be operated in either one of the two system modes: SCPI mode and HP 3488A mode. Specifying 0|SCPI will cause the instrument to operate in SCPI mode. Specifying 1|HP3488A will cause the instrument to return to HP 3488A mode.
- **Switching Modes:** Switching the system modes between SCPI mode and HP 3488A mode will cause the instrument to return to its default state, but the GPIB address and the RS-232 settings will remain at what they had been configured.
- **Switching Interval:** The switching between the two system modes should have a minimum interval of 5 seconds, otherwise an error will occur.

Example

SYSMODE 0

or

SYSMODE SCPI *! Specify the instrument's system mode.*

SYSMODE?

SYSMODE? queries the system mode of the HP 3499A/B Switch/Control system. The returned string will be either “SCPI” or “HP3488A”, indicating the system mode.

Examples

SYSMODE 1 (or HP3488A) *! Specify the instrument's system mode.*
SYSMODE? *! Query the instrument's system mode. “HP3488A” will be returned to indicate that the instrument is in HP 3488A mode.*

The **SYSTem** subsystem resets the modules in the specified slots and queries the module type. It can also query the error queue and the firmware revision of the instrument. In addition, this subsystem can be used to set the instrument to LOCAL or REMOTE mode, lock the front panel, and clear the previously stored instrument states.

Subsystem Syntax

```
SYSTem
    :CPON <slot>|ALL
    :CTYPe? <slot>
    :ERRor?
    :STATe:DELete <1-10>|ALL
    :LOCal
    :REMote
    :RWLock
    :VERSion?
```

SYSTem:CPON

SYSTem:CPON *<slot>|ALL* resets the module in the specified slot, or resets all the plug-in modules to their power-on state.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	0 - 5 for HP 3499A 0 - 2 for HP 3499B	N/A

Comments

- **Differences between *RST and CPON:** Both the SYSTem:CPON ALL and *RST opens all switching channels on the plug-in modules. For digital I/O modules, the two commands set the DIO ports to Input state. SYSTem:CPON *<slot>* opens the channels on the module specified in the command, while *RST resets HP 3499A/B, including all the plug-in modules.

- CPON has no effect on a scan configuration or on module pairing status.

Example

SYST:CPON 1 — *! Reset the module in Slot 1 to its power-on state (all channels open).*

SYSTem:CTYPe?

SYSTem:CTYPe? *<slot>* causes the instrument to return the module type in the specified slot, followed by the serial number of this module.

Parameters

Name	Type	Range of Values	Default Value
<slot>	numeric	1 - 5 for HP 3499A 1 - 2 for HP 3499B	N/A

Comments

- This command queries only one module type each time.
- **Modules' Type:** The types and descriptions of the existing modules (cards) are listed in Table 6-3.

Table 6-3. Module's Type Descriptions

MODULE (CARD) TYPE	HP P/N	DESCRIPTION (RETURNED)	
Slot is empty	N/A	NO CARD	00000
10-Channel MUX Module	HP 44470A	RELAY MUX	44470
10 Channel GP Relay Module	HP 44471A	GP RELAY	44471
20-Channel MUX Module	HP 44470D	RELAY MUX	44470[1]
20-Channel GP Relay Module	HP 44471D	GP RELAY	44471
High Frequency Scanner	HP 44472A	VHF SW	44472
4X4 Matrix Module	HP 44473A	MATRIX SW	44473
16-Bit Digital I/O Module	HP 44474A	DIGITAL IO	44474
Breadboard Module	HP 44475A	BREADBOARD	44475
Microwave Switch Module	HP 44476A/B	GP RELAY	44471
7-Channel Form C Relay Module	HP 44477A	GP RELAY	44471[2]
1.3GHz MUX Module	HP 44478A/B	VHF SW	44472[3]
40-Channel MUX Module	HP N2260A	40CH MUX	N2260A, Serial #
40-Channel GP Relay Module	HP N2261A	40CH GP	N2261A, Serial #
4X8 Matrix Module	HP N2262A	4X8 MATRIX	N2262A, Serial #
32-Bit Digital I/O Module	HP N2263A	32BIT DIO	N2263A, Serial #
12-Channel GP Relay + 3-Channel Power Relay + 16-Bit Digital I/O Module	N2264A	12+3 (5A) CH GP+16BIT DIO	N2264A, Serial #
4X4 Matrix + 16-Bit Digital I/O Module	N2265A	4X4 MATRIX +16BIT DIO	N2265A, Serial #
4-Bit Built-in Digital I/O	None	Built-in DIO	3499, Serial # of the mainframe's controller board

[1]. Both the HP 44470A/D return "RELAY MUX 44470". You must physically check the module to determine which one is present.

[2]. All the HP 44471A/D, 44476A/B and 44477A return "GP RELAY 44471". To determine if the module is an HP 44471A/D, 44476A/B or 44477A, check the switching channels. For HP 44471A/D & 44476A/B, you must physically check the modules to determine which one is present.

[3]. Both the HP 44478A/B return "VHF SW 44472". You must physically check the module to determine which one is present.

- **Serial Number:** Only some modules' serial number can be read back. These modules are: HP N2260A, N2261A, N2262A, N2263A, N2264A and N2265A. For other modules, executing the command SYSTem:CTYPe? causes the instrument to return the module type only.

Example SYST:CTYP? 1 *! Query the module type.*

SYSTem:ERRor?

SYSTem:ERRor? queries the instrument's error queue. The error numbers and corresponding error messages in the error queue are returned. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error stored. See "Error Messages" on Page 271 for the error numbers and messages.

Comments

- **Error Numbers/Messages in the Error Queue:** Each error generated by HP 3499A/B stores an error number and a corresponding error message in the error queue.
- **Clearing the Error Queue:** When all the errors from the queue are read, the errors are cleared and the ERROR annunciator turns off. When the queue is empty, each following SYSTem:ERRor? query returns: +0, "No error". To clear all error numbers/messages in the queue, execute the *CLS command or power-on the instrument.
- **Maximum Error Numbers/Messages in the Error Queue:** The queue holds a maximum of 10 error number/message pairs. If the queue overflows, the last error number/message in the queue is replaced by: -350, "Queue overflow". The least recent error numbers/messages remain in the queue, and the most recent are discarded.

Example SYST:ERR? *! Query the error queue.*

SYSTem:LOCal

SYSTem:LOCal sets the instrument (HP 3499A/B) in the local mode for RS-232 operation. All keys on the front panel are fully functional in this mode.

Example SYST:LOC *! Set the instrument in the local mode.*

SYSTem:REMote

SYSTem:REMote sets the instrument (HP 3499A/B) in the remote mode for RS-232 operation. All keys on the front panel, except **Local, View, Mon, Enter,** the knob and the two arrow keys, are disabled in this mode.

Comments

- When the HP 3499A/B has been addressed to listen, the RMT & ADRS annunciators turn on to indicate the instrument is in the Remote mode.

- The ERROR annunciator turns on whenever an error occurs.

Example SYST:REM — *! Set the instrument in remote mode. The RMT & ADRS annuciators turn on.*

SYSTem:RWLock

SYSTem:RWLock sets the instrument (HP 3499A/B) in the remote mode for RS-232 operation. All keys on the front panel are disabled in this mode.

Comments

- When the HP 3499A/B has been addressed to listen, the REM & ADRS annunciators turn on to indicate the instrument is in the Remote mode.
- This command is the same as the SYSTem:REMote command except that all keys on the front panel are disabled.

Example SYST:RWL — *! Set the instrument in the remote mode. The RMT & ADRS annuciators turn on, all keys are disabled.*

SYSTem:STATe:DELete

SYSTem:STATe:DELete ***<1-10>|ALL*** clears one or all the previously stored instrument states.

Example

*RST	*! Reset the instrument.*
CLOSe (@100:209)	*! Close these channels.*
*SAV 5	*! Store the instrument channel setup (in location 5).*
SYST:STAT:DEL 5	*! Clear the previously stored instrument channel setup (in location 5).*

SYSTem:VERSion?

SYSTem:VERSion? queries the instrument to determine the present SCPI version.

Example SYST:VERS? — *! Returned string "Version A.01.00" indicates the present firmware of the instrument.*

The **TRIGger** command subsystem controls the triggering operation for the HP 3499A/B Switch/Control System.

Subsystem Syntax

```
TRIGger
    [:IMMediate]
    :SOURce <source>
    :SOURce?
    :TIMer <seconds>|MIN|MAX
    :TIMer?
```

TRIGger[:IMMediate]

TRIGger[:IMMediate] is used as a trigger source (for ARM:SOURce HOLD and TRIGger:SOURce HOLD) to advance the scan through the *scan_list*. It can be used to trigger a suspended scan operation.

Comments

- **Executing the TRIGger[:IMMediate] Command:** A scan list must be defined with [ROUTe:]SCAN *<scan_list>* and an INITiate[:IMMediate] command must be executed before executing TRIGger[:IMMediate].
- **Related Commands:** INITiate, [ROUTe:]SCAN, TRIGger:SOURce

Example

Advancing Scan Using TRIGger Command

ARM:SOUR HOLD	*! Set arm source to HOLD.*
TRIG:SOUR HOLD	*! Set trigger source to HOLD.*
SCAN (@100:105)	*! Define a scan list.*
INIT	*! Start scanning cycle.*
loop statement	*! Start count loop.*
TRIG	*! Advance the scan from arm layer to trigger layer.*
TRIG	*! Advance the scan to next channel (trigger layer).*
increment loop	*! Increment loop count.*

TRIGger:SOURce

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

Parameters

Name	Type	Parameter	Default
<source>	discrete	BUS|EXT|IMM|TIM|MIX|HOLD	IMM

Comments

- **Enabling the Trigger Source:** The TRIGger:SOURce command only selects the trigger source for the trigger layer. The trigger source can be selected using the command TRIGger:SOURce, or the trigger source is in the power-on state: TRIGger:SOURce IMMediate.

- **Using the TRIGger Command:** You can use TRIGger[:IMMediate] to advance the scan when a *TRG or a TRIGger:SOURce HOLD is selected.

- **Using Source BUS:** With BUS selected, the advance signal is either *TRG or GET.

- **Using Source EXTernal:** With EXTernal selected, the advance signal is an external trigger.

- **Using Source IMMediate:** With IMMediate selected, scan will continue immediately after a channel is closed.

Note If a delay time has been set for the last closed channel, the scan will not continue until the delay time is time-out.

- **Using Source TIMer:** With TIMer selected, the scan will continue after the timer is time-out. The TIMer must be set with the command TRIGger:TIMer.

- **Using Source MIX:** With MIX selected, the scan will continue after a BUS event or an EXTernal event comes.

- **Using Source HOLD:** The scan will continue after a TRIGger[:IMMediate] is received.

- **Related Commands:** ABORt, [ROUTe:]SCAN, OUTPut

- ***RST Condition:** TRIGger:SOURce IMMediate

Example 1 **Scanning Using External Triggers**

```
*RST                     ! Reset the instrument.
TRIG:SOUR  EXT           ! Set trigger source to external.
SCAN  (@100:105)         ! Set channel list.
INIT                     ! Start scanning cycle.
(trigger externally)     ! Advance channel list to next channel.
```

Example 2 **Scanning Using Bus Triggers**

```
*RST                     ! Reset the instrument.
TRIG:SOUR  BUS           ! Set trigger source to bus.
SCAN  (@100:105)         ! Set channel list.
INIT                     ! Start scanning cycle.
*TRG                     ! Advance channel list to next channel.
```

TRIGger:SOURce?

TRIGger:SOURce? queries the current trigger source of the instrument. One of BUS, EXT, IMM, TIM, MIX, HOLD will be returned to indicate the trigger source.

Example	TRIG:SOUR EXT	*! Set external trigger source.*
	TRIG:SOUR?	*! Query trigger source.*

TRIGger:TIMer

TRIGger:TIMer *<seconds>|MIN|MAX* sets the channel-to-channel interval in trigger layer. This timer is valid only after the command TRIGger:SOURce TIMer.

Parameter

Name	Type	Parameter	Default Value
<seconds>	numeric	0 - 99999.999 (seconds) MIN = 0; MAX = 99999.999	0

Comments

- **Difference between TRIGger:TIMer and ARM:TIMer:** The command TRIGger:TIMer is used to set the channel-to-channel interval in trigger layer. Whereas the command ARM:TIMer is used to set the sweep-to-sweep interval in arm layer.
- **TRIGger:TIMer Command:** This setting is valid only after the TIMer is selected in command TRIGger:SOURce.
- **Valid Value of <*seconds*>:** 0 - 99999.999 (seconds), with 1 ms resolution.
- ***RST Condition:** The default value is 0 after an instrument power-on or reset. *CLS command has no effect on the TRIG:TIM.

Example	TRIG:SOUR TIM	*! Set the trigger source in trigger layer.*
	TRIG:TIM 10	*! Set the timer to 10 seconds.*
	SCAN (@100:139)	*! Specify a sequence of channels to be scanned.*
	INIT	*! Start scanning through the scan_list.*

TRIGger:TIMer?

TRIGger:TIMer? queries the channel-to-channel interval in trigger layer. A value between 0 and 99999.999 (seconds) will be returned, indicating the channel-to-channel interval when scanning through the *scan_list*.

Example	TRIG:SOUR TIM	*! Set the trigger source in trigger layer.*
	TRIG:TIM 10	*! Set the timer to 10 seconds.*
	TRIG:TIM?	*! Query the channel-to-channel interval. Returned value "10" indicates that the interval is 10 seconds.*

SCPI Command Quick Reference

The following table summarizes the SCPI commands for the HP 3499A/B.

<table>
<tr><th colspan="2">Command</th><th>Description</th></tr>
<tr><td>ABORt</td><td></td><td>Abort a scan in progress regardless
of the trigger sources.</td></tr>
<tr><td>ARM</td><td>:SOURce *<BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>*
:SOURce?
:COUNt *<number>*
:COUNt? *[MIN|MAX]*
:TIMer *<seconds>|MIN|MAX*
:TIMer?</td><td>Set trigger source in ARM layer.
Query trigger source in ARM layer
Set counter in ARM layer.
Query counter in ARM layer.
Set timer for sweep-to-sweep (sweeping).
Query timer in arm layer.</td></tr>
<tr><td>CONFigure</td><td>:EXTernal[:TRIGger]:SOURce *<number>*
:EXTernal[:TRIGger]:SOURce?
:EXTernal[:TRIGger][:OUTPut] *<0|1|OFF|ON>*
:EXTernal[:TRIGger][:OUTPut]?</td><td>Select the trigger source.
Query the trigger source.
Turn off/on the external trigger output.
Query state of external trigger output.</td></tr>
<tr><td>DIAGnostic</td><td>:DISPlay[:INFOrmation] *<message>*
:DISPlay:STATe *<0|1|OFF|ON>*
:DISPlay:STATe?
:MONitor *<slot>|<channel>|<port>|-1*
:MONitor?
[:RELay]:CYCLes? *<channel_list>*
[:RELay]:CYCLes:MAX? *<slot>*
[:RELay]:CYCLes:CLEar *<channel_list>*
SPEEK? *<slot>,<register>*
SPOKE *<slot>,<register>,<data>*</td><td>Display message on front panel.
Disable/Enable display.
Query state of display.
Monitor a slot or a channel/port, or disable a monitor.
Query which slot or channel is monitored.
Query relay cycle of the specified channels.
Query maximum cycles of channel relays.
Clear channel relay cycle.
Read a 8-bit data from the *<register>* specified.
Write a 8-bit data to the *<register>* specified.</td></tr>
<tr><td>INITiate</td><td></td><td>Start a scanning cycle.</td></tr>
<tr><td>[ROUTe:]</td><td>[CHANnel:]DELay *<seconds>,<channel_list>|ALL*
[CHANnel:]DELay? *<channel_list>*
CLOSe *<channel_list>*
CLOSe? *<channel_list>*
CLOSe:STATe?
CPAir *<slot1>,<slot2>|-1*
CPAir?
FUNCtion *<slot>,<1|2|3|4|WIRE1|WIRE2|BIWIRE2|WIRE4>*
FUNCtion? *<slot>*
OPEN *<channel_list>|ALL*
OPEN? *<channel_list>*
SCAN[:LIST] *<scan_list>*
SCAN[:LIST]?
SCAN CLEar
SCAN:SIZE?</td><td>Set channel-to-channel interval.
Query channel-to-channel interval.
Close one or multiple channels.
Queries relay closed state.
Query all closed relays.
Pair two cards of the same type or cancel a pair.
Query the paired cards.
Set function mode for HP N2260A.
Query the function mode for HP N2260A.
Open one, multiple or all channels.
Query channels open state.
Set a sequence of channels to be scanned.
Query the scan list.
Clear the scan list.
Query the size of the scan list.</td></tr>
</table>

<table>
<tr><th colspan="2">Command</th><th>Description</th></tr>
<tr><td>SOURce
:DIGital</td><td>:MODE *<slot>,<mode>*
:MODE? *<slot>*
:CONTrol:POLarity *<slot>,<polarity>*
:CONTrol:POLarity? *<slot>*
:FLAG:POLarity *<slot>,<polarity>*
:FLAG:POLarity? *<slot>*
:IO:POLarity *<slot>,<polarity>*
:IO:POLarity? *<slot>*
:DATA[:<BYTE|WORD|LWORD>]:POLarity
<port>,<0|1|POS|NEG>
:DATA[:<BYTE|WORD|LWORD>]:POLarity? *<port>*
:DATA:BIT *<bit_port>,<0|1>*
:DATA[:<BYTE|WORD|LWORD>[:VALue]] *<port>,<data>*
:DATA[:<BYTE|WORD|LWORD>]:BLOCK
<port>,<block_data>
:DATA:[<BYTE|WORD|LWORD>:]TRACE
<port>,<sys_mem_name>
:TRACe:DEFine *<sys_mem_name>,<size>[,<fill>]*
:TRACe:DEFine? *<sys_mem_name>*
:TRACe:CATalog?
:TRACe[:DATA] *<sys_mem_name>,<block_data>*
:TRACe:DELete[:NAME] *<sys_mem_name>*
:TRACe:DELete:ALL</td><td>Set the digital I/O mode.
Query the digital I/O mode.
Set the polarity of control lines.
Query the polarity of control lines.
Set the polarity of flag lines.
Query the polarity of flag lines.
Set the polarity of I/O direction lines.
Query the polarity of I/O direction lines.
Set the polarity of a port.

Query the polarity of a digital I/O port.
Write a 0/1 to a digital I/O bit_port.
Write a data to the specified port.
Write a block of data to the specified port.

Write the data block in system memory to
the specified digital I/O port.
Define the size of data block.
Query the size of data block.
Query the defined system memory name.
Write data to the data block in memory.
Remove one data block in system memory.
Remove all data block in system memory.</td></tr>
<tr><td>SENSe
:DIGital</td><td>:DATA:BIT? *<bit_port>*
:DATA[:<BYTE|WORD|LWORD>][:VALue]? *<port>*
:DATA[:<BYTE|WORD|LWORD>]:BLOCK? *<port>,<size>*
:DATA:[<BYTE|WORD|LWORD>:]TRACE
<port>,<sys_mem_name>
:TRACe[:DATA]? *<sys_mem_name>*</td><td>Read the specified bit_port.
Read data from the specified port.
Read a block of data from the specified port.
Read a block of data from the specified port to
the predefined memory block.
Get the data block being read.</td></tr>
<tr><td>STATus</td><td>:OPERation:CONDition?
:OPERation:ENABle *<unmask>*
:OPERation:ENABle?
:OPERation[:EVENt]?
:PRESet</td><td>Query the Operation Condition register.
Set the Operation Enable register.
Query the Operation Enable register.
Query the Operation Event register.
Clear the Standard Operation enable register.</td></tr>
<tr><td colspan="2">SYSMODE *<0|1|SCPI|HP3488A>*
SYSMODE?</td><td>Specify a system mode for the instrument.
Query the system mode for the instrument.</td></tr>
<tr><td>SYSTem</td><td>:CPON *<0|1|2|3|4|5|ALL>*
:CTYPe? *<1|2|3|4|5>*
:ERRor?
:LOCal
:REMote
:RWLock
:STATe:DELete *<1-10>|ALL*

:VERSion?</td><td>Reset the module to its power-on state.
Query the card type and the serial number.
Query the error queue.
Set the instrument to local mode.
Set the instrument to remote mode.
Lock all keys on the front panel.
Clear one or all the previously stored
instrument states.
Query the firmware version of the instrument.</td></tr>
<tr><td>TRIGger</td><td>[:IMMediate]
:SOURce *<BUS|EXTernal|IMMediate|TIMer|MIX|HOLD>*
:SOURce?
:TIMer *<seconds>|MINimum|MAXimum*
:TIMer? *<MINimum|MAXimum>*</td><td>Software trigger for HOLD off triggering.
Select trigger source in trigger layer.
Query trigger source in trigger layer.
Set timer for channel-to-channel (scanning).
Query timer in trigger layer.</td></tr>
</table>

IEEE 488.2 Common Command Reference

The following table lists the IEEE 488.2 Common (*) Commands accepted by the HP 3499A/B. For more information on Common Commands, refer to the *ANSI/IEEE Standard 488.2-1987*.

Command	Command Description
*CLS	Clear all status registers (see STATus:OPERation[:EVENt]?) and clears the error queue.
*ESE *<register value>*	Enable Standard Event.
*ESE?	Enable Standard Event Query.
*ESR?	Standard Event Register Query.
*IDN?	Query the instrument's ID. The returned string will be the ID of MFG, followed by the Model #, Serial # and firmware revision of the instrument.
*OPC	Operation Complete.
*OPC?	Operation Complete Query.
*RCL *<1-10>*	Recall the instrument state saved by *SAV. You must reconfigure the scan list.
*RST	Reset the module. Opens all channels and invalidates current channel list for scanning. Sets ARM:COUN 1, TRIG:SOUR IMM, and INIT:CONT OFF.
*SAV *<1-10>*	Store the instrument state but does not save the scan list.
*SRE *<register value>*	Service request enable, enables status register bits.
*SRE?	Service request enable query.
*STB?	Read status byte query.
*TRG	Trigger the module to advance the scan when scan is enabled and trigger source is TRIGger:SOURce BUS.
*TST?	Execute an internal self-test. A value of "+ 0" read back indicates all tests have passed. The other value indicates the instrument failed the tests. + 0 all tests have passed. + 1 ROM test failed. + 2 GPIB test failed. + 3 RS-232 test failed. + 4 Front Panel test failed.
*WAI	Wait to Complete.

Chapter 7
HP 3488A Command Reference

About This Chapter

HP 3499A/B Switch/Control Unit can be operated with existing HP 3488A commands[1]. This chapter provides the necessary information to program the instrument followed by detailed descriptions of the HP 3488A commands. A quick reference is listed at the end of this chapter. Chapter contents include:

HP 3488A Command Overview

General Information

To support continuing using HP 3488A plug-in modules and DOES NOT MAKE BIG CHANGE to existing HP 3488A application examples, most of the compatible HP 3488A commands included in the HP 3488A mode have the same behavior as in HP 3488A Switch/Control Unit but a little difference.

Note It is highly recommended that the users use SCPI commands (in SCPI mode) instead of HP 3488A commands (in HP 3488A mode). For the SCPI commands are much more powerful and flexible, the functions of compatible HP 3488A commands are only a subset of the SCPI commands.

HP 3488A Commands

The HP 3488A compatible commands can perform almost all the functions operated through the front panel, and a large amount of the functions performed in SCPI mode.

The HP 3488A commands are applicable to all the available plug-in modules for the HP 3499A/B, which include both the existing HP 3488A plug-in modules and the new developed option modules.

The HP 3488A commands are divided into three main categories: the Standard Commands, appropriate for all available plug-in modules, the Digital Commands used particularly with the digital I/O modules (HP N2263A, HP 44474A, etc.) and the HP 3488A System Commands.

[1]. The instrument must be set to HP 3488A mode first.

Simplified Programming Overview

Slot Number

In HP 3488A, there are only five programmable slots numbered as Slots 1 through 5. In HP 3499A, the full-rack-width mainframe, there are six programmable slots numbered as Slot 0 through 5. The Slot 1 through Slot 5 are available for the plug-in modules; Slot 0 is specified to the built-in 4-bit digital I/O.

HP 3499B is a half-rack-width mainframe with only three programmable slots. Slot 0 is also reserved for the 4-bit built-in digital I/O. The other two slots are for the plug-in modules.

The slot numbers are labelled on the rear panel of an HP 3499A/B.

Channel Number

The channels or bits of the available plug-in modules are numbered in different ways. The modules include the MUX, GP relay, Matrix, Digital I/O and the multifunction modules. See Table 7-1 on Page 140 for the detailed channel/bit information.

Note Pay special attention to the 4-bit built-in digital I/O. The port number of it is 090 (the first 0 refers to Slot 0), and its bits are numbered as 091-094.

Channel Address

Channel_address is used to refer to the channel or bit address of the HP 3499A/B plug-in modules. *Channel_address* is in the form of ***snn***, where ***s = Slot Number*** (0-5 for HP 3499A, 0-2 for HP 3499B) and ***nn = Channel Number*** (plug-in modules dependent). Slot 0 is reserved for the 4-bit built-in digital I/O, Slots 1-5 (HP 3499A) or 1-2 (HP 3499B are for the plug-in modules.

Table 7-1 lists the channels/bits for the existing plug-in modules.

Table 7-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules

HP P/N (Descriptions)	*Channel Address* (*snn*, *s* = Slot Number; *nn* = Channel Number)	Slot Number	
		HP 3499A	HP 3499B
HP 44470A 10-Channel MUX Module	*s00, s01, s02, s03... s08, s09*	1, 2, 3, 4, 5	1, 2
HP 44470D 20-Channel MUX Module	*s00, s01, s02, s03... s18, s19*	1, 2, 3, 4, 5	1, 2
HP 44471A 10-Channel GP Relay Module	*s00, s01, s02, s03... s08, s09*	1, 2, 3, 4, 5	1, 2
HP 44471D 20-Channel GP Relay Module	*s00, s01, s02, s03... s18, s19*	1, 2, 3, 4, 5	1, 2
HP 44472A Dual 4-Channel VHF Module	Group 0: *s00, s01, s02, s03*; Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP 44473A 4X4 Matrix Module	Row: 0, 1, 2, 3; Column: 0, 1, 2, 3 (*s00, s01, s02, s03; s10, s11, s12, s13; s20, s21, s22, s23; s30, s31, s32, s33)*[1]	1, 2, 3, 4, 5	1, 2

Table 7-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules

HP P/N (Descriptions)	*Channel Address* (*snn*, *s* = Slot Number; *nn* = Channel Number)	Slot Number	
		HP 3499A	HP 3499B
HP 44474A 16-Bit Digital I/O Module	Individual Bits: *s00, s01, s02... s14, s15;* 8-Bit Ports: *s00, s01;* 16-Bit Port: *s02*	1, 2, 3, 4, 5	1, 2
HP 44475A Breadboard Module	N/A	1, 2, 3, 4, 5	1, 2
HP 44476A 3-Channel 13 GHz Microwave Switch Module	*s00, s01, s02*	1, 2, 3, 4, 5	1, 2
HP 44476B 2-Channel 26 GHz Microwave Switch Module	*s00, s01*	1, 2, 3, 4, 5	1, 2
HP 44477A 7-Channel Form-C Relay Module	*s00, s01, s02, s03, s04, s05, s06*	1, 2, 3, 4, 5	1, 2
HP 44478A 50 Ω 1.3 GHz MUX Module	Group 0: *s00, s01, s02, s03* Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP 44478B 75 Ω 1.3 GHz MUX Module	Group 0: *s00, s01, s02, s03* Group 1: *s10, s11, s12, s13*	1, 2, 3, 4, 5	1, 2
HP N2260A 40-Channel MUX Module[2]	*s00, s01...s38, s39*	1, 2, 3, 4, 5	1, 2
HP N2261A 40-Channel GP Relay Module	*s00, s01, s02, s03... s37, s38, s39*	1, 2, 3, 4, 5	1, 2
HP N2262A 4X8 Matrix Module	Row 0, 1, 2, 3; Column 0, 1, 2, 3... 6, 7 *(s00, s01, s02... s07; s10, s11, s12... s17; s20, s21, s22... s27; s30, s31, s32... s37)*	1, 2, 3, 4, 5	1, 2
HP N2263A 32-Bit Digital I/O Module	Individual Bits: *s00, s01, s02... s30, s31;* 8-Bit Ports: *s00, s01, s02, s03;* 16-Bit Ports: *s04, s05;* 32-Bit Port: *s06.*	1, 2, 3, 4, 5	1, 2
HP N2264A 12-Channel GP Relay + 3-Channel High-current GP Relay + 16-Bit Digital I/O Module	12 GP Relays: *s00, s01, s02... s10, s11;* 3 High-current GP Relays: *s20, s21, s22;* **16-Bit Digital I/O:** Individual Bits: *s30, s31, s32... s44, s45;* 8-Bit Ports: *s30, s31;* 16-Bit Port: *s32.*	1, 2, 3, 4, 5	1, 2
HP N2265A 4X4 Matrix + 16-Bit Digital I/O Module	4X4 Matrix: Row 0, 1, 2, 3; Column 0, 1, 2, 3 *(s00, s01, s02, s03; s10, s11, s12, s13; s20, s21, s22, s23; s30, s31, s32, s33)* **16-Bit Digital I/O:** Individual Bits: *s40, s41, s42... s54, s55;* 8-Bit Ports: *s40, s41;* 16-Bit Port: *s42.*	1, 2, 3, 4, 5	1, 2

Table 7-1. Channel/Bit Address of the HP 3499A/B Plug-in Modules

HP P/N (Descriptions)	***Channel Address*** (*snn*, *s* = Slot Number; *nn* = Channel Number)	**Slot Number**	
		HP 3499A	**HP 3499B**
4-Bit Built-in Digital I/O	Individual Bits: *091, 092, 093, 094;* 4-Bit Port: *090.*	0	0

[1]. The channel number in a matrix module is formed in Slot-Row-Column format, i.e., channel address s23 means row 2, column 3 in the specific slot.
[2]. In HP 3488A mode, HP N2260A can be used only as a 40-channel 2-wire MUX.

Programming the Instrument

Here is an BASIC application example performing 4-wire ohms measurement with two paired MUX modules.

Assume there is an HP 3499A or 3499B in HP 3488 Mode, a multimeter (HP 34401A or HP 3478A or other DMM, an HP 3478A in this example), two MUX modules (HP 44470A/D or HP N2260A, the HP 44470D 20-channel MUX modules in this example). Be sure that the two HP 44470D modules are installed in Slots 1 & 2. Refer to Figure 7-1 on Page 143.

The address of the DMM is 723, and the address of HP 3499A/B is 709. Several HP 3488A commands are to be used to finish the measurement.

```
10   CLEAR 7                        ! Reset HP 3499A/B and the DMM.
20   OUTPUT 709 ; "CPAIR 1,2"       ! Pair the cards in Slots 1 and 2.
30   OUTPUT 709 ; "SLIST 100-119"   ! Set a scan list to be scanned.
40   OUTPUT 723 ; "H4T4"            ! Program the 3478A for 4-wire ohms
                                    measurements (H4) and trigger hold
                                    (T4).
50   FOR I = 1 TO 20                ! Lines 50 through 90 set up a loop to scan
                                    through the scan list. The reading are
                                    stored in array A(I).
60   OUTPUT 709 ; "STEP"
70   TRIGGER 723
80   ENTER 723 ; A(I)
90   NEXT I
100  !
110  ! Resistance measurements goes here
120  !
130  END
```

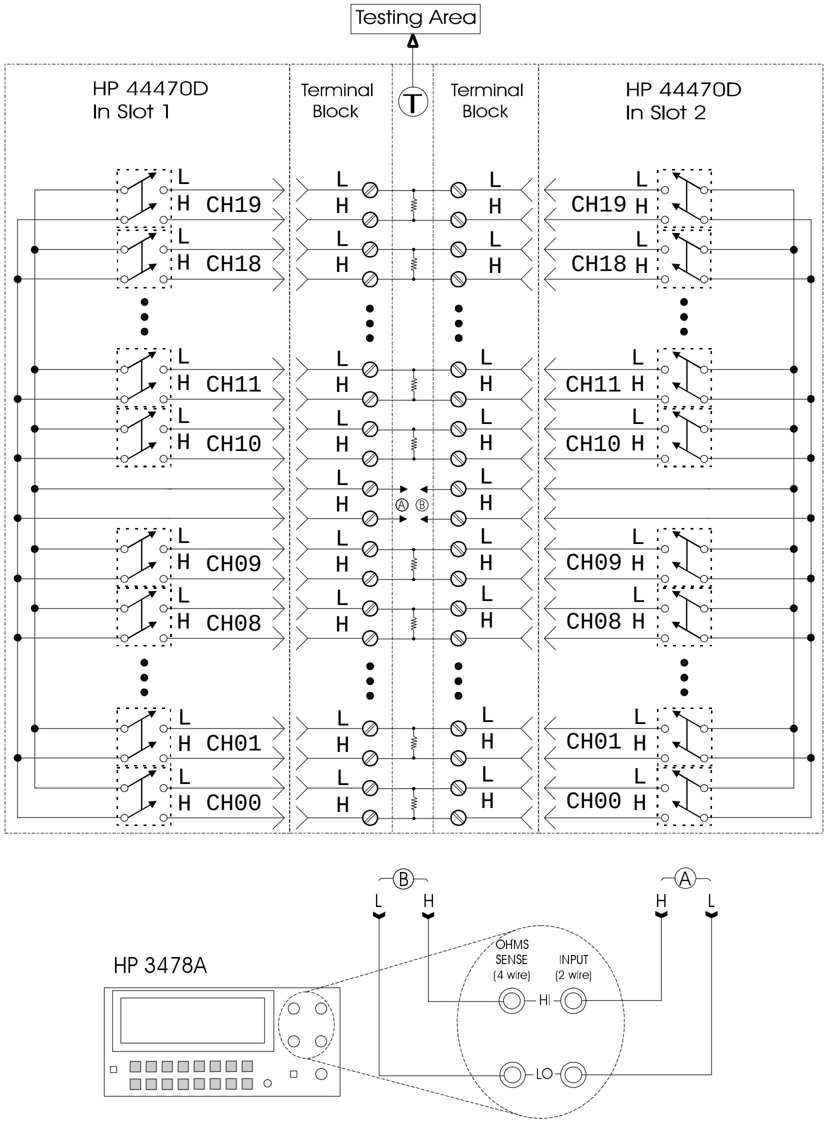


Figure 7-1. 4-Wire Ohms Measurement

HP 3488A Commands Reference

The HP 3488A commands are divided into three main categories:

- The Standard Commands;
- The Digital Commands;
- The HP 3488A System Commands.

The Standard Commands are used to open/close/scan the switching channels or digital I/O bits, to view and monitor the channel/bit status, to query the module's type and pair the same type modules. They are also used to reset the modules plugged into the HP 3499A/B. These commands[1] include:

Subsystem Syntax

CLOSE/OPEN *<channel_address>[,<channel_address>...]*
VIEW *<channel_address>*
CTYPE *<slot>*
CRESET *<slot>*[,*<slot>,...*]
SLIST *<channel_address>[(, or -)<channel_address>...<channel_address>]*
STEP
CHAN [*<channel_address>*]
CMON *<slot>*
DELAY [*<time in mS>*]

CLOSE a channel/bit

CLOSE *<channel_address>[,<channel_address>,<channel_address>...]* is used to simply close one or more channels on the non digital I/O (DIO) modules. It can also be used to "clear" bits on the digital I/O modules. The CLOSE command does not open any channels/bits that were previously closed.

Parameters

Channel_address is in the form of **snn**, where **s** = Slot Number (0 - 5 for HP 3499A, 0-2 for HP 3499B) and **nn** = Channel Number (modules dependent). Slot 0 is reserved for the 4-bit built-in digital I/O, Slots 1-5 (HP 3499A) or 1-2 (HP 3499B) are for the plug-in modules. For more information about channel/bit address, refer to Table 7-1 on Page 140.

Comments

- **Multiple Close:** Several channels or bits can be closed with one CLOSE command by separating the channel or bit addresses with a comma. If more than one channel or bit is specified, they are closed or bits "cleared" in the order listed.
- **DIO Modules:** When CLOSE is used with the DIO modules (HP 44474A, N2263A, N2264A, N2265A), the DIO modules must be in either default Static Mode #1 or Static Mode #2. Using the CLOSE command in any other mode will cause an error. In these modes there is no read or write handshaking.
- **4-Bit Built-in DIO:** The bits 091-094 on the 4-bit built-in digital I/O can be also included in the *channel_address*.
- **Reset Status:** All the channels/bits in the plug-in modules are opened. For the DIO modules, all bits are operating as input bits, no handshaking enabled.
- **Related Command:** OPEN.

[1]. In the following discussions, brackets [ ] indicate optional parameters, items in brackets < > are mandatory.

Example OUTPUT 709; “CLOSE 102, 103, 212, 313” *! Close the specific channels.*

OPEN a channel/bit

OPEN ***<channel_address>[,<channel_address>,<channel_address>...]*** is used to open one or multiple channels/bits on the plug-in modules.

Parameters *Channel_address* is in the form of snn, where s = Slot Number (0 - 5 for HP 3499A, 0-2 for HP 3499B) and nn = Channel Number (modules dependent). Slot 0 is reserved for the 4-bit built-in digital I/O, Slots 1-5 (HP 3499A) or 1-2 (HP 3499B) are for the plug-in modules. For more information about channel/bit address, refer to Table 7-1 on Page 140.

Comments

- **Multiple Open:** Several channels/bits can be opened with one OPEN command by separating the channel/bit addresses with a comma. If more than one channel/bit is specified, they are opened in the order listed. Use CARD RESET command to open all channels/bits on the modules, it is easier than listing each channel/bit.

- **DIO Modules:** When OPEN is used with the DIO modules (HP 44474A, N2263A, N2264A, N2265A), the DIO modules must be in either default Static Mode #1 or Static Mode #2. Using the OPEN command in any other mode will cause an error. In these modes there is no read or write handshaking.

- **4-Bit Built-in DIO:** The bits 091-094 on the 4-bit built-in digital I/O can be also included in a *channel_address*.

- **Reset Status:** All the channels in the plug-in modules are opened. For the DIO modules, all bits are operating as input bits. There is no handshaking enabled.

- **Related Command:** CLOSE.

Example OUTPUT 709; “OPEN 103,105,113,116” *! Open channels 3, 5, 13, 16 in Slot 1.*

VIEW a channel/bit

VIEW ***<channel_address>*** is used to look at the state, either open or closed of a particular channel or a DIO bit. The HP 3499A/B responds with the string “OPEN 1” if the specified channel/bit is open. If the specified channel/bit is closed, the HP 3499A/B responds with the string “CLOSED 0”.

Parameters *Channel_address* is in the form of snn, where s = Slot Number (0 - 5 for HP 3499A, 0-2 for HP 3499B) and nn = Channel Number (modules dependent). For more information about channel/bit address, refer to Table 7-1. on Page 140.

Comments

- Only one channel/bit can be “viewed” each time with a VIEW command.

- VIEW can only be used to look at input bits. If an attempt is made to VIEW an output bit, the 8-bit port where the bit is located will revert to an input port.

Example

```
10 OUTPUT 709; "VIEW 105"      ! View channel 5 on slot 1.
20 ENTER 709; A$               ! Input the response from the HP 3499A/B.
30 DISP A$                     ! A$ will either be "OPEN 1" or "CLOSED 0".
```

or

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

Card TYPE

CTYPE *<slot>* causes the HP 3499A/B to output the name and number of the module in the specified slot. <*Slot*> = Slot Number (0-5 for HP 3499A, 0-2 for HP 3499B). When Slot 0 is specified, the HP 3499A/B will return "Built-in digital I/O".

Table 6-2 lists the card (module) type descriptions of the existing plug-in modules.

Table 7-2. Card Type Descriptions

CARD TYPE	HP P/N	DESCRIPTION (DISPLAY)	
Slot is empty	N/A	NO CARD	00000
10-Channel MUX Module	HP 44470A	RELAY MUX	44470
10 Channel GP Relay Module	HP 44471A	GP RELAY	44471
20-Channel MUX Module	HP 44470D	RELAY MUX	44470[1]
20-Channel GP Relay Module	HP 44471D	GP RELAY	44471
High Frequency Scanner	HP 44472A	VHF SW	44472
4X4 Matrix Module	HP 44473A	MATRIX SW	44473
16-Bit Digital I/O Module	HP 44474A	DIGITAL IO	44474
Breadboard Module	HP 44475A	BREADBOARD	44475
Microwave Switch Module	HP 44476A/B	GP RELAY	44471
7-Channel Form C Relay Module	HP 44477A	GP RELAY	44471[2]
1.3GHz MUX Module	HP 44478A/B	VHF SW	44472[3]
40-Channel MUX Module	HP N2260A	40CH MUX	N2260A
40-Channel GP Relay Module	HP N2261A	40CH GP	N2261A
4X8 Matrix Module	HP N2262A	4X8 MATRIX	N2262A
32-Bit Digital I/O	HP N2263A	32BIT DIO	N2263A
12-Channel GP Relay + 3-Channel High-current GP Relay + 16-Bit Digital I/O	HP N2264A	12+3 (5A) CH GP+16BIT DIO	N2264A

Table 7-2. Card Type Descriptions

CARD TYPE	HP P/N	DESCRIPTION (DISPLAY)	
4X4 Matrix + 16-Bit Digital I/O	HP N2265A	4X4 MATRIX+ 16BIT DIO	N2265A
4-Bit Built-in Digital I/O	N/A	Built-in Digital I/O	N/A

[1]. Both the HP 44470A/D display “RELAY MUX 44470”. You must physically check the module to determine which one is present.

[2]. All the HP 44471A/D, 44476A/B and the 44477A display “GP RELAY 44471”. To determine if the module is an HP 44471A/D, 44476A/B or 44477A, turn the knob on the front panel to check the switching channels and determine the modules installed. For HP 44471A/D & 44476A/B, you must physically check the modules to determine which one is present.

[3]. Both the HP 44478A/B modules display “VHF SW 44472”. You must physically check the module to determine which one is present.

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

CRESET *<slot>[,<slot>...]* is used to reset all channels/bits on the specified modules to their open state. Only the modules in the specified slots are affected.

Comments

- **Switching Module:** All the switching channels on the specific module are reset to their open state.
- **DIO Module:** A DIO module is reset to its default mode. That means the bits on the module are set to open (high impedance), and the module is in the Static Mode #1 (no handshaking).
- **Related Command:** RESET

Example

```
OUTPUT 709; “CRESET 2”            ! Reset the module in slot 2.
```

Card PAIR

CPAIR *<slot>,<slot>* is used to pair up two same (type) plug-in modules, e.g. two HP N2261A modules. This operation will effectively assign both modules to both slot numbers so that closing/opening/scanning a channel on either one module will perform the same operation on the respective channel on the other module.

Comments

- This feature is especially useful when doing 4-wire scanning with the MUX modules, such as HP 44470A/D, HP N2260A, etc.
- Commands used with the CPAIR function are: CLOSE, OPEN, CRESET, CHAN, STEP, DWRITE and DREAD. Of course, the channels/bits on the paired slots can be included into a scan list.
- Executing a CPAIR command cancels any previous CPAIR command that

involved either of the two modules. It is possible, however, to have two sets of card pairs, e.g. Slot 1 paired with 2 and Slot 3 paired with 4.

- **Paired DIO Modules:** Two same (type) DIO modules used in Mode #1 or #2 can be paired[1].

- ***RST Condition:** No module is paired up.

Example 1

OUTPUT 709; “CPAIR 1,3”	*! Pair the modules in Slot 1 and Slot 3.*
OUTPUT 709; “CLOSE 105”	*! Close Channels 105 and 305 simultaneously.*

or

OUTPUT 709; “CLOSE 305”	*! Close 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 2

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.*

Card MONitor mode

CMON *<slot>* causes the HP 3499A/B to monitor the individual card (module) in the specified slot (1-5 for HP 3499A, 1-2 for HP 3499B). Specifying 0 as the slot number turns off the monitor. Power up the instrument or reset the modules will cancel the monitoring.

Comments

- Executing CMON 0 turns the card monitor off.

- To monitor the 4-bit built-in DIO, the individual DIO port, or the switching channel will cause the instrument generate an error.

- The displayed information is module dependent, refer to Table 5-2 on Page 55 for more details.

- ***RST** Condition: Card monitor turns off.

Example

```
OUTPUT 709; “CMON 2”
ENTER 709; A$
DISP A$
```

[1]. Two same (type) DIO modules can not be paired when used in Mode #3 or #4 or #5.

Scan LIST

SLIST *<channel_address>[(, or -)<channel_address>...<channel_address>]* is used to specify a sequence of channels to be scanned. The sequence is specified as a list of up to 85 channel addresses (relays 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.

Parameters *Channel_address* is in the form of snn, where s = slot number (0 - 5 for HP 3499A, 0-2 for HP 3499B) and nn = channel number (modules dependent). For more information about channel/bit address, refer to Table 7-1 on Page 140.

Comments

- The 4-bit built-in DIO bits (091-094) can be included in a scan_list.
- Channels may be scanned in any sequence, i.e., 309-300.
- Stepping beyond the last channel specified in the scan list cause a wrap-around to the first channel in the list. The number 0 can be used as a stop channel.
- CHAN may be used to specify a particular channel/bit to close. If CHAN is used, any channel/bit previously closed in the scan list will open and the channel/bit specified by CHAN will close. In addition, if the channel/bit closed by CHAN is specified in the scan list, subsequent scanning with the STEP command will start with that channel/bit.
- The commands OPEN, CLOSE, CRESET, or RECALL will have no effect on the scan list even though the states of individual channels change.
- Stored channel setups may be recalled as part of a scan list by simply specifying the register number.

Example 1

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

In example 1, the scan would start by closing channel 104, followed by channels 205, 300, 301, 302,... 309 and finally channel 410. The 0 channel specified at the end of the list is a stop channel, which is used to open the last channel closed (channel 410) without closing any other channel.

