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104-AIM-32

ANALOG INPUT SIGNAL CONDITIONER

USER MANUAL

FILE: M104-AIM-32-A1w

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Table of Contents

Chapter 1: Introduction

Standard Features

- Designed to pair with an A/D board to increase channel count and signal conditioning capabilities
- 32 single-ended or 16 differential inputs
- 6 software-programmable ranges: ±25mV, ±50mV, ±0.1V, ±2.5V, ±5V, ±10V (analog input ranges can be mixed, any channel may have any range at any time)
- Up to 7 104-AIM-32s can be stacked per A/D board for up to 224 S.E. or 112 diff. Inputs
- +5VDC-only operation
- 15VDC sensor excitation
- Input signal conditioning
- Full system calibration including sensor and A/D board
- Individual offset and gain factors for each channel and gain

Factory Options

- 4-20mA inputs
- RTD & thermocouple measurement
- Voltage divider on each input
- RC filters on each input
- Bridge completion configuration
- 0 to 70°C and -40 to +85°C versions available
- TC break detect

Description

This board is an analog signal conditioner/multiplexer. Any one of 16 differential or 32 single-ended analog signals may be selected via a software command. The multiplexer's high impedance along with the signal conditioning front end provides an interface to multiple sensors without compromising the quality of the gathered data.

An optional screw terminal block is available for the termination of the input signals, which can come from a variety of sensors: thermocouples (J,K,T,E,S,R, and B), three-wire RTD's (both 392- and 385-alpha), strain gages, 4-20mA current inputs as well as DC and AC voltage inputs. Provision for installation of bridge completion resistors, current sensing resistors and for resistors in series with RTDs are provided as well as a 15VDC source for bridge and RTD excitation (see the Factory-Installed Options section).

To provide a reference junction compensation for the thermocouples, a two-wire temperature sensor should be installed on the input terminal block. The eighth output channel is dedicated to this temperature measurement.

The signal selected by the input multiplexer is filtered (RC, low pass) and amplified. After the conditioning, the signal can be jumpered to one of seven output channels.

While any A/D converter that will accept inputs in common voltage ranges (0-5V, +5V) is compatible, this board output is designed to connect to a 12-8-type Analog to Digital board.

Mixed-range analog inputs are conveniently managed with the extensive programming flexibility of the board. Six dynamically software-programmable gains, each with automatic offset compensation and gain correction, allow the system to utilize the full resolution of the A/D converter.

The offset and gain correction coefficients for up to 32 analog channels (times the 6 voltage ranges that may be selected for each channel) are available. Software tools are provided for the user to 'null out' input voltage offsets and adjust gain for all channels.

The board may be used as part of a large data acquisition system. A system may comprise one to seven of these boards per Analog to Digital Converter board. An on-board DC-DC converter which operates from the +5VDC computer power supply provides +15VDC for the board's circuitry, and also the regulated excitation voltage.

The board occupies eight bytes of I/O address space. The base address is selectable via jumpers anywhere within the range of 0-3F8 hex (mapped only into the first 1K of I/O space, compatible with PC/104-Plus addressing). An illustrated setup program is provided, interactive displays show locations and proper settings of jumpers. Also, sample programs in several languages are provided on CD and are described in the Programming section of this manual.

Specification

Analog Inputs

- Channels: 16 Differential or 32 Single-ended.
- ESD Protection Greater than 2000V.
- Input Impedance: 5M Ohms Differential, 10M Ohms Single-ended.
- Common Mode Voltage: +13V.
- Maximum Input Voltage: 250V with voltage divider, 40V without voltage divider
- Current Loop: 4-20mA with on-board attenuator installed, factory option.
- Voltage Ranges: ±10V, ±5V, ±2.5V, ±100mV, ±50mV, ±25mV. Selectable per channel

Analog Outputs

- Channels: 1 of 8, jumper selected (8th channel is temp sensor output if used)
- Output Drive: 10mA
- Output Voltage: +5V with a full scale input (+12V rails).

General

- Operating Temperature: 0 to 70°C, -40 to +85°C optional, all options.
- Storage Temperature: -55 to +125°C.
- Humidity: 5% to 95% RH, non-condensing.
- Power Required: +5V @ 200mA with no load on excitation.
- Temp. Sensor: +10mV / °K @ 25°C. Output voltage temperature coefficient

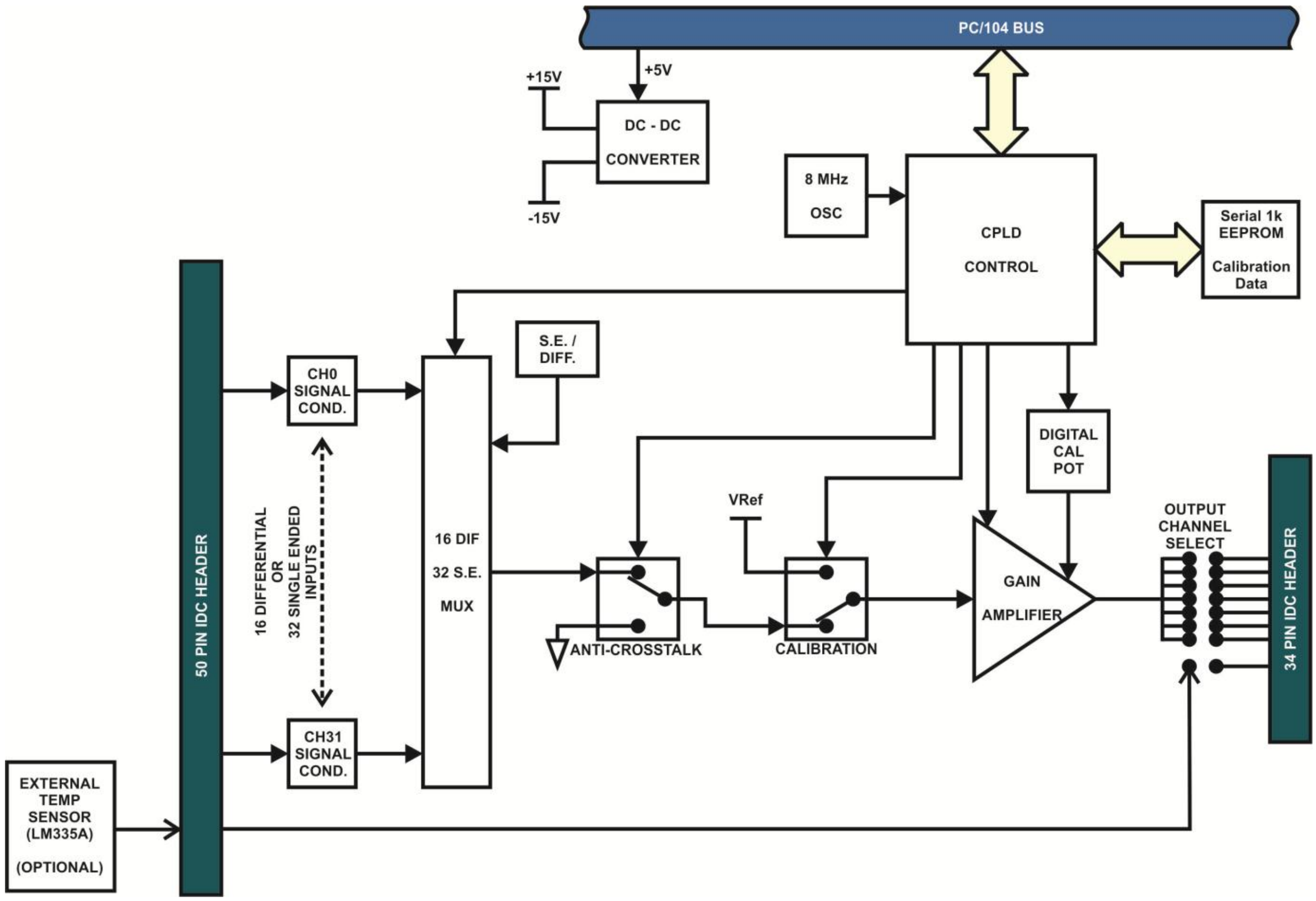


Figure 1-1: Block Diagram

Chapter 2: Installation

A printed Quick-Start Guide (QSG) is packed with the board for your convenience. If you've already performed the steps from the QSG, you may find this chapter to be redundant and may skip forward to begin developing your application.

