Agilent E2270A/E2271A/E2272A
E2270A 16-Channel Form A Switch
E2271A 4x4 Matrix Switch
E2272A Dual 8-to-1 Relay Multiplexer

User's and SCPI Programming Manual

Where to Find it - Online and Printed Information:

System installation (hardware/software)	VXIbus Configuration Guide* Agilent VIC (VXI installation software)*
Module configuration and wiring	This Manual
SCPI programming	This Manual
SCPI example programs	This Manual
SCPI command reference	This Manual
Register-Based Programming	This Manual
VXI*plug&play* programming	VXI*plug&play* Online Help
VXI*plug&play* example programs	VXI*plug&play* Online Help
VXI*plug&play* function reference	VXI*plug&play* Online Help
Soft Front Panel information	VXI*plug&play* Online Help
VISA language information	Agilent VISA User's Guide
Agilent VEE programming information	Agilent VEE User's Manual

**Supplied with Agilent Command Modules, Embedded Controllers, and VXLink.*

Agilent Technologies

Manual Part Number: E2270-90000
Printed in Malaysia E0806

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E2270A 16-Ch Form A Sw/E2271A 4x4 Matrix Sw/E2272A Dual 8-to-1 Relay Sw M-Module User's Manual and Programming Guide

Agilent Technologies

Edition 1 Rev 2

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 . . . . . .June 1997

Edition 1 Rev 2 . . . . . .August 2006

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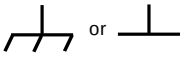
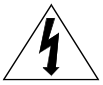
Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.



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

Alternating current (AC)

Direct current (DC).



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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 an Agilent Technologies Sales and Service Office for service and repair to ensure that safety features are maintained.

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According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies, Incorporated
Manufacturer's Address: *Measurement Product Generation Unit*
815 14th ST. S.W.
Loveland, CO 80537 USA

Declares, that the product

Product Name: 16 Channel GP Relay M-Module
Model Number: E2270A
Product Options: *This declaration covers all options of the above product(s).*

Conforms with the following European Directives:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE Marking accordingly

Conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1997 +A1:1997 / EN 55011:1998	*Group 1 Class A [1]*
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	*4kV CD, 8kV AD*
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	*3 V/m, 80-1000 MHz*
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	*0.5kV signal lines, 1kV power lines*
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	*0.5 kV line-line, 1 kV line-ground*
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	*3V, 0.15-80 MHz*
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	*I cycle, 100%*
	Canada: ICES-001:1998	
	Australia/New Zealand: AS/NZS 2064.1	
Safety	*IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995*	
	Canada: CSA C22.2 No. 1010.1:1992	
	UL 3111-1:1994	

Supplemental Information:

[1] The product was tested in a typical configuration with Agilent Technologies test systems.

September 5, 2000
Date

Jim White
Name

Quality Manager
Title

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Manufacturer's Name: Agilent Technologies, Incorporated
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815 14th ST. S.W.
Loveland, CO 80537 USA

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Product Name: 4x4 Relay Matrix M-Module
Model Number: E2271A
Product Options: *This declaration covers all options of the above product(s).*

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Conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1997 +A1:1997 / EN 55011:1998	*Group 1 Class A [1]*
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	*4kV CD, 8kV AD*
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	*3 V/m, 80-1000 MHz*
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	*0.5kV signal lines, 1kV power lines*
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	*0.5 kV line-line, 1 kV line-ground*
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	*3V, 0.15-80 MHz*
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	*I cycle, 100%*
	Canada: ICES-001:1998	
	Australia/New Zealand: AS/NZS 2064.1	
Safety	*IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995*	
	Canada: CSA C22.2 No. 1010.1:1992	
	UL 3111-1:1994	

Supplemental Information:

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Authorized EU-representative: Agilent Technologies Deutschland GmbH, Herrenberger Strabe 130, D 71034 Böblingen, Germany

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies, Incorporated
Manufacturer's Address: *Measurement Product Generation Unit*
815 14th ST. S.W.
Loveland, CO 80537 USA

Declares, that the product

Product Name: Dual 8:1/Single 16:1 Relay Multiplexer
Model Number: E2272A
Product Options: *This declaration covers all options of the above product(s).*

Conforms with the following European Directives:

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Conforms with the following product standards:

EMC	Standard	Limit
	IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998	
	CISPR 11:1997 +A1:1997 / EN 55011:1998	*Group 1 Class A [1]*
	IEC 61000-4-2:1995+A1:1998 / EN 61000-4-2:1995	*4kV CD, 8kV AD*
	IEC 61000-4-3:1995 / EN 61000-4-3:1995	*3 V/m, 80-1000 MHz*
	IEC 61000-4-4:1995 / EN 61000-4-4:1995	*0.5kV signal lines, 1kV power lines*
	IEC 61000-4-5:1995 / EN 61000-4-5:1995	*0.5 kV line-line, 1 kV line-ground*
	IEC 61000-4-6:1996 / EN 61000-4-6:1996	*3V, 0.15-80 MHz*
	IEC 61000-4-11:1994 / EN 61000-4-11:1994	*I cycle, 100%*
	Canada: ICES-001:1998	
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Safety	*IEC 61010-1:1990+A1:1992+A2:1995 / EN 61010-1:1993+A2:1995*	
	Canada: CSA C22.2 No. 1010.1:1992	
	UL 3111-1:1994	

Supplemental Information:

[1] The product was tested in a typical configuration with Agilent Technologies test systems.

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Notes:

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Chapter 1
Getting Started

What's in this Manual?

This manual contains module descriptions, configuration and wiring information, SCPI programming information, register programming information, and specifications for these M-Modules:

- Agilent E2270A 16-Channel Form A Switch
- Agilent E2271A 4x4 Matrix Switch
- Agilent E2272A Dual 8-to-1 Relay Multiplexer

In this manual, where the information is identical for all three M-Modules, they will be referred to collectively as the *Switch M-Modules*. Differences between the modules include switching schematics, wiring diagrams, channel numbering, and specifications. These differences are documented individually for each module.

The Switch M-Modules are intended to be installed on an M-Module Carrier. When it is necessary to reference a particular carrier, the Agilent E2251 C-Size VXIbus M-Module Carrier will be used.

Caution **The Switch M-Modules use latching relays that retain their last programmed state whenever power is removed.**

If you are programming at the register level, THESE RELAYS DO NOT RESET THEMSELVES AUTOMATICALLY WHEN POWER IS RE-APPLIED. This means that closed relays will remain closed when power is re-applied, and will stay closed until you open them programmatically.

If you are using the D-SCPI driver, the driver WILL open all Switch M-Module relays shortly after power is re-applied to the Command Module.

Caution **The Switch M-Modules DO NOT have provision for on-board current limiting components. If it is possible that input current could exceed 2 A DC or 2 A AC-Peak per channel, you must install external current limiting circuitry.**

Module Descriptions

General Product Features

- FIFO register structure allows fast system operation.
- Standard 44-Pin D-Sub connectors provide a common interface to all three Switch M-Modules.
- Single-width M-Modules provide high-density and maximum flexibility of configuration.
- Low-cost switching in VXI environment when used in an Agilent E2251 M-Module Carrier.

Agilent E2270A 16-Channel Form A Switch

The Agilent E2270A is a general purpose relay switch consisting of 16 one-wire switches on a single-width M-Module. This module can be used to connect test points on a device under test to instrumentation or to switch factory automation and fixturing. The switching schematic and user connector diagram are shown in Figure 1-2 on page 17.

Agilent E2271A 4x4 Matrix Switch

The Agilent E2271A is a 4x4 matrix consisting of 16 DPST relays configured as 4 rows and 4 columns of two-wire switches. This module can connect multiple instruments to multiple points in your test system. This provides flexible interconnections between test points, instrumentation, factory automation, and test fixtures. The switching schematic and user connector diagram are shown in Figure 1-3 on page 18.

Agilent E2272A Dual 8-to-1 Relay Multiplexer

The Agilent E2272A provides two separate 8-to-1, two-wire multiplexers. Alternatively, you can move a jumper to connect the common channels of each multiplexer together and create a single 16-to-1, two-wire multiplexer. The switching schematic and user connector diagram are shown in Figure 1-4 on page 19.

Wiring and Configuration

This section describes how to connect user wiring to each of the three Switch M-Modules. It also describes how to configure the Agilent E2272A as a dual 8-to-1 or a single 16-to-1 multiplexer.

Note The procedures in this section assume the M-Module(s) have already been installed into an M-Module Carrier. Since installation is dependent on the carrier used, instructions for installing M-Modules into the carrier are not included here. Refer to your M-Module carrier documentation for installation instructions. Each Agilent Technologies M-Module is shipped with identifying labels that you should install on the carrier.

Identfying M-Modules

The Switch M-Modules have a module ID number printed on the PC-board. The ID number consists of a model number prefix/PC-board number suffix. For example, "E2270-66501" is the ID number for the Agilent E2270 M-Module. ID number locations are shown in Figures 1-2, 1-3, and 1-4.

WARNING **SHOCK HAZARD. Only service-trained personnel who are aware of the hazards involved should install, remove, or configure the modules. Before installing or removing any module or carrier, disconnect power from the mainframe and user wiring.**

Caution **MAXIMUM VOLTAGE/CURRENT. The maximum voltage that may be applied to any connector on the Agilent E2270A, E2271A, or E2272A is 200 VDC, 125 VAC rms, or 175 VAC peak. These limits apply only if the product is installed in a humidity-controlled (<60% RH) environment where airborne contaminants and transients are controlled, and NO relay connection is made to power mains. If these conditions CANNOT be maintained, then the maximum voltage is 60 VDC, 48 VAC-rms or 68 VAC-peak.**
The maximum current (non-inductive) that may be appied to the Agilent E2270A, E2271A, or E2272A is:
Per Switch: 2 ADC, 2 AAC peak
Per Module: 8 ADC, 8 AAC peak

Caution **STATIC ELECTRICITY. Static electricity is a major cause of component failure. To prevent damage to the electrical components on an M-Module or the carrier, observe anti-static techniques whenever installing, removing, or working on a carrier or M-Module.**

Assembling the Field Wiring Connector

Each Switch M-Module includes a 44-pin connector and hood (Agilent kit part number E2273-01203). You must supply your own cable. The drawing below shows how to connect wiring and assemble the connector and hood.

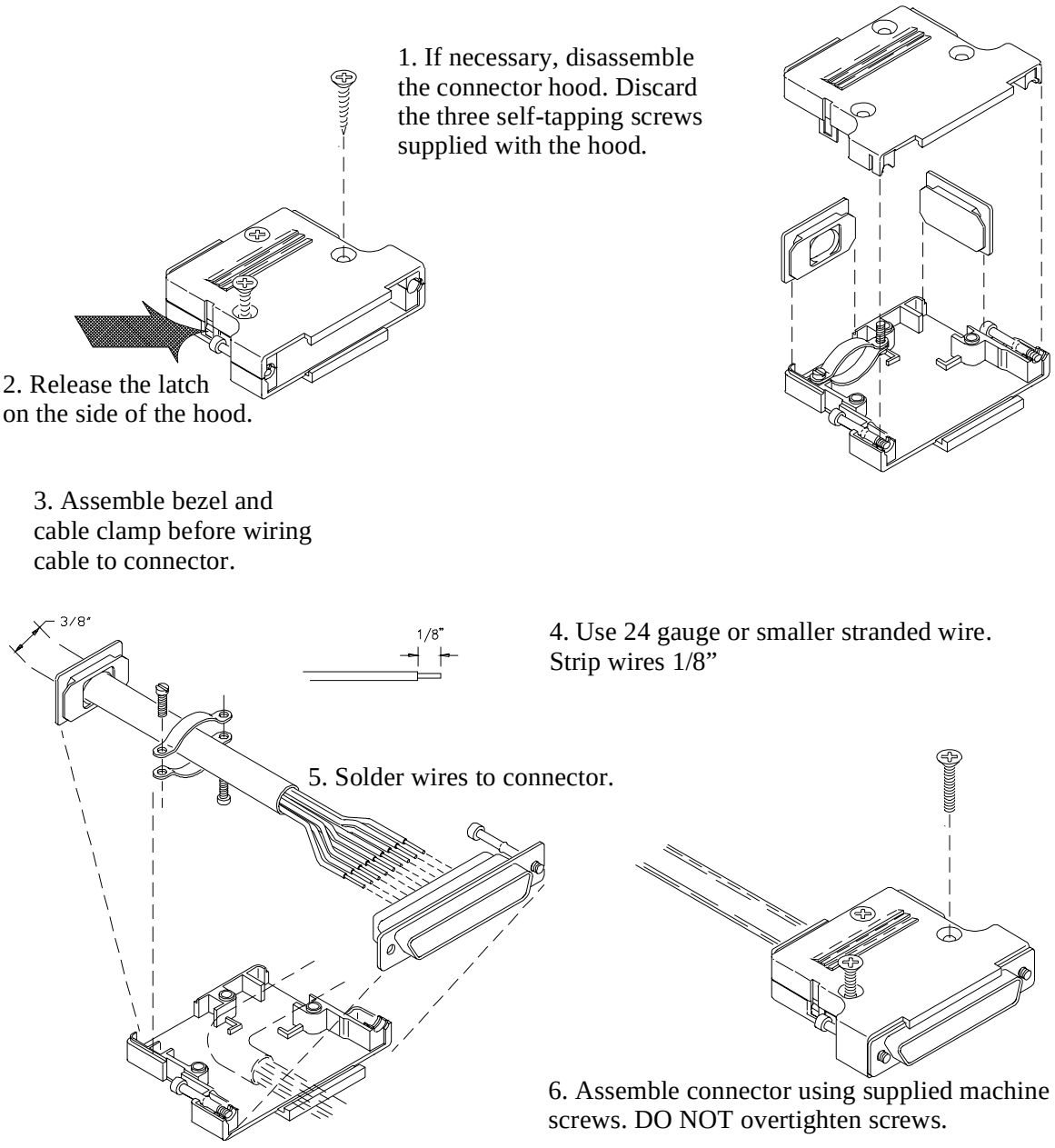
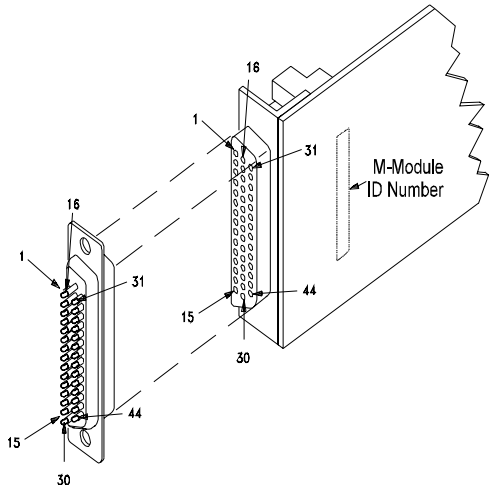


