HP Z2468A

32-Channel, 5 Amp Mosfet VXI Switch

In Stock

Used and in Excellent Condition

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According to ISO/IEC Guide 22 and EN 45014

The Hewlett-Packard Company declares that the HP Z2468A conforms to the following Product Specifications.

Safety:	IEC 1010-1 (1990) CSA 234 UL 1244
EMC:	CISPR 11:1990/EN 55011 (1991): Group1 Class A IEC 801-2:1991/EN 50082-1 (1992): 4kVCD, 8kVAD IEC 801-3:1984/EN 50082-1 (1992): 3 V/m IEC 801-4:1988/EN 50082-1 (1992): 1kV

Tested in HP VXI mainframe.

Jean White
Q.A. Manager
March, 1994

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Printing History

The Printing History shown below lists all Editions and Updates of this manual and the printing date(s). The first printing 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 the current Edition of the manual. Updates are numbered sequentially starting with Update 1. When a new Edition is created, it contains all the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this printing history page. Many product updates or revisions do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

Edition 1 (Part Number Z2468-90001) ..... March 1994

Safety Symbols

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

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

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

Alternating current (AC).

Direct current (DC).

Indicates hazardous voltages.

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

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

WARNINGS

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

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

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

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

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

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

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

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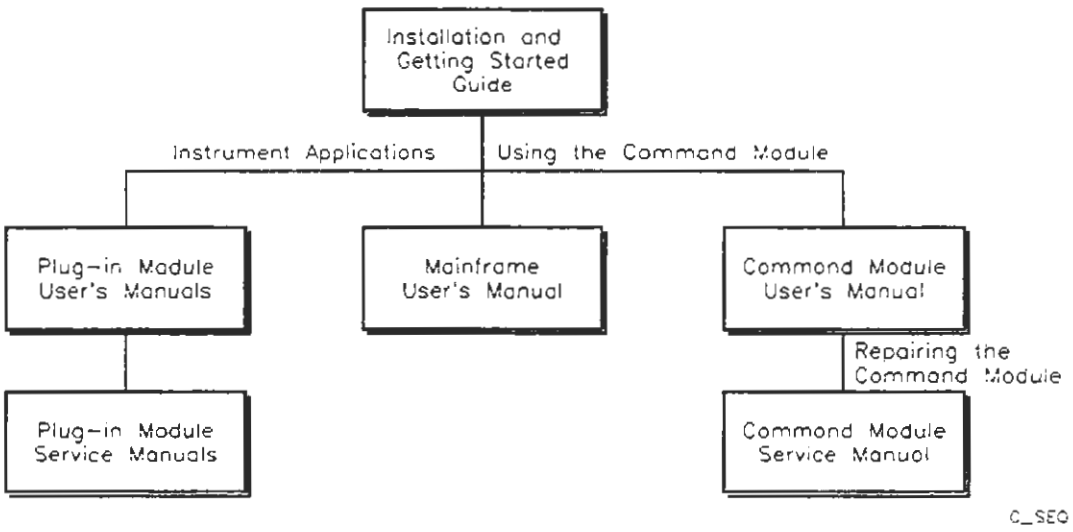
HP 75000 Series C Documentation

Suggested Sequence to Use Manuals



Manual Descriptions

Title	Description
Series C Installation and Getting Started Guide	Step-by-step instructions for all aspects of plug-in module, mainframe, and command module installation. Also contains introductory programming information and examples.
Mainframe User's Manual	Information to prepare the mainframe and to install plug-in modules.
Command Module User's Manual	Programming information for the command module and general programming information for instruments installed in the mainframe.
Command Module Service Manual	Command module service information. Includes information and procedures for functional verification, operation verification, performance verification, troubleshooting, and repair.
Plug-in Module User's Manuals	Plug-in module programming and configuration information. Contains programming examples and SCPI command reference for the module.
Plug-in Module Service Manuals	Plug-in module service information. Depending on the module, includes information and procedures for functional verification, operation verification, performance verification, adjustment, troubleshooting, and repair.

What's in this Manual

Manual Overview

This manual shows how to operate, configure and program the HP Z2468A Solid State Relay Module. Consult the appropriate mainframe manual for information on configuring and operating the mainframe.

Manual Content

Chap	Title	Content
1	General Information	Provides module description, simplified schematic, instrument definition, and operating information. Shows how to set the address switches and how to select the interrupt priority switches.
2	Configuring the Module	Defines the registers for the module and provides examples for register based programming.
A	Specifications	Lists complete specifications for the module.
B	Power Switching Specification	Describes how switching power is specified for the solid state relays.

MANUAL COMMENT SHEET

HP Z2468A User Manual
Manual Part Number Z2468-90001
Edition 1 (February 1994)

You can help us improve our manuals by sharing your comments and suggestions. Please complete this questionnaire after becoming familiar with the manual and then return it to us. **In appreciation of your time, we will enter your name in a quarterly drawing for a Hewlett-Packard calculator.**

Please describe the system controller, operating system, and programming language you are using to program this product.

_____
_____
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Please pencil-in one circle for each statement below as it applies to this documentation:

	Disagree				Agree
• The manual is well organized.	O	O	O	O	O
• Instructions are easy to understand.	O	O	O	O	O
• The manual is clearly written.	O	O	O	O	O
• Examples are clear and useful.	O	O	O	O	O
• The manual contains enough examples.	O	O	O	O	O
• Illustrations are clear and helpful.	O	O	O	O	O
• The manual meets my overall expectations.	O	O	O	O	O

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Table of Contents

Chapter 1

Solid State Switch Module Setup

Module Description

Figure 1-1 shows a simplified block diagram, individual channel schematic, and front panel of the HP Z2468A 32-Channel DC Power Solid State Relay Module. The HP Z2468A provides 32 unipolar (passes DC current) Form A (SPST) Solid State power switches. The transformer isolated design gives the module short closure times and low closed contact resistance. Multiple channels can be wired in parallel to increase current carrying capability. Normally, the switches carry unipolar (DC) current but two switches can be wired together to form an AC switch.

Note

This module cannot be programmed using SCPI (Standard Commands for Programmable Instruments) commands. You must use register based programming to set or reset the solid state relays. Refer to Chapter 2.

For specific technical information regarding solid state relays and switching power specifications, refer to Appendix B in this manual.

Terminal Connections

Dual DIN-E compatible termination connections are built in. There is no dedicated terminal card; however, an HP E1463-80001 Terminal Module may be purchased separately and used with the HP Z2468A.

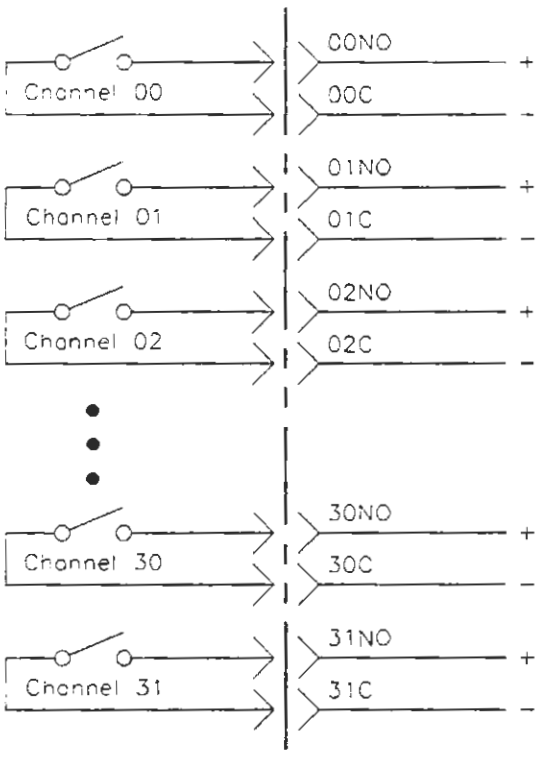
Warning

SHOCK HAZARD. Only service-trained personnel who are aware of the hazards involved should install, remove, or configure the switch modules. Before you remove any installed module, disconnect AC power from the mainframe and from other modules that may be connected to the modules.