The software provided with this PC/104 Board is on CD and must be installed onto your hard disk prior to use. To do this, perform the following steps as appropriate for your operating system. Substitute the appropriate drive letter for your CD-ROM where you see d: in the examples below.

CD Installation

The following instructions assume the CD-ROM drive is drive "D". Please substitute the appropriate drive letter for your system as necessary.

DOS

1. Place the CD into your CD-ROM drive.
2. Type [D][:][Enter] to change the active drive to the CD-ROM drive.
3. Type [I][N][S][T][A][L][L][Enter] to run the install program.
4. Follow the on-screen prompts to install the software for this board.

WINDOWS

1. Place the CD into your CD-ROM drive.
2. The system should automatically run the install program. If the install program does not run promptly, click START | RUN and type [D][:][I][N][S][T][A][L][L], click OK or press [Enter].
3. Follow the on-screen prompts to install the software for this board.

LINUX

1. Please refer to linux.htm on the CD-ROM for information on installing under linux.

Installing the Hardware

Before installing the board, carefully read Chapter 3 and Chapter 4 of this manual and configure the board according to your requirements. The SETUP Program can be used to assist in configuring jumpers on the board. Be especially careful with Address Selection. If the addresses of two installed functions overlap, you will experience unpredictable computer behavior. To help avoid this problem, refer to the FINDBASE.EXE program installed from the CD. The setup program does not set the options on the board, these must be set by jumpers.

To Install the Board

1. Install jumpers for selected options and base address according to your application requirements, as mentioned above.
2. Remove power from the PC/104 stack.
3. Assemble standoff hardware for stacking and securing the boards.
4. Carefully plug the board onto the PC/104 connector on the CPU or onto the stack, ensuring proper alignment of the pins before completely seating the connectors together.
5. Install I/O cables onto the board's I/O connectors and proceed to secure the stack together or repeat steps 3-5 until all boards are installed using the selected mounting hardware.
6. Check that all connections in your PC/104 stack are correct and secure then power up the system.
7. Run one of the provided sample programs appropriate for your operating system that was installed from the CD to test and validate your installation.

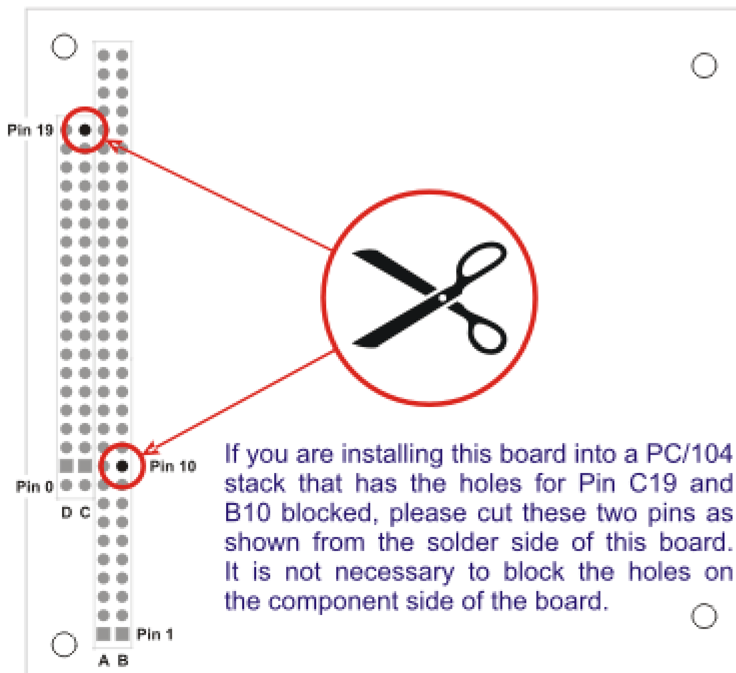


Figure 2-1: PC/104 Key Information

Chapter 3: Option Selection

The board's base address, output channel, and temp sensor output are the only jumper selectable options. Voltage input ranges are selected via software. Special signal conditioning for different input types are factory installed options.

