CIO-EXP-BRIDGE16

User's Manual

Revision 2

January, 2001

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1 INTRODUCTION

The CIO-EXP-BRIDGE16 is a signal conditioning accessory designed for use with the DAS08 and DAS16 family of data acquisition boards. The CIO-EXP-BRIDGE16 contains circuitry to condition strain gauge sensors on a per channel basis and convert the sensor's output to a voltage suitable for conversion by a DAS08 or other analog-to-digital conversion board.

This manual is organized into sections that explain the CIO-EXP-BRIDGE16 as follows:

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 Resistance Measurement:	Users interested in resistance or strain gauge measurement applications should review this section.

Please read the manual carefully. There are many optional resistors, jumpers and other connections to be made on the CIO-EXP-BRIDGE16. Failure to set up the channels correctly will frustrate you with inaccurate measurements.

2 SOFTWARE INSTALLATION

Software is not included with the CIO-EXP-BRIDGE16, 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 CIO-EXP-BRIDGE16. 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.

3 GENERAL CONFIGURATION

3.1 A/D Board Type Select Jumper

The CIO-EXP-BRIDGE16 may 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 C-EXP2DAS16-10 cable. Select the A/D board type via the JB10 jumper.

Jumper JB10 on the CIO-EXP-BRIDGE16, 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 CIO-EXP-BRIDGE16 with a CIO-DAS08 family board.

DAS08   DAS16

Figure 3-1
DAS08/16 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. There are 16 jumper positions for outputs, each corresponding to one of the 16 output pins on the 37-pin connectors. When the board is connected to a DAS08, only the first eight channels (labeled 0-7) can be used. When the board is connected to a DAS16, any one of the 16 jumper positions can be selected. In each case, the jumper position corresponds to a channel number on the A/D board. See Figure 3-2.
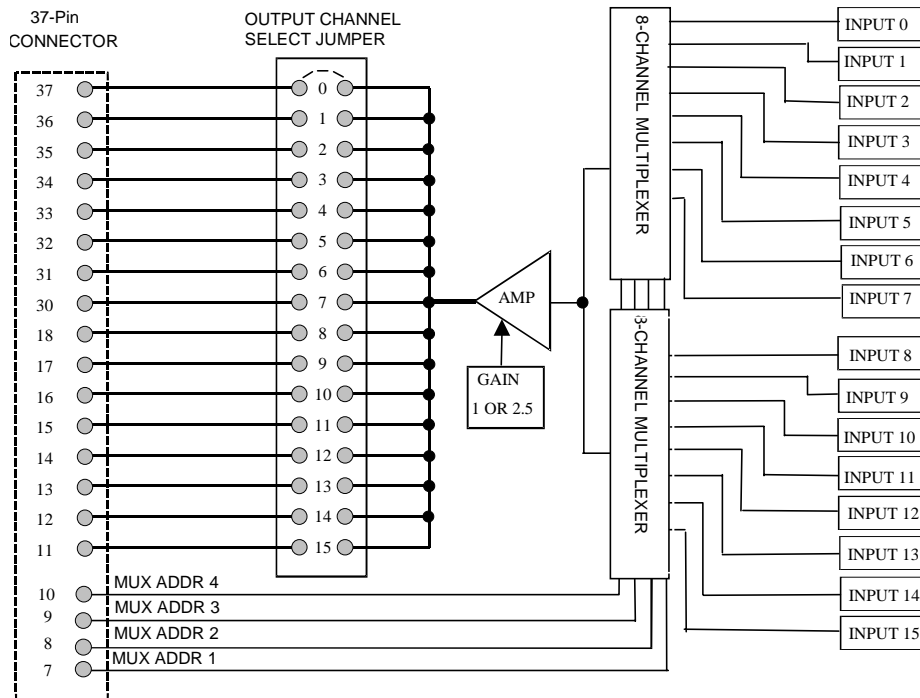
Figure 3-2. Output Channel Jumper

Figure 3-3 is a diagram of the Channel Select jumper blocks shown using channel 0 of the A/D board.

JB6   CH SEL   JB16

0 1 2 3 4 5 6 7   8 9 10 11 12 13 14 15
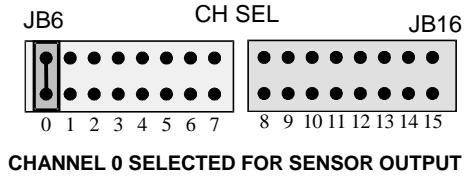
CHANNEL 0 SELECTED FOR SENSOR OUTPUT

Figure 3-3. Output Channel Select Jumpers

Place the jumper on the pin which corresponds to the A/D board's input channel.

