CyDAS Series

CYEXP GP

8-Channel
General Purpose
Multiplexing Panel

USER'S MANUAL

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1 INTRODUCTION

The CYEXP GP is an eight-channel, signal conditioning accessory designed for use with the DAS08 and DAS16 family of data acquisition boards. It can condition signals from bridge sensors, RTDs or thermocouples on a per-channel basis. It converts the sensor's output to a voltage suitable for conversion by a DAS08/DAS16 or other analog to digital conversion board.

This manual is organized into sections that explain the CYEXP GP on a sensor by sensor basis. The CYEXP GP is complex, and the information on bridge sensors may confuse those interested in RTDs only, and vice-versa. Here are the sections of this manual:

Software Installation	All users should review this section regardless of the application.
General Configuration:	All users should review this section regardless of the application.
Configuration for Voltage Measurement:	Users interested in voltage measurement applications should review this section.
Configuration for Thermocouples	Users interested in temperature measurement applications using thermocouples should review this section.
Configuration for RTD Measurement	Users interested in temperature measurement applications using RTDs should review this section.
Configuration for Resistance Measurement:	Users interested in resistance or strain gauge measurement applications should review this section.

Please carefully read the installation and general configuration sections, and each of the sections pertaining to the sensors you intend to use. There are optional resistors, jumpers, switches, and other connections to be made on the CYEXP GP. Failure to set up the channels correctly for the sensor in use will result in inaccurate or invalid measurements.

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2 SOFTWARE INSTALLATION

Software is not included with the CYEXP GP, but each of the data acquisition boards with which it is intended to be used includes software called *Insta*Cal™ that may be used to aid installation, verify operation and perform calibration of the CYEXP GP. The disk or CD labeled *Insta*Cal contains this software package. If you ordered the Universal Library™, you should load *Insta*Cal from that CD or disk set.

The board has a variety of switches and jumpers to set before installing the board in your computer. *Insta*Cal will show you all available options, how to configure the various switches and jumpers to match your application requirements, and will create a configuration file that your application software (and the Universal Library) will refer to so the software you use will automatically have access to the exact configuration of the board.

Please refer to the *Software Installation Manual* regarding the installation and operation of *Insta*Cal. Use *Insta*Cal along with the following hard copy information to set the hardware configuration of the board.

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3 GENERAL CONFIGURATION

3.1 A/D Board Type Select Jumper

The CYEXP GP can be used with either DAS08 or DAS16 family boards because the signal assignments of the 37-pin connectors match those of the DAS08 and may be adapted to those of the DAS16 with a CBL MX10 cable. Select the A/D board type via the JB10 jumper.

Jumper JB10 on the, CYEXP GP located near the 37-pin connector, selects the A/D board family as DAS08 or DAS16.

Figure 3-1 shows the jumper set to use the CYEXP GP with a CYDAS 8 family board.

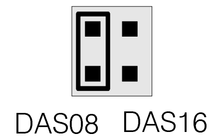

Figure 3-1
DAS Family Select

3.2 Setting The Output Channel

Jumpers labeled "CH SEL" located near the 37-pin connector select the A/D board channel that the output from the active sensor will be connected to.

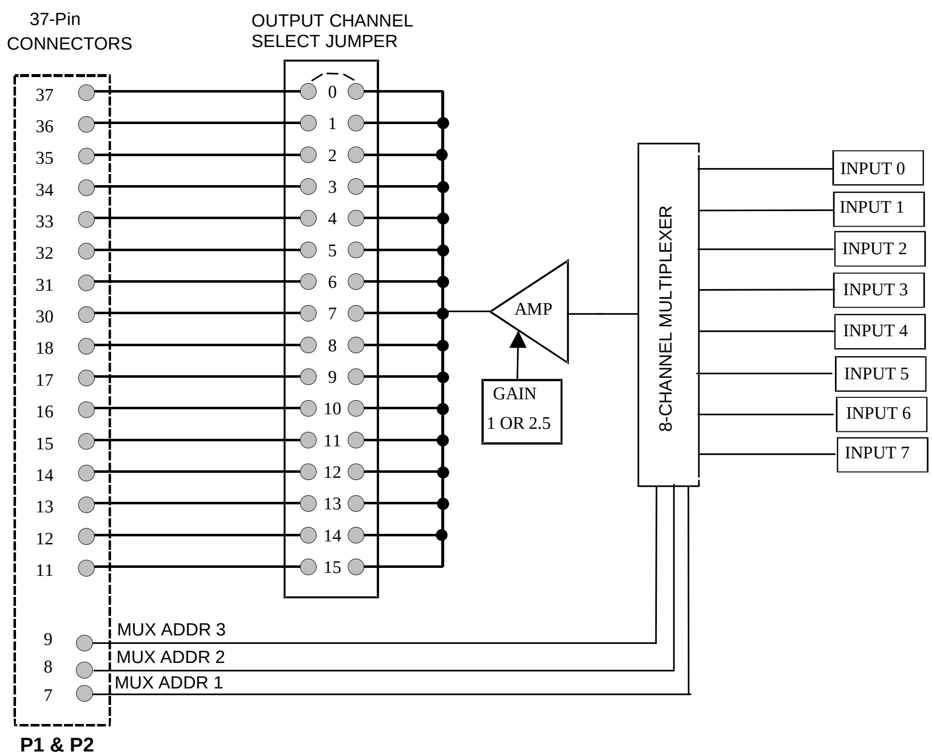

Figure 3-2. Output Channel Select Jumper

There are three groups of 16-position jumpers. One jumper group determines the signal output channel, one jumper group determines the excitation voltage output channel and one determines the Cold Junction Compensation (CJC) output channel. Signal output is always used, CJC output is used only with thermocouples and excitation output may be used with bridge sensors.

There are 16 jumper locations for each function. Each corresponds to one of the 16 pins on the 37 pin connector. When the CYEXP GP is connected to a DAS08, only the first 8 channels (labeled 0-7) can be used. When the CYEXP GP is connected to a DAS16, all 16 jumper positions can be used. In each case, the jumper corresponds to a channel number on the A/D board.

If the jumper setting does not agree with the selection made in InstaCal setup, InstaCal and the Universal Library will not be able to make readings from the CYEXP GP. Figure 3-3 is a diagram of the Channel Select jumper. There are two other groups of output jumpers similar to this group.

The top group (shown here) is marked CH SEL (Channel Select), the center jumper group is VEXC SEL (excitation voltage select) and the bottom group is marked CJC SEL (Cold Junction Compensation Select).

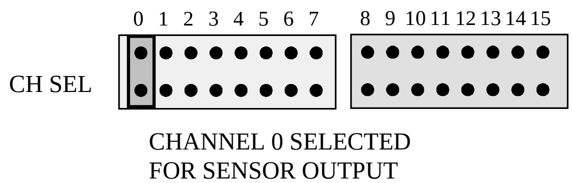

Figure 3-3. Output Channel Select Jumper

Place the jumper on the pin which corresponds to the A/D board's input channel. Each jumper set must select a unique A/D channel. For example, if you are using the excitation or CJC outputs in addition to the signal output, each should be set to a different channel number.

One individual channel must be selected for each bank of 8 EXP channels. For example, if you are using several CYEXP GP boards, the jumper setting for each board must be unique. If you select channel 0 for the first board, do not use this channel for any of the other boards.

3.3 Configuring the A/D Board

3.3.1 DAS08 Family Setup

The input mode of the A/D board must be single-ended to be compatible with the CYEXP outputs. Some of the boards in the DAS08 series have differential inputs that can be converted to single-ended inputs. See the information shipped with your A/D board for conversion to single-ended inputs.

3.3.2 DAS16 Family Setup

The input mode of the A/D board must be single-ended to be compatible with the CYEXP outputs. Most of the DAS16 series is switch selectable for either 8 differential or 16 single ended inputs. When used with the CYEXP, set the switch to 16 channel, single-ended mode.

3.3.3 All A/D Boards

If you are using an A/D board with switch - selectable ranges, consider the application and determine the best fit for range vs. expected voltage. For example, when measuring resistance such that the output of the EXP board is expected to be in the range of 3 to 4.5 volts, a unipolar 5V range would be the best choice.

If the range on your A/D board is fully programmable, the software you use for measurement will determine the range.

3.4 CONNECTING THE CYEXP GP TO THE A/D BOARD

3.4.1 Connecting to a DAS08 Series A/D Board

A CYDAS 8 series board may be connected directly through a CBL 3700 series cable from the P1 connector on the CYEXP GP to the A/D analog connector. The JB10 jumper should be left in the DAS08 position as set at the factory.

3.4.2 Connecting to a DAS16 Series A/D Board

Connection to a DAS16 series board requires a special 37-conductor cable (CBL MX10) since pin relationship of CYEXP and DAS16 signals is not 1:1.

Install the CBL MX10 cable connector labeled "MUX" into the P1 connector of the CYEXP GP board and the other end into the DAS16 series board's analog connector.

3.4.3 Other A/D Boards

For other boards, use the connector diagram in Figure 3-4 to construct a cable, or call us and discuss the possibility of a custom manufactured cable.

The signals from the CYEXP GP are voltages from each channel and an analog ground. There should be no voltage between the analog ground and the power ground.

The MUX address lines control the setting of the channel multiplexer. When all are low, the mux is set to channel 0. The lines are binary coded. MUXADDR1 is the LSB and MUXADDR3 is the MSB.

A jumper (CH SEL) selects which output channel is read by the DAS08 or DAS16 board.

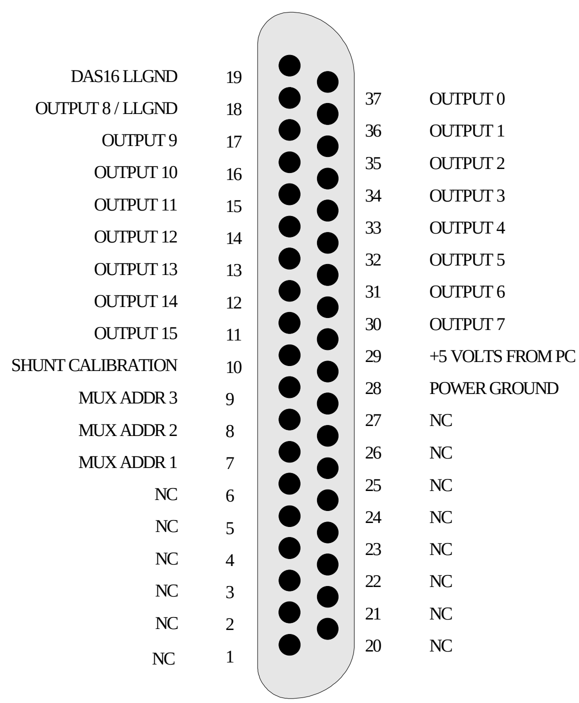

Figure 3-4. 37-Pin Connectors

3.5 Powering The CYEXP GP

The CYEXP GP can be powered through the 37-pin cable, the power screw terminal or the Molex connector. The power that can be carried through the 37-pin connector is limited so we recommend using this source only when a single CYEXP GP is used.

The power required to run a CYEXP GP is dependent on the board configuration. Remember that additional power will be drawn when the CYEXP GP is configured for resistance measurement (bridge configuration) due to the current required for each bridge.

3.5.1 Power Source Switch

One of the switches on the eight-position DIP switch (S17) near the output channel jumpers controls the source of the +5 volts power to the board. Shown in Figure 3-5 it is the 3rd switch from the left.

When positioned *down*, (ON, +5 COMP), the +5V power is drawn from the personal computer through the signal cable.

When positioned up (OFF, REM) , +5V power is taken from the optional external 5V power connector (the Molex connector labeled P19) or the +5V screw terminal connection.

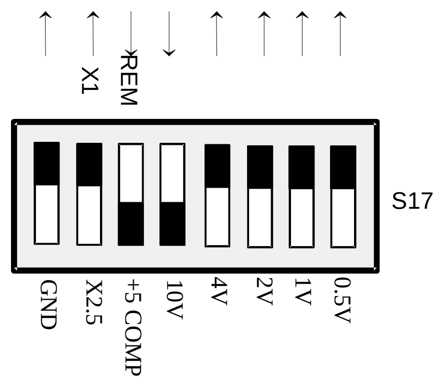

Figure 3-5. Power Source Switch

3.5.2 Powering with the 37-Pin Connector

You can power the CYEXP GP via the 37-pin cable. No more than one CYEXP GP should be powered using the 37-pin cable.