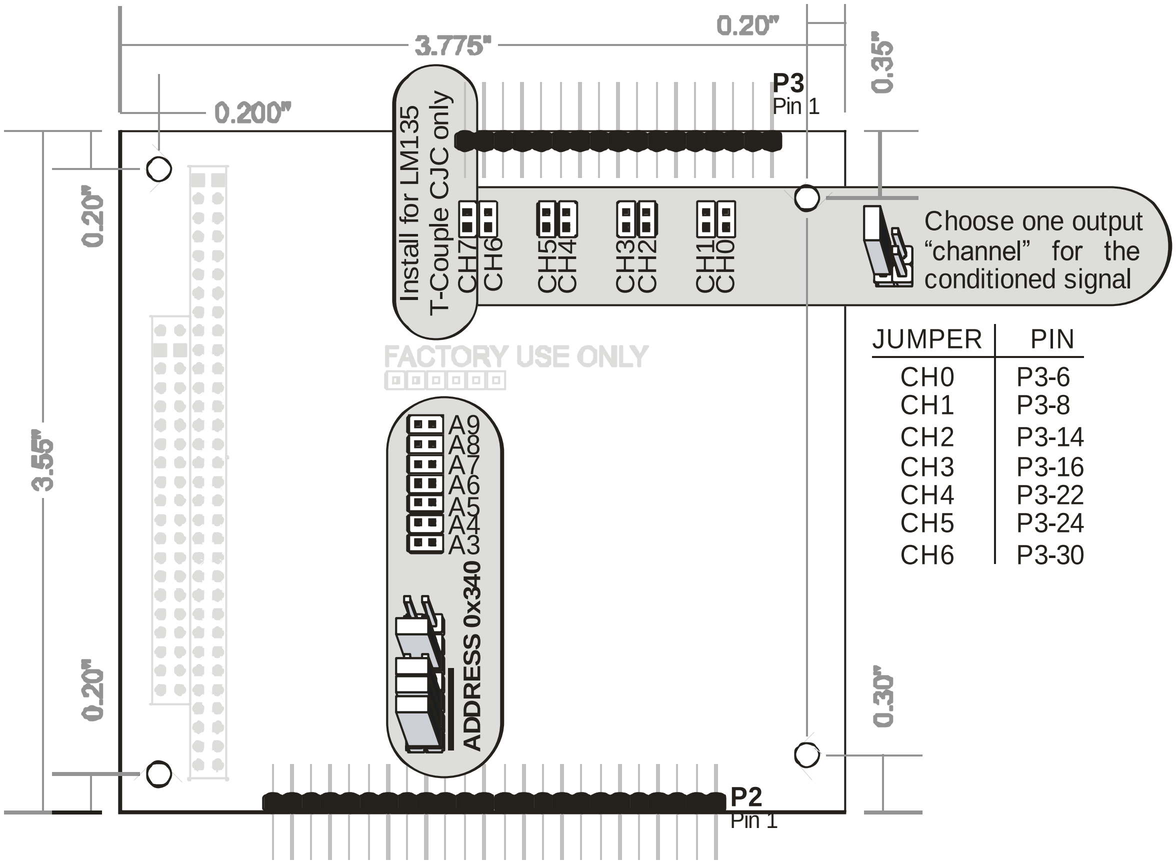


Figure 3-1: Option Selection Map

Adding cold junction compensation when using thermocouples

Connect an LM335 Precision Temperature Sensor lead 2 (cathode) to P2-25 (Temperature Sensor) and put the LM335 pin 3 (anode) to GND (P2-24 or P2-26 are the nearest physical ground pins on the connector). Leave the LM335 lead 1 not connected (NC). Install a jumper at position CH7 on the board, which routes the Temperature Sensor to the output connector pins for channel 7 (P3-33). Using the AI12-8 and a ribbon cable that has a one to one connection reading CH7 on the A/D board would give the user the CJC value. Otherwise you could route channel 7 output of the AIM-32 to any of your A/D inputs and read that channel for the CJC value.

Note: There is a 2.7K ohm bias resistor (R17) from VCC (+5V) to P2-25 (TEMP) on the board.

Chapter 4: Address Selection

The board occupies 8 bytes of I/O space. The board base address can be selected anywhere within the I/O address range 0-3F8 hex. If in doubt of where to assign the base address, refer to the following tables and the FINDBASE program to find an available address for your system.

HexRange	Usage
000-00F	DMA Controller 1
020-021	INT Controller 1, Master
040-043	Programmable Interrupt Timer
060-06F	Keyboard Controller
070-07F	Real Time Clock, NMI Mask
080-09F	DMA Page Register
0A0-0BF	INT Controller 2
0C0-0DF	DMA Controller 2
0F0-0F1	Math Coprocessor
0F8-0FF	Math Coprocessor
170-177	Fixed Disk #1
1F0-1F8	Fixed Disk #2
200-207	Game I/O
238-23B	Bus Mouse
23C-23F	Alt. Bus Mouse
278-27F	Parallel Printer
2B0-2BF	EGA
2C0-2CF	EGA
2D0-2DF	EGA
2E0-2E7	GPIB (AT)
2E8-2EF	Serial Port
2F8-2FF	Serial Port
300-30F	Prototype Board
310-31F	Prototype Board
320-32F	Hard Disk (XT)
370-377	Floppy Controller #2
378-37F	Parallel Printer Port 1
380-38F	SDLC
3A0-3AF	SDLC
3B0-3BB	Monochrome Display/Printer
3BC-3BF	Parallel Printer Port 2
3C0-3CF	VGA EGA
3D0-3DF	CGA
3E8-3EF	Serial Port
3F0-3F7	Floppy Diskette Controller
3F8-3FF	Serial Port

Table 4-1: Standard Address Assignments for Standard Computers

To set the desired board address, jumpers must be installed on the board. These jumpers are marked A5-A9 and form a binary representation of the address in negative-true logic. (assign '0' to all Address Setup jumpers installed, and assign '1' to all Address Setup jumpers left off.)

Base Address Table

To set the base address of the board, install the jumpers “ON” the posts for that address according to the table.

Chapter 5: Programming

Address	Port Assignment	Operation
Base Address	Command Register	Write
Base Address +1	Setup Register	Read / Write
Base Address +2	EEPROM Address, LSB	Write
Base Address +3	EEPROM Address, MSB	Write
Base Address +4	EEPROM I/O Register	Read / Write
Base Address +5	Reserved	
Base Address +6	Reserved	
Base Address +7	Reserved	

Table 5-1: Register Map

The purpose of this board is to select an input signal, condition it (filter ,attenuate, amplify) and present the result on output pins. This output is usually applied to an analog to digital converter. To accomplish this, three things must happen: the input must be identified as either singled-ended or differential, the pin or pins to which the signal is applied must be identified, and the gain to be applied to the signal must be selected. The Command Register and bit 0 of the Setup Register are used to supply this information to the board.

Gain and offset calibration data can be stored for the board alone or for the entire system (i.e. for sensors and an analog to digital converter board as well).

Base + 0: Command Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Voltage Range Select Bit 2	Voltage Range Select Bit 1	Voltage Range Select Bit 0	Channel Select Bit 4	Channel Select Bit 3	Channel Select Bit 2	Channel Select Bit 1	Channel Select Bit 0

This register specifies which input channel the multiplexer routes to the amplifier circuit (bits 0 through 4) and to specify the gain (also called 'range') of the amplifier (bits 5 through 7). Writing to this register will update the multiplexer channel and will load calibration data appropriate to the channel and gain settings from the EEPROM to the digital potentiometers that modify the DC offset and gain of the amplifier. Note that the gain settings may be different for each channel. If Cal Data Enable (bit 4 of the Setup Register) is LOW, the EEPROM will be ignored and the pots will be fixed at mid-range.

At gains of 50, 100, or 200, the switching "glitches" of the multiplexers will be amplified to the extent that they appear as noise at the output. A delay of approximately 35 microseconds is recommended before the output of the board is used at one of the higher gains.

Bit 7, Bit 6, Bit 5	Voltage Range	Gain
0 0 0	±10	0.5
0 0 1	±5	1.0
0 1 0	±2.5	2.0
0 1 1	±100mV	50
1 0 0	±50mV	100
1 0 1	±25mV	200

Table 5-2: Range Selection

Base + 1: Setup Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
EEPROM Busy (read)	Digital Pots Busy (read)	Reserved	Cal. Data Enable	Cal. Data Space	Source Gnd / Vref	Internal Cal. Source	SE / Diff.

This register contains various setup-oriented bits:

- SE / Diff (bit 0) identifies the input signal as either single-ended (HIGH) or differential (LOW).
- Cal Data Enable (bit 4) enables (if HIGH) or disables (if LOW) the loading of calibration constants from the EEPROM.
- Cal Data Space (bit 3) selects which of two EEPROM spaces calibration constants are taken from, factory calibration (HIGH) or user calibration (LOW).
- When Internal Cal Source (bit 1) is HIGH, the board ignores its normal inputs, instead using one of two voltage sources provided internally for calibrating the board.
- Source Gnd / Vref (bit 2) selects between these internal voltage sources. When LOW, 0V will be provided internally (for offset calibration), and when HIGH, 4.096V will be provided internally (for gain calibration).
- The Digital Pots Busy bit indicates that offset and gain calibration data is being moved from the EEPROM to the digital potentiometers. This happens each time that a byte is written to the COMMAND register and takes about 3uS.
- EEPROM Busy (bit 7) is HIGH when the EEPROM is being accessed. While busy, any further EEPROM accesses will be ignored or return garbage data.

On power-up all control bits are LOW, the factory calibration space is selected (as explained in the Calibration section), the internal calibration source is disconnected, and inputs are differential.