Figure 1-1. Assembling the Field Wiring Connector

Agilent E2270A Form A Switch Wiring Information



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Per Switch: 2 ADC, 2 AAC peak
Per Module: 8 ADC, 8 AAC peak

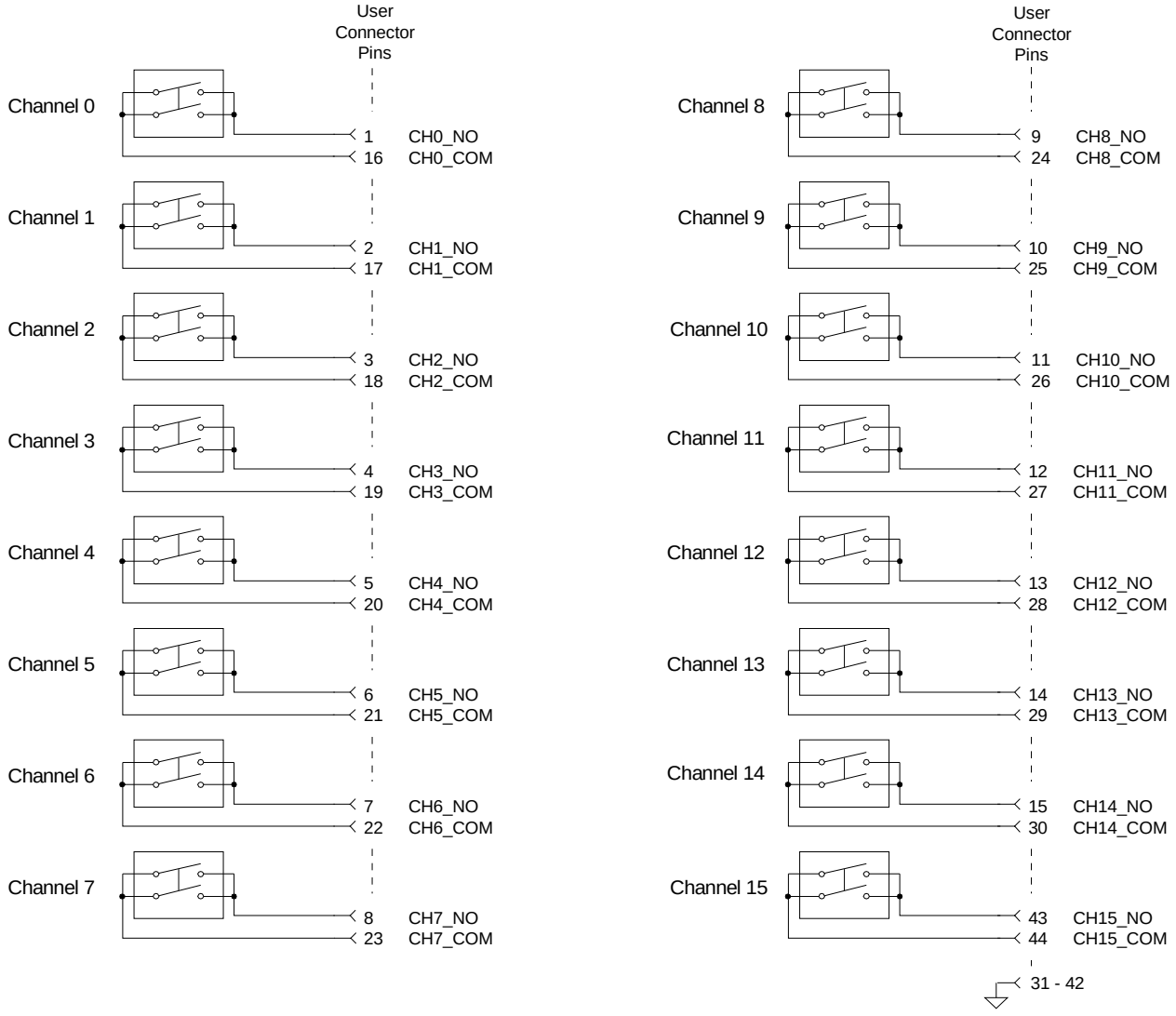
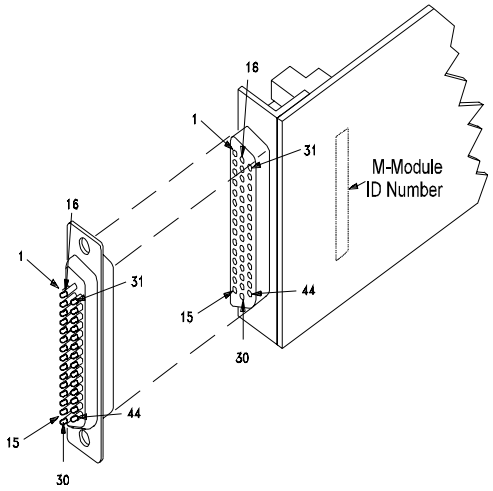


Figure 1-2. Agilent E2270A User Connector and Switching Schematic

Agilent E2271A 4x4 Matrix Switch Wiring Information



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The maximum current (non-inductive) that may be applied to the Agilent E2270A, E2271A, or E2272A is:

Per Switch: 2 ADC, 2 AAC peak
Per Module: 8 ADC, 8 AAC peak

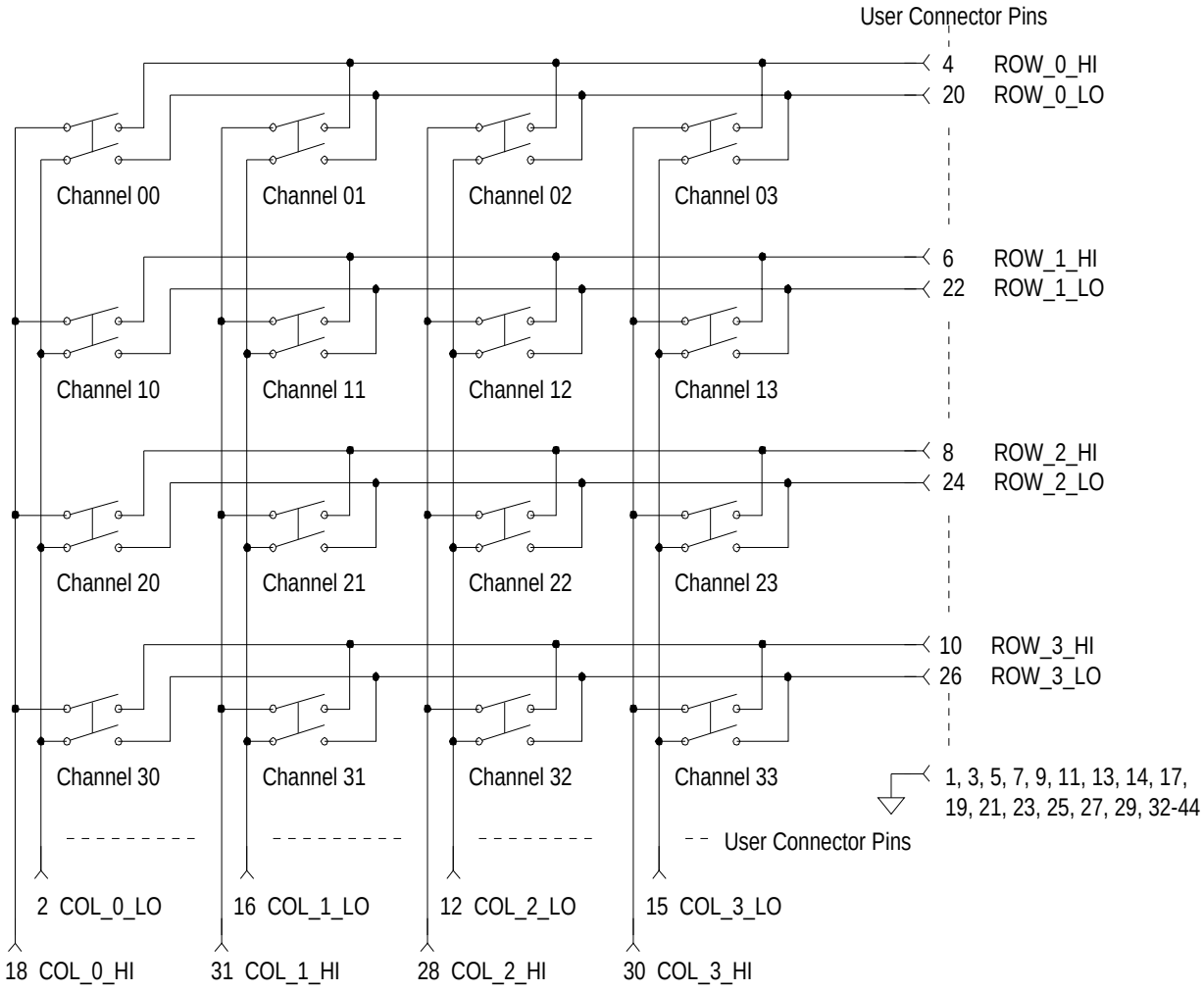
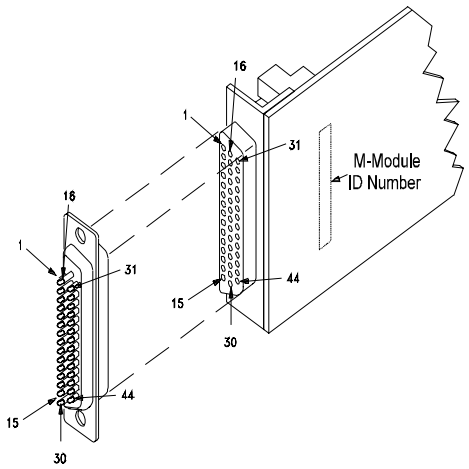


Figure 1-3. Agilent E2271A User Connector and Switching Schematic

Agilent E2272A Dual 8-to-1 Relay Multiplexer Wiring Information



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The maximum current (non-inductive) that may be applied to the Agilent E2270A, E2271A, or E2272A is:

Per Switch: 2 ADC, 2 AAC peak
Per Module: 8 ADC, 8 AAC peak

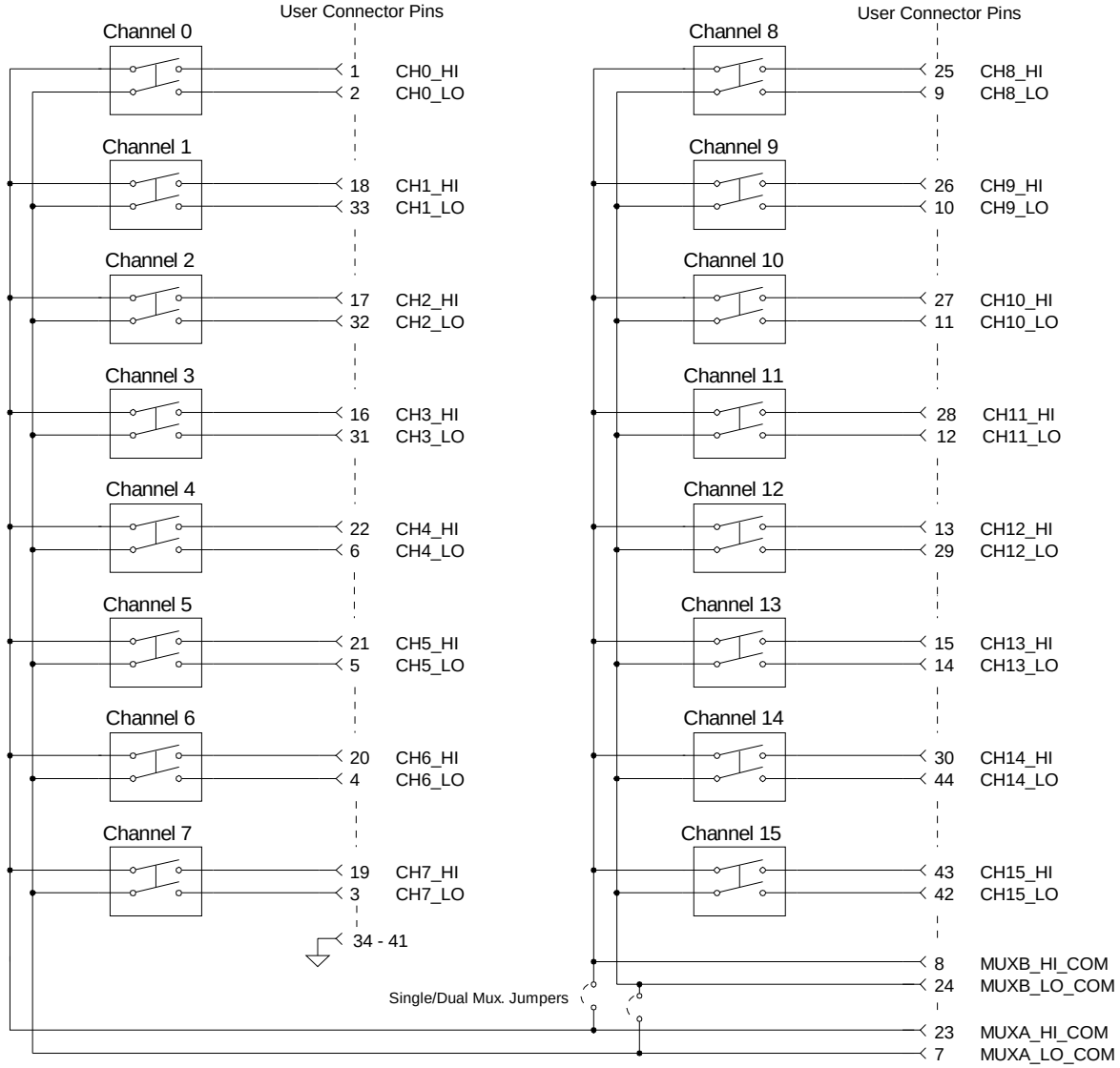


Figure 1-4. Agilent E2272A User Connector and Switching Schematic

Setting Agilent E2272A Multiplexer Size

Figure 1-4 shows the two jumper positions for the Agilent E2272A. When in position A (jumper **not** connecting one row of pins), the module is configured as a dual 8-to-1 multiplexer. When in position B (jumper connecting all pins), the module is configured as a single 16-to-1 multiplexer. The Agilent E2272A leaves the factory with the jumper placed in position A (dual 8-to-1 multiplexer). If you need to change this jumper postion, it must be done **before** installing the M-Module onto the carrier.