Example 2

```
10 OUTPUT 709; “SLIST 104-106,10,200-219,0”
20 FOR I= 1 TO 28
30 OUTPUT 709; “STEP”
40 NEXT I
```

! In line 10, the number 10 is a stored channel setup.

STEPping Through the Scan List

STEP is used to open the last channel closed and close the next channel in the Scan List.

Comments

- If STEP is executed and no Scan List exists, the HP 3499A/B will generate an execution error.
- The HP 3499A/B 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 a digital I/O line, that channel/bit is closed. If the next item in the list is a stored channel setup, that channel setup is recalled. If the next item in the list is a stop channel 0, the last channel/bit closed will be open without closing any channel/bit.
- Channels that are closed by a channel setup will remain closed; they are not opened by the next execution of the STEP command.

Example

```
10 OUTPUT 709; "SLIST 100-119; CMON 1"
20 FOR I= 1 TO 20
30 OUTPUT 709; "STEP"
40 NEXT I
```

CHANnel command

CHAN *[<channel_address>]* is used to open the last channel/bit closed by either STEP or CHAN command and close the specified channel/bit.

Comments

- If no channel/bit is specified with CHAN, the HP 3499A/B will respond with the number of the last channel closed by either STEP or CHAN command. 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 3499A/B 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 HP 3499A/B will open the channel closed by CHAN and go to the beginning of the Scan List.

Example

```
OUTPUT 709; "CHAN 203"                 ! Close channel 203.

OUTPUT 709; "CHAN"
ENTER 709; A
DISP A
```

The Digital Commands are used particularly with the digital I/O modules to establish the handshake mode and polarity of the DIO modules, to read from or write to a DIO module and to insert a time delay for the bits scanning, etc. The Digital Commands include:

Subsystem Syntax

DMODE *<slot>[,<mode>][,<polarity>][,<EI>]*
DWRITE *<slot><port>,<data>[,<data>]...*
DREAD *<slot><port>[,number of times to read]*
DELAY *[<time in mS>]*
DBW *<slot><port>,#I<block data>*
DBR *<slot><port>[,<number of times to read>]*
SREAD *<slot><register>*
SWRITE *<slot><register>,<data>*

Digital MODE Command

DMODE *<slot>[,<mode>][,<polarity>][,<EI>]*[1] is used to establish the handshake mode as well as polarity of the digital I/O bits and control lines for the plug-in DIO modules. It is also used to enable/disable the External Increment (EI) and Channel Closed (CC) pulse functions for the HP 44474A DIO module.

Parameters

- **Slot Number:** The valid slot number is 0-5 for HP 3499A and 0-2 for HP 3499B. Slot 0 is reserved for the 4-bit built-in digital I/O. The other slots are for the plug-in DIO modules.
- **Mode Definition:** Refer to Table 7-3.

Table 7-3. Mode Definition

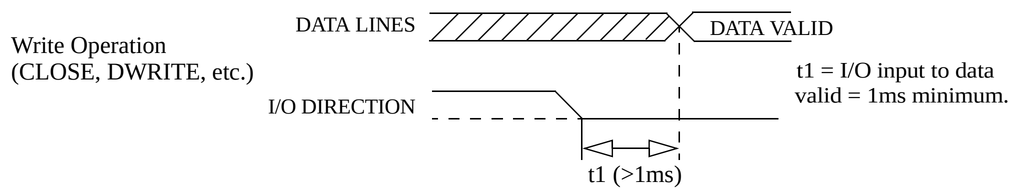
Mode Type	Specifier Value
Static 1 (default) mode	1
Static 2 (read what was written) mode	2
R/W and Strobe mode	3
Read & Write Strobe mode	4
Handshake (no EI or CC) mode	5

Note Only the ports including the first bit (i.e. Ports 00, 04, 06, etc.) on a digital I/O can be set in Mode #3, #4 or #5, and the three control lines are valid for these ports. The other ports can be only in Static Mode #1 or #2, and the three control lines are invalid.

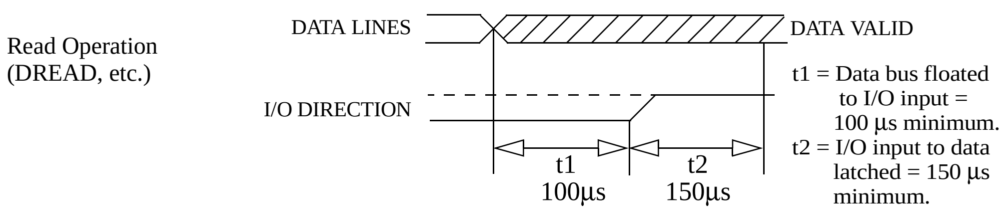
[1]. The *<EI>* in this command is only applicable for the 4-bit built-in DIO and the plug-in HP 44474A. For other DIO modules, *<EI>* is ignored. When Slot 0 is specified, the EXT TRIG IN & OUT lines on the mainframe's controller board will be enabled if EI = 1, the polarity of Port 090 can be configured accordingly.

■ **Static Mode #1**

Static Mode #1 is the default mode of the HP 3499A/B plug-in digital I/O modules. In this mode, data is transferred statically, that is, no read or write strobe pulses or handshaking. The I/O direction line is active though to indicate direction of transfer. This is shown in the following timing diagrams.



This diagram shows that approximately 1ms after the HP 3499A/B is instructed to write data to the 16 or 32 data I/O lines (I/O direction line goes to a low state), the digital I/O modules take control of the data lines.



This diagram shows that 100 µs after the HP 3499A/B is instructed to read the 16 or 32 data I/O lines, it releases control of the lines and the I/O direction line goes to a high state. 150 µs later, the data is actually read (latched).

■ **Static Mode #2**

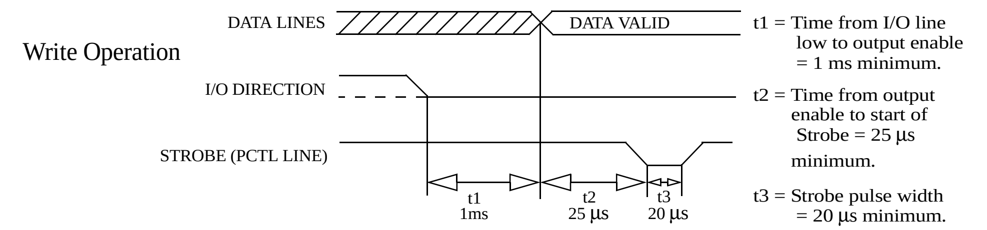
Static Mode #2 acts just like Mode #1 except that the output lines are not disabled when the option is read (DREAD, etc.). This means that if a port is written to and then read from, the data read will be that which was just written to it. It is possible, however, that external devices might load the lines and cause a false read.

Timing for the I/O direction line is as shown in Mode #1, except for read. During a read operation, there is no change in the I/O direction line.

■ **R/W and Strobe Mode #3**

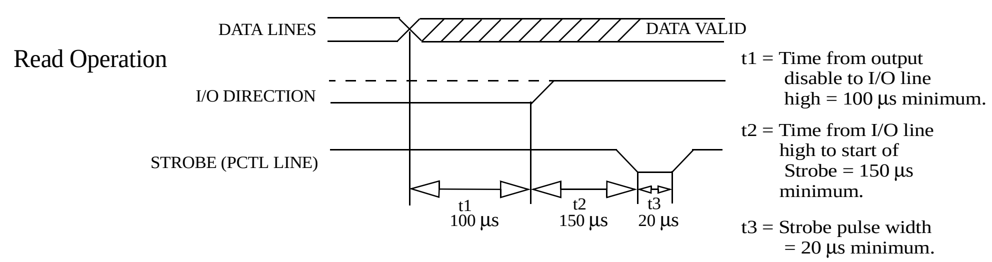
In this mode, the I/O direction line is still used to indicate direction of transfer (input or output) but the PCTL (Peripheral control) line is used to strobe the data.

During a Write operation, where the HP 3499A/B writes the data to some external device, the strobe pulse signifies that the data on the 16 or 32 data I/O lines is valid. This is shown in the following timing diagram.



A Strobe pulse is used by the HP 3499A/B to signify that the data on the data lines is valid. Therefore, during a Write operation, the device receiving the data is triggered by the Strobe pulse.

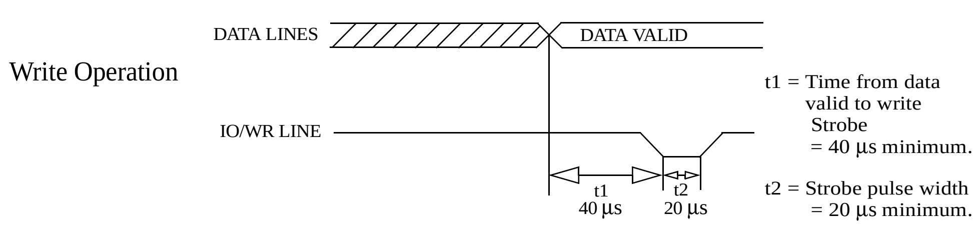
The Strobe pulse is used during a Read operation to signify that the HP 3499A/B has completed the read operation. This is shown in the following diagram.



When used during a Read operation, the Strobe pulse signifies that the HP 3499A/B has latched (read) the data from the data lines.

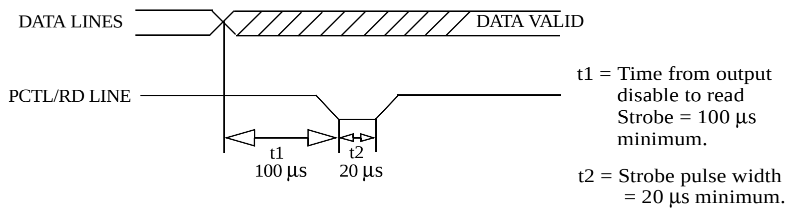
- **Read and Write Strobe Mode #4**

The Read and Write Strobe Mode #4 uses the I/O direction line as a Strobe pulse to indicate writing operations. The PCTL line is used to indicate Read operations. It is thus similar to the R/W and Strobe Mode #3 except separate control lines are used for the Strobe pulses and there is no I/O direction line.



The IO/WR line is used to indicate that the data is valid on the data bus lines. IO/WR is used to trigger the receiving device.

Read Operation



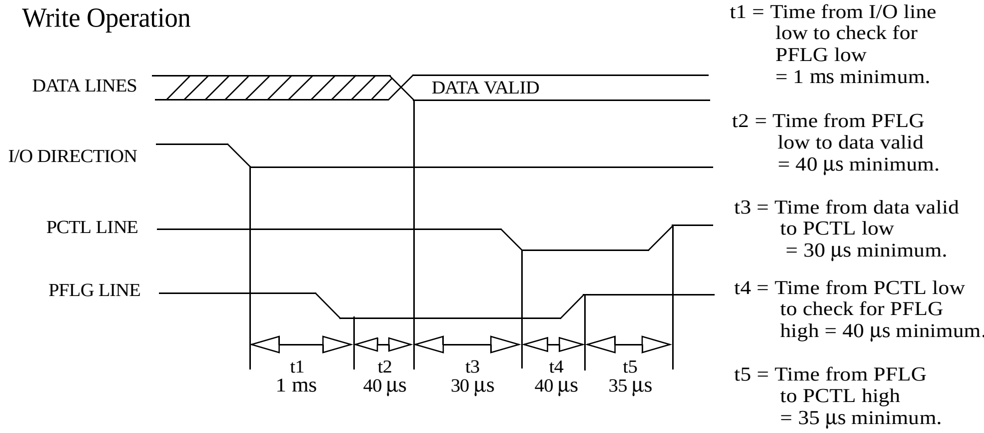
As in Mode #3, the PCTL/RD line is used to indicate to the sending device that the HP 3499A/B has latched (read) the data.

Handshake Mode #5

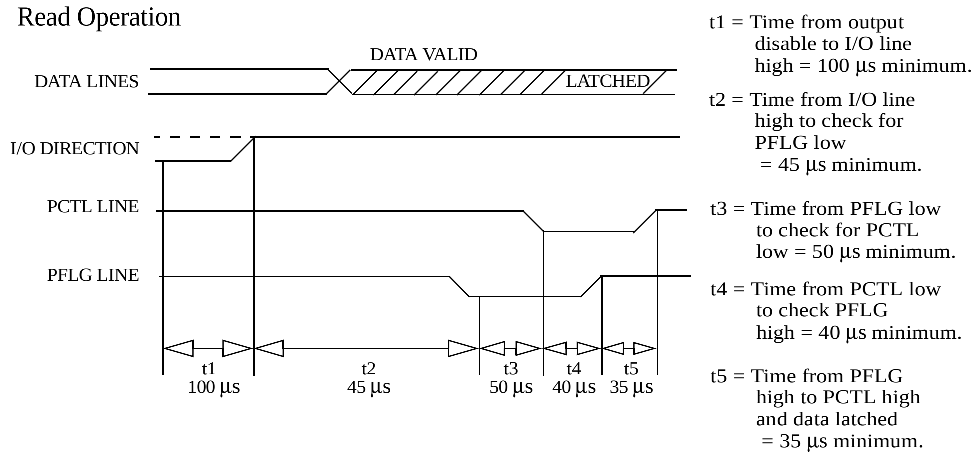
The Handshake Mode #5 provides a complete two wire handshake with a data direction line. During Write operations, the PCTL line indicates that output data is valid; during Read operations, it indicates that the digital I/O module (i.e.HP 44474A) is “ready for data”. The PFLG line is used by the peripheral device to indicate “ready for data” during write operations or “data valid” for Read operations.

Remember, Write operations are the plug-in digital I/O modules controlling the data on the 16 or 32 data I/O lines. Two commands used during Write operations are DWRITE and CLOSE. Read operations are where external devices control the 16 or 32 data lines and the digital I/O module simply reads the data and controls the PCTL/RD line.

Write Operation



The complete handshaking sequence for Mode #5 is as follows: The HP 3499A/B checks to see if the receiving device has set the PFLG line low, this indicates the receiving device is ready to accept data. When PFLG is low, the HP 3499A/B sets the data on the data bus and sets PCTL low. The HP 3499A/B then waits for the receiving device to set PFLG high, indicating that it has latched the data. To complete the handshake, the HP 3499A/B sets PCTL high.



As with the Write operation, the HP 3499A/B begins by testing PFLG for a low state, indicating that the data is valid. When PFLG is low, the HP 3499A/B sets PCTL low and waits for PFLG to go high. The HP 3499A/B will set PCTL high to indicate that it has completed the data read operation. Data on the data bus must remain valid until after the HP 3499A/B sets PCTL high.

- **Polarity Definition:** the Polarity specifier for the DMODE command is used to set the polarity of both the 16/32-bit data lines and the handshake/control lines. When the polarity of the control lines is changed by this command, the DIO modules will immediately change the states of the affected lines. For the data lines, the current state is not immediately changed, but the new polarity will be used in subsequent operations.

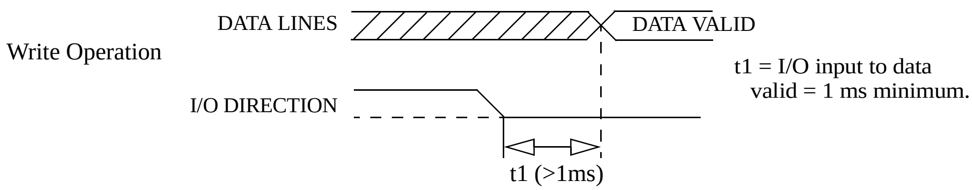
  The polarity specifier in the DMODE command is decimal weighted and defined in Table 7-4.

Table 7-4. Polarity Specifier

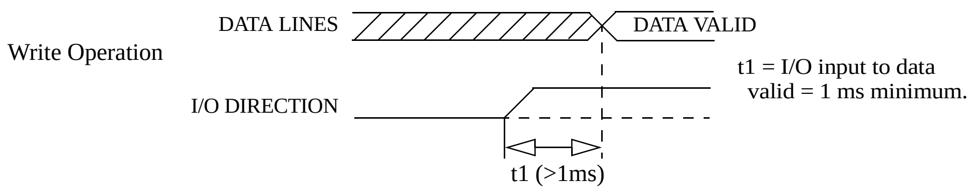
Definition	Bit #	Value
Default, data lines high true (open), PCTL and PFLG low means ready, I/O Direction line high for ready.		0 = Default
1st 8-bit port polarity	0	1 = Low means positive, High means negative
2nd 8-bit port polarity	1	2 = Low means positive, High means negative
PCTL Polarity	2	4 = Low means busy, High means ready
PFLG Polarity	3	8 = Low means busy, High means ready
I/O Direction line polarity	4	16 = Low means input, High means output
3rd 8-bit port polarity	5	32 = Low means positive, High means negative
4th 8-bit port polarity	6	64 = Low means positive, High means negative

To illustrate the use of the polarity specifier for the Hi and Lo bytes, consider that normally, that is the default mode, the 16/32 data lines are high (+5V) for open and low (0V) for closed. This is true whether a write or read operation is performed. By inverting the polarity for either or both bytes, high (+5V) then becomes closed and low (0V) becomes open.

Changing the polarity of the PCTL, PFLG or I/O Direction line will affect the handshaking control. Refer to the handshaking timing diagrams in the Mode definition. If you change the polarity of either the PCTL, PFLG or I/O Direction lines, invert the drawing for that line. For example, the I/O Direction line in Static Modes #1 & #2 for a Write operation looks like:



Here, a low on the I/O direction line indicates a Write or output operation. After executing the command “DMODE 5,1,16,0” (polarity specifier of 16 changes the polarity of the I/O Direction Line), the diagram would look like:



Now, the direction line effectively becomes inverted and a high means an output operation.

Note If the slot is 0, the *mode* will be ignored, just the polarity of the built-in DIO Port 090 is specified. In this case, the EI is used to enable/disable the external Trig In/Out lines.

- **External Increment:** External Increment (EI) provides a method of sequencing through a scan list without system computer intervention. EI is enabled by specifying 1 in the EI specifier for DMODE and disabled by specifying 0.

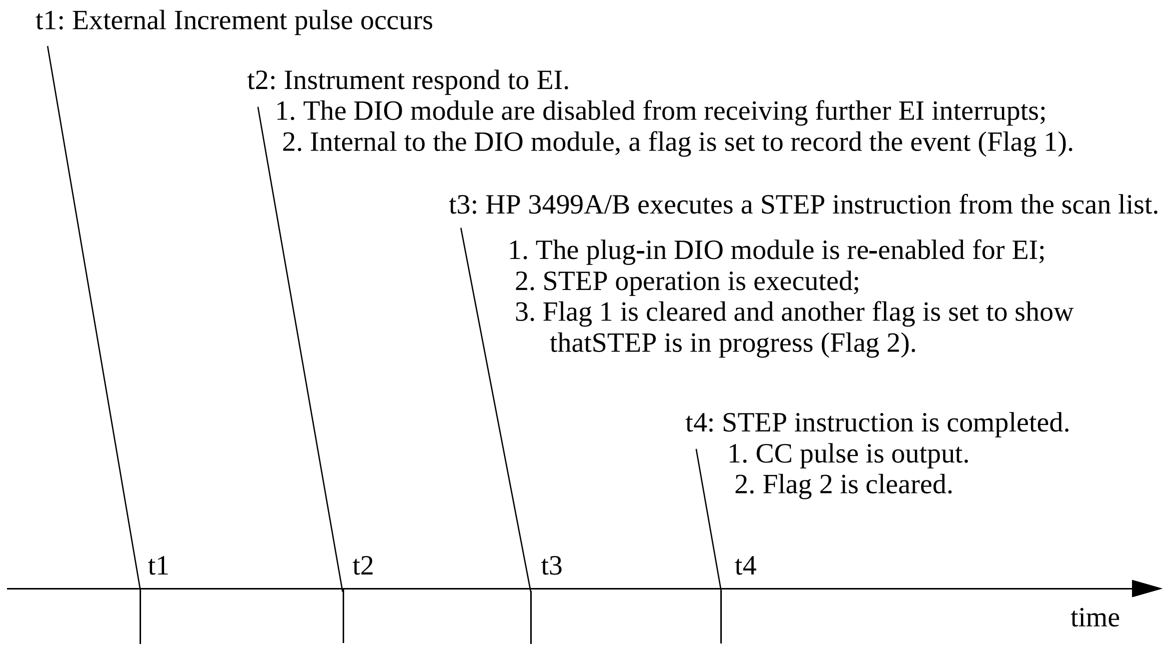
  Typically, EI is connected to the Voltmeter Complete[1] output on a system voltmeter. The Channel Closed line (CC) can be connected to the External Trigger input on the voltmeter. The scan is started by executing either STEP or CHAN. As soon as the channel closes, the HP 44474A digital I/O module

[1]. Voltmeter Complete is a feature on most HP digital voltmeters (e.g. HP 3458A) to signal the completion of a measurement by means of a TTL compatible pulse.

output a CC pulse, triggering the voltmeter. As soon as the voltmeter completes its measurement, it outputs the Voltmeter complete pulse which increments the scan list. When the next channel closes, CC is once again sent and the process continues to sequence through the scan list.

The number 0 may be inserted in the scan list to act as a stop channel. When it is encountered, the HP 3499A/B opens the last channel closed but will not close a new one and CC is not sent.

Figure 7-2 shows the timing relationship for the scan sequence when using EI and CC. If the HP 3499A/B receives either an EI or the GPIB Trigger command while the instrument is busy with another command, the STEP command will be executed as soon as the command in progress is completed. If EI is received while the HP 3499A/B is busy executing a previous EI, a "trigger too fast" error will be generated.



Note that time period t2-t3 is essentially dead time with regard to EI interrupts. This means that interrupts received during this time will be ignored. If an EI interrupt occurs during times t1-t2 or t3-t4, it will be recorded but will cause a "trigger too fast" error.

Figure 7-2. Scan Timing

- **Channel Closed[1]:** Channel Closed (CC) provides a 15 µS TTL pulse for signaling when a channel has been closed in the HP 3499A/B. 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 from the system computer.

[1]. Channel Closed is applicable for the HP 44474A only.

Comments

- Contents of the DMODE register can be read by deleting the parameters and executing only: DMODE <*slot*>. The HP 3499A/B will respond with a display in the same form as you send to set the DMODE in (i.e., mode, polarity, EI).
- Whenever power on or reset the instrument, the DIO modules are put in Static Mode #1, with High True Logic on all lines, EI/CC are disabled.

Example

```
OUTPUT 715; "DMODE 5,1,0,1"          ! Set the EI & CC Mode and STATIC Mode #1.
```

WRITE to a Digital I/O

DWRITE *<slot><port>,<data>[,<data>...]* configures all or part of the plug-in DIO to digital output ports and writes data to the DIO ports.

Parameters

The port specifier is a two digital number that indicates whether the data is to be written to the 4-bit built-in DIO port (090), or to the two/four 8-bit ports (for 16/32-bit DIO), or to the one/two 16-bit ports (for 16/32-bit DIO), or to one 32-bit port (for 32-bit DIO). The port number is listed in Table 7-5.

Comments

- When writing to an 8-bit port, the decimal value of the bits must be between 0 and 255 (Example 1). When writing to the 4-bit built-in DIO port (Port 090), the decimal value will be 0-15.
- When writing to a 16-bit port, the decimal value of the 16 bits must between -32768 and 32767. Any time the summed decimal value of the 16 bits would exceed +32768, the 2's complement form must be used and expressed as a negative number (Example 2).
- When writing to a 32-bit port, the decimal value must between -2147483648 and 2147483647. Any time the summed decimal value of the 32 bits would exceed +2147483647, the 2's complement form must be used and expressed as a negative number (Example 3).
- There is no limit to the number of data items that can be sent with the DWRITE command.
- ***RST conditions:** All ports on the plug-in digital I/O modules are input ports.
- **Related Commands:** DREAD, DBW.

Table 7-5. Port # on DIO Modules

HP P/N	4-Bit Port	8-Bit Port	16-Bit Port	32-Bit Port
4-Bit Built-in DIO	090	N/A	N/A	N/A
HP 44474A 16-Bit DIO	N/A	s00, s01	s02	N/A
HP N2263A 32-Bit DIO	N/A	s00, s01, s02, s03	s04, s05	s06
HP N2264A Multifunction	N/A	s30, s31	s32	N/A
HP N2265A Multifunction	N/A	s40, s41	s42	N/A

Example 1 **Writing to a 8-bit port (Port 100)**

To close only bits 2 and 5 in slot 1 (Port 00). The bit pattern is represented as:

Bit Number:	7	6	5	4	3	2	1	0
Bit state:	1	1	0	1	1	0	1	1

Where a “1” indicates the bit is open, and a “0” means the bit is closed. Summing the values for the open bits yield: 128 + 64 + 16 + 8 + 2 + 1 = 219. Therefore, execute the command:

```
OUTPUT 709; “DWRITE 100,219”
```

Example 2 **Writing to a 16-bit port (Port 202).**

To close only bits 12, 9, 5, and 2 in slot 2, the bit pattern is represented as:

Bit Number:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit state:	1	1	1	0	1	1	0	1	1	1	0	1	1	0	1	1

Normally, the summed bit values for the open bits would be 60891. This exceeds the limit of 32767 and therefore must be converted to 2’s complement form. This conversion is a simple two step process.

First, complement, i.e, invert the bit states:

Bit Number:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit State:	1	1	1	0	1	1	0	1	1	1	0	1	1	0	1	1
Inverted State:	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0
(Added 1)	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	1

Now, add 1 to the inverted state, the final result is the 2’s complement form of the bit pattern desired. Add together the values of the bits designated as 1’s and execute that as a negative number (-4645):

```
OUTPUT 709; “DWRITE 202, -4645”
```

Example 3 **Writing to a 32-bit port (Port 206).**

To close only bits 30, 19, 10, and 2 in slot 2, the bit pattern is represented as:

Bit Number:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit state:	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Normally, the summed bit values for the open bits would be 3220700155. This exceeds the limit of 2147483647 and therefore must be converted to 2's complement form. This conversion is a simple two step process.

First, complement, i.e, invert the bit states:

Bit Number:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit state:	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1
Inverted:	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
(Added 1)	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1

Now, add 1 to the inverted state, the final result is the 2's complement form of the bit pattern desired. Add together the values of the bits designated as 1's and execute that as a negative number (-1074267141):

OUTPUT 709; "DWRITE 206, -1074267141"

READ from a Digital I/O

DREAD *<slot><port>[,number of times to read]* permits reading the current status of the DIO modules' ports designated as inputs. The decimal value read back is equal to the decimal sum of the bit values that are set. When Slot 0 is specified, only Port 090 is valid. See the DWRITE command on Page 158 for an explanation of the port specifier.

Comments

- If the DIO modules are in the Static Mode #1, the DREAD command will read the input data. In order to verify an output port, the DIO modules must be in the Static Mode #2, this will enable reading the outputs.
- If no number of reading is given, the specified port will be read one time only.
- The maximum number of times a port can be read with this command is 32767. For multiple readings, the HP 3499A/B must be in OLAP 1 mode and the information is sent as a block with the readings separated by commas.
- When reading the Port 090, the values read back will be 0-15; when reading an 8-bit port, the values read back will be 0-255. When reading a 16-bit port, the values read back will be between -32768 and +32767 (2's complement format included). When reading a 32-bit port, the values read back will be between -2147483648 and 2147483647 (2's complement format included).
- When a negative value (2's complement form) is read back, the reverse procedures must be performed to get the bits status. Refer to "WRITE to a Digital I/O" on page 158 for more information.

Example

```
10  DIM A$[700]
20  OUTPUT 709; "OLAP 1"
30  OUTPUT 709; "DREAD 501,100"        ! Take 100 readings.
40  ENTER 709; A$                      ! Enter all 100 readings.
50  DISP A$                            ! Display readings.
60  END
```

DELAY

DELAY *<time in mS>* is used to insert a time delay between the time that a channel is closed and the time that the next command or Channel Closed pulse is executed.

DELAY is used to read back the current delay time (in mS).

Parameters

The delay time may be a value between 0 and 32,767 mS (32 seconds) in 1 mS increments.

Comments

- The delay time does not become effective until either a CHAN or a STEP is executed.
- If any command is sent to the HP 3499A/B 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 HP 3499A/B will respond with the current value of the delay time.
- For HP 44474A digital I/O, remember that a Channel Closed pulse will be sent after the delay time is complete from the HP 44474A with the External Increment enabled.
- If no parameter is specified, executing DELAY will read back the current delay time in mS.
- The default delay time is “0” after an instrument power up or reset.

Examples

```
OUTPUT 709; “DELAY 2000; CHAN 101”    ! The delay time is 2 seconds.
OUTPUT 709; “DELAY”
ENTER 709; A
DISP A                                ! Display the delay time.
```

Digital Binary Write

DBW *<slot><port>,#I<block data>* is used to output a block of data to the specified digital I/O port. When DBW is received, the HP 3499A/B will interpret the block of data to be output according to the slot/port specification and DMODE (polarity, handshake) command. In 16-bit mode, the data block is interpreted as being the high byte first. In 32-bit mode (port 06), the data block is interpreted as being the highest byte first, then the second highest and so on. The transfer is completed by setting the GPIB EOI line true concurrently with the last byte of data.

Comments

- **Port Number:** See Table 7-5. on Page 159 for the detailed port information.
- **Port 090:** When Slot 0 is specified, only Port 090 is valid.
- ***RST Conditions:** All ports on the plug-in DIO modules are input ports.

Example

```
10  CONTROL 7,16,128     ! Set EOI true concurrent with the last
                         character sent.
20  DIM A$[30]
```

```
30  IOBUFFER A$
40  A$ = "CMON 5;DBW 504, #IAS"          ! Output a block of data"AS" to the
                                         plug-in DIO (Port 04, Slot 5).
50  TRANSFER A$ to 709 INTR
```

Digital Binary Read

DBR *<slot><port>,[<number of times to read>]* is used to read and output the data items according to the format setup by the slot/port specifier and the DMODE (for polarity and handshaking) command. I

Parameters The port number is the same as in DBW command. The *<number of times to read>* is an integer between 1 and 32767.

Comments

- When Slot 0 is specified, only Port 090 is valid.
- **16-bit Port:** If a 16-bit port is specified, data will be sent with the high or most significant byte first. The data transfer is terminated with the HP 3499A/B setting the GPIB EOI true line concurrently with the last data byte sent.
- **32-bit Port:** If a 32-bit mode (Port 06) is specified, data will be sent with the highest byte fist, then the second highest byte and so on. The data transfer is terminated with the HP 3499A/B setting the GPIB EOI true line concurrently with the last data byte sent.
- If more than one reading is requested, the HP 3499A/B must be in the OLAP1 mode. The maximum *<number of times to read>* is 32767.

Example

```
10  DIM A$[30]
20  IOBUFFER A$
30  A$ = "DBR 504,1"                     ! One digital binary reading.
40  TRANSFER A$ TO 709 INTR
50  ENTER 709 USING "%,K"; B$            ! Qualifiers "%,K" set PC to concurrent
                                         EOI and last data byte.
60  DISP B$
```

SREAD Command

SREAD *<slot><register>* is used to read data from the input port on an HP 44475A Breadboard in the specific slot. This command is for HP 44475A Breadboard only. The valid slot number is 1-5 for HP 3499A and 1-2 for HP 3499B. The data read back is in the form of a decimal number which is the sum of the binary weighted values of the bits that are high (+5 volts).

Comments

- Two 8-bit ports are available on the HP 44475A Breadboard. One port is a static read only port (04), the second port is static write only (00). Static means that there is no handshaking involved in data transfers.
- **<Register>:** The value of *<register>* is 04. If a number other than 04 is used (any number between 0 and 7 will not cause an error), the value 255 will be returned, thus indicating a floating input.

Example

```
10  OUTPUT 709; "SREAD 304"          ! Breadboard in Slot 3.
20  ENTER 709; A
30  DISP A
```

SWRITE Command

SWRITE *<slot><register>,<data>* is used to write data to the output port on an HP 44475A breadboard in the specific slot. The valid slot number is 1-5 for HP 3499A and 1-2 for HP 3499B. The data value is a decimal sum of the binary weighted values of the bits that are to be set high (+5 volts)

Comments

- Two 8-bit ports are available on the HP 44475A Breadboard. One port is a static read only port (04), the second port is static write only (00). Static means that there is no handshaking involved in data transfers.
- **<Register>:** The value of *<register>* is 00. Any number between 1 and 7 may be used without causing an error, however no action will be taken by the Breadboard.

Example

```
10  OUTPUT 709; "SWRITE 500,146"     ! Breadboard in Slot 5.
20  ENTER 709; A
30  DISP A
```

The HP 3488A System Commands are used to identify and reset the instrument, to perform the instrument's self test, to store/recall the channel/bit setups and to set/query the instrument's system mode. In addition, they are also used to turn on/off the display of the instrument and to lockout the keyboard, etc. The HP 3488A System Commands are listed as:

Subsystem Syntax

SYSMODE *<0|1|SCPI|HP3488A>*
SYSMODE?
RESET
TEST
ID?
STATUS
STORE *<1-40>*
RECALL *<1-40>*
ERROR
MASK *[<decimal value>]*
OLAP *<1/0>*
EHALT *<1/0>*
DISP *<ASCII character string>*
DON/DOFF
LOCK *1/0*

SYSMODE

SYSMODE *<mode>* specifies a system mode for the HP 3499A/B Switch/Control system.

Parameters

Name	Type	Range of Values	Default Value
<mode>	discrete	0|1|SCPI|HP3488A	SCPI|0

Comments

- **System Mode:** The HP 3499A/B can be operated in either one of the two system modes. Specifying 0|SCPI will cause the instrument to be operated in SCPI mode. Specifying 1|HP3488A will cause the instrument return to HP 3488A mode.

- **Switching Modes:** Switching the system modes between SCPI mode and HP 3488A mode will cause the instrument to return to its default state, but the GPIB address and the RS-232 settings will remain at what they had been configured.

- **Switching Interval:** The switching between the two system modes should have a minimum interval of 5 seconds, otherwise an error will occur.

Example

OUTPUT 709; "SYSMODE 0|SCPI" *! Specify the instrument system mode.*

SYSMODE?

SYSMODE? queries the system mode for the HP 3499A/B Switch/Control system. The returned string will be either “SCPI” or “HP3488A”, indicating the instrument’s system mode.

Example

OUTPUT 709; “SYSMODE 1|HP3488A”	*! Specify the instrument’s system mode.*
OUTPUT 709; “SYSMODE?”	*! Query the instrument’s system mode. “HP3488A” will be returned, indicating that the instrument is operated in HP 3488A mode.*

RESET an instrument

RESET is used to reset an HP 3499A/B to the power on state. This include the following sequence:

- Identify all the plug-in modules and reset them (all relays open);
- Remain GPIB address;
- Set all parameters of the instrument to their default conditions.

Note If RESET is executed from the system computer, interface functions are not affected (i.e. the HP 3499A/B stay in Remote mode, etc.). If the front panel RESET key is pressed, interface functions are reset.

Note Stored states (channel setups) are not affected after an instrument reset (see STORE/RECALL).

Example OUTPUT 709; “RESET”

Perform an internal self TEST

TEST causes the instrument to perform its internal self tests. Results of the test can be read back to the system computer. A value of “+00000” read back indicates all tests have passed. The other value indicates the instrument failed the tests. Table 7-6 shows the possible failures and associated error numbers.

Table 7-6. Self Test Error Numbers

Error Number	Description
+00001	ROM Test Failed.
+00002	GPIB Test Failed.
+00003	RS-232 Test Failed.
+00004	Front Panel Test Failed.

Example

```
OUTPUT 709; "TEST"
ENTER 709; A
DISP A
```

IDentify the instrument

ID? is used to query the HP 3499A/B's identity.

Example

```
10  OUTPUT 709; "ID?"
20  ENTER 709; A$
30  DISP A$                    ! The returned string is "HP3488A".
```

STATUS of the instrument

STATUS permits reading the HP 3499A/B's Status Byte and returns a decimal value, this decimal value is the sum of the values of the individual bits that are set (condition is true).

Refer to Table 7-7 for the following descriptions.

Bits 0, 2, and 3 will be cleared after the STATUS command is executed. Bit 1 will be cleared only after the data is read from the HP 3499A/B, or new data is requested, or the HP 3499A/B is reset. The Ready for Instructions bit (Bit 4) will be cleared whenever the HP 3499A/B is busy executing instructions. For this reason, Bit 4 will always be clear when STATUS is executed. The Error bit (Bit 5) will only be cleared after the Error Register is read. Bit 6, RQS, will only be cleared after STATUS, if the condition that caused Bit 6 to be set is cleared.

Table 7-7. Bit Definitions of the Status Byte

Bit	Weighted Value	Definition
0	1	End of scan sequence
1	2	Output available
2	4	Power-on SRQ asserted
3	8	Front panel SRQ key pressed
4	16	Ready for instructions
5	32	Error
6	64	RQS
7	128	Not used

Example

```
10  OUTPUT 709; "STATUS"
20  ENTER 709; A
30  DISP A
```

STORE the channel/bit setup

STORE ***<1-40>*** is used to record the current state of the HP 3499A/B (including the channel states, the static digital output states, etc.) in the specified register number (1-40).

Comments

- Up to 40 channel/bit setups can be stored when operating the instrument in HP 3488A mode.
- The channel/bit setup(s) can be included in a scan list.
- The plug-in digital I/O modules that are not in Static mode (Static Mode #1 & #2) are ignored.
- The channels' state will not be changed when STORE is executed.
- Resetting the HP 3499A/B does not affect the stored channel/bit setup.

Example

```
OUTPUT 709; "CLOSE 103,115,203,204,205,206,207,208,209"
OUTPUT 709; "STORE 9"          ! Store the channel setup in Register 9.
OUTPUT 709; "RECALL 9"         ! Recall the channel setup 9.
```

RECALL the stored states

RECALL ***<1-40>*** is used to re-assert the channel/bit setup stored by the command STORE. Only relays and static Digital Outputs are recalled. This means that only those channels/bits that are closed in the stored channel setup will be closed when the channel setup is recalled.

Example

```
OUTPUT 709; "CLOSE 103,104,202,204,206; STORE 6"
OUTPUT 709; "RECALL 6"
```

Note If no state has been stored in the channel setup selected, an error will result and the HP 3499A/B will send SRQ if it was enabled (see MASK). In this case, the HP 3499A/B remains in its previous state.

ERROR conditions

ERROR is used to read the HP 3499A/B's error register. The returned decimal value is equal to the sum of the values of the possible error conditions, as defined in Table 7-8 on Page 168

Table 7-8. Error Conditions

Bit	Weighted Value	Error Condition
0	1	Syntax Error
1	2	Execution Error possible meanings include: a. Parameter out of range b. Card type mismatch c. Attempt to access a nonexistent stored state or scan list
2	4	Hardware Trigger too fast
3	8	Logical Failure
4	16	Power Supply Failure

Example

```
OUTPUT 709; "ERROR"
OUTPUT 709; A
DISP A
```

Set the SRQ MASK

MASK *[<decimal value>]* is used to set the SRQ mask for certain conditions. The decimal value loaded into the mask is equal to the sum of the values of the conditions that will cause an SRQ interrupt. Table 7-9 shows the possible conditions and values for an SRQ interrupt.

If no value is sent with the MASK command, the HP 3499A/B will display or output the current value of its SRQ mask to the computer.

Table 7-9. Mask Bit Definitions

Mask Bit	Weighted Value	Description
0	1	End of Scan Sequence
1	2	Output available
2	4	Power-on SRQ true
3	8	Not used
4	16	Ready for instructions
5	32	Error
6		SRQ (This bit is not maskable)
7		Not used

Example

```
OUTPUT 709; "MASK 8"     ! Set the mask for Front Panel SRQ key.
OUTPUT 709; "MASK 33"    ! Set mask for Error (32) and End of Scan
                         Sequence (1).
```

```
10  OUTPUT 709; "MASK"
20  ENTER 709; A
30  DISP A                          ! The current mask value is displayed.
```

OverLAP on received command strings

OLAP *<0 or 1>* is used to hold up or release the GPIB I/O communications. In the Overlap disabled mode (default, OLAP 0), the HP 3499A/B holds up GPIB I/O communications while it processes received messages. If Overlap is enabled (OLAP 1), the HP 3499A/B will release the GPIB as soon as the command message is received. Overlap enabled allows faster I/O operations but does not guarantee sequential operation of other devices on the bus.

Comments

- Overlap goes into effect on the first Bus communication after the OLAP message sent.
- Overlap is only for commands received, not for data sent by the HP 3499A/B.
- In Overlap enabled, users should monitor Bit 4 in the HP 3499A/B Status Register to help insure sequential operation of other instruments on the GPIB interface.
- OLAP 1 is necessary for multiple readings from the digital I/O modules with the DREAD and DBR commands.
- Switching between OLAP 0 and OLAP 1 should have a minimum delay time of 5 seconds.

Example OUTPUT 709; "OLAP 1" *! Overlap is enabled.*

Stop on an Error (Error HALT)

EHALT *<0 or 1>* is used to enable (EHALT 1) the stop-on-error mode of the HP 3499A/B. When it discovers an error, it will lockup the GPIB interface (no GPIB communication). Default condition is EHALT disabled (EHALT 0), which allows GPIB communication after an error is discovered.

Note Once the GPIB is locked up, you must reset the GPIB interface. The HP 3499A/B can be reset by either pressing the front panel local key or executing the GPIB CLEAR command, the instrument will stay in its default condition (EHALT 0) accordingly.

Example OUTPUT 709; "EHALT 1" *! Enable the stop-on-error mode.*

Write to the DISPlay

DISP *<ASCII character string>* is used to write a message up to 13 characters to display on the front panel of the HP 3499A/B.

Comments

- The *<ASCII character string>* can be up to 13 characters. The characters supported by HP 3499A/B are listed in the following table.

Type	Letters (Supported by HP 3499A/B)
Number	0-9
Letter	a-z; A-Z
Special Character	‘ (space) ( ) * + , - . / \

- The lower case characters can be included in the *<ASCII character string>*. But the characters displayed on the front panel are the uppercase.

- A colon (:) or a semicolon(;) is used as the terminator to end the string. An error will occur if there are other characters following the colon or semicolon.

Example

```
OUTPUT 709; “DISP “It’s a DIO”          ! Display “IT’S A DIO”.
```

Turn ON/OFF the Display

DOFF is used to turn off the HP 3499A/B’s display. This allows the instrument to operate faster because it no longer needs to update the display.

DON is used to turn on the HP 3499A/B3499A/B’s display.

The display will be reactivated by either the DON command or pressing the LOCAL key. Use DON to remove a message written to the display with a DISP command.

Example

```
OUTPUT 709; “DOFF”          ! Turn off the display.
OUTPUT 709; “DON”           ! Turn on the display.
```

LOCKout the keyboard

LOCK *<0 or 1>* is similar to sending the Local Lockout command from the computer. Locking out the keyboard prevents the keyboard from being scanned thus permitting faster operation.

LOCK 1 activates LOCKOUT and LOCK 0 (default) deactivates LOCKOUT.

Example

```
OUTPUT 709; “LOCK 1”          ! Lockout the keyboard.
```

HP 3488A Command Quick Reference

Command	Description
SYSMODE	Set the instrument's system mode.
SYSMODE?	Query the instrument's system mode.
CHAN	Open the last channel/bit closed and close the specified channel/bit.
CLOSE	Close one or more relays (channels/bits) on the plug-in modules.
CMON	Monitor the open/close states of a plug-in module in the specified slot.
CRESET	Reset one or multiple cards in the specified slot(s) to their default states.
CPAIR	Pair up two plug-in modules of the same type.
CTYPE	Query the module's identification in the specific slot.
DBR	Read digital I/O port.
DBW	Output a block of binary data to the specified digital I/O port.
DELAY	Insert a delay time during scanning.
DISP	Write a message to display.
DMODE	Establish the handshake mode, polarity and trigger configuration of the DIO module.
DOFF	Turn off the front panel display of the instrument.
DON	Turn on the front panel display of the instrument.
DREAD	Read the status of a digital I/O port as inputs.
DWRITE	Output a block of data to the specified digital I/O port.
EHALT	Enable/Disable the stop-on-error mode.
ERROR	Query Error register.
ID?	Query the instrument's identity.
LOCK	Activate or deactivate locking out the keyboard of the instrument.
MASK	Query/set the SRQ mask conditions.
OLAP	Enable/Disable GPIB I/O overlap mode.
OPEN	Open one or more relays (channels/bits) on the plug-in modules.
RECALL	Re-assert the channel/bit setup stored by the command STORE (1-10).
RESET	Reset the instrument to its power on state. All channels/bits of the plug-in modules are open, etc.
SLIST	Specify a sequence of channels/bits to be scanned.
SYSMODE	Specify a system mode (SCPI or HP 3488A) for the instrument.
SREAD	Read back the read-only port on HP 44475A (for HP 44475A Breadboard only).
SWRITE	Write data to the static write-only port on HP 44475A (for HP 44475A Breadboard only).
STATUS	Query the Status Byte of the HP 3499A/B.
STEP	Sequence through a scan list set up by SLIST.
STORE	Store the current of the instrument in the specified register number (1-10).
TEST	Cause the HP 3499A/B to perform an internal self-test.
VIEW	Query the state of a particular channel/bit.

Chapter 8
Plug-in Modules

About This Chapter

The HP 3499 Switch/Control System consists of two mainframes (HP 3499A & HP 3499B) and a set of plug-in modules. This chapter provides the necessary information to use these plug-in modules, including a general description, simplified schematics, wiring information and specifications for each module. The wiring information for these modules is also provided at the end of this chapter.

This chapter contains the following sections:

HP N2260A 40-Channel MUX Module

General Description

HP N2260A is a configurable multiplexer (MUX) module. It provides 40 2-wire latching relays for switching, and two non-latching tree relays for configuration applications. The HP N2260A can be operated in either SCPI mode or HP 3488A mode. A parallel switching[1] feature makes it well suited for high speed switching.

In SCPI mode, the HP N2260A can be configured as an 80-channel 1-wire, a 40-channel 2-wire, two independent 20-channel 2-wire, or a 20-channel 4-wire MUX module. An instrument power-on or reset will set the HP N2260A to its default configuration (as a 40-channel 2-wire MUX module).

