USER'S MANUAL

4-CHANNEL PRECISION DC REFERENCE M-MODULE

MODEL M214

Document Part No: 11029264A

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INTRODUCTION

This manual describes the operation and use of the C&H Model M214 4-Channel Precision DC Reference (Part Number 11029264). This module is designed to interface with any standard M-Module carrier.

Contained within this manual are the physical and electrical specifications, installation and startup procedures, functional description, and configuration and programming guidelines to adequately use the product.

This manual is based on a low level register access, and is written in such a manner to provide understanding to the user based on this type of access. If a driver is provided, please refer to the driver documentation for instruction using the higher level interface provided by the driver.

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1.0 GENERAL DESCRIPTION

The M214 provides four precision four-wire voltage references in a single-wide M-module format. Each voltage reference is individually optically isolated to allow independent thermocouple simulation. An on-board microcontroller provides precise control of the voltage references.

The module conforms to the ANSI/VITA 12-1996 standard for M-modules, which allows it to be used in a variety of platforms, including VXI, LXI, PXI, VME, PCI, cPCI, and Ethernet, with the use of an M-module carrier.

1.1 PURPOSE OF EQUIPMENT

The M214 is specifically designed for test applications requiring precision voltage references, such as thermocouple simulation.

1.2 SPECIFICATIONS OF EQUIPMENT

1.2.1 Key Features

- Four independent and individually optically isolated outputs
- Sense lines for accurate remote voltage levels
- Three voltage ranges provide flexible output resolution options
- 20-bit Resolution
- Bipolar output
- On-board EEPROM for non-volatile calibration constant storage
- On-board measurement of PCB temperature with automatic temperature compensation
- External analog input supports external temperature sensing
- Outputs are short circuit protected

1.2.2 Specifications

MAXIMUM RATINGS

Parameter	Condition	Rating	Units
Operating Temperature		0 to +50	°C
Non-Operating Temperature		-40 to +71	°C
Humidity	non-condensing	5 to 95	%
Power Consumption	+5V +12V -12V	1200 * 20 15	mA mA mA
Input Voltage (AIN)	no damage	±20	V
Voltage Source Outputs	Short circuit current	15	mA
+5VOUT	Short circuit current	50	mA

* The +5V power consumption exceeds the ANSI/VITA 12-1996 Specification for M-modules. Be sure check the specifications of the M-module carrier and system environment to ensure that it can handle the rated current load and heat dissipation.

SPECIFICATIONS (full operating temperature, unless otherwise specified)

Parameter	Conditions	Specification	Units
Voltage Outputs (Channels 0 – 3)			
Output Voltage Range		±10.0 ±2.0 ±99	V V mV
Voltage Resolution	±10.0V range ±2.0V range ±99mV range	19.1 3.81 0.188	µV µV µV
Voltage Accuracy [1, 2]	within ±5°C of on-board calibrated temperature and within 98% of full-scale range	±(0.01% of setting + 0.005% of range + 15µV)	
Linearity Error		±0.0015	%
Output Current	minimum (short circuit protected)	±10	mA
Programming Time	register write to start of output change	6.5	ms (max)
Slew Rate	typical	100	V/s
+5VOUT			
Voltage Accuracy		±1.0	%
Thermal Coefficient		20	ppm/°C
Output Current	minimum (short circuit protected)	30	ma
AIN (Analog Input)			
Data Resolution		10	bits
A/D Conversion Error		0.5	LSB
Input Range		±5	V
Accuracy		±(1.5% + 10mV)	
Input Current	maximum	800	nA
On-board Temperature			
Data Resolution		10	bits
Accuracy		±3	°C

Notes:
1. The output level is automatically temperature compensated by the on-board processor. The specified accuracy is typically maintained for a wider temperature difference; however, it is not guaranteed. Unit should be allowed to stabilize for a minimum of 5 minutes after power-up.
2. Accuracy may be somewhat degraded at the limits of each range. Stay within 98% of full scale for specified accuracy.