A second set of jumpers is marked VEXC SEL (excitation voltage select). This jumper connects the excitation voltage used for the bridge excitation to one of the A/D channels for monitoring. Installation of this jumper is optional. If you decide to monitor excitation voltage, make sure you install this jumper on a different channel number than that selected for the CH SEL jumper.

One individual channel must be selected for each bank of 16 EXP channels. For example, if you are using several CIO-EXP-BRIDGE16 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 CIO-EXP 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 CIO-EXP outputs. Most of the DAS16 series is switch selectable for either 8 differential or 16 single ended inputs. When used with the CIO-EXP, 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

3.4 CONNECTING THE CIO-EXP-BRIDGE16 TO THE A/D BOARD

3.4.1 Connecting to a DAS08 Series A/D Board

A CIO-DAS08 series board may be connected directly through a C37FF series cable from the P1 connector on the CIO-EXP-BRIDGE16 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 (C-EXP2DAS16-10) since pin relationship of CIO-EXP and DAS16 signals is not 1:1.

Install the C-EXP2DAS16-10 cable connector labeled "MUX" into the P1 connector of the CIO-EXP-BRIDGE16 board and the other end into the DAS16 series board's analog connector.

3.4.3 Other A/D Boards

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

The signals from the CIO-EXP-BRIDGE16 are voltages from each channel and an analog ground. There should be no voltage between analog ground and power ground.

The MUX address lines control the setting of the input channel multiplexer(s). When all are low, the mux is set to Input 0. The lines are binary coded where MUXADDR1 is the LSB and MUXADDR4 is the MSB.

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

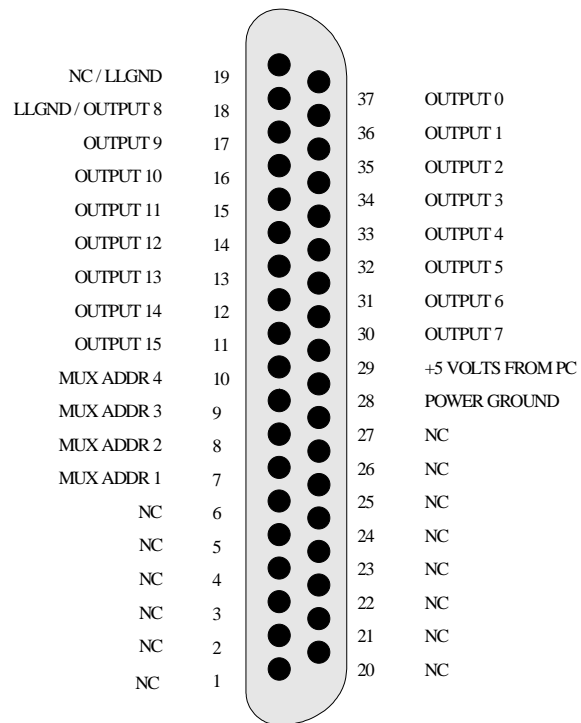|			
NC / LLGND	19		
LLGND / OUTPUT 8	18	37	OUTPUT 0
OUTPUT 9	17	36	OUTPUT 1
OUTPUT 10	16	35	OUTPUT 2
OUTPUT 11	15	34	OUTPUT 3
OUTPUT 12	14	33	OUTPUT 4
OUTPUT 13	13	32	OUTPUT 5
OUTPUT 14	12	31	OUTPUT 6
OUTPUT 15	11	30	OUTPUT 7
MUX ADDR 4	10	29	+5 VOLTS FROM PC
MUX ADDR 3	9	28	POWER GROUND
MUX ADDR 2	8	27	NC
MUX ADDR 1	7	26	NC
NC	6	25	NC
NC	5	24	NC
NC	4	23	NC
NC	3	22	NC
NC	2	21	NC
NC	1	20	NC

Figure 3-4. 37-Pin Output Connector Pinout

3.5 Powering The CIO-EXP-BRIDGE16

The CIO-EXP-BRIDGE16 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 CIO-EXP-BRIDGE16 is used.