This option is not available when using some A/D boards. If the A/D board you are using supplies +5V at pin 29 (or at pin 1 when using the CBL MX10 signal cable), you can power the CYEXP GP through the 37-pin connector by setting the power select switch on S17 to “+5 COMP.”

3.5.3 Powering with the Molex Connector

The CYEXP GP can be powered off the PC's power supply by connecting the optional external 5V power connector (the Molex connector labeled P19) to the PC’s power supply through a C-MOLEX-10 cable. This cable has the same Molex connector that is used inside the PC and so can be connected directly to the PC's power supply through one of the spare connectors. The cable is keyed, so it should not be forced. When inserted properly it will slide easily and snap in place.

3.5.4 Powering Through the Power Screw Terminals:

A set of screw terminals labeled “+5V REM” and “REM GND” are located below the 37-pin connectors P1 and P2. You can power the CYEXP GP from a +5V (±5%) power supply capable of at least 400 mA. For this option, set the power select switch on S17 to “REM.”

CAUTION: Connect the ground of the power supply to the ground of the personal computer with a heavy gauge wire. If you do not strap the two grounds together, a voltage between these grounds will affect measurements. If the potential exceeds the protection range of the input circuits, the board may be damaged.

At this time, ignore the other screw terminals located next to the power and ground terminals. They are needed only with certain sensors and will be explained in those sections.

3.6 Daisy-Chaining CYEXP GP Boards

Connect one CYEXP GP to another using a CBL 370x ribbon cable. Connect from P2 on the ‘upstream’ board to P1 on the ‘downstream’ board. Make sure each of the boards in the chain have a unique channel selected (CH SEL jumper is set to a different number on each board).

3.7 Connecting a Test Voltage

Make your initial test of the CYEXP GP with a voltage signal of between -5 and 5V. If you use an AC signal source, keep the frequency below 70 Hz to avoid attenuation by the CYEXP GP’s low pass filter.

Each input circuit has eight screw terminals associated with it. These terminals are shown in the diagram to the right.

To connect a voltage signal to the input circuit you use three screw terminals as follows:

+SENSE Connect to + voltage
−SENSE Jumper to −P
−P Connect to Ground

There is not enough room on the board for the full name next to each terminal so the eight screw terminals associated with each input circuit are labeled on the CYEXP GP as follows:

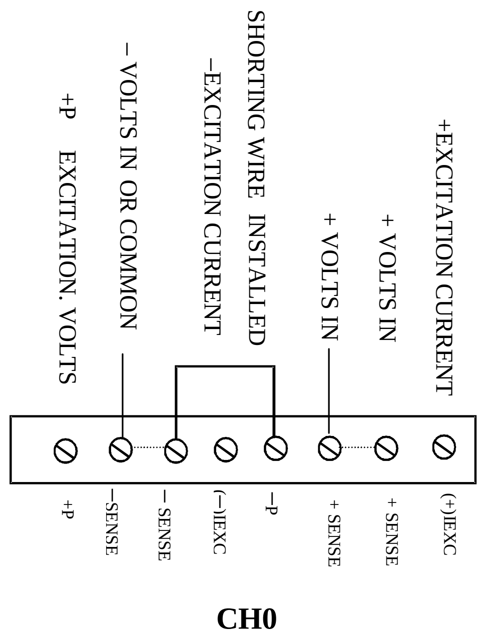

Figure 3-6. Input Screw Terminals

+P	Excitation voltage
−SENSE	Low side of input
−SENSE	Hardwired to the other −SENSE, same function
−IEXC	Excitation current return
−P	Excitation voltage return, common with −IEXC
+SENSE	High side of input
+SENSE	Hardwired to other +SENSE, same function
+IEXC	Excitation current

The use of the terminals is dependent on the type of sensor you have connected to the input circuit, and the nomenclature on the terminals has been chosen to make the most sense for bridge and RTD sensors. For voltage and thermocouple sensors the names on the terminals are not typical. Please refer to the section on the measurement you are making in order to learn how to use the terminals.

3.8 Verifying the Installation

For verification of the installation, leave any switches or jumpers not mentioned above in their default positions. Each of the gain switches (CH0 through CH7 and S17-7) should be off (toward the upper edge of the board) for a gain of X1 (unity gain). The channel configuration switches (labeled “IN CONFIG” should be left in the default position (the switches labeled “4” in the ON position and those labeled “3” in the OFF position - the label is printed on the board, not the switch).

To verify the installation, use the InstaCal program installed on your computer. This software came with your A/D board if you bought the board from the same manufacturer as the CYEXP GP. If your A/D board is not from the same manufacturer but is compatible, please call technical support and request a copy of InstaCal.

Use InstaCal's TEST option to verify that a signal present at one of the CYEXP GP inputs can be read. You will not need to set any jumpers other than those previously mentioned, and should not set any switches or install any passive components until you have verified the installation.

When using an AC signal source, keep the frequency below 70 Hz to avoid attenuation by the low pass filter.

4 CONFIGURATION FOR VOLTAGE MEASUREMENT

The CYEXP GP is an amplification, signal conditioning and multiplexing accessory for DAS boards. The inputs are suitable for connecting a low frequency voltage to the DAS board so it can be measured. The CYEXP GP is a one-of-eight multiplexer which means that for every channel in your DAS board, you can multiplex eight different signals to it. You can expand the number of inputs of your DAS board by eight for every CYEXP GP board, up to the number of inputs on the DAS board. For example, a DAS08 has 8 inputs. Eight times eight is sixty-four. Using CYEXP GP boards you can bring 64 inputs into the PC with one DAS08 in one slot.

It is unlikely that you purchase a CYEXP GP to measure voltages. The CYEXP GP has a 70Hz low pass filter and quite a bit of elaborate circuitry designed for bridges, TCs, and RTD sensors. For applications requiring only voltage measurements, a CYEXP 16 or CYEXP 32 would be less expensive and do the same job.

Possibly you have one or two voltages to measure in addition to bridge or RTD sensors and would like to connect those signals to the CYEXP GP.

4.1 Channel Selection

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CYEXP GP with your data acquisition board. Configure your boards as described in that section before continuing with this section.

4.2 Powering the CYEXP GP

The *General Configuration* section describes the power selection options, setting the power select switch and verifying the installation and operation of the CYEXP GP with your data acquisition board. Configure your boards as described in that section before continuing with this section.

4.3 Determining The Appropriate Gain

To accurately measure a voltage, the full scale of the signal should be matched to the full range of the input circuit. (Most DAS boards have an input range of ±5V, which is the native range of the analog to digital converter at the heart of the board. Some DAS boards include amplification on the input circuit to allow the signal to be amplified to make better use of the resolution of the A/D.) For example, an input signal which varies between 0 and 1 volt would only be using 1/10th of a ±5V A/D converter's resolution. By switching the input signal of the DAS board to unipolar (no negative voltage) and amplifying the input signal by 5, the entire range of the A/D converter is used and a higher resolution measurement may be made. By adding this gain and selecting this range, the resolution on a 12-bit A/D improves from 2.4 millivolts per bit to 0.24 millivolts per bit. If you needed to measure a change of 1 millivolt, you would need an amplification of 10.

In order to match your signals with the input range of the A/D board, you should do a similar calculation and set switches on the CYEXP GP for the required gain. Remember to make sure that the settings in InstaCal match the switches on the DAS and CYEXP GP boards.

If you are measuring signals greater than the maximum full scale range of the A/D, see the section on attenuation.

To choose a switch-selectable amplification, here are the calculations you need to perform:

Divide the full range selected for the A/D board by the full range of the signal to be measured to determine the maximum gain of the CYEXP board. For best resolution, use the highest gain possible up to the calculated maximum gain.

For example, if the A/D board is to be used at a range of ±5V, the full range of the board is 10. If your signal ranges between -0.5 volts and 0.5 volts, the full range of the signal is 1 volt. Divide 10 by 1 for a result of 10. That is the maximum gain you can use.

If your signal is *unipolar* and ranges less than 0 to 5V, you would likely choose the 5V unipolar range for the A/D board (if available). Given an input signal ranging from 0 to 0.5 volts, the full range of the signal is 1/2 volt. Divide 5 (the full range of the A/D) by 0.5 (the full range of the signal for a result of 10. That is the maximum gain you can use.

4.4 Setting the Gain

Gain (amplification) allows you to boost your signal to take full advantage of the resolution of the A/D converter. However, when amplifying a signal, any noise is amplified as well.

Amplification for ALL channels (board output gain) is switch selectable (S17) for X1 or X2.5.

Input amplification for EACH CHANNEL is switch selectable (GAIN switches CH0 through CH7) for X1, X10, X100 or X1000. A user-specified gain may be set by supplying a precision resistor at position RX### and setting the "U" option on the CH ## GAIN switch to ON.

4.4.1 Setting Board Gain

There is a switch on DIP switch block S17 labeled X1 and X2.5. Sliding this switch down amplifies the output of the multiplexers by 2.5. The factory default position (up) has a gain of 1 (unity). Refer to Figure 4-1.

The X2.5 gain switch is useful in some voltage and bridge measurements. If you desire a voltage gain of 2.5, 25, 250 or 2500, set this switch *down*.

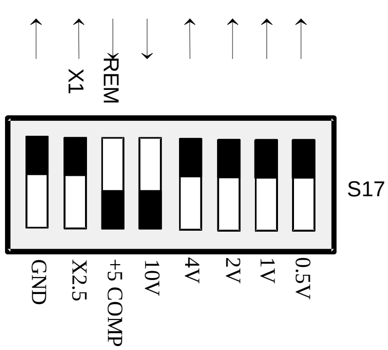

Figure 4-1. Board Output Gain Switch Location

For voltage measurements, a gain of 2500 is very high and will reduce your signal to noise ratio.

The effect of this switch is multiplicative with respect to the individual channel gains. For example, if you have set an input channel gain to X100 and the board output gain to X2.5, the signal is amplified by 250 before it reaches the A/D board.

4.4.2 Setting Channel Gain

Select a gain (higher than unity) by moving the switch for that gain down. All other switches should be left in the UP position.

A custom gain may be selected on the CYEXP GP by installing a precision resistor and setting the switch marked “U” (User) in the down position. See Table 4-1 following for board positions and some sample gain values.

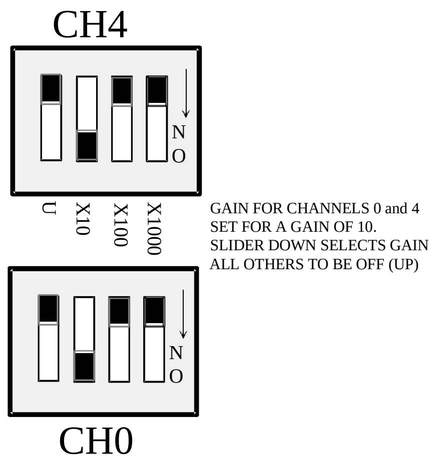

Figure 4-2. Input Channel Gain Select Switches

Table 4-1. Resistor Positions for User-Selected Gains

Channel	Resistor Position	Channel	Resistor Position
0	RX100	4	RX104
1	RX101	5	RX105
2	RX102	6	RX106
3	RX103	7	RX107

Gain	Resistor Value
50	776 Ohms
100	364 Ohms
200	161 Ohms
500	40 Ohms
700	17 Ohms
800	10 Ohms

The equation for selecting the USER gain resistor is:

$$R_{USER} = [40000 / (Gain - 1)] - 40$$

Amplifying a signal on one channel will not affect the reading on another channel.

4.5 Attenuation

If your signal is in a range greater than the full scale range of the A/D, you must either set the A/D for a higher full scale range (if available) or divide (attenuate) the signal until the result is less than or equal to the A/D’s full scale range. This section describes signal attenuation.

A voltage divider is constructed from a pair of precision resistors selected according to the equation:

Attenuation = (Ra + Rb) / Rb

See Figure 4-3 at right for the schematic of a voltage divider.