1.2.3 Mechanical

The mechanical dimensions of the module are in conformance with ANSI/VITA 12-1996 for single-wide M-Module modules. The nominal dimensions are 5.687” (144.5 mm) long × 2.082” (106.2 mm) wide.

1.2.4 Bus Compliance

The module complies with the ANSI/VITA 12-1996 Specification for single-wide M-Modules with the exception that the +5V power consumption exceeds the specification limit of 1A. The module also supports the optional IDENT and VXI-IDENT functions.

Module Type:	M-Module
Addressing:	A08
Data:	D16
Interrupts:	not supported
DMA:	not supported
Triggers:	not supported
Identification:	IDENT and VXI-IDENT
Manufacturer ID:	$0FC1_{16}$
Model Number:	$00D6_{16}$ (214 dec.)
VXI Model Code:	$0FDA_{16}$ (M214)

1.2.5 Applicable Documents

ANSI/VITA 12-1996 Standard for The Mezzanine Concept M-Module Specification, Approved May 20, 1997, American National Standards Institute and VMEbus International Trade Association, 7825 E. Gelding Dr. Suite 104, Scottsdale, AZ 85260-3415, www.vita.com

2.0 INSTALLATION

2.1 UNPACKING AND INSPECTION

Verify that there has been no damage to the shipping container. If damage exists then the container should be retained, as it will provide evidence of carrier caused problems. Such problems should be reported to the shipping courier immediately, as well as to C&H. If there is no damage to the shipping container, carefully remove the module from its box and anti static bag and inspect for any signs of physical damage. If damage exists, report immediately to C&H.

2.2 HANDLING PRECAUTIONS

The M214 contains components that are sensitive to electrostatic discharge. When handling the module for any reason, do so at a static-controlled workstation, whenever possible. At a minimum, avoid work areas that are potential static sources, such as carpeted areas. Avoid unnecessary contact with the components on the module.

2.3 INSTALLATION OF M MODULES

All M-Modules must be installed into the carrier before the carrier is installed into the host system. To install a module, firmly press the connector on the M-Module together with the connector on the carrier as shown in Figure 1. Secure the module through the holes in the bottom shield using the original screws.

CAUTION: M-Module connectors are NOT keyed. Use extra caution to avoid misalignment. Applying power to a misaligned module can damage the M-Module and carrier.

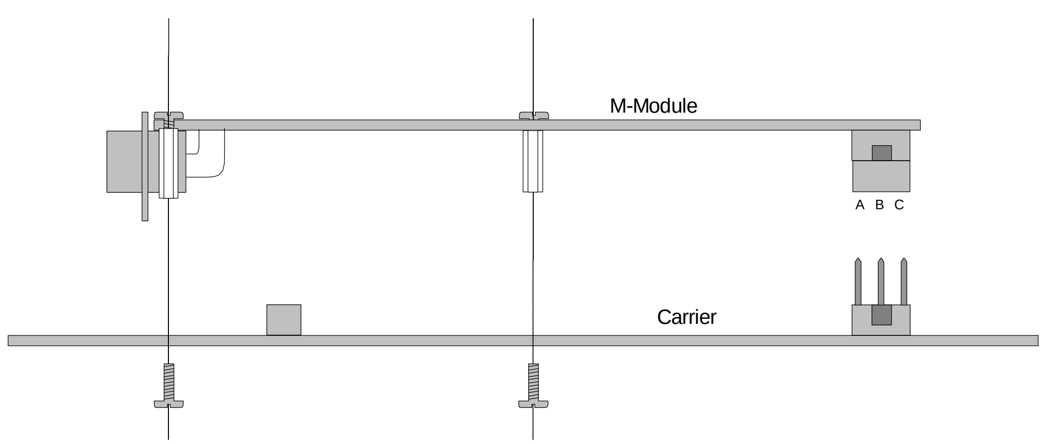

Figure 1. M-Module Installation

2.4 PREPARATION FOR RESHIPMENT

If the module is to be shipped separately it should be enclosed in a suitable water and vapor proof anti-static bag. Heat seal or tape the bag to insure a moisture-proof closure. When sealing the bag, keep trapped air volume to a minimum. The shipping container should be a rigid box of sufficient size and strength to protect the equipment from damage. If the module was received separately from a C&H system, then the original module shipping container and packing material may be re-used if it is still in good condition.