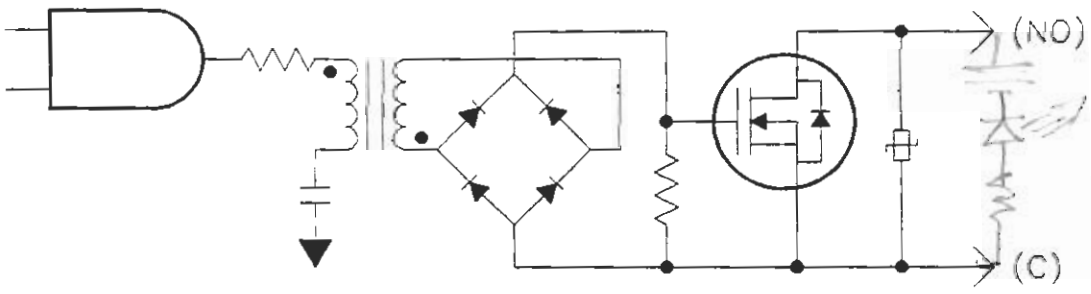
CHANNEL WIRING INSULATION. All channels that have a common connection must be insulated so that the user is protected from electrical shock in the event that two or more channels are connected together. This means wiring for all channels must be insulated as though each channel carries the voltage of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

Caution

Do not use the HP Z2468A for switching inductive loads (for example, motors, relays, etc.).



Each Channel Consists Of The Following Unipolar (DC Only) Circuit:



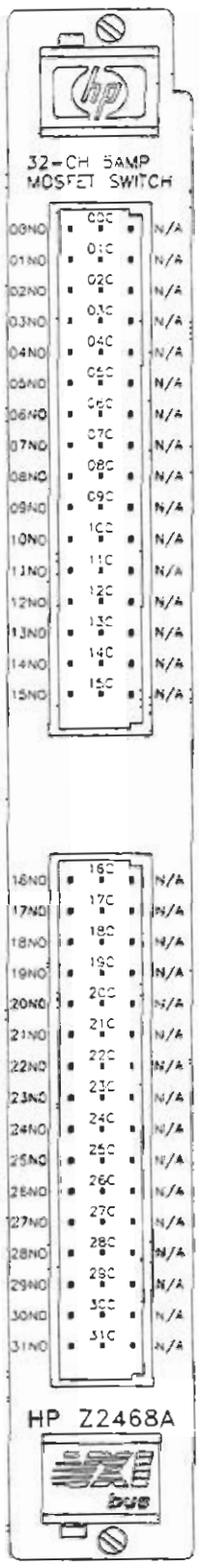


Figure 1-1. HP Z2468A Simplified Block Diagram and Front Panel

1-2 Solid State Switch Module Setup

Front Panel Terminal Connections

All wiring to the module is done external to the module's dual DIN-E front panel connectors. No terminal modules are supplied with the HP Z2468A. A mating HP connector may be purchased separately (HP part number 1252-1574 for a solder lug connector, 1252-1577 for a right angle, PC mount connector) or an HP E1463-80001 Terminal Block may be purchased separately.

Figure 1-1 shows the simplified diagram and terminal connections for the module. Notice that the column of pins on the far right side of the connectors is not used. In general, spread the DUT connecting wires out and away from each other to help dissipate heat.

Typical Use

The HP Z2468A relays are general purpose Form A relays. Figure 1-2 shows a typical use for one switch on the module. In particular note the polarity of the power supply, load, and wiring of the switch. Because the HP Z2468A solid state relays are unipolar, they pass only DC current. Therefore be very careful when wiring the module.

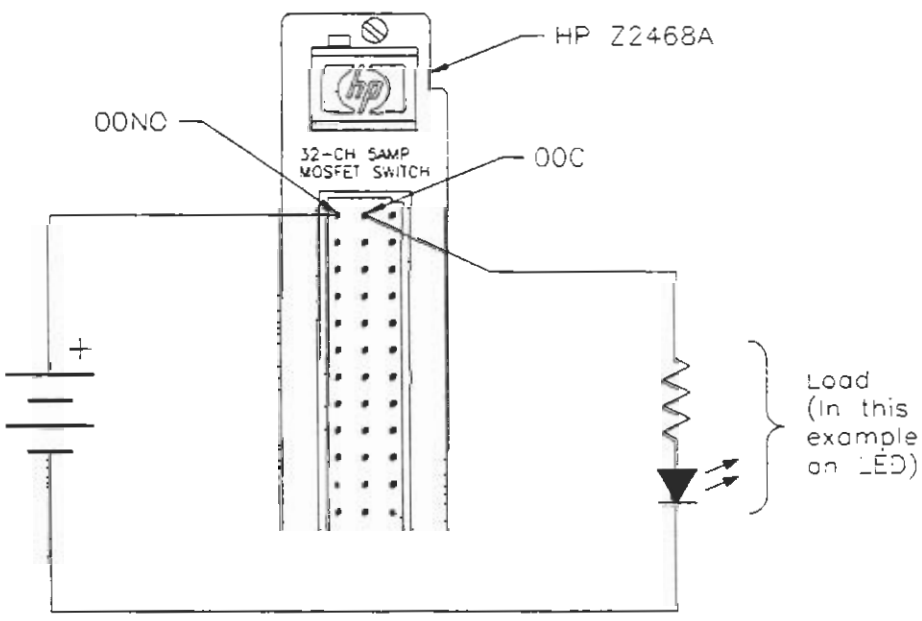


Figure 1-2. Typical Use for the HP Z2468A Solid State Relay
Note the polarity of the power supply as it connects to the relay.

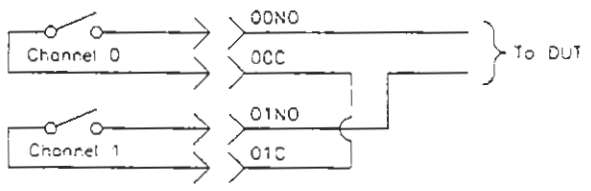
Forming an AC/DC Switch

The HP Z2468A has 32 Form A unipolar channels. However, connecting the Channel Commons of two channels forms an AC/DC switch. Figure 1-3 shows an example. The Channel Commons of channels 0 and 1 are connected together. The NO terminals connect to the DUT. Both switches must be closed for the configuration to conduct AC current.

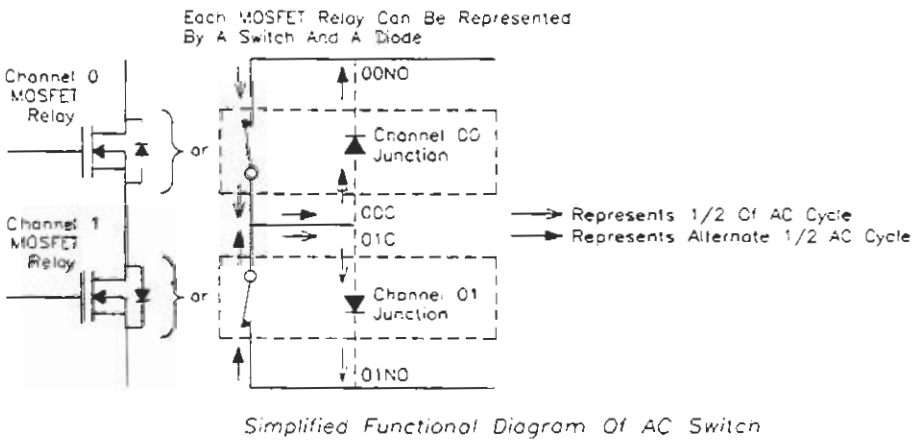
In this configuration, on one half of the AC cycle switch channel 0 conducts and the forward biased junction of switch channel 1 conducts. On the other half of the AC cycle, switch channel 1 and the forward biased junction of switch channel 0 conduct.

Note

Channels paired to form an AC/DC switch should be in the same register bank. This lets you use one VXI WRITe statement to close (or open) both channels. If you use channels in separate banks, two VXI WRITe statements must be used to close (or open) the relays and a short timing gap occurs between relay closures. Refer to Chapter 2 for specific information. The two channel banks are channels 00 - 15 and channels 16 - 31.



