Agilent TS-5400 Functional Test System Series IIB

Agilent E6171B Measurement Control Module User's Manual

Manual Part Number E6171-90032

Agilent Technologies

Notices

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.

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Caution

A **Caution** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **Caution** notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Safety Summary

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

General

This product is provided with a protective earth terminal. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

WARNING: DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE
Do not operate the system in the presence of flammable gases or flames.

If the equipment in this system is used in a manner not specified by Agilent Technologies, the protection provided by the equipment may be impaired.

Cleaning Instructions

Clean the system cabinet using a soft cloth dampened in water.

WARNING: DO NOT REMOVE ANY SYSTEM COVER
Operating personnel must not remove system covers. Component replacement and internal adjustments must be made only by qualified service personnel. Equipment that appears damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

Environmental Conditions

Unless otherwise noted in the specifications, this system is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate at a maximum relative humidity of 80% and at altitudes of up to 2000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

Before applying power

Verify that all safety precautions are taken. Note the external markings described in “Safety Symbols and Regulatory Markings” on page 4.

Ground the System

To minimize shock hazard, the system chassis must have a hard-wired connection to an electrical protective earth ground. The system must also be connected to the ac power mains through a power cable that includes a protective earth conductor. The power cable ground wire must be connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective grounding will cause a potential shock hazard that could result in personal injury.

Fuses

Use only fuses with the required rated current, voltage, and specified type (normal blow, time delay). Do not use repaired fuses or short-circuited fuse holders. To do so could cause a shock or fire hazard.

Operator Safety Information

MODULE CONNECTORS AND TEST SIGNAL CABLES CONNECTED TO THEM CANNOT BE OPERATOR ACCESSIBLE: Cables and connectors are considered inaccessible if a tool (e.g., screwdriver, wrench, socket, etc.) or a key (equipment in a locked cabinet) is required to gain access to them. Additionally, the operator cannot have access to a conductive surface connected to any cable conductor (High, Low or Guard).

ASSURE THE EQUIPMENT UNDER TEST HAS ADEQUATE INSULATION BETWEEN THE CABLE CONNECTIONS AND ANY OPERATOR-ACCESSIBLE PARTS (DOORS, COVERS, PANELS, SHIELDS, CASES, CABINETS, ETC.): Verify there are multiple and sufficient protective means (rated for the voltages you are applying) to assure the operator will NOT come into contact with any energized conductor even if one of the protective means fails to work as intended. For example, the inner side of a case, cabinet, door, cover or panel can be covered with an insulating material as well as routing the test cables to the module's front panel connectors through non-conductive, flexible conduit such as that used in electrical power distribution.

Safety Symbols and Regulatory Markings

Symbols and markings on the system, in manuals and on instruments alert you to potential risks, provide information about conditions, and comply with international regulations. Table 1 defines the symbols and markings you may encounter.

Table 1 Safety Symbols and Markings

Safety symbols	
	Warning: risk of electric shock.
	Caution: refer to accompanying documents.
	Alternating current.
	Both direct and alternating current.
	Earth (ground) terminal
	Protective earth (ground) terminal
	Frame or chassis terminal
	Terminal is at earth potential. Used for measurement and control circuits designed to be operated with one terminal at earth potential.
O |	Switch setting indicator. O = Off, | = On.
	Standby (supply); units with this symbol are not completely disconnected from ac mains when this switch is off. To completely disconnect the unit from ac mains, either disconnect the power cord, or have a qualified electrician install an external switch.
Regulatory Markings	
	The CE mark is a registered trademark of the European Community.
	The CSA mark is a registered trademark of the Canadian Standards Association.
N10149	The C-tick mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australian EMC Framework regulations under the terms of the Radio Communications Act of 1992.
ISM 1-A	This text indicates that the product is an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4).

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Any adjustment, maintenance, or repair of this product must be performed by qualified personnel. Contact your customer engineer through your local Agilent Technologies Service Center.

Agilent on the Web

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http://www.agilent.com

Click the link to **Test & Measurement**. Select your country from the drop-down menus. The Web page that appears next has contact information specific for your country.

Agilent by Phone

If you do not have access to the Internet, call one of the numbers in Table 2.

Table 2 Agilent Call Centers and Regional Headquarters

United States and Canada:	Test and Measurement Call Center (800) 452 4844 (toll-free in US)
Europe:	(41 22) 780 8111
Japan:	Measurement Assistance Center (81) 0426 56 7832
Latin America:	305 269 7548
Asia-Pacific:	(85 22) 599 7777

Declaration of Conformity

According to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name:	Agilent Technologies Loveland Manufacturing Center
Manufacturer's Address:	815 14th Street S.W. Loveland, Colorado 80537

Declares, that the product:

Product Name:	Agilent Technologies E617B Measurement Control Module
Model Number:	Agilent E6171B
Product Options:	All

Conforms to the following Product Specifications:

Safety:	IEC 61010-1 (1990)+A2:1995/EN61010-1:1993+A2:1995 CSA C22.2 #1010.1 (1992) UL 3111
EMC:	CISPR 11:1990/EN55011 1991: Group 1, Class A EN50082-1:1992 IEC 61000-4-2:1995/: 4kV CD IEC 61000-4-3:1995/: 3V/m IEC 61000-4-4:1995/: 1 kV Power line

Supplementary Information: This product complies with the requirements of the Low Voltage Directive 73/23/EEC (inclusive 93/68/EEC). This product also wherewith complies with the protection requirements of: The EMC Directive 89/336/EEC and carries the "CE" marking accordingly. Attestation is provided according to article 10(2) of the Directive by a Technical Construction File.

Technical File Number: 95-0900-002-TCF Rev. C Dated: 28 June, 1999

A Technical Report/Certificate has been issued by the following appointed Competent Body, namely,
KEMA Registered Quality Nederland B.V.
Utrechtseweg 310, 6812 AR Arnhem
6800 ET Arnhem, The Netherlands
Certificate Number: 71301-KRQ/EMC 97-4165 **Dated:** February 18, 1997

June 28, 1999

For Compliance Information ONLY, contact:

Australian Contact: Product Regulations Manager, Agilent Technologies Australia Ltd., 31-41 Joseph Street, Blackburn, Victoria 3130, Australia

European Contact: Your local Agilent Technologies Sales and Service Office or Agilent Technologies GmbH, Department HQ-TRE, Standards Europe, Herrenberger Straße 130, D-71034 Böblingen (FAX: +49-7031-14-3143)

USA Contact: Product Regulations Manager, Agilent Technologies Company, P.O. Box 301, Mail Stop BU212, Loveland, CO 80537

Notes:

Contents

Chapter 1
Getting Started

Introduction

The Agilent E6171B Measurement Control Module is an instrument multiplexer and voltage/current source module designed for automotive electronic test applications. Key features of the module include:

- An isolated voltage source.
- An isolated current source with a programmable voltage limit.
- A 16 X 5 instrument multiplexer that multiplexes four analog buses plus Device Under Test (DUT) common.
- Multiplexing for eight external triggers and eight VXIbus TTL triggers to and from each other or to and from the DUT.
- An analog comparator, with programmable thresholds, whose output connects to the trigger multiplexer.
- A programmable high-voltage attenuator.
- A amplifier with programmable gain that can amplify the output of an Agilent E6173A Arbitrary Function Generator module (formerly the Agilent Z2471A) via a step-up transformer to provide output for simulating VRS (Variable Reluctance Sensors) signals.
- A Programmable IRQ.
- A programmable general-purpose timer whose output also can be used to generate interrupts, trigger delays, and pacing.

Note The Agilent E6171A and E6171B are functionally equivalent. The module was updated to the "B" version to improve overall manufacturability and calibration.

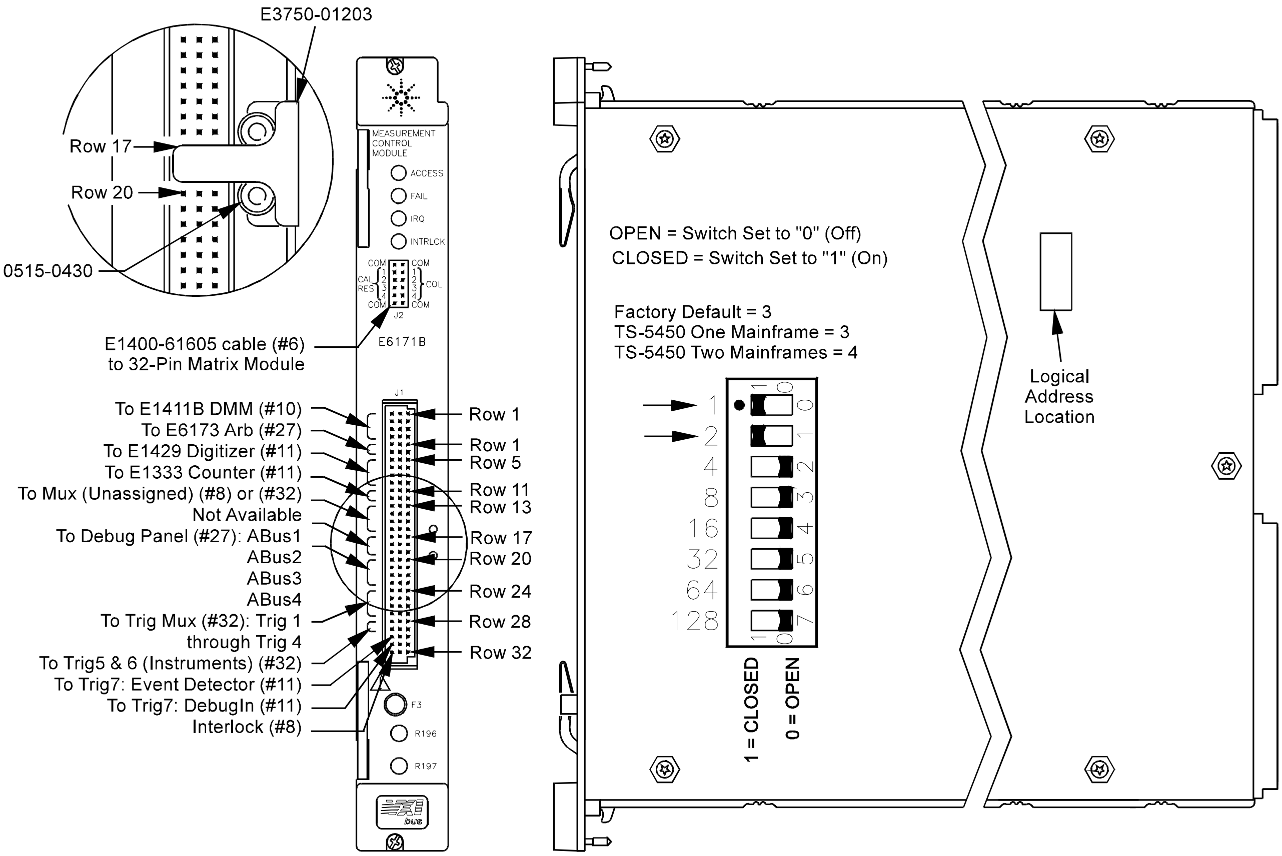


Figure 1-1. Measurement Control Module LADD Switch Access

Note that the Measurement Control Module has four LEDs on its front panel. They are:

Accessed This LED flashes when the module is accessed.