In HP 3488A mode, the HP N2260A can only be used as a 40-channel 2-wire MUX module.

Two terminal blocks and two DIN-to-D cables are available with this module for wiring conveniences.

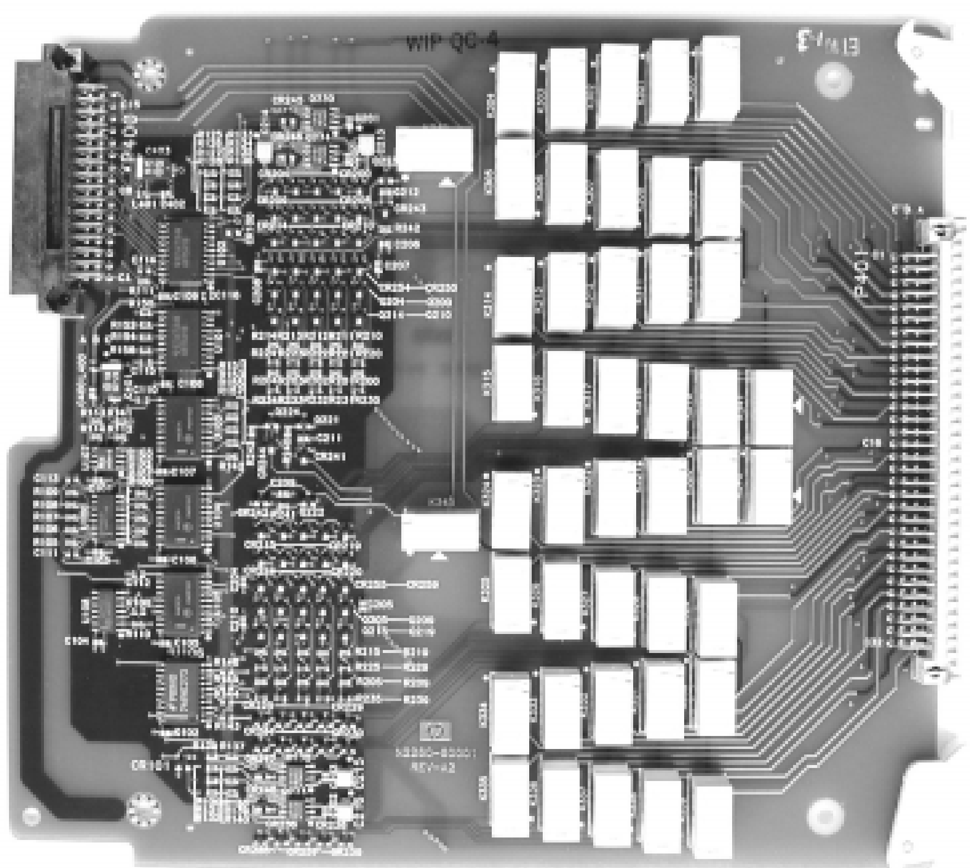


Figure 8-1. HP N2260A

[1]. The 40 2-wire relays on the HP N2260A can be separated into four groups: Group 1 (CH00-09) through Group 4 (CH30-39). The relays (up to 10) in the same group can be closed simultaneously (parallel switching).

Simplified Schematic

As shown in Figure 8-2, the 40 2-wire channel relays (CH00-CH39) are divided into two banks: BANK 0 and BANK 1. Each bank consists of 20 2-wire switching channels and a common bus (COM0 & COM1). A single-ended common terminal (SE-COM) is provided in the 80-channel 1-wire mode.

Two Tree relays (T98 & T99) are used to configure the HP N2260A.

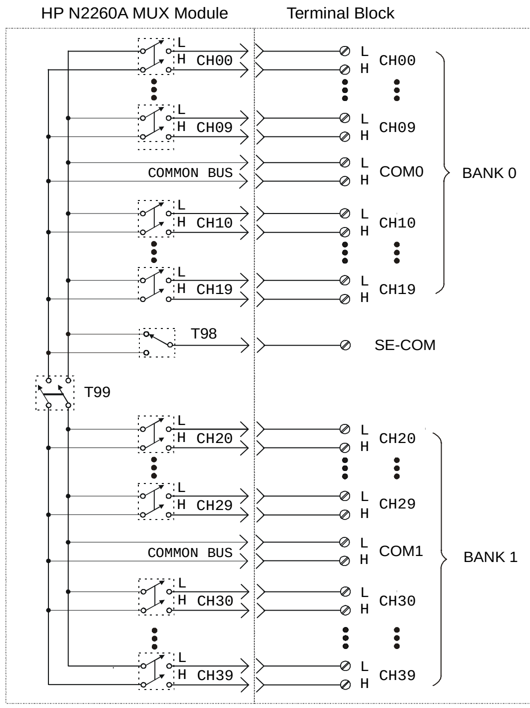


Figure 8-2. HP N2260A Simplified Schematic

Configurations

Operated in SCPI mode, the HP N2260A can be configured as:

- an 80-channel 1-wire MUX module (1-wire mode);
- or a 40-channel 2-wire MUX module (2-wire mode);
- or two independent 20-channel 2-wire MUX modules (dual 2-wire mode);
- or a 20-channel 4-wire MUX module (4-wire mode).

1-Wire Mode

In this mode, either the High (H) or Low (L) terminals of a channel is switched to the single-ended (SE-COM) terminal. A maximum of 80 1-wire channels can be switched. The Low terminals of the 40 2-wire channels form the first 40 1-wire channels (00-39), and the High terminals of the 40 2-wire channels form the second 40 1-wire channels (40-79).

Note Only one channel can be closed at a time in 1-wire mode.

2-Wire Mode

This is the default mode of HP N2260A. In this mode, the High and Low terminals of a channel are switched to the High and Low terminals of the common bus (COM0 and COM1), respectively. The 20 channels in BANK 0 are numbered 00-19, and the channels in BANK 1 are 20-39. A maximum of 40 2-wire channels can be switched.

Dual 2-Wire Mode

In this mode, HP N2260A is separated into two banks (BANK 0 & BANK1). Each bank consists of 20 2-wire channels and a common bus, COM0 and COM1. The channel number is the same as in 2-wire mode. The 20 channels in BANK 0 are numbered 00-19, and the channels in BANK 1 are 20-39.

4-Wire Mode

In this mode, the two banks (BANK 0 & BANK1) are paired to form a 20-channel 4-wire MUX, which can be used to perform the 4-wire resistance measurements.

The valid channel number is 00 through 19. The first channels of the two banks (CH00 & CH20) form Channel 00, the second channels of the two banks (CH01 & CH21) form Channel 01, and so on.

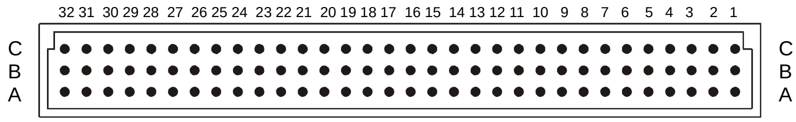
Note An instrument power-on or reset will set the HP N2260A to its default configuration as a 40-channel 2-wire MUX module.

Note These function modes can be selected from the front-panel (refer to “Mode Key Operation” on Page 61), or with a SCPI command (refer to Chapter 6 “[ROUTe:]FUNCtion” on Page 104).

Wiring Information

P401 Pinout

P401 is a 96-pin male DIN connector mounted on the HP N2260A. The pinout is listed in Table 8-1.



View from the Pin Side of the Connector

Table 8-1. P401 Pinout

Pin #	A	B	C	Pin #	A	B	C
1	CH0_L	CH1_L	CH2_L	17	CH20_L	CH21_L	CH22_L
2	CH0_H	CH1_H	CH2_H	18	CH20_H	CH21_H	CH22_H
3	CH3_L	CH4_L	CH5_L	19	CH23_L	CH24_L	CH25_L
4	CH3_H	CH4_H	CH5_H	20	CH23_H	CH24_H	CH25_H
5	CH6_L	CH7_L	CH8_L	21	CH26_L	CH27_L	CH28_L
6	CH6_H	CH7_H	CH8_H	22	CH26_H	CH27_H	CH28_H
7	CH9_L	--[1]	COM0_L	23	CH29_L	--	COM1_L
8	CH9_H	--	COM0_H	24	CH29_H	--	COM1_H
9	CH10_L	CH11_L	CH12_L	25	CH30_L	CH31_L	CH32_L
10	CH10_H	CH11_H	CH12_H	26	CH30_H	CH31_H	CH32_H
11	CH13_L	CH14_L	CH15_L	27	CH33_L	CH34_L	CH35_L
12	CH13_H	CH14_H	CH15_H	28	CH33_H	CH34_H	CH35_H
13	CH16_L	CH17_L	CH18_L	29	CH36_L	CH37_L	CH38_L
14	CH16_H	CH17_H	CH18_H	30	CH36_H	CH37_H	CH38_H
15	CH19_L	--	SE-COM	31	CH39_L	--	--
16	CH19_H	--	SE-COM	32	CH39_H	--	--

[1]. A "--" used in this table and this chapter indicates that the pin is not used.

Terminal Blocks

A screw terminal block (HP N2290A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2260A. Figure 8-3 shows the pinout of the screw connectors on the HP N2290A. For wiring information on the terminal blocks, refer to "Plug-In Modules Wiring Information" on Page 254.

DIN-TO-D Cables

Two DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P401 on the HP N2260A to an external circuitry. Refer to Page 260 of this manual for more information.

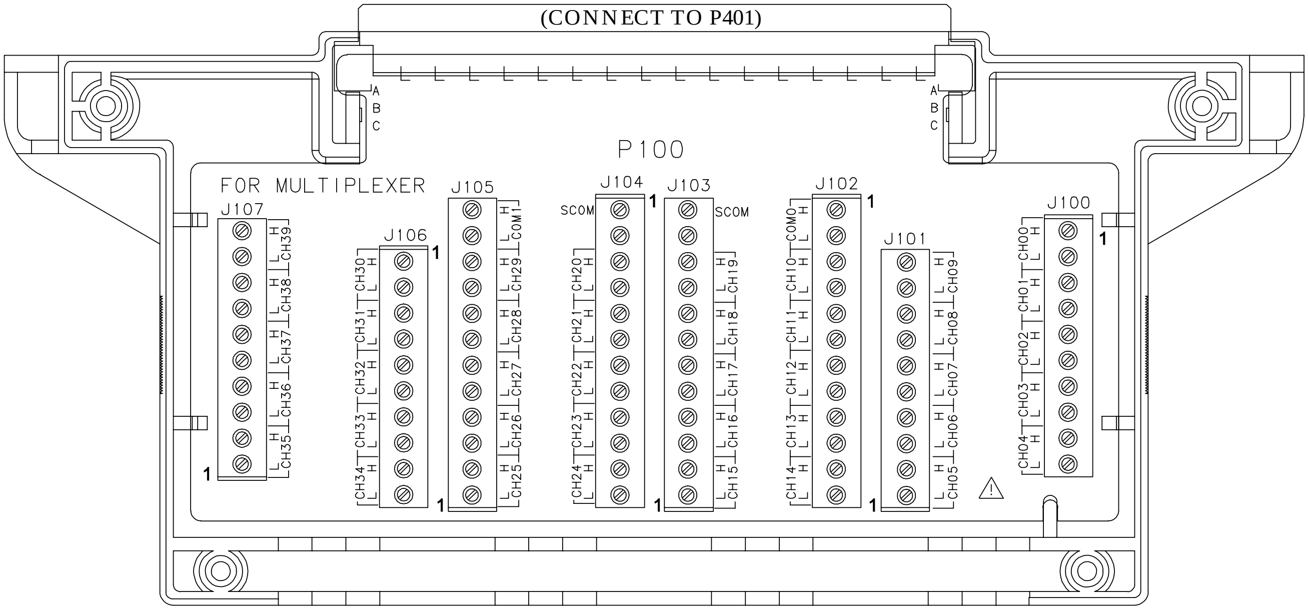


Figure 8-3. HP N2290A Screw Connectors Pinout

Specifications

The specifications of the HP N2260A MUX Module are listed in Table 8-2.

Table 8-2. HP N2260A Specifications

ITEMS		SPECIFICATIONS	
INPUT CHARACTERISTICS			
Total Channels		80 1-wire; or 40 2-wire; or dual 20 2-wire; or 20 4-wire	
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	200 V, dc or ac rms	
Maximum Current	Per Channel	1 A, dc or ac rms	
	Per Module	2A, dc or ac rms	
Maximum Power	Per Channel	60 W dc; 62.5 VA ac	
	Per Module	120 W dc; 125 VA ac	
Thermal Offset		< 3 μV differential or single-ended	
Initial Closed Channel Resistance		< 1 Ω	
Relay Life	Mechanical Electrical	10^8 (at 36000 operations/hour) 5×10^5 (1A load)	
Maximum Scan Rate		80 Chans/sec	
DC ISOLATION (with terminal block)			
Open Channel, Channel-Channel (with 1 channel closed)	< (40°C, 50% RH) < (40°C, 80% RH)	> 10^{10} Ω > 10^9 Ω	
HI-LO (with 1 channel closed)	< (40°C, 50% RH) < (40°C, 80% RH)	> 10^{10} Ω > 10^9 Ω	
Channel-Chassis (with 1 channel closed)	< (40°C, 50% RH) < (40°C, 80% RH)	> 10^{10} Ω > 10^9 Ω	
AC ISOLATION / PERFORMANCE[1] (without terminal block)			
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF (2-wire) < 75 pF (2-wire) < 150 pF (2-wire)	< 7 pF (dual 2-wire) < 45 pF (dual 2-wire) < 90 pF (dual 2-wire)
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 1.50 dB	
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -70 dB (2-wire) < -50 dB (2-wire) < -30 dB (2-wire)	< -40 dB (1-wire) < -25 dB (1-wire) NA (1-wire)

[1]. With chassis of all instruments connected, and with the Low Terminal of the input connected to the Low Terminal of the output (either directly or via HP 3499A/B switching channels).

HP N2261A 40-Channel GP Relay Module

General Description

The HP N2261A GP Relay Module contains 40 independent Single Pole - Single Throw (SPST, Form A) latching relays. Multiple channels can stay closed. If necessary, High (H) and Low (L) signal lines can be switched together by using a pair of channels on the two paired HP N2261A modules.

The HP N2261A can be operated in either mode: single channel break-before-make (BBM) or multiple channels staying closed together. The parallel switching[1] feature makes it well suited for high speed switching applications.

Two terminal blocks and two DIN-to-D cables are available for wiring conveniences.

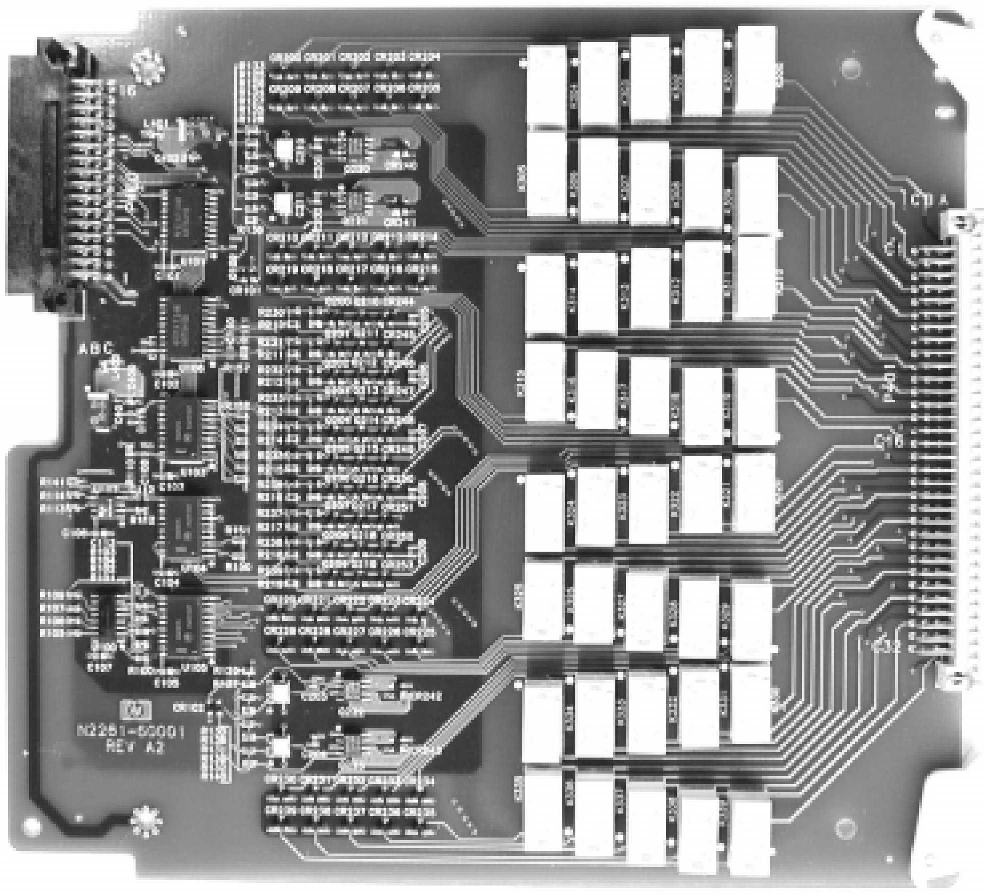


Figure 8-4. HP N2261A

[1]. The 40 relay channels on the HP N2261A can be separated into four groups: Group 1 (CH00-09) through Group 4 (CH30-39). Multiple relay channels (up to 10) in the same group can be operated all at once (parallel switching).

Simplified Schematic

As shown in Figure 8-5, the HP N2261A contains 40 independent Single Pole-Single Throw (SPST, Form A) latching relays. A channel refers to an individual relay on the module. Therefore, when speaking of closing a channel, we are referring to closing a particular relay. Channels are numbered 00 through 39 for HP N2261A.

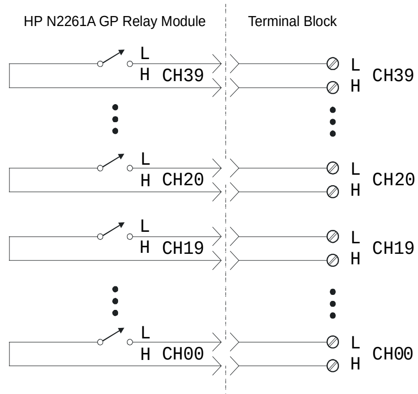
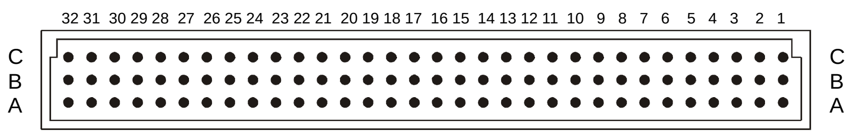


Figure 8-5. HP N2261A Simplified Schematic

Wiring Information

P401 Pinout

P401 is a 96-pin male DIN connector mounted on the HP N2261A. The pinout is listed in Table 8-3.



View from the Pin Side of the Connector

Table 8-3. P401 Pinout

Pin #	A	B	C	Pin #	A	B	C
1	CH0_L	CH1_L	CH2_L	17	CH20_L	CH21_L	CH22_L
2	CH0_H	CH1_H	CH2_H	18	CH20_H	CH21_H	CH22_H
3	CH3_L	CH4_L	CH5_L	19	CH23_L	CH24_L	CH25_L
4	CH3_H	CH4_H	CH5_H	20	CH23_H	CH24_H	CH25_H
5	CH6_L	CH7_L	CH8_L	21	CH26_L	CH27_L	CH28_L
6	CH6_H	CH7_H	CH8_H	22	CH26_H	CH27_H	CH28_H
7	CH9_L	--[1]	--	23	CH29_L	--	--
8	CH9_H	--	--	24	CH29_H	--	--
9	CH10_L	CH11_L	CH12_L	25	CH30_L	CH31_L	CH32_L
10	CH10_H	CH11_H	CH12_H	26	CH30_H	CH31_H	CH32_H

Table 8-3. P401 Pinout

Pin #	A	B	C	Pin #	A	B	C
11	CH13_L	CH14_L	CH15_L	27	CH33_L	CH34_L	CH35_L
12	CH13_H	CH14_H	CH15_H	28	CH33_H	CH34_H	CH35_H
13	CH16_L	CH17_L	CH18_L	29	CH36_L	CH37_L	CH38_L
14	CH16_H	CH17_H	CH18_H	30	CH36_H	CH37_H	CH38_H
15	CH19_L	--	--	31	CH39_L	--	--
16	CH19_H	--	--	32	CH39_H	--	--

[1]. A "--" used in this table and this chapter indicates that the pin is not used.

Terminal Blocks

A screw terminal block (HP N2291A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2261A. Figure 8-6 shows the pinout of the screw connectors on the HP N2291A. For wiring information on the terminal blocks, refer to "Plug-In Modules Wiring Information" on Page 254.

DIN-TO-D Cables

Two DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P401 on the HP N2261A to an external circuitry. Refer to Page 260 of this manual for more information.

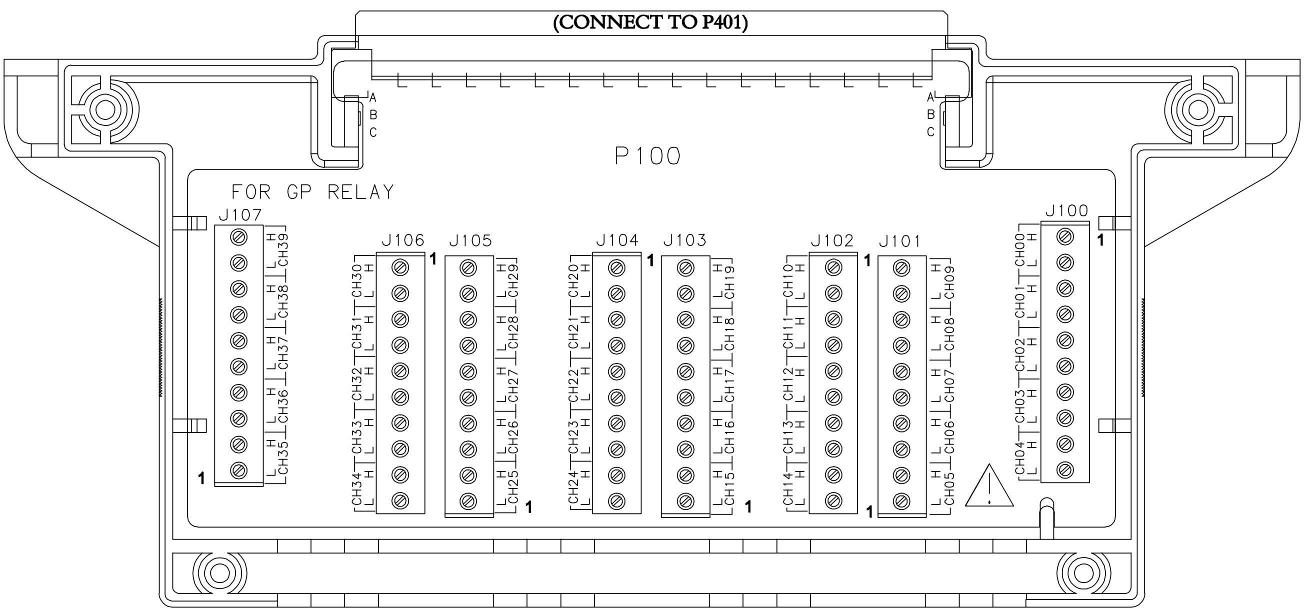


Figure 8-6. HP N2291A Screw Connectors Pinout

Specifications

HP N2261A 40-Channel GP Relay Module specifications are listed in Table 8-4.

Table 8-4. HP N2261A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		40
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	200 V, dc or ac rms
Maximum Current	Per Channel Per Module	1 A, dc or ac rms 20 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 62.5 VA ac 1200 W dc; 1250 VA ac
Thermal Offset	Per Channel	< 3 μV
Initial Closed Channel Resistance		< 0.5 Ω
Relay Life	Mechanical Electrical	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate		80 Chans/sec
DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[1] (without terminal block)		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel Channel-Chassis	< 10 pF < 10 pF < 20 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -70 dB < -50 dB < -30 dB

[1]. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via HP 3499A/B switching channels)

HP N2262A 4 x 8 2-Wire Matrix Switch Module

General Description

The HP N2262A 4 x 8 Matrix module contains 32 2-wire nodes/crosspoints organized in a 4-row by 8-column configuration. Each node or crosspoint in the matrix contains a 2-wire latching relay, for switching both High (H) and Low (L) terminals of a signal line. Multiple switches can stay closed, allowing any combination of row-to-column connections. The parallel switching[1] feature makes it well suited for high speed switching applications.

The HP N2262A provides a convenient way to connect multiple test instruments to multiple test points on a device or to multiple devices. Moreover, multiple HP N2262A modules can be connected together, or used in conjunction with other modules such as the HP 2260A 40-Channel MUX to provide a wide variety of switching combinations.

Two terminal blocks and three DIN-to-D cables are also available for wiring conveniences.

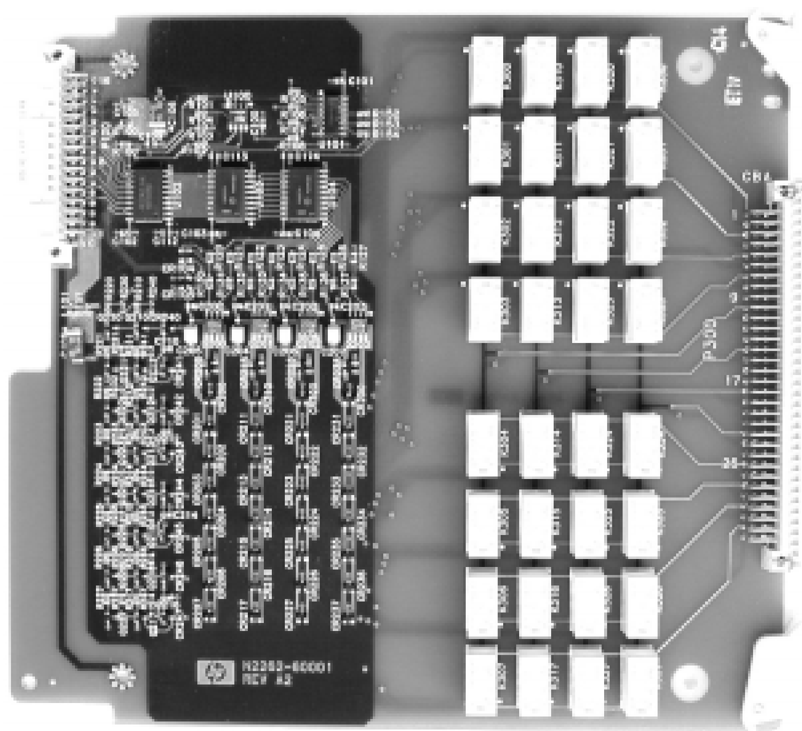


Figure 8-7. HP N2262A

Simplified Schematic

As shown in Figure 8-8 on Page 185, the HP N2262A contains 32 2-wire crosspoints organized in a 4-row by 8-column configuration. Each crosspoint relay has a unique two digit channel number mn, where m = row number (0-3) and n = column number (0-7).

[1]. Up to 8 2-wire node/crosspoint relays in the same row can be closed all at once (parallel switching).

For example, Channel 31 represents the relay at the crosspoint of Row 3 (ROW3) and Column 1 (COL1).

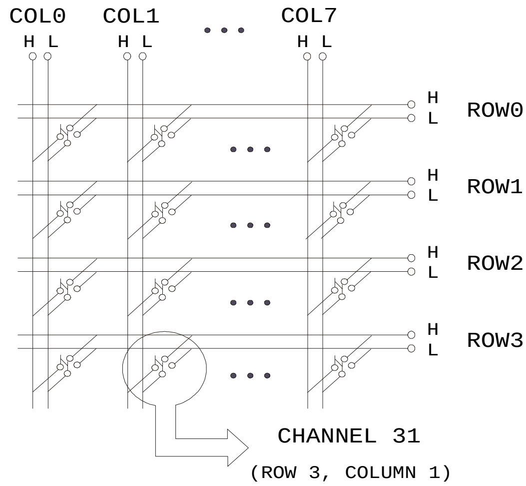
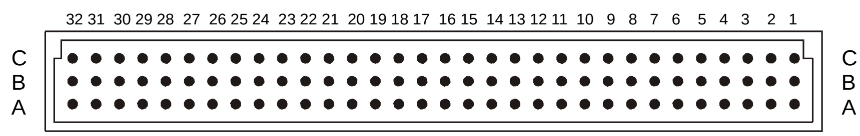


Figure 8-8. HP N2262A Simplified Schematic

Wiring Information

P300 Pinout

P300 is a 96-pin male DIN connector mounted on the HP N2262A. The pinout is listed in Table 8-5.



View from the Pin Side of the Connector

Table 8-5. P300 Pinout

Pin #	C	Pin #	Pinout	Pin #	Pinout	Pin #	Pinout
1	COL0_L	9	--[1]	17	--	25	COL4_L
2	COL0_H	10	ROW0_L	18	ROW2_L	26	COL4_H
3	COL1_L	11	ROW0_H	19	ROW2_H	27	COL5_L
4	COL1_H	12	--	20	--	28	COL5_H
5	COL2_L	13	--	21	--	29	COL6_L
6	COL2_H	14	ROW1_L	22	ROW3_L	30	COL6_H
7	COL3_L	15	ROW1_H	23	ROW3_H	31	COL7_L
8	COL3_H	16	--	24	--	32	COL7_H

[1]. A1-A32 & B1-B32 and the pins identified with “--” are not used.

Terminal Blocks

A screw terminal block (HP N2292A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2262A. Figure 8-9 shows the pinout of the screw connectors on the HP N2292A. For wiring information on the two terminal blocks, refer to "Plug-In Modules Wiring Information" on Page 254.

DIN-TO-D Cables

Three DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P300 on the HP N2262A to an external circuitry. Refer to Page 260 of this manual for more information.

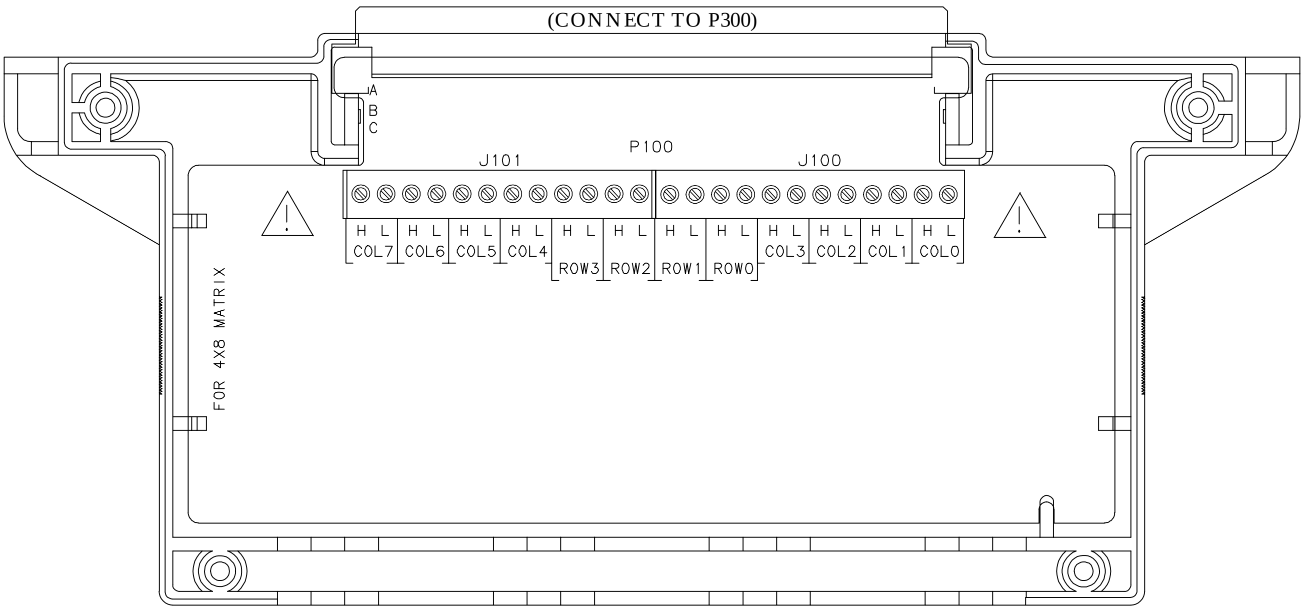


Figure 8-9. HP N2292A Screw Connectors Pinout

Specifications

HP N2262A 4 x 8 2-Wire Matrix Module specifications are listed in Table 8-6.

Table 8-6. HP N2262A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		4 x 8
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	200 V, dc or ac rms
Maximum Current	Per Channel Per Module	1 A, dc or ac rms 4 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 62.5 VA ac 240 W dc; 250 VA ac
Thermal Offset		< 3 μV differential
Initial Closed Channel Resistance		< 1 Ω
Relay Life	Mechanical Electrical	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate		80 Chans/sec
DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
HI-LO (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[1] (without terminal block)		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF < 30 pF < 50 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 0.60 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -73 dB < -53 dB < -28 dB

[1]. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via HP 3499A/B switching channels)

HP N2263A 32-bit Digital I/O Module

General Description

The HP N2263A is a 32-bit digital I/O module. It provides 32 bidirectional data lines (bits) and 3 handshake lines, the latter are used for control and handshaking. All lines are TTL compatible. The 32 I/O bits can be addressed as thirty-two 1-bit ports, or four independent 8-bit ports, or two independent 16-bit ports, or one 32-bit port.

The four 8-bit ports are completely independent of each other and may be used separately. For instance, some of the ports can be used for output operation, while the other(s) for input. However, all the 8 bits in each of the four ports are dependent, i.e. they can be used either all as input or all as output, but not as a combination of input and output bits.

Two screw terminal blocks and two DIN-to-D cables are available for wiring conveniences.

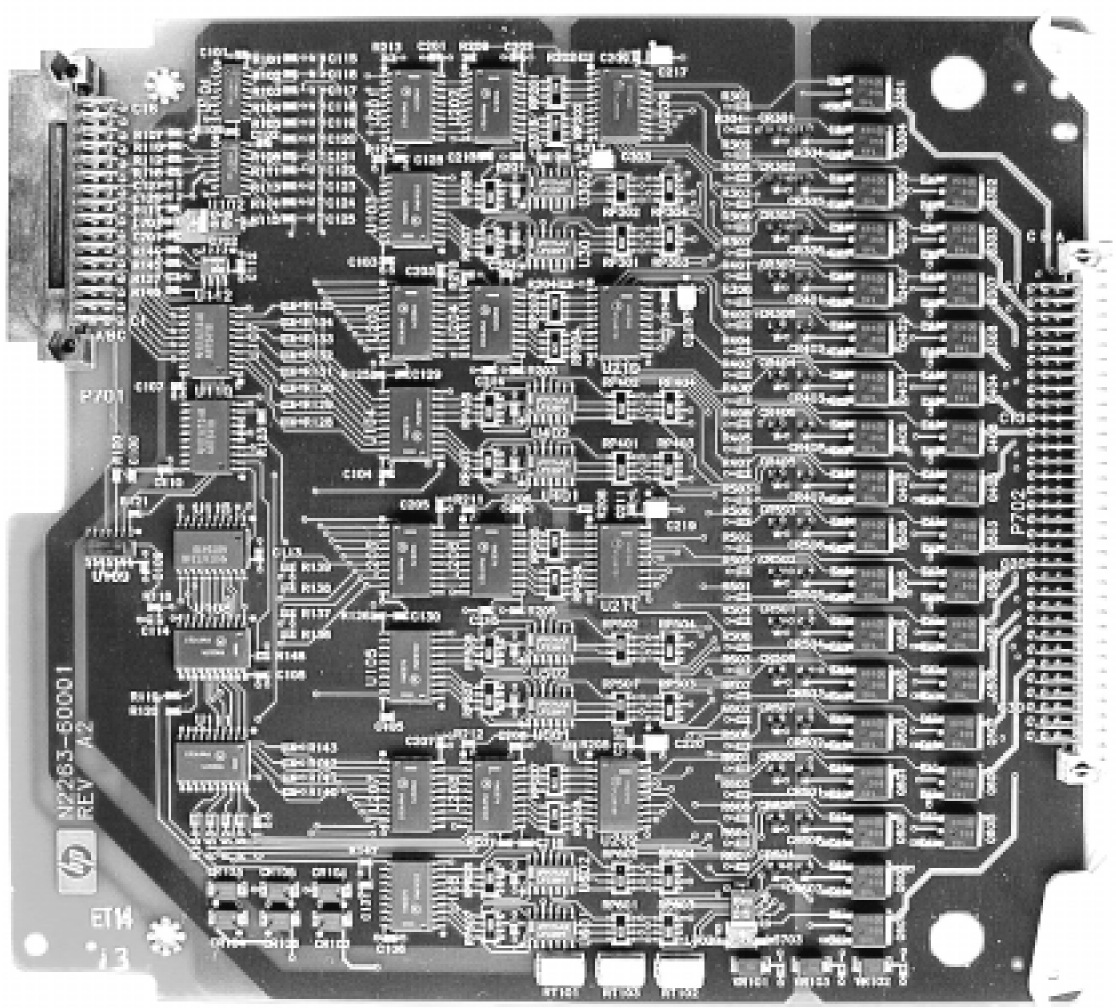


Figure 8-10. HP N2263A

Simplified Schematic

The HP N2263A consists of 32 bidirectional I/O channels, each of which includes digital in and digital out circuits as shown in Figure 8-11. Each input has its own pull-up resistor, allowing easy detection of external termination (grounded or open-circuited) status. Each output driver is capable of sinking an external supplied current up to 600 mA, making it possible to control relays directly without the need for additional driver circuitry.

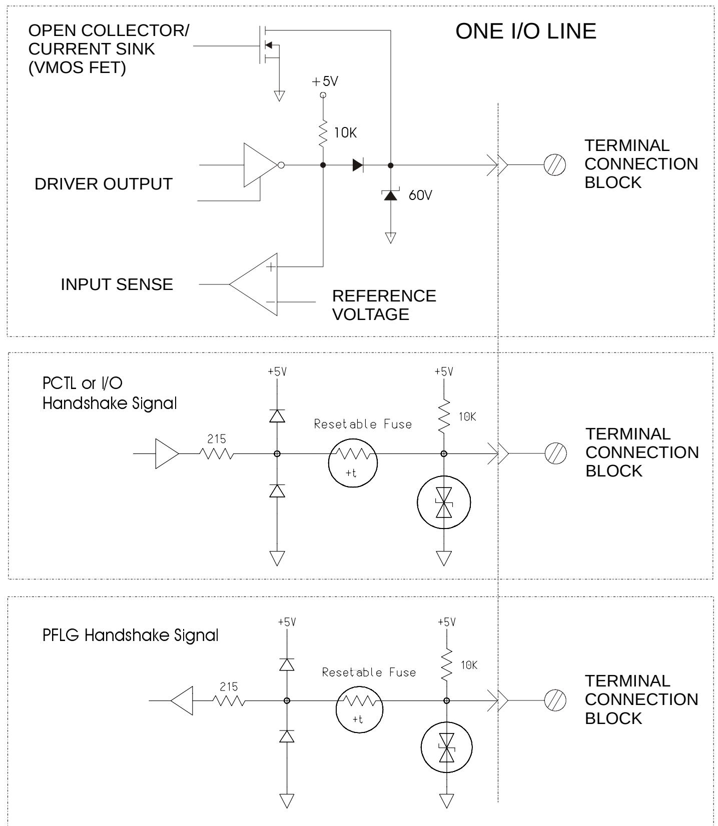


Figure 8-11. HP N2263A Simplified Schematic

The module can be addressed on a bit-by-bit basis (bits 00 through 31), as four independent 8-bit ports, as two 16-bit ports, or as one 32-bit port.

Note The port numbering is different in SCPI mode and HP 3488A mode. See Table 8-8 on Page 191 for more information.

Moreover, in order to communicate with peripherals, five handshaking modes are defined in this module, they are established via the three control lines:

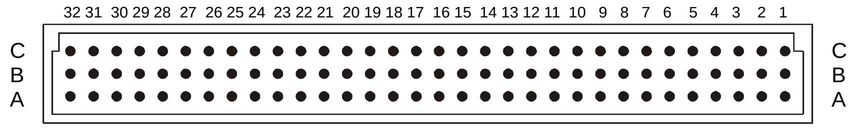
- Peripheral Control (PCTL),
- I/O direction (I/O),
- Peripheral Flag (PFLG).

For more information on the five handshaking modes, refer to Chapter 7 “Digital Commands” on Page 151.

Wiring Information

P702 Pinout

P702 is a 96-pin male DIN connector mounted on the HP N2263A. The pinout is listed in Table 8-3 on Page 190.



View from the Pin Side of the Connector

Table 8-7. P702 Pinout

Pin #	A	B	C	Pin #	A	B	C
1-2	--[1]	--	--	19	BIT16	BIT17	BIT18
3	BIT0	BIT1	BIT2	20	GND	GND	GND
4	GND	GND	GND	21	BIT19	BIT20	BIT21
5	BIT3	BIT4	BIT5	22	GND	GND	GND
6	GND	GND	GND	23	BIT22	BIT23	GND
7	BIT6	BIT7	GND	24	GND	GND	GND
8	GND	GND	GND	25	BIT24	BIT25	BIT26
9	BIT8	BIT9	BIT10	26	GND	GND	GND
10	GND	GND	GND	27	BIT27	BIT28	BIT29
11	BIT11	BIT12	BIT13	28	GND	GND	GND
12	GND	GND	GND	29	BIT30	BIT31	GND
13	BIT14	BIT15	GND	30	GND	GND	GND
14	GND	GND	GND	31	I-#O	PCTL	PFLG
15-18	--	--	--	32	GND	GND	GND

[1]. The pins identified with “--” are not used.

Table 8-8 lists the 8/16/32-bit Port # vs.the Bit # and the Pin #.

Table 8-8. Port # vs. Bit #

System Mode	32-Bit Port #	16-Bit Port #	8-Bit Port #	Bit #	Pin #
SCPI mode	PORT 00	PORT 00	PORT 00	Bits 0-7	A3, B3, C3, A5, B5, C5, A7, B7
			PORT 01	Bits 8-15	A9, B9, C9, A11, B11, C11, A13, B13
		PORT 02	PORT 02	Bits 16-23	A19, B19, C19, A21, B21, C21, A23, B23
			PORT 03	Bits 24-31	A25, B25, C25, A27, B27, C27, A29, B29
HP 3488A Mode	PORT 06	PORT 04	PORT 00	Bits 0-7	A3, B3, C3, A5, B5, C5, A7, B7
			PORT 01	Bits 8-15	A9, B9, C9, A11, B11, C11, A13, B13
		PORT 05	PORT 02	Bits 16-23	A19, B19, C19, A21, B21, C21, A23, B23
			PORT 03	Bits 24-31	A25, B25, C25, A27, B27, C27, A29, B29

Terminal Blocks

A screw terminal block (HP N2293A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2263A. Figure 8-12 shows the pinout of the screw connectors on the HP N2293A. For wiring information on the terminal blocks, refer to “Plug-In Modules Wiring Information” on Page 254.

DIN-TO-D Cables

Two DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P702 to an external circuitry. Refer to Page 260 of this manual for more information.

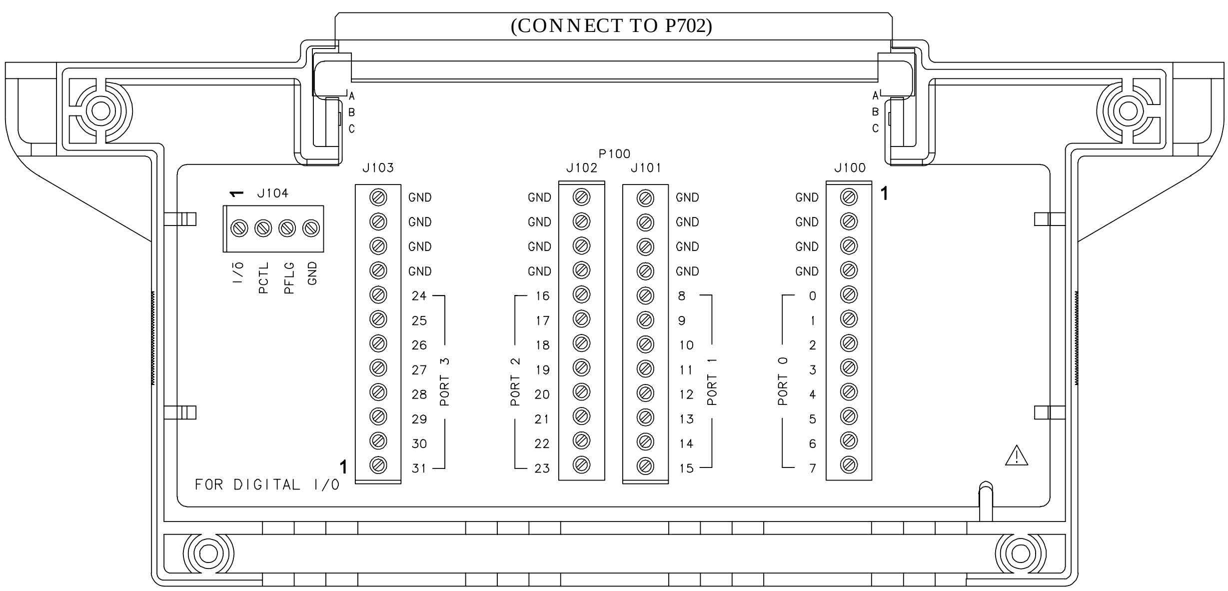


Figure 8-12. HP N2293A Screw Connectors Pinout

Specifications

HP N2263A 32-bit Digital I/O Module specifications are listed in Table 8-9.