The power required to run a CIO-EXP-BRIDGE16 is dependent on the board configuration. Remember that additional power will be drawn when the CIO-EXP-BRIDGE16 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 +5V power to the CIO-EXP-BRIDGE16. Shown in Figure 3-5, it is the 3rd switch from the left.

When positioned down (ON, +5 COMP), +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.
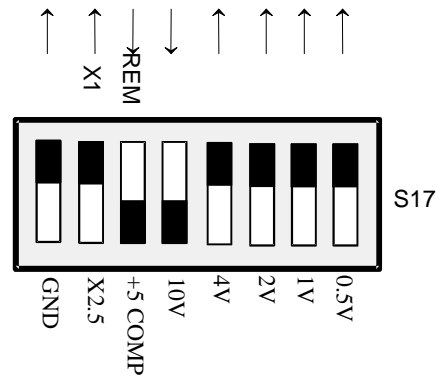
Figure 3-5. Power Source Switch & Jumper

3.5.2 Powering with the 37-pin Connector

You can power the CIO-EXP-BRIDGE16 via the 37-pin cable. No more than one CIO-EXP-BRIDGE16 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 C-EXP2DAS16 signal cable), you can power the CIO-EXP-BRIDGE16 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 CIO-EXP-BRIDGE16 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 and GND are located next to the 37-pin connector, P2. You can power the CIO-EXP-BRIDGE16 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: The ground of the power supply and the ground of the personal computer should be tied together through a heavy gauge wire. If you do not strap the two grounds together, a voltage difference between theses 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 CIO-EXP-BRIDGE16 Boards

Connect one CIO-EXP-BRIDGE16 to another using a C37FF-# 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 CIO-EXP-BRIDGE16 with a voltage signal of between -5 and 5V. If you use an AC signal source, keep the frequency below 70Hz to avoid attenuation by the CIO-EXP-BRIDGE16's low pass filter. Each bridge input circuit has four screw terminals. These terminals are shown in Figure 3-6 below.

To connect a voltage signal to the input circuit, connect the voltage to the screw terminals as follows:

+SENSE: Connect to + voltage.
−SENSE : Jumper this to −P.
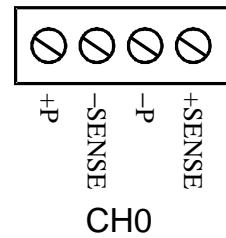−P: Connect to ground.
+P: No connection.

Figure 3-6.
Input Screw Terminal Strip

The four screw terminals associated with each input circuit are labeled on the CIO-EXP-BRIDGE16 as follows:

+SENSE	High side of input
-P	Excitation voltage return
-SENSE	Low side of input
+P	Excitation voltage

The use of the terminals is dependent on the type of sensor you have connected to the input circuit. The nomenclature on the terminals has been chosen to be appropriate for bridge sensors.

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 CH15 and S17-7) should be off (toward the upper edge of the board) for a gain of X1 (unity gain).

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 CIO-EXP-BRIDGE16. 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 CIO-EXP-BRIDGE16 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.

4   CONFIGURATION FOR VOLTAGE MEASUREMENT

The CIO-EXP-BRIDGE16 is an amplification, signal conditioning and multiplexing front-end for DAS boards. The inputs are suitable for connecting a voltage to the DAS board so it can be measured. The CIO-EXP-BRIDGE16 is a one-of-sixteen multiplexer which means that for every channel in your DAS board, you can multiplex sixteen different signals to it. You can expand the number of inputs of your DAS board by sixteen for every CIO-EXP-BRIDGE16 board, up to the number of inputs on the DAS board. For example, a DAS08 has eight inputs. Eight times sixteen is one hundred and twenty eight. Thus, by using sixteen CIO-EXP-BRIDGE16 boards, you could bring 128 inputs into a PC with only one DAS08 in one PC slot. Using a DAS16, up to 256 inputs could be accommodated.

It is unlikely that you purchased a CIO-EXP-BRIDGE16 to measure only voltages. The board was designed for bridge sensors. For voltage only measurements, a CIO-EXP16 or CIO-EXP32 would be less expensive and would do the same job.

However, if you have only one or two voltages to measure in addition to bridge sensors, you can use the CIO-EXP-BRIDGE16.

4.1   Channel Selection

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CIO-EXP-BRIDGE16 with your data acquisition board. Configure your boards as described in that section before continuing with this section.