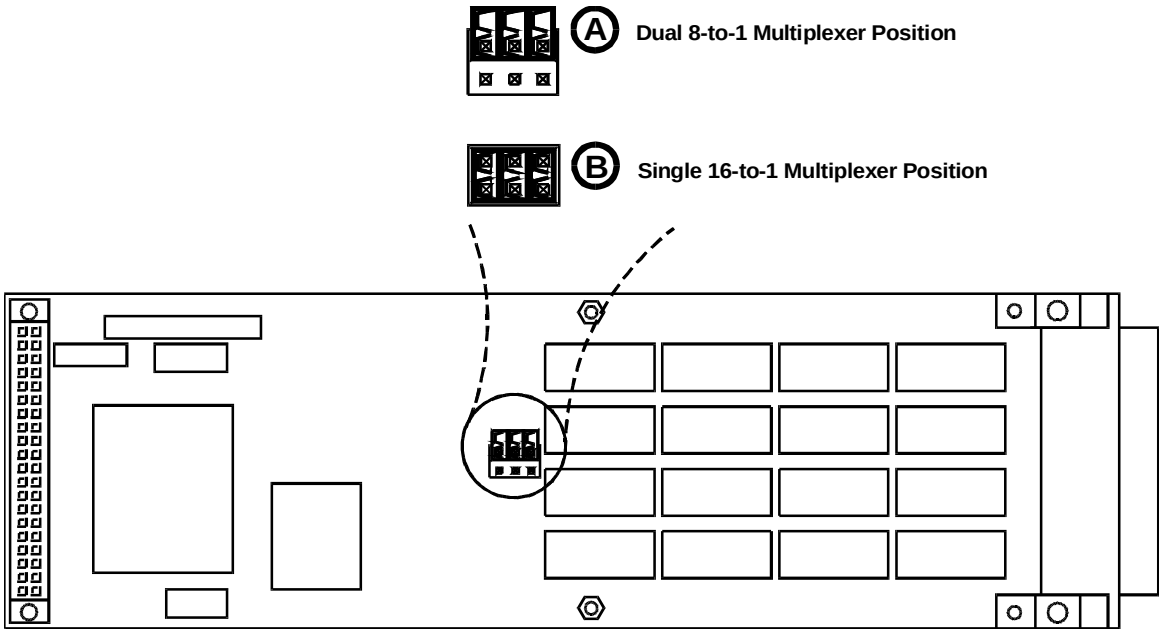


Figure 1-5. Agilent E2272A Jumper Positions

Chapter 2
SCPI Programming

Using This Chapter

This chapter contains SCPI program examples that demonstrate how to read a module ID, perform self-test, and open and close channels. The program examples are written in C language and can be used on any of the three Switch M-Modules. To run one of these programs you must have the Agilent SICL Library, the Agilent VISA Library, an GPIB interface module installed in an external PC, an Agilent E1406 Command Module, and a Switch M-Module installed on the Agilent E2251 Carrier.

Example1: Initial Operation

The following example reads the module ID string, performs module self-test, and displays the results. This program can be used on any of the three Switch M-Modules.

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

    /* Interface address is 9, M-Module secondary address is 3*/
#define INSTR_ADDR "GPIB0::9::3::INSTR"

int main()
{
   ViStatus errStatus;                  /*Status from each VISA call*/
   ViSession viRM;                      /*Resource mgr. session */
   ViSession m_mod;                     /* M-module session  */
   char id_string[256];                 /*ID string*/
   char selftst_string[256];            /*self-test string*/

    /* Open the default resource manager  */
   errStatus = viOpenDefaultRM ( &viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n",errStatus);
      return errStatus;}

    /* Open the M-Module instrument session  */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&m_mod);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n",errStatus);
      return errStatus;}
```

(program continued on next page)

```
    /* Reset the M-Module */
    errStatus = viPrintf(m_mod, "*RST\n");
    if(VI_SUCCESS > errStatus){
        printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
        return errStatus;}

    /* Perform M-Module Self-Test */
    errStatus = viQueryf(m_mod,"*TST?\n","%t",selftst_string);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
        return errStatus;}
    printf("Self Test Result is %s\n",selftst_string);

    /* Query the M-Module ID string */
    errStatus = viQueryf(m_mod,"*IDN?\n","%t",id_string);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
        return errStatus;}
    printf("ID is %s\n",id_string);

    /* Close the M_Module Instrument Session */
    errStatus = viClose (m_mod);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n",errStatus);
        return 0;}

    /* Close the Resource Manager Session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n",errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Closing and Opening Channels

The [ROUTe]:CLOSe<*channel_list*> command closes one or more channels on a Switch M-Module. The [ROUTe]:OPEN<*channel_list*> opens one or more channels.

Note The [ROUTe]: portion of the command is optional syntax and can be omitted. For example, the command [ROUTe]:CLOSE <*channel list*> can be shortened to CLOSE <*channel list*>.

Note **Agilent E2272 Relay Multiplexer Note:** In the dual 8-to-1 mode, ROUTe:CLOSe ensures that only one relay is closed at a time in each multiplexer. In the single 16-to-1 mode, ROUTe:CLOSe ensures that only one relay is closed at a time on the entire module.

Channel Lists

The <*channel list*> parameter in the CLOSE or OPEN command has the form (@*ccnn*), where *cc* is the card number and *nn* is the channel number.

Note The SCPI Driver supports single modules only, therefore *cc* is always 1. To simplify programming, the card number (*cc*) can be eliminated. The remainder of this manual will use the shortened (no card number) channel list format (@*nn*).

You can specify a single channel (@*nn*), use commas to specify multiple channels (@*nn*,*nn*,...), or use a colon to specify a range of channels (@*nn*:*nn*). You can also specify any combination of single channels, multiple channels, and channel ranges. Some examples:

```
CLOS (@00,03)
    !Close channels 00 and 03

OPEN (@01,02,03,10)
    ! Open channels 01, 02, 03 and 10

OPEN (@00:07)
    ! Open channels 00 through 07

CLOS (@02:05,07,09:11)
    ! Close channels 02 through 05, 07, and 09 through 11
```

Note A range of channels (@*nn:nn*) must be specified in ascending order, that is lower channel number on the left, higher number on the right.

Switch M-Module Channel Numbers

- The Agilent E2270's channels are numbered 00 through 15.
- The Agilent E2271's channels aare numbered 00 through 03, 10 through 13, 20 through 23, and 30 through 33.
- The Agilent E2272's channels are numbered 00 through 15.

Example 2: Closing Multiple Channels

The following example closes channel 01 and channels 10 through 13 on a Switch M-Module. The program then opens channels 01 and 11. This program can be used on any of the three Switch M-Modules. The program assumes an M-Module secondary address of 3 and an interface address of 9.

Note **Agilent E2272A Relay Multiplexer Note:** The driver will ensure that only one channel per multiplexer is closed at a time. If multiple channels are specified in a channel list (as in the following program), then only the last channel for each multiplexer specified in the channel list will be closed when the CLOSe command completes (channel 13 in this example).

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>
    /* Interface address is 9, M-Module secondary address is 3*/
#define INSTR_ADDR "GPIB0::9::3::INSTR"

int main()
{
   ViStatus errStatus;                    /*Status from each VISA call*/
   ViSession viRM;                        /*Resource mgr. session */
   ViSession m_mod;                       /* M-module session */

    /* Open the default resource manager */
   errStatus = viOpenDefaultRM ( &viRM);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpenDefaultRM() returned 0x%x\n",errStatus);
      return errStatus;}

    /* Open the M-Module instrument session  */
   errStatus = viOpen(viRM,INSTR_ADDR, VI_NULL,VI_NULL,&m_mod);
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viOpen() returned 0x%x\n",errStatus);
      return errStatus;}

    /* Reset the M-Module */
   errStatus = viPrintf(m_mod, "*RST\n");
   if(VI_SUCCESS > errStatus){
      printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
      return errStatus;}
```

(program continued on next page)

```
    /* Close channels 1 and 10 through 13 on the M-Module */
    errStatus = viPrintf(m_mod,"ROUT:CLOS (@01,10:13)\n");
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
        return errStatus;}

    /* Open channels 1 and 11 on the M-Module */
    errStatus = viPrintf(m_mod,"ROUT:OPEN (@01,11)\n");
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viPrintf() returned 0x%x\n",errStatus);
        return errStatus;}

    /* Close the M_Module Instrument Session */
    errStatus = viClose (m_mod);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n",errStatus);
        return 0;}

    /* Close the Resource Manager Session */
    errStatus = viClose (viRM);
    if (VI_SUCCESS > errStatus) {
        printf("ERROR: viClose() returned 0x%x\n",errStatus);
        return 0;}

    return VI_SUCCESS;
}
```

Chapter 3
SCPI Command Reference

Using This Chapter

This chapter describes the **Standard Commands for Programmable Instruments** (SCPI) command set and the **IEEE-488.2 Common Commands** for the Agilent E2270, E2271, and E2272 Switch M-Modules. This chapter contains the following sections:

Command Fundamentals

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

Common Command Format

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

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

SCPI Command Format

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

```
[ROUTe:]
    CLOSe <channel_list>
```

[ROUTe:] is the root command, CLOSe is second-level command with parameter.

Command Separator

A colon (**:**) always separates one command from the next lower-level command as shown below:

[ROUTe**:**]OPEN?

Abbreviated Commands

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

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

Implied Commands

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

Examine the [ROUTe:] subsystem shown below:

[ROUTe:]
CLOSe <*channel_list*>
CLOSe? <*channel_list*>
OPEN <*channel_list*>
OPEN? <*channel_list*>

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

[ROUTe:]CLOSe (@100:103) *or* CLOSe (@100:103)

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 numbers including optional signs, decimal points, and scientific notation. 123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MIN, MAX, and INF.
Boolean	Represents a single binary condition that is either true or false. ON, OFF, 1, 0.

Linking Commands

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

*RST;CLOS (@01) *or* OPEN (@02);*RST

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

CLOS (@02);:OPEN (@03)

Relay Numbering

All relays numbers have the form *ccnn*. Where *cc* represents the card number and *nn* represents the channel number. The SCPI Driver supports single modules only, therefore *cc* is always 1. To simplify programming, the card number (*cc*) can be eliminated.

- Channel numbering on each Switch M-Module begins with channel 00.
- The Agilent E2270 supports channels 00 through 15.
- The Agilent E2271 supports channels 00 through 03, 10 through 13, 20 through 23, and 30 through 33.
- The Agilent E2272 supports channels 00 through 15.

Channel Lists

The <*channel list*> parameter in the CLOSE or OPEN command has the form (@*ccnn*), where *cc* is the card number and *nn* is the channel number.

Note The SCPI Driver supports single modules only, therefore *cc* is always 1. To simplify programming, the card number (*cc*) can be eliminated.

You can specify a single channel (@*nn*), use commas to specify multiple channels (@*nn*,*nn*,...), or use a colon to specify a range of channels (@*nn*:*nn*). You can also specify any combination of single channels, multiple channels, and channel ranges. Some examples:

```
CLOS (@00,03)
    !Close channels 00 and 03

OPEN (@01,02,03,10)
    ! Open channels 01, 02, 03 and 10

OPEN (@00:07)
    ! Open channels 00 through 07

CLOS (@02:05,07,09:11)
    ! Close channels 02 through 05, 07, and 09 through 11
```

Note A range of channels (@*nn:nn*) must be specified in ascending order, that is lower channel number on the left, higher number on the right.

The DIAGnostic subsystem allows you to set and query the interrupt line used by the M-Module and to run an extended hardware self-test.

Syntax	Description
:DIAGnostic	
:INTerrupt	
:LINE <*intr_line*>	Sets VXI interrupt line on the Agilent E2251 Carrier
:LINE?	Returns VXI interrupt line being used by Agilent E2251 Carrier
:TEST?	Performs an extended hardware self-test

DIAGnostic:INTerrupt:LINE <*intr_line*>

DIAGnostic:INTerrupt:LINE <*intr_line*> sets the VXIbus interrupt line the module will use and allows you to enable/disable interrupts.

Note The VXIbus Interrupt Line is controlled by the VXIbus M-Module carrier NOT by the M-Module. DIAGnostic:INTerrupt:LINE reprograms the Agilent E2251 M-Module carrier. It will work properly only if the M-Module is installed in an Agilent E2251 M-Module carrier.

Parameters

Name	Type	Range	Default	Description
<*intr_line*>	int16	0 through 7	1	VXIbus interrupt line

Comments

- Interrupts for an M-Module are automatically enabled whenever interrupt line 1 through 7 is selected (1 = default). To disable an M-Module from interrupting, set the interrupt line to 0.
- When enabled to interrupt, a Switch M-Module asserts an interrupt whenever a relay close/open operation has been performed ([ROUTe] Subsytem).
- Normally, the interrupt line does not have to be modified.
- If the interrupt line is changed, it may be necessary to re-configure the I/O software and/or Resource Manager on the controlling computer.

Reset Condition

*RST does not affect the interrupt line.

Related Commands

DIAGnostic:INTerrupt:LINE?

Example

```
DIAG:INT:LIN 6          Set the module's interrupt line to 6
```

DIAGnostic:INTerrupt:LINE?

DIAGnostic:INTerrupt:LINE? returns the VXIbus interrupt line being used by the module

Returned Data

Type	Range	Default	Description
int16	0 through 7	1	VXIbus interrupt line

Reset Condition

*RST does not affect the interrupt line.

Related Commands

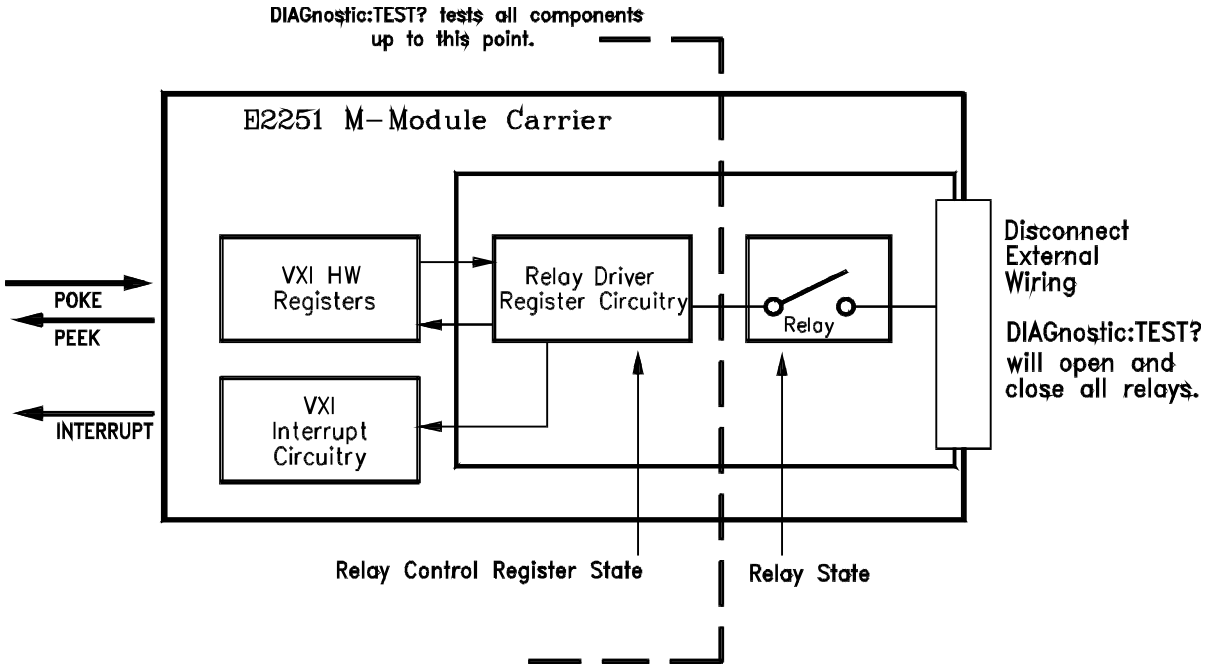
DIAGnostic:INTerrupt:LINE

Example