Wiring Diagram For AC Switch



Simplified Functional Diagram Of AC Switch

Figure 1-3. Forming an AC/DC Switch with two HP Z2468A Channels

1-4 Solid State Switch Module Setup

Increasing Current Capacity

The HP Z2468A is designed to carry 5 ADC continuous on up to eight (8) channels (module total = 40 Amps). Multiple channels wired in parallel can be used for different current carrying requirements. For example, two channels wired in parallel can carry a total of 10 Amps, three channels wired in parallel can carry 15 Amps, four channels can carry 20 Amps, and so on up to eight channels which can carry 40 Amps. In this parallel configuration each channel carries the same amount of current. Refer to Figure 1-4.

As a general rule, you can increase reliability using multiple relays in parallel. Therefore, don't let any relays go unused on the module when switching more than 10 amps.

Note

The total maximum current switched by the module must not exceed 40 Amps. The current through any individual switch must not exceed 5 Amps. Refer to Appendix B for specific information on power switching.

Note

Channels grouped together to increase current capacity should be in the same register bank. This lets you use one VXI WRITe statement to close (or open) all channels. If you use channels in separate banks, two VXI WRITe statements must be used to close (or open) the relays and a short timing gap occurs between relay closures. Refer to Chapter 2 for specific information. The two channel banks are channels 00 - 15 and channels 16 - 31.

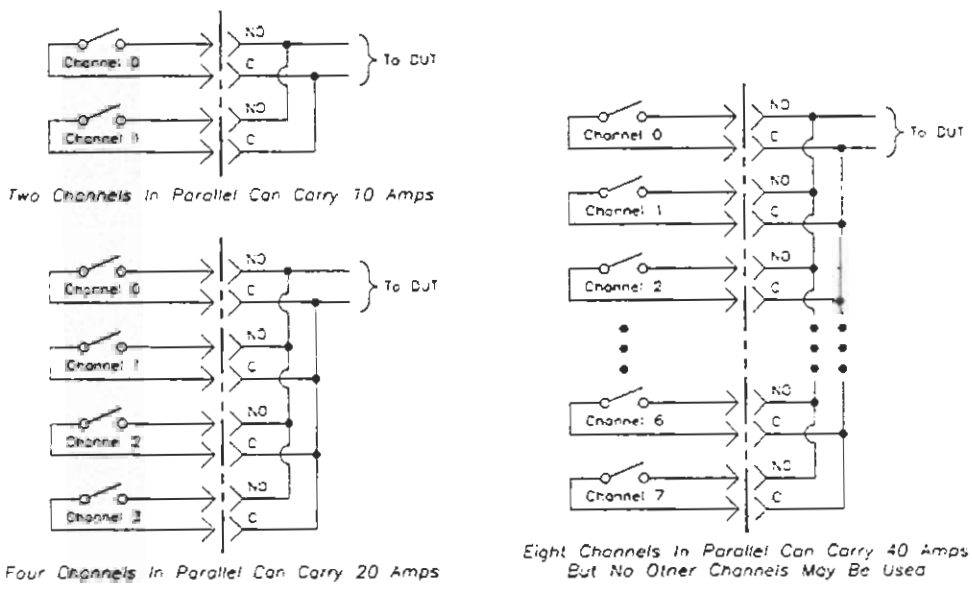


Figure 1-4. Combining HP Z2468A Channels to Increase Current Capacity

Using an HP E1463-80001 Terminal Block

Figure 1-5 shows the HP E1463-80001 Terminal Block. This terminal block must be purchased separately from the HP Z2468A Relay module. Maximum terminal wire size is 16 AWG. Each screw terminal on the HP E1463-80001 terminal block can carry a maximum of 5 amps. Wires ends should be stripped 6 mm (0.25 inch) and tinned. When combining channels (either to form an AC/DC switch or to increase current capacity) individual channel wires should be soldered together as soon as the wires leave the terminal module strain relief. The NC (Normally Closed) contacts are not used.

Because the HP Z2468A solid state relays are unipolar, they pass only DC current. Therefore, be very careful when wiring the module. Refer to Figure 1-2 for polarity wiring information.

As a general rule, you can increase reliability using multiple relays in parallel. Therefore, don't let any relays go unused on the module.

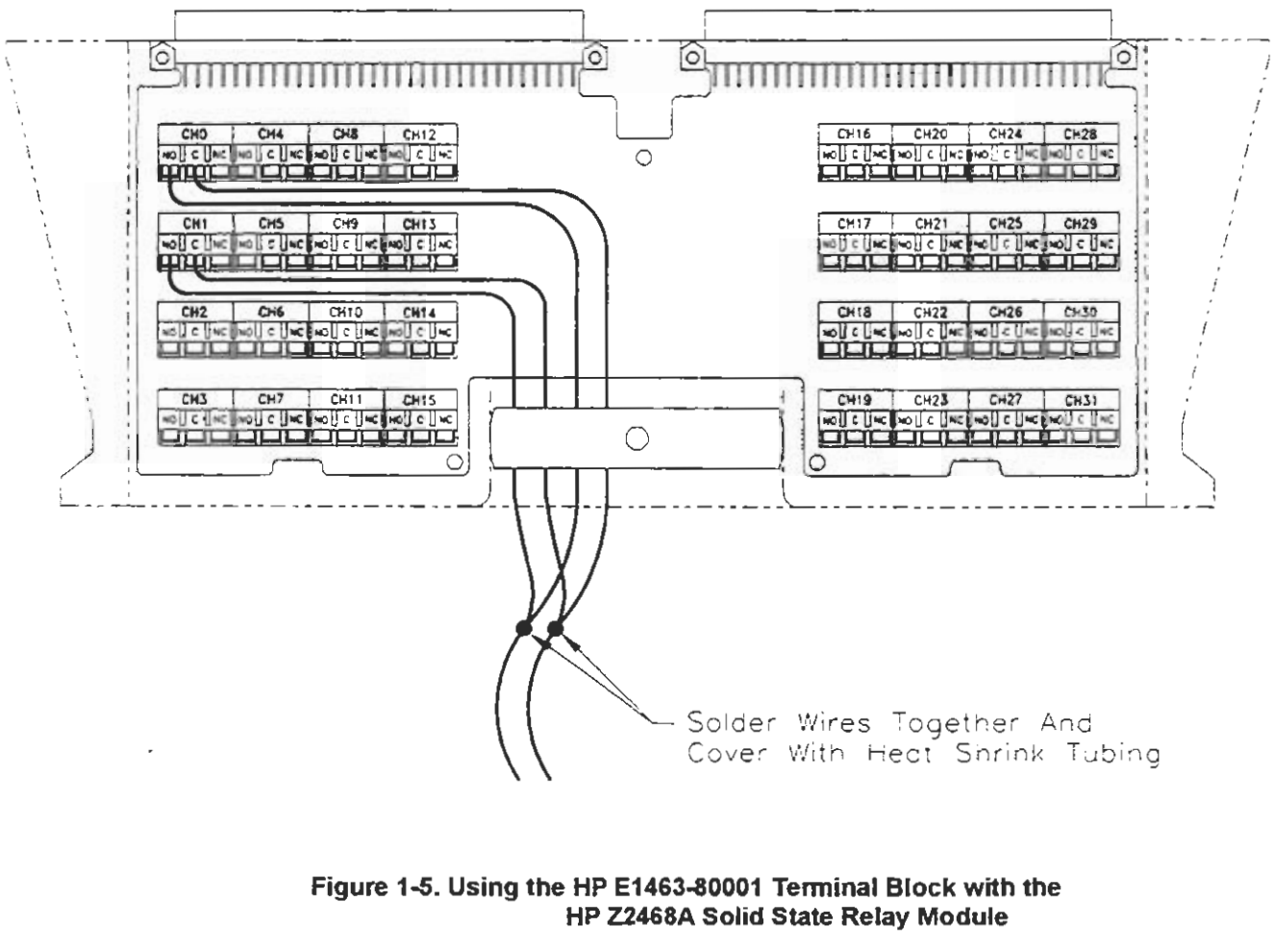


Figure 1-5. Using the HP E1463-80001 Terminal Block with the HP Z2468A Solid State Relay Module

1-6 Solid State Switch Module Setup

Setting the Address Switch

The logical address switch (LADDR) factory setting is 120. You may have to change the setting during module installation. Valid address values are from 1 to 254. If the switch modules are used with an HP Command Module in a C Size Mainframe, refer to the "HP Command Module User's Guide" for addressing information. Otherwise, use Figure 1-6 to change the setting.