4.2   Powering the CIO-EXP-BRIDGE16

The *General Configuration* section describes the power selection options, setting the power select switch and verifying the installation and operation of the CIO-EXP-BRIDGE16 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 CIO-EXP-BRIDGE16 for the required gain. Remember to make sure that the settings in InstaCal match the switches on the DAS and CIO-EXP-BRIDGE16 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 CIO-EXP 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 (CH0 through CH15) 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.

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*.
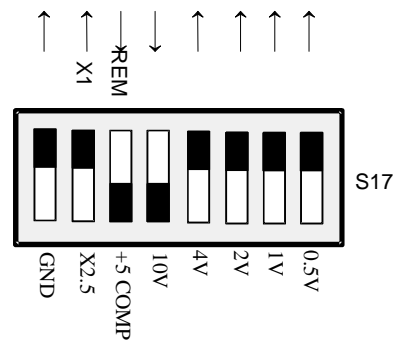
Figure 4-1. Board Output Gain Switch Location

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 CIO-EXP-BRIDGE16 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.
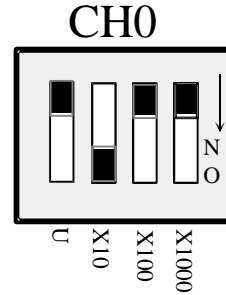
CH0

GAIN SWITCHES FOR CHANNEL 0
SET FOR A GAIN OF 10.
PUSH SLIDER TO 'ON' (DOWN) TO SELECT GAIN
ALL OTHERS TO BE OFF (UP)

Figure 4-2. Input Channel Gain Select Switch- Typ.

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

Channel	Resistor Position	Channel	Resistor Position
0	RX100	8	RX108
1	RX101	9	RX109
2	RX102	10	RX110
3	RX103	11	RX111
4	RX104	12	RX112
5	RX105	13	RX113
6	RX106	14	RX114
7	RX107	15	RX115

Gain	Resistor Value
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 readings 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 (A) = (Ra + Rb) / Rb

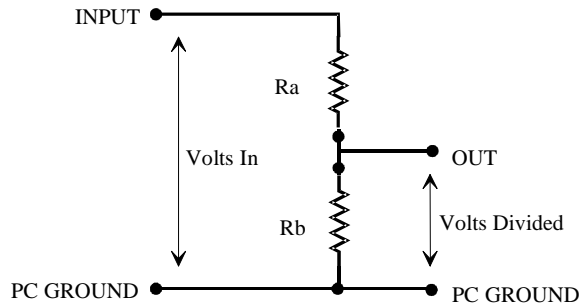See Figure 4-3 at right for the schematic of a voltage divider.

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 CIO-EXP-BRIDGE16 board.

4.6 Connecting Voltage Signals

Voltage input signals can be single-ended or differential. In addition, the full scale may have to be matched to the range of the CIO-EXP-BRIDGE16 and DAS board combination using amplification or attenuation. To connect a voltage and make an accurate measurement, both of these factors must be considered (see section 4.3).

After the range has been matched and the signal connected, the measurement is made using the DAS board and software. You can use InstaCal to display the value read on any channel of the CIO-EXP-BRIDGE16.

Each input circuit has four screw terminals associated with it. These terminals are shown in Figure 4-4. To connect a voltage signal to the input circuit you need only use three screw terminals. These are:

+SENSE: High side of a differential or single-ended voltage signal.
−SENSE: Signal low, or CH LO on a DAS board. Must be jumpered to −P for single-ended.
−P: Ground of a differential voltage signal or Low side of a single - ended signal.
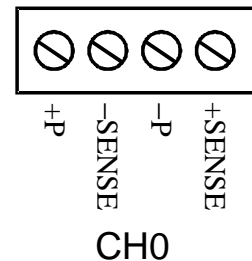
Figure 4-4.
Input Screw Terminal Strip

4.6.1 Single Ended

A single-ended input has two wires connected to the CIO-EXP-BRIDGE16; 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 input low (−SENSE) and ground (−P). The -SENSE terminal is then connected to the signal ground and the +SENSE terminal is connected to the signal.

4.6.2 Floating Differential

A floating differential input has two wires from the signal source and a 10K ground reference resistor installed at the CIO-EXP-BRIDGE16 input. The two signals from the signal source are Signal High and Signal Low. The reference resistor is connected between the CIO-EXP-BRIDGE16 (−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! Determine that the signal source is actually floating. Check it with a voltmeter before risking the CIO-EXP-BRIDGE16 and PC!