```
DIAG:INT:LINE?                    Query the interrupt level
```

DIAGnostic:TEST?

DIAGnostic:TEST? performs an extensive relay self-test and returns a numerical and string response indicating the results of the test.



Caution

The extended self-test will open and close each relay in the module. Before performing this test, make sure that external devices will not be affected by these actions. It is recommended that external devices be disconnected from the module while executing DIAGnostic:TEST?.

Returned Data

Type	Description of Numerical Response	Possible Strings Returned
int16, string	0 = self-test passed	"Self test passed"
	1 = ERROR: status register	"Busy, full bit failed. Expect 4, got X" "Busy, stuck at 0. Expect 1, got X" "Init or full bit wrong. Expect X, got X"
	2 = ERROR: register readback	"Readback reg X failed, expect 0, got X"
	3 = ERROR: interrupt	"Interrupt failed VISA error X"

Comments

- DIAG:TEST? opens all relays and then closes each relay, one at a time. It then waits for an interrupt and reads the register to verify that the relay actually closed. If an interrupt does not occur, a 3 is returned indicating a missing interrupt error. If the value that was read back does not match what was set, a 1 is returned indicating that there is a problem somewhere in the relay driver circuitry. Following the self-test, all relays are left in the open state.
- A query response of 0 means that the module is operating properly, a non-zero result means an error occurred.
- The extended self-test **does not** measure the actual relay state position to ensure that it is closed or open, it only queries the state of the Control Register circuitry. It may be possible to pass DIAGnostic:TEST? (return a 0) and still have relay failures.

Reset Condition

*RST does not affect this query.

Related Commands

*TST?

Example

DIAG:TEST? *Perform diagnostic test.*

The display subsystem monitors the instrument state of the module. Display output can be viewed on a terminal connected to the E1406 Command Module's RS-232 port.

Syntax	Description
:DISPlay	
:MONitor	
[:STATe] <*boolean*>	Enables or disables instrument state over RS-232
[:STATe?]	Returns the state of monitor mode(enabled/disabled)

DISPlay:MONitor:[STATe] <*boolean*>

DISPlay:MONitor:[STATe] <*boolean*> enables or disables the monitor display output over RS-232 (Display Terminal Interface).

Monitoring is a feature of SCPI Instrument drivers that allows you to monitor the status of the module while it being controlled remotely (i.e. over GPAgilentIB). Monitoring mode is useful for debugging programs.

When monitor mode is enabled, the bottom two rows of the Display Terminal Interface will contain the instrument specific information.

Parameters

Name	Type	Range	Default	Description
<*boolean*>	boolean	ON, OFF, 0, 1	0	enables or disables monitor mode

Comments

- **Monitoring Instrument State**: Monitor mode is enabled using DISPlay:MONitor:[STATe] ON or DISPlay:MONitor:[STATe] 1. Enabling monitor mode will display the current state of module over the RS-232 port.
- Monitor mode is disabled using DISPlay:MONitor:[STATe] OFF, DISPlay:MONitor:[STATe] 0, by *RST, or by pressing any key from the RS-232 user interface (Display Terminal Interface).
- Enabling monitor mode *slows* operations. If the timing or speed of the module is critical, you should not enable monitoring mode.

Reset Condition

At *RST, DISplay:MONitor:[STATe] is set to 0 (disabled).

Related Commands

DISPlay:MONitor:[STATe]?

Example

```
DISP:MON 1                    Turn the monitor mode on
```

DISPlay:MONitor:[STATe]? returns the state of monitor mode (enabled = 1 or disabled = 0).

Returned Data

Type	Range	Default	Description
boolean	0,1	0	State of Monitor Mode

Reset Condition

At *RST, DISplay:MONitor:[STATe] is set to 0 (disabled).

Related Commands

DISPlay:MONitor:[STATe]

The ROUTe subsystem opens and closes channel relays.

Syntax:	Description
[:ROUTe]	
:CLOSe <*channel list*>	Closes channels specified in <*channel list*>
:CLOSe? <*channel list*>	Returns close state of channels in <*channel list*>
:OPEN <*channel list*>	Opens channels specified in <*channel list*>
:OPEN? <*channel list*>	Returns open state of channels in <*channel list*>

[ROUTe]:CLOSe <*channel list*>

The [ROUTe]:CLOSe command closes the channels specified in the channel list.

Parameters

Agilent E2270 16-Channel Form A Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to close

Agilent E2271 4 x 4 Matrix Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-03, 10-13, 20-23, 30-33	none	List of channels to close

Agilent E2272 Dual 8-to-1 Relay Multiplexer

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to close

Comments

- The <*channel list*> parameter in the CLOSE or OPEN command has the form (@*ccnn*), where *cc* is the card number and *nn* is the channel number. The SCPI Driver supports single modules only, therefore *cc* is always 1. To simplify programming, the card number (*cc*) can be eliminated.

- You can specify a single channel (@*nn*), use commas to specify multiple channels (@*nn*,*nn*,...), or use a colon to specify a range of channels (@*nn*:*nn*). You can also specify any combination of single channels, multiple channels, and channel ranges. For example, to close only channel 3, use

[ROUTe]:CLOSe (@ 03); to close channels 5 and 8, use [ROUTe]:CLOSe (@05,08); to close channels 3 through 7, use [ROUTe]:CLOSe (@ 03:07); to close channels 2 through 5 and 7 through 9, use [ROUTe]:CLOSe (@ 02:05, 07:09).

- A range of channels (@*nn:nn*) must be specified in ascending order, that is lower channel number on the left, higher number on the right.
- The sequence in which multiple channels are closed in a single CLOSe command is not guaranteed. To ensure sequential operation, send multiple CLOSe command with one channel specified per command.
- If any of the channels in the channel list cannot be closed, an execution error is reported.

Additional Agilent E2272 Dual 8-to-1 Relay Multiplexer Comments

- The Agilent E2272 SCPI Driver will open all channels in a multiplexer before closing any relays specified in the channel list. This provides a “break before make” switching operation.
- When the Agilent E2272A is configured as **Dual 8-to-1 multiplexers**, each multiplexer is independent. This means that channels are opened and closed on a per multiplexer basis. For example, executing [ROUTe]:CLOSe (@ 12), will open all channels in Multiplexer B (open channels 8 through 15) and then close channel 12. Channels 0 through 7 (Multiplexer A) are not affected.
- When the Agilent E2272A is configured as a **Single 16-to-1 multiplexer**, every channel is part of the same multiplexer. This means that closing any channel will first open all other channels on the module. For example, executing [ROUTe]:CLOSe (@ 12), will open all channels on the module (open channels 0 through 15) and then close channel 12
- The SCPI driver ensures that only one channel per multiplexer is closed at a time. If multiple channels are specified in a channel list, then only the last channel of each multiplexer specified in the channel list will be closed when the [ROUTe]:CLOSe command completes.
- Multiple channels can be closed using register programming.

Reset Condition

*RST will open all relays.

Error Conditions

The following are some of the most common error conditions relating to channel lists. Error numbers and corresponding error messages can be found using SYSTem:ERRor? query.

Number	Message	Probable Cause
-222	“Data out of range”	An invalid channel range was specified. One or more of the range channel elements is out or range. Valid ranges are from 0-15 or 100-115. Both channel elements in the range need to be of the same type. For example: (@4:6) specifies channels four, five, and six. (@1:115) will generate an error, since you can not mix cc types.
2000	“Invalid card number”	A channel element was specified using the *ccnn* format. And *cc* was not 00 or 01.
2001	“Invalid channel number”	A channel element is improperly specified. Valid channel numbers are 0-15 or 100-115.
2011	“Empty channel list”	No channel element was specified in the channel list.

Related Commands

[ROUTe]:CLOSe?, [ROUTe]:OPEN

Examples

CLOS (@00,03)
!Close channels 00 and 03

CLOS (@02:05,07,09:11)
! Close channels 02 through 05, 07, and 09 through 11

[ROUTe]:CLOSe? *<channel list>*

The [ROUTe]:CLOSe? returns the state of the channel(s) in the channel list. A 1 or 0 is returned for each channel in the list--in the same order as was specified in the list. A response of 1 means the channel is closed and a 0 means the channel is open.

Parameters

Agilent E2270 16-Channel Form A Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to query

Agilent E2271 4x4 Matrix Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-03, 10-13, 20-23, 30-33	none	List of channels to query

Agilent E2272 Dual 8-to-1 Relay Multiplexer

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to query

Returned Data

Type	Range	Default	Description
string	0,1	none	A string containing a comma separated array of 0's and 1's that corresponds to the list of channels specified in the <*channel list*> input parameter. A "0" indicates the channel is open. A "1" indicates the channel is closed.

Comments

- Channel elements have the form *ccnn*, where *cc* = card number (01) and *nn* = channel number (00 - 15). Since the SCPI driver does not support multiple cards you can omit the card number and specify only the channel number. To be consistent with other Agilent Switch modules it is permissible to specify a card number of 1.
- To query a single channel, use [ROUTe]:CLOSe? (@ nn); for multiple channels use [ROUTe]:CLOSe? (@ nn, nn, …); for sequential channel, use [ROUTe]:CLOSe? (@ nn:nn); for groups of sequential channels, use [ROUTe]:CLOSe? (@ nn:nn, nn:nn); or any combination.
- The instrument driver returns a 1 or 0 for each channel in the list, in the same order that the list was specified. A response of 1 means the channel is closed and a 0 means the channel is open. *Note: The response of the [ROUTe]:CLOSe? query is the opposite of [ROUTe]:OPEN? query.*

Error Conditions

Refer to the [ROUTe]:CLOSe command for a list of common error conditions related to channel lists. Error numbers and corresponding error messages can be found using SYSTem:ERRor? query.

Example

```
CLOS? (@00,03)          Query channels 0 & 3.
```

[ROUTe]:OPEN <channel list>

The [ROUTe]:OPEN command opens the channels specified in the channel list.

Parameters

Agilent E2270 16-Channel Form A Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to open

Agilent E2271 4x4 Matrix Switch

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-03, 10-13, 20-23, 30-33	none	List of channels to open

Agilent E2272 Dual 8-to-1 Relay Multiplexer

Name	Type	Range	Default	Description
<*channel list*>	channel list	00-15	none	List of channels to open

Comments

- Channel elements have the form *ccnn*, where *cc* = card number (01) and *nn* = channel number (00 - 15). Since the SCPI driver does not support multiple cards you can omit the card number and specify only the channel number. To be consistent with other Agilent Switch modules it is permissible to specify a card number of 1.
- To open a single channel, use [ROUTe]:OPEN (@ nn); for multiple channels use [ROUTe]:OPEN (@ nn, nn, …); for sequential channels, use [ROUTe]:OPEN (@ nn:nn); for groups of sequential channels, use [ROUTe]:OPEN (@ nn:nn, nn:nn); or any combination.
- The sequence in which multiple channels are opened in a single OPEN command is not guaranteed. To ensure sequential operation, send multiple OPEN command with only one channel specified per command.
- If any of the channels in the channel list cannot be opened, an execution error is reported.

Reset Condition

*RST will open all relays.

Error Conditions

Refer to the [ROUTe]:CLOSe command for a list of common error conditions related to channel lists. Error numbers and corresponding error messages can be found using SYSTem:ERRor? query.

Related Commands

[ROUTe]:OPEN?, [ROUTe]:CLOSe

Examples

```
OPEN (@01,02,03,10)
    ! Open channels 01, 02, 03 and 10

OPEN (@00:07)
    ! Open channels 00 through 07
```

The [ROUTe]:OPEN? query returns the state of the channel(s) in the channel list. A 1 or 0 is returned for each channel in the list--in the same order as was specified in the list. A response of 1 means the channel is open and a 0 means the channel is closed.

Parameters

Agilent E2270 16-Channel Form A Switch

Name	Type	Range	Default	Description
<channel list>	channel list	00-15	none	List of channels to query

Agilent E2271 4x4 Matrix Switch

Name	Type	Range	Default	Description
<channel list>	channel list	00-03, 10-13, 20-23, 30-33	none	List of channels to query

Agilent E2272 Dual 8-to-1 Relay Multiplexer

Name	Type	Range	Default	Description
<channel list>	channel list	00-15	none	List of channels to query

Returned Data

Type	Range	Default	Description
string	0,1	none	A string containing a comma separated array of 0's and 1's that corresponds to the list of channels specified in the *<channel list>* input parameter. A "0" indicates the channel is closed. A "1" indicates the channel is open.

Comments

- Channel lists have the form "(@ ...)", where the "..." is replaced a comma separated list of channel elements. Channel lists can also include a range of channel elements. This is specified by separating the starting channel elements and ending channel elements with a colon ":". You can combine individual channels and ranges.

- Channel elements have the form *ccnn*, where *cc* = card number (01) and *nn* = channel number (00 - 15). Since the SCPI driver does not support multiple cards you can omit the card number and specify only the channel number. To be consistent with other Agilent switch modules it is permissible to specify a card number of 1.

- To query a single channel, use [ROUTe]:OPEN? (@ nn); for multiple

channels use [ROUTe]:OPEN? (@ nn, nn, …); for sequential channel, use [ROUTe]:OPEN? (@ nn:nn); for groups of sequential channels, use [ROUTe]:OPEN? (@ nn:nn, nn:nn); or any combination.

- A 1 or 0 is returned for each channel in the list--in the same order specified in the list. A response of 1 means the channel is open and a 0 means the channel is closed. *Note: The response of the [ROUTe]:OPEN? query is the opposite of [ROUTe]:CLOSe? query.*

Error Conditions

Refer to the [ROUTe]:CLOSe command for a list of common error conditions related to channel lists. Error numbers and corresponding error messages can be found using SYSTem:ERRor? query.

Related Commands

[ROUTe]:OPEN, [ROUTe]:CLOSe

Example