Table 8-9. HP N2263A Specifications

ITEMS		SPECIFICATIONS
I/O LINES		
Maximum Voltage (line-chassis)		+ 42 V dc
Maximum Sink Current (per bit)		0.6 A
Output Characteristics	Vout (high) Vout (low)	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600mA input
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V
HANDSHAKE LINES		
Maximum Voltage (Line-Chassis)		+5 V dc
Output Characteristics	Vout (high) Vout (low) Iout (low)	≥ 2.4 V @ I ≤ 400 µA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V

HP N2264A Multifunction Module

General Description

The HP N2264A multifunction module combines a general-purpose relay function, a high-current GP relay[1] function, and a digital input/output function into one module. It consists of:

- 12-Channel GP relays (non-latching Form-A);
- 3-Channel High-current GP relays (non-latching Form-A);
- 16-bit Digital I/O.

Therefore it is well-suited for applications that require multiple functions in one slot. The parallel switching[2] feature makes the module well suited for high speed switching applications.

Two terminal blocks and two DIN-to-D cables are available for wiring conveniences.

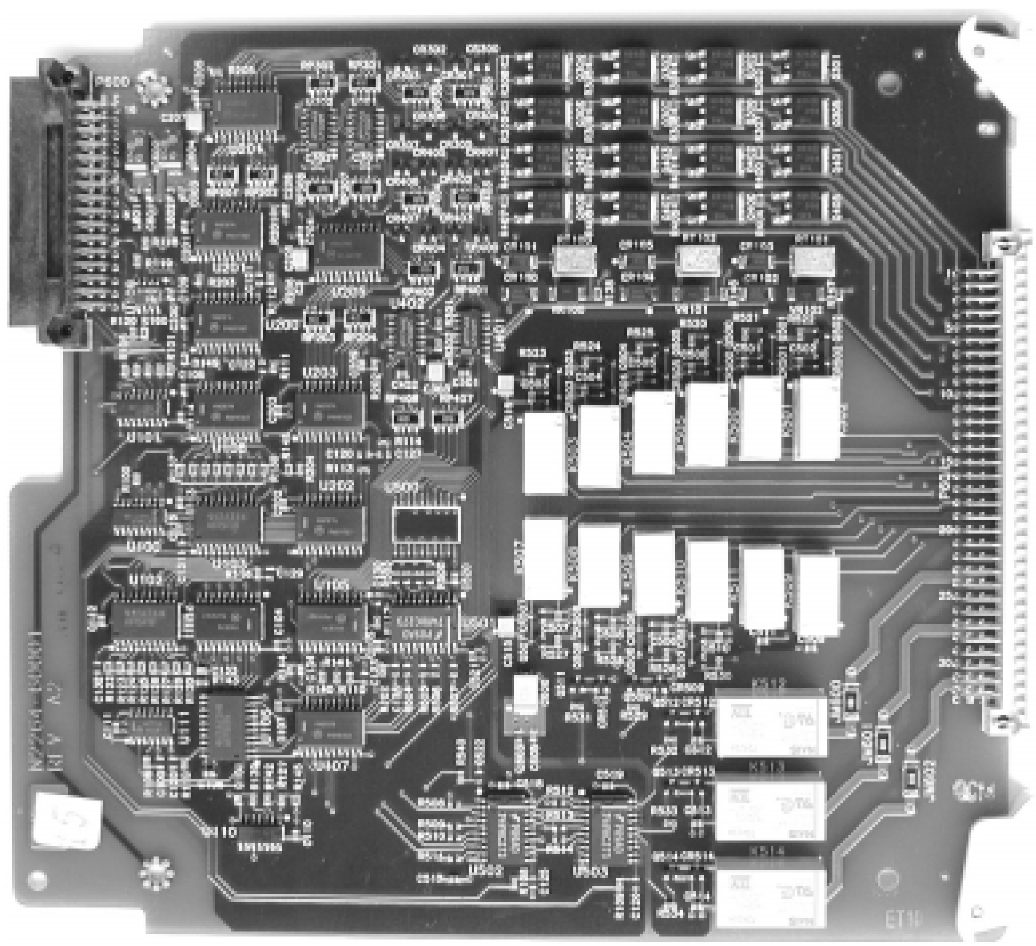


Figure 8-13. HP N2264A Multifunction Module

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[1]. Each channel of the High-current GP relays on the HP N2264A can switch up to 5 amps of current.
[2]. Any 10 of the 15 GP relays on the HP N2264A can be closed all at once (parallel switching).

Simplified Schematic

As shown in Figure 8-14, there are three independent functions on the HP N2264A: the 12-channel GP Relay (CH00-11), the 3-channel High-current GP Relay (CH20-22), and the 16-bit Digital I/O (bits 30-45).

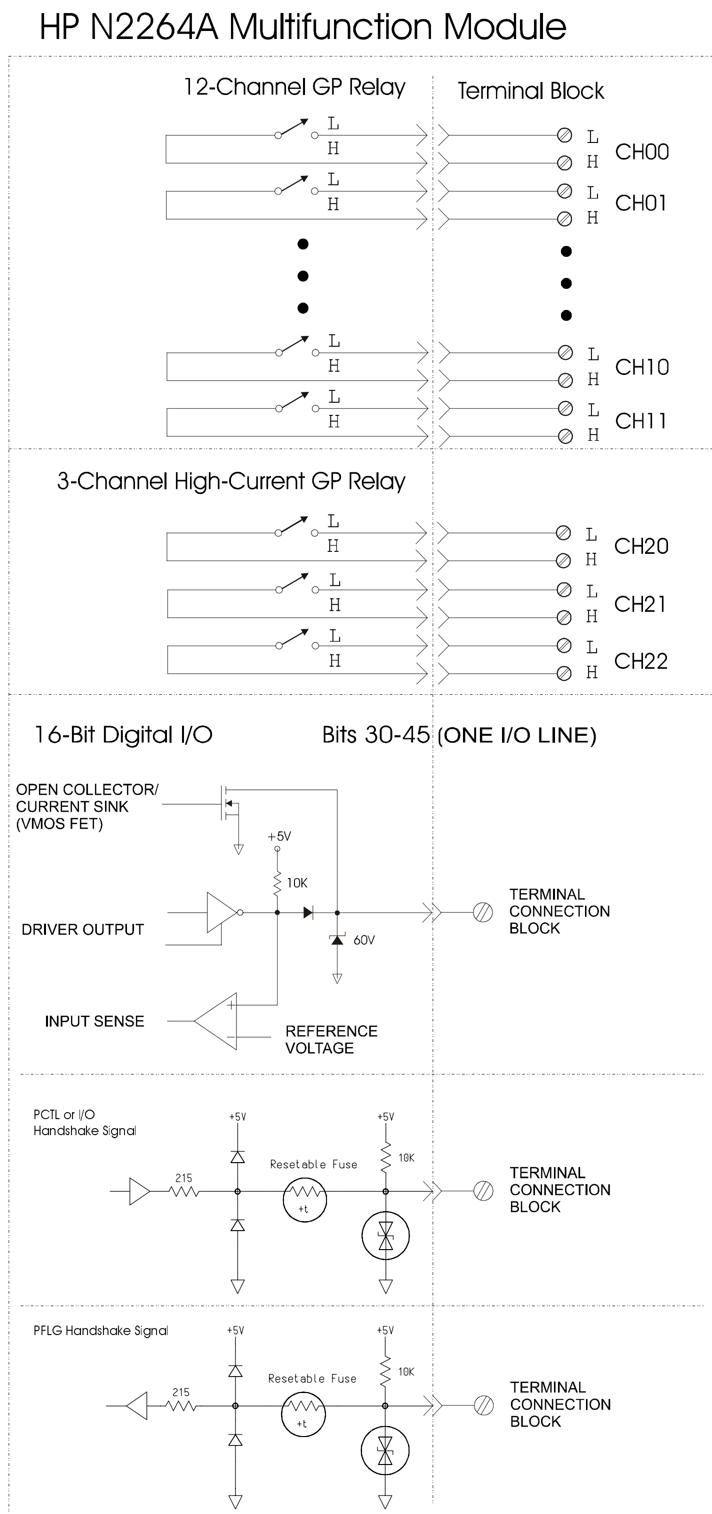


Figure 8-14. HP N2264A Simplified Schematic

Wiring Information

P601 Pinout

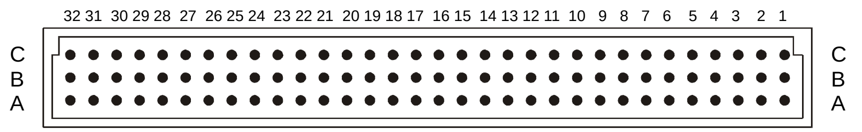
P601 is a 96-pin male DIN connector mounted on the HP N2264A. The pinout is listed in Table 8-10 on Page 195.

Terminal Blocks

A screw terminal block (HP N2294A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2264A. Figure 8-15 on Page 196 shows the pinout of the screw connectors on the HP N2294A. For wiring information on the terminal blocks, refer to “Plug-In Modules Wiring Information” on Page 254.

DIN-TO-D Cables

Two DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P601 on the HP N2264A to an external circuitry. Refer to Page 260 of this manual for more information.



View from the Pin Side of the Connector

Table 8-10. P601 Pinout

Pin #	A	B	C	Pin #	A	B	C
1	BIT30	BIT31	BIT32	17	CH6_L	CH7_L	CH8_L
2	GND	GND	GND	18	CH6_H	CH7_H	CH8_H
3	BIT33	BIT34	BIT35	19	CH9_L	CH10_L	CH11_L
4	BIT36	BIT37	GND	20	CH9_H	CH10_H	CH11_H
5	GND	GND	GND	21	CH20_L	CH20_L	CH20_L
6	BIT38	BIT39	BIT40	22	CH20_L	CH20_L	CH20_L
7	GND	GND	GND	23	CH20_H	CH20_H	CH20_H
8	BIT41	BIT42	BIT43	24	CH20_H	CH20_H	CH20_H
9	BIT44	BIT45	GND	25	CH21_L	CH21_L	CH21_L
10	I-#O	PCTL	PFLG	26	CH21_L	CH21_L	CH21_L
11	GND	GND	GND	27	CH21_H	CH21_H	CH21_H
12	--[1]	--	--	28	CH21_H	CH21_H	CH21_H
13	CH0_L	CH1_L	CH2_L	29	CH22_L	CH22_L	CH22_L
14	CH0_H	CH1_H	CH2_H	30	CH22_L	CH22_L	CH22_L
15	CH3_L	CH4_L	CH5_L	31	CH22_H	CH22_H	CH22_H
16	CH3_H	CH4_H	CH5_H	32	CH22_H	CH22_H	CH22_H

[1]. The pins identified with “--” are not used.

Caution **12 pins are provided for each channel of the 3-Channel High-current GP Relay. Make sure to use ALL the 12 pins to switch one channel whenever the switched current exceeds 1 amp.**

Table 8-11lists the Port # vs. Bit # for the 16-bit digital I/O on the HP N2264A.

Table 8-11. Port # vs. Bit # (16-bit DIO)

Operating Mode	16-Bit Port #	8-Bit Port #	Bit #	Pin #
SCPI mode	PORT 30	PORT 30	Bits 30-37	A1, B1, C1, A3, B3, C3, A4, B4
		PORT 31	Bits 38-45	A6, B6, C6, A8, B8, C8, A9, B9
HP 3488A Mode	PORT 32	PORT 30	Bits 30-37	A1, B1, C1, A3, B3, C3, A4, B4
		PORT 31	Bits 38-45	A6, B6, C6, A8, B8, C8, A9, B9

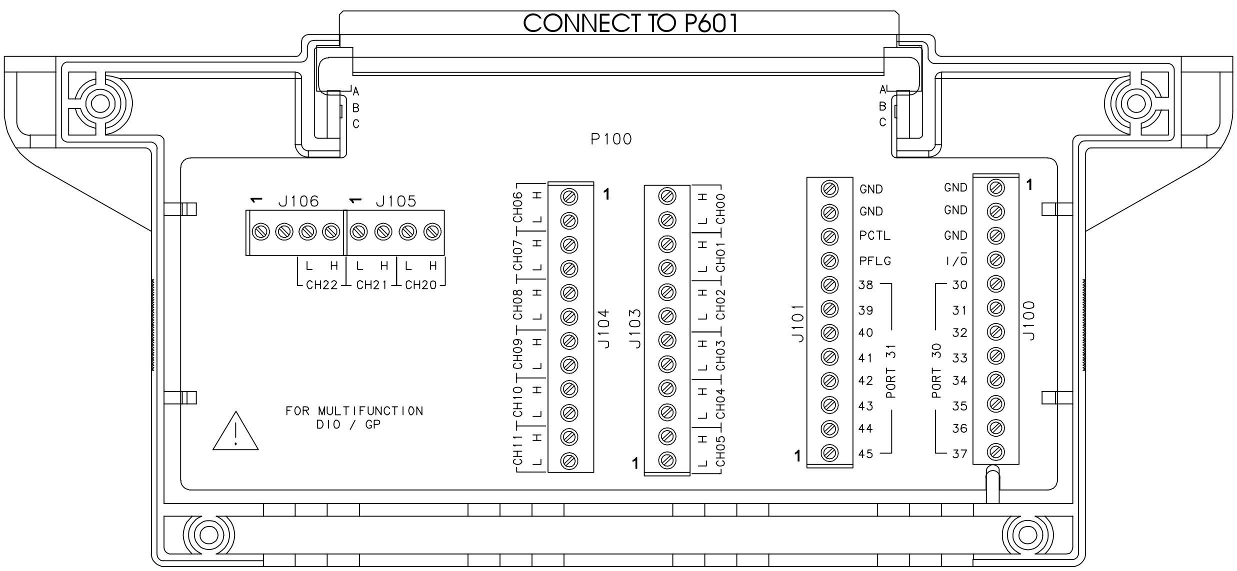


Figure 8-15. HP N2294A Screw Connectors Pinout

Specifications

Table 8-12 through Table 8-14 list the specifications of the individual functions on the HP N2264A Multifunction Module.

Table 8-12. HP N2264A Specifications for 12-Channel GP Relay Function[1]

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		12
Maximum Voltage	terminal-terminal or terminal-chassis	200 V, dc or ac rms
Maximum Current	per channel	1 A, dc or ac rms
Maximum Power	per channel	60 W dc; 62.5 VA ac
Thermal Offset	per channel	< 3 μV
Initial Closed Channel Resistance		< 0.5 Ω
Relay Life	Mechanical Electrical	10^8 (at 36000 operations/hour) 5 x 10^5 (1A load)
Maximum Scan Rate		80 Chans/sec
DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[2] (without terminal block)		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel Channel-Chassis	< 10 pF < 20 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -70 dB < -50 dB < -30 dB

[1]. The maximum number of channels that can be closed simultaneously is 10 (including the GP & High-current GP relays). The maximum carrying current is 15 A (including GP, High-current GP and DIO).

[2]. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via HP 3499A/B switching channels).

Table 8-13. HP N2264A Specifications for High-current GP Relay Function

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		3
Maximum Voltage (terminal-terminal or terminal-chassis)		125 V dc or 200 V ac rms
Maximum Current (per channel)		5 A, dc or ac rms
Maximum Power (per channel)		150 W dc; 1250 VA ac
Thermal Offset	per channel	< 3 μV
Initial Closed Channel Resistance		< 0.1 Ω
Relay Life	Mechanical Electrical	5 x 10^7 (at 180 cycles/minute) 10^5 (at rated load)
Time to Close One Channel		16 mS
DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^oC, 50% RH) < (40^oC, 80% RH)	> 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^oC, 50% RH) < (40^oC, 80% RH)	> 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[1] (without terminal block)		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel Channel-Chassis	< 10 pF < 20 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -70 dB < -50 dB < -30 dB

[1]. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via HP 3499A/B switching channels).

Table 8-14. HP N2264A Specifications for 16-bit DIO Function

ITEMS		SPECIFICATIONS
I/O LINES		
Maximum Voltage (line-chassis)		+ 42 V dc
Maximum Sink Current (per bit)		0.6 A
Output Characteristics	Vout (high) Vout (low)	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600 mA input
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V
HANDSHAKE LINES		
Maximum Voltage (Line-Chassis)		+5 V dc
Output Characteristics	Vout (high) Vout (low) Iout (low)	≥ 2.4 V @ I ≤ 400 µA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V

HP N2265A Multifunction Module

General Description

The HP N2265A is a multifunction module which consists of a 4 x 4 2-wire matrix and a 16-bit digital I/O. It can be operated as:

- A 4 x 4 2-wire Matrix module (16 latching relays) and;
- A 16-bit digital I/O module.

which makes it well-suited for the applications that require multiple functions in one slot. The parallel switching[1] feature makes this module well suited for high speed switching applications.

Two terminal blocks and two DIN-to-D cables are available for wiring conveniences.

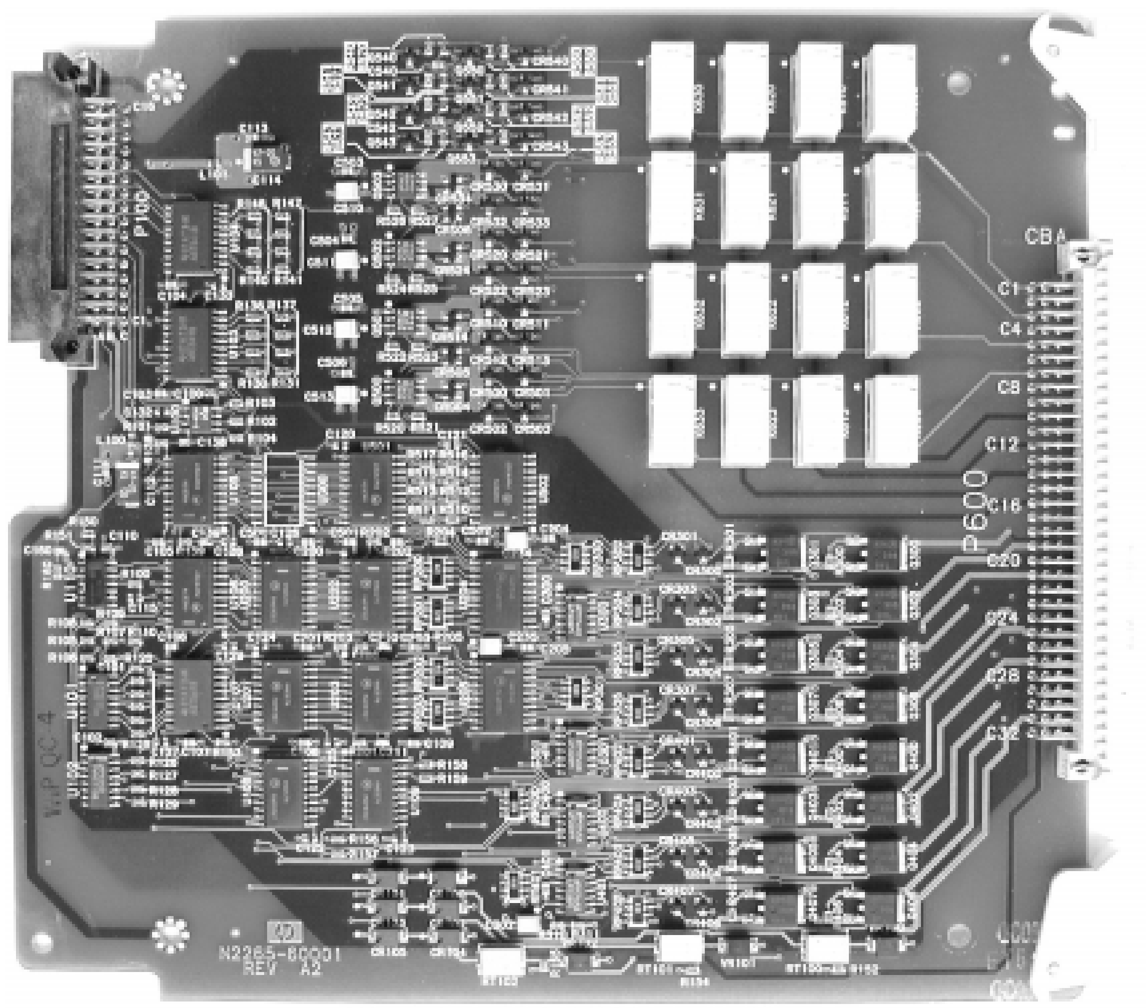


Figure 8-16. HP N2265A Multifunction Module

[1]. Up to 8 2-wire node/crosspoint relays in the same row can be closed all at once (parallel switching).

Simplified Schematic

As shown in Figure 8-17 on Page 201, the HP N2265A is separated into two sections: the 4 x 4 2-wire matrix and the 16-bit digital I/O. A channel on the HP N2265A refers to an individual crosspoint on the matrix, or an individual bit on the 16-bit digital I/O.

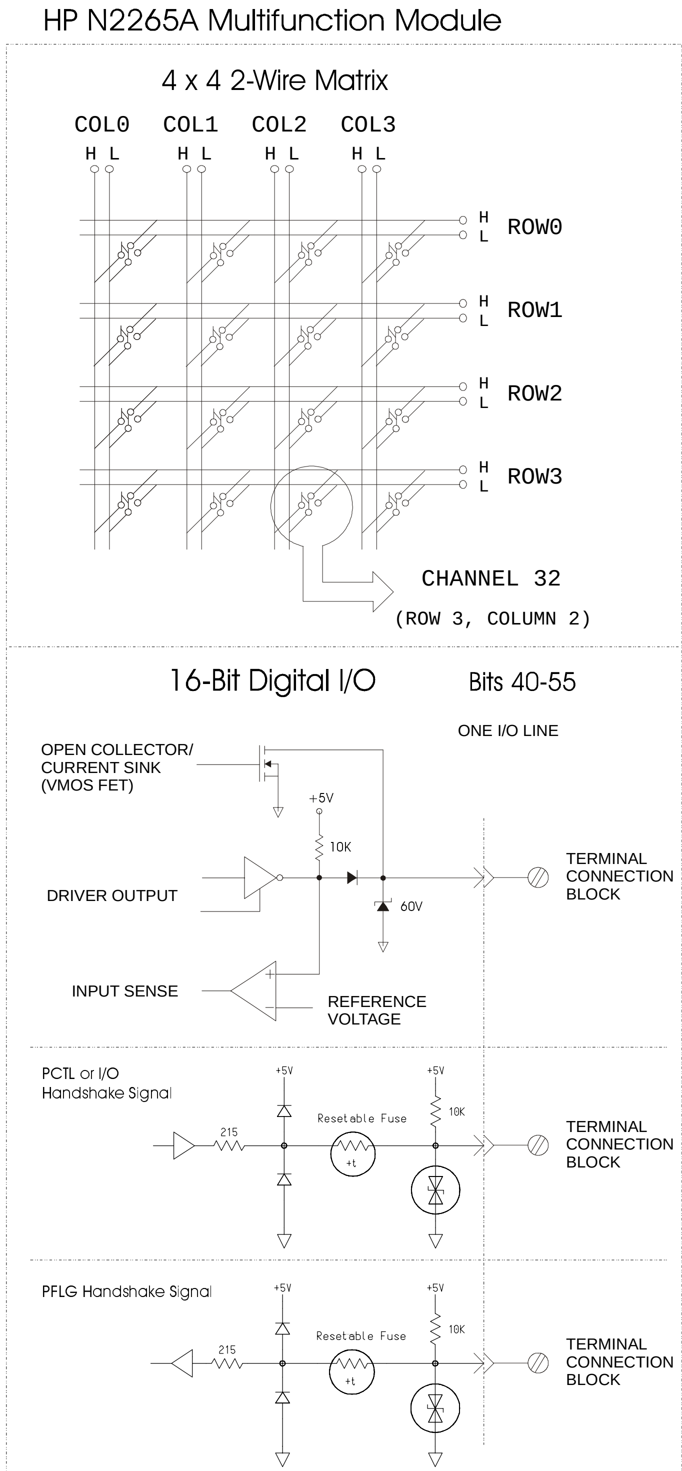


Figure 8-17. HP N2265A Simplified Schematic

Wiring Information

P600 Pinout

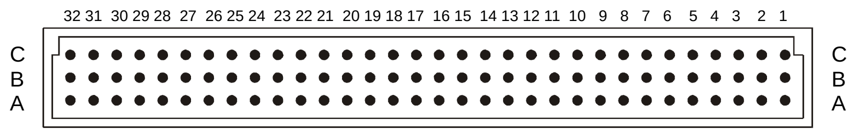
P600 is a 96-pin male DIN connector mounted on the HP N2265A. The pinout is listed in Table 8-15 on Page 202.

Terminal Blocks

A screw terminal block (HP N2295A) and a crimp-and-insert terminal block (HP N2296A) are available with the HP N2265A. Figure 8-18 on Page 203 shows the pinout of the screw connectors on the HP N2295A. For wiring information on the two terminal blocks, refer to “Plug-In Modules Wiring Information” on Page 254.

DIN-TO-D Cables

Two DIN-to-D cables (see Table 8-36 on Page 260) are also available for connecting the DIN connector P600 on the HP N2265A to an external circuitry. Refer to Page 260 of this manual for more information.



View from the Pin Side of the Connector

Table 8-15. P600 Pinout

Pin #	A	B	C	Pin #	A	B	C
1	--[1]	--	COL0_L	17	--	--	--
2	--	--	COL0_H	18	--	--	--
3	--	--	COL1_L	19	BIT40	BIT41	BIT42
4	--	--	COL1_H	20	GND	GND	GND
5	--	--	COL2_L	21	BIT43	BIT44	BIT45
6	--	--	COL2_H	22	GND	GND	GND
7	--	--	COL3_L	23	BIT46	BIT47	GND
8	--	--	COL3_H	24	GND	GND	GND
9	--	--	ROW0_L	25	BIT48	BIT49	BIT50
10	--	--	ROW0_H	26	GND	GND	GND
11	--	--	ROW1_L	27	BIT51	BIT52	BIT53
12	--	--	ROW1_H	28	GND	GND	GND
13	--	--	ROW2_L	29	BIT54	BIT55	GND
14	--	--	ROW2_H	30	GND	GND	GND
15	--	--	ROW3_L	31	I-#O	PCTL	PFLG
16	--	--	ROW3_H	32	GND	GND	GND

[1]. The pins identified with “--” are not used.

Table 8-16 lists the Port # vs. the Bit # and the Pin # for the 16-bit digital I/O.

Table 8-16. Port # vs. Bit #

Operating Mode	16-Bit Port #	8-Bit Port #	Bit #	Pin #
SCPI mode	PORT 40	PORT 40	Bits 40-47	A19, B19, C19, A21, B21, C21, A23, B23
		PORT 41	Bits 48-55	A25, B25, C25, A27, B27, C27, A29, B29
HP 3488A Mode	PORT 42	PORT 40	Bits 40-47	A19, B19, C19, A21, B21, C21, A23, B23
		PORT 41	Bits 48-55	A25, B25, C25, A27, B27, C27, A29, B29

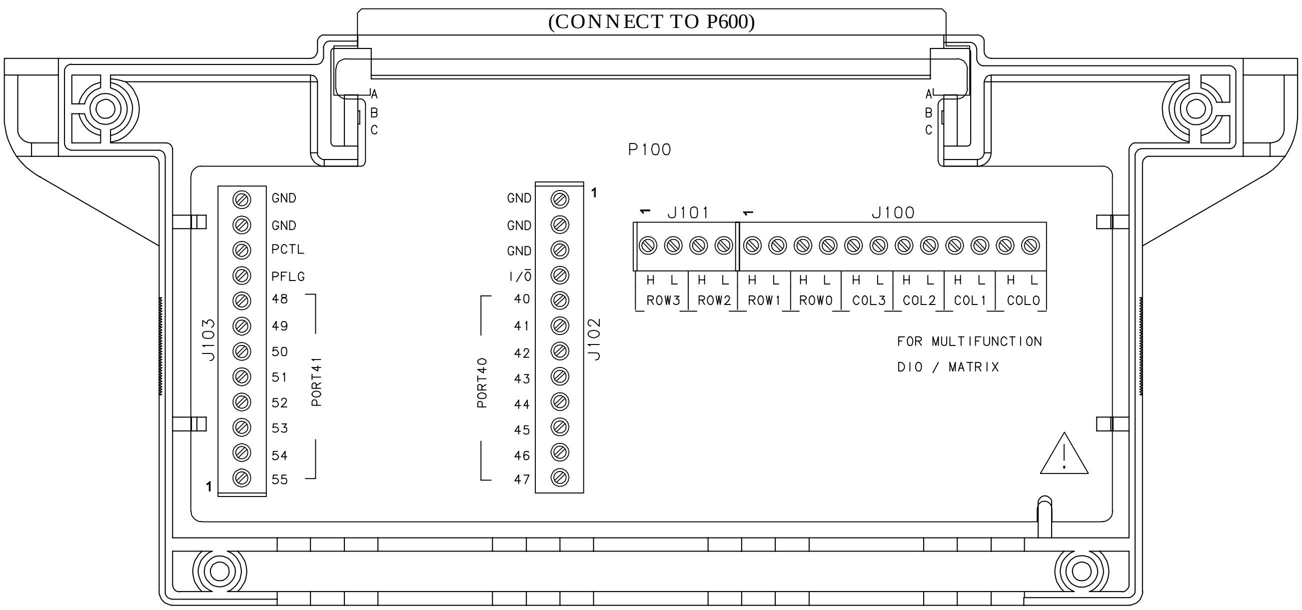


Figure 8-18. HP N2295A Screw Connectors Pinout

Specifications

Table 8-17 and Table 8-18 list the specifications of the two functions on the HP N2265A Multifunction Module.

Table 8-17. HP N2265A Specifications for 4 x 4 Matrix Function

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		4 x 4
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	200 V, dc or ac rms
Maximum Current	Per Channel Per Module	1 A, dc or ac rms 4 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 62.5 VA ac 240 W dc; 250 VA ac
Thermal Offset		< 3 µV differential
Initial Closed Channel Resistance		< 1 Ω
Relay Life	Mechanical Electrical	10^8 (at 36000 operations/hour) 5×10^5 (1A load)
Maximum Scan Rate		80 Chans./sec
DC ISOLATION (with terminal block)		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
HI-LO (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^{o}C, 50% RH) < (40^{o}C, 80% RH)	> 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[1] (without terminal block)		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF < 25 pF < 40 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.10 dB < 0.20 dB < 0.60 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -76 dB < -56 dB < -33 dB

[1]. With chassis of all instruments connected, and with Low Terminal of the input connected to Low Terminal of the output (either directly or via HP 3499A/B switching channels).

Table 8-18. HP N2265A Specifications for 16-bit DIO Function

ITEMS		SPECIFICATIONS
I/O LINES		
Maximum Voltage (line-chassis)		+ 42 V dc
Maximum Sink Current (per bit)		0.6 A
Output Characteristics	Vout (high) Vout (low)	≥ 2.4 V @ I ≤ 10 mA output ≤ 0.8 V @ I ≤ 600 mA input
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V
HANDSHAKE LINES		
Maximum Voltage (Line-Chassis)		+5 V dc
Output Characteristics	Vout (high) Vout (low) Iout (low)	≥ 2.4 V @ I ≤ 400 µA output ≤ 0.5 V @ I ≤ 1 mA input < 25 mA (when shorted to +5 V)
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V

HP 44470A 10-Channel MUX Module

General Description

The HP 44470A Relay Multiplexer (MUX) module provides 10 2-wire channels (latching relays) to switch both High (H) and Low (L) input signal lines to a common bus, respectively. Relays on this module are rated at a maximum voltage of 250 volts, maximum current of 2 amps dc or ac rms. The module exhibits low thermal offset characteristics, making them ideal for precision low level measurements[1].

HP 44470A can be operated in either of two modes, single channel break-before-make (BBM), or multiple channels staying closed.

A screw terminal block is provided for wiring conveniences.

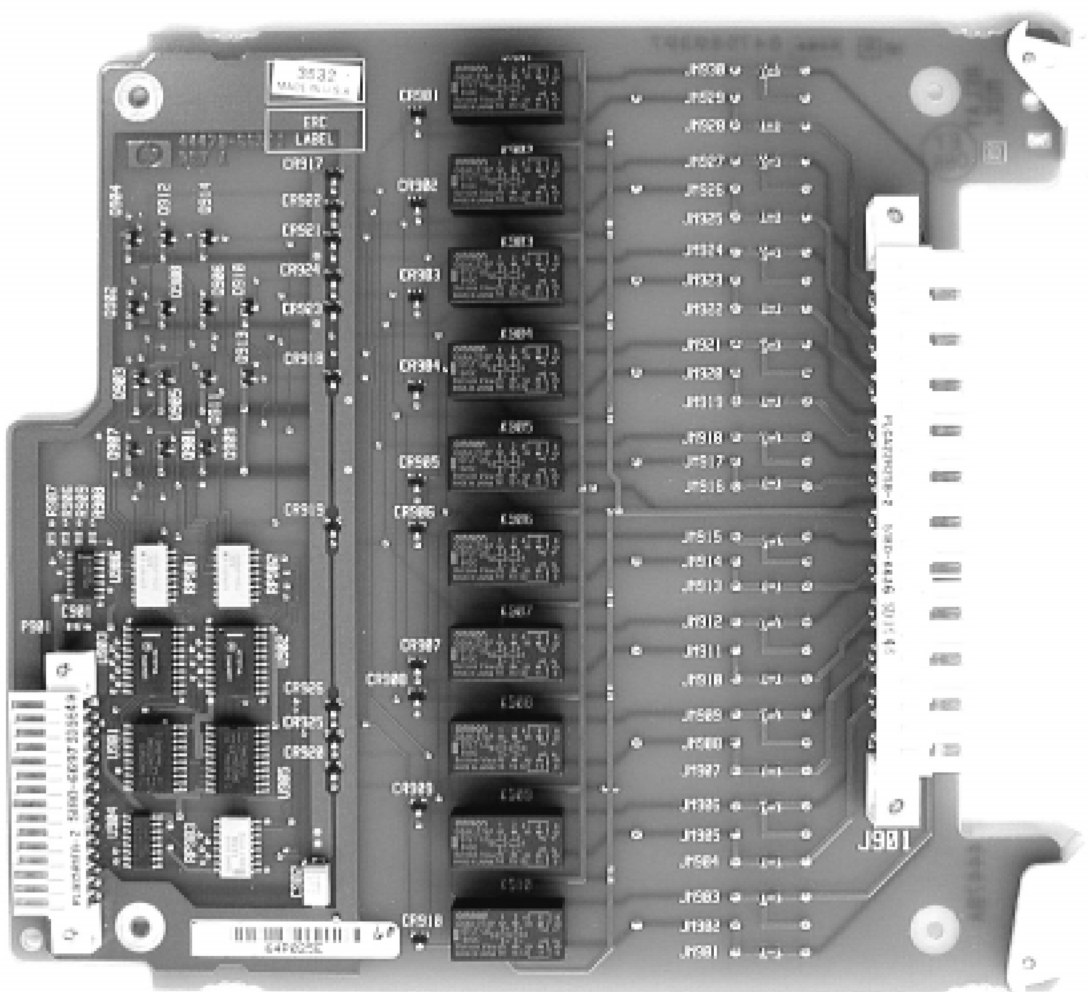


Figure 8-19. HP 44470A

[1]. Although the HP 44470A MUX module can be used to switch thermocouples, there is no compensation built-in and errors may occur.

Simplified Schematic

As shown in Figure 8-20, the HP 44470A consists of 10 2-wire relay channels connected to a common bus. Channels on HP 44470A are numbered as 00 through 09 (CH00 through CH09).

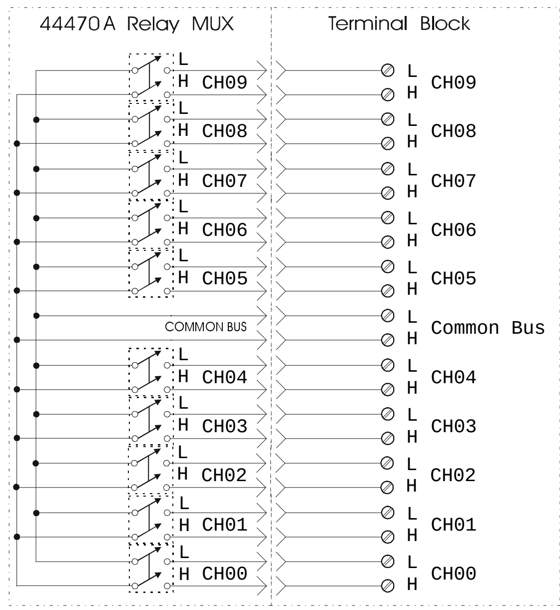
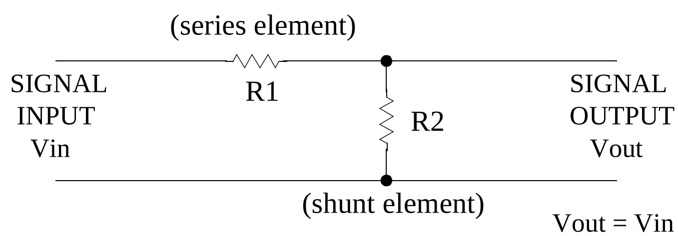


Figure 8-20. HP 44470A Simplified Schematic

Configurations

Provisions have been made on the HP 44470A circuit board for installing simple attenuators or filter networks. Three jumper locations are provided for installing components in the signal High lead, Low lead, and as a shunt from High to Low. Figure 8-21 shows the 44470A circuit board with the locations of where attenuators are to be installed.



Vout = Vin * (R2/(R1 + R2))

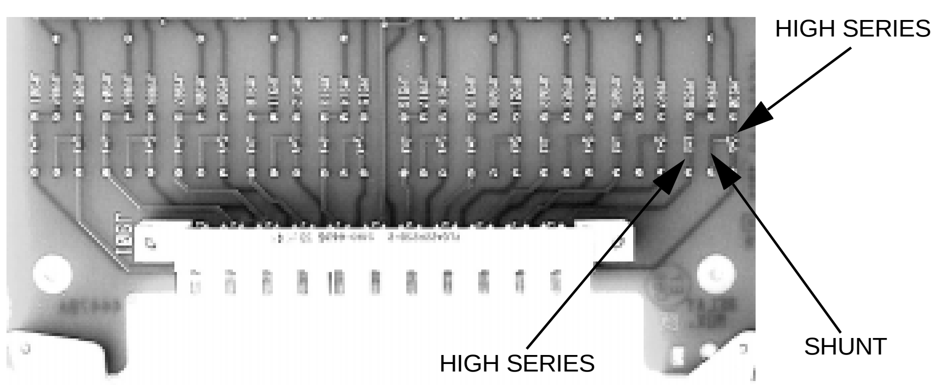


Figure 8-21. HP 44470A Circuit Board with Attenuator Locations

An attenuator is composed of two resistors that act as a voltage divider. A typical attenuator circuit is also shown in Figure 8-21 on Page 207.

To select the attenuator components, use the following equation:

$$Vo = Vi \times R2 / (R1 + R2)$$

One typical use for the shunt component is with 4 to 20 mA transducers. A 50 Ω, ±1%, 0.5 watt resistor can be installed in the R2 (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.

Wiring Information

The HP 44470A is shipped along with a screw terminal block (HP 44480A). A label (numbered as 1 through 5) is also provided for the slot identification.

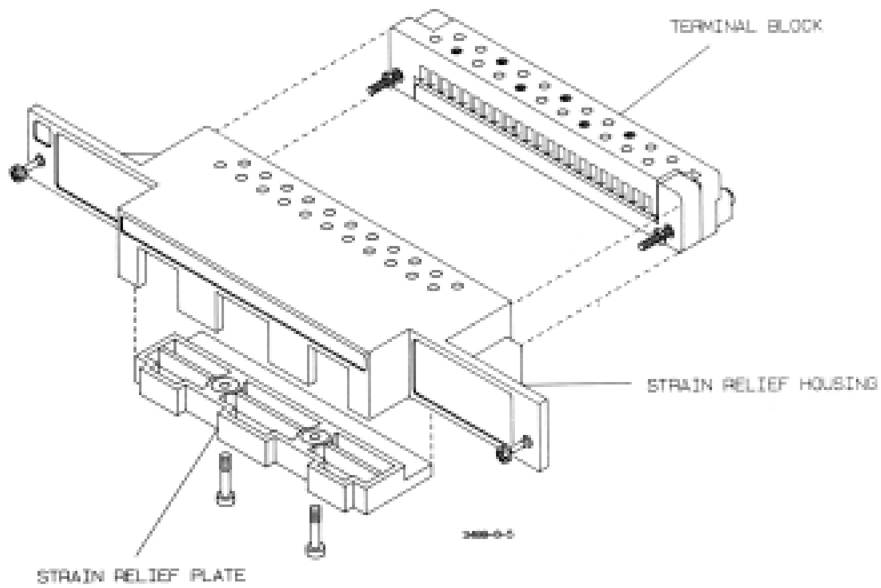


Figure 8-22. HP 44480A Terminal Block

The HP 44480A must be wired prior to installing the screw terminal block to a plug-in module. For more information on wiring this kind of screw terminal block, refer to “Plug-In Modules Wiring Information” on Page 254.

Specifications

HP 44470A 10-Channel MUX Module specifications are listed in Table 8-19.

Table 8-19. HP 44470A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		10
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V, dc or ac rms
Maximum Current	Per Channel or Module	2 A, dc or ac rms
Maximum Power	Per Channel or Module	60 W dc; 500 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 μV differential or single-ended
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{11} Ω >10^9 Ω
HI-LO (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{10} Ω > 10^8 Ω
Channel-Chassis (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{10} Ω > 5 x 10^8 Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 5 pF < 27 pF < 80 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -73 dB < -53 dB < -33 dB

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3499A/B switched channel).

HP 44470D 20-Channel MUX Module

General Description

The HP 44470D Relay MUX Module provides 20 2-wire channels (latching relays) to switch both High (H) and Low (L) input signals to a common bus. The individual relays on this module are rated at a maximum voltage of 250 volts, maximum current of 2 amps dc or ac rms. The module exhibits low thermal offset characteristics, making them ideal for precision low level measurements[1].

The HP 44470D can be operated in either mode: single channel break-before-make (BBM) or multiple channels closed together.

A screw terminal block is provided for wiring conveniences.

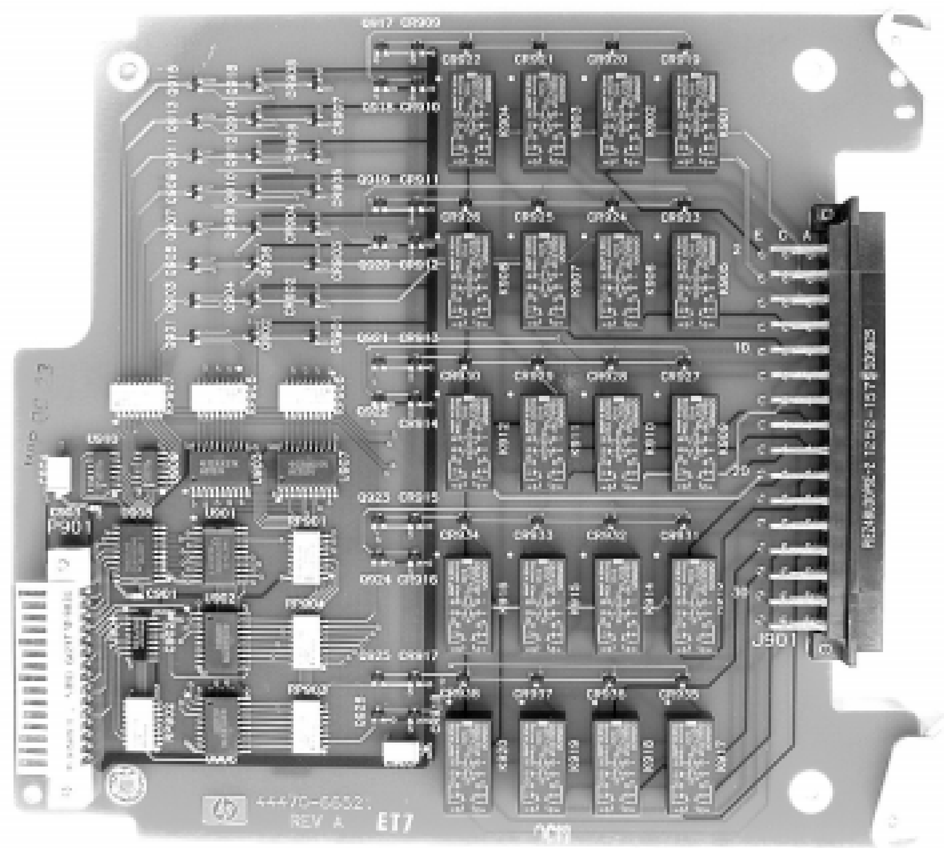


Figure 8-23. HP 44470D

Simplified Schematic

As shown in Figure 8-24 on Page 211, the HP 44470D consists of 20 2-wire relays connected to a common bus. A channel refers to an individual relay on the module. Therefore, when speaking of closing a channel, we are referring to closing a particular relay. Channels on the HP 44470D are

[1]. Although the HP 44470A MUX module can be used to switch thermocouples, there is no compensation built-in and errors may occur.

numbered as 00 through 19 (CH00 through CH19).

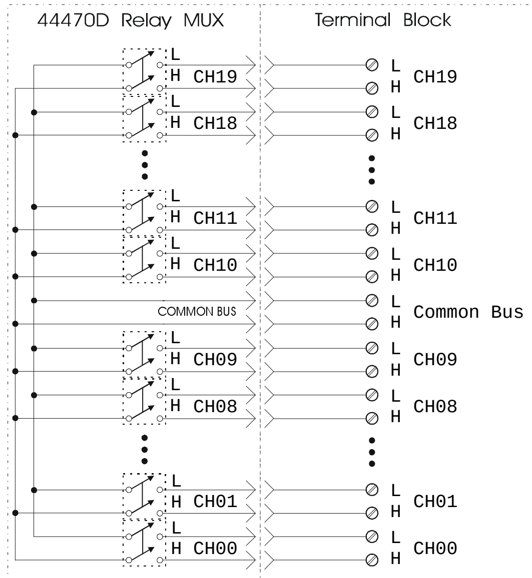


Figure 8-24. HP 44470D Simplified Schematic

Wiring Information

An screw terminal block (HP 44480B) is shipped along with the HP 44470D MUX module. A label numbered as 1 through 5 is also provided for the slot identification.