Base + 2 & Base + 3: EEPROM Address Register (read/write)

To read from or write to the serial 1k EEPROM, first write the 10-bit address (000h-3FFh) of the byte within the EEPROM to this word-wide register. The address bytes can also be written separately to Base + 2 and Base + 3, for example on an 8-bit PC/104 bus. After setting the address, read or write data via the EEPROM I/O Register at Base + 4. Use the EEPROM Busy bit (in the Setup Register at Base + 1) to tell when the EEPROM is ready to be accessed again.

The EEPROM address corresponding to each calibration constant is shown in Appendix B: EEPROM Calibration Addresses.

Base + 4: EEPROM I/O Register

This register is used to read data from or write data to the EEPROM once the address has been set in the EEPROM Address Register at Base + 2. A READ reads the byte and a WRITE writes over it. Use the EEPROM Busy bit (bit 7 in the Setup Register at Base + 1) to tell when the EEPROM is ready to be accessed again.

Base + 5 through 7: Reserved

Factory-Installed Options

Each channel can have one of the following configurations.

Standard Configuration. An RC filter is installed on the input of each channel (Fig. 5-1). The user may specify the filter's capacitance for each channel. 1K ohms and 100pF are standard.

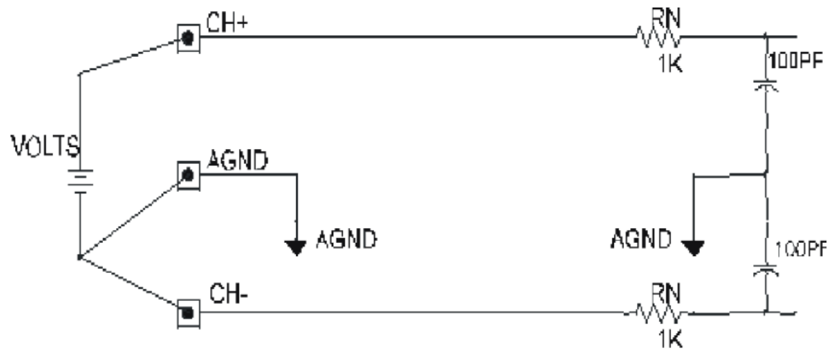


Figure 5-1: Standard Voltage Input Configuration

Input Voltage Divider. The standard model configuration is intended for voltage inputs of no more than +10V, while this input option allows voltages higher than +10V. Resistive voltage dividers are installed on channels specified by the user (Fig. 5-2).

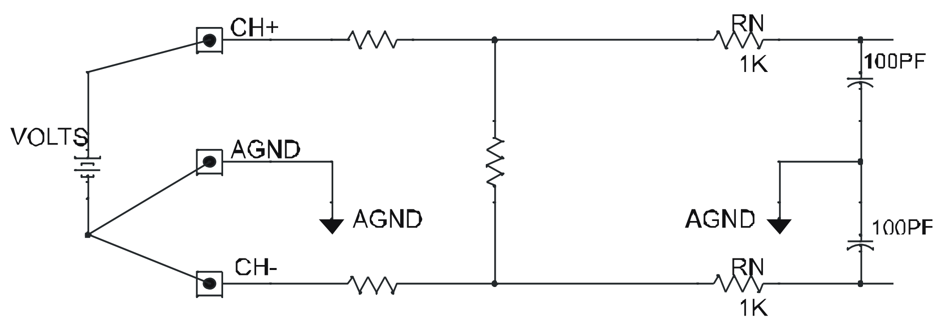


Figure 5-2: Voltage Input With Attenuator

4-20mA Current Input. Precision resistors are installed from the positive input to the negative input of all differential channels. (Fig. 5-3). The input is **not** offset, so that a 4-20mA input will be read as 1 to 5V. Readings below 4mA will read between 0 and 1V (providing fault detection, i.e. for a blown circuit fuse).

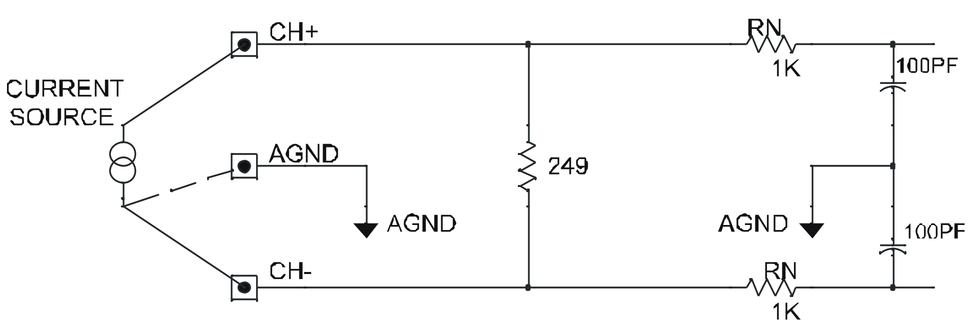


Figure 5-3: Current Input Configuration

Thermocouple Measurement with reference junction temperature sensor. The temperature sensor is located at terminal block positions 25 and 26, and its output is connected to the Channel 7 output jumper. If more than one board is used, a reference junction sensor can be connected on an S.E. voltage input channel. This would also allow for complete sensor calibration.

Thermocouple Break Detect. Break-detect resistors may be installed. With this feature an open thermocouple condition will cause a full-scale negative voltage output. Break-detect resistors are installed between each channel's positive input and +15V and between each channel's negative input and ground (Fig. 5-4).

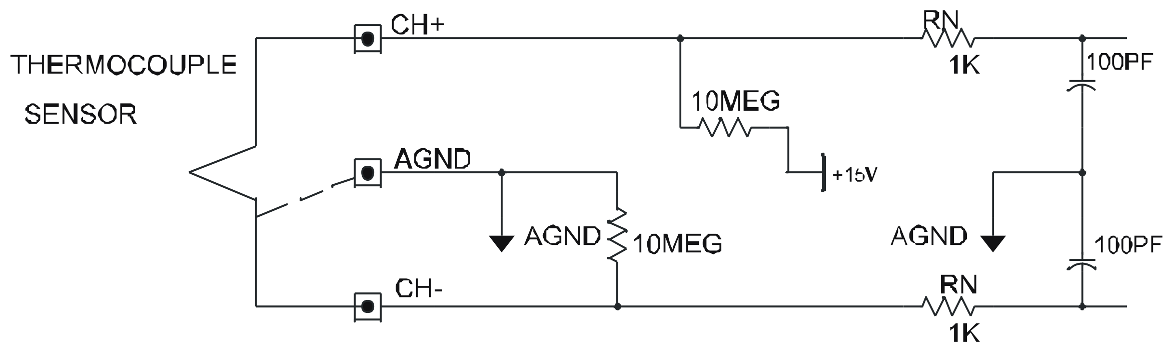


Figure 5-4: Thermocouple Input Configuration

RTD Measurement. The RTD option accommodates three-wire RTD's (Fig. 5-5). A 66.5KOhm precision resistor in series with an RTD lead wire and the RTD sensor determines the sensor supply current. The 66.5KOhm resistor is connected between the +15V supply and ground through the 2nd lead wire to provide lead length compensation. The voltage drops across the lead wires cancel at the differential signal input.