```
OPEN? (@00,02)
```

Querying the states of channels 0 & 2.

SCPI uses four status groups - the Status Byte, the Standard Event status group, the Operation status group, and the Questionable Data status group.

Note This subsystem is included in the Switch M-Modules SCPI Driver for compatibility reasons only. None of the events in the STATus:OPERation or STATus:QUEStionable register are used by the Switch M-Modules.

Each status group consists of a condition register, transition filters, event register, and enable register. The STATus subsystem controls those commands and queries that affect the Operation status group and the QUEStionable status group.

Syntax:	**Description**
:STATus	
:OPERation	
:CONDition?	Returns condition register of operation status group
:ENABle <*mask*>	Sets enable register of operation status group
:ENABle?	Returns enable register of operation status group
:EVENt?	Returns event register of operation status group
:PRESet	Clears operation & questionable enable registers
:QUEStionable	
:CONDition?	Returns condition register of questionable status group
:ENABle <*mask*>	Sets enable register of questionable status group
:ENABle?	Returns enable register of questionable status group
:EVENt?	Returns event register of questionable status group

The SYSTem subsystem allows you to query error conditions and the SCPI compliance version.

Syntax:	Description
:SYSTem	
:ERRor?	Returns error number and message from error queue
:VERSion?	Returns SCPI Version compliance year

SYSTem:ERRor?

SYStem:ERRor? returns the error number and corresponding error message from the error queue.

Returned Data

Type	Range	Default	Description
int16	-32768 through 32767	none	Error number
string			Error message

Comments

- The response format is: error_number, “error description string”.
- **Error Numbers/Message in the Error Queue:** Each error generated by this instrument driver stores an error number and corresponding error message in the error queue. The error message can be up to 255 characters long.
- **Clearing the Error Queue:** An error number/message is removed from the queue each time the SYSTem:ERRor? command is sent. The errors are cleared on a first-in, first-out basis. When all errors have been read and the queue is empty, SYSTem:ERRor? returns 0, “No error”. To clear all error number/messages in the queue, execute the *CLS command.
- **Maximum Error Numbers/Message in the Error Queue:** The queue holds a maximum of 30 error numbers/messages. If the queue overflows, the last error number/message in the queue is replaced by -350, “Too many errors”. The least recent error number/message remains in the queue and the most recent are discarded.

Reset Condition

*RST does not affect the error queue, use *CLS to clear the error queue.

Related Commands

*CLS

Example

```
SYST:ERR?                    Query the error queue.
```

SYStem:VERSion? returns the M-Module's SCPI version.

Returned Data

Type	Range	Default	Description
string	"1990.0"	none	Error message

Example