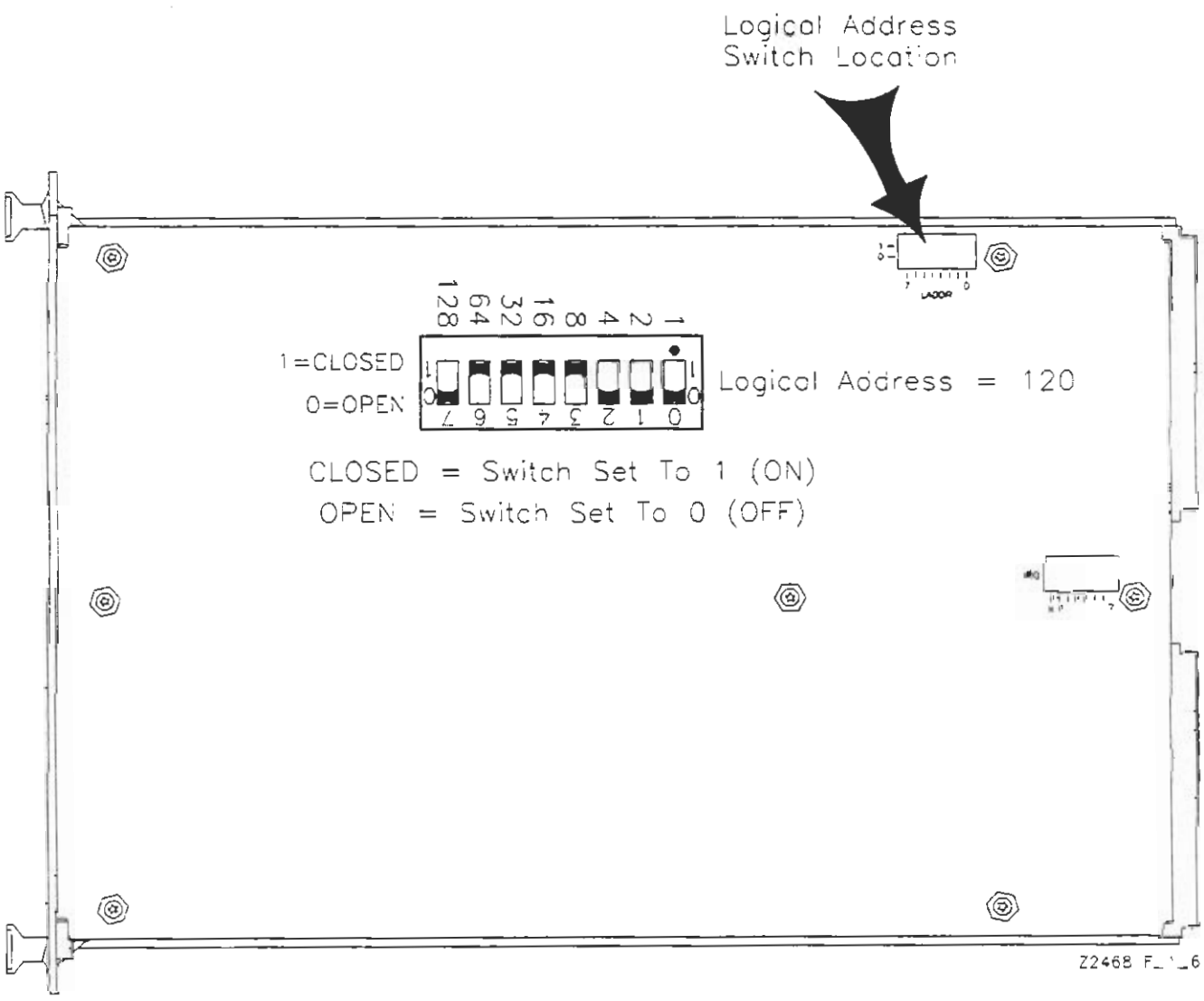


Figure 1-6. Setting the Switch Module Address Switches

Setting the Interrupt Level

A switch module generates an interrupt indicating that a relay has been opened or closed. These interrupts are sent to, and acknowledged by the HP Command Module or other system controller via one of seven VXI backplane interrupt lines. Different controllers treat the interrupt lines differently. Refer to your controller's documentation to determine how to set the interrupt level jumpers on your switch module. Since no SCPI firmware is available for the HP Z2468A, the interrupt is ignored. Query the control module's error register to read the interrupt information.

Note

Many mainframes have backplane switches or jumpers for the interrupt lines. If your mainframe is of this type, make certain those switches or jumpers are open for the slot where the switch module is installed. The HP E1401A mainframe provides automatic switch opening for installed modules.

HP Command Modules configured as VXI Resource Managers (i.e. logical address set to zero) treat all interrupt lines as having the same priority. For interrupters using the same line, priority is determined by which mainframe slot they are installed in. Lower-numbered slots have higher priority than higher-numbered slots. HP Command Modules service line 1 by default, so it is normally correct to leave the switch module's jumpers at their factory setting of 1. If in doubt, refer to your Command Module User's Manual.

If your controller's documentation instructs you to change the interrupt level, refer to Figure 1-7. To cause the module to interrupt on one of the VXI interrupt lines (1 through 7), put the jumper in the position with the same number. To disable the module's interrupt, put the jumper in the "X" position. If your module has two 2-pin jumpers instead one 4-pin jumper, make certain both jumpers are at the same position.

Note

Moving the interrupt level jumper from its factory position of 1 is not recommended. Do not place the jumper in the X position if you are using an HP Command Module.

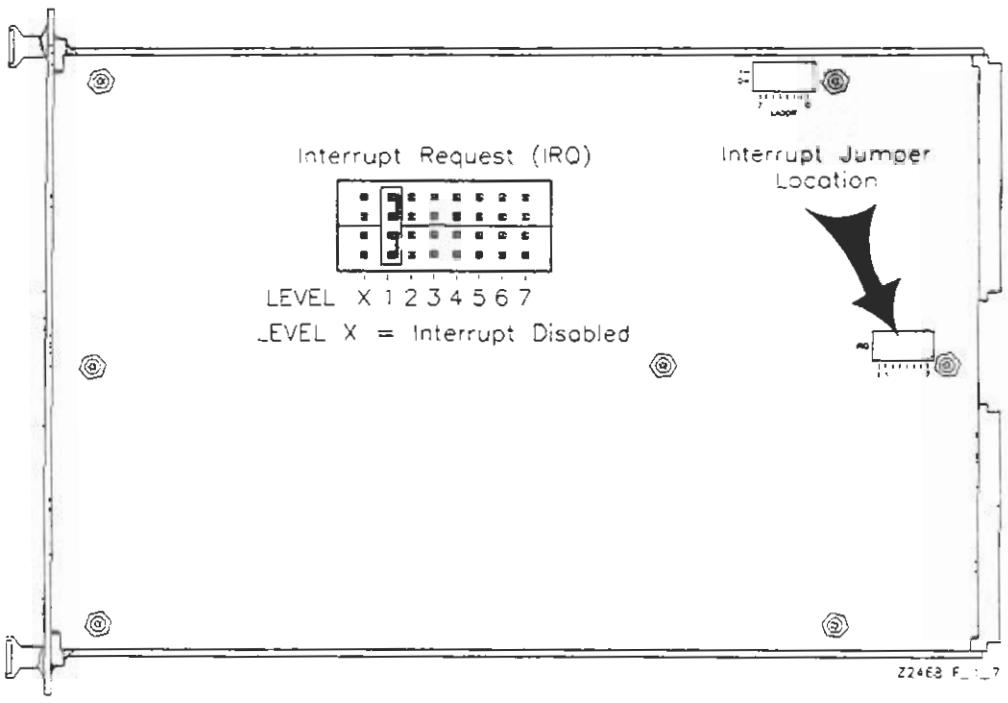


Figure 1-7. Setting the Interrupt Priority Level

Chapter 2

Solid State Relay Module Programming

Using this Chapter

This chapter contains:

Addressing the Registers

Use the register address to access a specific register for either read or write operations. Register addresses for the VXI plug-in modules are found in an address space known as A16. The exact location of the A16 address space within a VXIbus master's memory map depends on the design of the VXIbus master you are using; for the HP E1405 and E1406 Command Modules, the A16 space starts at $1F0000_{16}$.