3.0 FUNCTIONAL DESCRIPTION

3.1 OVERVIEW

A simplified functional block diagram of the module is shown in Figure 2.

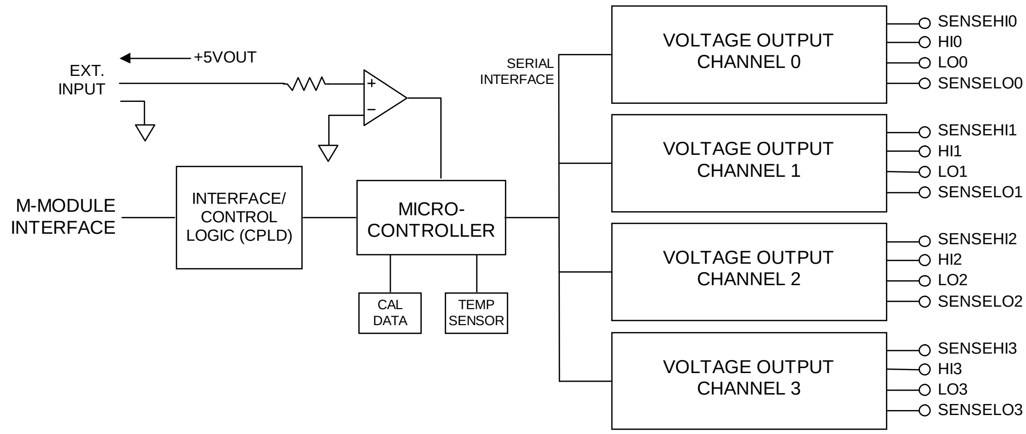

Figure 2. Functional Block Diagram

3.1.1 Interface/Control Logic

The interface/control interface provides the electrical interface between the M-module bus and M214 logic. The interface is implemented in a programmable CPLD.

3.1.2 Microcontroller

The microcontroller provides the overall control of the module. It contains firmware that controls the voltage sources, compensates for on-board temperature, and processes calibration values.

3.1.3 Temperature Sensor

There are two on-board sensors that provide temperature data to the microcontroller. The temperature is used to correct the outputs for temperature variation.

3.1.4 External Input

An external analog input is provided that can be used for external temperature sensing. The external level is provided to the user through a user accessible software register.

3.1.5 Voltage Output Channel

There are four independent and isolated voltage output channels as shown in Figure 3.