```
SYST:VER?
```

Returned value is the version number of the SCPI driver.

These commands are defined in the IEEE 488.2 standard and are found on most SCPI instruments.

*CLS

*CLS clears all status groups and empties the error queue.

Comments

- All event registers are cleared. This includes the Standard Event Status register, the OPERation event status register, and the QUEStionable data status register.
- *CLS does not affect the enable bits in any of the status register groups. (The SCPI command STATus:PRESet does clear the Operation Status Enable register and the Questionable Data Enable registers).
- *CLS disables the Operation Complete (*OPC) and the Operation Complete query (*OPC?).
- Use *CLS to clear the error queue. It typically follows *RST to reset the module to a know state.

Reset Condition *RST does not affect the status system

Related Commands STATus:OPERation:EVENt?, STATus:QUEStionable:EVENt?, *ESR?

*ESE <*mask*>

*ESE <*mask*> command sets the value of the enable register in the Standard Event status group.

The standard event status group provides that status of common instrument events including synchronization (Operation Complete) and Errors (Parser, Execution, Command Errors, and Instrument Dependent).

The enable register specifies which bits in the event register can generate a summary bit. The instrument logically ANDs corresponding bits in the event and enable registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are, in turn, recorded in another register. The standard event status summary bit is recorded in the Status Byte. Enable registers are read-write. Enable registers are not affected by *CLS (Clear status). Querying enable registers does not affect them.

The following table describes each bit in the Standard Event status group:

Bit	Description	Decimal Value
0	Operation Complete (OPC)	1
1	Request Control (RQC)	2
2	Query Error (QYE)	4
3	Instrument Dependent (DDE)	8
4	Execution Error (EXE)	16
5	Command Error (CME)	32
6	User Request (URQ)	64
7	Power On (PON)	128

Parameter

Name	Type	Range	Default	Description
<*mask*>	int16	0 - 255	none	Bit mask indicating which enable bits are set (1) or cleared (0) for the Standard Event status group.

Comments

- This query is provided only for SCPI Compliance

Reset Condition

*RST does not affect the status system

Related Commands

STATus:OPERation:ENABle, STATus:QUEStionable:ENABle, *ESE?

*ESE?

*ESE? query returns the value of the enable register in the Standard Event status group.

The standard event status group provides that status of common instrument events including synchronization (Operation Complete) and Errors (Parser, Execution, Command Errors, and Instrument Dependent).

The enable register specifies which bits in the event register can generate a summary bit. The instrument logically ANDs corresponding bits in the event and enable registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are, in turn, recorded in another register. The standard event status summary bit is recorded in the Status Byte. Enable registers are read-write. Enable registers are not affected by *CLS (Clear status). Querying enable registers does not affect them.

The following table describes each bit in the Standard Event status group:

Bit	Description	Decimal Value
0	Operation Complete (OPC)	1
1	Request Control (RQC)	2
2	Query Error (QYE)	4
3	Instrument Dependent (DDE)	8
4	Execution Error (EXE)	16
5	Command Error (CME)	32
6	User Request (URQ)	64
7	Power On (PON)	128

Returned Data

Type	Range	Default	Description
int16	0 - 255	none	Bit mask indicating which enable bits are set (1) or cleared (0) for the Standard Event status group.

Comments

- This query is provided only for SCPI Compliance

Reset Condition

*RST does not affect the status system

Related Commands

STATus:OPERation:ENABle?, STATus:QUEStionable:ENABle?, *ESE

*ESR? query returns the value of the event register for the Standard Event status group.

The standard event status group provides that status of common instrument events including synchronization (Operation Complete) and Errors (Parser, Execution, Command Errors, and Instrument Dependent).

The event register latches transition events from the condition register as specified by the transition filter. Only the positive transition filter is active in the module, this means that a transition event will occur when a condition makes a transition from a low to a high state. Bits in the event register are latched, and once set, they remain set until cleared by a *ESR? query or *CLS (clear status). There is no buffering; so while an event bit is set, subsequent events corresponding to that bit are ignored. Event registers are read only.

The following table describes each bit in the Standard Event status group:

Bit	Description	Decimal Value
0	Operation Complete (OPC)	1
1	Request Control (RQC)	2
2	Query Error (QYE)	4
3	Instrument Dependent (DDE)	8
4	Execution Error (EXE)	16
5	Command Error (CME)	32
6	User Request (URQ)	64
7	Power On (PON)	128

Returned Data

Type	Range	Default	Description
int16	0 - 255	none	Bit mask indicating which enable bits are set (1) or cleared (0) for the Standard Event status group.

Reset Condition

*RST does not affect the status system. Use *CLS to clear all event registers in the status system.

Related Commands

STATus:OPERation:EVENt?, STATus:QUEStionable:EVENt?

*IDN?

*IDN? query returns the module's identification string.

Returned Data

Type	Range	Default	Description
string	none	none	Module identification string containing the revision of the SCPI driver.

Comments

- The identification string returns four field (separated by commas)

1. Manufacturer
2. Model Number and, for E2272A only, Mode (either dual 8x1 or single 16x1)
3. Serial Number (returns 0, if not available)
4. Firmware Revision (returns 0 if not available)

- The identification string is less than 255 characters.

Note

The firmware revision is the revision of the SCPI driver. This is the only indication of which version of the driver is installed.

*OPC

*OPC command will cause the OPC event to occur in the Standard Event status group when all pending operations are complete.

Comments

- By enabling this bit to be reflected in the Status Byte Register (sending *ESE 1), you can ensure synchronization between the instrument and an external computer or between multiple instruments.

Related Commands

*ESE, *OPC?, *WAI

*OPC?

*OPC? Query returns a 1 when all pending operations are complete.

Returned Data

Type	Range	Default	Description
int16	1	none	Returns 1 when all pending operations are complete

Comments

- By requiring your computer to read this response before continuing program execution, you can ensure synchronization between one or more instruments

and the computer.

- This query does not affect the OPC bit in the Standard Status Event status group. In order to set this event use *OPC.

Related Commands *OPC, *WAI

*RCL <*state*>

This command will recall a previously saved state of the instrument.

Parameter

Name	Type	Range	Default	Description
<*state*>	int16	0 - 9	none	number used to describe where the instrument state will be recalled.

Comments

- Ten different states can be recalled. They are numbered from 0 through 9.
- Instrument state can be stored using the save (*SAV) command.

Reset Condition Instrument state storage (*SAV & *RCL) is unchanged by reset (*RST)

Related Commands *SAV

*RST

*RST will reset the module to a known state.

Comments

- *RST opens all M-Module relays
- The VXIbus Interrupt line (DIAGnostic:INTerrupt:LINE) is not affect by the *RST command.
- The status system is unaffected by the *RST command. Use *CLS to clear the status system.
- The save (*SAV) and recall (*RCL) states are not affected by the *RST command.

Related Commands *CLS

*SAV <*state*>

*SAV command will save the current state of the instrument.

Parameter

Name	Type	Range	Default	Description
<*state*>	int16	0 - 9	none	number used to describe where the instrument state will be saved.

Comments

- Ten different states can be saved. They are numbered from 0 through 9.
- The instrument can be returned to a saved state using the recall (*RCL) command.

Reset Condition

Instrument state storage (*SAV & *RCL) is unchanged by reset (*RST)

Related Commands

*RCL

*SRE <*mask*>

*SRE <*mask*> command sets the value of the enable register in the Status Byte status group.

The Status Byte is used to summarize information from all other status groups.

The enable register specifies which bits in the event register can generate a summary bit. The instrument logically ANDs corresponding bits in the event and enable registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are, in turn, recorded in another register. The standard event status summary bit is recorded in the Status Byte. Enable registers are read-write. Enable registers are not affected by *CLS (Clear status). Querying enable registers does not affect them.

The following table describes each bit in the Status Byte status group:

Bit	Description	Decimal Value
0	Instrument Dependent	1
1	Instrument Dependent	2
2	Instrument Dependent	4
3	Summary bit from the Questionable Data status group (QUE)	8
4	Messages available in the Output Queue (MAV)	16
5	Summary bit from the Standard Event status group (ESB)	32
6	Service Request (RQS)	64
7	Summary bit from the Standard Operation status group (OPR)	128

Parameters

Name	Type	Range	Default	Description
<*mask*>	int16	0 - 255	none	Bit mask indicating which enable bits are set (1) or cleared (0) for the Status Byte status group.

Comments

- This query is provided only for SCPI Compliance

Reset Condition

*RST does not affect the status system

Related Commands

STATus:OPERation:ENABle, STATus:QUEStionable:ENABle, *ESE?

*SRE?

*SRE? query returns the value of the enable register in the Status Byte status group.

The Status Byte is used to summarize information from all other status groups.

The enable register specifies which bits in the event register can generate a summary bit. The instrument logically ANDs corresponding bits in the event and enable registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are, in turn, recorded in another register. The standard event status summary bit is recorded in the Status Byte. Enable registers are read-write. Enable registers are not affected by *CLS (Clear status). Querying enable registers does not affect them.

The following table describes each bit in the Status Byte status group:

Bit	Description	Decimal Value
0	Instrument Dependent	1
1	Instrument Dependent	2
2	Instrument Dependent	4
3	Summary bit from the Questionable Data status group (QUE)	8
4	Messages available in the Output Queue (MAV)	16
5	Summary bit from the Standard Event status group (ESB)	32
6	Service Request (RQS)	64
7	Summary bit from the Standard Operation status group (OPR)	128

Returned Data

Type	Range	Default	Description
int16	0 - 255	none	Bit mask indicating which enable bits are set (1) or cleared (0) for the Status Byte status group.

Comments

- This query is provided only for SCPI Compliance

Reset Condition

*RST does not affect the status system

Related Commands

STATus:OPERation:ENABle?, STATus:QUEStionable:ENABle?, *ESE

*STB?

*STB? query returns the value of the event register for the Status Byte status group.

The Status Byte is used to summarize information from all other status groups.

The event register latches transition events from the condition register as specified by the transition filter. Only the positive transition filter is active in the module, this means that a transition event will occur when a condition makes a transition from a low to a high state. Bits in the event register are latched, and once set, they remain set until cleared by a *STB? query or *CLS (clear status). There is no buffering; so while an event bit is set, subsequent events corresponding to that bit are ignored. Event registers are read only.

The following table describes each bit in the Status Byte status group:

Bit	Description	Decimal Value
0	Instrument Dependent	1
1	Instrument Dependent	2
2	Instrument Dependent	4
3	Summary bit from the Questionable Data status group (QUE)	8
4	Messages available in the Output Queue (MAV)	16
5	Summary bit from the Standard Event status group (ESB)	32
6	Service Request (RQS)	64
7	Summary bit from the Standard Operation status group (OPR)	128

Returned Data

Type	Range	Default	Description
int16	0 - 255	none	Bit mask indicating which events are set (1) or cleared (0) in the Status Byte status group.

Comments

- The Status Byte can be read using either *STB? or by a serial poll. There are some subtle differences between *STB? and serial polling. You can use either method to read the state of bits 0-5 and bit 7. Bit 6 is treated differently depending on whether you use *STB? or serial poll. In general, use serial polling inside interrupt service routines, not a *STB?.
- This query is provided only for SCPI Compliance

Reset Condition *RST does not affect the status system

Related Commands *SRE

*TST?

*TST? query will return the result of running the self-test routine. T

Returned Data

Type	Range	Default	Description
int16	0,1,2	none	Result of running the self-test. 0 = SUCCESS: self-test passed. 1 = ERROR: driver register images does not match hardware image 2 = ERROR: interrupt not detected

Comments

- *TST? will not change the state of any relays. *TST tests only the Module Control circuitry--*TST? may pass even though there may be a hardware problem. A more comprehensive self-test which does change relay positions can be performed using DIAGnostic:TEST?
- *TST? can return a 1, if you are register programming the module and using the SCPI driver at the same time.

Related Commands DIAGnostic:TEST?

*WAI

*WAI command will not return until all pending operations have completed.

Comments

- This command is identical to *OPC? except that it does not return a value.

Related Commands *OPC?

Keyword	Parameters	Notes	Description
:DIAGnostic			
:INTerrupt			
:LINE	<*intr_line*>		Changes VXI interrupt line
:TEST?		[query only]	Performs extended hardware self-test
:DISPlay			
:MONitor			
[:STATe]	<*boolean*>		Displays instrument state over RS-232
[:ROUTe]			
:CLOSe	<*channel list*>		Closes relays
:OPEN	<*channel list*>		Opens relays (for Agilent E2270 & E2271 only)
:STATus			
:OPERation			
:CONDition?		[query only]	OPERation status group conditions.
:ENABle	<*mask*>		Enable mask for OPERation status
[:EVENt?]		[query only]	OPERation status group events
:PRESet			Clears OPER & QUES enable registers
:QUEStionable			
:CONDition?		[query only]	QUEStionable status group conditions
:ENABle	<*mask*>		Enable mask for QUEStionable status
[:EVENt?]		[query only]	QUEStionable status group events
:SYSTem			
:ERRor?		[query only]	Returns error numbers and messages
:VERSion?		[query only]	Returns SCPI Version number

Syntax:	Description
*CLS	Clear Status System
*ESR?	Return events of the standard event status group
*ESE <*mask*>	Sets enable register of the standard event status group
*ESE?	Returns enable register of the standard event status group
*IDN?	Return the SCPI Identification String
*OPC	Sets the operation complete bit when pending events finish
*OPC?	Returns 1 when pending events are finished
*SAV <*state*>	Saves the instrument state
*SRE <*mask*>	Sets the service request enable mask for the Status Byte
*SRE?	Returns the service request enable mask for the Status Byte
*STB?	Returns the contents of the status byte
*RCL <*state*>	Recalls the instrument state
*RST	Sets the module to a known state
*TST?	Returns the self-test result
*WAI	Waits for all pending operations to complete

Chapter 4
Register Programming

Introduction

This chapter describes how to program the Switch M-Modules at the register level in an Agilent E2251 Carrier installed in a VXIbus mainframe. Register programming is recommended only if you are unable to use the module's higher-level VXI*plug&play* driver. For information on using the VXI*plug&play* driver, refer to the on-line help.

Block Diagram Description

In order to register program a Switch M-Module, it is important to understand its operation at the block diagram level. The block diagram is identical for all three Switch M-Modules. All three have identical register maps and identical row and column matrix drive schemes. The only conceptual differences are the three different switch topologies (form A, multiplexer, matrix).

Figure 4-1 on page 59 shows the Switch M-Modules block diagram and the following paragraphs describe each block.

Module Control

This block contains the logic for the module including all registers, FIFO and FIFO control and interrupt control.

FIFO Structure

The FIFO (First-In-First-Out) structure allows multiple writes to the module to be stacked-up. This helps reduce interrupt overhead by allowing an interrupt only after the completion of the last relay operation in a sequence of up to eight operations. Eight was chosen because it allows at least one *open* and one *close* to each of the four relay rows--allowing a complete change of all relay states.

If the M-Module is enabled to interrupt, it asserts the INTn line on the M-Module interface to the Carrier when the last commanded relay operation in the FIFO has completed. For example, if relays in only one row were instructed to move, the module asserts an interrupt after that one row has been driven. If four rows were instructed to move (four writes to the FIFO--see Note below), then the module asserts an interrupt only after the completion of the fourth operation.

Note The module asserts an interrupt after the relay drive time is complete (relay drive timer) and no other operations have been stored in FIFO. The above example assumes the four writes are stored in FIFO one after the other with very little time between the writes. If, in the above example, the amount of time between writes is greater than the relay drive time (8 msec), the module would actually interrupt four times--one interrupt after driving each relay.

ID EEPROM

The EEPROM holds sixty-four 16-bit words of M-Module ID data and VXI M-Module data. Refer toTable 4-24, “ID EEPROM Contents,” on page 75 for EEPROM contents.

Row and Column Drivers

All of the Switch M-Modules use a matrix drive scheme (rows and columns) in which a maximum of four of the relays (one row) can be operated at any one time. An on-board timer (part of Module Control block) ensures the relay coils have been driven long enough for the contacts to move and settle.

The Row Driver block translates the **ROW_SET(4:1)** and **ROW_RESET(4:1)** command lines from the Module Control block into bipolar and tri-state capable buffered drive signals. The **ROW_DR(4:1)** signals provide either current source from the **+5VDR** supply (relay set), current sink to ground (relay reset), or tri-stated output (both current-source and current-sink off). Each output is tri-stated whenever that particular row is not being driven.

The Column Driver block translates the **COL(4:1)** command lines from Module Control into the bipolar buffered drive signals, **COL_DR(4:1)**. The **COL_DR(4:1)** signals provide either current source from the **+5VDR** supply (relay reset) or current sink to ground (relay set).

Driver Power Switch

This block removes all power from the Row and Column Driver circuitry except when needed to move relays. This FET switch is open at power-up to prevent any relay contact movement until register writes cause drive-power to be applied.

Relay Coils

This block contains the 16 relay coils arranged as a 4x4 matrix. To close a relay, a ROW_DR line sources current while a COL_DR line sinks current to ground. To open a relay, a COL_DR line sources current while a ROW_DR line sinks current to ground. Refer to Figures 1-1, 1-2, and 1-3 for relay switching schematics.

Reset and Power Conditioning

This block filters +5V power to produce VCC power (+5V) for logic and isolates the various grounds used by the module. This block also processes the /RESET signal from the Carrier Interface and monitors power to produce

the /RST reset signal for the module.

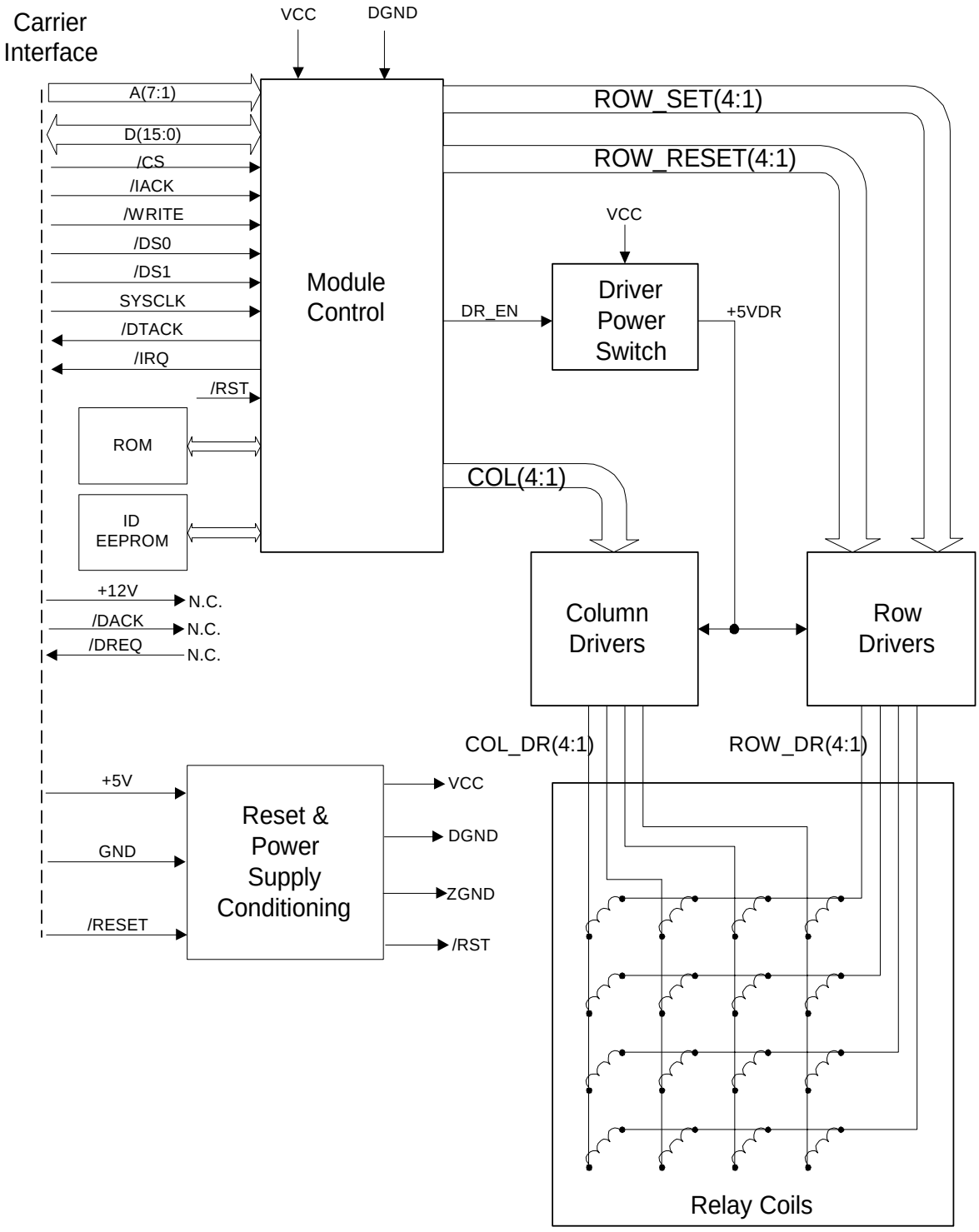


Figure 4-1. Switch M-Modules Block Diagram

Register Addressing in the VXIbus Environment

Logical Address

Each module in a VXIbus (VXI) system, whether VXI or M-Module, must have a unique logical address. The Agilent E2251 Carrier provides a logical address for each installed M-Module. Refer to the Agilent E2251 Installation and Wiring Manual for details (if you are using a different carrier, refer to that carrier's documentation for register-based addressing information).

A16/A24 Memory Mapping

The VXI Specification allows for only 64 bytes of address space in A16 memory. However, the M-Module Specification defines 256 bytes of address space. To resolve this conflict, the Agilent E2251 Carrier provides two memory segments for each installed M-Module. The first is in the VXI A16 memory space and contains the standard VXI registers. The second memory segment is in the VXI A24 memory space and contains all other M-Module registers (these registers are described starting on page 68). Figure 4-2 shows the A16/A24 mapping for a typical M-Module.

Note

The M-Module's ID word (from the ID EEPROM) is mapped into the VXI Manufacturer ID Register at address 00_h and the M-Module's VXI Device Type word is mapped into the VXI Device Type Register at address 02_h

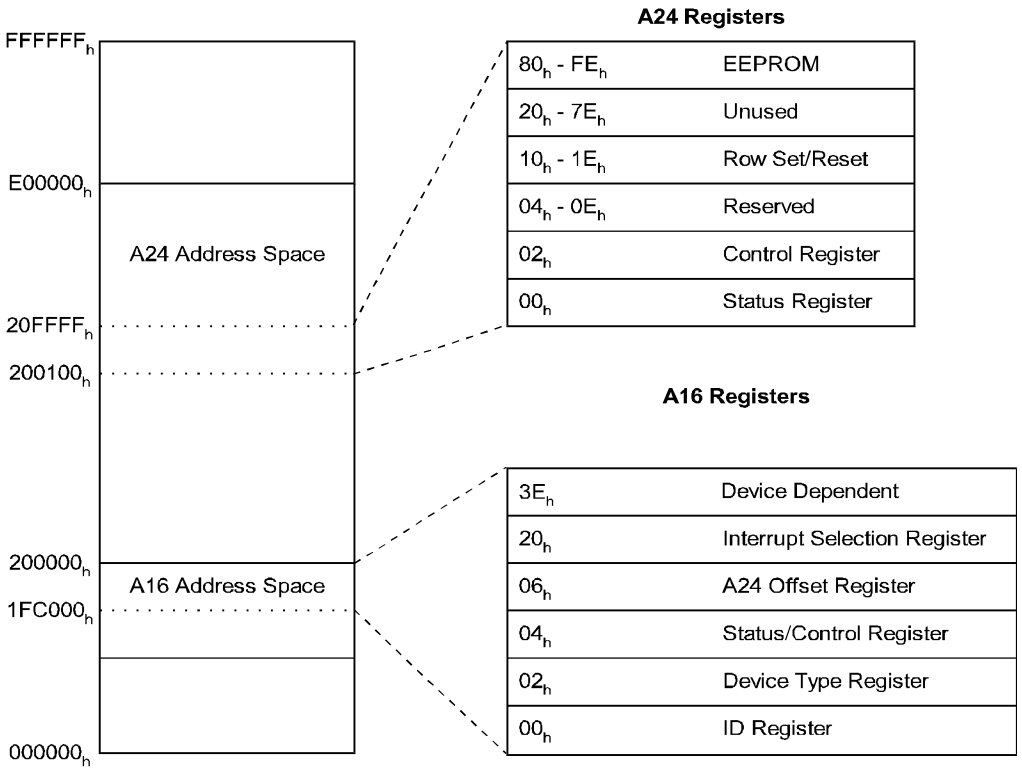


Figure 4-2. A16/A24 Register Mapping

Determining a Module's A16 Base Address

To access a register in A16 memory, you must specify a hexadecimal or decimal register address. This address consists of a base address plus a register offset. The A16 base address depends on whether or not you are using an Agilent E1406 Command Module.

When <u>using</u> an Agilent E1406 Command Module, the base address is computed as:

$1FC000_h + (LADDR_h \cdot 40_h)$
or (decimal)
2,080,768 + (LADDR · 64)

Where:
$1FC000_h$ (2,080,768) is the A16 starting address
LADDR is the module's logical address
40_h (64) is the number of address bytes allocated per module

For example, if the M-Module has a logical address of 78_h (120) the A16 base address becomes:

$1FC000_h + (78_h \cdot 40_h) = 1FC000_h + 1E00_h = 1FDE00_h$
or (decimal)
2,080,768 + (120 · 64) = 2,080,768 + 7680 = 2,088,448

When an Agilent E1406 Command Module is <u>not</u> part of your system, the base address is computed as:

$C000_h + (LADDR_h \cdot 40_h)$
or (decimal)
49,152 + (LADDR · 64)

Where:
$C000_h$ (49,152) is the A16 starting address
LADDR is the module's logical address
40_h (64) is the number of address bytes allocated per module

For example, if the M-Module has a logical address of 78_h (120) the A16 base address becomes:

$C000_h + (78_h \cdot 40_h) = C000_h + 1E00_h = DE00_h$
or (decimal)
49,152 + (120 · 64) = 49,152 + 7680 = 56,832

Addressing A16 Registers

As shown in Figure 4-2 on page 60, VXI registers for an M-Module are mapped into A16 address space. To access one of these registers, add the A16 base address to the register offset. For example, an M-Module's VXI Status/Control Register has an offset of 04_h. To access this register (assuming the system does not have an Agilent E1406 Command Module), use the register address:

$1FDE00_h + 04_h = 1FDE04_h$
or (decimal)
2,088,488 + 4 = 2,088,452

Addressing A24 Registers

As shown in Figure 4-2 on page 60, most of the registers for an M-Module are mapped into A24 address space. To access one of these registers:

1. Obtain the A24 base address by reading the VXI Offset Register (06_h) in A16 memory.

2. Add the A24 base address to the register offset (see Table 4-7. on page 68).

For example, if the A24 base address is 200100_h, to access a Switch M-Module's Row 0 Set Register (10_h):

$200100_h + 10_h = 200110_h$
or (decimal)
2,097,408 + 16 = 2,097,424

Program Example

The following C language program can be used with any of the Switch M-Modules and demonstrates how to program at the register level. The program resets (opens) all relays and then closes channels 00 and 02. This program was written and tested in Microsoft Visual C++ but should compile with any standard ANSI C compiler.

To run this program you must have the Agilent SICL Library, the Agilent VISA Library, an GPIB interface module installed in your PC, and an Agilent E1406 Command Module.