J901 Pinout

J901 is a 3-row, 48-pin male connector mounted on the HP 44470D. Figure 8-25 shows the pinout of J901.

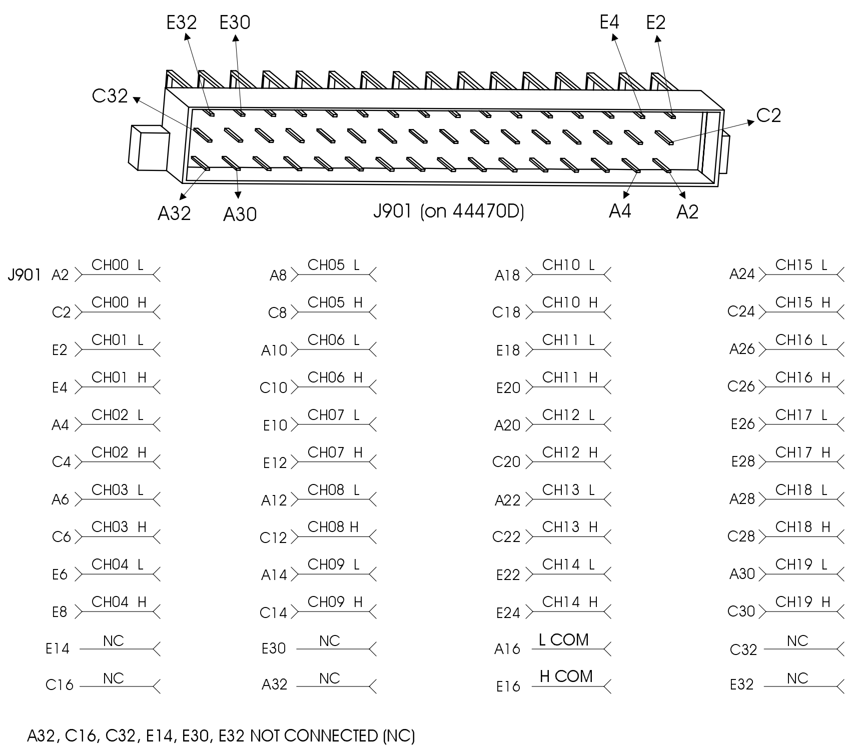


Figure 8-25. J901 Pinout

Terminal Block Connectors Pinout

There are four screw connectors (P101-P104) on the HP 44480B. The pinout of which is shown in Figure 8-26.

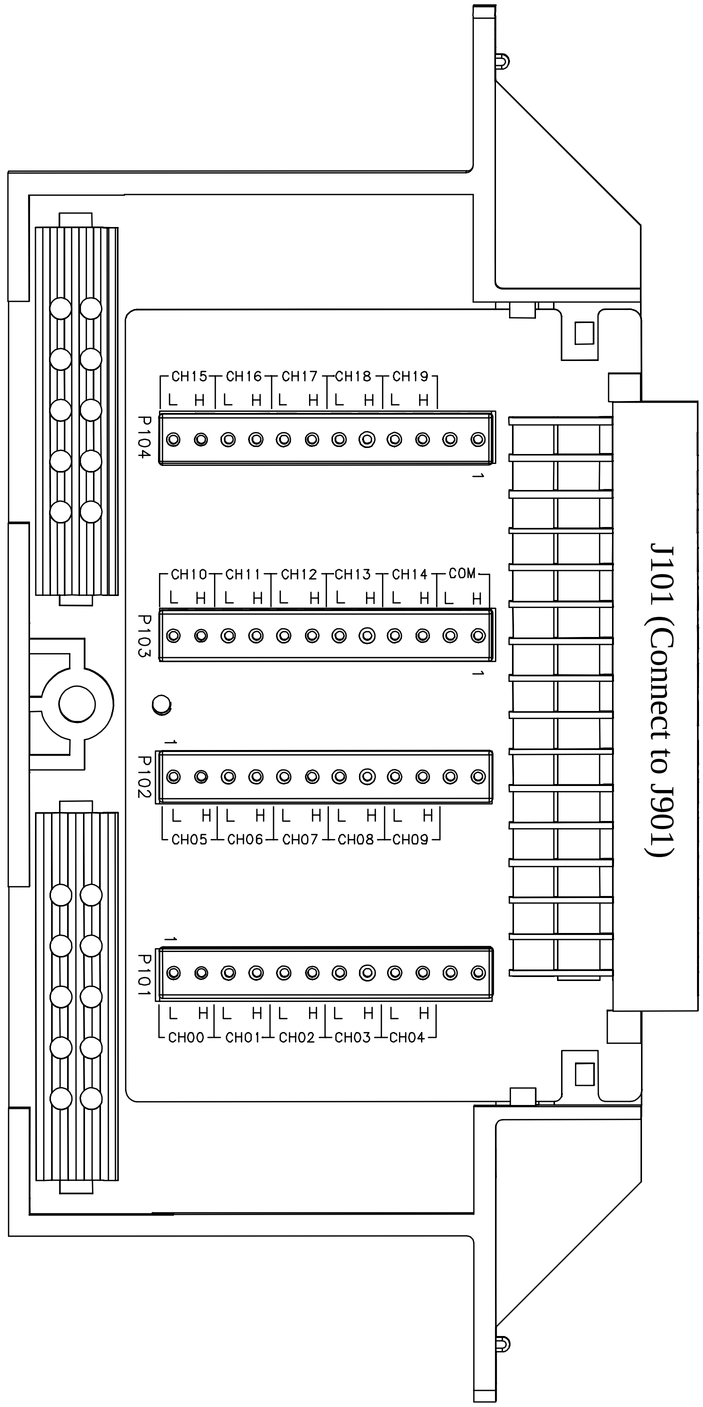


Figure 8-26. HP 44480B Screw Connectors Pinout

Wiring the Terminal Block

It is necessary to wire the screw terminal block prior to installing the HP 44480B to the HP 44470D. For more information on wiring this kind of screw terminal block, refer to “Plug-In Modules Wiring Information” on Page 254.

Specifications

HP 44470D 20-Channel MUX Module specifications are listed in Table 8-20.

Table 8-20. HP 44470D Module Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		20
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V, dc or ac rms
Maximum Current	Per Channel or Module	2 A, dc or ac rms
Maximum Power	Per Channel or Module	60 W dc; 125 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 µV differential or single-ended
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{11} Ω > 5 x 10^9 Ω
HI-LO (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 5 x 10^{10} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 5 x 10^{10} Ω > 10^9 Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF < 27 pF < 80 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.20 dB < 0.25 dB < 1.20 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -73 dB < -53 dB < -31 dB

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3488A switched channel)

HP 44471A 10-Channel GP Relay Module

General Description

The HP 44471A GP Relay Module provides 10 independent single pole - single throw (SPST, Form A) latching relays. The individual relays on this module are rated for a maximum open circuit voltage of 250 volts dc or ac rms. Maximum current per relay is 2 amps dc or ac rms, and maximum power per relay is 60 watts dc or 125 VA ac. Maximum closed channel resistance is lower than 2 Ω.

HP 44471A exhibits low thermal characteristics, which make it ideal for independent (non-multiplexed) signal switching. It can be operated in either mode: single channel break-before-make (BBM), or multiple channels closed together.

A screw terminal block is provided for wiring conveniences.

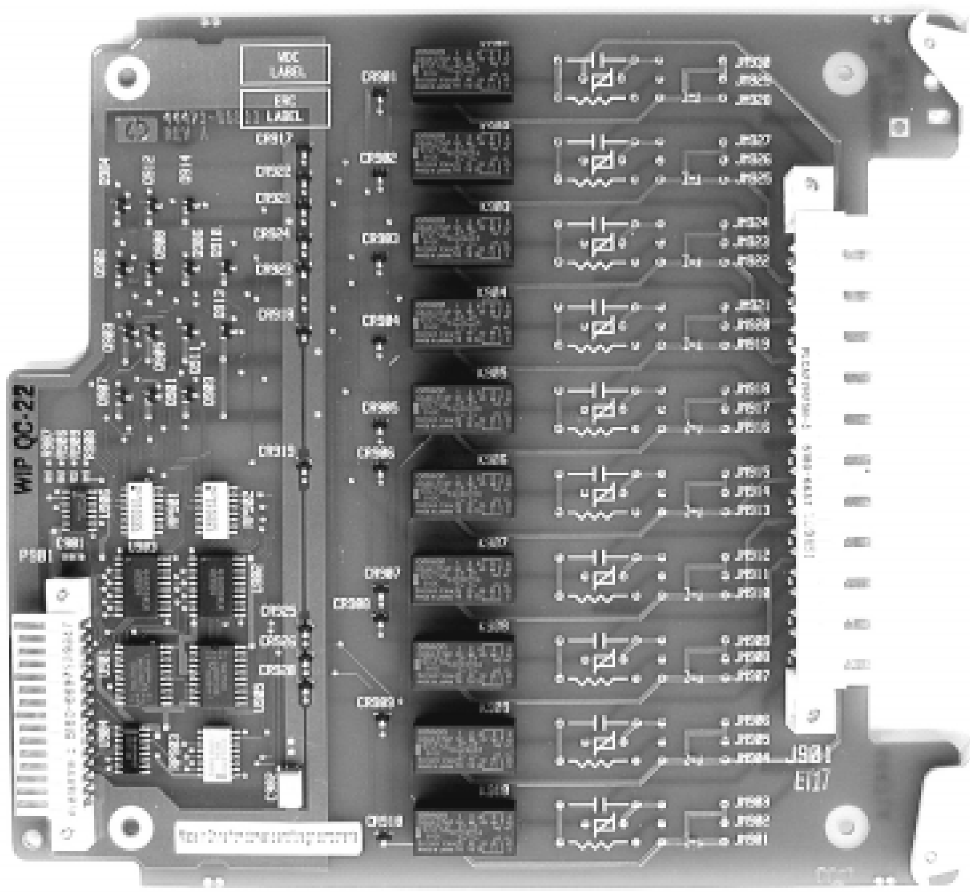


Figure 8-27. HP 44471A

Simplified Schematic

As shown in Figure 8-28 on Page 215, the HP 44471A consists of 10 independent Single Pole-Single Throw (SPST, Form A) relays. A channel refers to an individual relay on the module. Therefore, when speaking of closing a channel, we are referring to closing a particular relay. Channels on the HP 44471A are numbered as 00 through 09 (CH00 through CH09)

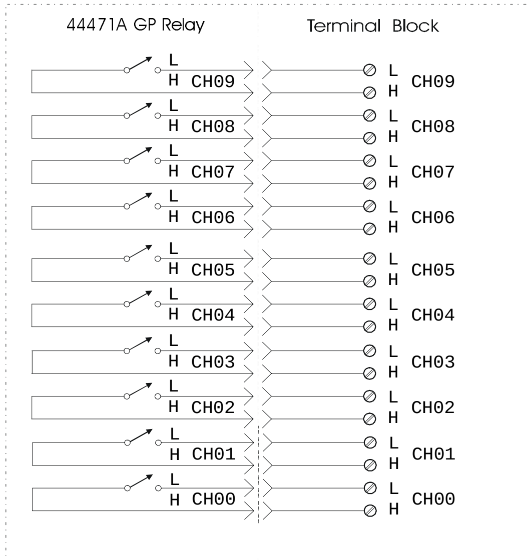


Figure 8-28. HP 44471A Simplified Schematic

Configurations

Whenever relay contacts open and close, electrical breakdown can occur between the contacts. This can cause high frequency radiation, voltage and current surges, and physical damage to the relay contacts.

Provisions have been made on the HP 44471A circuit board for installing simple protection networks. These simple networks provide contact protection when actuating ac power line for inductive loads.

Although many types of contact protection networks can be used, only RC networks and varistors are described here. Refer to Figure 8-29.

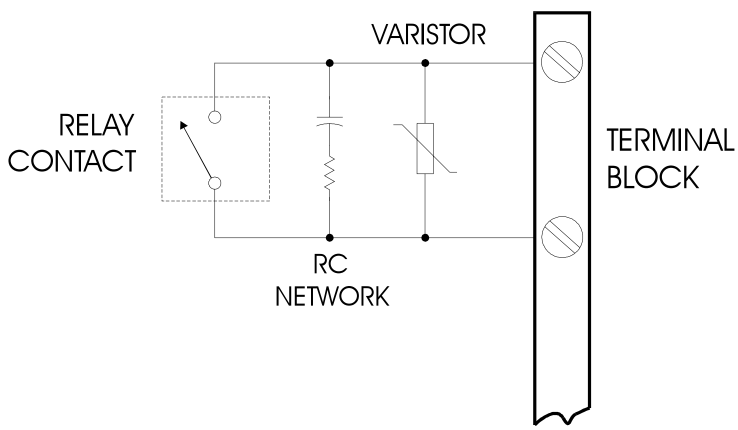


Figure 8-29. Contact Protection Networks

In designing RC protection networks, the protection resistor Rp is selected as a compromise between two values. The minimum value of Rp is determined by the maximum acceptable relay contact current (Io). The maximum allowable relay current (Io) is 2 amps ac rms or 2 amps dc. Thus, the minimum value for Rp is V/Io, where V is the peak value of the supply voltage.

$$Rp = V/Io = V/2 \qquad \text{Equation 1}$$

The maximum value for Rp is usually made equal to the load resistance, RI. Therefore, the limits on Rp can be stated as:

$$V/Io < Rp < RI \qquad \text{Equation 2}$$

Note, the actual value of Io in a circuit is determined by the equation:

$$Io = V/RI \qquad \text{Equation 3}$$

Where V is the peak value of the source voltage and RI is the resistance of the load. Equations 1 & 2 use Io as the maximum allowable relay current to determine the minimum value of Rp. The value for Io calculated in Equation 3 will be used to determine the value of the protection capacitor, Cp.

In determine the value of the protection network capacitor Cp, there are several things that need to be considered. First, the total circuit capacitance (C) must be such that the peak voltage across the open relay contacts does not exceed 353 volts peak (250 V rms = 353 Vp). The equation for determining the minimum allowable circuit capacitance is:

$$C \geq (Io/353)^{2L} \qquad \text{Equation 4}$$

where L = the inductance of the load and Io is the value calculated in Equation 3.

In reality, the total circuit capacitance (C) is made up of the wiring capacitance plus the value of the protection network capacitor Cp. Therefore, the minimum value for Cp should be the value obtained for the total circuit capacitance, C, from Equation 3. Indeed, the actual value used for Cp should be substantially greater than the value calculated for C.

Figure 8-30 on Page 217 shows an example to determine the typical values for an RC protection network. The circuit is shown, the load is a small ac motor running off a 120 V ac line (170 V peak). This motor draws a maximum of 2 amps.

Using Equation 1 we can find the minimum value for Rp:

$$Rp = V/Io = 170/2 = 85\ \Omega$$

The maximum value for Rp would be equal to the load resistance or 400 Ω. Therefore, any resistor (preferably at least 1 watt) between 85 and 400 Ω's will suffice.

To keep the peak contact voltage below 353V peak, use equation 3 to determine Io:

$$Io = V/R1 = 170/400 = 0.425\ A$$

Now use equation 4 to determine C:

$$C \geq (Io/353)^{2L} = (0.425/353)^{2(0.1)} = 0.144\ \mu F$$

Since Rp can vary between 85 Ω's and 400 Ω's, an appropriate protection network to be connected to this circuit is Rp = 220 Ω and Cp = 0.15 μF.

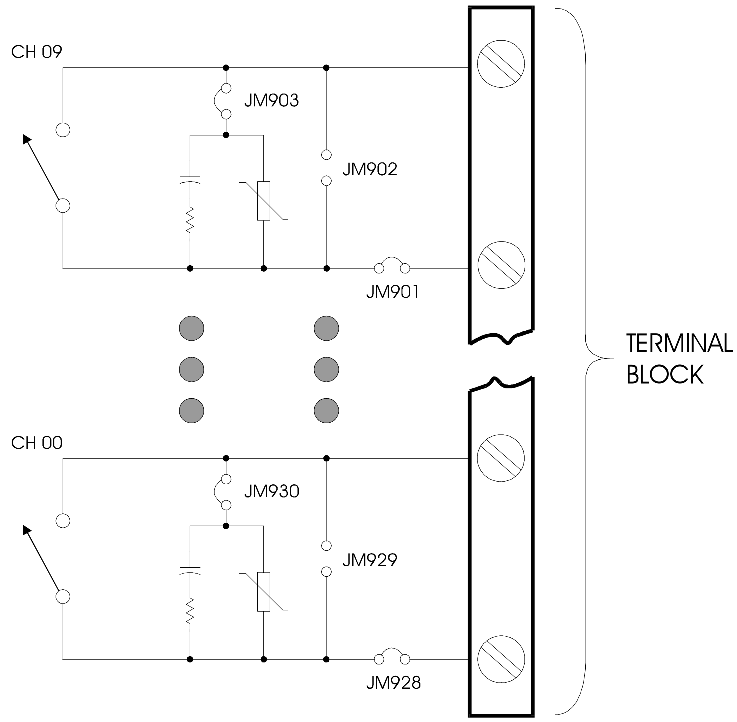


Figure 8-30. Protection Networks

Figure 8-30 also shows where protection networks should be mounted on the HP 44471A circuit board. Note that with the RC network in shunt (parallel) with the relay contacts, there is a loss of high isolation when the relay is open.

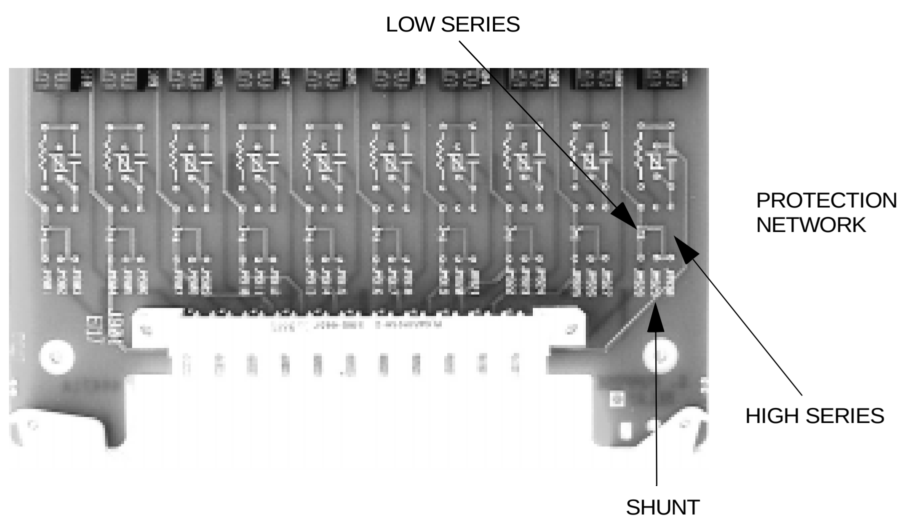


Figure 8-31. Locations for Protection Networks

Using Varistors

Just as contact protection circuits are important to supress noise while relay contacts are opening and closing, transient protection should be provided while the relays are open. This is the purpose of the varistor. When selecting a varistor, make certain that it has a voltage rating sufficient for your application. A typical 250 VAC varistor can be purchased from Hewlett-Packard with the part number 0873-0227.

Wiring Information

An HP 44481A screw terminal block is shipped along with an ordered HP 44471A. A label numbered as 1 through 5 is also provided for the slot identification.

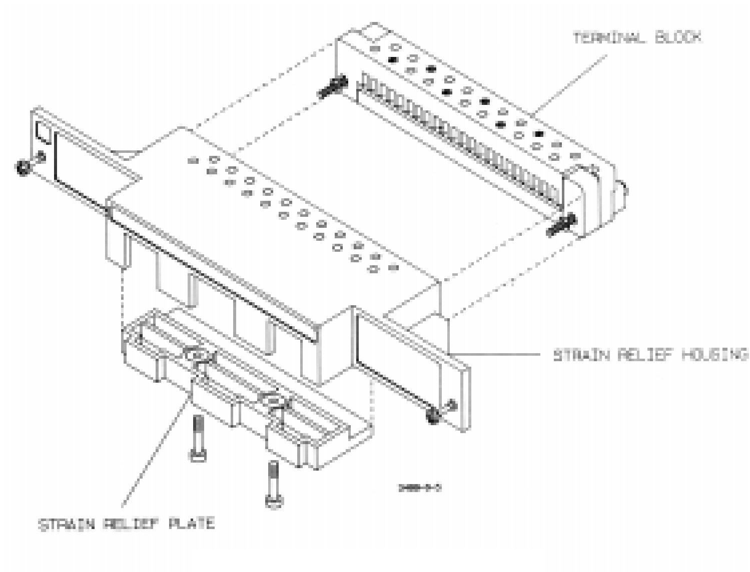


Figure 8-32. HP 44481A Terminal Block

It is necessary to wire the HP 44481A prior to installing this terminal block to an HP 44471A. For more information on wiring this kind of terminal block, refer to “Plug-In Modules Wiring Information” on Page 254.

Specifications

HP 44471A 10-Channel GP Relay Module specifications are listed in Table 8-21.

Table 8-21. HP 44471A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		10
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V, dc or ac rms
Maximum Current	Per Channel Per Module	2 A, dc or ac rms 20 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 500 VA ac 600 W dc; 5000 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 µV differential or single-ended
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{11} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 5 x 10^{11} Ω > 10^{10} Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF < 10 pF < 25 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -73 dB < -53 dB < -33 dB

[1]. Using HP 44474A external increment & channel closed, display off.

[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3488A switched channel)

HP 44471D 20-Channel GP Relay Module

General Description

The HP 44471D GP Relay module provides 20 independent single pole - single throw (SPST, Form A) latching relays. The module can find many uses as an actuator assembly. Its low thermal characteristics make it ideal for independent (non-multiplexed) signal switching.

The individual relays on this module are rated for a maximum open circuit voltage of 250 volts dc or ac rms. Maximum current per relay is 1 amps dc or ac rms, and maximum power per relay is 60 watts dc or 125 VA ac. Maximum closed channel resistance is lower than 2 Ω.

A screw terminal block is provided for wiring conveniences.

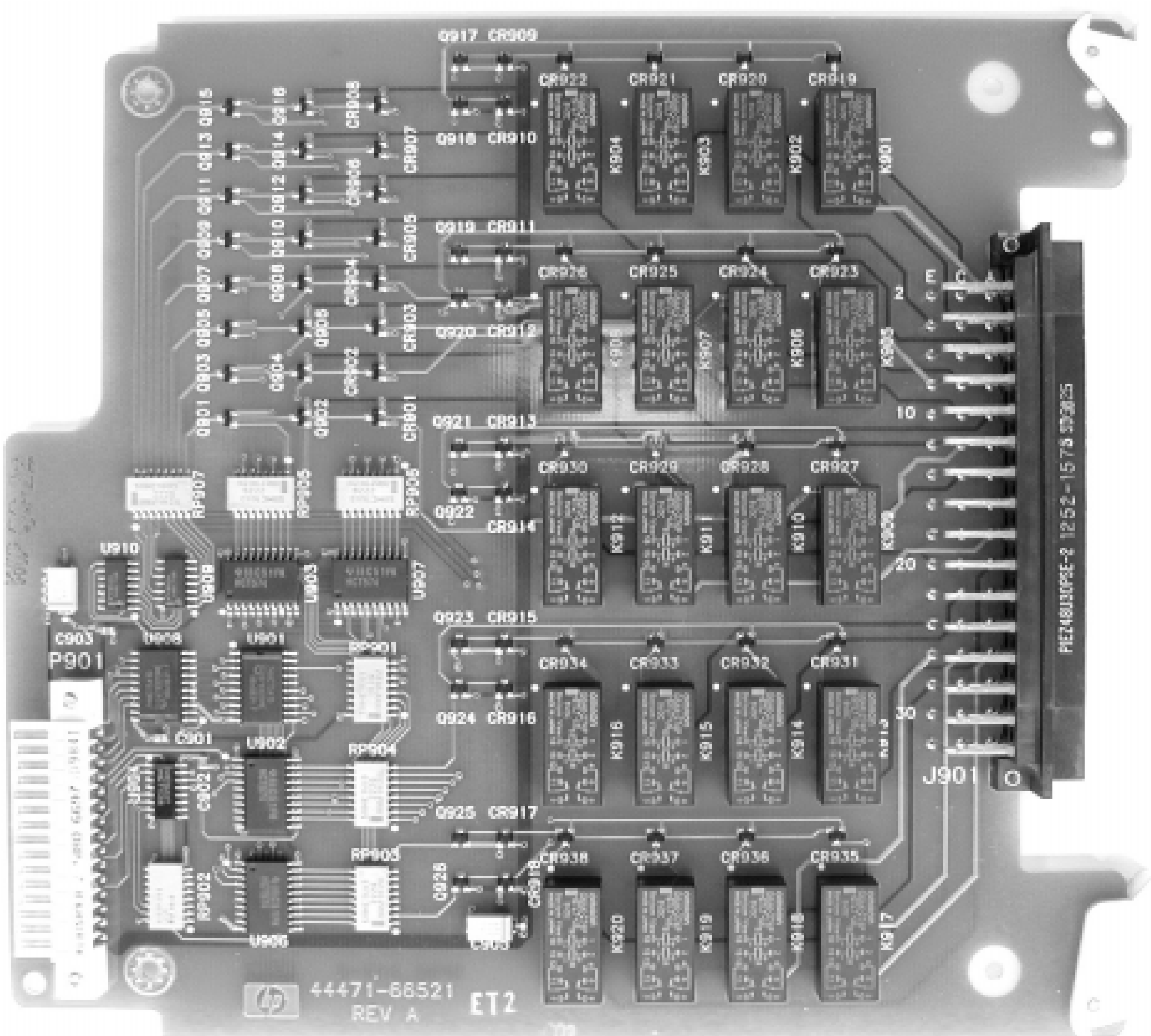


Figure 8-33. HP 44471D

Simplified Schematic

As shown in Figure 8-34, the HP 44471D GP Relay Module consists of 20 independent SPST (single pole-single through) relays. Channels on the HP 44471D are numbered as 00 through 19 (CH00 through CH19).

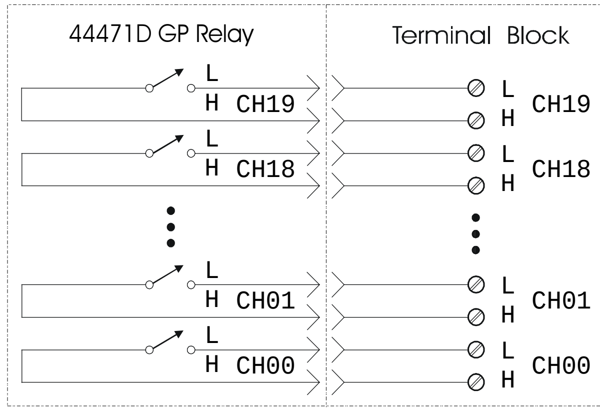


Figure 8-34. HP 44471D Simplified Schematic

Wiring Information

An HP 44481B screw terminal block is shipped along with an ordered HP 44471D. A label numbered as 1 through 5 is also provided for the slot identification.

J901 Pinout

J901 is a 3-row, 48-pin male DIN connector mounted on the HP 44471D. Figure 8-35 shows the pinout of J901.

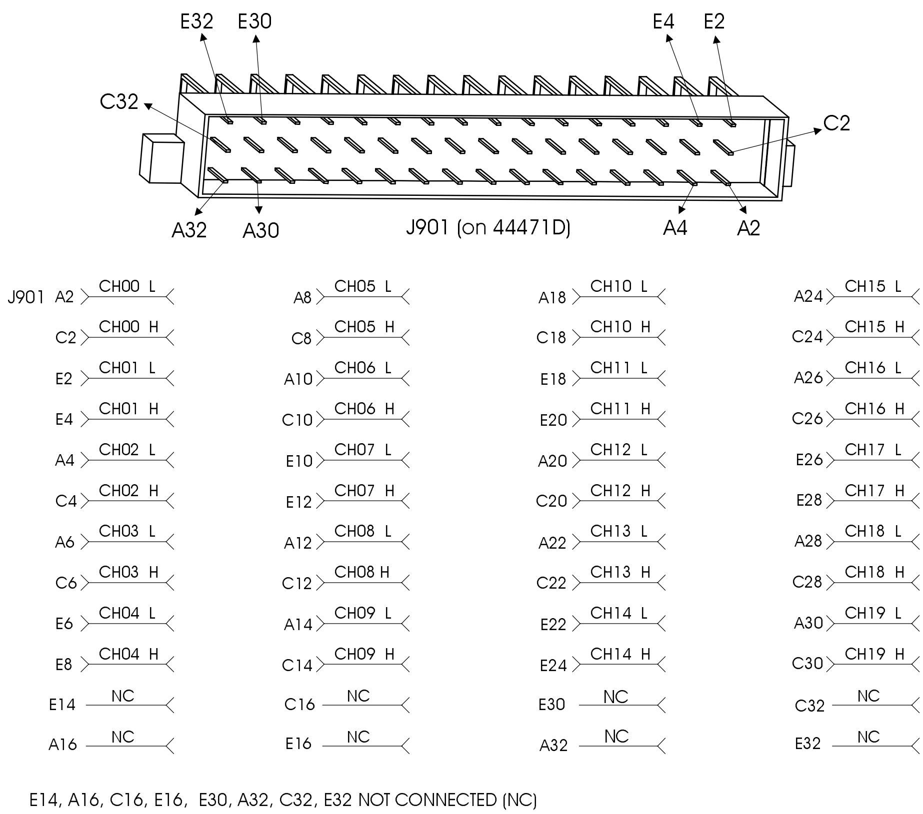


Figure 8-35. J901 Pinout

Terminal Block Connectors Pinout

The pinout of the four screw connectors (P101-P104) on the HP 44481B is shown in Figure 8-36.

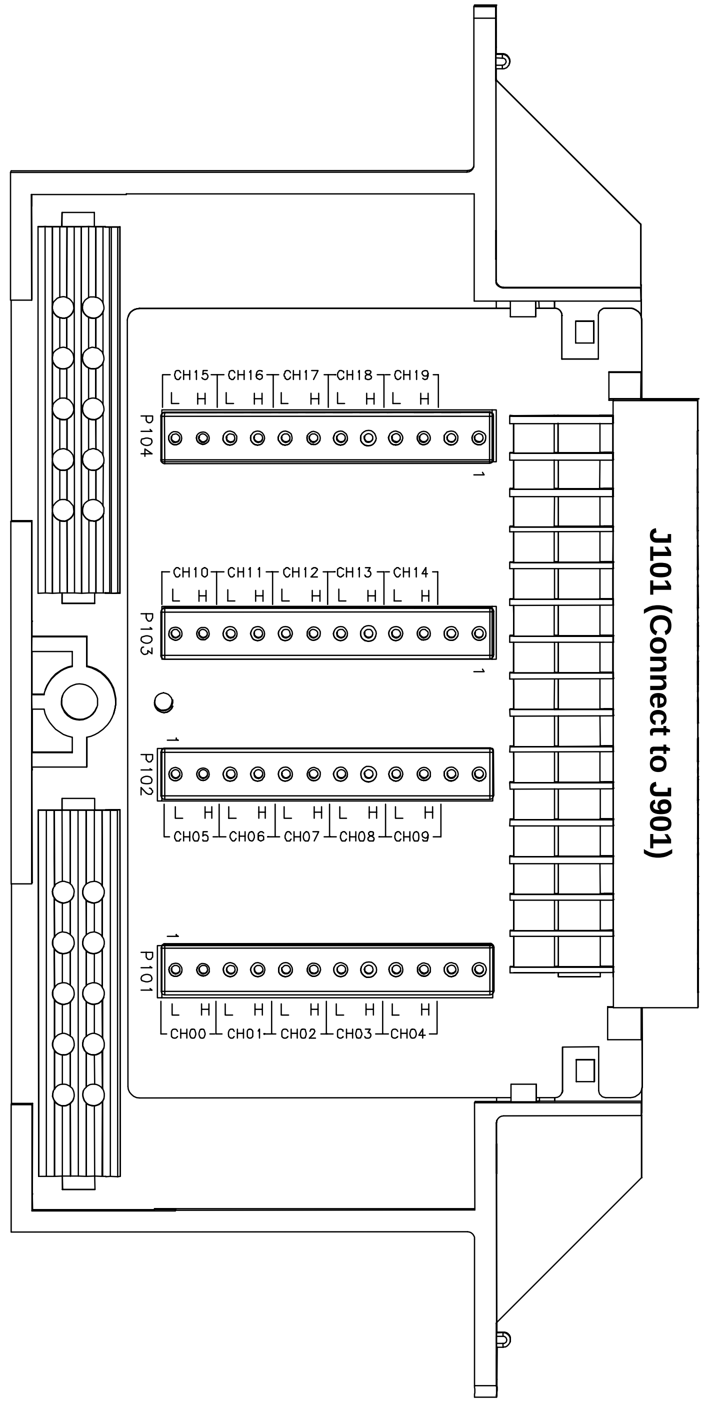


Figure 8-36. HP 44481B Screw Connectors Pinout

Wiring the Terminal Block

It is necessary to wire the HP 44481B prior to installing this screw terminal block to the HP 44471D. For more information on wiring this kind of screw terminal block, refer to “Plug-In Modules Wiring Information” on Page 254.

Specifications

HP 44471D 20-Channel GP Relay Module specifications are listed in Table 8-22.

Table 8-22. HP 44471D Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		20
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V, dc or ac rms
Maximum Current	Per Channel Per Module	1 A, dc or ac rms 20 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 125 VA ac 1200 W dc; 2500 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 µV differential or single-ended
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	< (40^{o}C, 60% RH) < (40^{o}C, 95% RH)	> 10^{11} Ω > 10^9 Ω
Channel-Chassis (with 1 channel closed)	< (40^{o}C, 60% RH) < (40^{o}C, 95% RH)	> 5 x 10^{11} Ω > 10^{10} Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 7 pF < 10 pF < 25 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.20 dB < 0.25 dB < 1 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -71 dB < -51 dB < -31 dB

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3488A switched channel)

HP 44472A Dual 4-Channel VHF Switch Module

General Description

The HP 44472A VHF Switch Module contains 14 latching relays, which provides dual independent 4-to-1 coaxial MUXs. These MUXs are specifically designed for broadband signals switching up to 300MHz. This module is the ideal choice for wide dynamic range measurements with spectrum and distortion analyzers.

Dual 4-to-1 VHF MUXs are provided on each HP 44472A. These can be used independently, together, or in combination with other HP 44472A modules.

Connections to the module are made through 10 BNC (coaxial) connectors mounted directly on the HP 44472A.

Note The HP 44472A is not recommended for instruments that require high DC isolation from earth ground (such as a DVM).

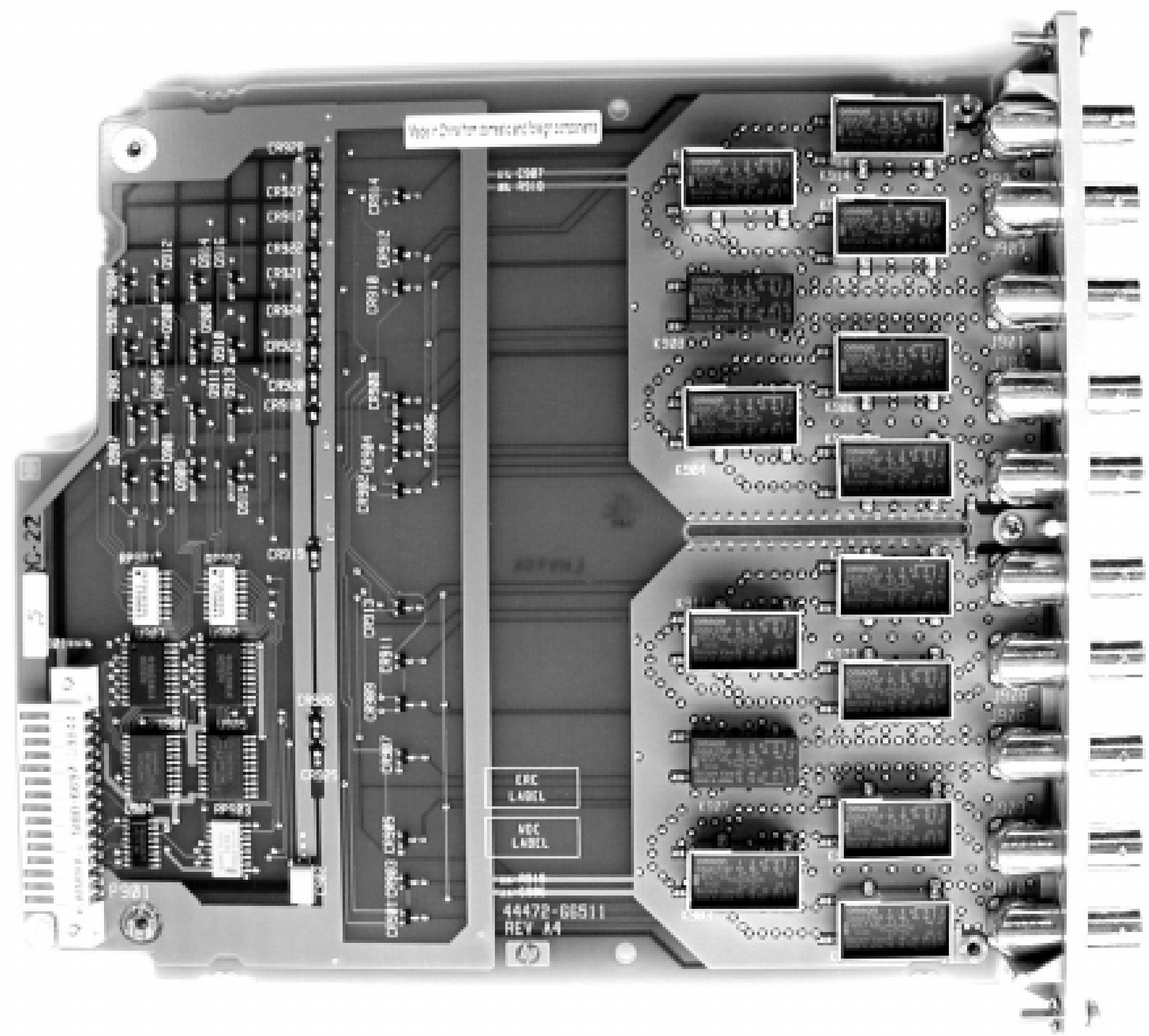


Figure 8-37. HP 44472A

Simplified Schematic

As shown in Figure 8-38, the HP 44472A VHF Switch module consists of two groups (GROUP 0 & GROUP 1) of 4-to-1 coaxial MUXs. The two groups are isolated from each other and also from the mainframe chassis ground. This eliminates ground loops. Furthermore, the shield (or low) of each channel is NOT switched; the shields of the four channels in each group are in common. Characteristic impedance is 50 Ω.

A channel refers to an individual set of relays on the module. Therefore, when speaking of closing a channel, we are referring to closing a particular set of relays, thereby connecting the common BNC to one of the four BNC inputs.

Channels on the HP 44472A are numbered as 00 through 03 for group 0, and 10 through 13 for group 1.

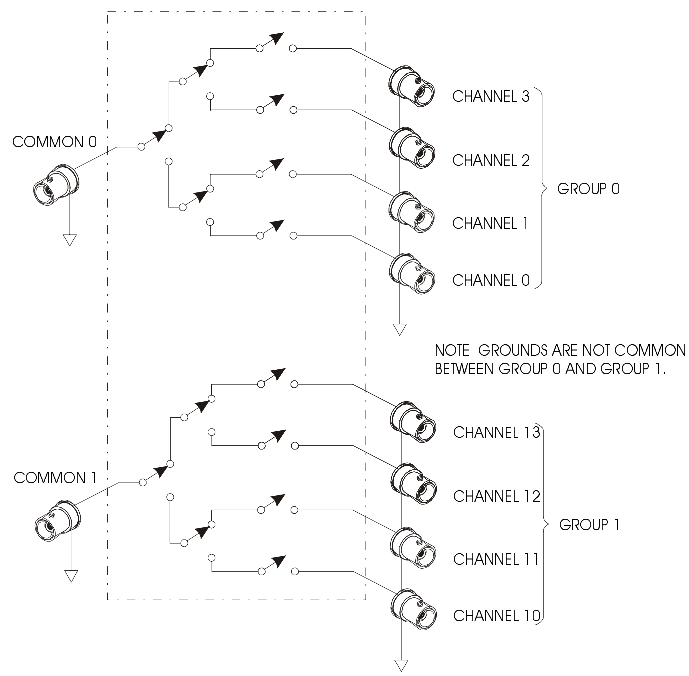


Figure 8-38. HP 44472A Simplified Schematic

Wiring Information

Regardless of the topology (configuration) you are using, always use 50 Ω shielded coaxial cables to maintain both characteristic impedance and isolation. Keep cables as short as possible, especially in high frequency circuits or pulse circuits where a rise/fall time of less than 50 nsec is critical. Long cables can add considerable delay time which may cause timing problem. All test equipment, such as counters, spectrum analyzers, oscilloscopes, etc., must be terminated with a 50 Ω impedance to minimize reflection loss.

Specifications

HP 44472A Dual VHF Switch Module specifications are listed in Table 8-23.

Table 8-23. HP 44472A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		8
Connector Type		BNC
Maximum Voltage	Center-Center or Center-Low Low-Chassis or Low-Low	250 V dc, 30 V ac rms or 42 V ac peak 42 V dc
Maximum Current	Per Channel	30 mA dc, 300 mA ac rms
Thermal Offset	Per Channel	< 15 µV
Characteristic Impedance		50 Ω
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Between Any Two Points	< (40°C, 95% RH)	> 10^7 Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance	Center-Center, Center-Common Center-Low Low-Chassis	< 0.002 pF < 70 pF < 0.20 µF
Rise Time		< 0.7 nsec
Signal Delay		< 2.5 nsec (channel match < 90 psec)
Insertion Loss (with 50Ω termination)	30 MHz 100 MHz 300 MHz	< 0.50 dB < 0.75 dB < 1.25 dB
Crosstalk Within a Group (Channel-Channel or Channel-Common, with 50Ω termination)	30 MHz 100 MHz 300 MHz	< -100 dB < -85 dB < -65 dB
Crosstalk Group to Group (with 50Ω termination)	30 MHz 100 MHz 300 MHz	< -85 dB < -85 dB < -50 dB
VSWR (with 50 Ω termination)	30 MHz 100 MHz 300 MHz	< -1.06 < -1.12 < -1.43

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. When all channels in a group are opened, the last channel opened (or channel 00 or 13 following a group RESET) has channel-common isolation of > 80 dB @ 30 MHz, > 60 dB @ 100 MHz, and > 40 dB @ 300 MHz.

HP 44473A 4 x 4 2-Wire Matrix Switch Module

General Description

The HP 44473A Matrix Switch module provides a 4 x 4 matrix of 2-wire switches. Each node or crosspoint in the matrix contains a latching relay, which switches both High (H) and Low (L) signals. More than one switch can be closed at a time, allowing any combination of rows connected to columns.

Matrix switching provides a convenient way to connect a group of test instruments to multiple test points on a device or to multiple devices. This matrix switch offers highly flexible switching for testing devices over a frequency range of DC to 100 kHz.

Multiple HP 44473A modules may be connected together to form a 4 x 8, 4 x 12, 4 x 16, 4 x 20 or 8 x 8 2-wire matrix. In addition, the HP 44473A can be used in conjunction with other modules (such as HP 44470A 10-Channel MUX module) to provide a wide variety of switching combinations.

A screw terminal block is provided for wiring convenience.

Note When wiring between multiple modules, keep wire length as short as possible to minimize noise and signal degradation.

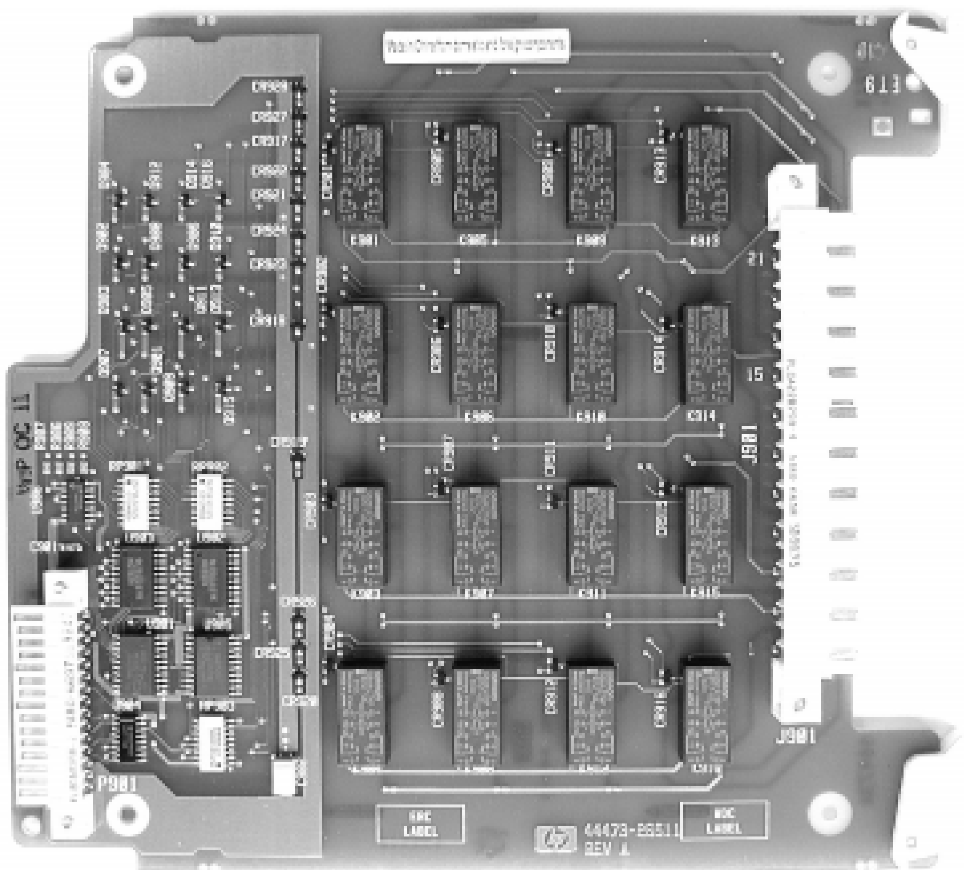


Figure 8-39. HP 44473A

Simplified Schematic

As shown in Figure 8-40, the HP 44473A consists of 16 2-wire relays (nodes/crosspoints) organized in a 4-row by 4-column matrix. A channel refers to an individual relay (node/crosspoint) in the matrix. Therefore, when speaking of closing a channel, we are referring to closing a particular relay.