The A16 space is further divided so that the modules are addressed only at locations above $1FC000_{16}$ within A16. Further, every module is allocated 64 register addresses (40_{16}). The address of a module is determined by its logical address (set by the address switches on the module) times 64 (40_{16}). For the HP Z2468A modules, the factory preset address is 120 (78_{16}), so the addresses start at $1FDE00_{16}$:

$$1FC000_{16} + (78_{16} * 40_{16}) = 1FDE00_{16}$$

Register addresses for register based devices are located in the upper 25% of VXI A16 address space. Every VXI device (up to 256) is allocated a 64 byte block of addresses. Figure 2-2 shows the register address locations within A16 address space in the HP E1406 Command Module.

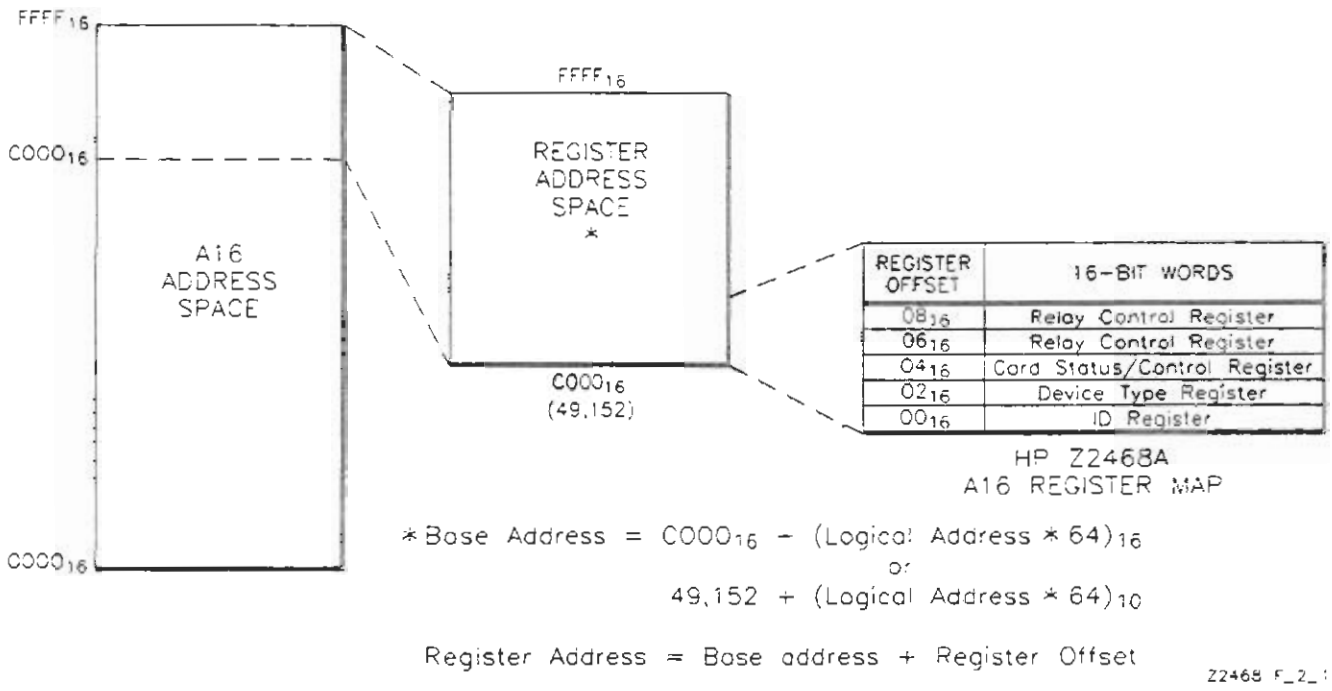


Figure 2-1. Register Address Location within A16

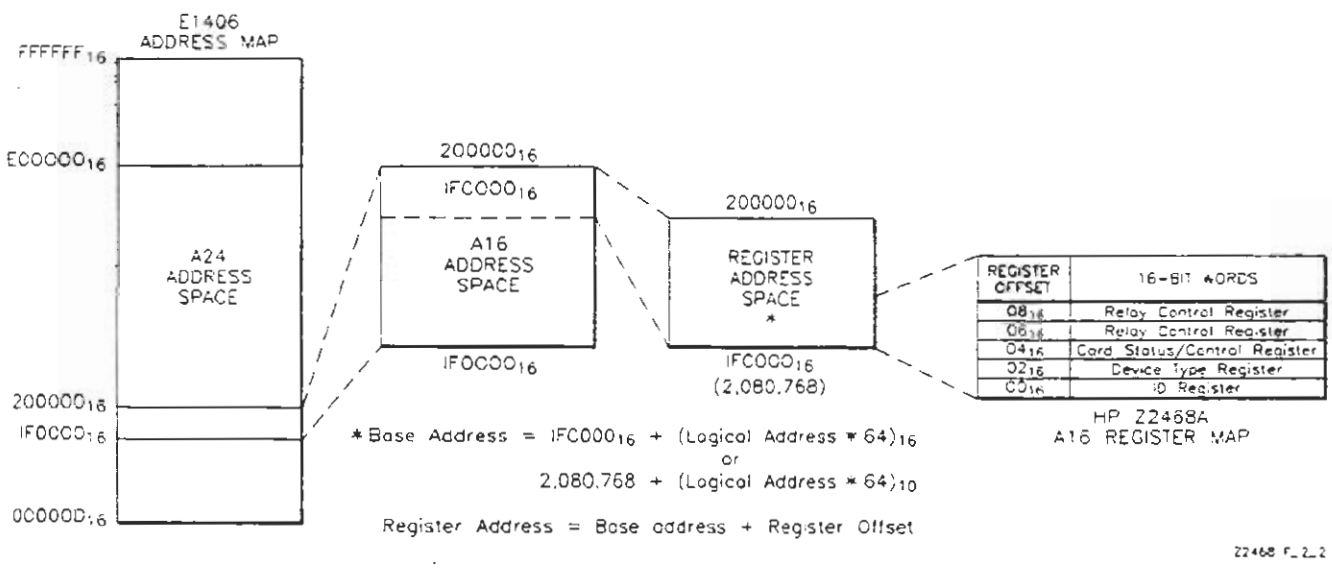


Figure 2-2. A16 Address Space in the HP E1406A

2-2 Solid State Relay Module Programming

The Base Address

When you are reading or writing to a module register, you must specify a hexadecimal or decimal register address. This address consists of a base address plus a register offset. The base address used in register programming depends on whether the A16 address space is inside or outside the HP E1405 or E1406 Command Module.