Failed When lit, this LED indicates either the module failed to power-up correctly or the VCC is noisy. When the module is powered-up, this LED remains lit until the VXIbus backplane is initialized.

IRQ When lit, this LED indicates that an IRQ has been asserted. This LED flashes periodically during normal operation and during reset.

Interlock When lit, this LED indicates the safety interlock feature is enabled, which can be used to prevent access to dangerous high voltages.

Warnings and Cautions

WARNING

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

Do not defeat the Agilent E6171B Measurement Control Module Interlock feature with jumpers.

An interlocked safety cover is recommended to prevent operator access to electric shock hazard voltages and currents that may be applied to the unit under test.

Voltages greater than 30 Vrms, 42 Vpk, or 60 Vdc are considered hazardous voltages. Current greater than 8 A or energy greater than 150 VA is also considered hazardous.

AVERTISSMENT

NE pas neutraliser le verrouillage de l'appareil de mesure E6171B.

Un couvercle des sécurité à verrouillage est recommandé afin de protéger l'opérateur des chocs électriques causés par des tensions ou des courants qui peuvent ètre appliqués à l'appareil à l'essai. Les tensions superieures a 30 V (eff.), 42 V (crete) ou 60 V (c.c.) sont dangereuses. Un courant supérieures à 8 A ou une énergie supérieure à 150 V-A sont dangereux.

Caution

STATIC ELECTRICITY. Static electricity is a major cause of component failure. To prevent damage to the electrical components in the switch module, observe anti-static techniques whenever removing a module from the mainframe or whenever working on a module.

Setting the Address Switch

The logical address switch is factory set at 3. You may need to change the setting the during module installation. Valid addresses are from 1 to 254. Figure 1-1 shows the module and the location of the address switches.

Installing in a VXI Mainframe

The Agilent E6171B Measurement Control Module can be installed in any available mainframe slot except slot 0. The jumper cable that connects the Agilent E6171B to the first Agilent E6172A 32-Pin Matrix Module requires the two modules to be adjacent. See Figure 1-2.

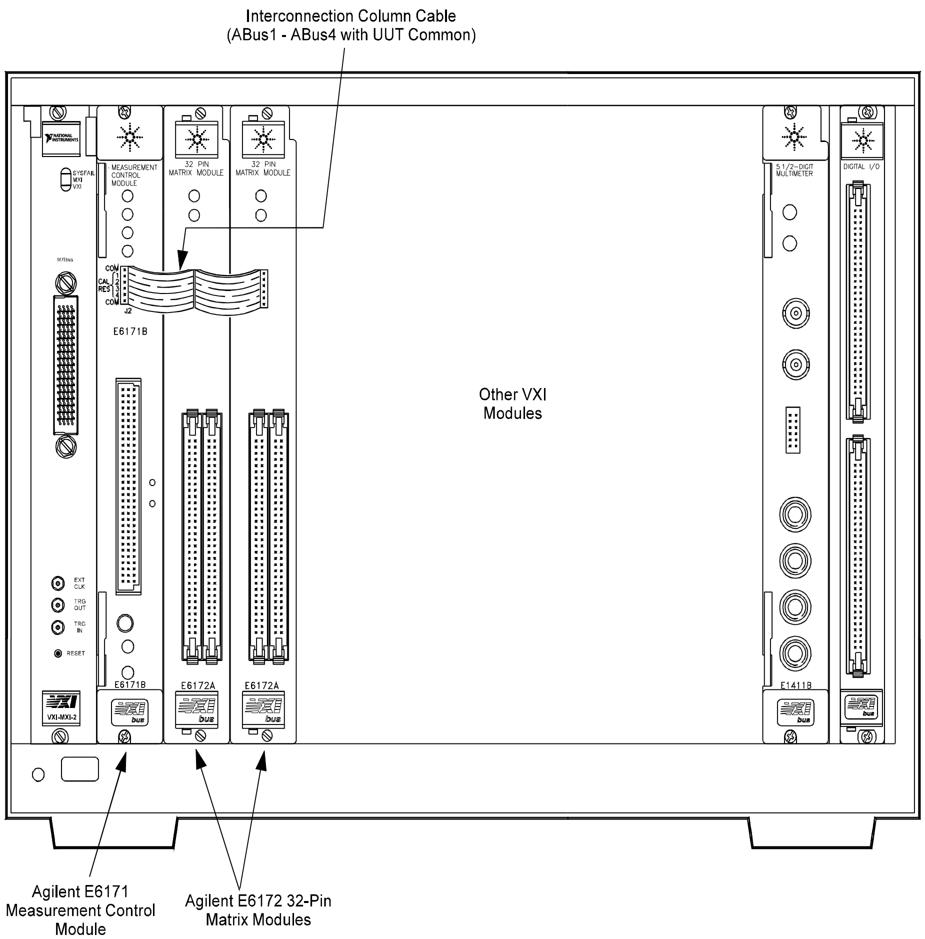


Figure 1-2. Placement of the Agilent E6171B Measurement Control Module in a VXI Mainframe

Chapter 2

Understanding the Agilent E6171B Measurement Control Module

Introduction

Figure 2-1 shows a simplified block diagram of the Agilent E6171B in a typical Agilent TS-5400 Family application. THe application includes one Agilent E6172A 32-Channel Pin Matrix module and four other test instruments.

Description of Features

The Measurement Control Module contains:

- A 16 X 5 matrix of dry reed relays used to multiplex instruments.
- An isolated—i.e., “floating”—dual-range voltage and current source that also can be used as an amplifier for the Agilent E6173A Arbitrary Waveform Generator Module (formerly Agilent Z2471A), and optionally, high-voltage transformer output.
- A trigger multiplexer that provides access for external equipment triggers to the VXIbus TTL triggers and Device Under Test (DUT).
- An analog comparator whose output is routed to the trigger multiplexer.
- A general-purpose timer that can run in one-shot or free running modes. Besides being used for general timing applications, its output can be routed to any of seven interrupt lines and used for triggering, generating delays, or pacing.
- A DUT-referenced measurement system (a path through relays that connects DUT ground to system or chassis ground).

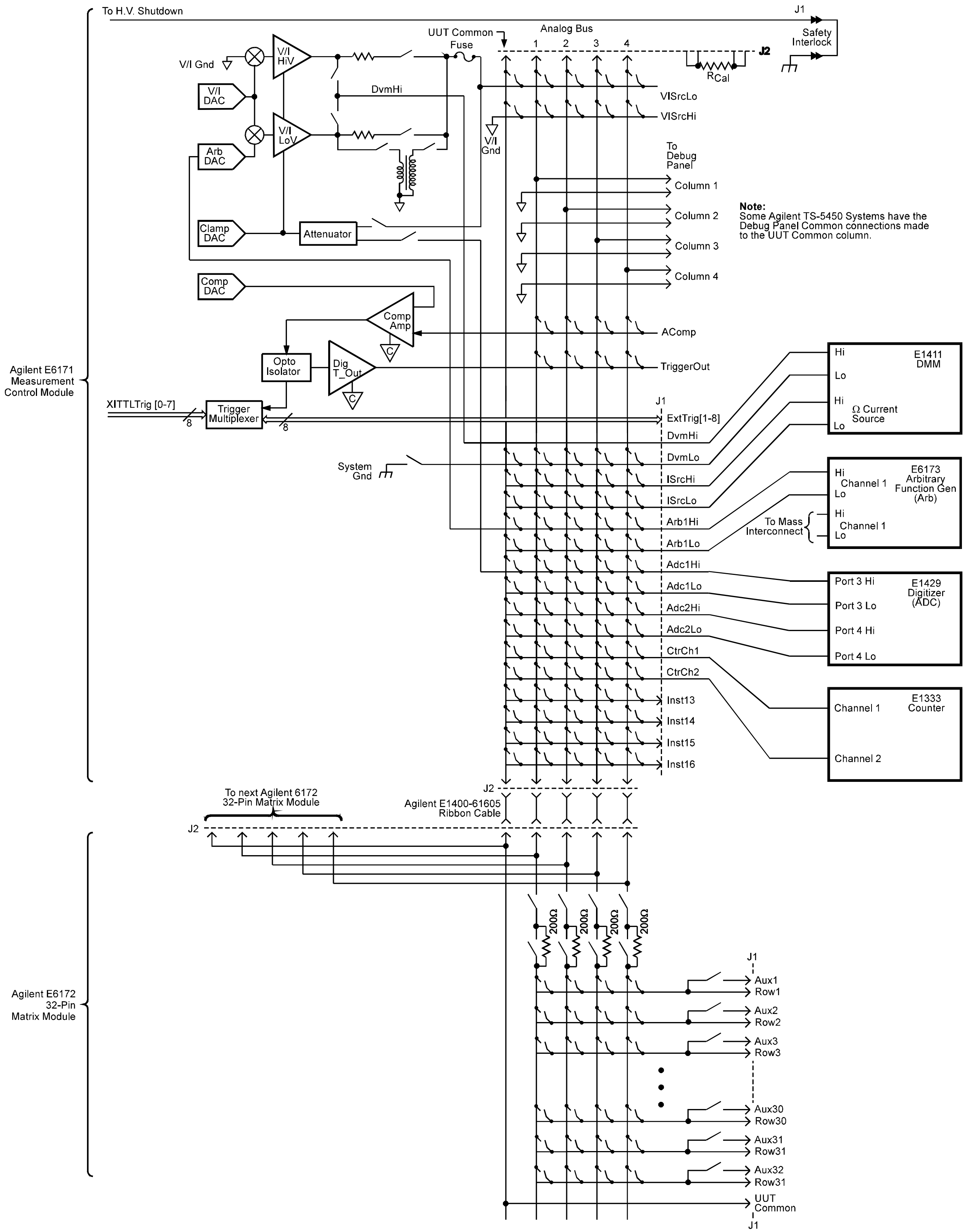


Figure 2-1. Conceptual Overview of a Measurement Control Module with Agilent E6172A Modules

16 X 5 Instrument Multiplexer

As many as sixteen external inputs to the Measurement Control Module can be connected to any of the four analog columns or to the common DUT ground that exit this card via the ABus1-ABus4. You can use these inputs as follows:

- Because the Agilent E1411 DMM is used to measure the output of the V/I source, the DMM must always be connected to external inputs 1-4 as DVM Hi, DVM Lo, Isource Hi, and Isource Lo, respectively.
- The Measurement Control Module provides special routing for signals from the Agilent E6173A Arbitrary Function Generator Module, which must always be connected to external inputs 5 & 6, Hi and Lo, respectively.
- If a digitizer, such as the Agilent E1429A, is used in the system, it should be wired to row 7 through 10.
- Finally, row 11 and 12 are set aside for a counter, such as the Agilent E1333A counter.
- The external inputs 13 through 16 are undefined and can be used with any additional instruments.
- Row 17-19 is not available, and rows 20 through 32 have assigned uses already.

The Agilent E6171B can route any of the 16 external instruments as well as any of its internal resources (V/I source, analog comparator, digital trigger, and attenuator) to the five measurement buses and then to one or more Agilent E6172A 32-Pin Matrix Modules.

Trigger Multiplexer

The trigger multiplexer lets you interconnect various combinations of external triggers, VXIbus trigger lines, and the output from the analog comparator on the Measurement Control Module. This helps with complex DUT trigger scenarios with VXI instruments. You can simultaneously connect two independent trigger paths.