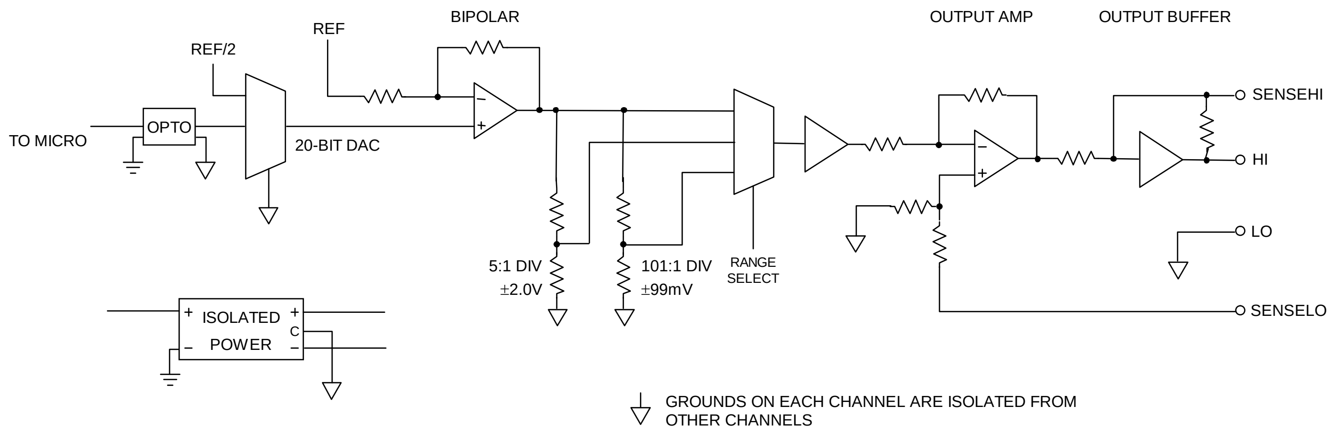

Figure 3. Voltage Output Channel

3.2 INPUT/OUTPUT SIGNALS

The front panel I/O connector is a 25-Pin female (socket) D-subminiature right angle connector (CONEC part number 164A10989X or equivalent). Any standard 25-pin male (plug) D-subminiature connector will mate with it. Below are the signals and functional descriptions provided on the connector (see Appendix A for pin assignments).

HIx	Source Output (High Side).
LOx	Source Output (Low Side).
SENSEHIx	Sense Input (High Side).
SENSELOx	Sense Input (Low Side).
AIN	External Analog Input (0 to 5V)
+5VOUT	External Reference Power
GND	External Ground Reference
CHGND	Chassis ground (capacitive coupled to GND)

3.3 CONFIGURATION AND IDENTIFICATION

3.3.1 Programming Registers

There are a variety of registers used to configure and control the M214 module. These registers are located as offset from the base address of the module. The absolute address depends on the M-module carrier for which the M214 is installed. See the carrier's User Manual for details. The address map of the registers is shown in Table I. Details of the registers are provided in Figure 4.

Table I. Address Map

IO REG. (HEX)	REGISTER DESCRIPTION
00	ID
02	Revision
04	On-Board Temperature
06	External Analog Input
08	Calibration Address
0A	Calibration Data Port
0C	Voltage Control/Status (see note)
0E	(reserved)
0F	(reserved)
10	Voltage Source 0 (MSB)
12	Voltage Source 0 (LSB)
14	Voltage Source 1 (MSB)
16	Voltage Source 1 (LSB)
18	Voltage Source 2 (MSB)
1A	Voltage Source 2 (LSB)
1C	Voltage Source 3 (MSB)
1E	Voltage Source 3 (LSB)

Note: The Voltage Control/Status Register was removed in Firmware Revision 2.0. The Range and Output Enable Control was moved to Voltage Source X (MSB) Register for each channel, thus simplifying independent control of each voltage source.

Reg 00

ID Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	(read only)								(read only)							
Read	Configuration								Model							

Configuration ⇨ Configuration Number (dash number of the unit according to the following table)
1 Fully programmable ranges (±10V, ±2.0V, ±99mV)
Others Undefined
Model ⇨ Model Number (always reads hex D6, decimal 214)

Reg 02

Revision Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	(read only)								(read only)							
Read	FWMAJ				FWMIN				HWMAJ				HWMIN			

FWMAJ ⇨ Firmware Major Revision (first major release is 1, prerelease is 0)
FWMIN ⇨ Firmware Minor Revision (minor releases involve insignificant changes or corrections)
HWMAJ ⇨ Hardware Major Revision (first major release is 1, prototype is 0)
HWMIN ⇨ Hardware Minor Revision (minor releases involve insignificant changes or corrections)

Reg 04

On-Board Temperature Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	(read only)								(read only)							
Read	Temp 2								Temp 1							

Temp 2 ⇨ On-Board Temperature 2 (Each bit represents 0.5°C with zero representing -20°C)
Temp 1 ⇨ On-Board Temperature 1 (Each bit represents 0.5°C with zero representing -20°C)

Note: Allow at least 30 seconds after power-up or reset for the temperature readings to stabilize. The register is updated every couple of seconds.