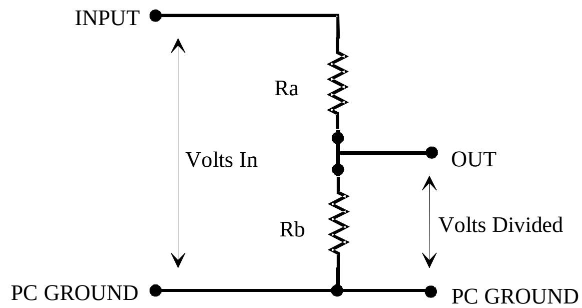

Figure 4-3. Voltage Divider

For example, if your signal is 0 to 10V, it must be attenuated to 5V max. for an attenuation of 2:1 or simply 2.

Using 10k resistors: 2 = (10K + 10K) /10K.

For any attenuation, pick a suitable resistor for Rb. Then use this formula to calculate Ra:

Ra = (A–1) x Rb

You will need to construct the voltage divider remote from the CYEXP GP board.

4.6 Setting the Input Configuration

Channel Configuration Switch - Voltages

A channel configuration switch is associated with each channel (Figure 4-5). The switches are used to configure the input circuits for voltage inputs, thermocouple inputs, 2, 3, or 4-wire RTDs and bridges.

For voltage measurements on a particular channel, set the switches labeled "4" to the ON (*down)* position for that channel.

Set the switches labeled "3" in the OFF (*up)* position.

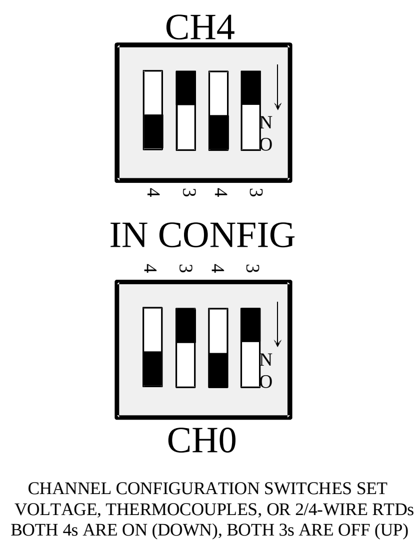

Figure 4-5. Channel Configuration Switches

4.7 Connecting Voltage Signals

Voltage signals can be single ended or differential, and the full scale may have to be matched to the range of the CYEXP GP and DAS board combination via amplification or attenuation. To connect a voltage and make an accurate measurement, each of these issues must be addressed (see section 4.3).

Each input circuit has eight screw terminals associated with it. These terminals are shown in Figure 4-4 to the right.

To connect a voltage signal to the input circuit you need only use three screw terminals. These are:

+SENSE   Signal high, or CH HI on a DAS board

−SENSE   Signal low, or CH LO on a DAS board. Must be jumpered to −P for single-ended

−P   Low Level Ground (LLGND)

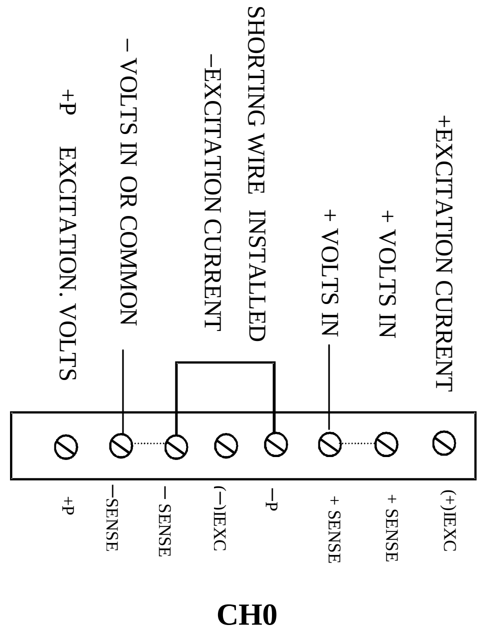

Figure 4-4. Input Screw Terminals

4.7.1 Single-Ended Inputs

A single-ended input has two wires connected to the CYEXP GP; a signal high and a Low Level Ground (LLGND). The LLGND signal *must be the same ground the PC is on.* Single-ended mode is selected by installing a jumper between the signal low (−SENSE) and ground (−P). The -SENSE terminal is then connected to the signal ground and the +SENSE terminal is connected to the signal.

4.7.2 Floating Differential

A floating differential input has two wires from the signal source and a 10K ground reference resistor installed at the CYEXP GP input. The two signals from the signal source are Signal High and Signal Low. The reference resistor is connected between the CYEXP GP "−SENSE" and "-P" pins and the Signal Low is connected to the -SENSE terminal. The +SENSE terminal is connected to the Signal High.

A floating differential hookup is handy when the signal source is floating with respect to ground, such as a battery. The floating differential input will reject up to 10V of EMI energy on the signal wires.

CAUTION: Is the signal source really floating? Check it with a voltmeter before risking the CYEXP GP and the PC.

4.7.3 Fully Differential

A differential signal has three wires from the signal source. The signals are Signal High, Signal Low and Signal Ground (LLGND). Signal High is connected to the +SENSE terminal and Signal Low is connected to the -SENSE terminal. The ground reference must be connected to the -P terminal.

A differential connection allows you to connect the CYEXP GP to a signal source with a ground that is different than the PC ground, but less than 10V difference, and still make a true measurement of the signal. For example, a laboratory instrument with its own wall plug. Sometimes there is a voltage between wall outlet grounds.

4.8 Verifying the Installation

To verify the installation, use the InstaCal program installed on your computer. This software came with your A/D board if you bought the board from the same manufacturer as the CYEXP GP. If your A/D board is not from the same manufacturer but is compatible, please call technical support and request a copy of InstaCal.

Use InstaCal's TEST option to verify that a signal present at one of the CYEXP GP inputs can be read. When using an AC signal source, keep the frequency below 70 Hz to avoid attenuation by the low pass filter.

5 CONFIGURATION FOR THERMOCOUPLE MEASUREMENT

Thermocouples are temperature sensors constructed of wires of two dissimilar metals fused together at a point. This junction of two metals produces a voltage that varies relative to temperature. Thermocouple voltages require several manipulations in order to be useful. These are:

1. A very low voltage is produced and so must be amplified by a factor of between 100 and 1,000.

2. The voltage produced by the thermocouple is not linear with respect to temperature, so it must be linearized. Linearization in this case is calculated by software after the voltage is acquired.

3. A voltage-producing junction is also created at the screw terminal where the thermocouple is connected to the CCYEXP GP. The temperature at this “cold junction” must be measured and the voltage calculated and subtracted from the total measured from the thermocouple. This is also calculated by software. The circuit that measures this temperature is the Cold Junction Compensation (CJC) circuit.

4. Thermocouples are subject to EMI and RFI noise due to the very low level of the voltage and the large amplification factor. These affects can be reduced through averaging and filtering. There is a 70Hz low pass filter on the CYEXP GP. Averaging may be done in software.

Thermocouples are not as accurate as RTDs or other precision temperature sensors, but they are much less expensive. Sometimes, an attempt is made to make a measurement beyond the accuracy of the thermocouple such as measuring 1/10th of a degree over the full scale. Read the accuracy and repeatability specification of the thermocouple, and consider the effects of linearization on the reading before choosing thermocouples.

The CYEXP GP is not the optimum choice for thermocouple-only applications. The CYEXP 32 and CYEXP 16 are less expensive and just as accurate for thermocouple measurements. The CYEXP GP has extra circuitry devoted to bridge and RTD sensors.

5.1 Selecting The Output Channel

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CYEXP GP with your data acquisition board. Configure your boards as described in that section before continuing with this section.

5.2 Selecting The CJC Output Channel

There is a set of jumpers near the 37-pin connectors labeled “CJC SEL,” which stands for cold junction compensation select. These jumpers connect the on-board measurement of the cold junction temperature to one of the A/D board channels for use in temperature calculations.

The CJC temperature reference is universally used by software to compensate for the voltage induced at the cold junction (the screw terminal). The software package you are using will determine which channel you need to set this jumper on. The default is channel 7 (the channel used by default by the Universal Library). If you are not using the Universal Library, check your software documentation before selecting a channel. Failure to supply the CJC reference by installing the jumper on the correct channel will result in inaccurate temperature calculations by the software.

The jumper for the CJC channel select (Figure 5-1) looks just like the jumper for output channel selection.

Set this jumper according to the instructions for the software package you are using.

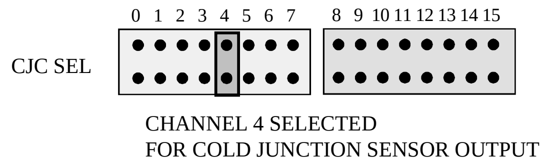

Figure 5-1. CJC Channel Select Jumper Pad

The CJC uses one analog input channel of the A/D board. The channel selected must be unique (the CJC SEL jumper must not be set to the same number as that for CH SEL jumper or VEXC SEL jumper on this board or any other EXP board that may be daisy-chained to this board).

5.3 Input Configuration

For thermocouple measurement, the channel input configuration switches must be set for two wire measurement. Also, a ground reference should be established and open thermocouple detection should be enabled. These options are selected by setting some switches and closing some solder pads on the underside of the CYEXP GP.

5.3.1 Setting the Input Configuration

A channel configuration switch is associated with each channel. The switch is used to configure the input circuit for two or four wire measurements. When measuring thermocouples, two wire measurement should be used.

Set the two switches labeled "4" on each IN CONFIG Channel Configuration switch to the ON (*down)* position for each channel used for thermocouple measurement. (See Figure 5-2 on the right.)

Set the two switches labeled "3" on each IN CONFIG switch for thermocouple channels to the OFF (*up*) position.

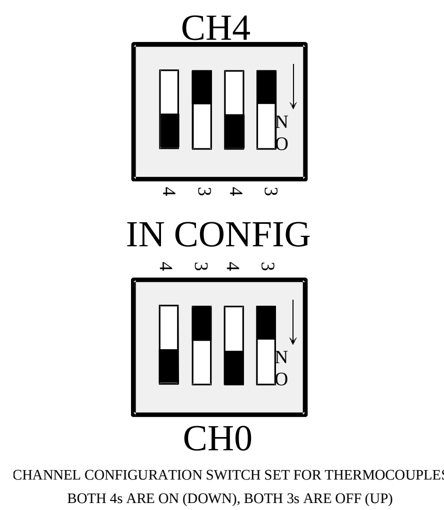

Figure 5-2. Channel Configuration Switches

5.3.2 Enabling Open Thermocouple Detection (OTD)

Open thermocouple detection (OTD) is enabled for a channel by installing a resistor and closing the 'TC' pad with a solder bridge (see Figures 5-3 and 5-4). There are locations marked "TC" for each channel for this purpose.

OTD provides the high side of the thermocouple signal with a reference to −50mVDC at very low current. If a thermocouple opens, it ceases to produce a voltage. If that happens, the OTD voltage drives the signal on that channel to full minus. Most software is set up to alarm for an open thermocouple when a temperature falls to full scale minus value. The CYEXP GP will accurately measure thermocouples without the 'TC' pad closed but you must close it and install a 100K resistor to have OTD.

Table 5-1. 100K ohm Resistors to be Installed for OTD:

Channel 0	RX 5	Channel 2	RX 17	Channel 4	RX 29	Channel 6	RX41
Channel 1	RX11	Channel 3	RX 23	Channel 5	RX 35	Channel 7	RX47

Please solder the pads with the solder provided. It has a water soluble flux which should be washed off. If you use another type of solder or do not wash off the flux it may affect your readings.

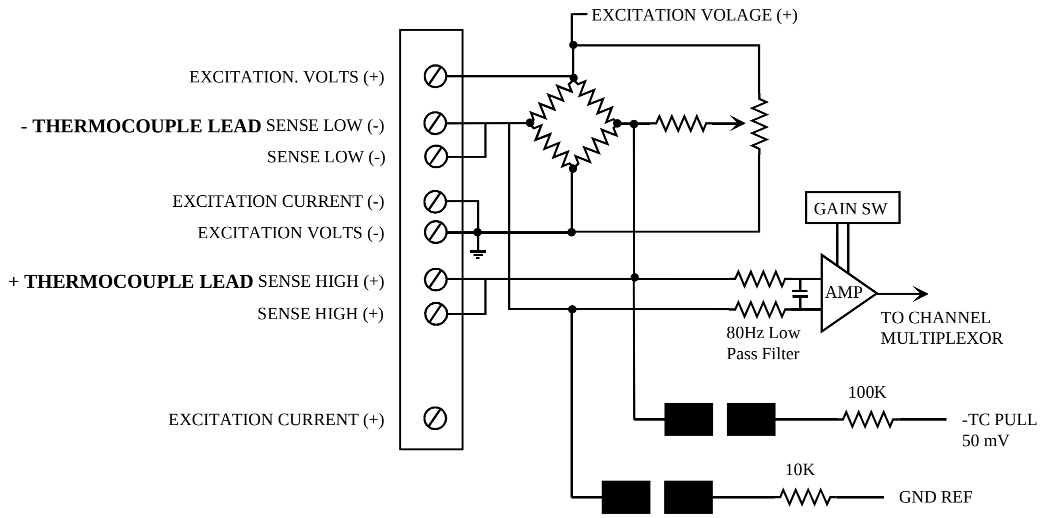

Figure 5-3. OTD and Ground Reference Jumper Pads - Schematic

NOTE: If you want to change the use of the input circuit to an RTD or bridge sensor, remove the solder that closes the TC pad (and the G pad also).