Figure 2-2 is a simplified block diagram of the trigger MUX-DEMUX arrangement. The sources and destinations of the triggers are shown in greater detail in Figure 2-3.

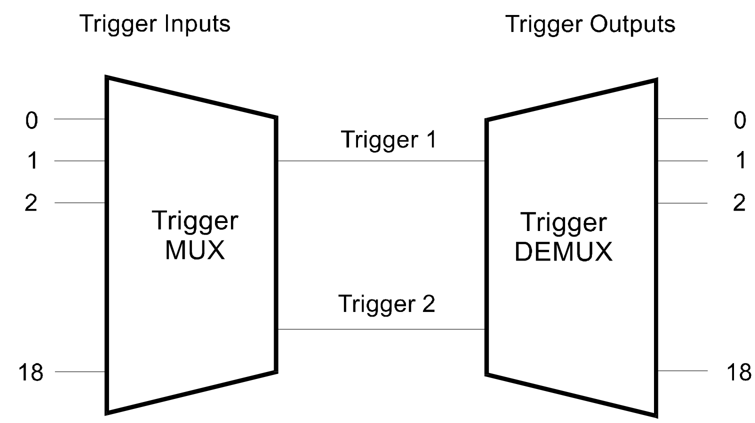


Figure 2-2. Block Diagram of Trigger MUX-DEMUX Arrangement

Table 2-1. Trigger Sources and Destinations

Trigger Sources (inputs)	Trigger Destinations (outputs)
8 external triggers (on front panel of module)	8 external triggers (on front panel of module)
8 VXIbus TTL triggers	8 VXIbus TTL triggers
output from analog comparator	digital trigger output
output from general-purpose timer	timer start
software programmable trigger	software poll

By default, external trigger outputs and the digital trigger output are pulled up to 5 volts. However, the digital trigger output can be pulled up to 30 volts via external source and pull-up resistors for DUT triggering. The digital trigger output from the trigger multiplexer can be connected to any of the columns on ABus1-ABus4. The digital trigger output and comparator input "float" to the DUT common.

You can connect more than one trigger source and trigger destination per trigger path to provide synchronization between devices. For example, a trigger source on the DUT could connect to both a counter and the external trigger port on a DVM and use only one path in the trigger multiplexer.

Figure 2-3 shows a conceptual diagram of the bus structure in the trigger multiplexer. Arrows indicate whether the various lines connected to the trigger buses are inputs, outputs, or bi-directional.

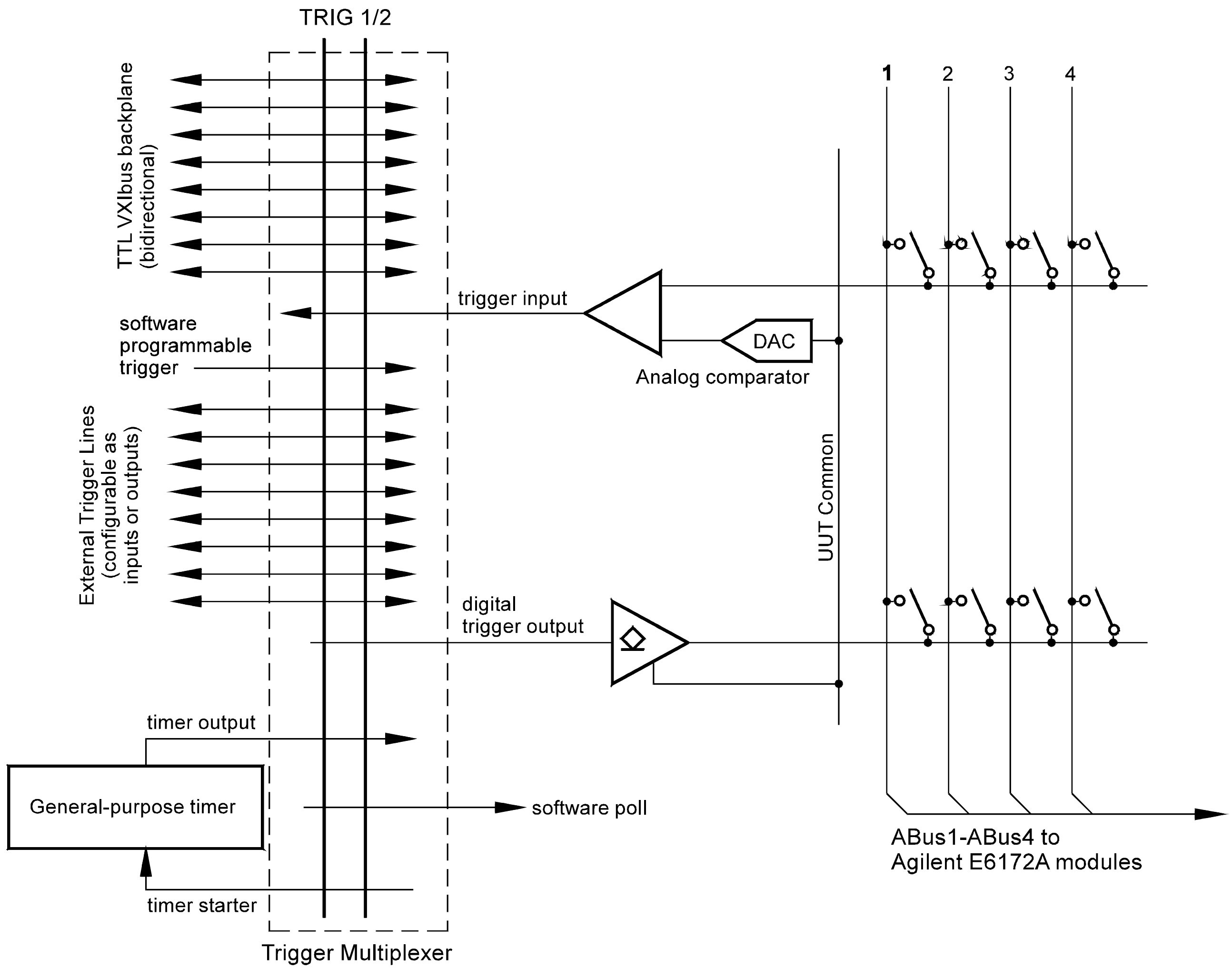


Figure 2-3. Bus Structure of the Trigger Multiplexer

The trigger multiplexer contains two trigger buses, nominally known as TRIG1 and TRIG2, used to route signals. Any of the eight, bi-directional TTL-level triggers at the VXIbus backplane can connect to either of the trigger multiplexer's buses and can be used as trigger sources or trigger destinations. The connections are made electronically through an “open-collector” bus. If any selected input is low, then the bus is low. Otherwise, the bus is high. In a similar fashion, any of the eight external trigger lines available on the module's front panel can connect to either of the two multiplexer buses.

The routing and configuration of all sixteen of the lines described above is controlled by writing control data to the various Trigger Configuration Registers (see Appendix B).

There are three other trigger sources you can connect to the trigger buses. The first, “timer output” in the diagram, is an output from the general-purpose timer. Its routing to TRIG1 or TRIG2 is controlled by bits 1 and 4 of the Other Trigger Resources Register (see Appendix B). The second source is a software programmable trigger, whose routing is controlled by bits 0 and 3 of the same register. And the third trigger source is the output from the analog comparator, denoted “trigger input,” whose routing is controlled by bits 2 and 5 of the same register. If desired, bit 13 of the register lets you invert the comparator's output sensing.

There are three additional outputs from trigger buses TRIG1 and TRIG2. One, shown as “digital trigger output,” can connect to any of the four columns on ABus1-ABus4. It can connect, via buses TRIG 1 or TRIG2, any of the nineteen trigger sources to ABus1-ABus4. Its routing is controlled by bits 8 and 11 of the Other Trigger Resources Register.

Another output from the trigger multiplexer is a line—”timer start”—that connects either trigger bus to the input of the general-purpose timer. This lets you use any of the trigger sources to start the timer. Bits 7 and 10 of the same register let you control which trigger bus connects to the timer's input, and allow for timer initialization on a trigger pulse. Refer to the section on the General Purpose Timer later in this chapter.

The last trigger output is a line denoted “software poll.” Connecting the software poll line to trigger bus TRIG1 or TRIG2 and then monitoring the line lets you poll the status of either trigger bus to see if a trigger signal is present. Bit 6 enables readback via bit 14 of TRIG1 and bit 9 enables readback via bit 15 of TRIG2.

There are two rules you must following when using the trigger multiplexer:

1. You can connect any input(s)—i.e., trigger source—to any output(s) or bi-directional line(s) via a trigger path.

2. You cannot connect more than two trigger paths at the same time; i.e., you can connect one trigger path per trigger bus.

Isolated V/I Source

The V/I source lets you source a voltage and measure the resultant current, or source a current and measure the resultant voltage. It consists of two separate amplifiers, denoted “low” and “high,” that share a common connection to the analog bus structure. The “low” amplifier provides voltages in the range of (16 volts at up to 200 ma., and the “high” amplifier provides voltages in the range of (100 volts at up to 20 mA. (see Appendix A for specifications). Typical applications for the low-voltage amplifier include I/O pin parametrics of leakage, bias current, impedance, threshold, and clamp voltage. The main application for the high-voltage amplifier is verifying the presence of clamp diodes at the outputs of modules that drive inductive loads. Both amplifiers can sense the amount of current flowing while forcing a constant voltage.

When the V/I source is used to source a voltage, the signal is routed to the external DVM to measure the current flow. When the V/I source is used to source a current, the external DVM is used to measured the resultant voltage developed.

The high-voltage amplifier includes a safety interlock that automatically disables the high-voltage amplifier and opens all relays (OAR) on the board when the interlock circuit is broken; i.e., the interlock must be enabled for the high-voltage amplifier to work. See Chapter 1, “Warnings and Cautions.” Interlock events are latched and indicated by an LED on the module's front panel. You cannot close relays on the module during an interlock event. A programmable override allows self-tests or diagnostics if the physical interlock is not present.

The purpose of the interlock is to provide a means of prohibiting DUT access while dangerously high voltages may be present. This can be accomplished, for example, by installing a DUT safety cover secured by a fixture screw and activating a limit switch.

Internally, when the card is switched to the high-voltage amplifier, the card senses either an open or a short across the two interlock pins on the front panel connector J1. (See Figure 2-1 on page 16)

ARB Features

When an Agilent E6173A Arbitrary Function Generator Module is connected to external inputs 5 & 6, the ARB can use the low voltage V/I source as an amplifier/current sensor, which allows measuring the input capacitance of RFI filters. Also, a step-up transformer on the Measurement Control Module lets you amplify the ARB's signal to (80 volts peak to simulate VRS (Variable Reluctance Sensor) signals.

An ARB DAC also allows for rapid amplitude programming for different gains of the same waveform

Analog Comparator

You can use the analog comparator to condition trigger signals from the DUT to make them compatible with TTL levels (see Appendix A for specifications). The analog comparator has two ranges, with programmable thresholds of ±20 volts and ±200 volts for the low and high ranges, respectively.

General-Purpose Timer

The general-purpose timer is used to:

- Time single events, such as the open/close time of relays in the module.
- Synchronize repetitive events, such as triggering a measurement at a regular interval.
- Generate interrupts.
- Generate Trigger delays.

The timer supports two kinds of operation, which are:

- One-shot, where the counter stops upon reaching the terminal value for which it is programmed; i.e., achieving its maximum count. This value is stored in the General-Purpose Timer Register (see Appendix B).