A16 Address Space Outside the Command Module

When an HP Command Module is not a part of your VXIbus system (see Figure 2-1), the module's base address is computed as:

$$A16_{base} + C000_{16} + (LADDR_{16} * 40_{16})$$

or (decimal)

$$A16_{base} + 49,152 + (LADDR * 64)$$

where $C000_{16}$ (49,152) is the starting location of the the register addresses, LADDR is the module's logical address, and 64 is the number of address bytes per VXI device. For example, the HP Z2468A's factory set logical address (LADDR) is 120 (78_{16}); therefore it will have a base address of:

$$A16_{base} + C000_{16} + (78_{16} * 40_{16}) = A16_{base} + DE00_{16}$$

or (decimal)

$$A16_{base} + 49,152 + (120 * 64) = A16_{base} + 56,832$$

A16 Address Space Inside the Command Module

When the A16 address space is inside the Command Module (see Figure 2-2), the module's base address is computed as:

$$FC000 + (LADDR * 64)_{16}$$

or

$$2,080,768 + (LADDR * 64)$$

where $1FC000_{16}$ (2,080,768) is the starting location of the VXI A16 addresses, LADDR is the module's logical address, and 64 is the number of address bytes per register-based device. Again, the module's factory set address is 120. If this address is not changed, the modules will have a base address of:

$$1FC000_{16} + (78_{16} * 40_{16}) = 1FC000_{16} + 1E00_{16} = 1FDE00_{16}$$

or

$$2,080,768 + (120*64) = 2,080,768 + 7680 = 2,088,448$$

Register Offset

The register offset is the register's location in the block of 64 address bytes that belong to the module. For example, the module's Status/Control Register has an offset of 04_{16}. When you write a command to this register, the offset is added to the base address to form the register address:

$$1FDE00_{16} + 04_{16} = 1FDE04_{16}$$

or

$$2{,}088{,}448 + 4 = 2{,}088{,}452$$

Register Descriptions

The HP Z2468A modules have the following registers:

- Manufacturer ID Register (base + 00_{16})
- Device Type Register (base + 02_{16})
- Status/Control Register (base + 04_{16})
- Relay Control Registers (base + 06_{16} and base + 08_{16})

ID Register

The ID Register is a read only register at address 00_{16} (MSB) and 01_{16} (LSB). Reading this register returns $FFFF_{16}$. This shows Hewlett-Packard as the manufacturer and that the module is an A16 register based device. With the HP E1406A Command Module you can use the optional register name ID to specify the Identification Register in VXI programs. This is shown in an example program later in this chapter.

Manufacturer ID Register — **base + 00_{16}**

b+00_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined															
Read	Manufacturer ID: $FFFF_{16}$ (Hewlett Packard A16 only register based module)															

Device Type Register

The Device Type Register is a read only register at address 02_{16} (MSB) and 03_{16} (LSB). Reading this register returns 0127_{16} for the HP Z2468A Module. With the HP E1406A Command Module you can use the optional register name DTYP to specify the Device Type Register in VXI programs. This is shown in an example program later in this chapter.

Device Type Register — **base + 02_{16}**

b+02_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined															
Read	0127_{16} for the HP Z2468A															

Status/Control Register

The Status/Control Register is a read/write register (address 04_{16}) that controls the module and indicates its status. Each relay requires about 3 msec to change state during which time the switch modules are "busy". A "1" in Bit 7 of this register indicates a "busy" condition.

In addition, the interrupt generated after a relay has changed state can be disabled. Bit 6 of this register indicates whether interrupts are enabled or disabled. To disable the interrupt generated when relays change state, write a "1" to bit 6 of the Status/Control Register (base + 04_{16}).

With the HP E1406A Command Module you can use the optional register name STATUS to specify the Status Register in VXI programs. This is shown in an example program later in this chapter.

Note

It is possible to permanently disable the interrupt by setting the Priority Level Jumper at position "X" (see Setting the Interrupt Level in Chapter 2). In that case, the Status/Control register Bit 6 makes no difference.

Writing to the Status/Control Register (base + 04_{16}) enables you to reset the switch modules to their power-on/reset state (relays in their normally opened position), and disable/enable the interrupt generated when relays change state. To reset a switch module, write a "1" then a "0" to bit 0 of the Status/Control Register (base + 04_{16}).

Note

It is necessary to write a "0" to bit 0 after the reset has been performed before any other operations can be performed.

The Status/Control register (base + 04_{16}) bits are as follows:

Status/Control Register **base + 04_{16}**

b+04_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Undefined									D	Undefined					R
Read	Undef	M	Undefined						B	D	Undefined					

Bit 0 (Write): R = Force reset to power-on state by writing "1" then a "0" in bit #0.
Bit 6 (Write): D = Disable Interrupt by writing "1" in bit #6.
(Read): D = Status "Interrupt Disable" is "1" in bit #6.
Bit 7 (Read): B = Status "BUSY" if "0" in bit #7.
Bit 14 (Read): M = A "1" in this bit indicates that the device is not selected by the P2 MODID line. A "0" indicates the module is selected by a high state on the P2 MODID line.

Relay Control Registers

To close a particular channel, write a "1" to the corresponding register bit. To open a particular channel, write a "0" to the corresponding register bit. For example, to close relay channel 28, write a "1" to bit 12 of register base+08_{16}. Complete program examples are given later in this appendix. These registers are "Write Only"; reading from these registers always returns $FFFF_{16}$.

Switch Enable Register (Channels 0 - 15) **base + 06_{16}**

Address base +06_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	32766	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
Channel	Chan 15	Chan 14	Chan 13	Chan 12	Chan 11	Chan 10	Chan 09	Chan 08	Chan 07	Chan 06	Chan 05	Chan 04	Chan 03	Chan 02	Chan 01	Chan 00

Register Power-on/Reset State: all bits set to 0.

Switch Enable Register (Channels 16-31) **base + 08_{16}**

Address base +08_{16}	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	32766	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
Channel	Chan 31	Chan 30	Chan 29	Chan 28	Chan 27	Chan 26	Chan 25	Chan 24	Chan 23	Chan 22	Chan 21	Chan 20	Chan 19	Chan 18	Chan 17	Chan 16

Register Power-on/Reset State: all bits set to 0, all relays open.

Note

Channels paired to form an AC/DC switch or to increase current capacity should be in the same register bank. The two channel banks are channels 00 through 15 and channels 16 through 31. By keeping the channels in the same bank, one VXI WRITe statement is used to close both channels. Refer to examples later in this chapter.

Programming Examples

The examples in this section demonstrate how to program the modules at the register level. The examples in this section include:

- Resetting a Module
- Reading the ID, Device Type, and Status Registers
- Setting relays

System Configuration

The following examples were developed with the modules at logical address 120. The HP BASIC programs were developed on an HP Series 300/400 computer connected to an HP E1406 or E1405 Command Module through the HP-IB connector.

Resetting a Module

The following program resets a switch module by setting bit 0 of the Status Control Register to "1" and then to a "0". Reset puts all the relays on that module back to their power-on/reset state.

```
10 OUTPUT 70900; "VXI:SEL 120"          !Module Logical Addr. = 120
20 OUTPUT 70900; "VXI:REG:WRITE 4,1"!Write a 1 to the
                                        Status/Control Register
30 OUTPUT 70900; "VXI:REG:WRITE 4,0"!Write a 0 to the
                                        Status/Control Register
40 END
```

Reading the ID, Device Type, and Status Registers

The following example reads and prints the module ID, Device Type, and contents of the Status Register. With the HP E1406A Command Module you can use the optional register names ID, DTYP, and STATUS to specify the Identification Register, Device Type Register, and Status Register, respectively.

```
10 ! ************************************************************
20 ! *****              READ REGISTERS                  *****
30 ! ************************************************************
40 OUTPUT 70900; "VXI:SEL 120"          !Set logical address
50 OUTPUT 70900; "VXI:REG:READ? ID"!Read the ID register
60 ENTER 70900; Id_reg
70 PRINT "Identification Register = ";IVAL$(Id_reg,16)
80 OUTPUT 70900; "VXI:REG:READ? DTYP"!Read Device Type
                                        Register
90 ENTER 70900; Dev_reg
100 PRINT "Device Register = ";IVAL$(Dev_reg,16)
110 OUTPUT 70900; "VXI:REG:READ? STATUS"!Read Status/Control
                                          register
120 ENTER 70900; Stat_reg
130 PRINT "Status Register = ";IVAL$(Stat_reg,16)
140  END
```

This program returns:

Identification Register = FFFF
Device Register = 0127
Status Register = (depends on current status, default is FFBE)

Setting or Resetting the Solid State Relays

This program example is similar to the reset example. It sets (closes) solid state relay channels 02 and 03 and then resets (opens) them.

```
10 OUTPUT 70900; "VXI:SEL  120"      ! Select Logical Address
15 !Write to register 06₁₆ the value 12 (bits 2 & 3,values = 4 and 8
     respectively). This closes relay channels 02 and 03.
20 OUTPUT 70900; "VXI:REG:WRITE  #H06,12"25  !Write to register
06₁₆ the value 00 to open all relays
30 PAUSE
40 OUTPUT 70900;"VXI:REG:WRITE #H06,00"
50 END
```

As another example, if you first close relays 2 and 3 (VXI:REG:WRITE #H06,12) and then close relay channels 4 and 5 (VXI:REG:WRITE #H06,48) then relays 2 and 3 open. This is because the last VXI:REG:WRITE statement only specified register bits 4 and 5 (values 16 and 32 respectively) to be set to 1. If you want relays 2 and 3 to remain closed, you must specify all four relays: VXI:REG:WRITE #H06,60.