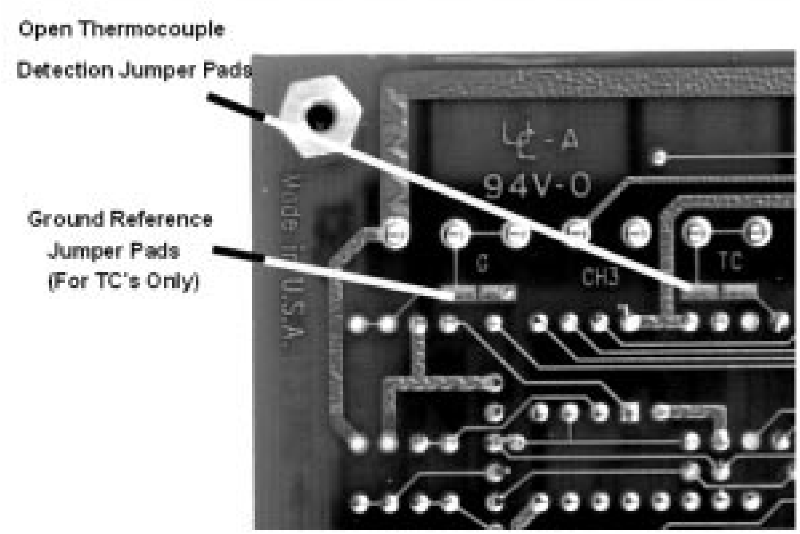

Figure 5-4. OTD and Ground Reference Jumper Pads - Locations (Typ.)

5.3.3 Adding a Ground Reference

The CYEXP GP inputs are fully differential which helps reject noise on thermocouple wires. If thermocouples connected to the CYEXP GP inputs are to work properly, the 'G' pad must be closed on any channel used for thermocouple measurement (see Figures 5-3 and 5-4). The 'G' pad provides a reference from ground to the analog low input via a 10K resistor. Only enough current passes through the resistor to provide a reference to ground. The analog high and low inputs are still able to float within the common mode range.

NOTE: If you want to change the use of the input circuit to an RTD or bridge sensor, remove the solder that closes the G pad (and the TC pad also).

5.4 Determining the Appropriate Gain

The voltage from a thermocouple must be amplified in order to take advantage of the A/D board's full resolution. Without amplification, you would not get much resolution from thermocouples, as you can see in the tables below. Typical gain settings for use with thermocouples are between X10 and X250.

Tables 5-3 and 5-4 below may be used to help determine the appropriate gain to use for the temperature range and thermocouple type in use.

Table 5-3. Resolution vs Thermocouple Gain Settings for a ±5V, 12 bit A/D

Type	**Output µV/°C**	**Min °C**	**Max °C**	**°C/bit @X10**	**°C/bit @X100**	**°C/bit @X250**	**°C/bit @X1000**
J	51	0	750	4.78	0.48	0.19	0.04
K	40	-200	1,250	6.1	0.61	0.24	0.06
T	40	–200	350	6.1	0.61	0.24	0.06
E	62	–200	900	3	0.39	0.16	0.03
S	7	0	1,450	34.9	3.49	1.4	0.35
R	7	0	1,450	34.9	3.49	1.4	0.35

A J-type thermocouple outputs 51mV per degree centigrade at 20°C. At a gain of 100, a 12 bit A/D on the ±5V range resolves to 0.00002442 volts per bit (24.42µV/bit).With an output of 51mV/°C, that represents about 0.5°C/bit. Look under the gain of 100 for a J-type and you will find 0.48°C/bit.

The table below shows the thermocouple output voltage at maximum temperature amplified by four possible gain values. Where the output voltage exceeds 5V, the reading is clipped.

Table 5-4. Voltage Output @ Maximum Temperature

Type	**Output @Max Temp**	**Max °C**	**Vout at Max Temp**			
			X10	**X100**	**X250**	**X1000**
J	42.3mV	750	0.42	4.2	***10.6***	***42***
K	50.6mV	1,250	0.51	***5.1***	***12.7***	***51***
T	17.8mV	350	0.18	1.8	4.5	***18***
E	68.8	900	0.69	***6.9***	***17.2***	***69***
S	15mV	1,450	0.15	1.5	3.8	***15***
R	16.7	1,450	0.17	1.7	4.2	***17***

Voltages which exceed the ±5V range are in bold italics in the table above. Table 5-5 shows the temperature at which the reading is clipped (the maximum readable temperature for thermocouple types at a given gain).

Table 5-5. Maximum Readable Temperatures with A/D on ±5V Range

Type	**Max °C**	**Max Readable Temp vs Gain**			
		X10	**X100**	**X250**	**X1000**
J	750	750°C	750 °C	366°C	95°C
K	1,250	1,250°C	1,232°C	484°C	121°C
T	350	350°C	350°C	350°C	115°C
E	900	900°C	660°C	287°C	80°C
S	1,450	1,450°C	1,450°C	1,450°C	576°C
R	1,450	1,450°C	1,450°C	1,450°C	548°C

From these tables, you can determine that if you want to use a J-type thermocouple to make a reading of 700 degrees, the gain should be set at 100. This yields a resolution of 0.48 degrees C per bit.

5.5 Setting the Gain

Once you have determined the gain required for your application, set the gain of the CYEXP GP using the following guide.

Amplification for ALL channels (board output gain) is switch selectable (S17) for X1 or X2.5.

Input amplification for EACH CHANNEL is switch selectable (CH0 through CH7) for X1, X10, X100 or X1000. A user-specified gain may be set by supplying a precision resistor at position RX### and setting the "U" option on switch CH ## to ON.

5.5.1 Setting the Board Gain

Output Gain Switch

There is a switch on DIP switch block S17 (Figure 5-5) labeled X1 and X2.5. Sliding this switch down amplifies the output of the multiplexers by 2.5. The factory default position (up) has a gain of 1 (unity).

The X2.5 gain switch is useful in some thermocouple measurements. If you desire a voltage gain of 2.5, 25 or 250, set this switch *down*. Recommended gains for thermocouples are between X10 and X200.

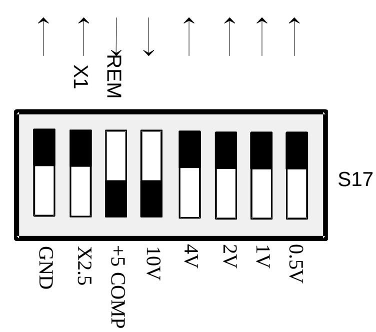

Figure 5-5. Output Gain Switch Location

The effect of this switch is multiplicative with respect to the individual channel gains. For example, if you have set an input channel gain to X100 and the board output gain to X2.5, the signal is amplified by 250 before it reaches the A/D board.

5.5.2 Setting the Channel Gain

There is a gain switch for each channel (Figure 5-6). Set the input channel gain to match the expected voltage output of the bridge you are measuring to the input range of the A/D board as described above.

Channel Gain Switches

There is a set of DIP gain switches for each input circuit labeled GAIN (Figure 5-6). There are four, two-position switches for each channel. The gain switches are labeled U, X10, X100, and X1000.

Select a gain (higher than unity) by moving the switch for that gain down. All other switches should be left in the UP position.

A custom gain may be selected on the CYEXP GP by installing a precision resistor and setting the switch marked "U" (User) in the down position. See Table 5-2 below for positions and some sample gain values.

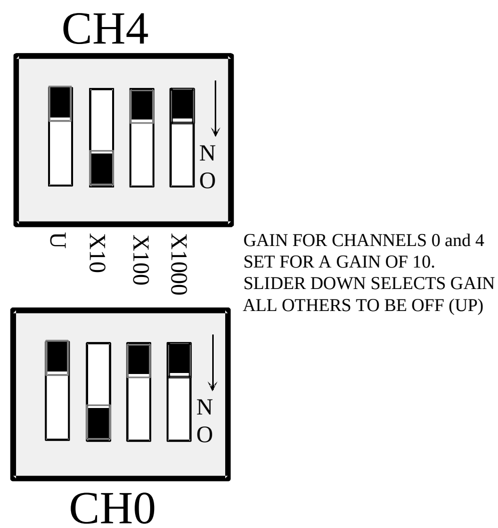

Figure 5-6. Channel Gain Switches

Table 5-2. User Gain Resistors - Identities

Channel	Resistor Position	Channel	Resistor Position
0	RX100	4	RX104
1	RX101	5	RX105
2	RX102	6	RX106
3	RX103	7	RX107

Gain	Resistor Value
50	776 Ohms
100	364 Ohms
200	161 Ohms
500	40 Ohms
700	17 Ohms
800	10 Ohms

The equation for selecting the gain resistor is:

$$R_{USER} = (40000 / (Gain - 1)) - 40$$

5.6 Verifying the Installation

Your channel is now configured to make thermocouple measurements. To verify the installation, use the InstaCal program installed on your computer. This software came with your A/D board if you bought the board from the same manufacturer as the CYEXP GP. Use the CALIBRATE option to calibrate the CJC and verify the operation of the channel. Use the TEST option to make a measurement in engineering units.

6 CONFIGURATION FOR RTD MEASUREMENTS

An RTD is a temperature sensor that consist of a resistive element, usually a length of wire encased in a sheath. Various wire materials are used with platinum being the most common. There are three types of hookups: two-wire, three-wire, and four-wire. An excellent source of information on RTDs and how to select one for your application may be found in the OMEGA Engineering catalog.

6.1 Channel Selection

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CYEXP GP with your data acquisition board. Configure your boards as described in that section before continuing with this section.

6.2 VEXC JUMPER Select

There is a set of jumpers near the 37-pin connectors labeled “VEXC SEL,” which stands for channel excitation voltage select. These jumpers connect the on-board excitation voltage to one of the A/D board channels so that it may be measured. CyberResearch does not use a measurement of the excitation voltage in any of its software. You do not need to set this jumper if you are using the CYEXP GP with CyberResearch software, or with packages such as Labtech Notebook™, which use the Universal Library. Use this jumper only with software from other manufacturers that specifically require it.

6.3 CJC Jumper Selection

There is a set of jumpers near the 37-pin connector labeled “CJC SEL,” which stands for cold junction compensation select. Remove this jumper. There is no cold junction compensation used with bridge sensors.

6.4 Powering the CYEXP GP

The *General Configuration* section describes the power selection options for powering the CYEXP GP itself. Configure your boards as described in *Powering the CYEXP GP* in the *General Configuration* section before continuing with this section.

6.5 Determining the Appropriate Gain

To accurately measure a voltage, the full scale of the signal should be matched to the full range of the input circuit. (Most DAS boards have an input range of ±5V, which is the native range of the analog to digital converter at the heart of the board. Some DAS boards include amplification on the input circuit to allow the signal to be amplified to make better use of the resolution of the A/D.) For example, an input signal which varies between 0 and 1 volt would only be using 1/10th of a ±5V A/D converter's resolution. By switching the input signal of the DAS board to unipolar (no negative voltage) and amplifying the sign wave signal by 5, the entire range of the A/D converter is used and a higher resolution measurement may be made. By adding this gain and selecting this range, the resolution on a

12-bit A/D improves from 2.4 millivolts per bit to 0.24 millivolts per bit. If you needed to measure a change of 1 millivolt, you would need an amplification of 10.

In order to match your signals with the input range of the A/D board, you should do a similar calculation and set switches on the CYEXP GP for the required gain. Remember to make sure that the settings in InstaCal match the switches on the DAS and CYEXP GP boards.