4.6.3 Fully Differential

A differential signal uses 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 to a signal source with a ground that is different than the PC ground, but less than 10V difference, and still measure the signal.

EXAMPLE: A laboratory instrument with its own wall plug. Sometimes there is a voltage between wall outlet grounds.

4.7 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 CIO-EXP-BRIDGE16. 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 CIO-EXP-BRIDGE16 inputs can be read. When using an AC signal source, keep the frequency below 70Hz to avoid attenuation by the low pass filter.

5   CONFIGURATION FOR RESISTANCE MEASUREMENT

Resistance measurements are made using the CIO-EXP-BRIDGE16 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.

5.1   Channel Select

The *General Configuration* section describes the channel selection, setting the jumper and verifying the installation and operation of the CIO-EXP-BRIDGE16 with your data acquisition board. Configure your boards as described in that section before continuing with this section.

5.2   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 may be measured. OMEGA Engineeering 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 CIO-EXP-BRIDGE16 with OMEGA Engineeering 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.

5.3   Powering The CIO-EXP-BRIDGE16

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.

5.3.1   Selecting the Power Source for the Board

The *General Configuration* section describes the power selection options for powering the CIO-EXP-BRIDGE16 itself. Configure your boards as described in *Powering the CIO-EXP-BRIDGE16* in the *General Configuration* section before continuing with this section.

5.3.2   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 16 sensors, the on-board excitation circuit would not have adequate power to supply all 16 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 5-1), 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).
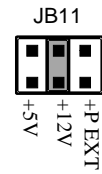

Figure 5-1.
Output Gain & Power Select

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 CIO-DAS08 family boards. The +12V jumper is not valid with the CIO-DAS08-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 CIO-EXP-BRIDGE16.

+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 CIO-DAS08-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 CIO-EXP-BRIDGE16 at the terminals labeled −PEXT and +PEXT on the screw terminal block located adjacent to the 37-pin connector, P2.

5.3.3 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 5-2 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 5-1) or +PEXT.

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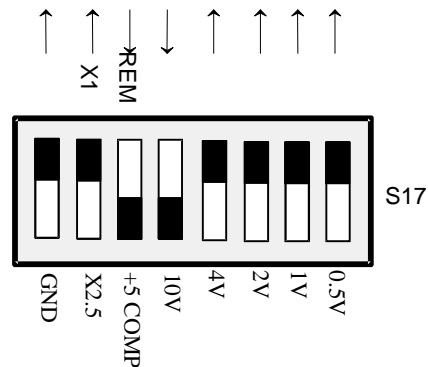

Figure 5-2. Excitation Voltage Select Switches

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5.4 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 CIO-EXP-BRIDGE16 for the required gain. Remember to make sure that the settings in InstaCal match the switches on the DAS and CIO-EXP-BRIDGE16 boards.

When using strain gauges, the expected output from the sensor should be calculated and the gain of the CIO-EXP-BRIDGE16 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.

5.5 Setting the Gain

Once you have determined the gain required for your application, set the gain of the CIO-EXP-BRIDGE16 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 CH15) 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 Board Gain

There is a switch on DIP switch block S17 (Figure 5-3) 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*.
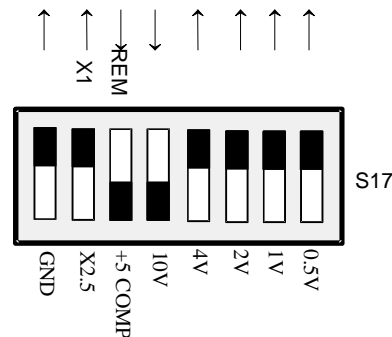
Figure 5-3. Board Gain

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.

5.5.2 Setting Channel Gain

There is a gain switch for each channel (Figure 5-4). 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 Switch

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 CIO-EXP-BRIDGE16 by installing a precision resistor and setting the switch marked "U" (User) in the down position. See Table 5-1 below for positions and some sample gain values.
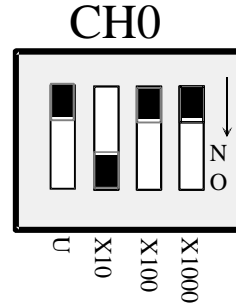
GAIN SWITCHES FOR CHANNEL 0
SET FOR A GAIN OF 10.
PUSH SLIDER TO 'ON' (DOWN) TO SELECT GAIN
ALL OTHERS TO BE OFF (UP)

Figure 5-4. Input Channel Gain Switches

Table 5-1. User-Specified Gain Resistor Positions

Channel	Resistor Position	Channel	Resistor Position
0	RX100	8	RX108
1	RX101	9	RX109
2	RX102	10	RX110
3	RX103	11	RX111
4	RX104	12	RX112
5	RX105	13	RX113
6	RX106	14	RX114
7	RX107	15	RX115

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 USER gain resistor between X100 and X1000 gain is:

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

5.6   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.