- Repetitive or free-running, where the counter reaches the terminal value for which it is programmed, reloads itself with the current contents of the General-Purpose Timer Register, and begins counting again. In repetitive mode, the timer is always running.

Both modes of operation are supported in the range from 20 µs. to 655.37 ms., programmable in steps of 10 µs within 16 bits of resolution.

Either of two sources can start the general-purpose timer counting: loading the General-Purpose Timer Register, or the falling edge of a waveform from the trigger multiplexer applied to its trigger input. Bit 8 of the Status/Control Register (see Appendix B) selects which source is used.

The general-purpose timer can generate a trigger output upon time-out. The output is a negative pulse of about 10 µs. duration.

The operating modes of the general-purpose timer are summarized in Table 2-2.

Table 2-2. Operating Modes of the General-Purpose Timer

Mode	Started by	Description
one-shot	loading of General-Purpose Timer Register	One timing cycle per loading of the register. Reloading the register restarts the timer immediately. Useful for timing individual events like relay timing.
one-shot	trigger input	One timing cycle per trigger input. A new trigger input restarts the timer immediately, even if it has not timed out from a previous trigger. Useful for generating programmable trigger delays. If a new trigger is received before the timer times out, the timer is restarted.
repetitive	time-out of previous count	Free-running timer. New values can be loaded into the General-Purpose Timer Register at any time. Use to generate pacing triggers or "watch-dog" timers.
repetitive	trigger input	Free-running timer started by the trigger input. It resynchronizes with trigger. Use to generate timing triggers and interrupts.

You can selectively route the general-purpose timer's output to any of three destinations:

- By default, to the Status Register (see Appendix B).
- The trigger multiplexer.
- Any of seven programmable interrupts, IRQ1 through IRQ7.

Which destination is used is determined by the contents of the TRIG 1 & 2 Source & Destination Selection registers (see Appendix B).

The proper order for setting up the timer is to first set the mode and source, then load the timing delay.

Digital Trigger

The digital trigger serves as an isolator to convert the earth-referenced trigger to a DUT referenced trigger. Below is a diagram of how the “floating” referenced trigger is generated.

Note that the Maximum allowable external pull-up is 30 Volts. Exceeding this value will cause the PCTR (positive coefficient thermal resistor) in the output series protection circuit to effectively become an open circuit until the circuitry cools down.

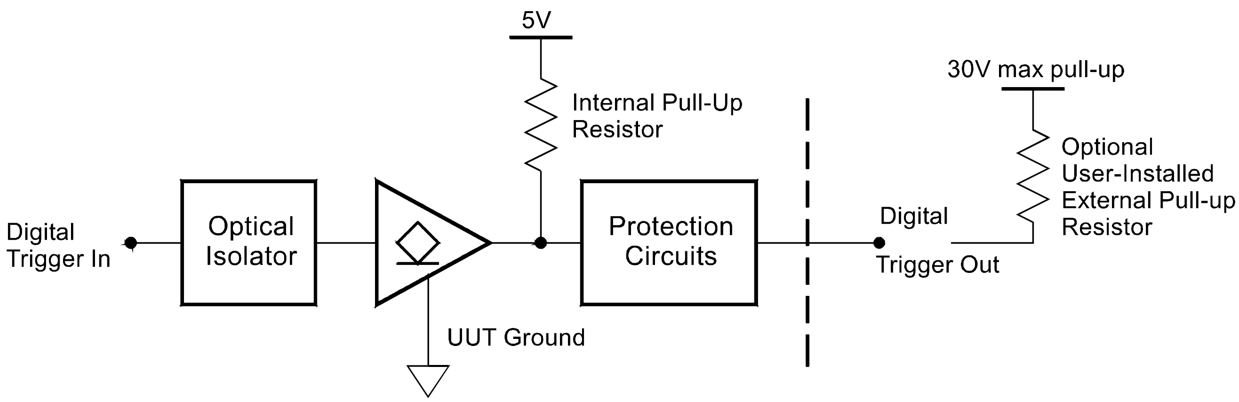


Figure 2-4. Digital Trigger Block Diagram

Programmable Attenuator

The Measurement Control Module has a programmable attenuator between the DUT input and the digitizer.

Figure 2-5 is a graph of the attenuator transfer function. The programmable "knee" can be set from ±1 volts to ±10 volts; ±2.5 volts is the default. Voltages near the knee voltage are not known with full accuracy and should not be measured. with the attenuator. For example, valid ranges for knee voltages of ±2.5 volts are ±2.0 volts unattenuated and ±(120 - 200) volts attenuated.

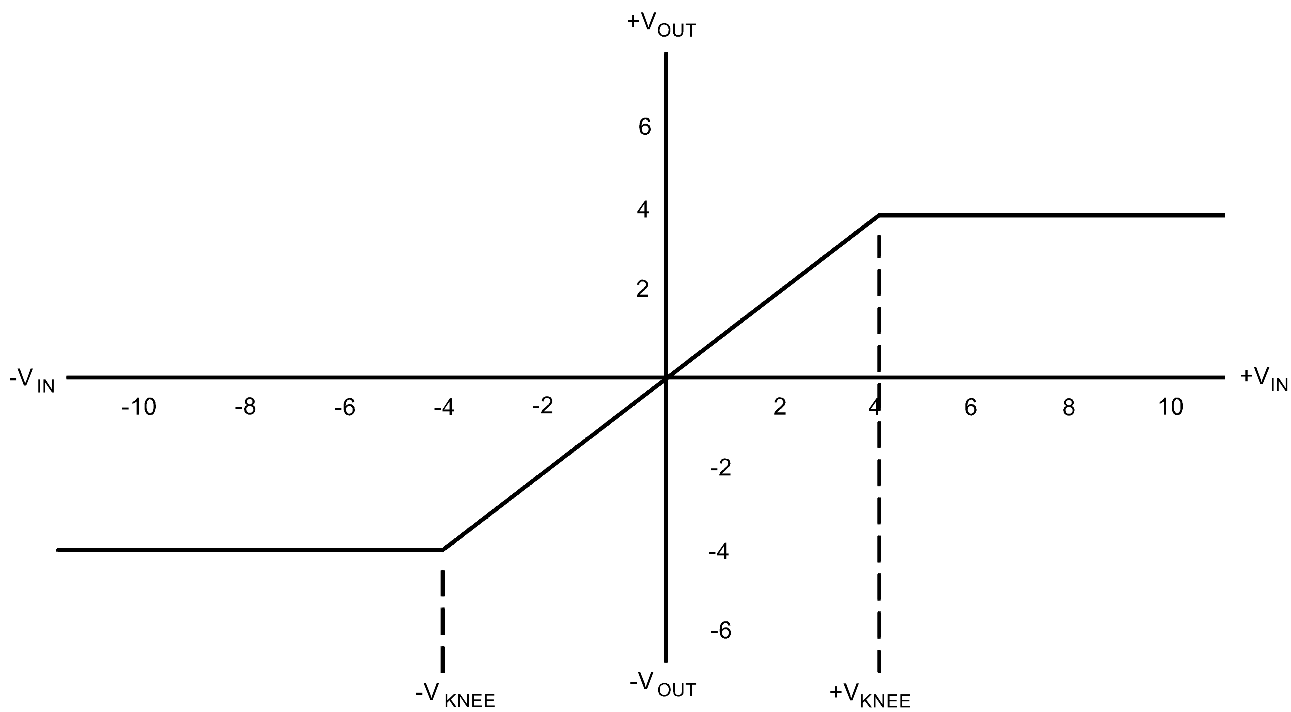


Figure 2-5. Programmable Attenuator Transfer Function

Figure 2-6 is a simplified schematic of the Programmable Attenuator input circuitry. As the figure indicates, adding an external 20.0 Kohm resistor doubles the impedance above the knee:

$$V_{out} = V_{in}\left(\frac{1.0\text{K}}{1.0K + 19.0K + 20.0K}\right)$$

Some signals characteristic of automotive test involve orders of magnitude difference in amplitude, making comparable or simultaneous measurements difficult. One specific example is the saturation and flyback voltages in an automotive ignition system. The Programmable Attenuator is available so that a units saturation and flyback voltages can be measured in the same measurement and with the same degree of resolution.

For example: Suppose a DUT operates at 12 V. It enters saturation at 0.2 V, and the flyback voltage is 150 V.

If the programmable attenuator "knee" is set for 1 V, all voltages above 1 V are attenuated by a factor of 20:1. So the digitizer would see the following voltages:

Vin = 12 V	Vdigit = 1 V + (0.05*11 V) = 1.55 V.
Vin = 0.2 V	Vdigit = 0.02 V
Vin = 150 V	Vdigit = 1 V + (0.05*149 V) = 8.45 V.

All voltages can now be easily measured by the digitizer without having to change the measurement range.

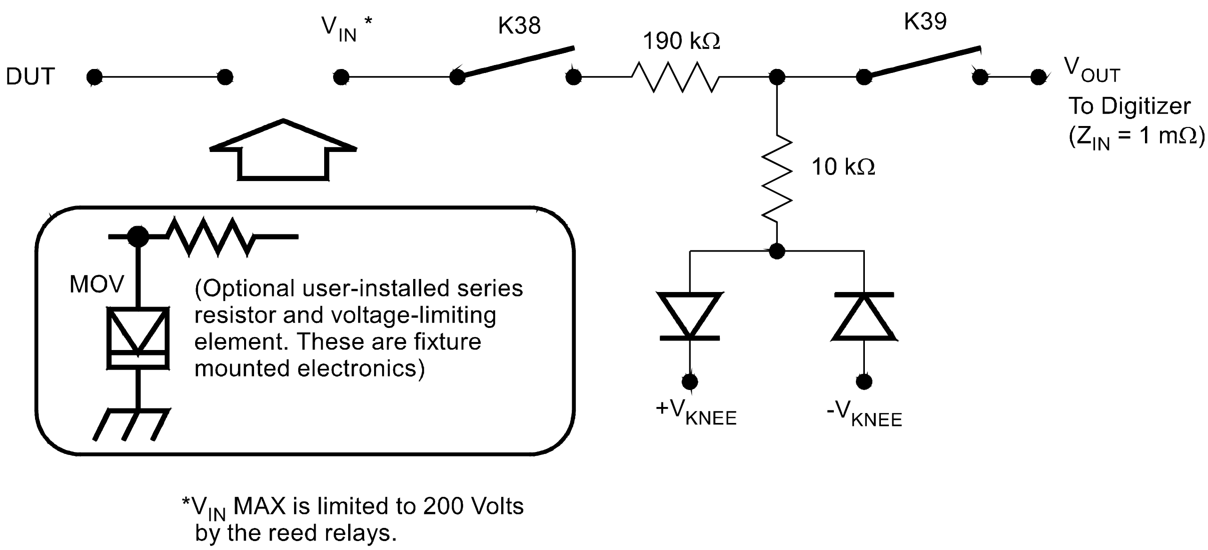


Figure 2-6. Simplified Attenuator Circuit

Connecting DUT Ground to Chassis Ground

Although the DUT ground by default “floats” independently of chassis or system ground, you can close relays and create a path that connects the two together. First, set bit 0 in the Other Configuration Register (see Appendix B), which connects DVM Low (external instrument 2) to chassis ground. Then set bit 14 in the Instrument 1-16 to DUT Common Register to close the relay that connects DVM Low to DUT Common.2

Interrupts

The three potential sources of interrupts in the Measurement Control Module are:

- An event associated with the high-voltage amplifier's safety interlock.
- An event associated with the output from the general-purpose timer.
- A programmable interrupt generated via software.