When using RTD's, the expected output from the sensor should be calculated and the gain of the CYEXP GP set accordingly.

To select the best gain for RTD type, base resistance and temperature range, consider that RTD resistance changes with temperature, but the magnitude of the change also changes with temperature.

RTD type determines the 'slope' of the ohms vs. temperature curve. The most popular type has an 'alpha' of .00385, known as the European standard. Its value is .00385 ohms per ohm per °C.

The Universal Library and InstaCal support six different RTD types. Please call if you do not see the RTD you are interested in listed here.

Material	'Alpha'	
Platinum	0.00392	American standard
Platinum	0.00391	
Platinum	0.00385	European standard (Most popular, OMEGA's standard also)
Copper	0.00427	
Nickel/Iron	0.00581	
Nickel/Iron	0.00527	

To determine which gain to use, you must know the maximum temperature the RTD will be used to measure, and thus the maximum resistance value of the RTD. Here is a table for platinum:

For 100 ohm RTD, alpha = .00385:

Temp (°C)	Resistance (ohms)
-200	18.49
-100	60.25
0	100.00
100	138.50
200	175.84
300	212.02
400	247.04

At a temperature of 400°C, the maximum resistance is 247.04 ohms

The equation for the voltage out of the CYEXP GP (the voltage your DAS board will convert into a number) is:

$$V_{OUT} = I_{EXC} * R_{RTD} * GAIN$$

Normally, the CYEXP GP supplies 1 mA of excitation current. The choices for standard gains are 1, 10, 25 and 100. (Higher gains are possible but are not generally practical for RTD applications.)

Thus, if you want to measure temperature in the range of -200 to 400°C with the RTD listed above, the maximum voltage output would be:

V = 0.001 * 247.04 = 0.24704

If gain is set to X10, the DAS board will see 2.474 volts. This is ideal for a DAS board with a 2.5V unipolar range.

If the gain were set to X25, the output would be 6.185 volts. The DAS board would have to be set in the 0 to 10 volt range.

If you are limiting your range of interest to -200 to 100°C, a common range, the calculations are:

V = 0.001 * 138.50 = 0.1385. Gain of 10 = 1.385V. Gain of 25 = 3.4625V. In this case, a gain of X25 and a DAS range of 0 to 10 volts would be best. A 12-bit A/D converter would be using 69% of its range of 4096 counts, or a total of 2836 counts. The converter would be able to resolve to 0.035 degrees C. That is more than enough converter resolution even though you are not using the full range of the DAS board in this example.

If your DAS board has 16 bits of resolution, the DAS board would resolve to 0.0022 degrees. This is far in excess of the accuracy of the RTD.

The stages of gain you choose are not only dependent on the RTD you choose, but on the range of temperature you are measuring. Use the equation above to fine tune the CYEXP GP circuit to your advantage, then be sure to update the InstaCal program so the Universal Library linearization routines will operate properly.

6.6 Setting the Gain

Once you have determined the gain required for your application, set the gain of the CYEXP GP using the following guide.

Amplification for ALL channels (board output gain) is switch selectable (S17) for X1 or X2.5.

Input amplification for EACH CHANNEL is switch selectable (CH0 through CH7) for X1, X10, X100 or X1000. A user-specified gain may be set by supplying a precision resistor at position RX### and setting the “U” option on switch CH ## to ON.

6.6.1 Setting the Board Gain

There is a switch on DIP switch block S17 (Figure 6-1) labeled X1 and X2.5. Sliding this switch down amplifies the output of the multiplexers by 2.5. The factory default position (up) has a gain of 1 (unity).

The X2.5 gain switch is useful in some voltage and bridge measurements. If you desire a voltage gain of 2.5, 25, 250 or 2500, set this switch *down*.

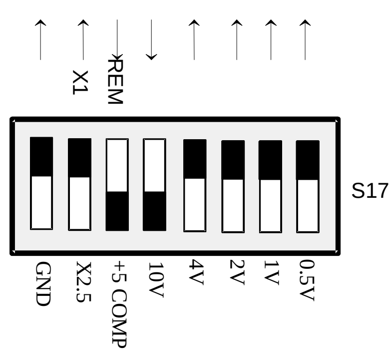

Figure 6-1. Board Gain

The effect of this switch is multiplicative with respect to the individual channel gains. For example, if you have set an input channel gain to X10 and the board output gain to X2.5, the signal is amplified by 25 before it reaches the A/D board.

6.6.2 Setting the Channel Gain

Channel Gain Switches

There is a set of gain switches for each input circuit (Figure 6-2). There are two, 4-switch DIP blocks for each channel. One is labeled “GAIN” and the other “IN CONFIG.” The gain switches are labeled U (user), 10, 100, and 1000.

Set the gain of your choice by placing a slide switch into the ON (*down)* position.

The “U” switch and associated user resistor is of no value to RTD measurement since the minimum specified value produces a gain of X100, for which there is a switch. A gain of X100 is the maximum you would use with an RTD.

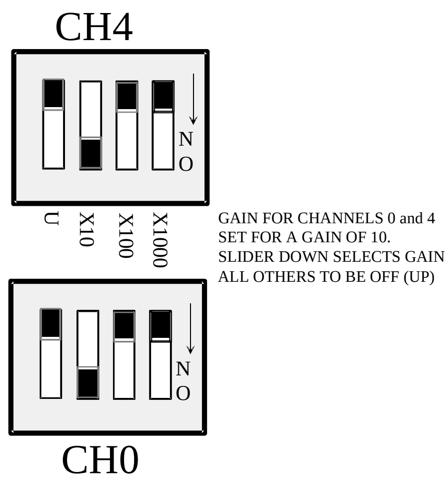

Figure 6-2. Channel Gain Switches

6.7 Input Configuration

RTDs may have 2, 3 or 4 wires coming from the probe. A switch labeled “IN CONFIG” must be set to match the number of wires on your RTD. There is one switch per channel.

RTD Type	IN CONFIG Setting
2 Wire	4 & 4 ON, 3 & 3 OFF
3 Wire	3 & 3 ON, 4 & 4 OFF
4 Wire	4 & 4 ON, 3 & 3 OFF

6.7.1 Setting the Input Configuration

A channel configuration switch is associated with each channel. The switch is used to configure the input circuit for 2, 3, or 4-wire RTDs (Figure 6-2).

Two- and four-wire RTDs share the same switch position. Set both “4” switches ON (*down*) and both “3” switches OFF (*up*).

For three-wire RTDs, set both “3” switches ON (*down*) and both “4” switches OFF (*up*).

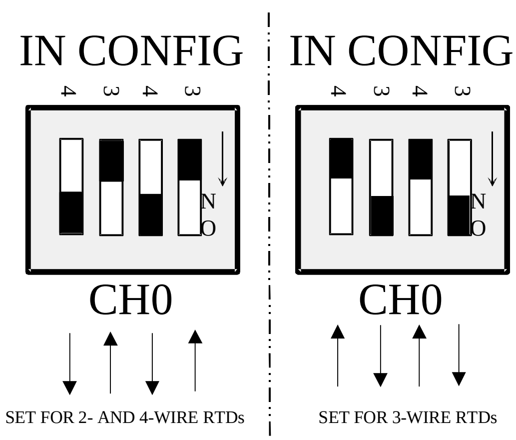

Figure 6-2. Channel Configuration Switches - RTDs

6.8 Connecting RTDs To Screw Terminals

The connections made to the screw terminal depend on the type of RTD you are using. The inputs of the CYEXP GP are designed to provide the excitation and signal conditioning required for RTDs. An RTD can have two, three, or four wires which you must connect to the CYEXP GP. This section shows the three types of RTD connections and describes how to connect them to the input channels.

6.8.1 Two-Wire RTD Hookup

A two wire RTD has two leads, one to each side of the temperature sensitive resistor. The excitation current is connected directly to the leads at the CYEXP GP screw terminals.

A two wire RTD is less accurate than the 4 wire type, and so is not the first choice for the best measurements. The reason for the inaccuracy is that there is a slight resistance associated with the excitation current flowing in the sense leads and this resistance is added to the RTD's resistance. The inaccuracy is determined by the wire gauge and length. However, as a general rule, the difference in accuracy between the 2- and 4-wire RTDs is often less than 0.1% of full scale.

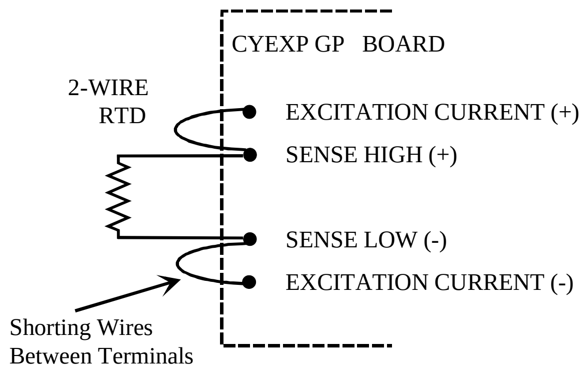

Figure 6-3. Two-wire RTD Hookup

6.8.2 Three-Wire RTD Hookup

A three wire RTD has three leads, one for each side of the temperature sensitive resistor and one for the excitation current.

The current return and sense signals of one side are shared. In the case of the CYEXP GP the shared signals are unconventional. The CYEXP GP is a true clone of the original CYEXP GP, and shares the unconventional circuit configuration, which is corrected on the CYEXP RTD. The unconventional configuration does not affect the quality of the measurement but, if you are familiar with RTDs and use a standard connection, please be mindful of this difference.

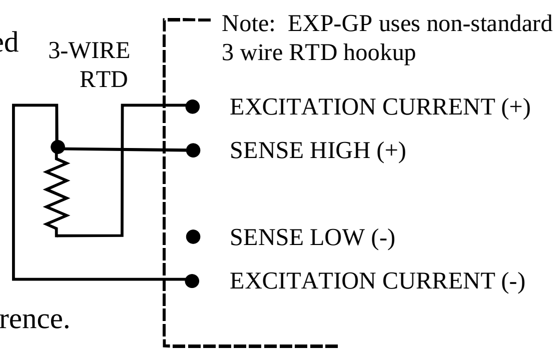

Figure 6-4. Three-Wire RTD Hookup

6.8.3 Four-Wire RTD Hookup

A four wire RTD has four leads. One to each side of the temperature sensitive resistor and an excitation current source and its return.

These connections eliminate the fixed inaccuracy associated with the 2-wire RTD. Since virtually no current flows on the sense lines, there is no voltage drop in the sense lines. Thus, the error associated with 2-wire RTDs is eliminated. We recommend the 4-wire RTD, but you must judge if the added cost is worth the additional accuracy.

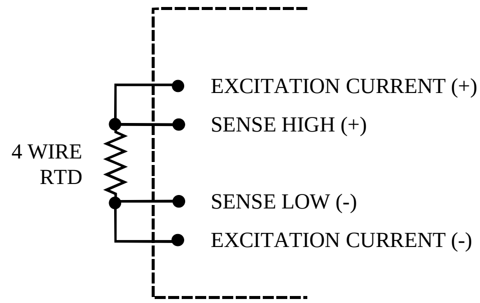

Figure 6-5. Four-Wire RTD Hookup

6.9 Verifying the Installation

To verify the installation, use the InstaCal program installed on your computer. This software came with your A/D board if you bought the board from the same manufacturer as the CYEXP GP. If your A/D board is not from the same manufacturer but is compatible, please call technical support and request a copy of InstaCal.

Use InstaCal's TEST option to verify that a signal present at one of the CYEXP GP inputs can be read.

7 CONFIGURATION FOR RESISTANCE MEASUREMENTS

Resistance measurements are made using the CYEXP GP by constructing a resistor "bridge" containing known resistor values that are to be compared to the resistor value to be measured. This is known as a Wheatstone Bridge. The typical application is a strain gauge.

Strain gauge sensors are variable-resistance devices. When installed in one leg of the resistor bridge (as the "unknown" resistor, their value can be measured. The Wheatstone Bridge circuit is extremely sensitive to changes in resistance in one leg relative to the others. There are various types of bridge sensors, but the descriptions and examples here are for strain gauges.

7.1 Channel Select

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CYEXP GP with your data acquisition board. Configure your boards as described in that section before continuing with this section.