```
#include <visa.h>
#include <stdio.h>
#include <stdlib.h>

ViSession defaultRM,m_mod;
void err_handler();

void main(void)
{
    /*ID & device type registers*/
    unsigned short id_reg, dt_reg;

    /* create and open a device session */
    ViStatus err;
    viOpenDefaultRM (&defaultRM);
    /* Command Module is GPIB-VXI0, M-Module logical address is 24 */
    err = viOpen (defaultRM,"GPIB-VXI0::24",VI_NULL,VI_NULL,&m_mod);
    if(err < VI_SUCCESS)
    {
    printf("Unable to open session ");
    return;
    }

    /* read and print the M-Module's ID and Device Type Registers */
    err = viIn16(m_mod,VI_A16_SPACE,0x00,&id_reg);
    if (err < VI_SUCCESS) err_handler(m_mod,err);

    err = viIn16(m_mod,VI_A16_SPACE,0x02,&dt_reg);
    if (err < VI_SUCCESS) err_handler(m_mod,err);

    printf("ID register = 0x%4X\n", id_reg);
    printf("Device Type register = 0x%4X\n", dt_reg);

    /*Enable driver power to relays*/
    err = viOut16(m_mod,VI_A24_SPACE,0x02,0x08);
    if (err < VI_SUCCESS) err_handler(m_mod,err);

    /*Reset all relays by writing zeros to row reset registers*/
    err = viOut16(m_mod,VI_A24_SPACE,0x12,0x0);
    err = viOut16(m_mod,VI_A24_SPACE,0x16,0x0);
    err = viOut16(m_mod,VI_A24_SPACE,0x1A,0x0);
    err = viOut16(m_mod,VI_A24_SPACE,0x1E,0x0);
```

```
    if (err < VI_SUCCESS) err_handler(m_mod,err);

    /*Close Channels 00 and 02*/
    err = viOut16(m_mod,VI_A24_SPACE,0x10,0x05);
    if (err < VI_SUCCESS) err_handler(m_mod,err);