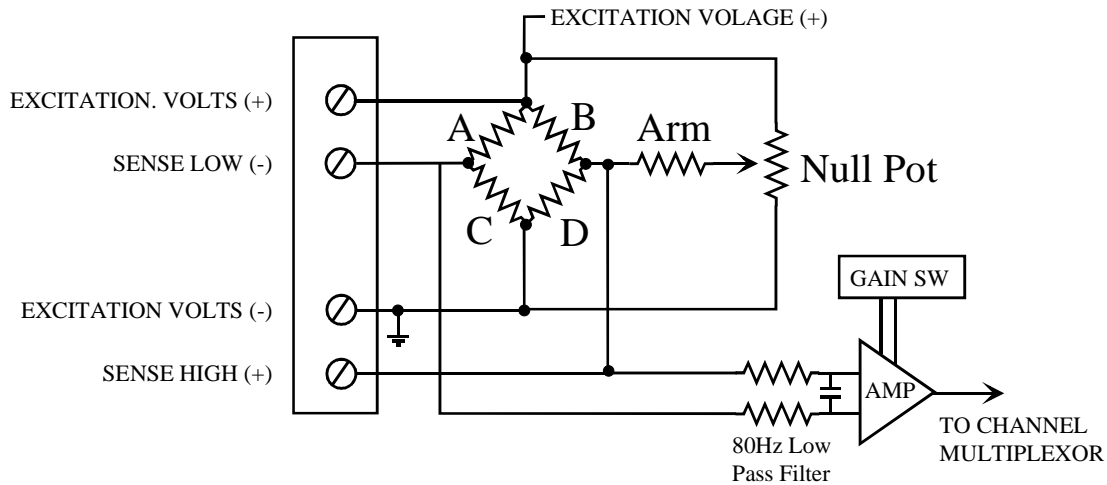Figure 5-5 is a schematic of the bridge circuit.

Figure 5-5. 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.

5.6.1   Bridge Completion Resistors

You will likely have to install bridge-completion resistors in the CIO-EXP-BRIDGE16 to match the resistance of the external gauge:

> If you are using a ¼ bridge, you will need to install three precision resistors to complete the bridge.

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

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

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Referring back to Figure 5-5, the legs of the bridge are labeled A, B, C and D. Table 5-3 below matches the legs of the bridge to the resistor number nomenclature that appears on the CIO-EXP-BRIDGE16.

Table 5-3. Bridge Resistor Identities

Channel	Bridge A	Bridge B	Bridge C	Bridge D	Arm	Null Pot
0	RX1	RX2	RX3	RX4	RX5	R6
1	RX7	RX8	RX9	RX10	RX11	R12
2	RX13	RX14	RX15	RX16	RX17	R18
3	RX19	RX20	RX21	RX22	RX23	R24
4	RX25	RX26	RX27	RX28	RX29	R30
5	RX31	RX32	RX33	RX34	RX35	R36
6	RX37	RX38	RX39	RX40	RX41	R42
7	RX43	RX44	RX45	RX46	RX47	R48
8	RX49	RX50	RX51	RX52	RX53	R54
9	RX55	RX56	RX57	RX58	RX59	R60
10	RX61	RX62	RX63	RX64	RX65	R66
11	RX67	RX68	RX69	RX70	RX71	R72
12	RX73	RX74	RX75	RX76	RX77	R78
13	RX79	RX80	RX81	RX82	RX83	R84
14	RX85	RX86	RX87	RX88	RX89	R90
15	RX91	RX92	RX93	RX94	RX95	R96

Some values of precision resistors are available from OMEGA Engineeering.

Note: Positions marked D1 through D64 are empty and are not used.

5.6.2   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 CIO-EXP-BRIDGE16 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.

5.6.3   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. 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 gauges 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 250$\mu\epsilon$ (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.