Reg 06

External Analog Input Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	-	-	-	-	-	-	(read only)									
Read	0	0	0	0	0	0	Voltage									

Voltage ⇨ External Analog Input Voltage Level (Each bit represents 4.9mV with zero representing 0V)

Figure 4. Programming Registers

Reg 08

Calibration Address Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	SC3	SC2	SC1	SC0	RD	WR	Cal Address									
Read	SC3	SC2	SC1	SC0	RD	WR	Cal Address									

SC3-0 ⇨ Initiate DAC Self-Calibration (writing a 1 to the bit will initiate self-calibration of the voltage sources DAC, the bit will clear when self-calibration is complete, see Section 4.2 for more detail)

RD ⇨ Read (1 = read the value specified in Cal Address and place it in the Calibration Data Port Register, bit is cleared when the operation is complete)

WR ⇨ Write (1 = write the value specified in the Calibration Data Port Register to the address specified in Cal Address, bit is cleared when the operation is complete)

Cal Address ⇨ Calibration Address

Note: If both the RD and WR bits are set to 1, the data will be written first then read-back.

Reg 0A

Calibration Data Port Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Cal Data															
Read	Cal Data [3]															

Cal Data ⇨ Calibration Data (data is written/read to/from the address in the Calibration Address Register)

Notes:

1. Data is written when the WR bit in the Calibration Address Register is to 1. Data is read when the RD bit in the Calibration Address Register is to 1.
2. The calibration data is only considered valid if Calibration Address 0 contains the value 0x1234.
3. This register does not read-back the value written.

Figure 4. Programming Registers (continued)

Reg 10
to 1C

Voltage Source X (MSB) Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	TC	-	-	-	-	-	-	OE	-	-	RANGE		Output Level (MSB)			
Read	TC	RDY	0	0	0	0	0	OE	0	0	RANGE		Output Level (MSB)			

TC ⇨ Automatic Thermal Compensation (0 = enabled, 1 = disabled)
RDY ⇨ Ready (0 = not ready, 1 = ready) [1]
OE ⇨ Output Enable (0 = disabled (default), 1 = enabled) [2]
RANGE ⇨ Range Select

Range 0	00	0V (default) [3]
Range 1	01	±99mV
Range 2	10	±2.0V
Range 3	11	±10V

Output Level (MSB) ⇨ Output Level Most Significant Bits [4]

Notes:

1. The RDY bit is cleared when this register is written. It goes high when the on-board DAC write operations are complete. Usage is optional.
2. When disabled, both the HIx and SENSEHIx outputs for the source specified are disconnected from the circuit.
3. In Range 0, the internal DAC is not connected to the circuit. The range select multiplexer is connected to GND (Channel LOx).
4. See the Voltage Source X (LSB) register for details on these bits. When changing the voltage level, always write the Voltage Source X (LSB) Register first, then the MSB register.

Reg 12
to 1E

Voltage Source X (LSB) Register

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Write	Output Level (LSB)															
Read	Output Level (LSB)															

Output Level (LSB) ⇨ Output Level Least Significant Bits (Two's Complement)

Range 1	01	~0.188 µV per bit [3], 80000 = -99mV, 0 = 0V, 7FFFF = +99mV
Range 2	10	~3.81µV per bit [4], 80000 = -2.0V, 0 = 0V, 7FFFF = +2.0V
Range 3	11	~19.1µV per bit [5], 80000 = -10V, 0 = 0V, 7FFFF = +10V

Notes:

1. The output level is only changed when the Voltage Source X (MSB) register is written.
2. The output level register is double-buffered to allow continuous updates; however, actual output level changes are limited by the internal programming and settling times specified in 1.2.2.
3. For Range 1, use 198000 / (2^{20}-1) µV per bit for greatest accuracy.
4. For Range 2, use 4000000 / (2^{20}-1) µV per bit for greatest accuracy.
5. For Range 3, use 20000000 / (2^{20}-1) µV per bit for greatest accuracy.