C Language Example

The following C programming language example uses an HP RADI-EPC7 Embedded Controller and the HP SICL Language driver. The program was written in Borland® C++ version 3.1. It cycles through each register bit, closing a relay, waiting for a time, opening all relays, and then proceeding to close the next relay - repeating the cycle. If you are not familiar with the INST, iopen, iclose, or imap statements, refer to HP SICL documentation.

```
#include <sicl.h>
#include <fcntl.h>
#include <stdio.h>
#include <math.h>
#include <dos.h>

#define LOOPS      16
void main (void)
{
    int  j;
    int  m;
    int  k;
    INST Z2468A;                    /*Establish Device System*/
struct              dev_regs {
    unsigned short inst_id;
    unsigned short device_type;
    unsigned short status_reg;
    unsigned short bank0_channels;
    unsigned short bank1_channels;
    } *base_addr;
```

```
Z2468A = iopen ("vxi,120");          /* Logical address = 120*/
    base_addr = (struct dev_regs*) imap (Z2468A,i_map_vxidev,0,1,0);
/*provides base address for each register defined in structure dev_regs*/
    printf ("base_addr = 0x%lx\n", base_addr);/*print contents of
                                        base address*/

/*Scan all channels in Bank 0*/
for (k=0 ; k<=0; k++){
for (j=0 ; j<LOOPS; j++){
base_addr->bank0_channels=ldexp(1,,j);
delay (3);                           /* wait 3 msec */
loc->bank0_channels=0x000;           /*resets register to open all
                                        channels*/
                    }
                      }

/*Scan all channels in Bank 1*/
for (k=0 ; k<=0; k++){
for (j=0 ; j<LOOPS; j++){
base_addr->bank1_channels=ldexp(1,,j);
delay (3);                           /* wait 3 msec */
loc->bank1_channels=0x000;           /*resets register to open all
                                        channels*/
                    }
                      }
iclose (Z2468A);
}
```

Appendix A

HP Z2468A Specifications

Maximum Voltage:

Terminal to Terminal: 250 VDC
Voltage clamped at 380 volts across each channel for protection.
Any Terminal to Ground: 250 VDC

Maximum Current:

Up to 40A per module:
5 ADC continuous maximum per switch for up to 8 channels, or
3 ADC continuous maximum per switch for up to 20 channels, or
1.2 ADC continuous maximum per switch for up to 32 channels

Maximum Switchable Power

5 ADC continuous maximum and 250 VDC per switch for up to 8 channels, or
3 ADC continuous maximum and 250 VDC per switch for up to 20 channels, or
1.2 ADC continuous maximum and 250 VDC per switch for up to 32 channels

Closed Channel Resistance:

<1Ω per channel @ 25°C
Channel resistance increases approx 1% per °C

Typical Offset Voltage:

<2μV

Time to open/close a channel:

3ms maximum

Appendix B

Power Switching Specification

Differences Between Electromechanical and Solid State Relays

Solid state relays (SSR's) have many advantages over electromechanical relays (EMR's). But they also have unique disadvantages. This appendix provides information on how relay lifetime is specified as it relates to the power switched by the relay.

SSR's generate no electrical or acoustical noise, they provide a virtually infinite lifetime, and have faster on/off settling times compared to mechanical relays.

EMR's, in contrast, are noisy and have a limited lifetime. With metallic contacts, the rapid charge transfer between the contact capacitance results in pitting as the contacts initially meet. Therefore, the metal contact surface becomes abraded and worn. Over the life of the relay, the contact resistance increases from a few milliohms to more than 1 ohm (1 ohm typically signifies the usable end of life for EMR's). Furthermore, the two metal contacts form a thermocouple. Temperature changes (caused in part by the heating of the contacts) generate a thermal EMF.

SSR's have on-state resistances of a few tenths of an ohm up to 10 ohms and consequently generate more heat. Also, SSR's do not have an infinite off-state impedance; there is always some leakage current.

Finally, EMR's use electromagnetic force (a current through a coil) to open or close the contacts. The space between the coil and the contacts allows a larger breakdown voltage than SSR's are capable of handling. EMR's can also withstand a much larger electrostatic discharge than an SSR. Consequently, HP SSR designs use Transzorbs® (similar to metal-oxide varistors) to provide protection.

Table B-1 compares typical specifications for solid state relays and electromechanical relays.

Table B-1 Solid State Relays vs. Electromechanical Relays

Trait	Solid State Relays	Electromechanical Relays
Lifetime	Virtually Infinite	10^4 - 10^6 switches (depends on load switched)
Thermal offset	< 1μv	from 0.5 μv to 15 μv
Electrical and Acoustic Noise	No	Yes
Leakage Current	Yes	No
Heat Dissipation	Yes (can be large)	Little concern until relay approaches end of life
On/Off Time	<1mS Typical	Between 1mS and 20mS
On-State Resistance	0.1Ω to 10Ω	0.04Ω to 1Ω (1Ω typically signifies end of relay life)
Electro-Static Discharge	Sensitive to ESD	Not Sensitive to ESD
Breakdown Voltage	Several Hundred Volts	Thousands of Volts
Switch Capacitance	Hundred to Thousands of pF	< 1.0 pF

Electromechanical Relay Switching Power

Refer to Figure B-1. To simplify this example, assume power supply PS1 is capable of generating over 200 watts (a typical supply is 28 volts at 10 amps, P = I x E = 10A x 28V = 280 watts). The load is varied so that is constantly dissipates 100 watts.

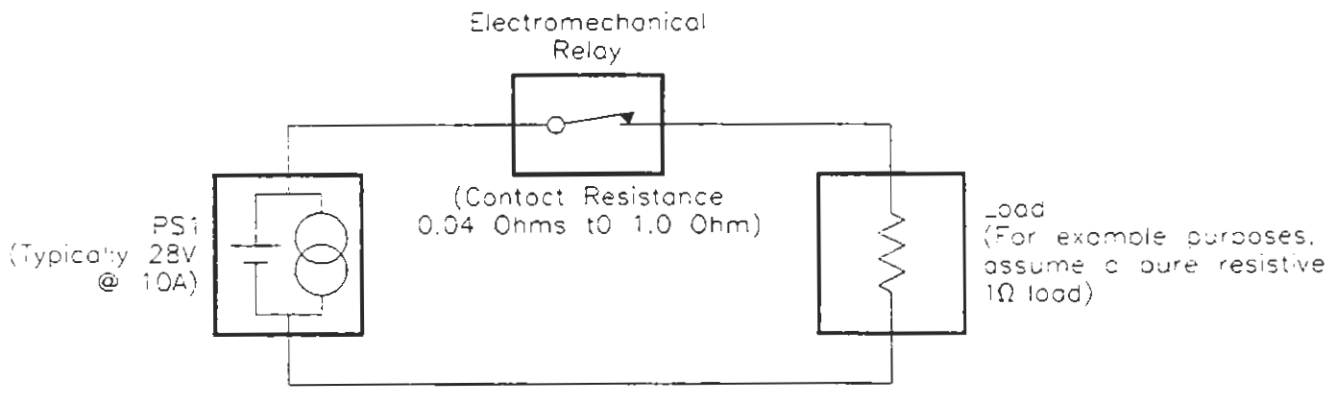


Figure B-1. Electromechanical Relay Switch Circuit

Typical contact resistance of a new relay is 0.04Ω. This means that the power dissipated by the relay contacts is $P = I^2 \times R = (10A)^2 \times 0.04\Omega = 4$ watts. In testing, the relay is cycled open/closed repeatedly. As the contact resistance increases with age, the power dissipated by the relay also increases. When the contact resistance increases to 1Ω, then the power dissipated by the relay is 100 watts (that is, $(10A)^2 \times 1\Omega = 100$ watts).