You can select which of these sources generates an interrupt, and select which interrupt—IRQ 1 through IRQ7—is generated by the source.

Interrupts are selected and controlled by the IRQ Register (see Appendix B).

Power-on State

At power-on or after setting/resetting Bit 0 in the Control Register, the Measurement Control Module is in its hardware reset state:

- All internal registers are cleared.
- All relay registers are cleared—i.e., all relays are open.
- The high voltage interlock is enabled.
- All IRQs are disabled.
- All DACs are programmed to logical zero.
- The general-purpose timer is stopped, its mode is set to one-shot, and its source is “load.”
- All trigger sources and destinations are cleared.

Note Run the Agilent TestExec SL software immediately after power-on to reset the Agilent E6171B (and all other instruments in the Agilent TS-5400 system). This helps the module thermally stabilize quickly. If left in its power-on state for extended time periods, the module may take several minutes to stabilize after the software resets it.

Software Reset

A software reset performed through the Agilent TestExec SL software the following functions:

- Performs a hardware reset.
- Selects the LV amplifier, and sets the Amplitude to zero.
- Clamps the comparator input.
- Sets the nominal clamp voltage on the DAC to 0 V.

Chapter 3

Adjusting the Agilent E6171BE6171B Measurement Control Module

Using This Chapter

This chapter provides procedures for adjusting the Measurement Control Module. It contains the following sections:

- Adjusting the VI VHI and VLO front panel potentiometers.
- Other Adjustments.

Adjusting the VI Pots

The Measurement Control Module has two field adjustable potentiometers accessible at the lower front panel of the module. The upper adjustment is the VI low voltage IGAIN and the lower adjustment if for the VI high voltage IGAIN.

Other Adjustments

There are three access holes on the side cover for three other adjustable potentiometers. One of the pots is for adjusting the maximum VI current for the High Voltage circuit, and the other two are for adjusting the VI maximum current for the Low voltage circuit.

These pots are intended for factory adjustments only. DO NOT attempt to adjust these three potentiometers in the field.

Caution **Unauthorized adjustment of these factory settings may allow excessive current flow in the circuitry, possibly damaging the Agilent E6171B Measurement Control Module or its components.**

Notes:

Appendix A

Agilent E6171B Measurement Control Module Specifications

General

Module Size/Device Type:
C-Size VXIbus, register based, A16/D16, static configuration

Power requirements: +5 and +12 Vdc

Operating temperature: 5 to 40 °C

Operating humidity: 80% Relative Humidity, 5 to 40 °C

External Instrument Multiplexer

No. of Analog Instrument Channels:16

Analog Channel:
Voltage (Max.):200 volts
Resistance: <1Ω
Unbalanced Bandwidth: 10 MHz (Minimum)
Balanced Pair Bandwidth: 5 MHz (Minimum)

Relay Type: dry reed

Relay Life:
@ No load: $1x10^8$ operations
@ Full load: $1x10^5$ operations

Relay Switching Speed:
Close: 500 µS
Open: 400 µS

Relay Switching Characteristics:
1.0 A carry
0.5 A while switching
7.5 Volt-Amps max. instantaneous switching

Other Relay Parameters:
300 VDC Standoff voltage
200 VDC Switching voltage

Voltage Source (Low Voltage)

Voltage Range:
±16Vdc @ rated current (0.2 Amp) (4 quadrant operation)
rated accuracy, no load ±(0.06% + 0.006 V)

DAC resolution:16 bits

Output Resistance:2Ω max.

Current Sense Accuracy:to ABus 1to Abus2 - 4, UUTCommon
200mA range:±(1.25% + 150µA)±(2.0% + 150µA)
20mA range:±(0.21% + 15 µA)±(0.29% + 15 µA)
2mA range:±(0.30% + 1.5µA)±(0.31% + 1.5µA)
200µA range:±(0.12% + 0.75µA)±(0.12% + 0.75µA)

Short Circuit Current Limit Protected:0.225A

Voltage Source (High Voltage)

Voltage Range:
-10 to +100Vdc or -100 to +10 Vdc
@ rated current (0.02 A)(4 quadrant operation)
rated accuracy, no load ±(0.06% + 0.06 V)

DAC resolution:16 bits

Output Resistance:2Ω max.

Current Sense Accuracy:to ABus 1to Abus2 - 4, UUTCommon
±(0.25% + 150µA)±(0.33% + 150µA)

Short Circuit Current Limit Protected:0.025A

Current Source (Low Voltage)

Current Range: ±200 mA over ±16V range (4 quadrant operation)

Current Accuracy:
200 mA range:±(0.3% + 500µA)
20 mA range:±(0.1% + 50µA)
2 mA range:±(0.3% + 5µA)
200 µA range:±(0.1% + 0.5 µA)

DAC resolution:16 bits

Voltage Compliance Limit Range: ±(1.5 to 16)Vdc

Voltage Compliance Limit Accuracy: ±0.25 Volts, specified at no load

Output Resistance:
200 mA range:> 20 kΩ minimum
20 mA range:> 200 kΩ minimum
2 mA range:> 2 MΩ minimum
200 µA range:> 20 MΩ minimum

Current Source (High Voltage)

Current Range: ±20mA @ rated voltage (4 quadrant operation)
(-10 to +100 Vdc or -100 to +10Vdc)
rated accuracy, no load ±(0.3% + 0.46 mA)

DAC resolution: 16 bits

Current Accuracy: ±(0.3% + 500 µA)

Voltage Compliance Limit Range: ±(10 to 100) Vdc

Voltage Compliance Limit Accuracy: ±2.5 Volts specified at no load

Output Resistance: 140 kΩ

Step Up Transformer

Transformer Ratio:10.2:1

Voltage Accuracy:10, +5% maximum error, 150Hz to 5kHz

Output voltage:160 V_{PP} max into a 10kΩ load

Output Current:10mA maximum

Output Impedance:1.0kΩ maximum @ 1.0kHz

Hi-Voltage Attenuator

Attenuation: 20:1 nominal

Accuracy, DC:[1] ±3mV maximum unattenuated
±(2.5% +250 mV) maximum attenuated

Settling Time (to within 2.0% of final value):
20µS maximum unattenuated
5µS maximum attenuated

1. Accuracy specification are with respect to the default knee voltage of 2.5V with no external source resistance. Unattenuated range of ±2.0V. Attenuated range of ±(20 to 200)V.

Input Impedance: 20kΩ

Maximum Input Voltage: ±100 DCV, ±200 Pulse <1mS, <1.0% DC
(500 Volts maximum with external series resistor
and clamp protection @ 200 Volts)

Programmable Knee: ±(1 to 10) Volts (2.5 Volts default)

MCM Trigger Subsystem

Resources (Trigger Inputs/Outputs):
External Triggers: 8 (TTL bi-directional, chassis referenced)
VXI TTL Triggers: 8 (bi-directional)
Timer: 1 timer done, 1 timer start
Software: 1 input, 1 output
Comparator: 1 (Input only, ref. to DUT common, programmable edge)
Digital Trigger: 1 (Output only, ref. to DUT common, internal pullup to +5V)

Time Delay:[1]
VXI TTL Trig in, any EXT Trig in, or Timer Done -to-
any other VXI TTL Trig, any other EXT Trig, or Timer Start: 100nS max.
VXI TTL Trig in, any EXT Trig in, or Timer Done -to-
Digital Trigger Out: 150nS max.
Comparator Threshold in - to-
any VXI TTL Trig out, any EXT Trig out, or Timer Start: 350 nS max.
Comparator Threshold in -to- Digital Trigger out: 400nS max.

Analog Comparator:
Maximum Voltage: ±100 Vdc or ±200V pulse ≤10mS, ≤2% duty cycle
Input Resistance: 100 kΩ (typical)
Input Bandwidth: 250 kHz (min.)

Comparator 200 V Range:
Programmable Threshold Range: ±200V
Programmable Threshold Accuracy: ±4 Volts
Threshold Sensitivity (hysteresis): 5.0 V_{PP} max., 1.0 V_{PP} min.

Comparator 20 V Range:
Programmable Threshold Range: ±20
Programmable Threshold Accuracy: ±0.4 Volts
Threshold Sensitivity (hysteresis): 0.5 V_{PP} max., 0.1 V_{PP} min.

1. All trigger timing specifications except comparator threshold, are from +1.5V driven edge to +1.5V driven edge.
All comparator timing specifications are referenced to the input crossing the nominal programmed threshold at 85 V/µS with 1V overdrive for the 20V range or 10V overdrive for the 200V range.

Digital Trigger Output:

Nominal Internal Pull-up:5V

Sink Current: 10 mA @ V_{ol} ≤0.4Vdc or

150mA @ V_{ol} ≤1Vdc

Maximum External Pull-up Voltage:30 Vdc

General Purpose Timer:

Resolution: 10µS typical

Range: 20µS to 655.37mS

Accuracy: ±(0.02 % + 10µS)

Programmable Modes:one-shot or programmable

Programmable Start Events:Software or Trigger

Programmable Outputs:Busy Bit in Status Register, 10 µS Trigger Pulse, or Interrupt (IRQ)

Relay Life

Electromechanical relays are subject to normal wear-out. Relay life depends on several factors including loading and switching frequency.

Relay Load. In general, higher power switching reduces relay life. In addition, capacitive/inductive loads and high inrush currents (e.g. turning on a lamp or starting a motor) reduces relay life. Exceeding specified maximum inputs can cause catastrophic failures.

Switching Frequency. Relay contacts heat when switched. As the switching frequency increases, the contacts have less time to dissipate heat. The resulting increase in contact temperature reduces relay life.

End-of-Life Detection

A preventative maintenance routine can prevent problems caused by unexpected relay failure. The end-of-life of a relay can be determined by using one or more of the three methods described below. The best method (or combination of methods), as well as the failure criteria, depends on the application in which the relay is used.

Contact Resistance. As the relay begins to wear out, its contact resistance increases. For the Agilent E6171B, the total resistance measured through and external instrument connector to an analog bus connector is less than 1Ω. Since most of this resistance is trace resistance, an increase of 1 or 2Ωs indicates relay deterioration.

Stability of Contact Resistance. The stability of contact resistance decreases with age. Using this method, the contact resistance is measured several (5 - 10) times, and the variance of the measurement is determined. An increase in the variance indicates deteriorating performance.

Number of Operations. Relays can be replaced after a predetermined number of contact closures. However, this method requires knowledge of the applied load and life specifications for the applied load. The expected life of the relays range from 1×10^5 operations at full load to 1×10^8 operations for mechanical end-of-life (no load).

Replacement Strategy

The replacement strategy depends on the application. If some relays are used more often, or at a higher load, than the others, the relays can be individually replaced as needed. If all the relays see similar loads and switching frequencies, the entire circuit board can be replaced when the end of relay life approaches. The sensitivity of the application should be weighed against the cost of replacing relays with some useful life remaining.

Note Relays that wear out normally or fail due to misuse should not be considered defective and are not covered by the products warranty.

Appendix B
Register Definitions

Addressing the Registers

To access a specific register for either read or write operations, you must use its register address. Register addresses for VXIbus plug-in modules reside in an address space called "A16" whose size is $FFFF_h$. The exact location of the A16 address space within a VXIbus master's memory map depends on the system resource manager.