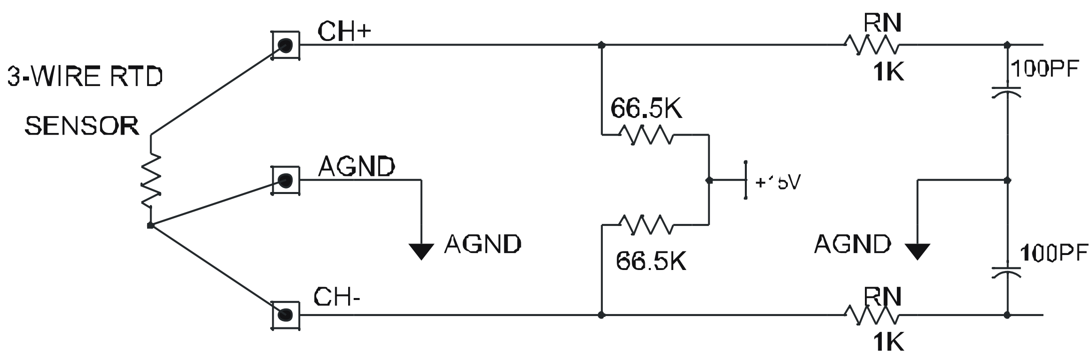


Figure 5-5: RTD Input Configuration

Bridge Completion Configuration. Three resistors are installed so as to form 3-arms of a full Wheatstone bridge. The resistor values are specified by the customer (Fig. 5-6).

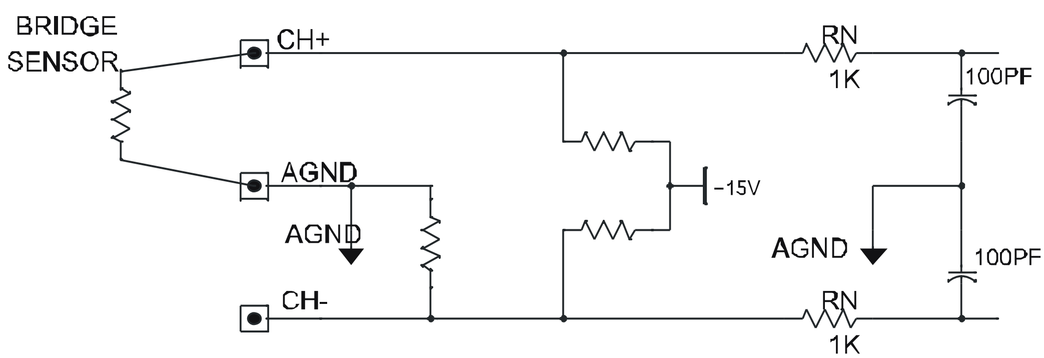
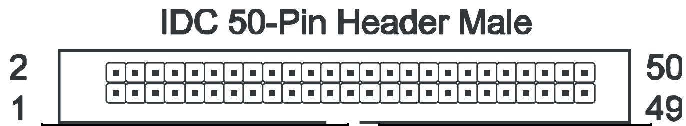


Figure 5-6: Bridge Completion Configuration

Chapter 6: Connector Pin Assignments

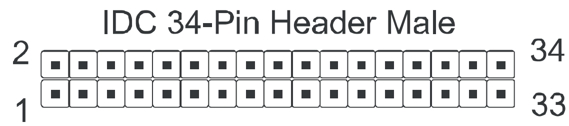


Pin #	Signal Name	Pin #	Signal Name
1	CH00	2	CH16
3	GROUND	4	CH01
5	CH17	6	GROUND
7	CH02	8	CH18
9	GROUND	10	CH03
11	CH19	12	GROUND
13	CH04	14	CH20
15	GROUND	16	CH05
17	CH21	18	GROUND
19	CH06	20	CH22
21	GROUND	22	CH07
23	CH23	24	GROUND
25	TEMP SENSOR	26	GROUND
27	CH08	28	CH24
29	GROUND	30	CH09
31	CH25	32	GROUND
33	CH10	34	CH26
35	GROUND	36	CH11
37	CH27	38	GROUND
39	CH12	40	CH28
41	GROUND	42	CH13
43	CH29	44	GROUND
45	CH14	46	CH30
47	GROUND	48	CH15
49	CH31	50	GROUND

Table 6-1: Connector P2, Single-Ended Inputs

Pin #	Signal Name	Pin #	Signal Name
1	CH00+	2	CH00-
3	GROUND	4	CH01+
5	CH01 -	6	GROUND
7	CH02+	8	CH02-
9	GROUND	10	CH03+
11	CH03-	12	GROUND
13	CH04+	14	CH04-
15	GROUND	16	CH05+
17	CH05-	18	GROUND
19	CH06+	20	CH06-
21	GROUND	22	CH07+
23	CH07-	24	GROUND
25	TEMP SENSOR	26	GROUND
27	CH08+	28	CH08-
29	GROUND	30	CH09+
31	CH09-	32	GROUND
33	CH10+	34	CH10-
35	GROUND	36	CH11+
37	CH11-	38	GROUND
39	CH12+	40	CH12-
41	GROUND	42	CH13+
43	CH13-	44	GROUND
45	CH14+	46	CH14-
47	GROUND	48	CH15+
49	CH15-	50	GROUND

Table 6-2: Connector P2, Differential Inputs



Pin #	Signal Name	Pin #	Signal Name
1	no connection	2	no connection
3	GROUND	4	no connection
5	no connection	6	CHANNEL 0
7	GROUND	8	CHANNEL 1
9	no connection	10	no connection
11	GROUND	12	no connection
13	no connection	14	CHANNEL 2
15	GROUND	16	CHANNEL 3
17	no connection	18	no connection
19	GROUND	20	no connection
21	no connection	22	CHANNEL 4
23	GROUND	24	CHANNEL 5
25	no connection	26	no connection
27	GROUND	28	no connection
29	no connection	30	CHANNEL 6
31	GROUND	32	CHANNEL 7
33	GROUND	34	no connection

Table 6-3: Connector P3, Outputs

Chapter 7: Calibration and Test

All boards may be calibrated prior to shipment at the user's request. Periodic calibration of this board is recommended. The calibration interval depends to a large extent on the board's environment. For environments where there are frequent large changes of temperature and/or vibration, a three-month interval is suggested. For laboratory or office conditions, six months to a year is acceptable.

A multi-meter that can measure a voltage change as low as 780uV is required to accurately calibrate the board. Also, a voltage calibrator or a stable, noise-free, DC voltage source that can be used in conjunction with the digital multi-meter is required for best results.

Calibration may be performed using one of the programs supplied with the board. This software will lead the user through the set up and calibration procedure with prompts and graphic displays.

The board's signal-conditioning circuit (that part which amplifies, attenuates, or level-shifts) may be calibrated independently. Six bytes (one per voltage range) for offsets and six bytes for gain adjustments are stored in the board's EEPROM for each input (16 diff. or 32 S.E.). If the user has a 12-8-type Analog to Digital Converter board, software is provided that will automate this internal calibration. Run the calibration program and follow the prompts.

The board comes with a calibration program that, in conjunction with current or voltage sources and meters and user interaction, will calibrate the system. Voltage offsets at the board's input pins plus any offset generated on the board plus offset from the A/DC can be nulled out. Gain adjustment of +5% can be saved in the EEPROM for each input (up to 32 signals) times each voltage range.

Appendix A: Calibration

System Calibration

The board accepts a mix of differential and single-ended inputs. There is a specific location in the board's EEPROM for each signal's offset adjustment and gain adjustment. For example, assume that a differential signal is connected to P2 pins 1 and 2. The DC offset and gain adjust values should be written to the board's EEPROM at 0h and 100h for the ±10V range, at 20h and 120h for the ±5V range, etc. Refer to the EEPROM memory map to identify the locations required.