Therefore, the life of the relay is determined by how many times it switches (given the specified load conditions) until the contact resistance equals 1Ω. For electromechanical relays, the lifetime specification (number of switches) depends on the load; the smaller the load, the longer the lifetime. For example, for a 100 watt load the lifetime may be 10^6 switch closures. At higher loads, 150 watts for example, the lifetime may be 10^5 switches and at 200 watts, the lifetime may be only 10^4 switches.

Switching capacitive or inductive loads and high inrush currents reduce relay life. As the switching frequency increases, the contacts have less time to dissipate heat. The resulting increase in contact temperature also reduces relay life.

Solid State (MOSFET) Relay Switching Power

For solid state relays, the lifetime is determined by the power dissipation of the MOSFET switch. Refer to Figure B-2. Again, power supply PS1 is capable of over 200 watts. Since the MOSFET switches used in the HP Z2468 are rated at 5 amps, we will use that in our example.

Note

The power dissipation for other solid state switches is different. For example, the MOSFETs used in the HP Z2469A are rated for 0.6A AC/DC. Use the specification for your specific solid state swtich in the following equations.

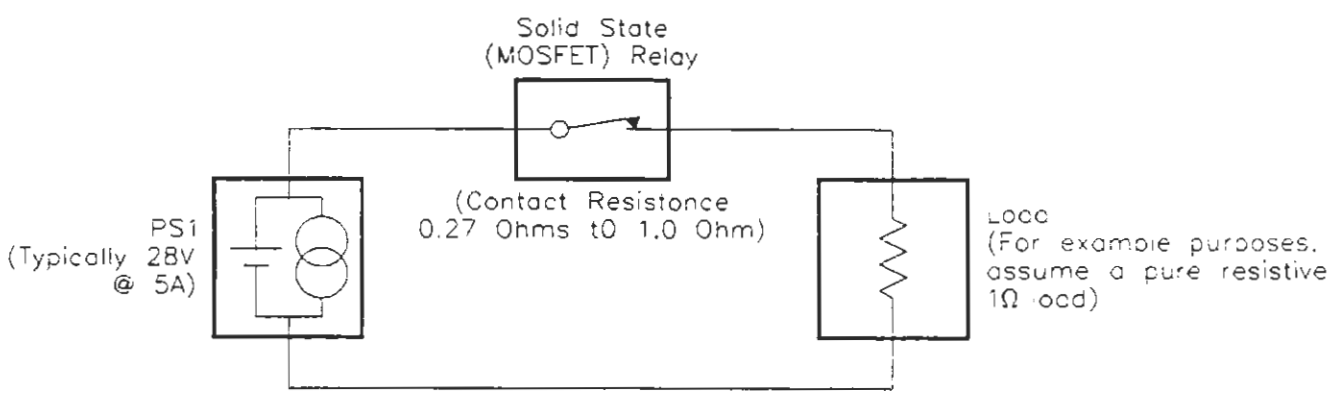


Figure B-2. Solid State Relay Switch Circuit

At initial turn on the relay on-state resistance is approximately 0.27Ω. So the power dissipated by the switch is $P = I^2 \times R = 5^2 \times 0.27 = 6.75$ watts. However, as the junction temperature rises, the on-state resistance increases. For the MOSFETs used in the HP Z2468A, the specified maximum on-state resistance is 1Ω. Therefore, the maximum power dissipated by the relay is 25 watts ($5^2 \times 1 = 25$ watts). Figure B-3 shows the curve of the junction temperature versus on-state resistance.

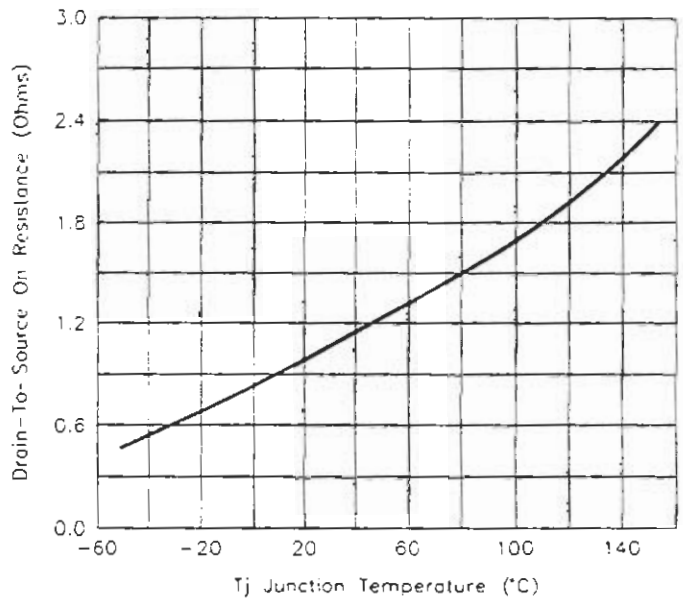


Figure B-3. Solid State Relay On-State Resistance vs. Temperature
Note: This curve is for the MOSFETs used in the HP Z2468ASolid State Relay Module. The curve for the MOSFETs used in other solid state relay modules will be different.

Two of the Z2468A MOSFET relays can dissipate 50 watts (25 watts each), four can dissipate 100 watts, eight can dissipate 200 watts, etc. Theoretically, all 32 relays could dissipate a total of 800 watts. But this is not practical because of cooling limitations on VXI modules and the physical size of the heatsink. VXI modules receive cooling air circulated by the mainframe; HP's C-Size High Power mainframe (the HP E1401A), is able to cool 65 watts per slot. Consequently, the total heat dissipated by a module must be limited.

Actually, the MOSFETs used in the HP Z2468A can handle up to 20A if the junction temperature is maintained at 25°C. It is not practical to maintain a 25°C junction temperature; however, an industry guideline is to maintain the junction temperature below 120°C to maintain high reliability. HP's VXI solid state relays are specified to operate up to 55°C ambient temperature which means the junction temperature is maintained below 90°C at normal room temperature.

Therefore, it is the MOSFET solid state relay heat dissipation, and the rate it is cooled, which limits the total amount of power that can be switched by the solid state relay modules.

B-4 Power Switching Specification

Momentary Switching Power

HP's Z2468A module has a maximum switching voltage of 250 volts (terminal to terminal) AND 5 amps (maximum of 8 channels). Under these conditions, when a solid state relay first opens, for a few nanoseconds it may have 250 volts across it and 5 amps through it. Thus, for those few nanoseconds, it dissipates 250V x 5A = 1250 Watts. This is the momentary power dissipated during the the actual switching of the relay and is different than the continuous power dissipated (shown earlier to be less than 25 watts).

IMPORTANT

For solid state relay modules, the switching power is defined in two ways: the momentary switching power dissipation and the continuous power dissipation. But it is the MOSFET solid state relay heat dissipation, and the rate it is cooled by the mainframe, which limits the total amount of current that can be switched by the solid state relay modules. That is why the HP Z2468A module is rated at 5 Amps maximum for up to 8 channels per module.

Along with the 5 Amps maximum for up to 8 channels, the momentary switching power must be no more than 1250 Watts per channel for up to 8 channels in the HP Z2468A.

Relays in Parallel

If two or more relays are wired in parallel, more current (and correspondingly more power) can be switched. Although the relays should be opened/closed simultaneously, in reality there is always a short time interval before both relays close. This time interval can be several milliseconds if the relays are in different register banks and therefore require different VXI:REG:WRITE statements. This is why we recommend that you pair relays in the same register (see Chapter 2). One VXI:REG:WRITE statement can be used and minimizes the delay.

With SSR's, the first relay to close will carry the full current and heat up accordingly; thus limiting the current. When the second relay closes, it initially has a much lower on-state resistance and hence most of the current will flow through it causing it to heat but allowing the first relay to pass a smaller current. Eventually, in a few milliseconds, the on-state resistances even out and the current is distributed equally in each relay.

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