VXIbus modules are addressed at locations above $C000_h$ within the A16 address space. Because each module requires one 64 byte (40_h) block of addresses, the A16 address space between $C000_h$ and $FFFF_h$ can accommodate as many as 255 VXIbus modules.

Given that the address space of each module is 64 bytes, the address of a module is determined by its logical address (set by the address switches on the module) multiplied by an offset of 64 (40_h). Suppose the A16 address space began at $1F0000_h$ and the Measurement Control Module's address was 120 (78_h). Then the addresses of the module's internal registers—i.e., the base address of the module—would start at $1FDE00_h$, like this:

$1F0000_h + C000_h + (78_h*40_h) = 1FDE00_h$

16 Address Space Outside the System Controller

When the A16 address space is outside the system controller, the base address of the Measurement Control Module is computed as:

$A16base + C000_h + (LADDR_h * 40_h)$

or (decimal)

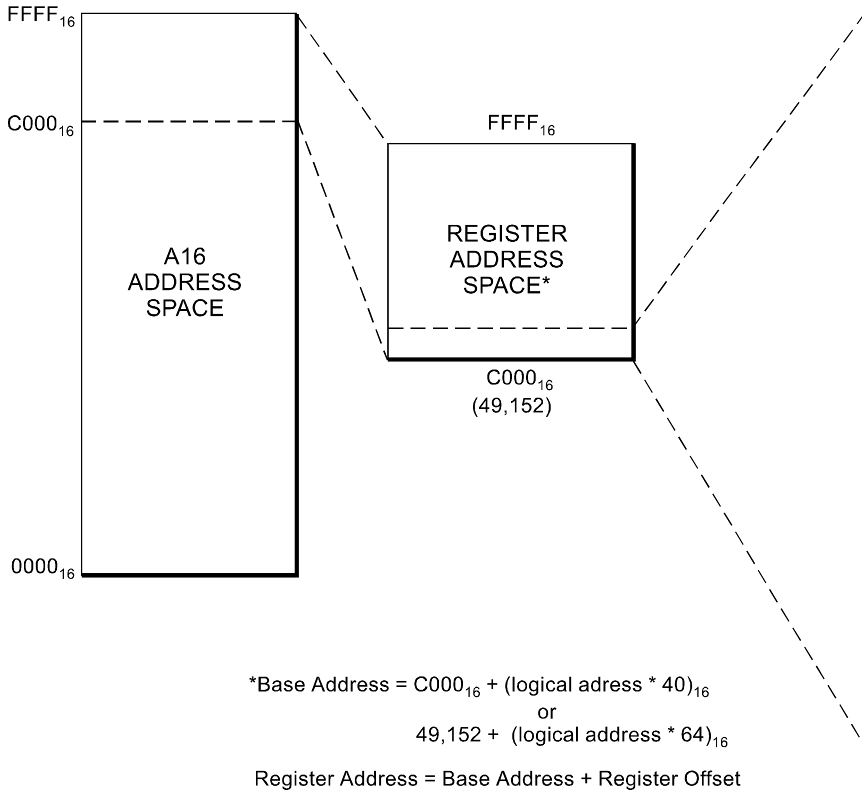
$A16_{base} + 49{,}152 + (LADDR * 64)$

where $C000_h$ (49,152) is the starting location of the register addresses, LADDR is the module's logical address, and 64 is the number of address bytes per VXIbus device. For example, if the Measurement Control Module's logical address (LADDR) was set to 120 (78_h), it would have a base address of:

$A16_{base} + C000_h + (78_h * 40_h) = C000_h + 1E00_h = DE00_h$

or (decimal)

$$A16_{base} + 49,152 + (120 * 64) = 49,152 + 7,680 = 56832$$



REGISTER OFFSET	16-BIT WORDS
3Eh	IRQ
38h	Other Trigger Resources
36h	TTL & Ext Trig Dest for Trig2
34h	TTL & Ext Trig Source for Trig2
32h	TTL & Ext Trig Dest for Trig1
30h	TTL & Ext Trig Source for Trig1
2Eh	Other Configuration
2Ch	V/I Source Configuration
2Ah	ABus Interconnection
28h	ABus4 to Instrument 1-16
26h	ABus3 to Instrument 1-16
24h	ABus2 to Instrument 1-16
22h	ABus1 to Instrument 1-16
20h	UUT Common to Instrument 1-16
0Eh	Comparator DAC
0Ch	Arb Amplifier DAC
0Ah	V/I Clamp Dac/Amp selector
08h	V/I Amplitude DAC
06h	Timer Control
04h	Status/Control
02h	Device Type
00h	Manufacturer ID

Measurement Control Module
A16 Register Map

Figure B-1. Register Locations Within the A16 Address Space

Register Offset

The offset for a specific register is that register's location in the block of 64 address bytes that belongs to the module. For example, the module's Status/Control Register has an offset of 04_h. Continuing with the previous example, whose base address was $1FDE00_h$, when accessing this register, you would add the offset to the base address to form the register address, like this:

$$1FDE00_h + 04_h = 1FDE04_h$$

or (decimal)

$$2,088,448 + 4 = 2,080,452$$

Register Descriptions

The Agilent E6171B module has the following registers:

- Manufacturer ID Register (base + 00_h)
- Device Type Register (base + 02_h)
- Status/Control Register (base + 04_h)
- Timer Control Register (base + 06_h)
- DAC Control Registers, which are:
  -- V/I Amplitude DAC (base + 08_h)
  -- V/I Clamp DAC & Amplifier Selector (base + $0A_h$)
  -- ARB Amplitude DAC (base + $0C_h$)
  -- Comparator DAC (base + $0E_h$)
- Relay registers, which are:
  -- DUT Common to Instrument 1-16 (base + 20_h)
  -- ABus1 to Instrument 1-16 (base + 22_h)
  -- ABus2 to Instrument 1-16 (base + 24_h)
  -- ABus3 to Instrument 1-16 (base + 26_h)
  -- ABus4 to Instrument 1-16 (base + 28_h)
  -- ABus Interconnection (base + $2A_h$)
  -- V/I Source Configuration (base + $2C_h$)
  -- Other Configuration (base + $2E_h$)
- TRIG 1 & TRIG2 Source & Destination Selection registers, which are:
  -- TTL & External Trigger Source for TRIG1 (base + 30_h)
  -- TTL & External Trigger Destination for TRIG1 (base + 32_h)
  -- TTL & External Trigger Source for TRIG2 (base + 34_h)
  -- TTL & External Trigger Destination for TRIG2 (base + 36_h)
  -- Other Trigger Resources (base + 38_h)
- IRQ Register (base + $3E_h$)

Manufacturer Identification Register

The Manufacturer ID Register is a 16-bit read-only register at address 00_h with the most significant byte (MSB) at 00_h and the least significant byte at 01_h. Reading this register returns the Agilent identification, $FFFF_h$.

Device Type Register

The Device Type Register is a 16-bit read-only register at address 02_h with the most significant byte (MSB) at address 02_h and the least significant byte (LSB) at address 03_h. Reading this register returns 0224_h, which uniquely identifies this module as an Agilent E6171B.

Status/Control Register

The Status/Control Register is actually two independent registers at a single address. The readable or "status" portion of the register returns information about the current state of the module. The writable or "control" portion of the register controls various functions of the module. The bit fields of both registers are described below, along with the definitions of terms that apply to them.

Status Register (base + 04_h)

Bit	15	14	13-11	10	9	8	7
Purpose	undefined	MODID\	undefined	Revision	Timer Mode	Timer Source	BUSY\
Value	1	state	111	state	state	state	state

Bit	6	5	4	3	2	1	0
Purpose	Ignore Interlock	undefined	High Voltage	READY	PASSED	Interlock Event	IRQ Pending\
Value	state	1	state	1	1	state	state

* The default state of this register at power-on is $FCB8_h$ when the safety interlock is enabled—i.e., Bit 1 = "1" —and $FCBA_h$ when it is not.

undefined: All undefined bits appear as "1" when read. Writing to an undefined bit has no effect.

MODID\: "0" indicates the module is present.

Revision: 1 = Agilent E6171A; 0 = Agilent E6171B

Timer Mode: "0" indicates single, which is the default, and "1" indicates repetitive or "free running."

Timer Source: The source of the stimulus that starts the timer. A "0" indicates the timer is started by loading the General-Purpose Timer Register if Timer Mode = 0, or restarted by timing out if Timer Mode = 1. A "1" indicates that a trigger event starts the timer.

BUSY\: "0" implies the relay state is undefined. Defaults to "1".

Ignore Interlock: "0" indicates the interlock is active. Defaults to "0".

High Voltage: "0" indicates high voltage is disabled. Defaults to "0".

READY: "1" indicates the module powered up successfully.

PASSED: "1" indicates the module powered up successfully.

Interlock Event: "0" indicates no event, and "1" indicates an event was detected. Defaults to "0" if the interlock is jumpered (enabled).

IRQ Pending\: A "0" indicates that an IRQ is pending, and a "1" that it is not. This bit monitors the status of three possible sources of interrupts in the Measurement Control Module. The selection of those sources is controlled elsewhere, in the IRQ Register. When the IRQ Pending bit is set, it indicates that an interrupt has occurred but has yet to be acknowledged and cleared via an IACK bus cycle on the VXIbus.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Control Register (base + 04_h)

Bit	15-10	9	8	7	6
Purpose	undefined	Timer Mode	Timer Source	undefined	Ignore Interlock
Value	X	state	state	X	state

Bit	5	4	3	2	1	0
Purpose	OAR	High Voltage	undefined	clear interlock	SYSFAIL Inhibit	RESET
Value	state	state	X	state	1	state

undefined: Writing to an undefined bit has no effect. Writing to an undefined bit has no effect.

Timer Mode: "0" indicates single, which is the default, and "1" indicates repetitive or "free running."

Timer Source: The source of the stimulus that starts the timer. If the Timer Mode = 0, writing a "0" here causes the timer to start whenever the General-Purpose Timer Register is loaded. If the Timer Mode = 1, writing a "0" here causes the timer to restart whenever it times out. Writing a "1" here causes trigger events to start the timer.

Ignore Interlock: "0" indicates the interlock is active. Defaults to "0".

OAR: (Open All Relays) A "1" opens all relays, a "0" causes no change. OAR clears itself upon execution.

High Voltage: "0" indicates high voltage is disabled. Defaults to "0".

Clear Interlock: A "1" clears an interlock event, a "0" retains an interlock event. This bit clears itself upon execution.

SYSFAIL inhibit: A "1" means inhibit, a "0" enables SYSFAIL. Because this module does not drive SYSFAIL, this bit does nothing.

RESET: A "1" causes reset, a "0" causes no change. RESET clears itself upon execution. The reset state of this module is all relays open, the interlock is enabled, IRQs are disabled, DAC values are set to 0, the timer mode is "single," and the timer source is the loading of the General-Purpose Timer Register.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

General-Purpose Timer Register

The General-Purpose Timer Register is a read/write register that:

- Controls the terminal value (maximum count) of the timer.
- Returns the counting status of the timer when queried.
- Starts the timer counting when loaded with a new value.

General-Purpose Timer Register (base + 06_h)

Bit	15-0
Purpose	StartCount (in write mode) ActualCount (in read mode)
Value	count

* The default state of this register at power-on or when the module has been reset is 0000_h with the timer stopped. At other times, the state of this register is $FFFF_h$ if the timer is stopped.