Figure 4. Programming Registers (continued)

3.3.2 M-Module Identification PROM

The M214 supports the identification function called IDENT. This IDENT function provides information about the module and is stored in a sixteen-word deep (32 byte) serial EEPROM. Access is accomplished with read/write operations on the last address in IOSpace (0xFE) and the data is read one bit at a time. Instructions for reading the IDENT PROM are given in section 4.3.

The module also supports the VXI-IDENT function. This function is not part of the approved ANSI/VITA 12-1996 standard. This extension to the M-module IDENT function increases the size of the EEPROM to at least 64 words (128 bytes) and includes VXI compatible ID and Device Type Registers. Details are shown in Table II.

Table II. M-Module EEPROM IDENT Words

Word	Description	Value (hex)
0	Sync Code	5346
1	Module Number	00D6 (214 dec.)
2	Revision Number [1]	1010
3	Module Characteristics [2]	1808
4-7	Reserved	0000
8-15	M-Module Specific	0000
16	VXI Sync Code	ACBA
17	VXI ID	0FC1 (C&H)
18	VXI Device Type [3]	FFDA
19-31	Reserved	0000
32-63	M-Module Specific	0000

Notes:

1) The Revision Number is the firmware and hardware functional revision level of the module. The hardware revision number does not necessarily correspond to the hardware assembly level. The bits definitions are:

Bit(s)	Description
15-12	Software Major Revision (1.0 is first major release)
11-8	Software Minor Revision
7-4	Hardware Major Revision (1.0 is first major release)
3-0	Hardware Minor Revision

2) The Module Characteristics bit definitions are:

Bit(s)	Description	Bit(s)	Description
15	0 = no burst access	8/7	00 = no DMA requestor
14/13	unused	6/5	00 = no interrupt support
12	1 = module needs ±12V	4/3	01 = 16-bit data
11	1 = module needs +5V	2/1	00 = 8-bit address bus
10	0 = trigger outputs not supported	0	0 = no memory access
9	0 = trigger inputs not supported		

3) The VXI Device Type word contains the following information:

Bit(s)	Description
15-12	F_{16} = 256 bytes of required memory
11-0	FDA_{16} = C&H specified VXI model code for M214

4.0 OPERATION

The M214 is a register-based instrument that is controlled through a series of registers described in Section 3.3.1.

4.1 PROGRAMMING

The module is programmed through a series of accesses to the configuration registers. A high-level software driver may be available to aid in programming of the module. The voltage control register are double buffered to allow continuous access; however, the on-board microcontroller and DAC's require a finite amount of processing time. The microcontroller will program the DAC's with the most current data available in the control registers.

4.2 CALIBRATION

System calibration data is stored in non-volatile memory located in the microcontroller. The firmware utilizes this calibration data to provide a calibrated output level. In addition, the firmware continuously monitors the temperature and adjusts the internal DACs as required. A software driver is available to aid in the calibration process.

It should be noted, that DAC Self-Calibration, available in the Calibration Address Register (Reg. 08) is an internal DAC operation and not equivalent to the system level calibration maintained and controlled by the on-board microcontroller. DAC Self-Calibration is performed automatically on power-up and anytime the unit is reset. The user may also manually perform a self-calibration at anytime. User initiated DAC Self-calibration is typically not required.