Channels in this matrix module are numbered in the Row-Column format. For example, channel 32 represents the crosspoint connection between row 3 and column 2; while the channel 23 represents the crosspoint connection between row 2 and column 3, and so on.

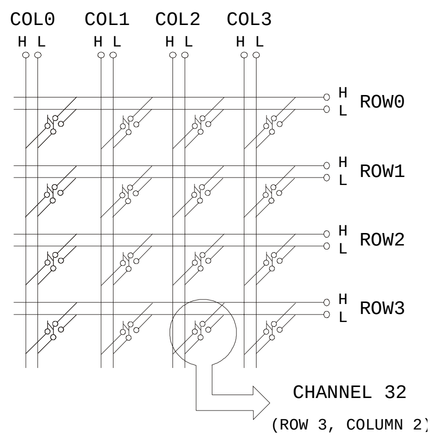


Figure 8-40. HP 44473A Simplified Schematic

Wiring Information

An HP 44483A screw terminal block is shipped along with an ordered HP 44473A. A label numbered as 1 through 5 is also provided for the slot identification.

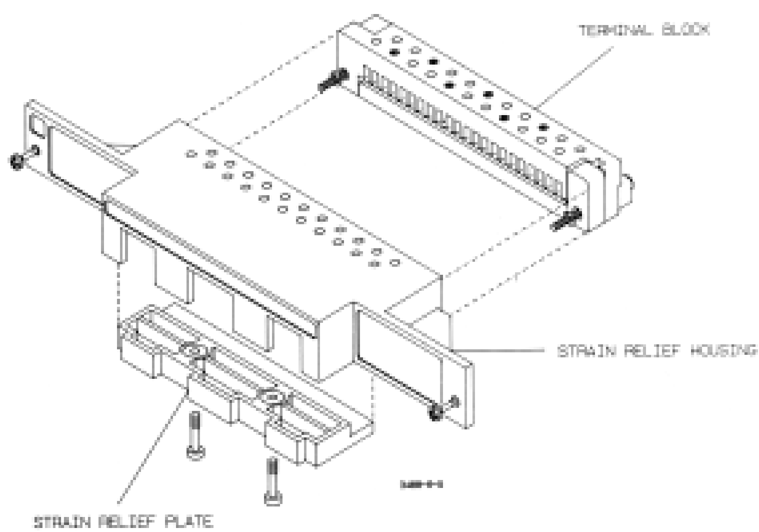


Figure 8-41. HP 44483A Screw Terminal Block

It is necessary to wire the HP 44483A prior to installing an HP 44483A to an HP 44473A. For more information on wiring this kind of screw terminal block, refer to "Plug-In Modules Wiring Information" on Page 254.

Specifications

HP 44473A 4 x 4 Matrix Switch Module specifications are listed in Table 8-24.

Table 8-24. HP 44473A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		16
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V, dc or ac rms
Maximum Current	Per Channel Per Module	2 A, dc or ac rms 8 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 500 VA ac 240 W dc; 2000 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 µV differential
Initial Closed Channel Resistance		< 1 Ω
Relay Life		10^6 operations
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{11} Ω > 10^9 Ω
HI-LO (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{10} Ω > 10^8 Ω
Channel-Chassis (with 1 channel closed)	< (40°C, 60% RH) < (40°C, 95% RH)	> 10^{10} Ω > $5x10^8$ Ω
AC ISOLATION / PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel HI-LO Channel-Chassis	< 5 pF < 40 pF < 70 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.30 dB < 0.35 dB < 0.90 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -76 dB < -56 dB < -36 dB

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3499A/B switched channels)

HP 44474A 16-Bit Digital I/O Module

General Description

The HP 44474A Digital I/O module provides 16 bidirectional data lines (bits) plus 4 lines used for control and handshaking. All lines are TTL compatible. The 16 I/O lines or bits can be addressed individually (bit-by-bit), as two independent 8-bit ports, or as one 16-bit word.

The two 8-bit ports are completely independent of each other and may be used separately. For instance, one port can be used for output operations, while the other for input. However, the 8 bits in one port are dependent, i.e. they can be used either as input or as output.

A screw terminal block is provided for wiring conveniences.

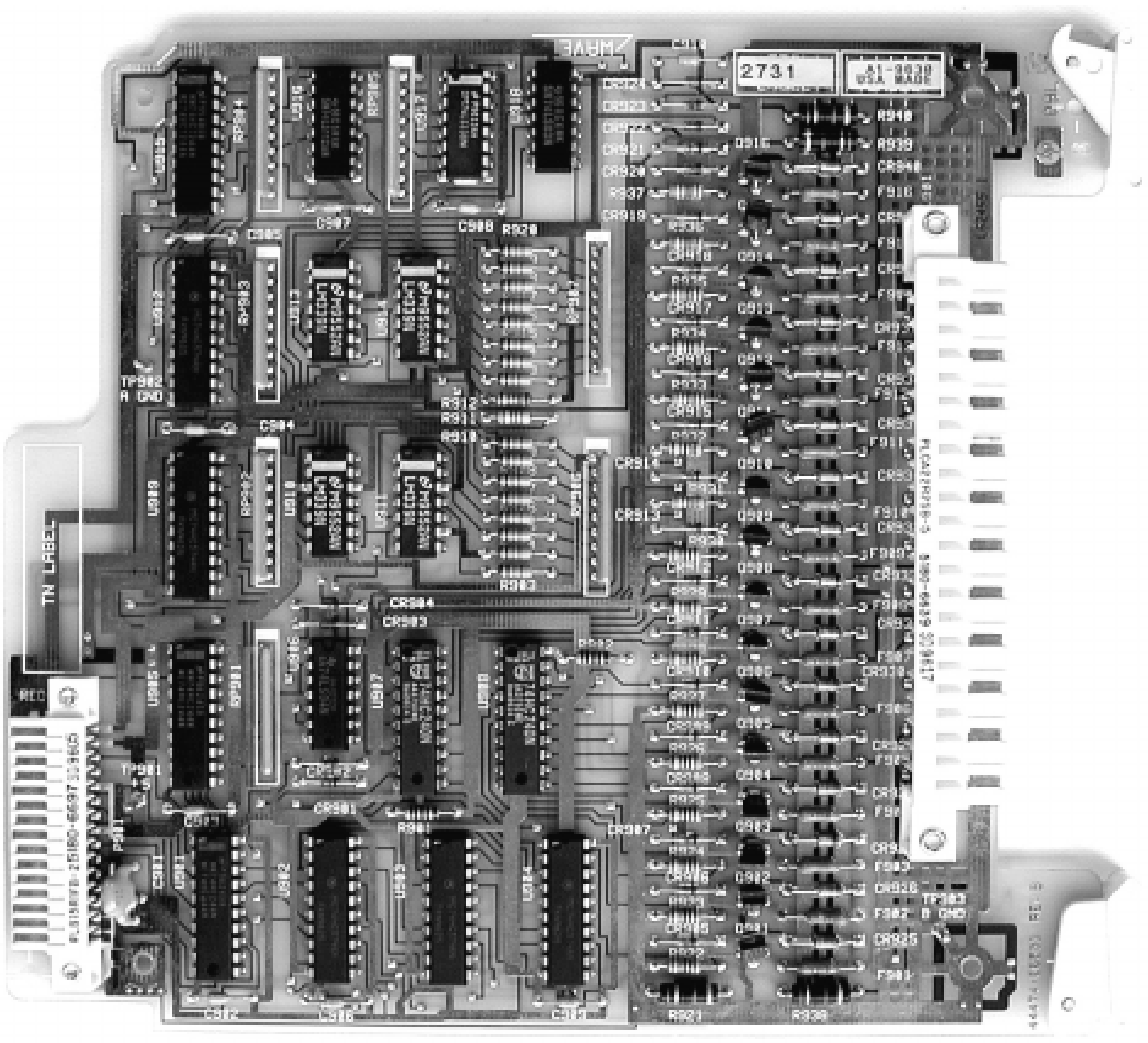


Figure 8-42. HP 44474A

Simplified Schematic

The HP 44474A consists of 16 bidirectional I/O lines which can be addressed individually on a bit-by-bit basis, as two independent 8-bit ports, or as one 16-bit port.

Figure 8-43 shows a simplified schematic of the HP 44474A. Note that all 16 I/O lines and 4 control lines share a common Low connection.

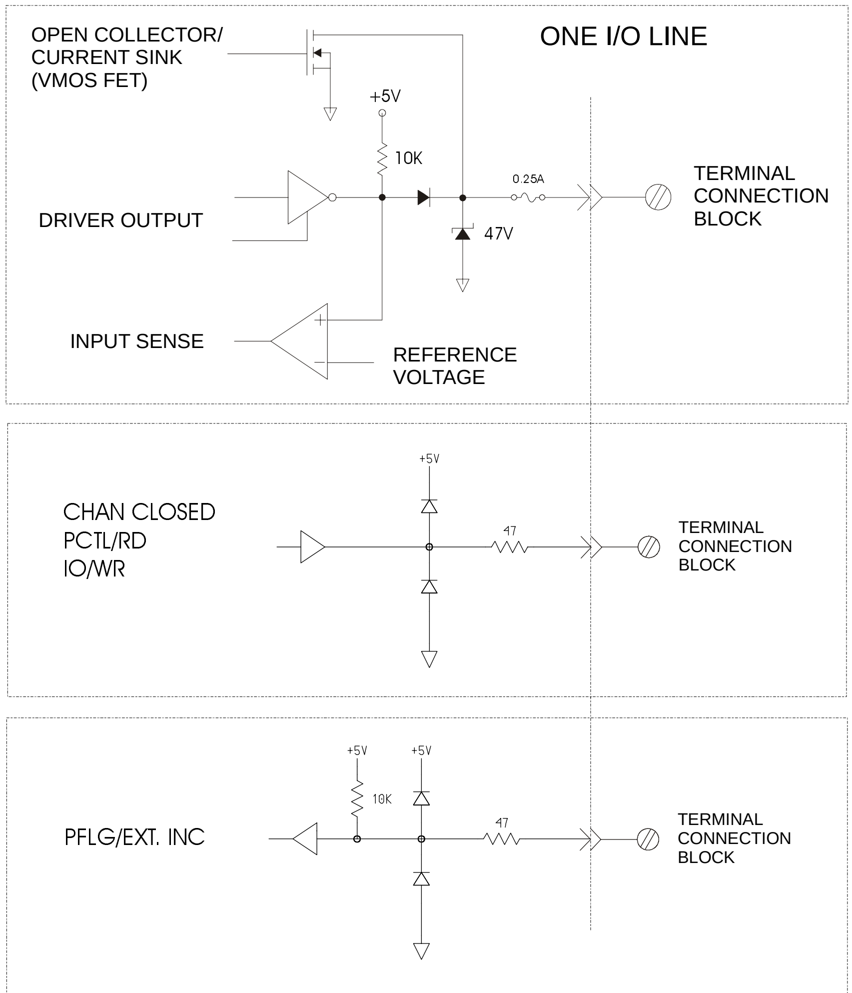


Figure 8-43. HP 44474A Simplified Schematic

The 16 bits (I/O lines) are numbered as bits 0 through 15 when the module is addressed individually. The bits 0-7 refer to the bits 0-7 of the LO BYTE, and the bits 8-15 refer to the bits 0-7 of the HI BYTE.

EI is usually connected to the Voltmeter Complete[1] output on a system voltmeter. The CC line can be connected to the External Trigger input on the voltmeter.

[1]. 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 port number is different in different system modes (see Table 8-25).

Table 8-25. Port # in Different Operating Modes

System Mode	16-Bit Port #	8-Bit Port #	Bit #
SCPI mode	PORT 00	PORT 00	Bits 0-7 (LO BYTE)
		PORT 01	Bits 0-7 (Hi BYTE)
HP 3488A Mode	PORT 02	PORT 00	Bits 0-7 (LO BYTE)
		PORT 01	Bits 0-7 (Hi BYTE)

Moreover, in order to communicate with peripherals, five handshaking modes are defined in this module, which are established via the three control lines:

- Peripheral Control (PCTL),
- I/O direction (I/O),
- Peripheral Flag (PFLG).

For more information on the five handshaking modes, refer to Chapter 7 "Digital Commands" on Page 151.

Wiring Information

An HP 44484A screw terminal block is provided along with the ordered HP 44474A. A label numbered as 1 through 5 is also provided for the module's identification.

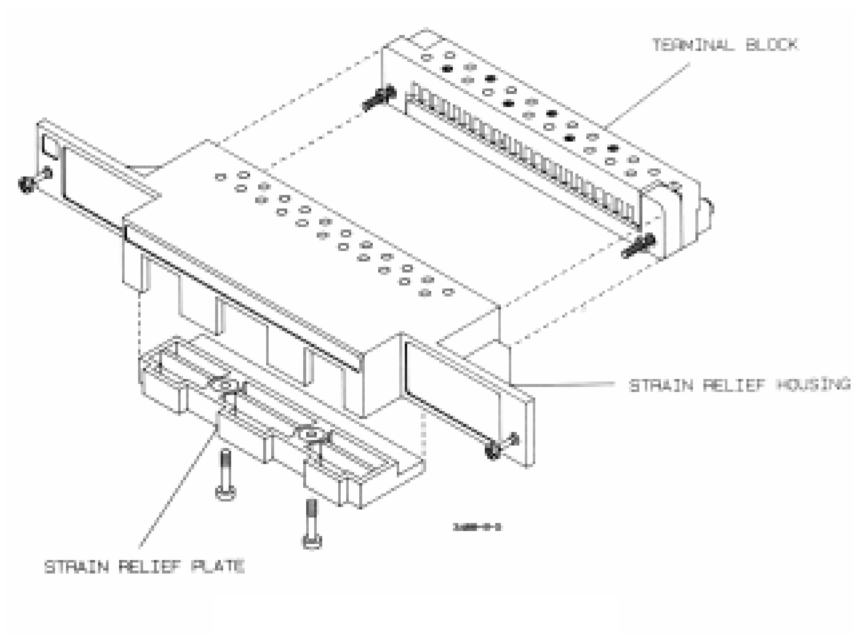


Figure 8-44. HP 44484A Screw Terminal Block

It is necessary to wire the HP 44484A prior to installing this screw terminal block to the HP 44474A. For more information on wiring this kind of screw terminal block, refer to "Plug-In Modules Wiring Information" on Page 254.

Specifications

HP 44474A 16-bit Digital I/O Module specifications are listed in Table 8-26.

Table 8-26. HP 44474A Specifications

ITEMS		SPECIFICATIONS
I/O LINES		
Maximum Voltage	Line-Chassis	+30 V dc
Output Characteristics	Vout (high) Vout (low) I (low) I (low)	≥ 2.4 V @ I ≤ 8 mA output ≤ 0.4 V @ I ≤ 16 mA input = 125 mA @ Vout (low) ≤ 1.25 V fused at 250 mA
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V
HANDSHAKE LINES		
Maximum Voltage (Line-Chassis)		+5 V dc
Output Characteristics	Vout (high) Vout (low)	≥ 2.4 V @ I ≤ 400 µA output ≤ 0.5 V @ I ≤ 2 mA input
Input Characteristics	Vin (high) Vin (low)	≥ 2.0 V ≤ 0.8 V
External Increment (EI)[1]	Minimum TTL pulse width	0.25 µsec
Channel Closed (CC)[2]	Minimum TTL pulse width	10 µsec

[1]. Both EI and CC lines are used for external controlled scanning. The HP 3499A will advance to the next channel in the scan list on the falling edge of EI pulse.

[2]. When the next channel closes, the HP 44474A outputs a CC pulse to trigger the voltmeter.

HP 44475A Breadboard Module

General Description

The HP 44475A Breadboard module provides a place for design engineers or technicians to mount custom designed circuits for use. Occasionally, some desired function may not be available on a standard plug-in module. In such instance, the HP 44475A provides the ideal solution.

Components are specified (but not supplied with the Breadboard module) for interfacing the Breadboard to the HP 3499A/B backplane. When these components are used, the Breadboard then provides 8 static input and 8 static output lines.

Two commands are used to control the Breadboard; SREAD reads data from the input port and SWRITE writes data to the output port.

A screw terminal block is provided for convenience in wiring.

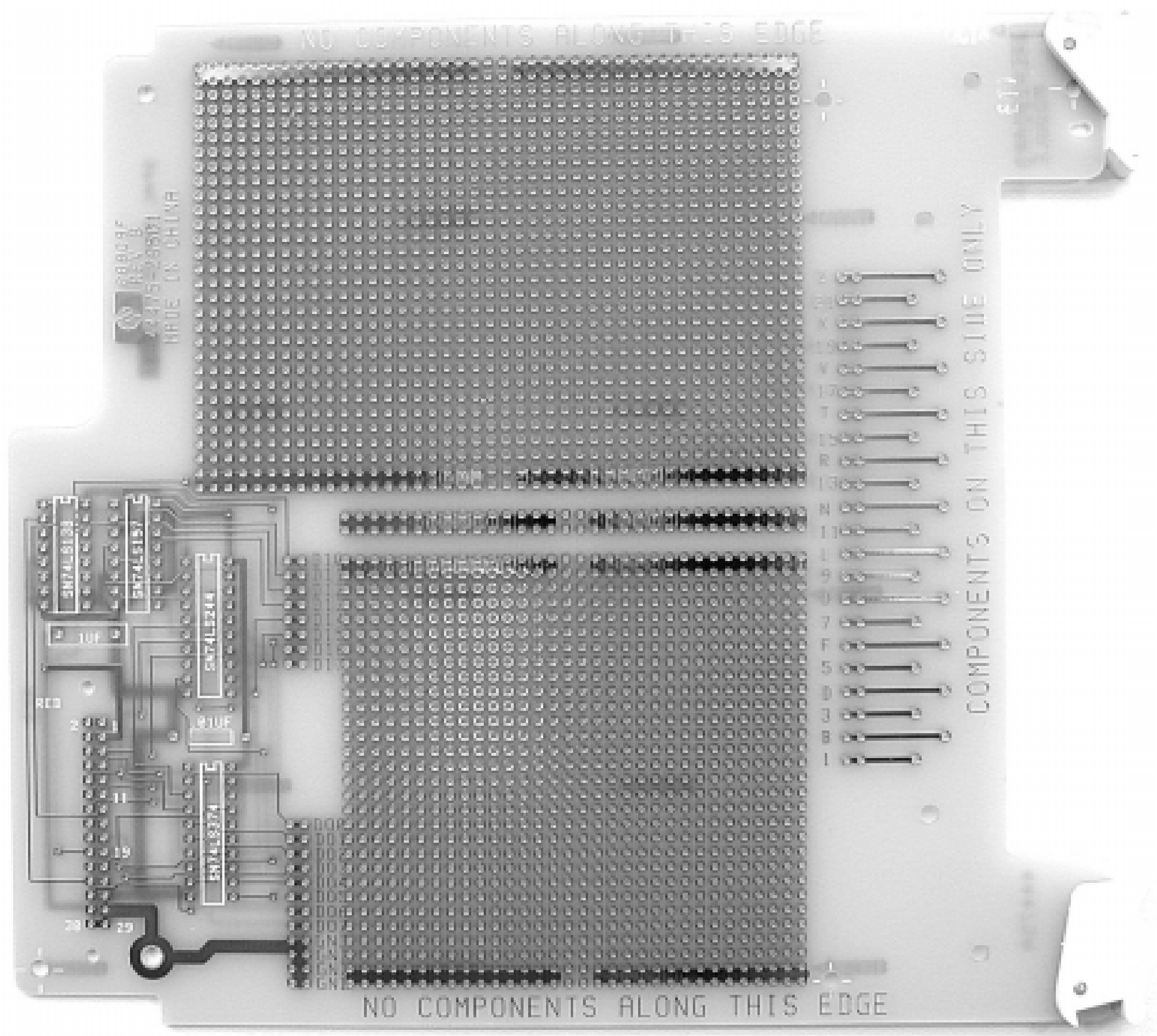


Figure 8-45. HP 44475A

Simplified Schematic

As shown in Figure 8-45, the HP 44475A consists of two areas. They are:

1. Breadboarding Grid consisting of holes on 0.10” centers. There is a 0.030” spacing between foil pads. Bus traces for power supply and ground, and provisions for the screw terminal block edge connector.
2. Built in design for providing an 8-bit digital input port and an 8-bit digital output port. Components required to use the 8-bit input and output ports are listed in Table 8-27. A schematic diagram for the two ports is shown in Figure 8-46.

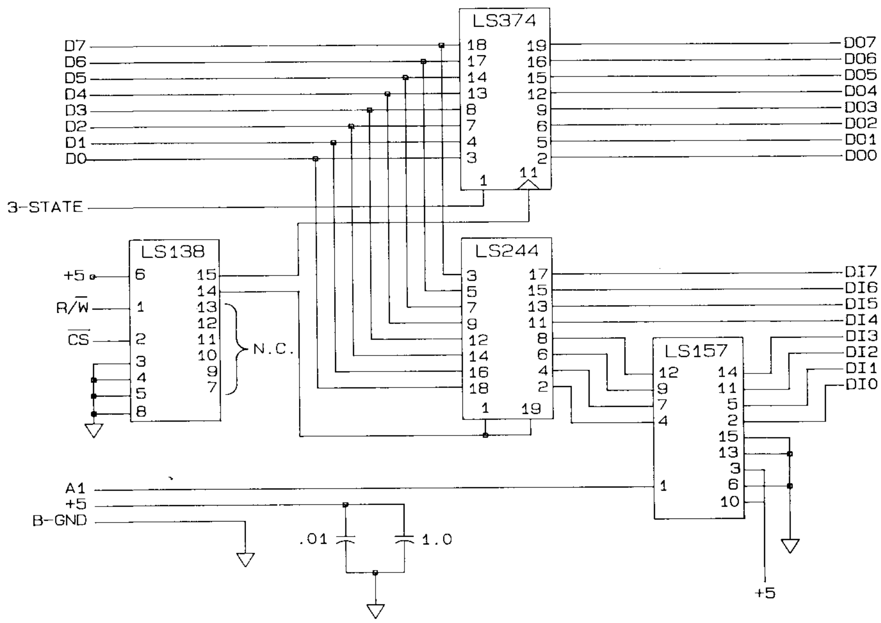


Figure 8-46. HP 44475A Schematic

Table 8-27. Required Components for 8-bit I/O Ports

Quantity	Component	Description
1	SN 74LS138	3 to 8 line decoder
1	SN 74LS157	Quad 2 to 1 line data selector/multiplexer (noninverted data outputs)
1	SN 74LS244	Octal Butters, line drivers, line receivers (noninverted 3-state outputs)
1	SN 74LS374	Octal D-Type Flip-Flops (3-state outputs)
1		0.01 uF Capacitor, 10 volts
1		1 uF Capacitor, 10 volts

Assembling the Breadboard

Three steps are involved in assembling the HP 44475A Breadboard.

- **The First Step** is to load the components (if you task requires them) for the 8-bit Input and 8-bit Output ports. Components were not supplied (but are listed in Table 8-27 on Page 235). Figure 8-45 on Page 234 shows where these components are to be mounted on the Breadboard.

- **The Second Step**, you will need install your custom circuitry. Component height restrictions and how far the component leads extend through the circuit board are limited by the top and bottom shields. These shields must never be eliminated as they provide RF shielding as well as structural strength.

  The absolute maximum component height allowed is 12.7 mm (0.50 in.). However, if the height of any component exceeds 10 mm, the conductive surface of the component must be insulated. On the circuit side of the Breadboard, the lead lengths are limited to 3.2 mm (0.125 in.) from the circuit board.

- **The Third Step** is assembling the hardware. Table 8-28 lists the parts supplied with the HP 44475A. Refer to Figure 8-47 on Page 237 for assembly information.

Table 8-28. Parts Supplied with the HP 44475A Breadboard

Part Number	Description
44475-26501	Breadboard circuit board
03488-00602	Bottom shield
03488-00603	Top shield (component side)
1251-8645	2 rows x 15 pins right angle connector (small connector)
44475-62102	2 rows x 11 pins right angle connector (large connector)
44475-62101	Terminal Block, keyed for the breadboard connector
5040-5193	Connector Housing
0515-5194	Cable Clamp
0515-0063	Pan Head screw, 2.5 x 12 (metric)
0515-0843	Flat Head screw, 2.5 x 20 Lock (metric)
0515-0045	Pan Head screw, 3 x 18 Lock (metric)
0535-0004	Hex Nut, 3 x 0.5
0535-0008	Hex Nut, 2.5 x 0.45
2190-0583	Lock Washer
2190-0584	Lock Washer

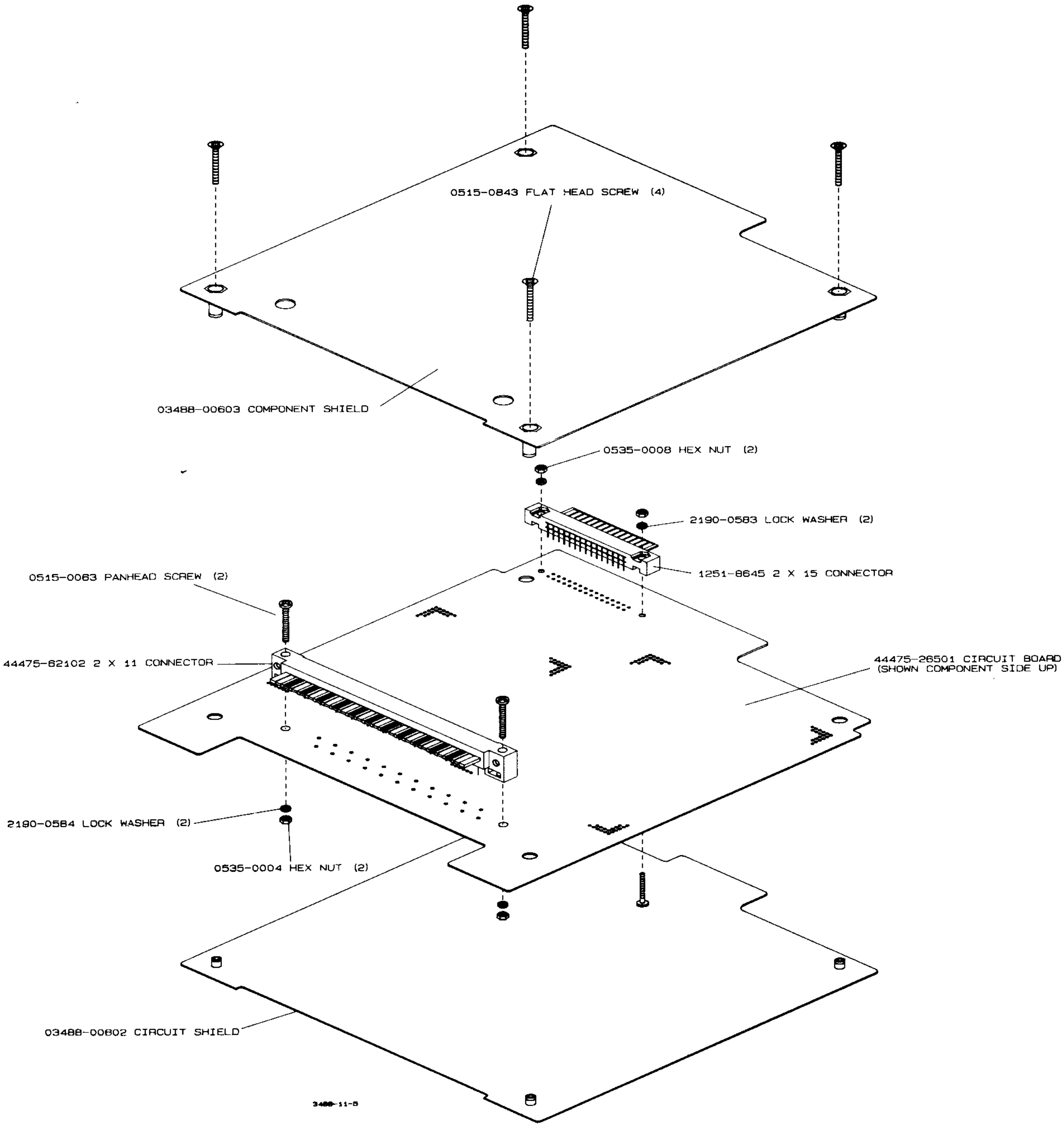


Figure 8-47. Hardware Assembly

Wiring Information

An HP 44485A screw terminal block is provided with the ordered HP 44475A. A label numbered as 1 through 5 is also provided for the module's identification.

It is necessary to wire the HP 44485A prior to installing this screw terminal block to HP 44475A. For more information on wiring this kind of screw terminal block, refer to "Plug-In Modules Wiring Information" on Page 254.

Specifications

HP 44475A Breadboard Module specifications are listed in Table 8-29.

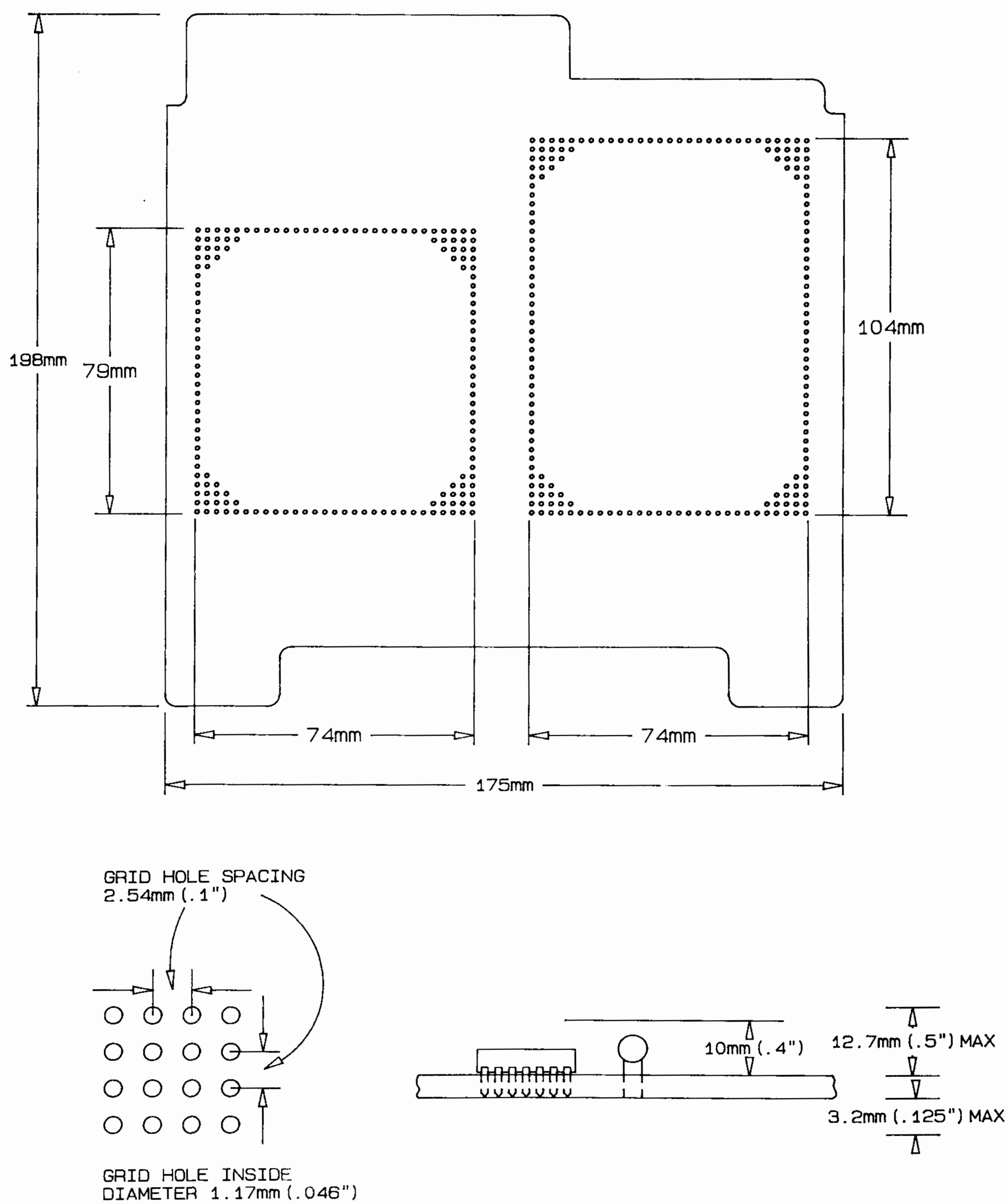


Figure 8-48. HP 44475A Breadboard Module Dimensions

Table 8-29. HP 44475A Specifications[1]

ITEMS	SPECIFICATIONS
MODULE DIMENTIONS	
Component Area Available	104mm x 74mm and 79mm x 74mm (4.1” x 2.9” and 3.1” x 2.9”)
Grid Hole Spacing (center-center)	2.54mm x 2.54 mm (0.1” x 0.1”)
Grid Hole Size (inside diameter)	1.17mm (0.046”)
Maximum Component Height (above board)	12.7mm (0.5”)
Maximum lead Length (below board)	3.2mm (0.125”)
INPUT CHARACTERISTICS	
Maximum Voltage	42 V dc, 30 V ac rms, 42 V ac peak (on Breadboard area) 5.5 V (on Digital Input port lines)
Maximum Power Dissipation (per module)	2 Watt

[1]. Components required but not supplied, are to be mounted on the Breadboard. Refer to the manufacturers data sheet for load/drive specifications of these components.

HP 44476A/B Microwave Switch Module

General Description

Both the HP 44476A and 44476B are Microwave Switch modules.

HP 44476A Description

The HP 44476A contains three HP 8762B Microwave Switches. These switches have the following features:

- Broad bandwidth (dc to 18 GHz)
- High isolation (> 90 dB to 18 GHz)
- Excellent repeatability (typically 0.03 dB after 1,000,000 switchings)
- Internal 50 Ω terminations

The HP 8762B is a break-before-make switch controlled by a latching solenoid. Once switched, coil voltage can be removed and the switch remains in the switched position. Internal coil contacts open and remove coil voltage after a switching operation to minimize the amount of heat dissipated near the switch contacts.

The SMA connectors allow user to easily connect or disconnect cables for multiple system configuration.

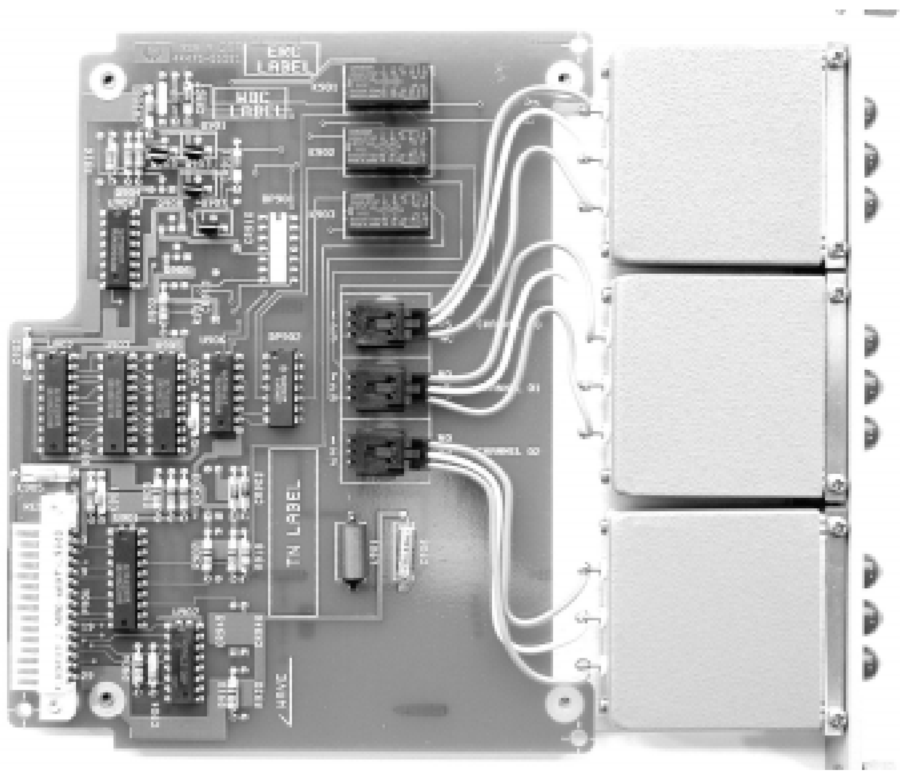


Figure 8-49. HP 44476A

HP 44476B Description

The HP 44476B differs from the HP 44476A in two ways:

1. It is not supplied with microwave switches (but does have the Form C relays). You provide your own microwave switches, mount them on

the assembly, and connect one of the module's Form C relay drive circuits to each switch.

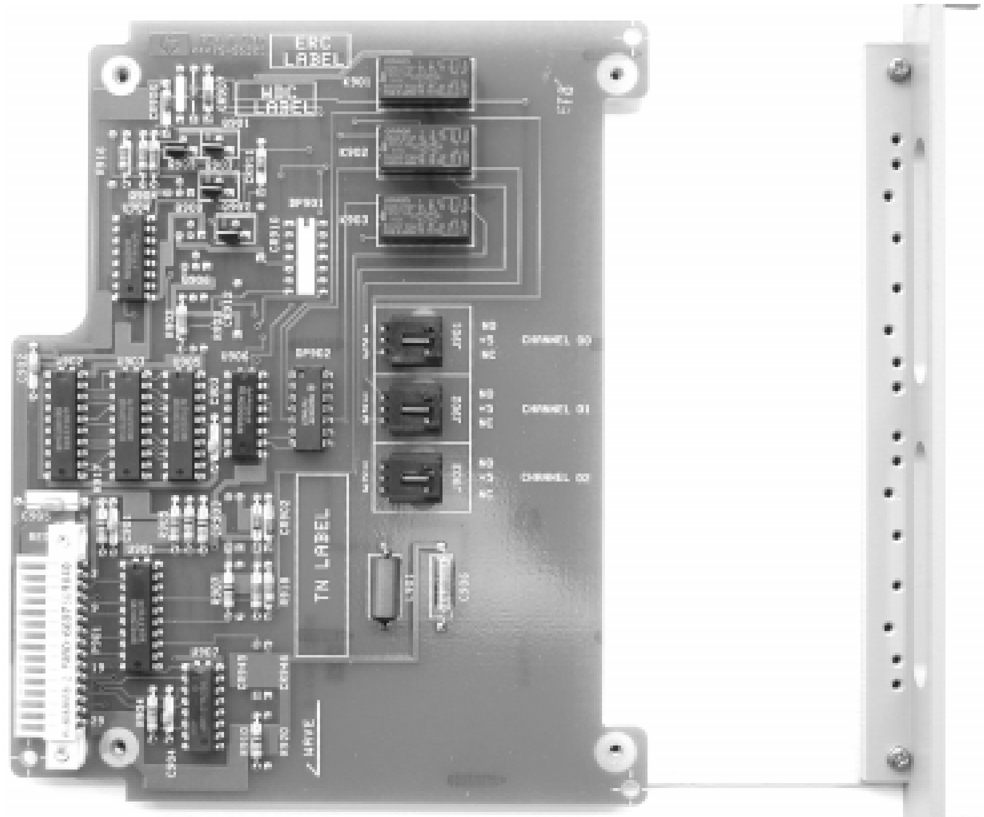


Figure 8-50. HP 44476B

2. Instead of three cutouts, the HP 44476B panel has two 53.8 X 9.6 mm cutouts for a set of microwave switches supplied by the user. The available HP microwave switches are listed in Table 8-30.

Table 8-30. HP Microwave Switches

Microwave Switch	Port	Frequency
HP 8762A	3	DC-4 GHz
HP 8762B	3	DC-18 GHz
HP 8762C	3	DC-26.5 GHz
HP 8762F[1]	3	DC-4 GHz
HP 8763B	4	DC-18 GHz
HP 8763C	4	DC-26.5 GHz
HP 8764B	5	DC-18 GHz
HP 8764C	5	DC-26.5 GHz

[1]. Except the HP 8762F Microwave Switch with 75 Ω characteristic impedance, all others are with 50 Ω.

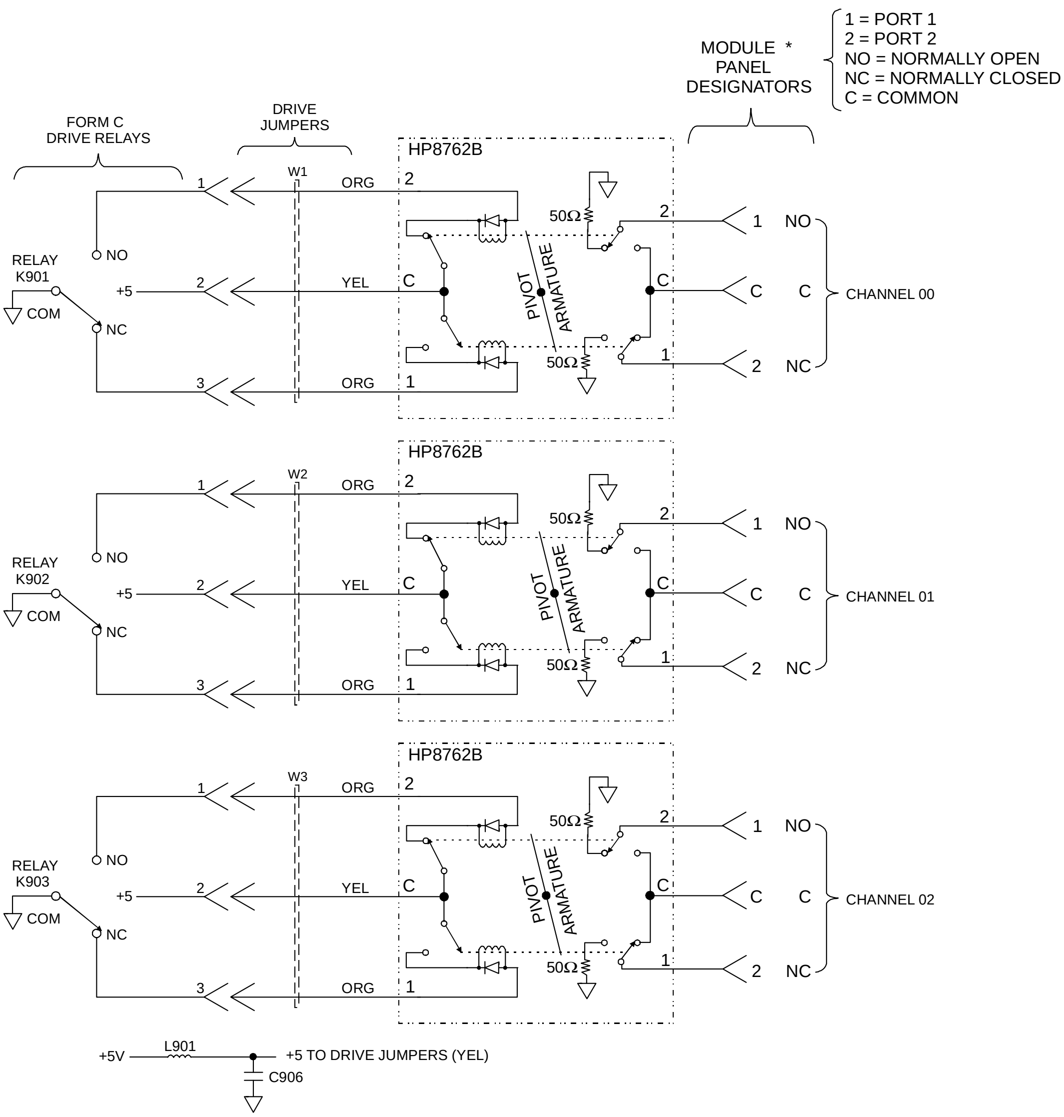
Simplified Schematic

HP 44476A

As shown in Figure 8-51, an HP 44476A contains three HP 8762B Microwave Switches. Each microwave switch is referred to a channel. The channels on the HP 44476A are numbered as 00, 01, and 02.

HP 44476B

The HP 44476B have two 53.8 x 9.6 mm cutouts for mounting the microwave switches supplied by the user. They are numbered as channels 00 and 01. Figure 8-52 on Page 243 shows the simplified schematic of the HP 44476B. Table 8-30 lists the available HP microwave switches.



* NOTE :
TERMINAL DESIGNATIONS INSIDE THE DASHED BOXES REFER TO THE HP8762B ONLY. MODULE PANEL DESIGNATORS OUTSIDE THE DASHED BOXES ARE THOSE SILKSCREENED ON THE HP44476A PANEL. ANY REFERENCE IN THIS MANUAL TO A PORT REFERS TO THE MODULE PANEL DESIGNATORS.