* Writing to bits in this register controls the module, and reading the bits returns their current values.

When programming the delay time counted by the timer is:

$$StartCount = 65537 - Delay * 10^5$$

where Delay is the desired delay in seconds. The delay can be in the range from 30 µs. to 655.38 ms. with 10 µs. resolution, which you specify as an integer from 0 to 65535 for StartCount.

Reading the status of this register returns the delay remaining before the counter reaches its terminal value, as follows:

$$Delay = (65537 - ActualCount) * 10^{-5}$$

where the value returned for Delay is an integer from 0 to 65535. This corresponds to a delay in the range from 20 µs. to 65.537 sec. with 10 µs. resolution.

DAC Control Registers

The DAC Control registers control various aspects of the operation of the V/I source in the module. They are individually described next.

V/I Amplitude DAC Register

The V/I Amplitude DAC Register is a read/write register that controls the DAC whose output drives both the high and low voltage amplifiers. The V/I source in this module consists of the DAC-plus-amplifier combination.

The nominal values for gain and offset in both voltage and current modes is given below. The V/I values can be calculated from the equation:

V/I dac = gain * programmed value - offset

LV Voltage Mode: $V_{out} = 609.75x10^{-6} * SETTING - 19.98V$

HV Voltage Mode: $V_{out} = 3.351x10^{-3}$ * SETTING - 109.8

LV Current Mode (Positive current defined as sourcing, negative is sinking:

200 mA Range $I_{out} = 30.52x10^{-6}$ * SETTING - 1 A

20 mA Range $I_{out} = 3.052x10^{-6}$ * SETTING - 100 mA

2 mA Range $I_{out} = 305.2x10^{-9}$ * SETTING - 10 mA

200 µA Range $I_{out} = 30.52x10^{-9}$ * SETTING - 1 mA

HV Current Mode: $I_{out} = 33.46x10^{-6}$ * SETTING - 0.998 A

You specify the programmed value via bits 0 through 15 in this register, as shown below. Programming these bits to integer values from 0000_h to $FFFF_h$ provides output voltage values of ±10 V for the DAC, and different values depending on range and mode.

V/I Amplitude DAC Register (base + 08_h)

Bit	**15-0**
Purpose	Set or read programmed output voltage
Value	Read current voltage value, or Write desired voltage

* The default value of this register at power-on or when the module has been reset is 0000_h.

V/I Clamp, Attenuator Knee, and DAC & Amplifier Selector Register

This register consists of two separate functions: Amplifier selection bits and an eight bit DAC.

The amplifier selection bits select which resources are connected to the low and high voltage V/I amplifiers. Available resources include: VI DAC, VI GROUND (High Voltage only), and ARB gain amplifier (Low voltage only).

The DAC bits control an eight bit DAC that sets the voltage compliance for both the low and high voltage VI amplifiers as well as the Knee voltage of the programmable attenuator. These functions are mutually exclusive. The clamp voltage of the DAC is:

Vdac = gain * programmed value - offset

The nominal values for gain and offset are given below. The actual values are determined during calibration.

$LV_{CLAMP} = \pm 78.13x10^{-3}$ * SETTING ± 2 * V_D Volts

$HV_{CLAMP} = \pm 430 \times 10^{-3} * SETTING \pm 11 * V_D$ Volts

You specify the programmed value via bits 0 through 7 in this register. The four remaining bits, bits 8 -11, control the amplifier selection.

The programmable attenuators knee can be varied from 1 to 10 volts. The attenuator passes the input voltage at 1:1 until the input reaches the knee, then any voltages above the knee level are attenuates at 20:1. The equation for setting the value of the attenuators knee is:

$ATTENUATOR\ KNEE = \pm 39.06 \times 10^{-3} * SETTING \pm V_D$ Volts

V/I Clamp, Attenuator Knee, and DAC & Amplifier Selector Register (base + A_h)

Bit	**15-12**	**11**	**10**	**9**	**8**	**7-0**
Purpose	undefined	Connects input of low voltage amplifier to output of ARB amplifier	Connects input of low voltage amplifier to output of V/I DAC	Connects input of high voltage amplifier to ground	Connects input of high voltage amplifier to output of V/I DAC	Sets value of V_{CLAMP} for V/I source/ V_{KNEE} for Attenuator
Value	X	0 = closed, 1 = open	0 = closed, 1 = open	0 = closed, 1 = open	0 = closed, 1 = open	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

* The only acceptable combinations of values for bits 11-8 are: 1001 (Normal LV AMP), 1110 (Normal HV AMP), 0111 (Normal ARB AMP), 0110 (ARB and HV AMP).

undefined: All undefined bits appear as "1" when read. Writing to an undefined bit has no effect.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

ARB Amplitude DAC Register

The ARB Amplitude DAC Register is a read/write register that controls the DAC that sets the gain of the ARB amplifier. The output voltage of the DAC is:

Varb_out = gain * programmed value * Varb_in

The nominal value for ARB standard gain is -7.723×10^{-3}. The actual value is determined during calibration.

The nominal value for the ARB transformer gain is -38.62×10^{-3}.

ARB Amplitude DAC Register (base + $0C_h$)

Bit	15-8	7-0
Purpose	undefined	Programmed value of ARB Amplitude DAC
Value	X	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

undefined: All undefined bits appear as "1" when read. Writing to an undefined bit has no effect.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Comparator DAC Register

The Comparator DAC Register is a read/write register that controls the DAC that sets the threshold for comparisons done with the analog comparator in this module.

The output voltage of the DAC is:

Vdac = gain * programmed value - offset

Note that the actual threshold of the comparator also depends upon which comparator attenuator is used.

The nominal values for gain and offset used in the equation above are:

20 V Range: $V_{Threshold} = 184.8X10^{-3}$*Programmed_Value - 23.75V

200 V Range: $V_{Threshold} = 1.848$ * Programmed_Value - 237.5 V

The actual values are determined during calibration.

Comparator DAC Register (base + 0Eh)

Bit	15-8	7-0
Purpose	undefined	Sets programmed value of Comparator DAC
Value	X	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

undefined: All undefined bits appear as "1" when read. Writing to an undefined bit has no effect.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Relay Registers

Relay registers directly control or return the status of relays in this module. All relay control signals use positive-true logic: i.e., "0" is open and "1" is closed. Reading the status of these registers returns to status of the relay drive voltage. Issuing an OAR command or resetting the module opens all relays and clears all control registers.

Instrument Interconnection Registers

The Instrumentation Interconnection Registers are read/write registers that directly control or report the current status of all user-controllable relays in the module. They are:

- Instrument 1-16 to DUT Common
  This register controls the connections between common (ground) on the DUT and the analog buses to which external instruments can be connected. If the relay associated with a given instrument bus is closed, then DUT common is connected to that bus.
- Instrument 1-16 to ABus1
- Instrument 1-16 to ABus2
- Instrument 1-16 to ABus3
- Instrument 1-16 to ABus4

These registers control the connections between ABus1-ABus4 that connect the Measurement Control module with one or more Agilent E6171B modules and the analog buses to which external instruments can be connected. If the relay associated with a given analog bus is closed, then that column is connected to that bus.

Instrument 1-16 to DUT Common Register (base + 20_h)

Bit	**0-15**
Purpose	Connect external instrument 1-16 to DUTCommon
Value	state of relay

Instrument 1-16 to ABus1 Register (base + 22_h)

Bit	**0-15**
Purpose	Connect external instrument 1-16 to ABus1
Value	state of relay

Instrument 1-16 to ABus2 Register (base + 24_h)

Bit	**0-15**
Purpose	Connect external instrument 1-16 to ABus2
Value	state of relay

Instrument 1-16 to ABus3 Register (base + 26$_h$)

Bit	0-15
Purpose	Connect external instrument 1-16 to ABus3
Value	state of relay

Instrument 1-16 to ABus4 Register (base + 28$_h$)

Bit	0-15
Purpose	Connect external instrument 1-16 to ABus4
Value	state of relay

* The default value of these five registers at power-on or after the module has been reset is 0000$_h$.

* Bit place to instrument number mapping is: bit 0 = Inst. 1, bit 1=Inst. 2, and so on.

state of relay: The value is the state of the bit (which determines the state of the relay) the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

ABus Interconnection Register

This read/write register controls the connections between the four columns on ABus1-ABus4 and:

- V/ISrcHi — the output of the V/I source.
- V/ISrcLo — the return connection of the V/I source.
- AComp — the input to the analog comparator.
- TriggerOut — the trigger output to pins on the DUT.

Setting a bit to "1" closes the indicated relay and makes a connection between the ABus and a resource. For example, setting bit 8 connects V/ISrcHi to ABus3.

Column Interconnection Register (base + 2A$_h$)

Bit	**15**	**14**	**13**	**12**
Purpose	TriggerOut to ABus4	AComp to ABus4	V/ISrcLo to ABus4	V/ISrcHi to ABus4
Value	state of relay			

Bit	**11**	**10**	**9**	**8**
Purpose	TriggerOut to ABus3	AComp to ABus3	V/ISrcLo to ABus3	V/ISrcHi to ABus3
Value	state of relay			

Bit	**7**	**6**	**5**	**4**
Purpose	TriggerOut to ABus2	AComp to ABus2	V/ISrcLo to ABus2	V/ISrcHi to ABus2
Value	state of relay			

Bit	**3**	**2**	**1**	**0**
Purpose	TriggerOut to ABus1	AComp to ABus1	V/ISrcLo to ABus1	V/ISrcHi to ABus1
Value	state of relay			

* The default value of this register at power-on or after the module has been reset is 0000$_h$.

state of relay: The value is the state of the bit (which determines the state of the relay) the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

V/I Source Configuration Register

This read/write register controls much of the functionality of the low and high voltage amplifiers used in the V/I source.

V/I Source Configuration Register (base + $2C_h$)

Bit	15	14	13	12
Purpose	Enable current source in low voltage mode with positive (+) feedback	Enable current source in low voltage mode with negative (-) feedback	Enable current sensing for low voltage amplifier	Connect output of low voltage amplifier to secondary of ARB amplifier transformer
Value	state of relay			

Bit	11	10	9	8
Purpose	Enable current source in high voltage mode with negative (-) feedback	Connect output of high voltage amplifier to matrix relays on ABus1-ABus4 (VISrcHi)	Enable high voltage mode with feedback	Enable current sensing for high voltage amplifier
Value	state of relay			

Bit	7	6	5	4
Purpose	Connect output of low voltage amplifier to primary of ARB amplifier transformer	Use 10 ohm resistor for current sensing with low voltage amplifier	Enable current source in low voltage mode with positive (+) feedback	Use 100 ohm resistor for current sensing with low voltage amplifier
Value	state of relay			

Bit	3	2	1	0
Purpose	Use 1K ohm resistor for current sensing with low voltage amplifier	Use 10K ohm resistor for current sensing with low voltage amplifier	Enable low voltage mode with feedback	Connect output of low voltage amplifier to matrix relays on ABus1-ABus4 (VISrcHi)
Value	state of relay			

* The default value of this register at power-on or after the module has been reset is 0000_h.

state of relay: The value is the state of the bit (which determines the state of the relay) the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Other Configuration Register

This register controls miscellaneous relays used to configure the module.