    /*Close Session */
    viClose (m_mod);
    viClose (defaultRM);
}

void err_handler ()
/* Error Handling Routine */
    {
    ViStatus err;
    char err_msg[1024] = {0};
    viStatusDesc(m_mod,err,err_msg);
    if (strcmp ("VI_SUCCESS: No error",err_msg) != 0)
    printf("ERROR = %s\n",err_msg);
    return;
    }
 /* End of Error Handling Routine */
```

Switch M-Module A16 Register Descriptions

When installed in an Agilent E2251 Carrier, the Switch M-Modules have the following A16 register definitions.

Word Address (Offset from A16 Base)	Register Name	Register Type
20_h	M-Module Interrupt Control Register	Read/Write
06_h	A24 Offset Register	Read Only
04_h	VXI Status/Control Register	Read/Write
02_h	VXI Device Type Register	Read Only
00_h	VXI ID Register	Read Only

VXI ID Register

This register contains the M-Module's Device Class, Address Space, and Manufacturer ID.

Table 4-1. VXI ID Register (Read Only) Base + 00_h

Bit Number	15 - 14	13 - 12	11 - 00
Bit Name	Device Class	Address Space	Manufacturer ID

Bit Definitions

Device Class -- 00 = memory module, 01 = extended memory, 10 = message-based device, 11 = register based device. Switch M-Modules are register-based devices (11).

Address Space -- indicates the M-Modules addressing mode. 00 = A16/A24, 01 = A16/A32, 10 = reserved, 11 = A16 only. Switch M-Modules are A16/A24 (00).

Manufacturer ID = 4095 for Agilent Technologies M-Modules.

VXI Device Type Register

This register contains the M-Module's required memory and model code..

Table 4-2. VXI Device Type Register (Read Only) Base + 02_h

Bit Number	15 - 12	11 - 00
Bit Name	Required Memory	M-Module Model Code

Bit Definitions

Required Memory -- indicates the amount of memory required by the

M-Module.

Bits 15 - 12	Memory Required	Bits 15 - 12	Memory Required
1111	256 Bytes	0111	64 kBytes
1110	512 Bytes	0110	128 kBytes
1101	1 kBytes	0101	256 kBytes
1100	2 kBytes	0100	512 kBytes
1011	4 kBytes	0011	1 MBytes
1010	8 kBytes	0010	2 MBytes
1001	16 kBytes	0001	4 MBytes
1000	32 kBytes	0000	8 MBytes

M-Module Model Code -- Agilent E2270A = $F25B_h$, Agilent E2271A = $F25C_h$, Agilent E2272A = $F25D_h$.

VXI Status/Control Register

This read/write register controls the module and indicates its status.

Control Register

When writing to this register, it is a Control Register with the following bit definitions:

Table 4-3. VXI Control Register (Write) Base 04_h

Bit Number	15	14 - 02	01	00
Bit Name	A24 Enable	Reserved	Sysfail Inhibit	Reset

A24 Enable -- Writing a logic "1" to this bit enables access to the module's A24 registers.

Sysfail Inhibit -- Writing a logic "1" to this bit disables the M-Module from driving the SYSFAIL* line.

Reset -- Writing a logic "1" to this bit resets the Switch M-Module's registers. This does not open any closed relays (see "Program Example" on page 63 for details on how to open all relays).

Status Register

When reading from this register, it is a Status Register with the following bit definitions:

Table 4-4. VXI Status Register (Read) Base 04_h

Bit Number	15	14	13 - 04	03	02	01 - 00
Bit Name	A24 Active	MODID*	M-Module Device Dependent	Ready	Passed	Device Dependent

A24 Active -- Reading a logic "1" from this bit means the M-Module's registers in A24 memory can be accessed (default = 1).

MODID* -- Reading a logic "1" from this bit means the M-Module is not selected via the P2 MODID line. A logic "0" indicates the M-Module is selected.

Ready -- Reading a logic “1” from this bit means the M-Module is ready to accept commands--a logic “0” means the M-Module is busy and is not ready to accept commands.

Passed -- Reading a logic “1” from this bit means the M-Module passed its self-test--reading a logic “0” means it failed.

A24 Offset Register

This register contains the value of the base address necessary to access the M-Module’s A24 address space.

Table 4-5. A24 Offset Register (Read Only) Base + 06_h

Bit Number	15 - 00
Bit Name	A24 Base Address

Interrupt Selection Register

This register specifies which interrupt line the M-Module will use. Agilent Command Modules service interrupt line 1 by default, so normally you do not need to change the interrupt line.

Table 4-6. Interrupt Selection Register (Read/Write) Base 20_h

Bit Number	15 - 04	03	02 - 00
Bit Name	Reserved	Interrupt Type	VXI Interrupt Line

Bit Definitions

Interrupt Type -- This bit determines which type of interrupt the M-Module supports. A logic “0” indicates the M-Module supports interrupt types A and B. A logic “1” indicates interrupt type C (type C is the default and also the type supported by the Switch M-Modules).

VXI Interrupt Line -- These bits determine which interrupt line is used by the M-Module.

Bits 2, 1, 0	Interrupt Line
000	None (interrupt disabled)
001	IRQ1 (default)
010	IRQ2
011	IRQ3
100	IRQ4
101	IRQ5
110	IRQ6
111	IRQ7

Switch M-Module A24 Register Descriptions

Table 3-1 shows the A24 register definitions shared by all three Switch M-Modules. The bits contained in each register are defined on the following pages. Notice that only the registers that actually control the relays can be stored in the FIFO structure (FIFO-able in Table 4-7).

Table 4-7. A24 Switch Module Registers

Word Address (Offset from A24 Base)	Register Name	Register Type	FIFO-able Register (Y/N)
00_h	Status Register	Read Only	N
02_h	Control Register	Read/Write	N
04_h	Reserved	NA	N
06_h	Reserved	NA	N
08_h	Reserved	NA	N
$0A_h$	Reserved	NA	N
$0C_h$	Reserved	NA	N
$0E_h$	Reserved	NA	N
10_h	Row 0 Set Register	Read/Write	Y
12_h	Row 0 Reset Register	Read/Write	Y
14_h	Row 1 Set Register	Read/Write	Y
16_h	Row 1 Reset Register	Read/Write	Y
18_h	Row 2 Set Register	Read/Write	Y
$1A_h$	Row 2 Reset Register	Read/Write	Y
$1C_h$	Row 3 Set Register	Read/Write	Y
$1E_h$	Row 3 Reset Register	Read/Write	Y
20_h - $7E_h$	Unused	NA	N
80_h - FE_h	ID EEPROM	Read/Write	N

Status Register

This register monitors the module's Interrupt Status, FIFO Status (full or empty), Multiplexer Size (Agilent E2272A only), and Init Status.

Table 4-8. Status Register (Read Only) Base + 00_h

Bit Number	15 - 05	04	03	02	01	00
Bit Name	Unused	Init Status	Multiplexer Size	FIFO Empty Status	FIFO Full Status	Interrupt Status

Reset Condition -- Bits 15 - 08 = logic "1", Bits 07 - 05 = logic "0"; Bits 04, 01, 00 = logic "0"; Bit 03--see text.

Bit Definitions

Interrupt Status -- When this bit reads logic "1" the module's interrupt line will be asserted (if interrupts are enabled) on the interface to the carrier. When this bit reads logic "0" the module's interrupt line will not be asserted (if interrupts are enabled).

FIFO Full Status -- When this bit reads logic "1" the module's FIFO is currently full. When full, any additional writes to any of the FIFO-able registers (**Row n Set** or **Row n Reset**) are not placed into FIFO and are lost. Such writes are not stored in the **Row n Set/Reset** readback register to indicate they were not accepted.

FIFO Empty Status -- When this bit reads logic "1" the module's FIFO is currently empty. When empty, up to eight writes to any of the FIFO-able registers (**Row n Set** or **Row n Reset**) will be stored into FIFO and will be immediately acted upon (until the FIFO is full). Such writes are stored in the **Row n Set/Reset** readback register to indicate they were accepted. When this bit reads logic "0" there are still pending relay operations stacked-up in the FIFO. When combined with the **FIFO Full Status** bit, you can determine whether the FIFO is partially full, totally full or empty. The **FIFO Empty Status** bit can be considered the *Not Busy* indicator for the module.

Multiplexer Size (Agilent E2272A only) -- When this bit reads logic "0" the Agilent E2272A is configured as a single 16-to-1 multiplexer. When this bit reads logic "1" Agilent E2272A is configured as a dual 8-to-1 multiplexer. Agilent E2272A multiplexer size is controlled by a jumper, refer to Chapter 1 for details.

This bit always reads logic "1" for the Agilent E2270A and Agilent E2271A.

Init Status -- When this bit reads logic "0" the module has not been initialized after a power-up or a hard reset (assertion of /RESET from carrier). You can initialize the module by 1) enabling driver power, and 2) writing all four column bits to zero in each **Row n Reset** register. This opens all relays and correlates **Row n Set/Reset** readback to the actual relay positions.

When the Init Status bit reads logic "1" the module has been initialized at least once since the last power-up or /RESET.

Control Register

This register controls module reset (soft reset), interrupt enabling, self-test mode selection, relay driver power enabling, and timer mode selection.

Table 4-9. Control Register (Read/Write) Base + 02_h

Bit Number	15 - 06	05	04	03	02	01	00
Bit Name	Unused	Timer Mode Bit2	Timer Mode Bit1	Driver Power Enable	Self-Test Enable	Interrupt Enable	Reset

Reset condition -- Bits 15 - 06 = logic “1”, Bits 05 - 00 = logic “0”

Bit Definitions

Reset -- Writing a logic “1” to this bit causes a soft reset of the module while the bit is high. Subsequently writing a logic “0” to this bit releases the module from the reset condition.

Interrupt Enable -- Writing a logic “1” to this bit enables the module to interrupt on the M-Module interface to the carrier. Writing a logic “0” to this bit disables the module from asserting interrupts.

Self-Test Enable -- Writing a logic “1” to this bit causes the module to disable power to all row and column drivers. This allows testing the operation of the FIFO, for example, without causing relay movement. Writing a logic “0” to this bit allows the row and column drivers to be powered (if driver power is enabled). Be sure that the FIFO is empty before returning this bit to logic “0”.

Driver Power Enable -- Writing a logic “1” to this bit enables power to the relay drivers. Writing a logic “0” to this bit removes power from the relay drivers so that no relay movements are possible. When power is cycled, this bit resets to logic “0” to ensure that relays will not move unexpectedly. You must enable this bit before any relay movements can be done.

Timer Mode Bit 2/1 -- These two bits set the amount of time the module will drive the relay coils. These values give some software control of the driving/settling times that may be useful for performance tuning as well as module testing.

Note

Proper operation is guaranteed only for the 00 (8 msec) mode.

The following table shows the four possible settings.

TIMER MODE BIT 2	TIMER MODE BIT 1	Time
0	0	8mSec
0	1	2mSec
1	0	4mSec
1	1	64mSec

Comments

- Changing the **Timer Mode**, **Self-Test**, or **Driver Power Enable** bits in the **Control Register** should only be done immediately after a reset or when the FIFO is empty and no relay operations are pending.

Reserved Registers

These registers are not available for use. You can write to them (but no data is stored) and reads always return all ones.

Table 4-10. Reserved Registers (Read Only)
Base + 04_h through $0E_h$

Bit Number	15 - 00
Bit Name	Unused

Reset Condition -- Bits 15 - 00 = logic “1”

Row Set and Reset Registers

The Switch M-Modules use a row and column relay drive scheme. To close a particular relay, write a logic “1” to the corresponding column in a **Row n Set** register. To open a relay, write a logic “0” in the corresponding column in a **Row n Reset** register. For example, to close the Channel 04 relay on the Agilent E2270A (Row 1, Column 0 in relay drive scheme) place a logic “1” in bit 00 of the **Row 1 Set** register. To open this relay, place a logic “0” in bit 00 of the **Row 1 Reset** register. Tables 2-13 through 2-15 show the correlation of the matrix drive rows and columns to Switch M-Module channels.

Reset Condition (all **Row n Set** and **Row n Reset** registers) -- Bits 15 - 04 = logic “1”, Bits 03 - 00 = logic “0”. Bits 15 - 04 always read logic “1”.

Table 4-11. Row 0 Set Register (Read/Write) Base + 10_h

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 0 Column 3 State	Row 0 Column 2 State	Row 0 Column 1 State	Row 0 Column 0 State

Table 4-12. Row 0 Reset Register (Read/Write) Base + 12_h

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 0 Column 3 State	Row 0 Column 2 State	Row 0 Column 1 State	Row 0 Column 0 State

Table 4-13. Row 1 Set Register (Read/Write) Base + 14_h

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 1 Column 3 State	Row 1 Column 2 State	Row 1 Column 1 State	Row 1 Column 0 State

Table 4-14. Row 1 Reset Register (Read/Write) Base + 16_h

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 1 Column 3 State	Row 1 Column 2 State	Row 1 Column 1 State	Row 1 Column 0 State

Table 4-15. Row 2 Set Register (Read/Write) Base + 18_h

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 2 Column 3 State	Row 2 Column 2 State	Row 2 Column 1 State	Row 2 Column 0 State

Table 4-16. Row 2 Reset Register (Read/Write) Base + $1A_h$

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 2 Column 3 State	Row 2 Column 2 State	Row 2 Column 1 State	Row 2 Column 0 State

Table 4-17. Row 3 Set Register (Read/Write) Base + $1C_h$

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 3 Column 3 State	Row 3 Column 2 State	Row 3 Column 1 State	Row 3 Column 0 State

Table 4-18. Row 3 Reset Register (Read/Write) Base + $1E_h$

Bit Number	15 - 04	03	02	01	00
Bit Name	Unused	Row 3 Column 3 State	Row 3 Column 2 State	Row 3 Column 1 State	Row 3 Column 0 State

Row n Column n State -- When the FIFO is empty (no relay operations pending) bits 03, 02, 01, and 00 in the above registers indicate the state of the corresponding relay. A logic "1" means the relay in **Row n Column n** is closed or soon will be (depending on the **FIFO Empty Status** bit's state). A logic "0" means the corresponding relay is open.

Comments

- Writing to a **Row n Set** register closes the relays only in the bit positions set to logic "1". Writing a logic "0" to a **Row n Set** register has no effect on relay position. Writing to a **Row n Reset** register opens relays only for the bit positions set to logic "0". Writing a logic "1" to a **Row n Reset** register has no effect on relay position.
- Reading either the **Row n Set** or **Row n Reset** register addresses returns identical data because they are actually mapped to the same register. When you write to one of these registers (and FIFO is not full), the data is stored in the register and stored in FIFO.
- The **Row n Set/Reset** readback registers return the programmed relay

state only if you use the module correctly. Since the driver power can be disabled (the power-on state), the **Row n Set** and **Row n Reset** registers can be written to and read from without moving any relay contacts.

- When the module loses power, any closed relays remain closed (latching relays). When power is restored, the relays remain closed but the **Row n Set** and **Row n Reset** registers have lost their relay state information. This relay information is lost whenever power is cycled or the carrier asserts /RESET. You must initialize the module after a power-up or /RESET to achieve correlation between the **Row n Set/Reset** readback registers and the actual relay positions. To initialize the module:

  1. Enable driver power.
  2. Write all four column bits to zero in each **Row n Reset** register.

  You can check for initialization by reading the **Init Status** bit. If the module has not been initialized since the last power-up or /RESET, the **Init Status** bit will be logic "0". The **Init Status** bit is set to logic "1" whenever the module has been successfully initialized.
- To guarantee break-before-make relay operation, write to the **Row n Reset** registers before writing to the **Row n Set** registers.
- It is important to use the FIFO status bits when writing to the **Row n Set/Reset** registers, especially when writing in bursts (such as when resetting the module's relays). Writing to a **Row n Set/Reset** register when the FIFO is full results in the loss of data since the FIFO has no room to hold it. You should always check the FIFO FULL status to ensure that FIFO is not full before writing to a **Row n Set/Reset** register.

Matrix Drive to Channel Mappings

Tables 2-13 and 2-15 correlate matrix drive rows and columns to channel numbers on the Agilent E2270A and E2272A, respectively. Table 2-14 correlates matrix drive rows and columns to Agilent E2271A rows and columns.

Table 4-19. Agilent E2270A Matrix Drive to Channel Mappings

Matrix Drive	Column 0	Column 1	Column 2	Column 3
Row 0	Channel 0	Channel 1	Channel 2	Channel 3
Row 1	Channel 4	Channel 5	Channel 6	Channel 7
Row 2	Channel 8	Channel 9	Channel 10	Channel 11
Row 3	Channel 12	Channel 13	Channel 14	Channel 15

Table 4-20. Agilent E2271A Matrix Drive to Row and Column Mappings

Matrix Drive	Column 0	Column 1	Column 2	Column 3
Row 0	Row 0, Col 0	Row 0, Col 1	Row 0, Col 2	Row 0, Col 3
Row 1	Row 1, Col 0	Row 1, Col 1	Row 1, Col 2	Row 1, Col 3
Row 2	Row 2, Col 0	Row 2, Col 1	Row 2, Col 2	Row 2, Col 3
Row 3	Row 3, Col 0	Row 3, Col 1	Row 3, Col 2	Row 3, Col 3

Table 4-21. Agilent E2272A Matrix Drive to Channel Mappings (8-to-1 Mode)

	Matrix Drive	Column 0	Column 1	Column 2	Column 3
Multiplexer A	**Row 0**	Channel 0	Channel 1	Channel 2	Channel 3
	Row 1	Channel 4	Channel 5	Channel 6	Channel 7
Multiplexer B	**Row 2**	Channel 8	Channel 9	Channel 10	Channel 11
	Row 3	Channel 12	Channel 13	Channel 14	Channel 15

Unused Registers

These registers can be written to (but no data is stored) and read from (but always returns all ones).

Table 4-22. Unused Registers (Read Only) Base + 20_h through $7E_h$

Bit Number	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Bit Name	Unused															

Reset Condition -- Bits 15 - 00 = logic “1”

ID EEPROM Register

The ID EEPROM Register allows you to access the contents of the ID EEPROM. The ID EEPROM contains sixty-four 16-bit words of M-Module ID data and VXI M-Module data.

Note

It is much easier to read the module ID data from the VXI registers (A16 memory area) instead of reading the ID EEPROM Register. A16 addressing is discussed earlier in this chapter

Table 4-23. ID EEPROM Register (Read/Write) Base 80_h through FE_h

Bit Number	15 - 03	02	01	00
Bit Name	Unused	Chip Select	Clock	Data In/Out

Reset Condition -- Bits 15 - 08 = logic “1”, Bits 07 - Bit 00 = logic “0”. Reads of bit-0 reflect the state of the ID EEPROM’s DO pin.

Caution

Do not attempt to write to Bit 00 of the ID EEPROM register. You could possibly write-over the contents of the ID EEPROM.

Bit Definitions

Data In/Out -- Reading this bit returns the value returned from the Data Out pin of the ID EEPROM.

Clock -- Writing a logic "1" to this bit forces the SK pin of the ID EEPROM high and writing a logic "0" drives it low. This bit is used as a clock to the ID EEPROM for reading data out. Reading this bit always returns a logic "0".

Chip Select -- Writing a logic "1" to this bit selects the ID EEPROM. Writing a logic "0" to this bit deselects the EEPROM. Reading this bit always returns a logic "0".

Table 4-24. ID EEPROM Contents

Word Number	Description	Agilent E2270A Form A Switch	Agilent E2271A 4x4 Matrix	Agilent E2272A Multiplexer
0	**Sync Code**	5346_h	5346_h	5346_h
1	**M-Module Number (binary code)**	0686_h (binary-coded 1670)	0687_h (binary-coded 1671)	0688_h (binary-coded 1672)
2	**Revision Number (binary code)**	0001_h	0001_h	0001_h
3	**Module Characteristics**	0860_h	0860_h	0860_h
4 - 15	**Reserved**	n/a	n/a	n/a
16	**VXI Sync Code**	$ACBA_h$	$ACBA_h$	$ACBA_h$
17	**VXI ID**	$CFFF_h$ (Agilent Technologies)	$CFFF_h$ (Agilent Technologies)	$CFFF_h$ (Agilent Technologies)
18	**VXI Device Type**	$F25B_h$	$F25C_h$	$F25D_h$
19 - 63	**Reserved**	n/a	n/a	n/a

Appendix A
Specifications

M-Module Specification Compliance

The Switch M-Modules comply with the Mezzanine M-Module Specification.

Agilent E2270A 16-Channel Form A Switch Specifications

Caution **The following voltage limits designated "Cleanroom Environment" apply only if the product is installed in a humidity-controlled (<60% RH) environment where airborne contaminants and transients are controlled, and NO relay connection is made to power mains. If these conditions CANNOT be maintained, then the maximum voltage is 60 VDC, 48 VAC-rms or 68 VAC-peak.**

Maximum Voltage--Cleanroom Environment (any terminal to any other terminal)

- 200 VDC
- 125 VAC rms
- 175 VAC peak

Maximum Voltage--Non-Cleanroom Environment (any terminal to any other terminal)

- 60 VDC
- 48 VAC rms
- 68 VAC peak

Maximum Current (non-inductive)

- Per Switch: 2 ADC, 2 AAC peak
- Per Module: 8 ADC, 8 AAC peak

Maximum Power

- Per Switch: 50 W DC, 50 VA AC
- Per Module: 200 W DC, 200 VA AC

Agilent E2270A Specifications (continued)

Maximum Thermal Offset

- < 3 μV (typical)

Closed Channel Resistance

- Initial: < 0.2Ω (typical)
- End of Life: < 2Ω

Insulation Resistance (between any two points)

- ≤ 40°C, ≤ 65% RH: 10^8 Ω (typical)
- ≤ 25°C, ≤ 40% RH: 10^8 Ω (typical)

AC Specifications

- Typical Bandwidth (-3dB): > 10 MHz
- Crosstalk (dB, channel-to-channel):
  - < 100 kHz: -64 dB (typical)
  - < 1 MHz: - 44 dB (typical)
  - < 10 MHz: -24 dB (typical)
- Closed Channel Capacitance:
  - Channel-to-Channel: < 15 pF (typical)
  - Channel-to-Common: < 25 pF (typical)

General Characteristics

- 16 Latching Relays
- Typical Relay Life (number of operations):
  - Rated Load: 10^5
  - Time to open or close a channel (register programming): 8 msec
- Connector Type: 44-pin D-Sub
- Standard Compliance: IDENT, A08, D08, INTC
- Field Wiring Connector: 44-pin D-Sub (male) with plastic housing
- VXI Device Type: Register-Based
- Interrupt: Type C interrupt when requested relay movements have completed.

Power Up/Down States

Latching relays retain last programmed state.

Agilent E2271A 4x4 Matrix Switch Specifications

Caution **The following voltage limits designated "Cleanroom Environment" apply only if the product is installed in a humidity-controlled (<60% RH) environment where airborne contaminants and transients are controlled, and NO relay connection is made to power mains. If these conditions CANNOT be maintained, then the maximum voltage is 60 VDC, 48 VAC-rms or 68 VAC-peak.**

Maximum Voltage--Cleanroom Environment (any terminal to any other terminal)

- 200 VDC
- 125 VAC rms
- 175 VAC peak

Maximum Voltage--Non-Cleanroom Environment (any terminal to any other terminal)

- 60 VDC
- 48 VAC rms
- 68 VAC peak

Maximum Current (non-inductive)

- Per Channel: 2 ADC, 2 AAC peak
- Per Module: 8 ADC, 8 AAC peak

Maximum Power

- Per Channel: 50 W DC, 50 VA AC
- Per Module: 200 W DC, 200 VA AC

Maximum Thermal Offset Per Channel, Differential Hi-Lo

- < 3 μV (typical)

Closed Channel Resistance

- Initial: < 0.3Ω (Hi or Lo) (typical)
- End of Life: < 2Ω (Hi or Lo)

Insulation Resistance (between any two points)

- ≤ 40°C, ≤ 65% RH: 10^8 Ω (typical)
- ≤ 25°C, ≤ 40% RH: 10^8 Ω (typical)

Agilent E2271A Specifications (continued)

AC Specifications

- Typical Bandwidth (-3dB): > 10 MHz
- Crosstalk (dB, channel-to-channel):
  - < 100 kHz: -64 dB (typical)
  - < 1 MHz: - 44 dB (typical)
  - < 10 MHz: -24 dB (typical)
- Closed Channel Capacitance:
  - Hi-Lo: < 40 pF (typical)
  - Hi-Chassis: < 60 pF (typical)
  - Lo-Chassis: < 60 pF (typical)

General Characteristics

- 16 Latching Relays
- Typical Relay Life (number of operations)
  - Rated Load: 10^5 (typical)
  - Time to open or close a channel (register programming): 8 msec
- Connector Type: 44-pin D-Sub
- Standard Compliance: IDENT, A08, D08, INTC
- Field Wiring Connector: 44-pin D-Sub (male) with plastic housing
- VXI Device Type: Register-Based
- Interrupt: Type C interrupt when requested relay movements have completed.

Power Up/Down States

Latching relays retain last programmed state.

Agilent E2272A Dual 8-to-1 Relay Multiplexer Specifications

Caution **The following voltage limits designated "Cleanroom Environment" apply only if the product is installed in a humidity-controlled (<60% RH) environment where airborne contaminants and transients are controlled, and NO relay connection is made to power mains. If these conditions CANNOT be maintained, then the maximum voltage is 60 VDC, 48 VAC-rms or 68 VAC-peak.**

Maximum Voltage--Cleanroom Environment (any terminal to any other terminal)

- 200 VDC
- 125 VAC rms
- 175 VAC peak

Maximum Voltage--Non-Cleanroom Environment (any terminal to any other terminal)

- 60 VDC
- 48 VAC rms
- 68 VAC peak

Maximum Current (non-inductive)

- Per Channel: 2 ADC, 2 AAC peak
- Per Module: 8 ADC, 8 AAC peak

Maximum Power

- Per Channel: 50 W DC, 50 VA AC
- Per Module: 50 W DC (16-to-1 mode), 100 W DC (8-to-1 mode)
  50 VA AC (16-to-1 mode), 100 VA AC (8-to-1 mode)

Maximum Thermal Offset Per Channel, Differential Hi-Lo

- < 3 μV (typical)

Closed Channel Resistance (per channel)

- Initial: < 0.2Ω (typical)
- End of Life: < 2Ω

Insulation Resistance (between any two points)

- ≤ 40°C, ≤ 65% RH: 10^8 Ω (typical)
- ≤ 25°C, ≤ 40% RH: 10^8 Ω (typical)

Agilent E2272A Specifications (continued)

AC Specifications

- Typical Bandwidth (-3dB): > 10 MHz
- Crosstalk (dB, channel-to-channel):
  - < 100 kHz: -64 dB (typical)
  - < 1 MHz: - 44 dB (typical)
  - < 10 MHz: -24 dB (typical)
- Closed Channel Capacitance:
  - Ch-Ch: < 20 pF (8-to-1 mode), < 25 pF (16-to-1 mode) (typical)
  - Hi-Lo: < 40 pF (8-to-1 mode), < 70 pF (16-to-1 mode) (typical)
  - Ch-Ch: < 75 pF (8-to-1 mode), < 140 pF (16-to-1 mode) (typical)

General Characteristics

- 16 Latching Relays
- Typical Relay Life (number of operations)
  - Rated Load: 10^5 (typical)
  - Time to open or close a channel (register programming): 8 msec
- Connector Type: 44-pin D-Sub
- Standard Compliance: IDENT, A08, D08, INTC
- Field Wiring Connector: 44-pin D-Sub (male) with plastic housing
- VXI Device Type: Register-Based
- Interrupt: Type C interrupt when requested relay movements have completed.

Power Up/Down States

Latching relays retain last programmed state.

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