7.2 VEXC Jumper Select

There is a set of jumpers near the 37 pin connector labeled "VEXC SEL," which stands for channel excitation voltage select. This jumper will connect the on board excitation voltage to one of the A/D board channels so that it can be measured. CyberReseach does not use a measurement of the excitation voltage in any of its software. You do not need to set this jumper if you are using the board with CyberResearch software, or with packages such as Labtech Notebook™, which use the Universal Library. Use this jumper only with software from other manufacturers that specifically require it.

7.3 CJC Jumper Select

There is a set of jumpers near the 37-pin connector labeled "CJC SEL," which stands for cold junction compensation select. Remove this jumper. There is no cold junction compensation used with bridge sensors.

7.4 Powering the CYEXP GP

There are two power issues to address. The first is the source of the 5 volt power to the board. The second is the source of the bridge excitation voltage power.

7.4.1 Selecting the Power Source for the Board

The *General Configuration* section describes the power selection options for powering the CYEXP GP itself. Configure your boards as described in *Powering the CYEXP GP* in the *General Configuration* section before continuing with this section.

7.4.2 Selecting the Power Source for the Excitation Voltage

Bridge sensors consume a lot of power. In some cases the bridge sensors consume so much power that if fully populated with eight sensors the on board excitation circuit would not have adequate power to supply all eight sensors. This is an extreme case but is indicative of the attention you must pay to power requirements when using bridge sensors.

Also, when selecting the power source for the excitation voltage, consider the voltage you will use for excitation. The options available are 0.5, 1, 2, 4 and 10V. In general, higher excitation voltages are better because a higher voltage increases the difference between the balance points of the bridge circuit, which increases the accuracy of your measurement. The excitation voltage must be less than the source.

Jumper JB11 (Figure 7-1), located near the bottom edge of the board, selects the source of the bridge excitation voltage. The three choices are +5V (the same 5V source chosen for board power above), +12V (from the PC through the 37-pin connector) or +PEXT (an external power supply connected at the ±P EXT screw terminal).

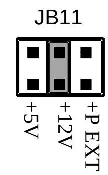

Figure 7-1
Output Gain & Power Select

If you choose a separate power supply, it must be a floating, isolated supply (one with three terminals). Do not tie the GND and –V terminal together. It must not exceed +15V.

The +5V and +12V jumpers are only valid with CYDAS 8 family boards. The +12V jumper is not valid with the CYDAS 8-AO and -PGx. For more information on excitation voltages, refer to the section on bridge sensors.

+5V Excitation Voltage Source

If your choice for the excitation voltage source is +5V, you may choose a 0.5V, 1V, 2V or 4V excitation voltage for your bridge sensors. The +5V option is always available, since +5V is required to power the CYEXP GP.

+12V Excitation Voltage Source

If your choice for the excitation voltage source is +12V PC power, you have the choice of 0.5, 1, 2, 4, or 10 volt excitation for your bridge sensors. The option to power from the PC 12 volt supply exists only with DAS08 family boards, except that +12V is not valid with the CYDAS 8-AO or PGA.

+PEXT Excitation Voltage Source

An external power supply can be used. If you choose a separate power supply, it must be a floating, or isolated supply (one with three terminals). *Do not* tie the GND and -V terminal together). Output voltage must not exceed +15V. If your power supply is not floating, it is likely that you will create a ground loop (current flow in the ground lines). A ground loop will induce an error in your reading. Connect the power supply to the CYEXP GP at the terminals labeled –PEXT and +PEXT on the screw terminal block located adjacent to the 37-pin connector, P2.

7.4.3 Selecting the Excitation Voltage

DIP switch S17 has five switches to select bridge excitation voltage. Only set one ON. All others must be OFF.

Figure 7-2 shows the switch and the excitation power source jumper set for the factory defaults. Excitation is set for 10V ON. Power source must be set to +12V (as shown in Figure 7-1) or +PEXT.

Do not select an excitation voltage at the switch that exceeds the excitation power supply voltage.

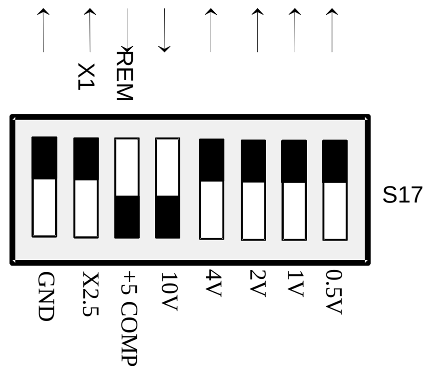

Figure 7-2. Excitation Voltage Select Switches

7.5 Determining the Appropriate Gain

To accurately measure a voltage, the full scale of the signal should be matched to the full range of the input circuit. (Most DAS boards have an input range of ±5V, which is the native range of the analog to digital converter at the heart of the board. Some DAS boards include amplification on the input circuit to allow the signal to be amplified to make better use of the resolution of the A/D.) For example, an input signal which varies between 0 and 1 volt would only be using 1/10th of a ±5V A/D converter's resolution. By switching the input signal of the DAS board to unipolar (no negative voltage) and amplifying the sign wave signal by 5, the entire range of the A/D converter is used and a higher resolution measurement may be made. By adding this gain and selecting this range, the resolution on a 12-bit A/D improves from 2.4 millivolts per bit to 0.24 millivolts per bit. If you needed to measure a change of 1 millivolt, you would need an amplification of 10.

In order to match your signals with the input range of the A/D board, you should do a similar calculation and set switches on the CYEXP GP for the required gain. Remember to make sure that the settings in InstaCal match the switches on the DAS and CYEXP GP boards.

When using strain gauges, the expected output from the sensor should be calculated and the gain of the CYEXP GP set accordingly. There are some examples at the end of this chapter detailing these calculations.You may also find it helpful to refer to the Appendix for additional strain gauge information.

7.6 Setting the Gain

Once you have determined the gain required for your application, set the gain of the CYEXP GP using the following guide.

Amplification for ALL channels (board output gain) is switch selectable (S17) for X1 or X2.5.

Input amplification for EACH CHANNEL is switch selectable (CH0 through CH7) for X1, X10, X100 or X1000. A user-specified gain may be set by supplying a precision resistor at position RX### and setting the “U” option on switch CH ## to ON.

7.6.1 Setting the Board Gain

There is a switch on DIP switch block S17 (Figure 7-3) labeled X1 and X2.5. Sliding this switch down amplifies the output of the multiplexers by 2.5.The factory default position (up) has a gain of 1 (unity).

The X2.5 gain switch is useful in some voltage and bridge measurements. If you desire a voltage gain of 2.5, 25, 250 or 2500, set this switch *down*.

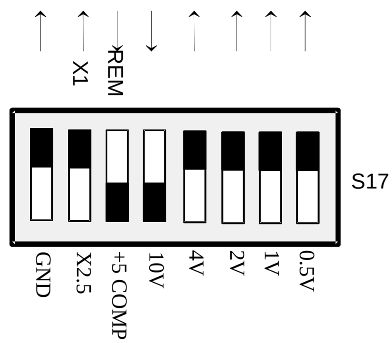

Figure 7-3. Board Gain

The effect of this switch is multiplicative with respect to the individual channel gains. For example, if you have set an input channel gain to X100 and the board output gain to X2.5, the signal is amplified by 250 before it reaches the A/D board.

7.6.2 Setting the Channel Gain

There is a gain switch for each channel (Figure 7-4). Set the input channel gain to match the expected voltage output of the bridge you are measuring to the input range of the A/D board as described above.

Channel Gain Switches

There is a set of DIP gain switches for each input circuit labeled GAIN (Figure 7-4). There are four, two-position switches for each channel. The gain switches are labeled U, X10, X100, and X1000.

Select a gain (higher than unity) by moving the switch for that gain down. All other switches should be left in the UP position.

A custom gain may be selected on the CYEXP GP by installing a precision resistor and setting the switch marked "U" (User) in the down position. See Table 7-1 below for positions and some sample gain values.

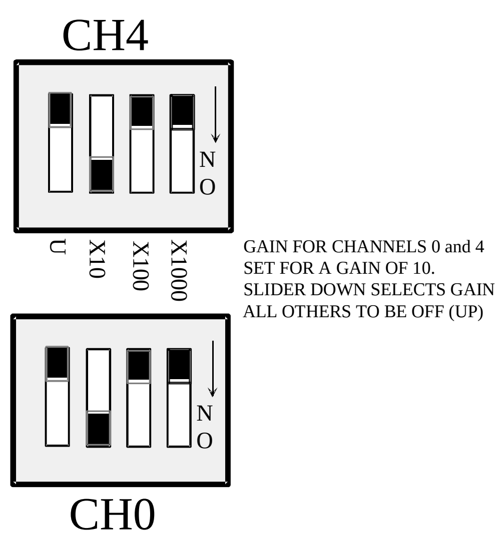

Figure 7-4. Input Channel Gain Switches

Table 7-1. User-Specified Gain Resistor Positions

Channel	Resistor Position	Channel	Resistor Position
0	RX100	4	RX104
1	RX101	5	RX105
2	RX102	6	RX106
3	RX103	7	RX107

Gain	Resistor Value
100	364 Ohms
200	161 Ohms
300	130 Ohms
500	40 Ohms
700	17 Ohms
800	10 Ohms

The equation for selecting the gain resistor, R_{USER}, for any gain between X100 and X1000 is:

$$R_{USER} = (40000 / (Gain - 1)) - 40$$

7.7 Setting the Input Configuration

Channel Configuration Switch - Voltages

A channel configuration switch is associated with each channel (Figure 7-5). The switches are used to configure the input circuits for voltage inputs, thermocouple inputs, 2, 3, or 4-wire RTDs and bridges.

For bridge measurements on a particular channel, set the switches labeled "4" to the ON (*down)* position for that channel.

Set the switches labeled "3" in the OFF (*up)* position.

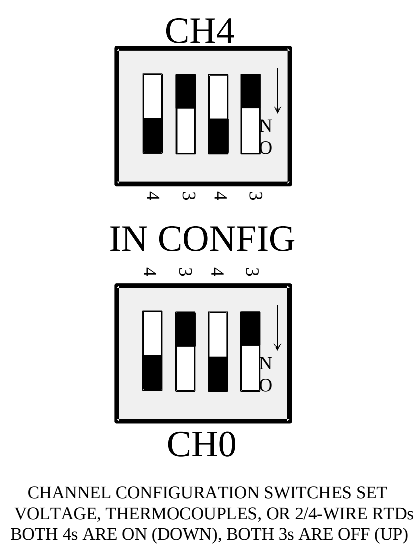

Figure 7-5.
Input Channel Configuration Switches

7.8 Configuring the Bridge

As mentioned earlier in this chapter, resistance measurements are made by constructing a bridge containing precision resistors with known values against which the unknown resistor is to be compared. In strain gauge applications, the strain gauge sensor itself may make up a quarter of this bridge, half of this bridge or the entire bridge. Examples of each of these configurations follow. Figure 7-6 is a schematic of the bridge circuit.

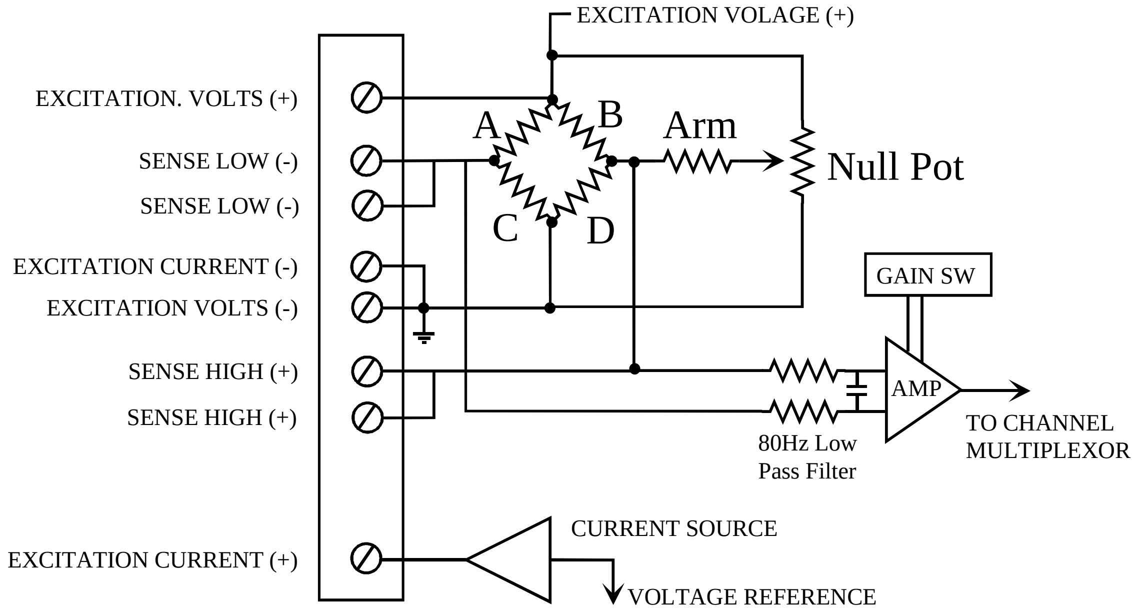

Figure 7-6. Bridge Circuit

This table shows how the measurement at the A/D board varies with respect to an increase or decrease of the resistance in one of the legs of the bridge.