Other Configuration Register (base + $2E_h$)

Bit	7	6	5	4
Purpose	K39 Attenuator Out to ADC1Hi	K38 VISrcHi to Attenuator In	K37 Connect ARB1Hi (external instrument 5) to ARB amplifier	K20 Divide the analog comparator's input voltage by 100
Value	state of relay			

Bit	3	2	1	0
Purpose	K19 Divide the analog comparator's input voltage by 10	K18 Connect V/ISrcLo to DUTCommon	K17 Connect output of V/I source to DUTCommon	K502 Connect DVMLo (external instrument 2) to GND
Value	state of relay			

* Note: actuation of K39 disables the high-voltage clamp feature for calibration purposes of the attenuator.

* The default value of this register at power-on or after the module has been reset is $FF00_h$.

state of relay: The value is the state of the bit (which determines the state of the relay) the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Trigger Configuration Registers

These registers control the configuration of the trigger multiplexer. The trigger multiplexer contains two trigger buses, each of which can be connected to various combinations of trigger sources and destinations. These registers let you specify the routing between sources and destinations.

Possible trigger sources and destinations include eight VXIbus backplane triggers (VXI TTLTrig1-8) and eight external triggers (ExtTrig1-8) on the module's front panel.

TTL & External Trigger Sources for TRIG1 Register

This register controls the selection of trigger sources for bus TRIG1 in the trigger multiplexer. Bits 15-8 control connections between external trigger buses and TRIG1, and bits 7-0 control connections between the TTL-level VXIbus backplane and TRIG1.

TTL & External Trigger Sources for TRIG1 Register (base + 30_h)

Bit	15	14	13	12	11	10	9	8
Purpose	ExtTrig8 to TRIG1	ExtTrig7 to TRIG1	ExtTrig6 to TRIG1	ExtTrig5 to TRIG1	ExtTrig4 to TRIG1	ExtTrig3 to TRIG1	ExtTrig2 to TRIG1	ExtTrig1 to TRIG1
Value	state	state	state	state	state	state	state	state

Bit	7	6	5	4	3	2	1	0
Purpose	VXITTL Trig7 to TRIG1	VXITTL Trig6 to TRIG1	VXITTL Trig5 to TRIG1	VXITTL Trig4 to TRIG1	VXITTL Trig3 to TRIG1	VXITTL Trig2 to TRIG1	VXITTL Trig1 to TRIG1	VXITTL Trig0 to TRIG1
Value	state	state	state	state	state	state	state	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

TTL & External Trigger Destinations for TRIG1 Register

This register controls the selection of trigger destinations for bus TRIG1 in the trigger multiplexer. Bits 15-8 control connections between external trigger buses and TRIG1, and bits 7-0 control connections between the TTL-level VXIbus backplane and TRIG1.

TTL & External Trigger Destinations for TRIG1 Register (base + 32_h)

Bit	15	14	13	12	11	10	9	8
Purpose	TRIG1 to ExtTrig8	TRIG1 to ExtTrig7	TRIG1 to ExtTrig6	TRIG1 to ExtTrig5	TRIG1 to ExtTrig4	TRIG1 to ExtTrig3	TRIG1 to ExtTrig2	TRIG1 to ExtTrig1
Value	state	state	state	state	state	state	state	state

Bit	7	6	5	4	3	2	1	0
Pur-pose	TRIG1 to VXITTL Trig7	TRIG1 to VXITTL Trig6	TRIG1 to VXITTL Trig5	TRIG1 to VXITTL Trig4	TRIG1 to VXITTL Trig3	TRIG1 to VXITTL Trig2	TRIG1 to VXITTL Trig1	TRIG1 to VXITTL Trig0
Value	state	state	state	state	state	state	state	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

TTL & External Trigger Sources for TRIG2 Register

This register controls the selection of trigger sources for bus TRIG2 in the trigger multiplexer. Bits 15-8 control connections between external trigger buses and TRIG2, and bits 7-0 control connections between the TTL-level VXIbus backplane and TRIG2.

TTL & External Trigger Sources for TRIG2 Register (base + 34_h)

Bit	15	14	13	12	11	10	9	8
Purpose	ExtTrig8 to TRIG2	ExtTrig7 to TRIG2	ExtTrig6 to TRIG2	ExtTrig5 to TRIG2	ExtTrig4 to TRIG2	ExtTrig3 to TRIG2	ExtTrig2 to TRIG2	ExtTrig1 to TRIG2
Value	state	state	state	state	state	state	state	state

Bit	7	6	5	4	3	2	1	0
Pur-pose	VXITTL Trig7 to TRIG2	VXITTL Trig6 to TRIG2	VXITTL Trig5 to TRIG2	VXITTL Trig4 to TRIG2	VXITTL Trig3 to TRIG2	VXITTL Trig2 to TRIG2	VXITTL Trig1 to TRIG2	VXITTL Trig0 to TRIG2
Value	state	state	state	state	state	state	state	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

TTL & External Trigger Destinations for TRIG2 Register

This register controls the selection of trigger destinations for bus TRIG2 in the trigger multiplexer. Bits 15-8 control connections between external trigger buses and TRIG2, and bits 7-0 control connections between the TTL-level VXIbus backplane and TRIG2.

TTL & External Trigger Sources for TRIG2 Register (base + 36_h)

Bit	15	14	13	12	11	10	9	8
Purpose	TRIG2 to ExtTrig8	TRIG2 to ExtTrig7	TRIG2 to ExtTrig6	TRIG2 to ExtTrig5	TRIG2 to ExtTrig4	TRIG2 to ExtTrig3	TRIG2 to ExtTrig2	TRIG2 to ExtTrig1
Value	state	state	state	state	state	state	state	state

Bit	7	6	5	4	3	2	1	0
Purpose	TRIG2 to VXITTL Trig7	TRIG2 to VXITTL Trig6	TRIG2 to VXITTL Trig5	TRIG2 to VXITTL Trig4	TRIG2 to VXITTL Trig3	TRIG2 to VXITTL Trig2	TRIG2 to VXITTL Trig1	TRIG2 to VXITTL Trig0
Value	state	state	state	state	state	state	state	state

* The default value of this register at power-on or after the module has been reset is 0000_h.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Other Trigger Resources Register

This register controls the selection of all trigger sources and destinations for buses TRIG1 and TRIG2 not controlled by the previously described source and destination registers.

You probably will find it helpful to refer to Figure 2-3 on page 19 when using the following table.

Other Trigger Resources Register (base + 38_h)

Bit	15	14	13	12	11	10	9	8
Purpose	Read status of TRIG2 (read-only)	Read status of TRIG1 (read-only)	Invert output of analog comparator	Trigger Bit Control	Connect TRIG2 to Digital Trigger out	Connect TRIG2 to "start" input of general-purpose timer	Connect TRIG2 to bit 15 of this register	Connect TRIG1 to Digital Trigger out
Value	state	state	state	state	state	state	state	state

Bit	7	6	5	4	3	2	1	0
Purpose	Connect TRIG1 to "start" input of general-purpose timer	Connect TRIG1 to bit 14 of this register	Connect output of analog comparator to TRIG2	Connect output of general-purpose timer to TRIG2	Connect bit 12 of this register to TRIG2	Connect output of analog comparator to TRIG1	Connect output of general-purpose timer to TRIG1	Connect bit 12 of this register to TRIG1
Value	state	state	state	state	state	state	state	state

* The default value of this register at power-on or after the module has been reset is $C000_h$.

* Setting bit 13 to "1" inverts the output from the analog comparator.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

IRQ Register

The IRQ Register lets you control or read the status of interrupts, as follows:

- The value written to bits 2-0 selects which interrupt, IRQ1 through IRQ7, is associated with the source(s) or cause of the interrupt.[1] A "0" disables an interrupt.
- The value written to bits 5-3 selects the source(s) of the interrupt. For example, setting bit 4 to "1" enables the general-purpose timer as the source of the interrupt. Or, setting bits 3 and 5 to "1" allows the INTRLCK or the Software IRQ to simultaneously be the source of the interrupt.[2] Thus, you can have from one to three sources of interrupts associated with a single interrupt output.
- Bits 10-8 return the status of the interrupt events sources. For example, bit 9 is "1" if the timer finished counting.
- When an interrupt occurs, it sets bit 0, IRQ Pending, in the Status/Control Register to "1".

IRQ Register (base + $3E_h$)

Bit	15-11	10	9	8	7	6	5	4	3	2-0
Purpose	Undefined	IRQ Bit Status	TMR Done Status	INTRLCK Status	IRQ Bit	Undefined	IRQ Bit Enable	Timer Enable	INTRLCK Enable	IRQ Select
Value	X	state	state	state	state	X	state	state	state	IRQ state

* The default value of this register at power-on or after the module has been reset is $F8C0_h$.

* Bits 0-5 are read/write, bit 7 is write only, and bits 8-10 are read-only.

undefined: All undefined bits appear as "1" when read. Writing to an undefined bit has no effect.

IRQ Bit Status: Reading this bit returns the status of the IRQ Bit.

TMR Done Status: Reading this bit returns the status of the general-purpose timer. A "1" indicates the timer has finished counting, and a "0" indicates it still is counting.

INTRLCK Status: Reading this bit returns the status of the safety interlock for the high-voltage amplifier. A "1" indicates the interlock is open, and a "0" indicates it is closed.

IRQ Bit: This bit is one of the three sources of interrupts. Unlike the other two sources, TMR and INTRLCK, this source is not hardware but software. Writing a "1" to this bit generates an interrupt, and once written the bit is self

1. IRQ7 has the highest priority, with the priority of the other IRQs following in descending order.

2. Note that there is an OR relationship among the interrupts; i.e., when multiple sources are enabled, any of them can generate an interrupt.

clearing. Writing a "0" does not generate an interrupt. This bit is intended for diagnostic purposes. This is a write-only bit, and the hardware will always read the bit value as "1."

IRQ Bit Enable: Writing a "1" to this bit enables the IRQ bit as the source of the interrupt, and writing a "0" disables it.

Timer Enable: Writing a "1" enables output from the general-purpose timer as the source of the interrupt, and writing a "0" disables it.

INTRLCK Enable: Writing a "1" to this bit enables the high-voltage amplifier's safety interlock as the source of the interrupt, and writing a "0" disables it.

IRQ Select: Writing a value from 01_h to 07_h selects which IRQ receives the interrupt; i.e., which IRQ is the output. Although multiple interrupt sources are allowed, there can be only one output.

NOTE: Selecting an IRQ of 0 (Zero) is illegal according to the VXI specifications. If an IRQ of 0 selected, no interrupt will be generated.

state: The value is the state of the bit the last time it was written to. If the bit was not written to, its value is the default from power-on or reset.

Programming the Registers

Programming the registers in this module tends to be straightforward because most of them open or close relays located at the intersection of buses. Thus, all you need to know is which bit in which register to set to 1 or 0 to make or break the desired connection.

The following topic describes how to program a register whose use is less obvious.

Using the IRQ Register

You might use the IRQ Register like this:

1. Write to bits 2-0 to select which interrupt is to be the output for the interrupt event.
2. Write to bits 5-3 to select a source for the interrupt.
3. Monitor bit 0, IRQ Pending, in the Status/Control Register to determine when an interrupt occurs.
4. Read bits 10-8 to determine which interrupt occurred.

Note that interrupts in the IRQ Register are automatically cleared upon being acknowledged via an IACK bus cycle on the VXIbus.