Figure 8-51. HP 44476A Simplified Schematic

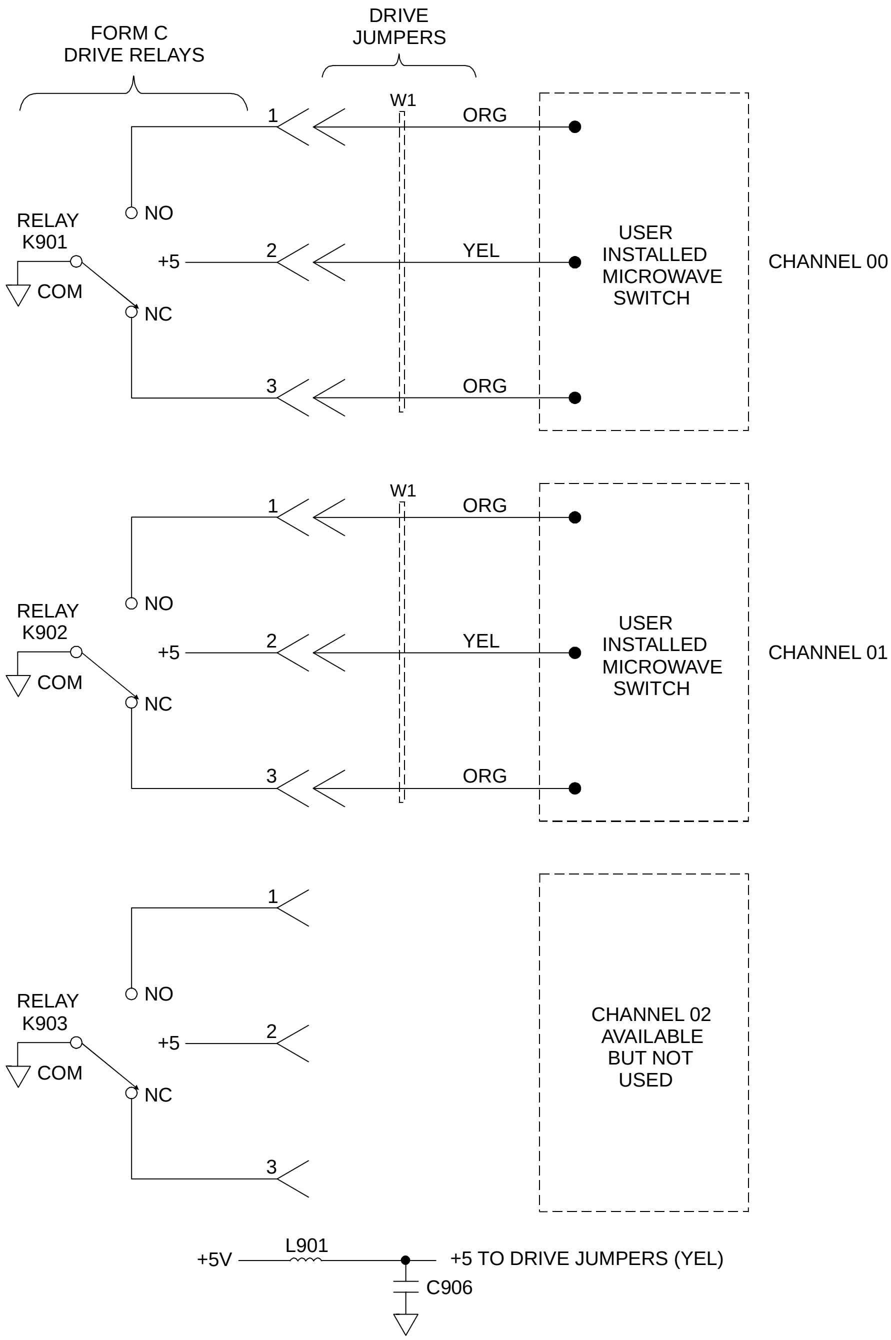


Figure 8-52. HP 44476B Simplified Schematic

Configuration

The HP 44476B is not supplied with microwave switches. You mount user-supplied microwave switches on the module after connecting the channels 00 and 01 drive jumpers (W1 and W2). Figure 8-53 on Page 244 shows the drive jumper orientation and Figure 8-54 on Page 244 shows an HP 33313B 5-port (which can be replaced with an HP 8764B/C) switch mounted on the module.

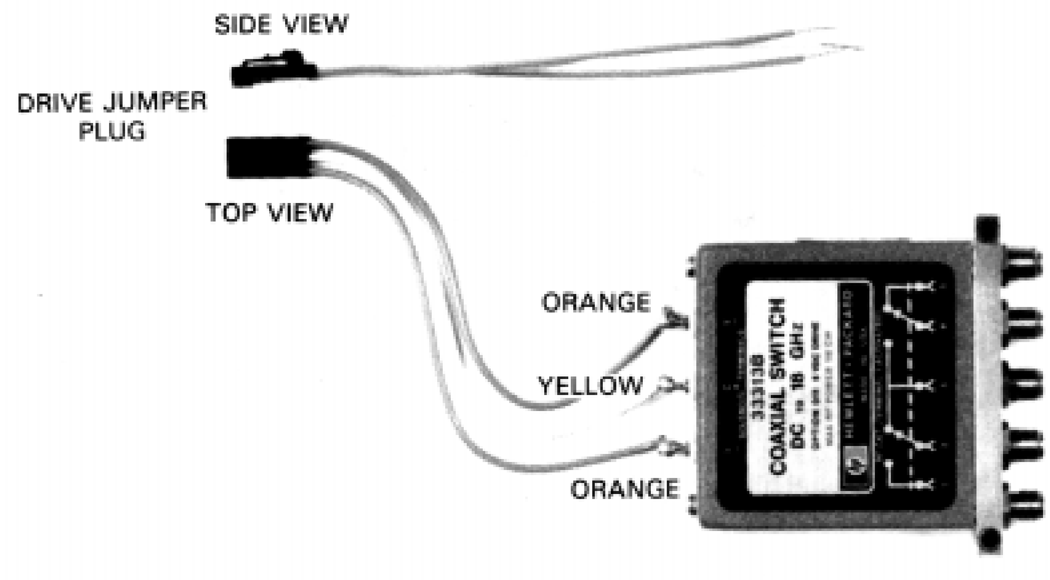


Figure 8-53. Drive Jumper Orientation

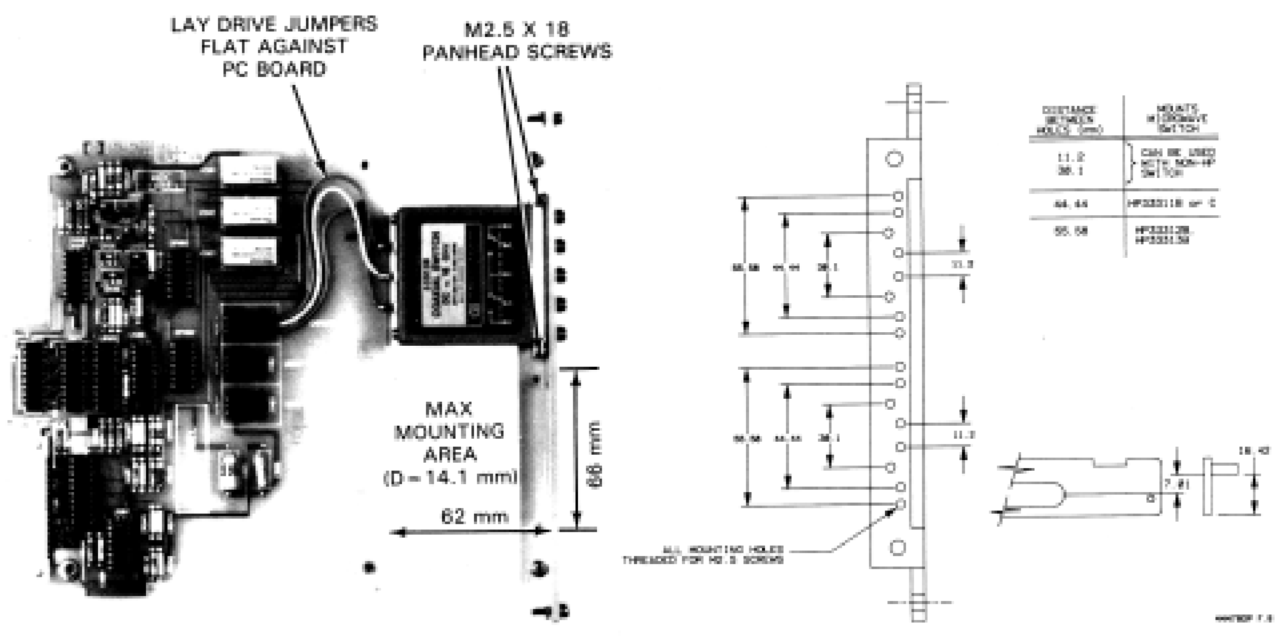


Figure 8-54. Mounting the Microwave Switch

Wiring Information

Both the HP 44476A/B provide SMA connectors, which allow user to easily connect or disconnect cables for multiple system configuration.

Specifications

HP 44476A Microwave Switch Module specifications are listed in Table 8-31. The HP 44476B Specifications are dependent on which HP microwave switch is installed on the module. For more information on the switch characteristics, refer to the HP 8762A/B/C, HP 8763B/C, and HP 8764B/C Date Sheets respectively.

Table 8-31. HP 44476A Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Frequency Range		DC to 18 GHz
Characteristic Impedance		50 Ω
Input Power Rating		1 Watt average, 100 Watts peak (Also less than ±7 V dc)
Average Switch Life		10^6 /chan
Repeatability (typical)		0.03 dB after 10^6 switchings
Maximum Scan Rate[1]		43 Chans./sec
Connector		SMA
AC ISOLATION / PERFORMANCE		
Isolation	DC - 18 GHz	> 90 dB
Insertion Loss	DC - 2 GHz DC - 18 GHz	< 0.25 dB < 0.50 dB
SWR (3 mm SMA)	DC - 2 GHz DC - 12.4 GHz DC - 18.0 GHz	< 1.15 dB < 1.25 dB < 1.40 dB

[1]. Using HP 44474A External Increment & Channel Closed, display off.

HP 44477A Form-C Relay Module

General Description

The HP 44477A consists of seven independent, break-before-make, SPDT Form-C latching relays (one contact normally open, one contact normally closed). The relay contacts are accessible at the screw terminal block for field wiring connections.

Typical uses for the HP 44477A are signal switching and power application (250V, 2A). Additionally, this module is ideally suited for driving remote RF, coaxial, and microwave devices such as the HP 8761, 8762A/B/C, 8763B/C, and 8764B/C switches or programmable step attenuators like the HP 876xx series.

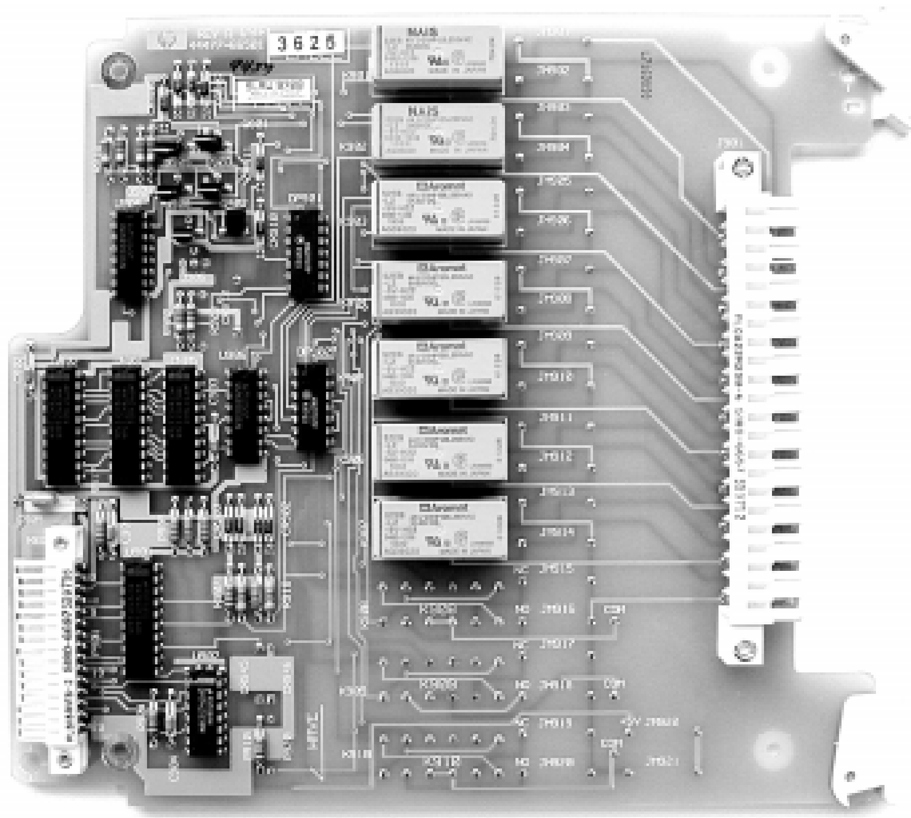


Figure 8-55. HP 44477A

Simplified Schematic

As shown in Figure 8-56 on Page 247, the HP 44477A consists of seven independent Form-C relays (K901-K907) which are numbered as channels 00 through 06. Closing a channel (relay) will connect the normally open (NO) contact to the common port (C). When power-on or reset the instrument, the Form C relays on the HP 44477A have their normally open (NO) contacts open and normally closed (NC) contacts closed.

Each relay circuit provides mounting holes (JM901 - JM914) so you can add a pull-up resistor from the NO (normally open) and NC (normally closed) contact to +5V power supply. Also, there are mounting holes (JM921 and JM922) at the +5V supply for the addition of a protection resistor or inductor if the internal supply is to be used. If the internal supply is not used, an external power supply can be applied through the screw terminal block via the “H” terminal. The addition of pull-up resistors is useful when driving logic circuits. The common (C) terminal can be connected to ground and used to pull either the NO or the NC line low.

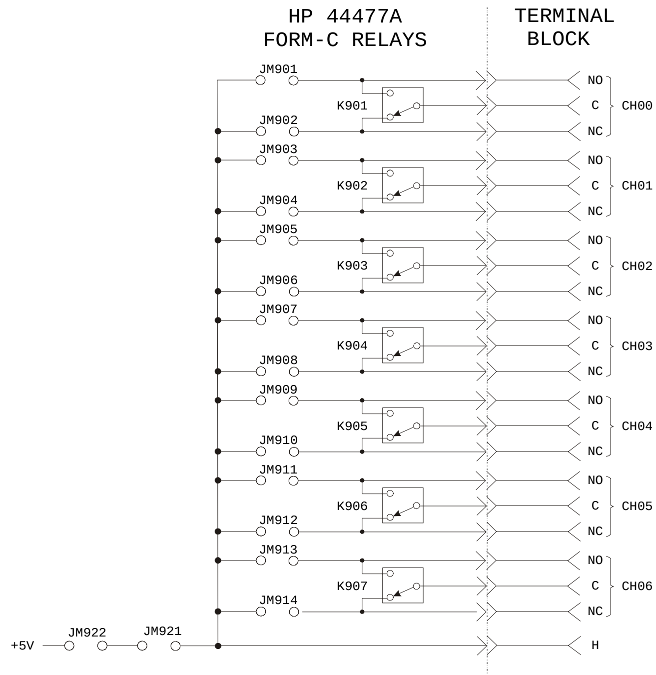


Figure 8-56. HP 44477A Simplified Schematic

Wiring Information

An HP 44487A screw terminal block is shipped along with an HP 44477A Form-C Relay module. A label (numbered as 1 through 5) is also provided for the slot identification.

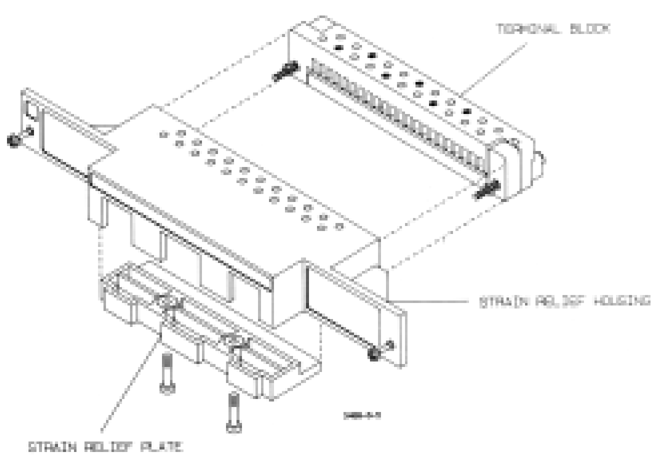


Figure 8-57. HP 44487A Screw Terminal Block

The HP 44487A must be wired prior to installing the screw terminal block to an HP 44477A. For more information on wiring this kind of screw terminal block, refer to “Plug-In Modules Wiring Information” on Page 254.

Specifications

HP 44477A Form C Relay Module specifications are listed in Table 8-32.

Table 8-32. HP 44477A Module Specifications

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		10
Maximum Voltage	Terminal-Terminal or Terminal-Chassis	250 V dc or ac rms, 350 V ac peak
Maximum Current	Per Channel Per Module	2 A, dc or ac rms 14 A, dc or ac rms
Maximum Power	Per Channel Per Module	60 W dc; 500 VA ac 420 W dc; 3500 VA ac
Maximum Overvoltage Transients		1400 V_{pk}
Thermal Offset		< 3 µV per channel
Initial Closed Channel Resistance		< 1 Ω
Relay Life	Dry Load of < 300 mA, < 10 V Maximum Rated Load	10^8 operations/Chan. 10^5 operations/Chan.
Maximum Scan Rate[1]		43 Chans./sec
DC ISOLATION		
Open Channel, Channel-Channel (with 1 channel closed)	≤ (40°C, 60% RH) ≤ (40°C, 95% RH)	> 10^{11} Ω >10^9 Ω
Channel-Chassis (with 1 channel closed)	≤ (40°C, 60% RH) ≤ (40°C, 95% RH)	> 5 x 10^{11} Ω > 10^{10} Ω
AC ISOLATION/PERFORMANCE[2]		
Capacitance (with 1 channel closed)	Open Channel, Channel-Channel Channel-Chassis	< 10 pF < 25 pF
Insertion Loss (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< 0.20 dB < 0.25 dB < 0.50 dB
Crosstalk (with 50Ω termination)	100 kHz 1 MHz 10 MHz	< -73 dB < -53 dB < -33 dB

[1]. Using HP 44474A external increment & channel closed, display off.
[2]. With chassis of all instruments connected, and with the Low of input lines connected to the Low of output lines (either directly or via HP 3499A/B switched channels)

HP 44478A/B 1.3GHz Dual 4-to-1 MUX Modules

General Description

Both the HP 44478A/B consist of two independent 4-to-1 MUX modules (group 00 and group 01) that provide bidirectional switching. The module relays (latching) are configured in a “tree” structure, which provides high isolation and low VSWR (voltage standing wave ratio). Each channel on this module can switch up to 42V dc +ac peak at frequencies up to 1.3 GHz.

User connections for the channels are through BNC connectors. Each channel has an SMB connector which allows to connect resistive terminations and terminate unused channels. The HP 44478A is a 50 Ω impedance, and the HP 44478B is a 75 Ω impedance.

Note To maintain proper operation of the instrument, unused channels should be terminated by plugging a 50 Ω or 75 Ω SMB type resistive termination (50 Ω for HP 44478A and 75 Ω for HP 44478B) onto the male SMB connector provided for each channel.

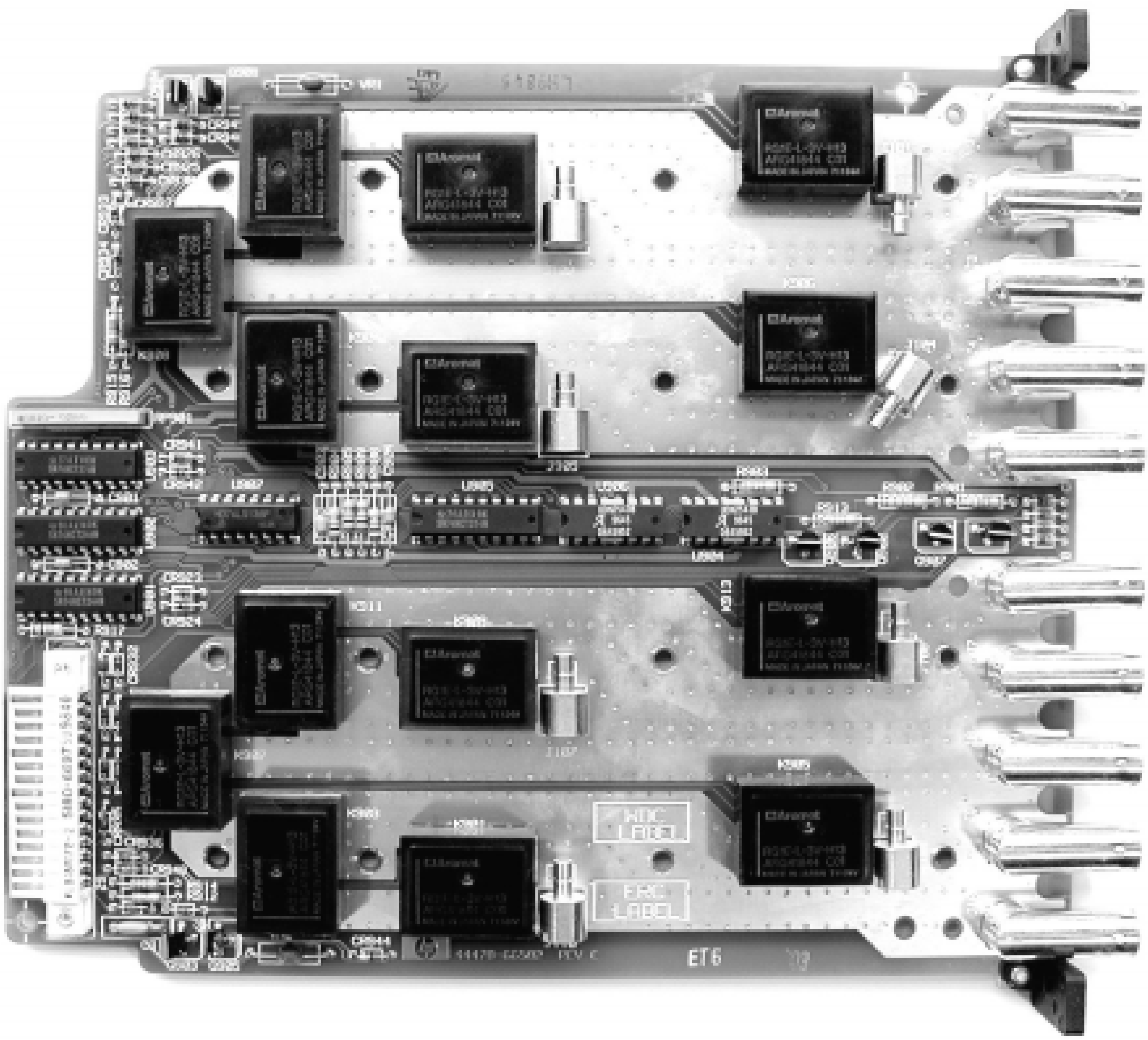


Figure 8-58. HP 44478A/B

Simplified Schematic

The two groups of 4-to-1 MUXs are specified as GROUP 00 and GROUP 01, they are isolated from each other. A channel refers to an individual set of relays on the HP 44478A/B. When a channel is closed, a particular set of relays close connecting the common BNC to one of the four BNC inputs. Channels within each group are break-before-make and are numbered as 00 through 03 for GROUP 00, 10 through 13 for GROUP 01.

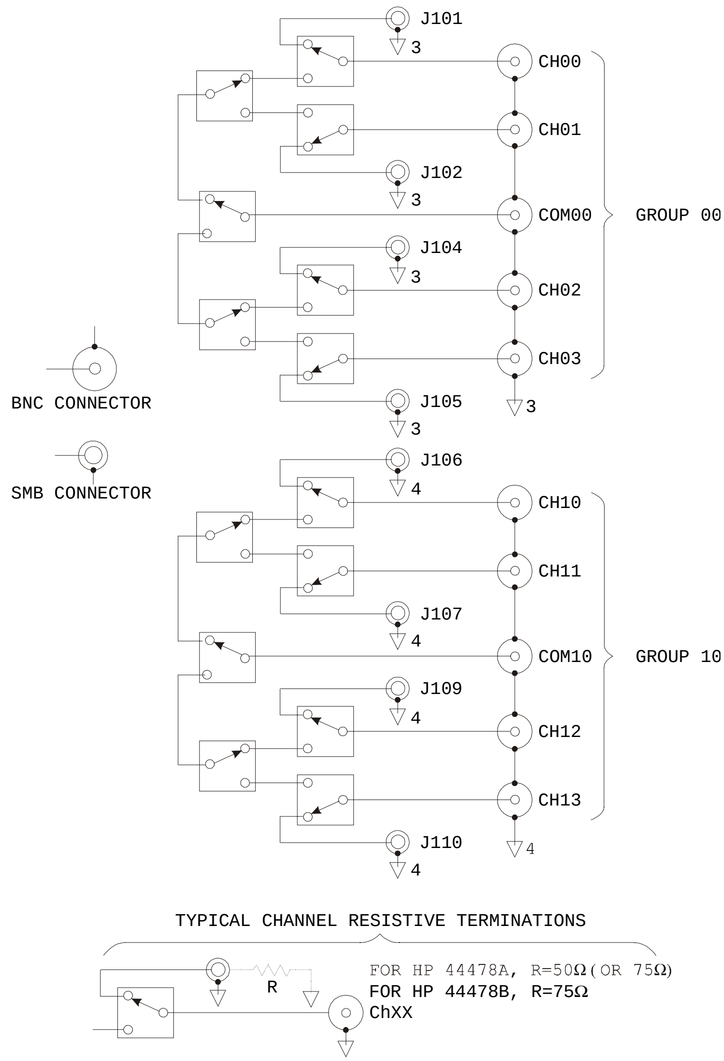


Figure 8-59. HP 44478A/B Simplified Schematic

Wiring Information

BNC Connectors

Figure 8-60 on Page 251 shows the module’s female BNC connectors and the channel group numbers. The BNC connectors accept user-supplied male BNC connectors.

SMB Connectors

Figure 8-58 shows the modules’ SMB connectors, their “J” numbers, and their corresponding channels. The SMB connectors allow you to connect SMB resistive terminations to the unused channels. SMB resistive terminations are available from Hewlett-Packard under the following HP part number:

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

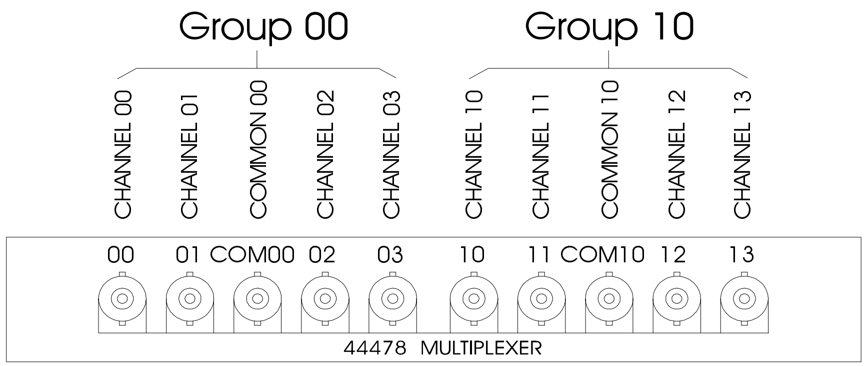


Figure 8-60. HP 44478A/B BNC Connectors

Cabling Considerations

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

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

Always use shielded coaxial cables with the characteristic impedance of the module used (50 Ω or 75 Ω). 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.

Specifications

Unless specifically indicated, the specifications listed in Table 8-33 apply for both HP 44478A and HP 44478B modules.

Table 8-33. HP 44478A/B Specifications[1]

ITEMS		SPECIFICATIONS
INPUT CHARACTERISTICS		
Total Channels		7
Maximum Voltage (any center or shield to any other center, shield, or to the chassis)		42 V dc + ac peak
Maximum Current (per channel or common)		1 A dc, or ac rms
Maximum Power	Per Channel or Common Each Resistive Termination	24 W, 24 VA or 44 dBm 0.25 W, 0.25 VA or 24 dBm
Characteristic Impedance	For HP 44478A For HP 44478B	50 Ω 75 Ω
Relay Life (*Typical*)	With no load At maximum rated power	5 x 10^6 operations 10^5 operations
Maximum Scan Rate[2]		43 Chans./sec
DC PERFORMANCE		
Thermal Offset (per channel)		< 6 μV (< 2 μV, *Typical*)
Initial Closed Channel Resistance		< 1 Ω
Insulation Resistance (any terminal to any terminal)	≤ (40°C, 95% RH) ≤ (25°C, 40% RH)	> 10^8 Ω > 10^{10} Ω (*Typ.*)
AC ISOLATION / PERFORMANCE ($Z_L = Z_S$ = 50Ω or 75Ω)[3]		
Insertion Loss		
≤ **40°C, 95% RH**	≤ 10 MHz ≤ 100 MHz ≤ 500 MHz ≤ 1.3 GHz	< 0.5 dB < 0.7 dB < 1.5 dB < 3.0 dB
≤ **25°C, 40% RH** (*Typical*)	≤ 10 MHz ≤ 100 MHz ≤ 500 MHz ≤ 1.3 GHz	< 0.2 dB < 0.5 dB < 1.1 dB < 1.9 dB
Crosstalk[4]		
Channel-Channel, Channel-Common (with 1 channel closed)	≤ 10 MHz ≤ 100 MHz ≤ 500 MHz ≤ 1.3 GHz	< -90 dB < -80 dB < -65 dB < -55 dB

Table 8-33. HP 44478A/B Specifications[1]

ITEMS		SPECIFICATIONS
Group-Group, Module-Module	≤ 10 MHz ≤ 100 MHz ≤ 500 MHz ≤ 1.3 GHz	< -90 dB < -80 dB < -70 dB < -60 dB
VSWR	≤ 10 MHz ≤ 100 MHz ≤ 500 MHz ≤ 1.3 GHz	< 1.20 < 1.25 < 1.35 < 1.55
Capacitance	Center-Center Center-Shield	< 0.006 pF < 60 pF
Rise Time		< 300 psec
Signal Delay		< 3 nsec (channel matched to ±50 psec)

[1]. Specifications in the above table describe the modules' warranted performance over the temperature range 0 to 55^{o}C. Information marked by the "*Typical"* designation is helpful in applying the modules, but is non-warranted information.

[2]. Using HP 44474A external increment & channel closed, display off.

[3]. $Z_L = Z_S = 50\ \Omega$ applies for HP 44478A and $Z_L = Z_S = 75\ \Omega$ applies for HP 44478B.

[4]. The CrossTalk specifications assume 50 Ω termination for HP 44478A and 75 Ω termination for HP 44478B. If all channels unterminated, derate specification by 6 dB.

Plug-In Modules Wiring Information

BNC and SMA Connection

The modules listed in Table 8-34 provide BNC or SMA connections to external devices.

Table 8-34. BNC & SMA Connection

Connection Type	Quantity	Module Description
BNC Connector	10	HP 44472A Dual 4-Channel VHF Switch Module
	10	HP 44478A 50Ω 1.3 GHz MUX Module
	10	HP 44478B 75Ω 1.3 GHz MUX Module
SMA Connector	9	HP 44476A 3-Channel 18 GHz Switch Module
	6[1]	HP 44476B 2-Channel Microwave Switch Module

[1]. The number of SMA connectors depends on the specified microwave modules installed. If the two modules are 5-port, the number of SMA connectors is 10, and so on.

Screw Terminal Blocks

A set of screw terminal blocks are available for wiring conveniences, as listed in Table 8-35. Figure 8-61 through Figure 8-64 illuminate wiring for the three screw terminal block types.

Table 8-35. Screw Terminal Blocks

Screw Terminal Block (Wiring Inf.)	HP P/N	Application
Type A[1] (Figure 8-61 on Page 255 & Figure 8-62 on Page 256)	HP 44480A	For HP 44470A module only (default).
	HP 44481A	For HP 44471A module only (default).
	HP 44483A	For HP 44473A module only (default).
	HP 44484A	For HP 44474A module only (default).
	HP 44485A	For HP 44475A module only (default).
	HP 44487A	For HP 44477A module only (default).
Type B (Figure 8-63 on Page 257)	HP 44480B	For HP 44470D module only (default).
	HP 44481B	For HP 44471D module only (default).
Type C[2] (Figure 8-64 on Page 258)	HP N2290A	For HP N2260A module only.
	HP N2291A	For HP N2261A module only.
	HP N2292A	For HP N2262A module only.
	HP N2293A	For HP N2263A module only.
	HP N2294A	For HP N2264A module only.
	HP N2295A	For HP N2265A module only.

[1]. Types A & B of the screw terminal blocks are provided with the ordered modules.
[2]. Type C of the screw terminal blocks must be ordered separately.

Screw Terminal Block Wiring (Type A)

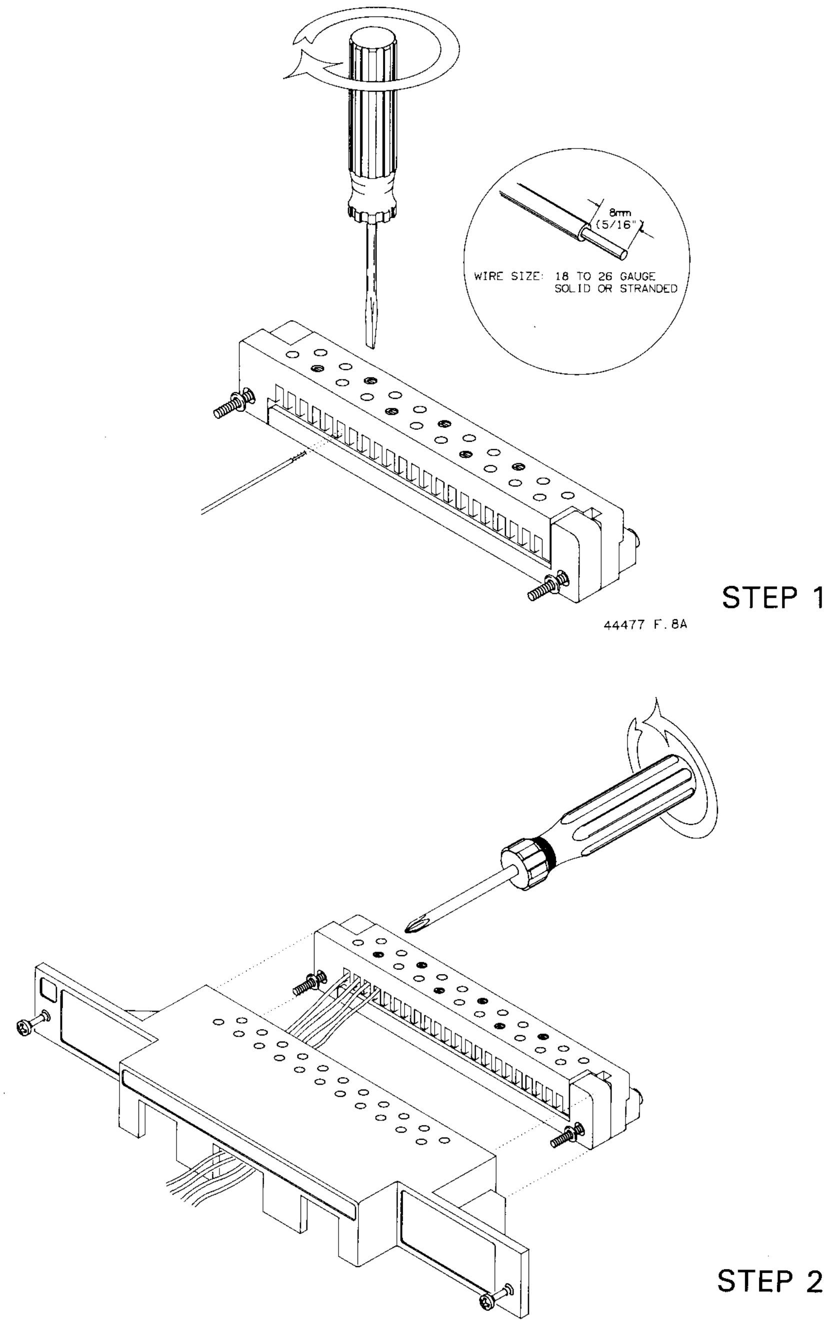


Figure 8-61. Type A Screw Terminal Block Wiring

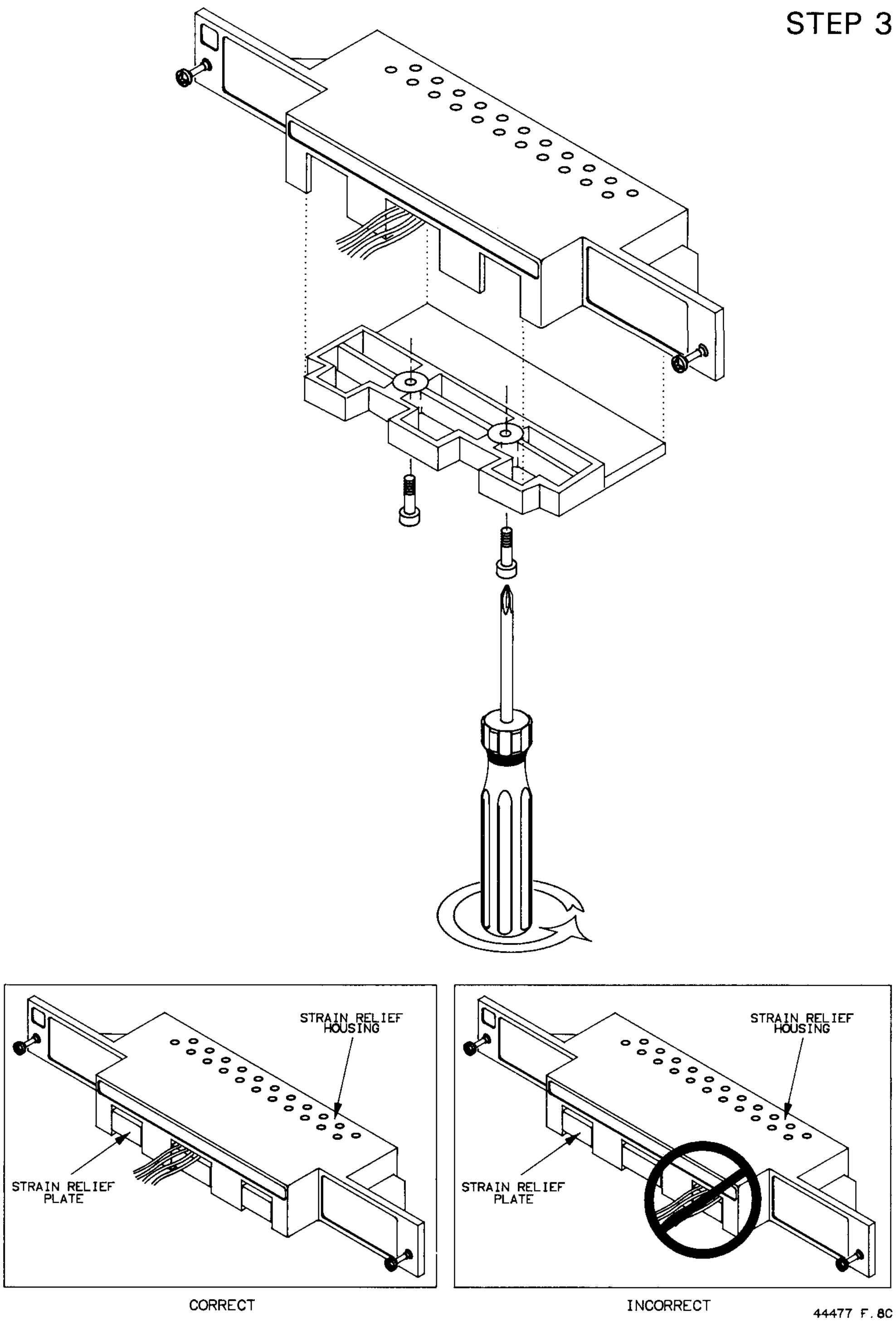


Figure 8-62. Type A Screw Terminal Block Wiring (Cont'd)

Screw Terminal Block Wiring (Type B)

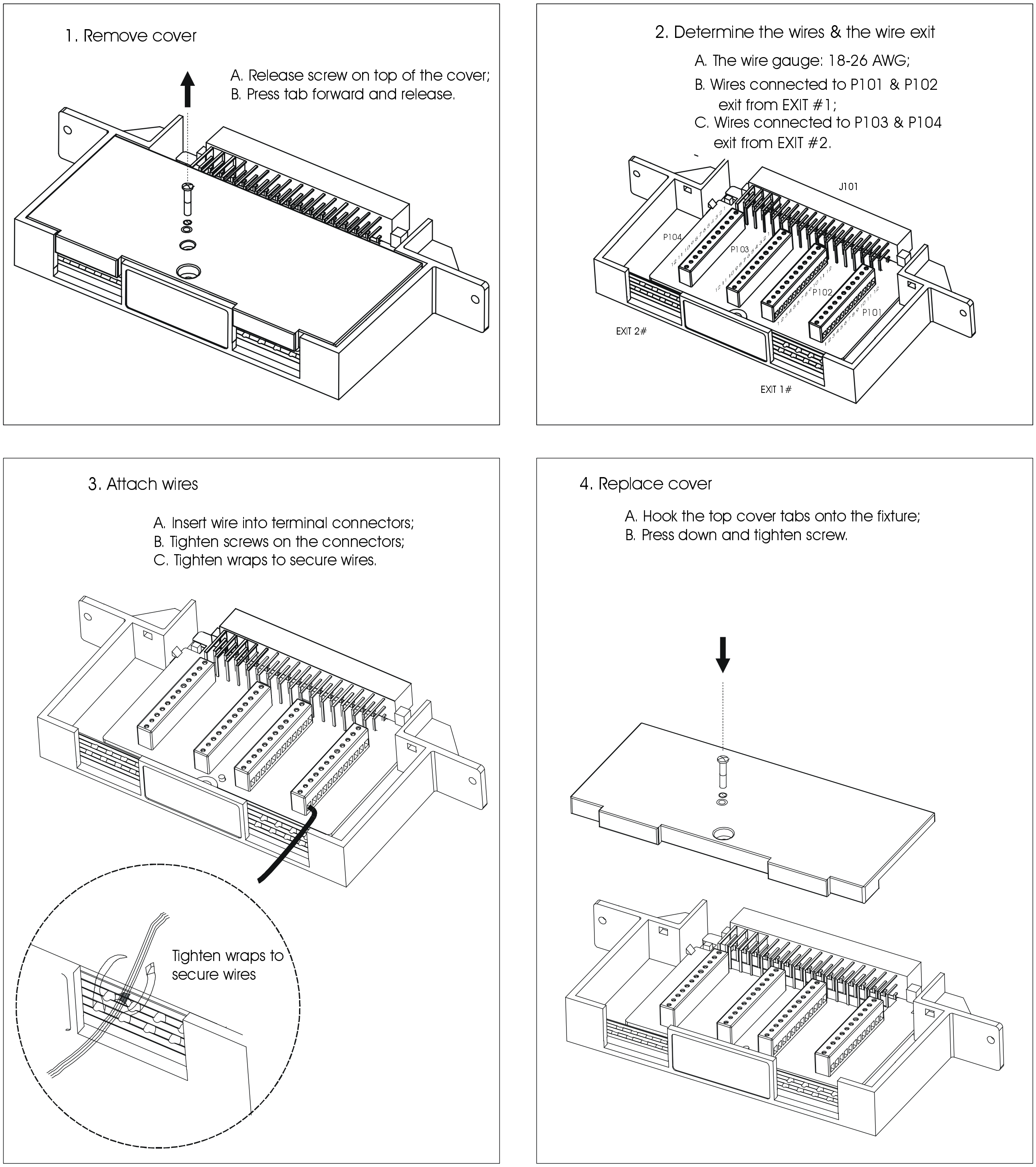


Figure 8-63. Type B Screw Terminal Block Wiring

Screw Terminal Block Wiring (Type C)

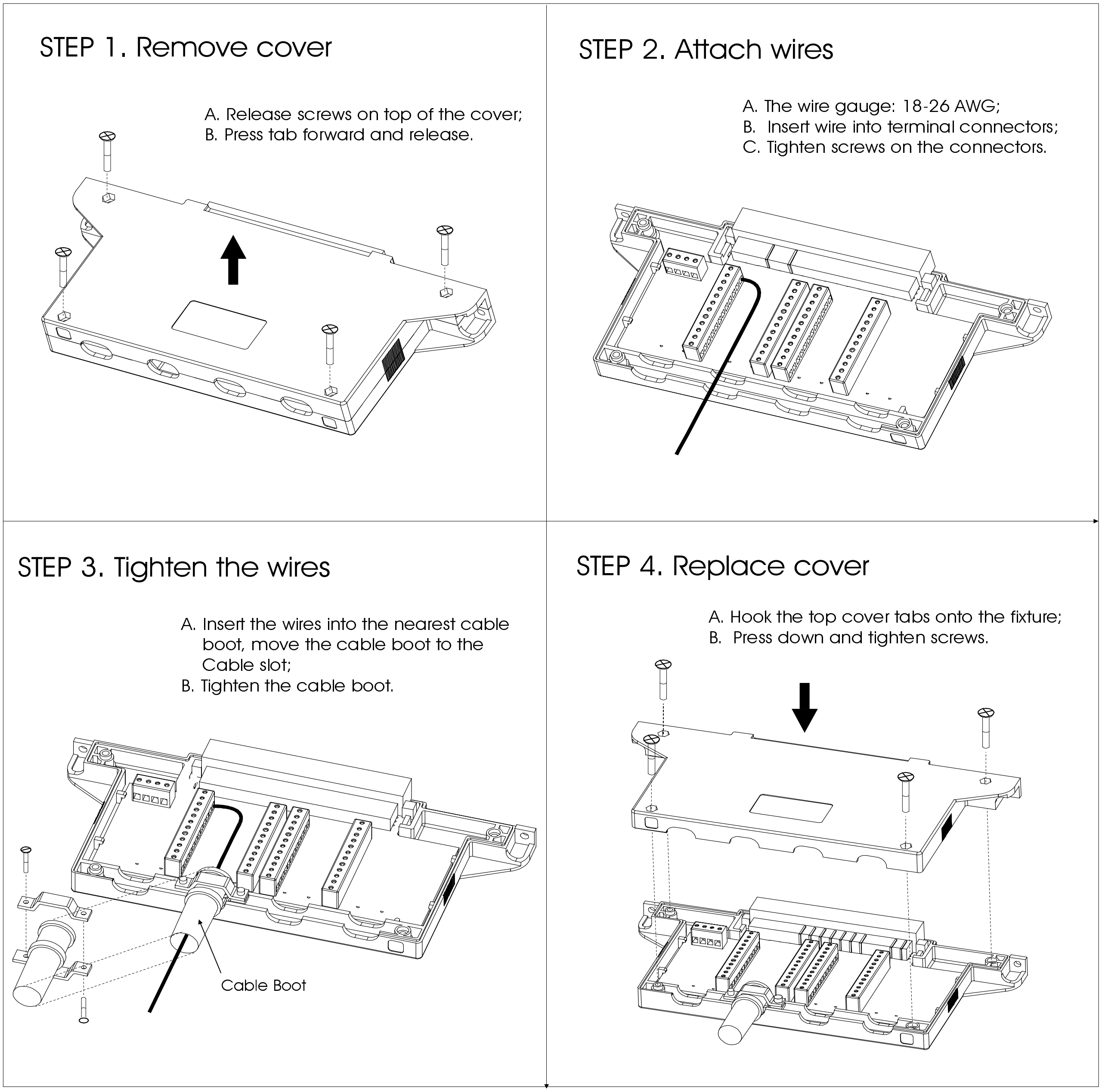


Figure 8-64. Type C Screw Terminal Block Wiring

Crimp-and-Insert Terminal Block

HP N2296A is a crimp-and-insert terminal block for HP N2260A, N2261A, N2262A, N2263A, N2264A and HP N2265A. It provides a flexibility for connecting the above modules to external devices. The wiring procedure for the HP N2296A is shown in Figure 8-65.