Resistance Change vs. Sense Voltage Change		
Leg	**+ Ohms**	**- Ohms**
A	+ Volts	- Volts
B	- Volts	+ Volts
C	- Volts	+ Volts
D	+ Volts	- Volts

Read the table by selecting the leg you are interested in and looking across that row to the ±volts indication under the column heading for the expected change in resistance. For example, if you are interested in leg 'A' and want to know what the relative change in volts at the A/D board will be if the resistance is increased, look under + Ohms. The measured voltage will increase.

7.8.1 Bridge Completion Resistors

You likely will have to install bridge-completion resistors on the CYEXP GP board to match the resistance of the external gauge. Refer to Table 7-2 for their identities and locations.

If you are using a ¼ bridge then you will have to install three precision resistors to complete the bridge.

If you are using a ½ bridge then you will need to install two resistors to complete the bridge.

If you are using a full bridge, there are no resistors to install.

Referring back to Figure 7-6, the legs of the bridge are labeled A, B, C and D. Table 7-3 below matches the legs of the bridge to the resistor number nomenclature that appears on the CYEXP GP.

Table 7-3. Bridge Completion Resistor Identities

Channel	Bridge A	Bridge B	Bridge C	Bridge D	Null Pot	Arm
0	RX1	RX2	RX3	RX4	RX6	RX52
1	RX7	RX8	RX9	RX10	RX12	RX53
2	RX13	RX14	RX15	RX16	RX18	RX54
3	RX19	RX20	RX21	RX22	RX14	RX55
4	RX25	RX26	RX27	RX28	RX30	RX56
5	RX31	RX32	RX33	RX34	RX36	RX57
6	RX37	RX38	RX39	RX40	RX42	RX58
7	RX43	RX44	RX45	RX46	RX48	RX59

Some values of precision resistors are available from CyberResearch.

7.8.2 Nulling Potentiometers & Arm Resistor

Each circuit has a position for a nulling potentiometer and associated arm resistor. The purpose of the nulling arm is to allow you to zero the reading of strain at a given strain position. There is no formula to use to select the nulling potentiometer and arm resistor. Bridge resistor values and total gain selected for the CYEXP GP will affect adjustability for a given nulling circuit. An average value for the arm resistor is 10k ohms. Start with that and adjust as required.

7.8.3 Strain Gauge Bridge Configuration Examples

Following are three typical strain gauge bridge configurations. They are by no means the only way to connect a strain gauge to the CYEXP GP. For example, there is no rule that says the 'A' leg must be the strain gauge on a ¼ bridge implementation.

The examples below show how to translate strain to input voltage for the strain gauge configuration used to measure simple bending strain. Other types of stress and strain: axial, torsion, shearing , etc. are beyond the scope of this description. These examples can be used to as a guide for calculating the bridge voltage in your own application, and thus help you select the proper amplifier gain and excitation voltage.

The use of quarter bridge, half bridge and full bridge strain gauge configurations are described.

The Application:

In these examples, imagine a beam extending out from a fixed point on a wall. Force is applied to deflect the end of the beam downward. We know that the maximum strain to be measured will be 250με (250 micro strain). Knowing the amount of force required and the size of the beam is not necessary, since strain relates to the change in length of the surface of interest.

The Strain Gauge will be a metal foil type, 350 ohms resistance, Gauge Factor = 2. Refer to the Appendix for information on these specifications.

The following example shows a bending strain measurement example. It can be used to calculate the bridge voltage, and thus help the user select the proper amplifier gain and excitation voltage.

The use of one, two and four strain gauges will be examined.

A Quarter Bridge Example

For ¼ bridge circuits, the strain gauge has a single resistive element that is connected as one leg of the bridge. The other three legs must be populated with the precision completion resistors.

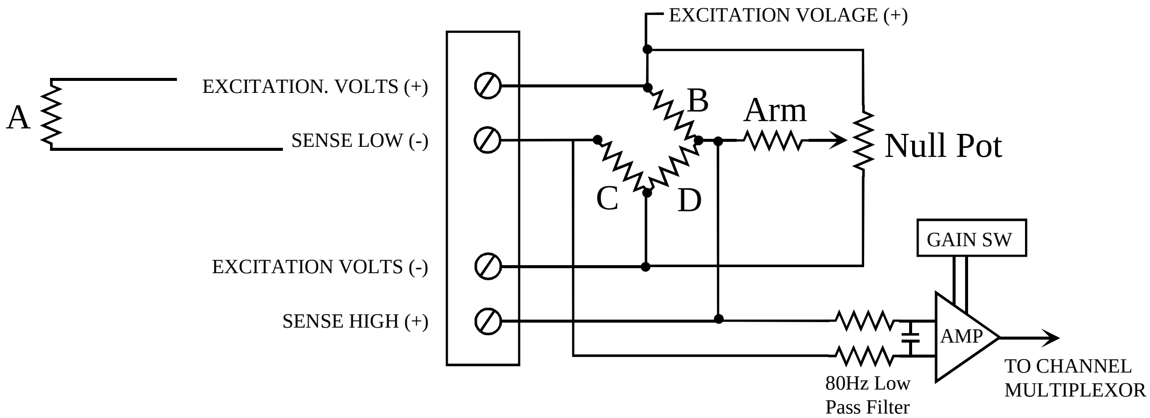

Figure 7-6. ¼ Bridge Circuit - Simplified

Quarter Bridge Calculations

The strain gauge is applied to the top of the beam. This strain gauge takes the place of resistor A (see Figure 7-6). Three other 350 ohm resistors (B, C and D) complete the bridge circuit. These are installed by the user in locations provided on the board or attached to the screw terminals.

As downward force is applied, the strain gauge on the top of the beam will be stretched, therefore its resistance will increase by:

Strain Gauge increase = 350 ohm x 250 x 10^{-6} x 2

= +0.175 ohm

Thus the value of gauge A (under tension) will be 350.175 ohms when the strain on the beam is +250με.

Initially, choosing an excitation voltage of 10V, the bridge voltage is:

V_{br} = 10V { (350 / 700) - [350 / (350 + 350))] } = 0V

After a downward force is applied:

V_{br} = 10V { (350 / 700) - [350 / (350 + 350.175)] }

V_{br} = 1.25mV

Choosing an amplifier gain of X1000 results in 1.25V maximum presented to the DAS board.

Choosing an additional X2.5 (overall output gain) results in a total gain of 2500, thus sending 3.125V maximum to the DAS board. This makes an optimum use of the 5V range.

A Half Bridge Example

For a ½ bridge circuit (Figure 7-7), the strain gauge has two resistive elements which are connected across two legs of the bridge. The two legs would always be A & C or B & D. The other two legs of the bridge must be populated with the precision (350 ohm) completion resistors.

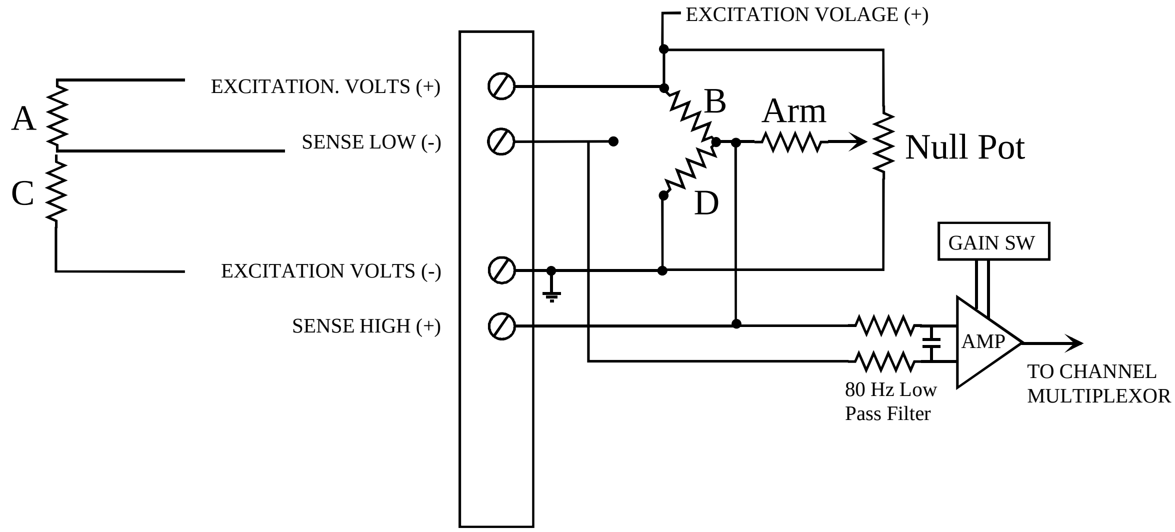

Figure 7-7. ½ Bridge Circuit- Simplified Schematic

Half Bridge Calculations

The ½ bridge implementation consists of two strain gauges; one on the top of the beam (as in the ¼ bridge example) and one on the bottom of the beam. The strain gauge on the bottom of the beam replaces completion resistor C in the ¼ bridge implementation.

Two active strain gauge elements (one in tension and one in compression) result in twice the sensitivity of the ¼ bridge. (One element increases resistance while the second element decreases resistance simultaneously.)

When the beam is forced down (250με change), the resistance in C decreases by 0.175 ohm, and resistance A increases by 0.175 ohm as shown in the ¼ bridge example above.

The bridge voltage V_{br} is then:

$$V_{br} = 10V \{ (350 / 700) - [(350 - 0.175) / ((350 - 0.175) + (350 + 0.175))] \}$$

$$V_{br} = 10V \{(350 / 700) - [(349.825) / (700)] \}$$

$$V_{br} = 2.500mV$$

Choosing Gain = X1000 would result in 2.5V being applied to the DAS board. Choosing Gain = X2500 (X1000 on the input channel and X2.5 on the output) could result in an amplified voltage that’s out of the DAS board’s range. In this case, the excitation voltage could be reduced to 4V, reducing the bridge voltage to 1.00mV. A gain selection of 2500 would then present a maximum voltage of 2.5V to the DAS board.

Full Bridge Example

Full bridge strain gauges consist of all four bridge resistors (Figure 7-8). Obviously, no bridge completion resistors are installed on the board when using this configuration.

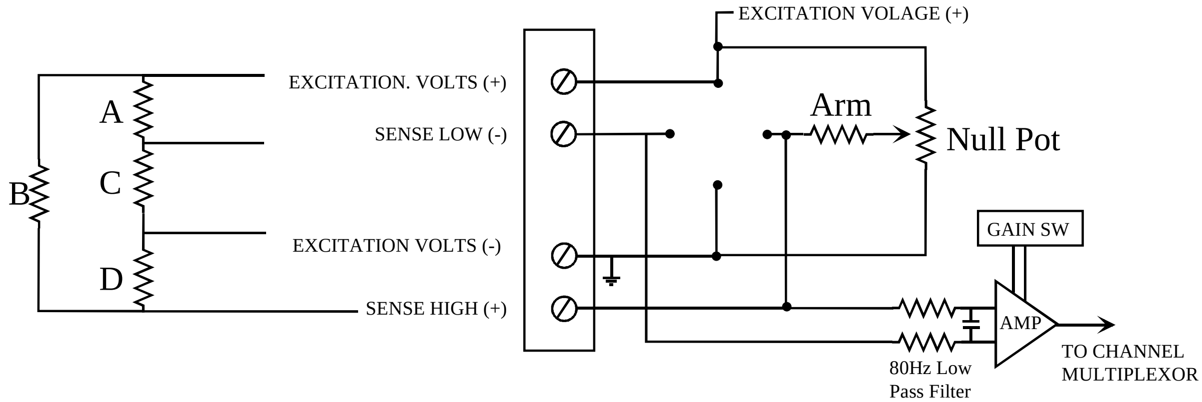

Figure 7-8. Full Bridge - Simplified Schematic

Full Cridge Calculations

With four active strain gauge elements, these are four times more sensitive than a 1/4 bridge. All four resistors are strain gauges and are attached to the beam in the following configuration:

Gauge resistors C and B are on the bottom. Their resistance decreases under the resultant compression (but bridge voltage increases).