4.3 ID PROM

Refer to 3.3.2 for a description of the ID PROM's function and contents. The ID PROM is a serial device and accessing it involves writing and reading a register in a sequential manner to acquire data. Figure 5 provides a general description of the code sequence necessary to read the information from the PROM. The PROM is a standard IC 9603 type PROM. For specific timing information refer to the 9603 or compatible PROM data sheet.

```
/*-----------------------------------------------------------------------*/
int read_idword (unsigned short id_addr, unsigned short *value){
  addr = 0xFE;                          /* M/MA address for IDPROM */
  id_addr = 0x80 | id_addr;             /* 80 is the read opcode for the PROM */
  write_eebyte (addr, id_addr);
  read_eebyte (addr,&rdval);            /* returns first byte of IDPROM */
  tmpval = rdval << 8;                  /* upper byte of sync code word */
  read_eebyte (addr,&rdval);            /* returns first byte of IDPROM */
  tmpval = tmpval | rdval;              /* combine bytes of sync code   */
  *value = tmpval;
  write_word(addr, 0x0000);             /* lower cs */
  return;
}
/*-----------------------------------------------------------------------*/
int write_eebyte (unsigned long addr, unsigned short value){
  write_word(addr, 0x0000);             /* insure cs is initially low */
  write_word(addr, 0x0004);             /* initialize */
  write_eebit(addr, 0x0001);            /* start bit */
  temp = value;
  for (i=0;i<=7;i++){
    write_eebit(addr, ((temp & 0x80)>>7));
    temp = (temp << 1);
  }
return;
}
/*-------------------------------------------------------------------------*/
int write_eebit (unsigned long addr, unsigned short value){
  temp = (0x0004 | (value & 0x0001));   /*  set data bit before clock */
  write_word(addr, temp);
  Delay(.000005);
  temp = (0x0006 | (value & 0x0001));   /*  set data bit & clock */
  write_word(addr, temp);
  Delay(.000005);
  return;
}
/*-----------------------------------------------------------------------*/
int read_eebyte (unsigned short addr, unsigned short *value){
  for (i=7;i>=0;i=i-1){
    read_eebit (addr, &rdval);
    temp = temp | ((rdval&0x01) << i);
  }
  *value = temp;
  return;
}
/*--------------------------------------------------------------------------*/
int read_eebit (unsigned short addr, unsigned short *value){
  write_word(addr, 0x4);                /* lower clock bit */
  Delay(.000005);
  write_word(addr, 0x6);                /* raise clock bit */
  Delay(.000005);
  read_word (addr, value);
  return;
}
/*--------------------------------------------------------------------------*/
```

NOTE: 1. write_word and read_word are low level memory access routines.
*2. **NOT** actual code and should be treated as a modeling tool only.*

Figure 5. ID PROM Access Routine

APPENDIX A: CONNECTORS

Pin	Row A	Row B	Row C
1	/CS	GND	(/AS)
2	A01	+5V	(D16)
3	A02	+12V	(D17)
4	A03	-12V	(D18)
5	A04	GND	(D19)
6	A05	(/DREQ)	(D20)
7	A06	(/DACK)	(D21)
8	A07	GND	(D22)
9	D08	D00/(A08)	TRIGA
10	D09	D01/(A09)	TRIGB
11	D10	D02/(A10)	(D23)
12	D11	D03/(A11)	(D24)
13	D12	D04/(A12)	(D25)
14	D13	D05/(A13)	(D26)
15	D14	D06/(A14)	(D27)
16	D15	D07/(A15)	(D28)
17	/DS1	/DS0	(D29)
18	DTACK	/WRITE	(D30)
19	/IACK	/IRQ	(D31)
20	/RESET	SYSCLK	(/DS2)

Note: Signals in parentheses ( ) are not used on this module.

Figure A-1. M/MA Interface Connector Configuration

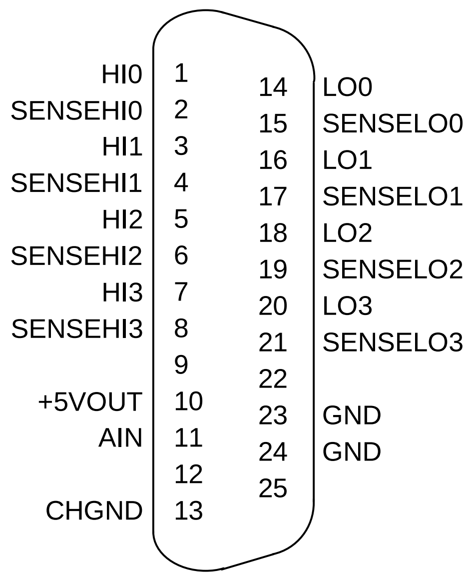

Figure A-2. Front Panel D-SUB Connector Configuration

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