Overview
These are the steps we recommend to null the offsets. Fill the user's section of the EEPROM with the digital pot's center value. Turn off the switch that applies an internal reference and turn on the calibration system. Connect the system's voltages that are to be monitored to the inputs at connector P2 and cause them to be 0V. Select an input channel (0 through 31 single-ended or 0 through 15 differential) and a voltage range (gain may be .5, 1, 2, 50, 100, or 200). Assuming that the output of the system is an A/DC, select an output pin at connector P3 (place a jumper on the appropriate pins, see the Option Selection map) and trigger a conversion. Iteratively modify the value in the EEPROM, update the value in the digital pot that controls the offset, and measure the output. The target output voltage is equal to the input voltage. Do this for each range.

These are the steps we recommend to adjust the gains. Turn off the switch that applies an internal reference and turn on the calibration system. Connect the system's voltages that are to be monitored to the board's inputs at connector P2 and cause them to be at their maximum. Select an input channel (0 through 31 single-ended or 0 through 15 differential) and the appropriate range (±25mV, ±50mV, ±100mV, ±2.5V, ±5V, ±10V). Assuming that the output of the system is an A/DC, select an output pin at connector P3 (place a jumper on the appropriate pins, see the Option Selection map) and trigger a conversion. Iteratively modify the value in the EEPROM, update the value in the digital pot that controls the offset, and measure the output. The target output voltage is equal to the input voltage. Do this for each input channel.

Procedures

1. If possible, set the output of a signal to be measured to 0V.

2. Write 10h to the Setup register if the signal channel to be calibrated is differential. Write 11h for single-ended signals.

Bit 7, Bit 6, Bit 5	Voltage Range	Gain
0 0 0	±10	0.5
0 0 1	±5	1.0
0 1 0	±2.5	2.0
0 1 1	±100mV	50
1 0 0	±50mV	100
1 0 1	±25mV	200

Table A-1: Range Selection

3. Write 80h to the EEPROM at the offset adjust and gain adjust addresses for the signal channel to be calibrated. The EEPROM requires approximately 1mS to store a byte, a 'busy' bit is set in the Setup byte while this happens (bit 7).

4. The Command register has two fields: the channel number (bits 0 through 4) and the range selection. For the signal channel to be calibrated, write the combined range and channel to the Command register. The board will retrieve calibration data from the EEPROM and load it in the digital pots each time a byte is written to the Command register.

5. If possible, use the A/DC connected to the output of the board to digitize the voltage. As in the internal calibration of the board, adjust the calibration value to compensate for any DC offset.

6. If possible, set the voltage of the signal to a value near the top of its range. Trigger a conversion and, as in the internal calibration, adjust the value in the EEPROM up or down until the output of the system is correct.

7. Repeat these steps for all of the channels in use.

Internal Calibration Procedure

The following steps are suggested methods for nulling the offsets and calibrating the gains of the instrumentation amplifier chain at it's six ranges. Note that only the lower gain settings can be calibrated internally, the input is fixed at the 4.096V reference and the output is limited to ± 12V.

The EEPROM memory stores calibration data in 24 blocks. Each gain setting has a block for the user's offset adjust, the user's gain adjust, the factory offset adjust, and the factory gain adjust (ie., 4 major blocks times 6 gains).

Overview

These are the steps we recommend to null the offsets (see paragraphs 1 through 11). Fill the user's section of the EEPROM with the digital pot's center value. Using a meter or 'scope or A/DC, monitor the output at connector P3 relative to the board's ground (P3 pin 3). Connect Ground to the board's instrumentation amplifier through an internal switch and turn on the calibration system. Select a voltage range (gain may be .5, 1, 2, 50, 100, or 200). Iteratively modify the value in the EEPROM, update the value in the digital pot that controls the offset, and measure the output. The target output voltage is 0V. Do this for each range.

Procedure

1. Write 80h to the first 1C0h EEPROM locations. Gain and offsets can be adjusted positive or negative, 80h is the midpoint (close to zero effect).
   a. A byte in the EEPROM is addressed by writing an eleven-bit pointer to a word-wide register at the board's base address plus 2 (i.e., if the board's address = 300h then this register is at 302h). Write 0h to this word-wide register.
   b. Write 80h to the EEPROM I/O address (base + 4), the value will be stored in the EEPROM. The Busy flag, bit 7 of the Setup register, will go HIGH for 1mS.
   c. When the Busy flag is LOW, increment the EEPROM address and repeat step B. Do this until the first 1C0h EEPROM bytes = 80h. Note that the EEPROM can be read in the same manner (load the address pointer, read base+6) as quickly as a read can be issued.

2. Connect a meter between the board's output and the board's GROUND.

3. Write 13h to the Setup register. This will connect Ground to the board's instrumentation amplifier input and allow calibration data to be copied from the EEPROM to the digital pots.

4. Write 0h to the Command register. This will select the ±10V range, gain = 0.5.

5. Null the output offset for the ±10V range by changing the calibration data in the EEPROM.

a. If the meter reads a positive voltage, write a value that's less than 80h to EEPROM addresses 0 through 1Fh (initialize the pointer at base+2 (LSB) and base+3 (MSB), write the value to base+4, increment the pointer, write the value, etc.).
b. Write 0h to the Command register. This will update the digital pots.
c. If the meter reads positive, decrement the value in the EEPROM. If the meter reads negative, increment the value and repeat step b.

Repeat as needed until the output is close to zero.

6. Write 20h to the Command register. This will select the +5V range, gain = 1.

7. Null the output offset for the ±5V range by changing the calibration data in the EEPROM.
   a. If the meter reads a positive voltage, write a value that's less than 80h to EEPROM addresses 20h through 3Fh.
   b. Write 20h to the Command register. This will update the digital pots.
   c. If the meter reads positive, decrement the value in the EEPROM and repeat step b. If the meter reads negative, increment the value and repeat step b.

   Repeat as needed until the output is close to zero.

8. Null the offset for the ±2.5V range (gain = 2). The value written to the command register is 40h. The EEPROM address block is 40h to 5Fh.

9. Null the offset for the ±0.1V range (gain = 50). The value written to the command register is 60h. The EEPROM address block is 60h to 7Fh.

10. Null the offset for the ±0.05V range (gain = 100). The value written to the command register is 80h. The EEPROM address block is 80h to 9Fh.

11. Null the offset for the ±0.025V range (gain = 200). The value written to the command register is A0h. The EEPROM address block is A0h to BFh.

These are the steps we recommend to adjust the gain (see paragraphs 12 through 18). Using a meter or 'scope or A/DC, monitor the output at connector P3 relative to the board's ground (P3 pin 3). Connect 4.096V to the instrumentation amplifier through an internal switch and turn on the calibration system. Select a voltage range (gain may be .5, 1, or 2). Iteratively modify the value in the EEPROM, update the value in the digital pot that controls the gain, and measure the output. The target output voltages are 2.048V (gain = .5), 4.096V (gain = 1), and 8.192V (gain = 2). Do this for the three lowest ranges, the higher ranges will be off-scale.

12. Write 17h to the Setup register (enable calibration data, connect 4.096V to the gain stage, select single ended inputs). Connect the negative meter probe to P3 pin 3 and the positive probe to the board's output. Alternatively, connect a AIO12-8 (or an AI12-8) to P3, trigger a conversion, and read the value.