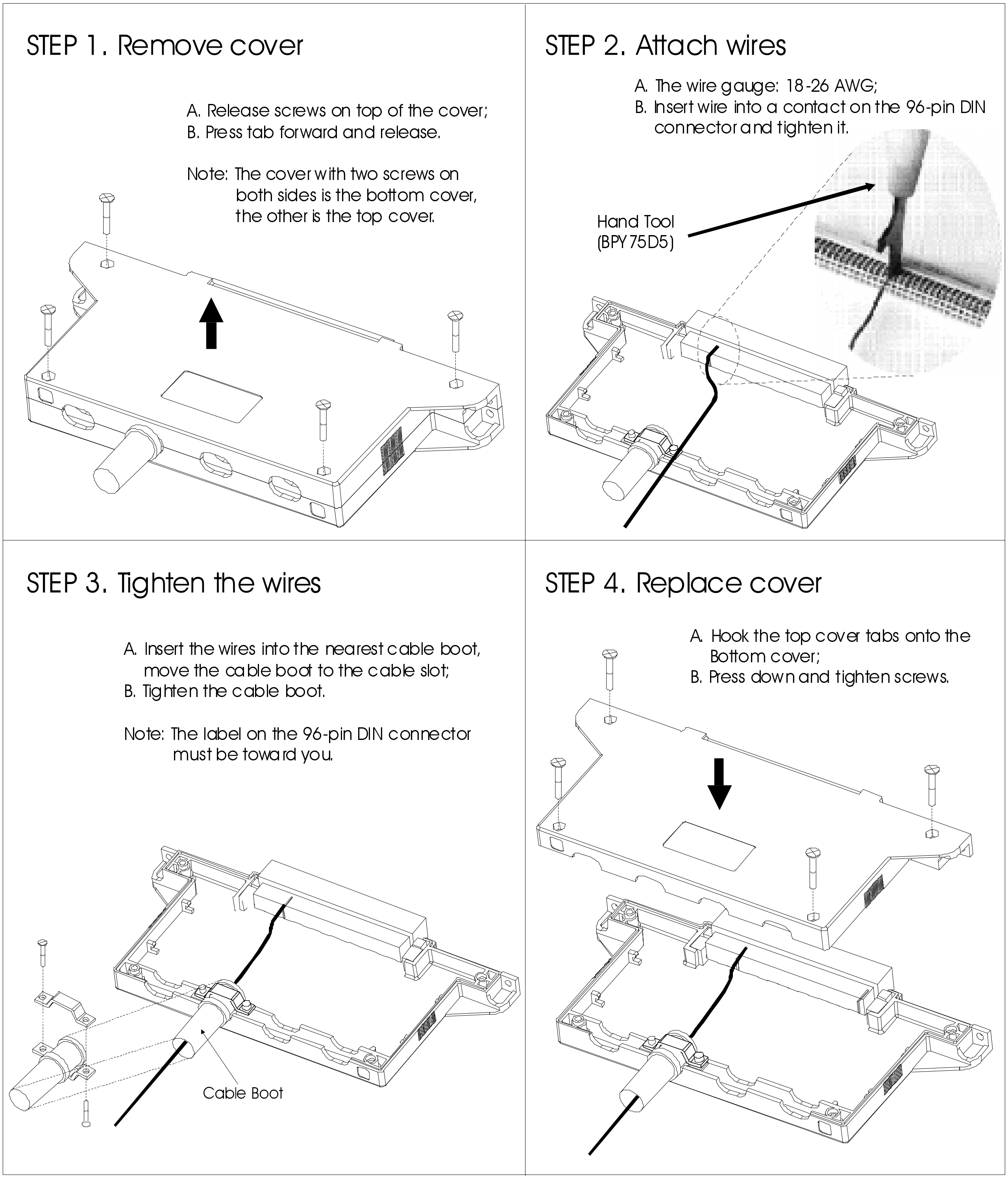


Figure 8-65. Crimp-and-Insert Terminal Block Wiring

DIN-TO-D Cables

Three DIN-to-D cables are available for the HP N22xx series modules. The 96-pin female DIN connectors at one end of the cables are used to connect the plug-in modules, and the other ends are either 50-pin or 25-pin female sub-D connectors, as listed in Table 8-36.

Table 8-36. DIN-TO-D Cables

HP P/N	Description	Application
HP N2297A	**DIN96-TO-TWIN-D50 CABLE:** 2-meter round cable terminated with a 96-pin female DIN connector at one end, two 50-pin male sub-D connectors at another end	For HP N2260A/61A/62A/63A/64A/65A.
HP N2298A	**DIN96-TO-D25 CABLE:** 2-meter round cable terminated with a 96-pin female DIN connector at one end, a 25-pin male sub-D connector at another end.	For HP N2262A only.
HP N2299A	**DIN96-TO-QUAD-D25 CABLE:** 2-meter round cable terminated with a 96-pin female DIN connector at one end, four 25-pin male sub-D connectors at another end	For HP N2260A/61A/62A/63A/64A/65A.

HP N2297A

Figure 8-66 shows an HP N2297A. The wire gauge is 26 AWG (which meets UL AWM: 2464), the maximum voltage is 200 volts per wire. The connection between the 96-pin female DIN connector and the two 50-pin sub-D male connectors is also listed.

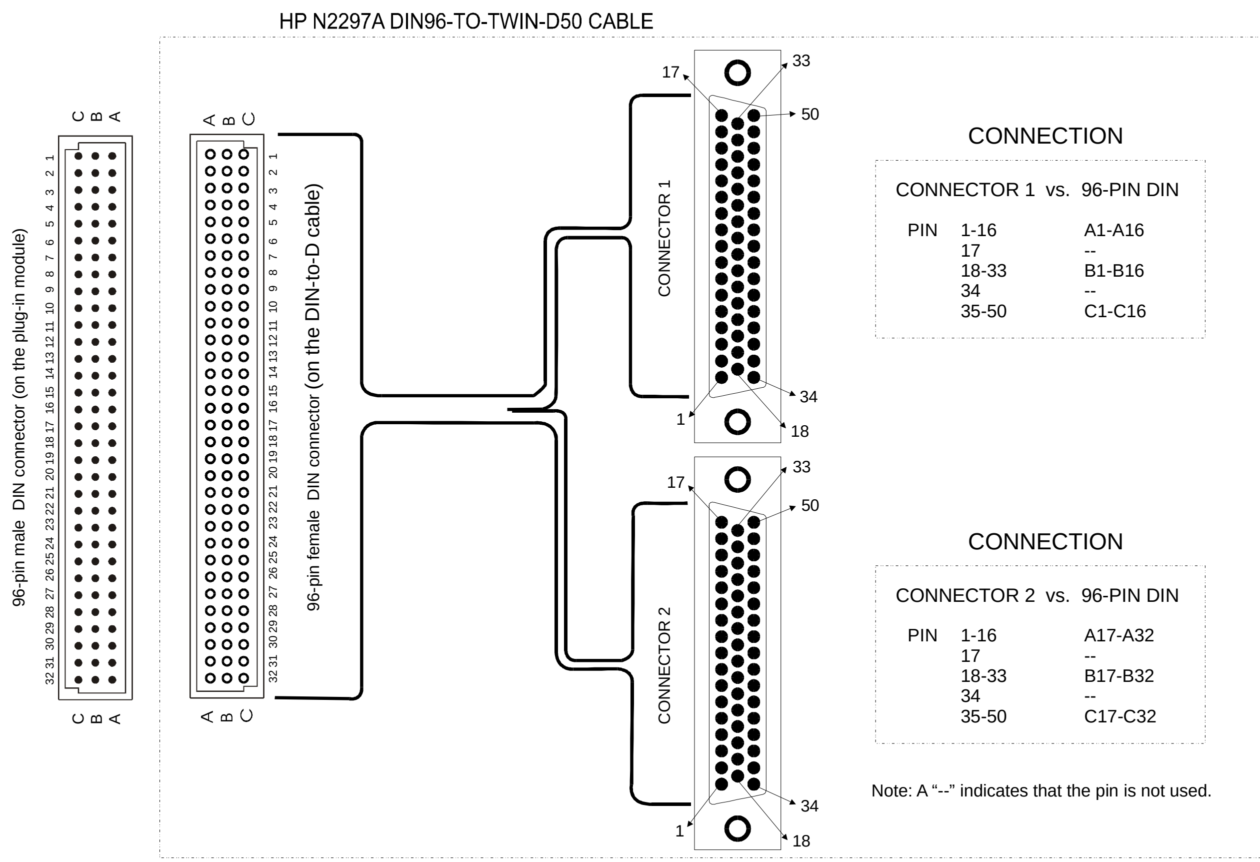


Figure 8-66. HP N2297A Cable

HP N2298A Figure 8-66 shows an HP N2298A. The wire gauge is 24 AWG (which meets UL AWM: 2464), the maximum voltage is 200 volts per wire. The connection between the 96-pin female DIN connector and the 25-pin sub-D male connector is also listed.

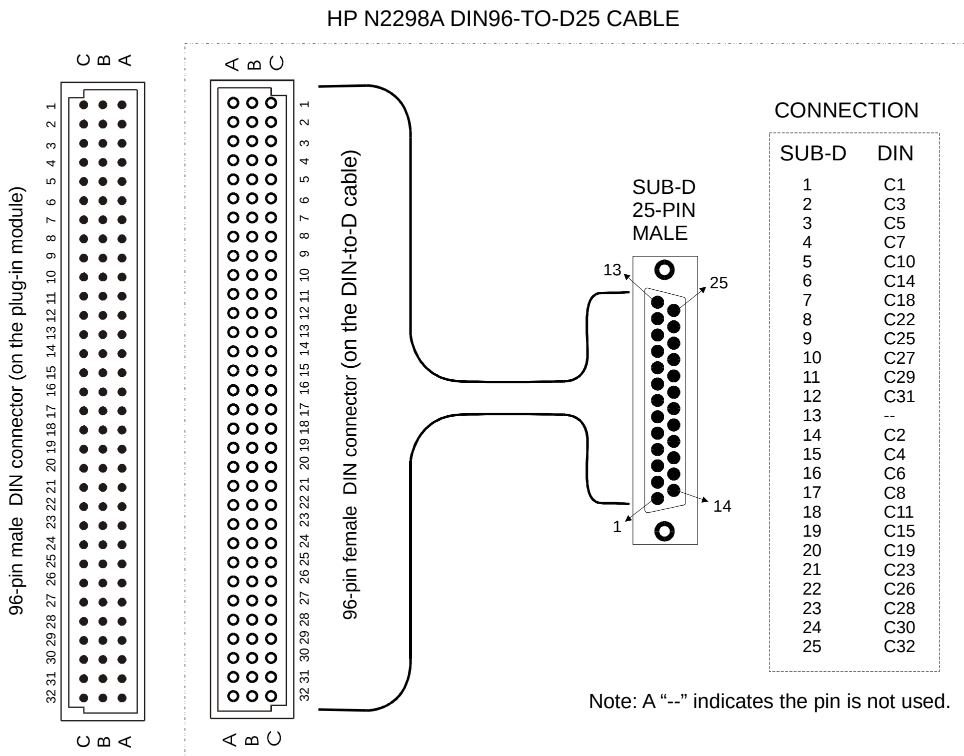
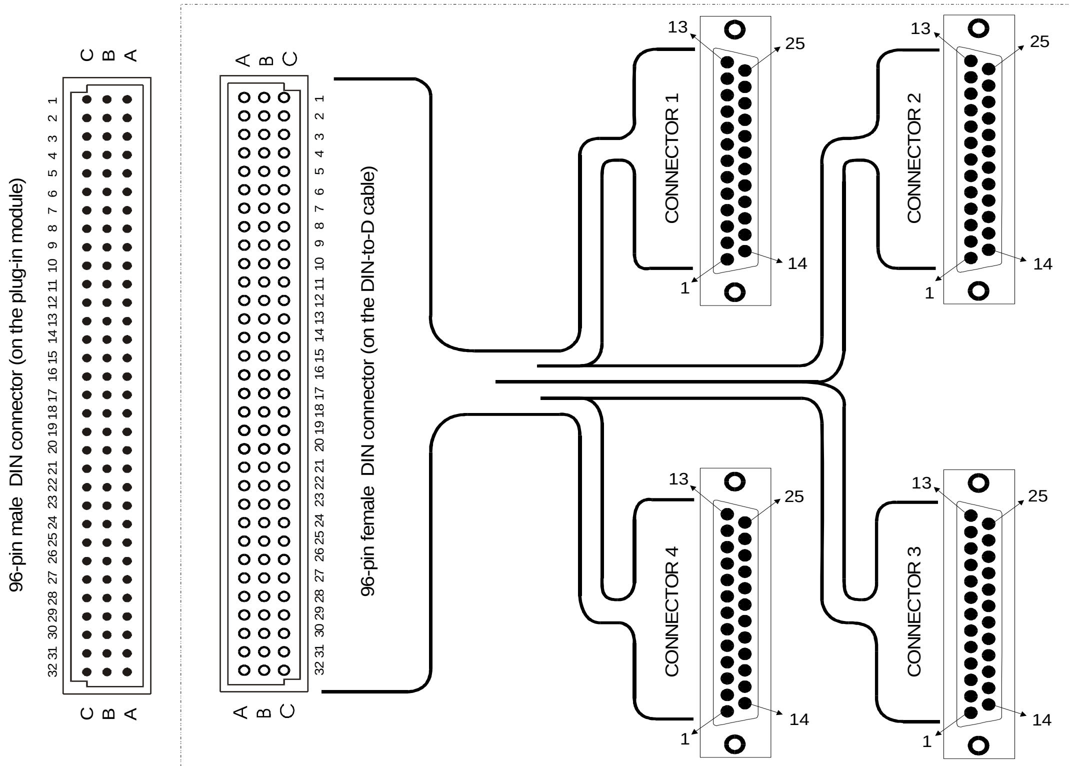


Figure 8-67. HP N2298A Cable

HP N2299A Figure 8-68 on Page 262 shows an HP N2299A. The wire gauge is 24 AWG (which meets UL AWM: 2464), the maximum voltage is 200 volts per wire. The connection between the 96-pin female DIN connector and the four 25-pin sub-D male connectors is also listed.

HP N2299A DIN96-TO-QUAD-D25 CABLE



CONNECTOR 1
vs. 96-PIN DIN

SUB-D	DIN
1	A1
2	B1
3	C1
4	A3
5	B3
6	C3
7	A5
8	B5
9	C5
10	A7
11	B7
12	C7
13	--
14	A2
15	B2
16	C2
17	A4
18	B4
19	C4
20	A6
21	B6
22	C6
23	A8
24	B8
25	C8

CONNECTOR 2
vs. 96-PIN DIN

SUB-D	DIN
1	A9
2	B9
3	C9
4	A11
5	B11
6	C11
7	A13
8	B13
9	C13
10	A15
11	B15
12	C15
13	--
14	A10
15	B10
16	C10
17	A12
18	B12
19	C12
20	A14
21	B14
22	C14
23	A16
24	B16
25	C16

CONNECTOR 3
vs. 96-PIN DIN

SUB-D	DIN
1	A17
2	B17
3	C17
4	A19
5	B19
6	C19
7	A21
8	B21
9	C21
10	A23
11	B23
12	C23
13	--
14	A18
15	B18
16	C18
17	A20
18	B20
19	C20
20	A22
21	B22
22	C22
23	A24
24	B24
25	C24

CONNECTOR 4
vs. 96-PIN DIN

SUB-D	DIN
1	A25
2	B25
3	C25
4	A27
5	B27
6	C27
7	A29
8	B29
9	C29
10	A31
11	B31
12	C31
13	--
14	A26
15	B26
16	C26
17	A28
18	B28
19	C28
20	A30
21	B30
22	C30
23	A32
24	B32
25	C32

Note: A “--” indicates the pin is not used.

Figure 8-68. HP N2299A Cable

Chapter 9
Application Examples

This Chapter provides several sample programs in Visual C++, Visual BASIC and HP BASIC to help you develop programs for your specific application. Chapter contents include:

Note For the sample programs provided in this chapter to run properly, make sure that your system has been properly setup according to the requirements of the individual example.

Sample Programs in Visual C++

Sample programs in this section are written in Visual C++ 6.0 and have been tested on a PC running WIN95/NT.

Example 1: Programming HP 3499A/B in SCPI Mode

```
******************************************************************************** **
** Requirements:                                                                   **
** 1. GPIB interface selected and set to the address of 09 from the front-panel;   **
** 2. Any one of the relay modules installed in Slot 1 of the mainframe;           **
** 3. A GPIB interface card installed in your PC with the VISA library.            **
******************************************************************************** **
```

Note To program an HP 3499A/B over the RS-232 interface, you will need to modify the code at the top of the program (change the line of "**# define USING_RS232 0**" to "**# define USING_RS232 1**"), select the RS-232 interface, and set its parameters to: BAUD RATE (9600), PARITY (NONE, 8 BITS), FLOW (FLOW NONE) from the front panel. A GPIB card in your PC is not necessary.

```
# include <stdio.h>
# include <windows.h>
# include "visa.h"

# define USING_RS232 0                          // Change 0 to 1 if RS-232 interface is to be used.

# if USING_RS232
# define INST_ADDR"ASRL1::INSTR"                // HP 3499A/B RS-232 address.
# else
# define INST_ADDR"GPIB0::9::INSTR"             // HP 3499A/B GPIB address.
# endif

void main()
{
    ViSession drm;                              // Session to default resource manager.
    ViSession vi;                               // Session to instrument.
    ViStatus status;                            // VISA function status return code.
    char retStr[128];                           // String returned from the instrument.

    /* Open the default resource manager. */
    status = viOpenDefaultRM( &drm );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpenDefaultRM()\n");
        exit(1);
```

```
    }

    /* Open a session to the HP 3499A/B. */
    status = viOpen( drm, INST_ADDR, VI_NULL, VI_NULL, &vi );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpen(). Address: %s\n",INST_ADDR);
        viClose( drm );
        exit(1);
    }

    # if USING_RS232
    /* Set RS-232 parameters according to HP 3499A/B settings: BAUD RATE (9600), */
    /* PARITY (NONE, 8 BITS), FLOW (FLOW NONE). */
    viSetAttribute( vi, VI_ATTR_ASRL_BAUD, 9600 );
    viSetAttribute( vi, VI_ATTR_ASRL_DATA_BITS, 8 );
    viSetAttribute( vi, VI_ATTR_ASRL_FLOW_CNTRL, VI_ASRL_FLOW_NONE );
    viSetAttribute( vi, VI_ATTR_ASRL_PARITY, VI_ASRL_PAR_NONE );
    # endif

    /* Set HP 3499A/B to SCPI mode. */
    viPrintf( vi, "SYSMODE SCPI\n" );
    Sleep(4000);                                        // Wait 4 seconds.

    /* Reset the instrument to a known state. */
    viPrintf( vi, "*RST\n" );
    Sleep( 4000 );

    /* Close channels 100 through 103.
    viPrintf( vi, "CLOSE (@ 100:103)\n" );

    /* Open channels 100 through 103. */
    viPrintf( vi, "OPEN (@ 100:103)\n" );

    /* Scanning setup: executing the following commands to make the instrument to scan sweep */
    /* channels 100 through 103 two times. The channels are scanned continuously and the */
    /* second scan sweep starts 1 second after the start of the first scan sweep. */
    viPrintf( vi, "SCAN (@ 100:103)\n" );               // Create a scan list.
    viPrintf( vi, "ARM:SOURCE TIMER\n" );               // Set arm source to TIMER.
    viPrintf( vi, "ARM:TIMER 1\n" );                    // Interval time between two scan sweeps is 1 second.
    viPrintf( vi, "ARM:COUNT 2\n" );                    // Set scan sweep 2 times.
    viPrintf( vi, "TRIG:SOURCE IMM\n" );                // Set trigger source to IMM (default).
    viPrintf( vi, "CHAN:DELAY 0, ( @100:103)\n");       // Set channel delay time to 0 (default).
    viPrintf( vi, "INIT\n");                            // Start the scan.

    /* Set visa time-out value to 10 seconds. */
    viSetAttribute( vi, VI_ATTR_TMO_VALUE, 10000 );

    /* *OPC command will wait until scan finishes. */
    status = viQueryf( vi, "*OPC?\n","%t*", retStr );
    printf("Scan End.\n");

    viClose( vi );                                      // Close session to HP 3499A/B.
    viClose( drm );                                     // Close session to the resource manager.
}
```

Example 2: Programming HP 3499A/B in HP 3488A Mode

```
******************************************************************************* **
** Requirements:                                                                **
** 1. GPIB interface selected and set to the address of 09 from the front-panel; **
** 2. Any one of the relay modules installed in Slot 1 of the mainframe;         **
** 3. A GPIB interface card installed in your PC with the VISA library.          **
******************************************************************************* **
```

Note Only the GPIB interface can be used in HP 3488A mode.

```
#include <stdio.h>
#include <windows.h>
#include "visa.h"

#define INST_ADDR"GPIB0::9::INSTR                       // HP 3499A/B GPIB address.

void main()
{
    ViSession drm;                                      // Session to default resource manager.
    ViSession vi;                                       // Session to instrument.
    ViStatus status;                                    // VISA function status return code.
    int i;

    /* Open the default resource manager. */
    status = viOpenDefaultRM( &drm );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpenDefaultRM()\n");
        exit(1);
    }

    /* Open a session to the HP 3499A/B. */
    status = viOpen( drm, INST_ADDR, VI_NULL, VI_NULL, &vi );
    if ( status < VI_SUCCESS ) {
        printf( "VISA ERROR: viOpen(). Address: %s\n",INST_ADDR);
        viClose( drm );
        exit(1);
    }

    /* Set HP 3499A/B to HP 3488A mode. */
    viPrintf( vi, "SYSMODE HP3488A\n" );
    Sleep( 4000 );                                      //Wait 4 seconds.

    /* Reset the instrument to a known state. */
    viPrintf( vi, "RESET\n" );
    Sleep( 4000 );

    /* Close channels 100 through 103. */
    viPrintf( vi, "CLOSE 100, 101, 102, 103\n");

    /* Open channels 100 through 103. */
    viPrintf( vi, "OPEN 100, 101, 102, 103\n");

    /* Create a scanlist, then set up a loop to scan through the channels two times. */
    viPrintf( vi, "SLIST 100-103\n");
    for ( i = 0; i < 8; i++ ) {
        viPrintf( vi, "STEP\n" );
        Sleep( 25 );                                    // Wait 25 milliseconds.
    }
    printf( "Scan End.\n" );

    viClose( vi );                                      // Close session to HP 3499A/B.
    viClose( drm );                                     // Close session to the resource manage.
}
```

Example Programs in Visual BASIC

Sample programs in this section are written in Visual BASIC 6.0 and have been tested on a PC running WIN95/NT.

Example 3: Programming HP 3499A/B in SCPI Mode

```
'' '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''' ''
'' Requirements:                                                                               ''
'' 1. GPIB interface selected and set to the address of  09 from the front-panel;             ''
'' 2. Any one of the relay modules installed in Slot 1 of the mainframe;                       ''
'' 3. A GPIB interface card installed in your PC with the VISA library.                        ''
'' '''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''' ''
```

Note To program an HP 3499A/B over the RS-232 interface, you will need to modify the code at the top of the program (change the line of "**Const USING_RS232 =0**" to "**Const USING_RS232 =1**"), select the RS-232 interface and set its parameters to: BAUD RATE (9600), PARITY (NONE, 8 BITS), FLOW (FLOW NONE) from the front panel. A GPIB interface card in your PC is not necessary.

```
Const USING_RS232 =0                                          ' Change 0 to 1 if RS-232 interface is to be used.

Declare Sub Sleep Lib "Kernel32" (ByVal s As Long)            ' Sleep( ) function declaration.

Sub main()

    Dim drm As Long                                           ' Session to default resource manager.
    Dim vi As Long                                            ' Session to instrument.
    Dim status As Long                                        ' VISA function status return code
    Dim retStr As String * 128                                ' String returned from the instrument.
    Dim str As String                                         ' String for individual channel number.

    On Error GoTo ErrorHandler

    ' Open default resource manager.
    drm = -1
    status = viOpenDefaultRM(drm)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler

    ' Select an interface for HP 3499A/B. GPIB interface is to be used when USING_RS232 = 0,
     or RS-232 interface is to be used when USING_RS232 = 1.
    If USING_RS232 Then
        INST_ADDR = "ASRL1::INSTR"
    Else
        INST_ADDR = "GPIB0::9::INSTR"
    Endif

    ' Open a session to HP 3499A/B.
    status = viOpen(drm, INST_ADDR, 0, 0, vi)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler

    ' Set RS-232 interface parameters when USING_RS232 equals 1.
    If USING_RS232 Then
        Call viSetAttribute(vi, VI_ATTR_ASRL_BAUD, 9600)
        Call viSetAttribute(vi, VI_ATTR_ASRL_DATA_BITS, 8)
        Call viSetAttribute(vi, VI_ATTR_ASRL_STOP_BITS, VI_ASRL_STOP_ONE)
        Call viSetAttribute(vi, VI_ATTR_ASRL_FLOW_CNTRL, VI_ASRL_FLOW_NONE)
        Call viSetAttribute(vi, VI_ATTR_ASRL_PARITY, VI_ASRL_PAR_NONE)
    End If

    ' Set the HP 3499A/B to SCPI mode.
    Call viVPrintf(vi, "SYSMODE SCPI" + Chr$(10), 0)
    Call Sleep(4000)                                          ' Wait 4 seconds

    ' Reset the instrument to a known state.
    Call viVPrintf(vi, "*RST" + Chr$(10), 0)
    Call Sleep(4000)
```

```
    'Close channels 100 through 103.
    Call viVPrintf(vi, "CLOSE ( @ 100:103)" + Chr$(10), 0)

    'Open channels 100 through 103.
    Call viVPrintf(vi, "OPEN ( @ 100:103)" + Chr$(10), 0)

    'Scanning setup: executing the following commands to make the instrument to scan sweep
    'channels 100 through 103 two times. The channels are scanned continuously and the
    'second scan sweep starts 1 second after the start of the first scan sweep.
    Call viVPrintf(vi, "SCAN (@100:103)" + Chr$(10), 0)             'Create a scan list 100 through 103.
    Call viVPrintf(vi, "ARM:SOURCE TIMER" + Chr$(10), 0)            'Set arm source to TIMER.
    Call viVPrintf(vi, "ARM:TIMER 1" + Chr$(10), 0)                 'Interval time between two scan sweeps is 1 second.
    Call viVPrintf(vi, "ARM:COUNT 2" + Chr$(10), 0)                 'Set scan sweep two times.
    Call viVPrintf(vi, "TRIG:SOURCE IMM" + Chr$(10), 0)             'Set trigger source to IMM (default).
    Call viVPrintf(vi, "CHAN:DELAY 0, (@100:103)" + Chr$(10), 0
                                                                    'Set channel delay time to 0 (default).
    Call viVPrintf(vi, "INIT" + Chr$(10), 0)                        'Start scanning.

    'Set visa time-out value to 10 seconds
    Call viSetAttribute(vi, VI_ATTR_TMO_VALUE, 10 * 1000)

    '*OPC command will wait until scan finished.
    Call viVQueryf(vi, "*OPC?" + Chr$(10), "%t*", retStr)

    viClose (vi)                                                    'Close session to HP 3499A/B.
    viClose (drm)                                                   'Close session to default resource manager.
    End

ErrorHandler:
    'Display the error message.
    MsgBox "*** Error : " + Error$, MB_ICON_EXCLAMATION
    If drm <> -1 Then
        viClose (drm)
    End If
    End

VisaErrorHandler:
    Dim strVisaErr As String * 200
    Call viStatusDesc(defrm, status, strVisaErr)
    MsgBox "*** Error : " + strVisaErr
    If drm <> -1 Then
        viClose (drm)
    End If
    End
End Sub
```

Example 4: Programming HP 3499A/B in HP 3488A Mode

```
'' ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''' ''
'' Requirements:                                                                                          ''
'' 1. GPIB interface selected and set to the address of  09 from the front-panel;                         ''
'' 2. Any one of the relay modules installed in Slot 1 of the mainframe;                                  ''
'' 3. A GPIB interface card installed in your PC with the VISA library.                                   ''
'' ''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''' ''
```

Note Only GPIB interface can be used in HP 3488A mode.

```
Declare Sub Sleep Lib "Kernel32" (ByVal s As Long)              ' Sleep( ) function declaration.

Sub main()

    Dim drm As Long                                             ' Session to default resource manager.
    Dim vi As Long                                              ' Session to instrument.
    Dim status As Long                                          ' VISA function status return code
    Dim retStr As String * 128                                  ' String returned from the instrument.
    Dim str As String                                           ' String for individual channel number.

    On Error GoTo ErrorHandler

    ' Open default resource manager.
```

```
    drm = -1
    status = viOpenDefaultRM(drm)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler

    'Open a session to HP 3499A/B.
    INST_ADDR = "GPIB0::9::INSTR"                         'Set HP 3499A/B GPIB address to 9 (default).
    status = viOpen(drm, INST_ADDR, 0, 0, vi)
    If (status < VI_SUCCESS) Then GoTo VisaErrorHandler

    'Set HP 3499A/B to HP 3488A mode.
    Call viVPrintf(vi, "SYSMODE HP3488A" + Chr$(10), 0)
    Call Sleep(4000)                                      'Wait 4 seconds

    'Reset the instrument to a known state.
    Call viVPrintf(vi, "RESET" + Chr$(10), 0)
    Call Sleep( 4000 )

    'Close channels 100 through 103.
    Call viVPrintf(vi, "CLOSED 100, 101, 102, 103" + Chr$(10), 0)

    'Open channels 100 through 103.
    Call viVPrintf(vi, "OPEN 100, 101, 102, 103" + Chr$(10), 0)

    'Create a scanlist, then set up a loop to scan through the channels two times.
    viVPrintf(vi, "SLIST 100-103" + Chr$(10), 0)          'Create a scan list including 100 through 103.
    For I = 0 To 8
        Call viVPrintf(vi, "STEP" + Chr$(10), 0)          'Step through the channels.
        Sleep ( 25 )                                      'Wait 25 milliseconds.
    Next

    viClose (vi)                                          'Close session to HP 3499A/B.
    viClose (drm)                                         'Close session to the resource manager.
    End

ErrorHandler:
    'Display the error message
    MsgBox "”Error : " + Error$, MB_ICON_EXCLAMATION
    If drm <> -1 Then
        viClose (drm)
    End If
    End

VisaErrorHandler:
    Dim strVisaErr As String * 200
    Call viStatusDesc(defrm, status, strVisaErr)
    MsgBox "”Error : " + strVisaErr
    If drm <> -1 Then
        viClose (drm)
    End If
    End

End Sub
```

Example Programs in HP BASIC

Sample programs in this section are written in HP BASIC 6.0 and have been tested on a UNIX workstation.

Example 5: Programming HP 3499A/B in SCPI Mode

```
!! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! !!
!! Requirements:                                                                                  !!
!! 1. GPIB interface selected and set to the address of 09 from the front-panel;                  !!
!! 2. Any one of the relay modules installed in Slot 1 of the mainframe;                          !!
!! 3. A GPIB interface card installed in your UNIX workstation.                                   !!
!! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! !!
```

Note Either GPIB or RS-232 interface can be used in SCPI mode. However, we only provide and test the HP BASIC program examples over the GPIB interface.

```
10    ! EXAMPLE.BAS: TEST HP 3499A/B IN SCPI MODE
20    DIM Retstr$[128]                          ! String returned from the instrument.
30    OUTPUT 709; "SYSMODE SCPI"                ! Set HP 3499A/B to SCPI mode.
40    WAIT 4                                    ! Wait 4 seconds.
50    OUTPUT 709; "*RST"                        ! Reset HP 3499A/B.
60    WAIT 4                                    ! Wait 4 second.
70    OUTPUT 709; "CLOSE (@100:103)"            ! Close channels 100 through 103.
80    OUTPUT 709; "OPEN (@100:103)"             ! Open channels 100 through 103.

100   ! LINES 150 TO 200 SET UP A TIMER CONTROLLED SCANNING.
110   ! HP 3499A/B SCAN SWEEP CHANNELS 100 THROUGH 139 TWO TIMES.
120   ! THE CHANNELS ARE SCANNED CONTINUOUSLY.
130   ! THE SECOND SCAN SWEEP STARTS 1 SECOND AFTER THE START
140   ! OF THE FIRST SCAN SWEEP.
150   OUTPUT 709; "SCAN (@100:103)"             ! Create a scan list.
160   OUTPUT 709; "ARM:SOUR TIMER"              ! Set arm source to timer.
170   OUTPUT 709; "ARM:TIMER 1"                 ! Interval time between two scan sweeps is 1 second.
180   OUTPUT 709; "ARM:COUNT 2"                 ! Set scan sweep 2 times.
190   OUTPUT 709; "TRIG:SOUR IMM"               ! Set trigger source to IMM (default).
200   OUTPUT 709; "CHAN:DELAY 0, (@100:103)"    ! Set channel delay time to 0 (default).
210   OUTPUT 709; "INIT"                        ! Start scanning
220   OUTPUT 709; "*OPC?"                       ! Wait until scan finishes.
230   ENTER 709; Retstr$
240   Done: END
```

Example 6: Programming HP 3499A/B in HP 3488A Mode

```
!! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! !!
!! Requirements:                                                                                   !!
!! 1. GPIB interface selected and set to the address of 09 from the front-panel;                    !!
!! 2. Any one of the relay modules installed in Slot 1 of the mainframe;                            !!
!! 3. A GPIB interface card installed in your UNIX workstation.                                     !!
!! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! !!
```

Note Only GPIB interface can be used in HP 3488A mode.

```
10    ! EXAMPLE.BAS: TEST HP 3499A/B IN HP 3488A MODE
20    DIM Retstr$[128]                        ! String returned from the instrument.
30    OUTPUT 709; "SYSMODE HP3488A"           ! Set HP 3499A/B to HP 3488A mode
40    WAIT 4                                  ! Wait 4 seconds.
50    OUTPUT 709; "RESET"                     ! Reset HP 3499A/B.
60    WAIT 4
70    OUTPUT 709; "CLOSE 100, 101, 102, 103"  ! Close channels 100 through 103.
80    OUTPUT 709; "OPEN 100, 101, 102, 103"   ! Open channels 100 through 103.
100   ! A SIMPLE SCAN.
110   OUTPUT 709; "SLIST 100-103"             ! Create a scan list.
120   FOR I=0 TO 8                            ! Step through the channels two times.
130   OUTPUT 709; "STEP"
140   WAIT .025
150   NEXT I
160   Done: END
```

Appendix A
Error Messages

HP 3499A/B Switch/Control System can be operated in either SCPI mode or HP 3488A mode. The error messages are different in different system modes. This Appendix lists all these error messages.

In SCPI mode

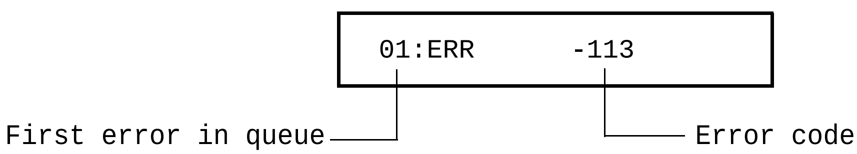
- Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. Errors are cleared as you read them. When you have read all errors from the queue, the ERROR annunciator turns off and the errors are cleared. The instrument beeps once each time an error is generated.

- If more than 10 errors have occurred, the last error stored in the queue (the most recent error) is replaced with -350, “Queue overflow”. No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the instrument responds with +0, “No error”.

- The error queue is cleared by the *CLS (clear status) command or when power is cycled. The errors are also cleared when you read the queue. The error queue is not cleared by an instrument reset (*RST command) or a card/module reset (SYSTem:CPON command).

- ***Front-Panel Operation:***

  If the ERROR annunciator is on, press **View** to view the errors stored in the queue. Use the knob to scroll through the error numbers. Press the arrow key (right) to view the text of the error message. All errors are cleared when you exit the menu.



- ***Remote Interface Operation:***

  SYSTem:ERRor? Read and clear one error from the error queue

  Errors have the following format (the error string may contain up to 80 characters):

  -113, “Undefined header”.

Execution Errors

-101 **Invalid character**

An invalid character was found in the command string. You may have used an invalid character such as #, {, $, or % in the command header or within a parameter.
Example: *OPEN {@101)*

-102 **Syntax error**

Invalid syntax was found in the command string. You may have inserted a blank space before or after a colon in the command header, or before a comma. Or you may have omitted the ''@'' character in the channel list syntax.

Examples: *ROUT:CHAN: DEL 1 or ROUT:OPEN (101:102)*

-103 **Invalid separator**

An invalid separator was found in the command string. You may have used a comma instead of a colon, semicolon, or blank space -- or you may have used a blank space instead of a comma.
Example: *TRIG:COUNT,1*

-105 **GET not allowed**

A Group Execute Trigger (GET) is not allowed within a command string.

-108 **Parameter not allowed**

More parameters were received than expected for this command. You may have entered an extra parameter or added a parameter to a command that does not require a parameter.
Example: *ROUT:CLOS:STAT? 2*

-109 **Missing parameter**

Fewer parameters were received than were expected for this command. You have omitted one or more parameters that are required for this command.
Example: *ROUT:CHAN:DEL 10,*

-112 **Program mnemonic too long**

A command header was received which contained more than the maximum 12 characters allowed.
Example: *CONFIGURE:EXTERNAL:TRIGGER:SOURCE 2*

-113 **Undefined header**

A command was received that is not valid for this instrument. You may have misspelled the command or it may not be a valid command. If you are using the short form of this command, remember that it may contain up to four letters.
Examples: *TRIGG:SOUR TIM*

-121 **Invalid character in number**

An invalid character was found in the number specified for a parameter.

Example: *TRIG:TIMER 12..34*

-123 **Exponent too large**

A numeric parameter was found whose exponent was large than 32,000.

-124 **Too many digits**

A numeric parameter was found whose mantissa contained more than 255 digits, excluding leading zeros.

-128 **Numeric data not allowed**

The wrong parameter type was found in the command string. You may have specified a number where a string or expression was expected, or vice versa.
Examples: *DISP:TEXT 5.0 or ROUT:CLOSE 101*

-131 **Invalid suffix**

A suffix was incorrectly specified for a numeric parameter. You may have misspelled the suffix.

-134 **Suffix too long**

A header suffix is the number that can be appended to the end of some command headers. This error is generated if the header suffix contains more than 12 characters.

-138 **Suffix not allowed**

A suffix was received following a numeric parameter. You may have misspelled the suffix.

-148 **Character data not allowed**

A discrete parameter was received but a character string or a numeric parameter was expected. Check the list of parameters to verify that you have used a valid parameter type. ***Examples:*** *ROUTE:CLOSE CH101 or DIAG:DISP TEXT123 (the string must be enclosed in quotes)*

-151 **Invalid string data**

An invalid character string was received. Check to see if you have enclosed the character string in quotation marks and verify that the string contains valid ASCII characters.

Example: *DIAG:DISP 'TESTING (the ending quote is missing)*

-158 **String data not allowed**

A character string was received but is not allowed for this command. Check the list of parameters to verify that you have used a valid parameter type.

-161 **Invalid block data**

For a definite-length block, the number of types of data sent does not match the number of bytes that you specified in the block header

-168 **Block data not allowed**

Data was sent to the instrument in SCPI definite length block format but this command does not accept this format.

-178 **Expression data not allowed**

A channel list was received but is not allowed for this command.

Example: *SYST:CTYPE? (@100)*

-222 **Data out of range**

A numeric parameter value is outside the valid range for this command.

Example: *ARM:COUNT -3*

-223 **Too much data**

A character string was received but could not be executed because the string length was more than 12 characters. This error can be generated by the DIAGnostic:DISPlay command.

-224 **Illegal parameter value**

A discrete parameter was received which was not a valid choice for this command. You may have used an invalid parameter choice.

Example: *TRIG:SOURCE ALARM (ALARM is not a valid choice)*

-310 **System error**

A firmware defect has been found. This is not a fatal error but you should contact your nearest Hewlett-Packard Service Center if this error is reported.

-350 **Queue overflow**

The error queue is full because more than 10 errors have occurred. No additional errors are stored until you remove errors from the queue. The error queue is cleared by the *CLS (clear status) command or when power is cycled. The errors are also cleared when you read the queue.

-410 **Query INTERRUPTED**

A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power has been off or after a bus Device Clear.

-420 **Query UNTERMINATED**

The instrument was addressed to talk (i.e., send data over the interface) but a command has not been received which sends data to the output buffer. For example, you may have executed a CONFigure command (which does not generate data) and then attempted to read data from the remote interface.

-430 **Query DEADLOCKED**

A command was received which generates too much data to fit in the output buffer and the input buffer is also full. Command execution continues but all data is lost.

-440 **Query UNTERMINATED after indefinite response**

The *IDN? command must be the last query command within a command string. The *IDN? command returns an indefinite length string which cannot be combined with any other query command.
Example: **IDN?;*STB?*

Instrument Errors

100 **Number of SAV/RCL out of range**

Up to 10 channel setups (1-10) can be stored and recalled. This error will occur if a number included in *SAV/*RCL is not between 1 and 10.
Examples: **SAV 12 or *RCL 0*

101 **Unable to recall - scan is running**

102 **Unable to recall - memory is empty**

103 **Unable to recall - modules were changed**

Before recalling a stored channel setup, the instrument verifies the same module types are installed in each slot. This error indicates that the instrument has detected one or multiple modules in the specific slots have been replaced with other types or removed from the instrument.

104 **Unable to store - scan is running**

110 **Slot number out of range**

The specified slot number is invalid. The channel number has the form (@snn), where s is the slot number and nn is the channel number.
Example: *OPEN (@604)*

111 **Data out of range**

The data for some commands is invalid.
Example: *SOUR:DIG:DATA:BYTE:VAL 266 (valid data should be 0-255)*

112 **Not able to perform requested operation**

The requested operation is not valid for the instrument.
Example: *FUNC 3,BIWIRE2 (the module in Slot 3 is not an HP N2260A).*

113 **Block name not exist**

In an HP 3499A/B, maximum two blocks can be defined. The two defined blocks can be read and written, etc. If you read or write a block that has not been previously defined, this error occurs.

114 **Block name already exist**

The instrument has detected a defined block name, while you are to define it once more.

115 **Two Blocks already exist**

The instrument has detected two defined block names while you are to define them once more.

116 **Channel number out of range**

The specified channel number is invalid for the module in the selected slot. The channel number has the form (@snn), where s is the slot number and nn is the channel number.

Example: *ROUT:CLOSE (@156)*

201 **Scan list is empty**

202 **Scan initiated**

203 **Scan init ignored**

204 **Trig ignored**

205 **Hardware trigger too fast**

206 **Too many channels**

207 **Card in use.**

300 **Unable to execute this command in local mode**

501 **RS232 data receiving error**

502 **Internal command error**

503 **RS232 only - unable to execute on GPIB**

There are three commands which are allowd only with the RS-232 interface: SYSTem:LOCal, SYSTem:REMote, SYSTem:RWLock.

Self-Test Errors

The errors listed in Table 9-1 indicate failures that may occur during a self-test (in SCPI mode).

Table 9-1. Self -Test Errors

Error Number	Description
+1	ROM test failed.
+2	GPIB test failed.
+3	RS-232 test failed.
+4	Front-panel test failed.

Note A string “+0” read back (with command *TST) indicates that all the tests have passed. In this case, a string “PASSED” displays on the front panel of the instrument.

In HP 3488A Mode

Error Conditions

In HP 3488A mode, you can also query the error queue when the ERROR annunciator is on. The returned decimal value is equal to the sum of the values of the possible error conditions, as defined in Table 9-2.

Table 9-2. Error Conditions in HP 3488A Mode

Weighted Value	Error Condition
1	Syntax Error
2	Execution Error which include: a. Parameter out of range; b. Module type mismatch; c. Attempt to access a nonexistent stored state or scan list.
4	Hardware Trigger too fast
8	Logical Failure
16	Power Supply Failure

Note A string "+00000" read back (with the command ERROR**)** indicates that the error queue is empty. In this case, a string "0000" displays on the front panel of the instrument.

Self Test Errors

The errors listed in Table 9-3 indicate failures that may occur during a self-test (in HP 3488A mode).

Table 9-3. Self -Test Errors

Error Number	Description
+1	ROM test failed.
+2	GPIB test failed.
+3	RS-232 test failed.
+4	Front-panel test failed.

Note A string "+0" read back (with the command TEST) indicates that all the tests have passed. In this case, a string "PASSED" displays on the front panel of the instrument.

Symbols

Numerics

A

B

C

F

G

H

I

N

O

P

R

S

T

V

W

X