Gauge resistors D and A are on the top of the beam. Their resistance increases under the resultant tension (and bridge voltage likewise increases), equal in magnitude to the changes in D and A.

V_{br} = 10V {[(350 + 0.175) / ((350 + 0.175) + (350 - 0.175))] - [(350 - 0.175) / ((350 - 0.175) + (350 + 0.175))] }

V_{br} = 10V { [(350 + 0.175) / 700] - [(349.825) / 700] }

V_{br} = 5.00mV

Choosing a gain of X1000 presents 5V to the DAS board covering its entire 5V unipolar range.

An excitation voltage of 4V could be been used in combination with a gain of 2500 (X1000 on the input channel and X2.5 on the output). This would also result in 5V to the DAS board. The advantage to using a lower excitation voltage is that it causes less power dissipation on the strain gauge element itself, reducing thermal expansion from self-heating.

7.9 Verifying the Installation

To verify the installation, use the InstaCal program installed on your computer. This software came with your A/D board if you bought the board from the same manufacturer as the CYEXP GP. If your A/D board is not from the same manufacturer but is compatible, please call technical support and request a copy of InstaCal.

Use InstaCal's TEST option to verify that a signal present at one of the CYEXP GP inputs can be read.

8 SPECIFICATIONS

Power Consumption

+5V	380mA typical, 533mA maximum

Analog Input Section

Input Amplifier Type	INA102
Number of Channels	8 differential
Gains	Each channel individually switch selectable for X1, X10, X100 or custom and board gain switch selectable for X1 or X2.5
Gain Error	
Gain = 1, 2.5	0.01%FS typical, 0.15%FS maximum
Gain = 10, 25	0.02%FS typical, 0.35%FS maximum
Gain = 100, 250	0.05%FS typical, 0.40%FS maximum
Gain = 1000, 2500	0.20%FS typical, 0.90%FS maximum
Linearity	
Gain = 1, 2.5	0.045%FS typical
Gain = 10, 25	0.045FS typical
Gain = 100, 250	0.075%FS typical
Gain = 1000, 2500	0.15%FS typical
Input Offset	Each channel adjustable to zero
Gain TC	
Gain = 1	10ppm/°C typical
Gain = 100	15ppm/°C typical
Gain = 1000	20ppm/°C typical
Input Offset TC	
Gain = 1, 2.5	20µV/°C typical
Gain = 10, 25	6µV/°C typical
Gain = 100, 250	5.1µV/°C typical
Gain = 1000, 2500	5.1µV/°C typical
Common Mode Range	±10V
CMRR	
Gain = 10, 25, 100, 250, 1000, 2500	100dB typical
Gain = 1, 2.5	94dB typical
Absolute Maximum Input	±50V
Channel to Channel Settling Time	
5V step to .01%	50 µs
MUX Switching Time	
5V step to .01%	5 µs typical
Miscellaneous	Each input channel has a 79Hz low pass filter X2.5 gain is adjustable for zero error Jumper selects compatibility with DAS08 or DAS16 series Locations provided for bridge completion resistors for each channel. Locations provided for bridge nulling pots and resistors for each channel

Analog Output Section

Output Amplifier Type	OP07
Number of Channels	1
Maximum Output Range	±10V
Current Drive	±5 mA
Output Short-Circuit Duration	25 mA indefinite
Output Coupling	DC
Output Impedance	100 Ohms maximum
Miscellaneous	Output jumper selectable for one of 16 channels (P1 & P2 Output 0 to Output 15)

Digital Input / Output Section

Digital Type	
DIn 0 through 2	HI508A multiplexer
DIn 3	2N2222 transistor inverter
Configuration	3 digital inputs for selecting multiplexer channel 1 digital input for controlling calibration relay
Input Low Voltage	
DIn 0 through 2	0.8V max, -4V absolute minimum
DIn 3	1.0V max, -4V absolute minimum
Input High Voltage	
DIn 0 through 2	2.4V min, 9V absolute maximum
DIn 3	1.27V min, 9V absolute maximum

Voltage Excitation Section

Excitation Voltages	10V, 4V, 2V, 1V, 0.5V
Sources for Excitation Voltage	5V from PC, 5V from MOLEX, 12V from PC, external (±PEXT screw terminal)
Current	
5V Source from P1, 4V VEXC	100mA
5V Source from P19, 4V VEXC	275mA
12V Source, 10V VEXC	350mA
15V External Source, 10 VEXC	670mA
Miscellaneous	Output jumper selectable for one of 16 channels (P1 & P2 Output - to Output 15) Voltage adjustable for zero error

Current Excitation Section

Excitation	1mA
Channels	8
Voltage Compliance	4.6V typical, 2V minimum
Accuracy	Adjustable for zero error

CJC Section

Conversion Ratio	24.4mV/°C (0mV @ 0°C)

Environmental

Operating Temperature Range	0 to 60°C
Storage Remperature Range	-40 to 100°C
Humidity	0 to 90%, non-condensing

9 APPENDIX

9.1 About Strain Gauges

9.1.1 What Are Strain Gauges?

A Strain Gauge is a variable resistance device whose resistance changes in proportion to the amount it is stretched or compressed. Physically it is an etched metal-foil in a grid pattern that is glued to any surface which undergoes strain. The output is a dimensionless quantity defined as change in length and whose symbol is ε. A micro-strain of "1" means that length of the surface of interest has changed by 1 ppm. The ratio of resistance change to strain change is known as the Gauge Factor (GF). Typical metal foil strain gauges have Gauge Factors of 2 to 2.1. This means that the resistance will change twice as much as the strain does. A change of 1 micro-strain means that the resistance of the strain gauge has changed by 2 ppm or .0002% (.0001% x 2). For a 350 ohm strain gauge with GF = 2, a $1\mu\varepsilon$ change results in a resistance change of:

Resistance change	=	[SG Resistance]	x	[change in length]	x	[Gauge Factor]
	=	[350 ohm]	x	[.000001]	x	[2]
	=	0.0007 ohm				

9.1.2 Specification of Strain Gauges

Metal Foil gauges are available in 120, 350 and 1000 ohms. Semiconductor strain gauges exist and have resistance of up to 10000 ohms. They can readily be used with the CYEXP GP, but may not be as linear as metal foil gauges.

Maximum strain allowed is 3% to 5% depending on type and thickness of strain gauge material.

This means a limit of 30,000 to $50,000\mu\varepsilon$ or a maximum resistance change of 6% to 10%.

Strain Gauges are typically used to calculate a change in strain; that is, the difference between the unstrained and the strained state.

9.2 Reference Material for Application of Strain Gauges

The Bonded Electrical Resistance Strain Gage, First Edition

by William M. Murray and William R. Miller.

1992, 424 pages ISBN: 0-19-507209-X

Available from Society for Experimental Mechanics, order # OX-2.

Strain Gage Users' Handbook , First Edition.

1992, 424 pages. ISBN: 0-912053-36-4

Published by Society for Experimental Mechanics, order #ELS-017

<ins>The Art of Practical and Precise Stain Based Measurement</ins>
by James Pierson.
1992, 400 pages in 3-ring binder . ISBN: 1-895976-00-6
Available from Society for Experimental Mechanics, order # JP-001

<ins>Strain Gage and Transducer Techniques</ins>
1984, 72 pages.
Published by Published by Society for Experimental Mechanics, order # S-023

Society for Experimental Mechanics
7 School St.
Bethel CT 06801
(203) 790-6373

EC Declaration of Conformity

We, the manfacturer, declare under sole responsibility that the product:

Part Number	Description
CYEXP GP	Voltage, TC, RTD and Bridge inputs for ISA bus

to which this declaration relates, meets the essential requirements, is in conformity with, and CE marking has been applied according to the relevant EC Directives listed below using the relevant section of the following EC standards and other normative documents:

EU EMC Directive 89/336/EEC: Essential requirements relating to electromagnetic compatibility.

EU 55022 Class B: Limits and methods of measurements of radio interference characteristics of information technology equipment.

EN 50082-1: EC generic immunity requirements.

IEC 801-2: Electrostatic discharge requirements for industrial process measurement and control equipment.

IEC 801-3: Radiated electromagnetic field requirements for industrial process measurements and control equipment.

IEC 801-4: Electrically fast transients for industrial process measurement and control equipment.

For your notes

Product Service

Diagnosis and Debug

CyberResearch, Inc. maintains technical support lines staffed by experienced Applications Engineers and Technicians. There is no charge to call and we will return your call promptly if it is received while our lines are busy. Most problems encountered with data acquisition products can be solved over the phone. Signal connections and programming are the two most common sources of difficulty. CyberResearch support personnel can help you solve these problems, especially if you are prepared for the call.

To ensure your call's overall success and expediency:

1) Have the phone close to the PC so you can conveniently and quickly take action that the Applications Engineer might suggest.

2) Be prepared to open your PC, remove boards, report back-switch or jumper settings, and possibly change settings before reinstalling the modules.

3) Have a volt meter handy to take measurements of the signals you are trying to measure as well as the signals on the board, module, or power supply.

4) Isolate problem areas that are not working as you expected.

5) Have the source code to the program you are having trouble with available so that preceding and prerequisite modes can be referenced and discussed.

6) Have the manual at hand. Also have the product's utility disks and any other relevant disks nearby so programs and version numbers can be checked.

Preparation will facilitate the diagnosis procedure, save you time, and avoid repeated calls. Here are a few preliminary actions you can take before you call which may solve some of the more common problems:

1) Check the PC-bus power and any power supply signals.

2) Check the voltage level of the signal between SIGNAL HIGH and SIGNAL LOW, or SIGNAL+ and SIGNAL– . It CANNOT exceed the full scale range of the board.

3) Check the other boards in your PC or modules on the network for address and interrupt conflicts.

4) Refer to the example programs as a baseline for comparing code.

Warranty Notice

CyberResearch, Inc. warrants that this equipment as furnished will be free from defects in material and workmanship for a period of one year from the confirmed date of purchase by the original buyer and that upon written notice of any such defect, CyberResearch, Inc. will, at its option, repair or replace the defective item under the terms of this warranty, subject to the provisions and specific exclusions listed herein.

This warranty shall not apply to equipment that has been previously repaired or altered outside our plant in any way which may, in the judgment of the manufacturer, affect its reliability. Nor will it apply if the equipment has been used in a manner exceeding or inconsistent with its specifications or if the serial number has been removed.

CyberResearch, Inc. does not assume any liability for consequential damages as a result from our products uses, and in any event our liability shall not exceed the original selling price of the equipment.

The equipment warranty shall constitute the sole and exclusive remedy of any Buyer of Seller equipment and the sole and exclusive liability of the Seller, its successors or assigns, in connection with equipment purchased and in lieu of all other warranties expressed implied or statutory, including, but not limited to, any implied warranty of merchant ability or fitness and all other obligations or liabilities of seller, its successors or assigns.

The equipment must be returned postage prepaid. Package it securely and insure it. You will be charged for parts and labor if the warranty period has expired.

Returns and RMAs

If a CyberResearch product has been diagnosed as being non-functional, is visibly damaged, or must be returned for any other reason, please call for an assigned RMA number. The RMA number is a key piece of information that lets us track and process returned merchandise with the fastest possible turnaround time.

PLEASE CALL FOR AN RMA NUMBER!

Packages returned without an RMA number will be refused!

In most cases, a returned package will be refused at the receiving dock if its contents are not known. The RMA number allows us to reference the history of returned products and determine if they are meeting your application's requirements. When you call customer service for your RMA number, you will be asked to provide information about the product you are returning, your address, and a contact person at your organization.

Please make sure that the RMA number is prominently displayed on the outside of the box.

• Thank You •