13. Write 0h to the Command register. This will set the gain to 0.5 (+10V range) and cause the calibration value to be copied from the EEPROM to the digital potentiometer. Ideally, the meter should read 2.048V.

14. Adjust the gain for the ±10V range by changing the calibration data in the EEPROM.
    a. If the meter reads more than 2.048V, write a value that's less than 80h to EEPROM addresses 100h through 11Fh (initialize the pointer at base+2 (LSB) and base+3 (MSB), write the value to base+4, increment the pointer, write the value, etc.).
    b. Write 0h to the Command register. This will update the digital pots.
    c. If the meter reads HIGH, decrement the value in the EEPROM and repeat step b. If the meter reads LOW, increment the value and repeat step b. If the meter reads as close as it's going to get then write the value to the EEPROM locations.

    Repeat as needed until the output is close to 2.048V.

15. Write 20h to the Command register. This will select the +5V range, gain = 1.

16. Adjust the gain for the ±5V range by changing the calibration data in the EEPROM.

a. If the meter reads more than 4.096V, write a value that's less than 80h to EEPROM addresses 120h through 13Fh.
b. Write 20h to the Command register. This will update the digital pots.
c. If the meter reads HIGH, decrement the value in the EEPROM and repeat step b. If the meter reads LOW, increment the value and repeat step b. If the meter reads as close as it's going to get then write the value to the EEPROM locations.

Repeat as needed until the output is close to 4.096V.

17. Write 40h to the Command register. This will select the ±2.5V range, gain = 2.

18. Adjust the gain for the ±2.5V range by changing the calibration data in the EEPROM.
    a. If the meter reads more than 8.192V, write a value that's less than 80h to EEPROM addresses 140h through 15Fh.
    b. Write 40h to the Command register. This will update the digital pots.
    c. If the meter reads HIGH, decrement the value in the EEPROM and repeat step b. If the meter reads LOW, increment the value and repeat step b. If the meter reads as close as it's going to get then write the value to the EEPROM locations.

    Repeat as needed until the output is close to 8.192V.

The gain error of the ±100mV range (gain = 50), the ±0.05V range (gain = 100), and the ±0.025V range (gain = 200) cannot be calibrated out using the internal reference, the outputs are limited to ~12V. Optionally, these ranges may be calibrated at the factory (using the 'system calibration' method).

Appendix B: EEPROM Calibration Addresses

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	00h	100h	200h	300h
01 SE / 01 Diff.	01h	101h	201h	301h
02 SE / 02 Diff.	02h	102h	202h	302h
03 SE / 03 Diff.	03h	103h	203h	303h
04 SE / 04 Diff.	04h	104h	204h	304h
05 SE / 05 Diff.	05h	105h	205h	305h
06 SE / 06 Diff.	06h	106h	206h	306h
07 SE / 07 Diff.	07h	107h	207h	307h
08 SE / 08 Diff.	08h	108h	208h	308h
09 SE / 09 Diff.	09h	109h	209h	309h
10 SE / 10 Diff.	0Ah	10Ah	20Ah	30Ah
11 SE / 11 Diff.	0Bh	10Bh	20Bh	30Bh
12 SE / 12 Diff.	0Ch	10Ch	20Ch	30Ch
13 SE / 13 Diff.	0Dh	10Dh	20Dh	30Dh
14 SE / 14 Diff.	0Eh	10Eh	20Eh	30Eh
15 SE / 15 Diff.	0Fh	10Fh	20Fh	30Fh
16 SE	10h	110h	210h	310h
17 SE	11h	111h	211h	311h
18 SE	12h	112h	212h	312h
19 SE	13h	113h	213h	313h
20 SE	14h	114h	214h	314h
21 SE	15h	115h	215h	315h
22 SE	16h	116h	216h	316h
23 SE	17h	117h	217h	317h
24 SE	18h	118h	218h	318h
25 SE	19h	119h	219h	319h
26 SE	1Ah	11Ah	21Ah	31Ah
27 SE	1Bh	11Bh	21Bh	31Bh
28 SE	1Ch	11Ch	21Ch	31Ch
29 SE	1Dh	11Dh	21Dh	31Dh
30 SE	1Eh	11Eh	21Eh	31Eh
31 SE	1Fh	11Fh	21Fh	31Fh

Table B-1: EEPROM Memory Map, Gain = 0.5

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	20h	120h	220h	320h
01 SE / 01 Diff.	21h	121h	221h	321h
02 SE / 02 Diff.	22h	122h	222h	322h
03 SE / 03 Diff.	23h	123h	223h	323h
04 SE / 04 Diff.	24h	124h	224h	324h
05 SE / 05 Diff.	25h	125h	225h	325h
06 SE / 06 Diff.	26h	126h	226h	326h
07 SE / 07 Diff.	27h	127h	227h	327h
08 SE / 08 Diff.	28h	128h	228h	328h
09 SE / 09 Diff.	29h	129h	229h	329h
10 SE / 10 Diff.	2Ah	12Ah	22Ah	32Ah
11 SE / 11 Diff.	2Bh	12Bh	22Bh	32Bh
12 SE / 12 Diff.	2Ch	12Ch	22Ch	32Ch
13 SE / 13 Diff.	2Dh	12Dh	22Dh	32Dh
14 SE / 14 Diff.	2Eh	12Eh	22Eh	32Eh
15 SE / 15 Diff.	2Fh	12Fh	22Fh	32Fh
16 SE	30h	130h	230h	330h
17 SE	31h	131h	231h	331h
18 SE	32h	132h	232h	332h
19 SE	33h	133h	233h	333h
20 SE	34h	134h	234h	334h
21 SE	35h	135h	235h	335h
22 SE	36h	136h	236h	336h
23 SE	37h	137h	237h	337h
24 SE	38h	138h	238h	338h
25 SE	39h	139h	239h	339h
26 SE	3Ah	13Ah	23Ah	33Ah
27 SE	3Bh	13Bh	23Bh	33Bh
28 SE	3Ch	13Ch	22Ch	33Ch
29 SE	3Dh	13Dh	23Dh	33Dh
30 SE	3Eh	13Eh	23Eh	33Eh
31 SE	3Fh	13Fh	23Fh	33Fh

Table B-2: EEPROM Memory Map, Gain = 1

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	40h	140h	240h	340h
01 SE / 01 Diff.	41h	141h	241h	341h
02 SE / 02 Diff.	42h	142h	242h	342h
03 SE / 03 Diff.	43h	143h	243h	343h
04 SE / 04 Diff.	44h	144h	244h	344h
05 SE / 05 Diff.	45h	145h	245h	345h
06 SE / 06 Diff.	46h	146h	246h	346h
07 SE / 07 Diff.	47h	147h	247h	347h
08 SE / 08 Diff.	48h	148h	248h	348h
09 SE / 09 Diff.	49h	149h	249h	349h
10 SE / 10 Diff.	4Ah	14Ah	24Ah	34Ah
11 SE / 11 Diff.	4Bh	14Bh	24Bh	34Bh
12 SE / 12 Diff.	4Ch	14Ch	24Ch	34Ch
13 SE / 13 Diff.	4Dh	14Dh	24Dh	34Dh
14 SE / 14 Diff.	4Eh	14Eh	24Eh	34Eh
15 SE / 15 Diff.	4Fh	14Fh	24Fh	34Fh
16 SE	50h	150h	250h	350h
17 SE	51h	151h	251h	351h
18 SE	52h	152h	252h	352h
19 SE	53h	153h	253h	353h
20 SE	54h	154h	254h	354h
21 SE	55h	155h	255h	355h
22 SE	56h	156h	256h	356h
23 SE	57h	157h	257h	357h
24 SE	58h	158h	258h	358h
25 SE	59h	159h	259h	359h
26 SE	5Ah	15Ah	25Ah	35Ah
27 SE	5Bh	15Bh	25Bh	35Bh
28 SE	5Ch	15Ch	25Ch	35Ch
29 SE	5Dh	15Dh	25Dh	35Dh
30 SE	5Eh	15Eh	25Eh	35Eh
31 SE	5Fh	15Fh	25Fh	35Fh

Table B-3: EEPROM Memory Map, Gain = 2

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	60h	160h	260h	360h
01 SE / 01 Diff.	61h	161h	261h	361h
02 SE / 02 Diff.	62h	162h	262h	362h
03 SE / 03 Diff.	63h	163h	263h	363h
04 SE / 04 Diff.	64h	164h	264h	364h
05 SE / 05 Diff.	65h	165h	265h	365h
06 SE / 06 Diff.	66h	166h	266h	366h
07 SE / 07 Diff.	67h	167h	267h	367h
08 SE / 08 Diff.	68h	168h	268h	368h
09 SE / 09 Diff.	69h	169h	269h	369h
10 SE / 10 Diff.	6Ah	16Ah	26Ah	36Ah
11 SE / 11 Diff.	6Bh	16Bh	26Bh	36Bh
12 SE / 12 Diff.	6Ch	16Ch	26Ch	36Ch
13 SE / 13 Diff.	6Dh	16Dh	26Dh	36Dh
14 SE / 14 Diff.	6Eh	16Eh	26Eh	36Eh
15 SE / 15 Diff.	6Fh	16Fh	26Fh	36Fh
16 SE	70h	170h	270h	370h
17 SE	71h	171h	271h	371h
18 SE	72h	172h	272h	372h
19 SE	73h	173h	273h	373h
20 SE	74h	174h	274h	374h
21 SE	75h	175h	275h	375h
22 SE	76h	176h	276h	376h
23 SE	77h	177h	277h	377h
24 SE	78h	178h	278h	378h
25 SE	79h	179h	279h	379h
26 SE	7Ah	17Ah	27Ah	37Ah
27 SE	7Bh	17Bh	27Bh	37Bh
28 SE	7Ch	17Ch	27Ch	37Ch
29 SE	7Dh	17Dh	27Dh	37Dh
30 SE	7Eh	17Eh	27Eh	37Eh
31 SE	7Fh	17Fh	27Fh	37Fh

Table B-4: EEPROM Memory Map, Gain = 50

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	80h	180h	280h	380h
01 SE / 01 Diff.	81h	181h	281h	381h
02 SE / 02 Diff.	82h	182h	282h	382h
03 SE / 03 Diff.	83h	183h	283h	383h
04 SE / 04 Diff.	84h	184h	284h	384h
05 SE / 05 Diff.	85h	185h	285h	385h
06 SE / 06 Diff.	86h	186h	286h	386h
07 SE / 07 Diff.	87h	187h	287h	387h
08 SE / 08 Diff.	88h	188h	288h	388h
09 SE / 09 Diff.	89h	189h	289h	389h
10 SE / 10 Diff.	8Ah	18Ah	28Ah	38Ah
11 SE / 11 Diff.	8Bh	18Bh	28Bh	38Bh
12 SE / 12 Diff.	8Ch	18Ch	28Ch	38Ch
13 SE / 13 Diff.	8Dh	18Dh	28Dh	38Dh
14 SE / 14 Diff.	8Eh	18Eh	28Eh	38Eh
15 SE / 15 Diff.	8Fh	18Fh	28Fh	38Fh
16 SE	90h	190h	290h	390h
17 SE	91h	191h	291h	391h
18 SE	92h	192h	292h	392h
19 SE	93h	193h	293h	393h
20 SE	94h	194h	294h	394h
21 SE	95h	195h	295h	395h
22 SE	96h	196h	296h	396h
23 SE	97h	197h	297h	397h
24 SE	98h	198h	298h	398h
25 SE	99h	199h	299h	399h
26 SE	9Ah	19Ah	29Ah	39Ah
27 SE	9Bh	19Bh	29Bh	39Bh
28 SE	9Ch	19Ch	29Ch	39Ch
29 SE	9Dh	19Dh	29Dh	39Dh
30 SE	9Eh	19Eh	29Eh	39Eh
31 SE	9Fh	19Fh	29Fh	39Fh

Table B-5: EEPROM Memory Map, Gain = 100

CHANNEL NUMBER	OFFSET, USER CAL	GAIN ADJUST, USER CAL	OFFSET, FACTORY CAL	GAIN ADJUST, FACTORY CAL
00 SE / 00 Diff.	A0h	1A0h	2A0h	3A0h
01 SE / 01 Diff.	A1h	1A1h	2A1h	3A1h
02 SE / 02 Diff.	A2h	1A2h	2A2h	3A2h
03 SE / 03 Diff.	A3h	1A3h	2A3h	3A3h
04 SE / 04 Diff.	A4h	1A4h	2A4h	3A4h
05 SE / 05 Diff.	A5h	1A5h	2A5h	3A5h
06 SE / 06 Diff.	A6h	1A6h	2A6h	3A6h
07 SE / 07 Diff.	A7h	1A7h	2A7h	3A7h
08 SE / 08 Diff.	A8h	1A8h	2A8h	3A8h
09 SE / 09 Diff.	A9h	1A9h	2A9h	3A9h
10 SE / 10 Diff.	AAh	1AAh	2AAh	3AAh
11 SE / 11 Diff.	ABh	1ABh	2ABh	3ABh
12 SE / 12 Diff.	ACh	1ACh	2ACh	3ACh
13 SE / 13 Diff.	ADh	1ADh	2ADh	3ADh
14 SE / 14 Diff.	AEh	1AEh	2AEh	3AEh
15 SE / 15 Diff.	AFh	1AFh	2AFh	3AFh
16 SE	B0h	1B0h	2B0h	3B0h
17 SE	B1h	1B1h	2B1h	3B1h
18 SE	B2h	1B2h	2B2h	3B2h
19 SE	B3h	1B3h	2B3h	3B3h
20 SE	B4h	1B4h	2B4h	3B4h
21 SE	B5h	1B5h	2B5h	3B5h
22 SE	B6h	1B6h	2B6h	3B6h
23 SE	B7h	1B7h	2B7h	3B7h
24 SE	B8h	1B8h	2B8h	3B8h
25 SE	B9h	1B9h	2B9h	3B9h
26 SE	BAh	1BAh	2BAh	3BAh
27 SE	BBh	1BBh	2BBh	3BBh
28 SE	BCh	1BCh	2BCh	3BCh
29 SE	BDh	1BDh	2BDh	3BDh
30 SE	BEh	1BEh	2BEh	3BEh
31 SE	BFh	1BFh	2BFh	3BFh

Table B-6: EEPROM Memory Map, Gain = 200

Customer Comments

If you experience any problems with this manual or just want to give us some feedback, please email us at: ***manuals@accesio.com***. Please detail any errors you find and include your mailing address so that we can send you any manual updates.

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