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.
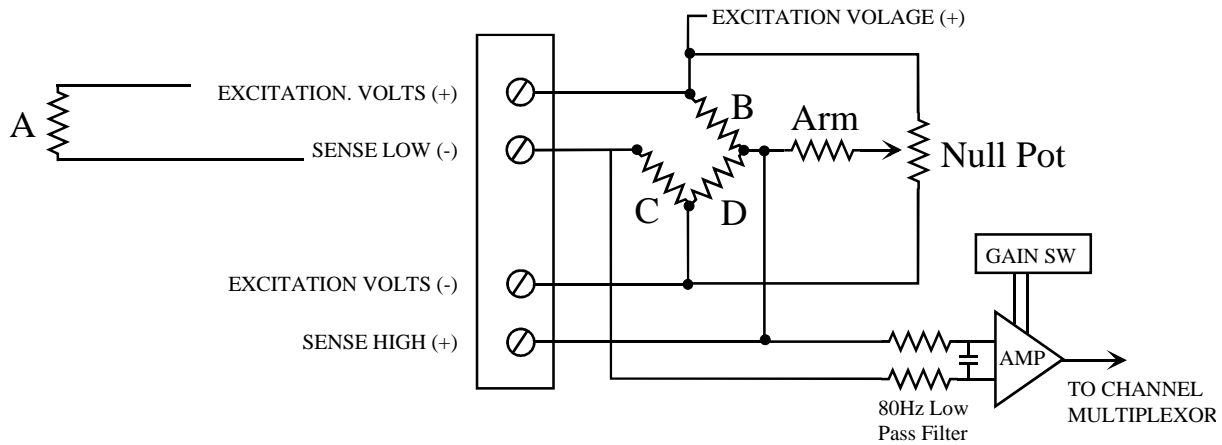

Figure 5-6. ¼ Bridge Circuit - Simplified

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 5-6). 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 is stretched. Therefore, its resistance increases by:

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

$$= +0.175 \text{ ohm}$$

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

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

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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 unipolar range.

A Half Bridge Example

For a ½ bridge circuit (Figure 5-7), 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.
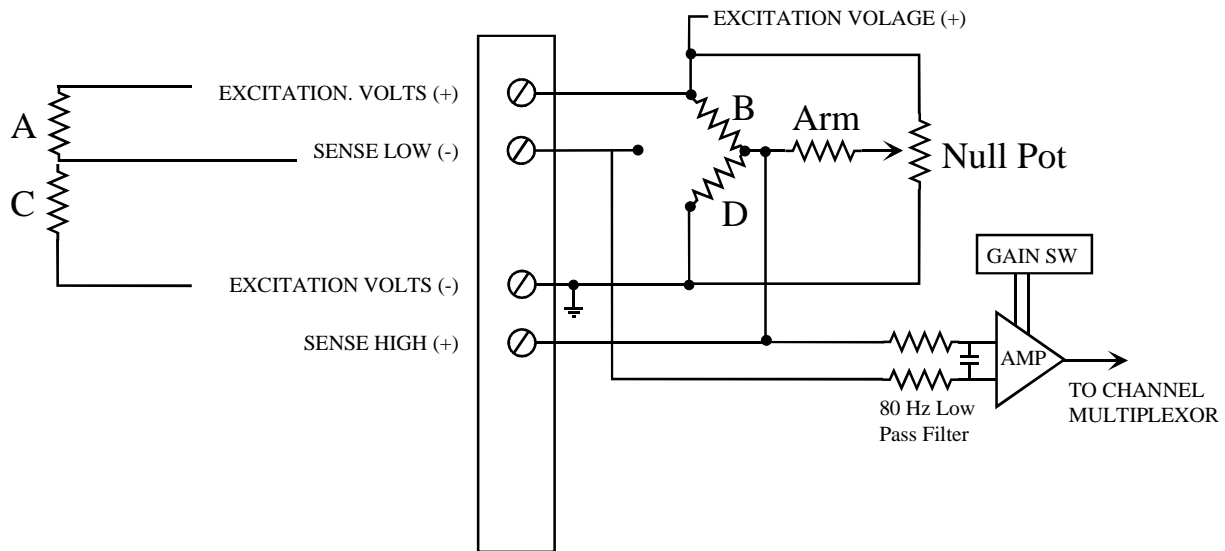

Figure 5-7. ½ Bridge Circuit- Simplified Schematic

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 5-8). Obviously, no bridge completion resistors are installed on the board when using this configuration.
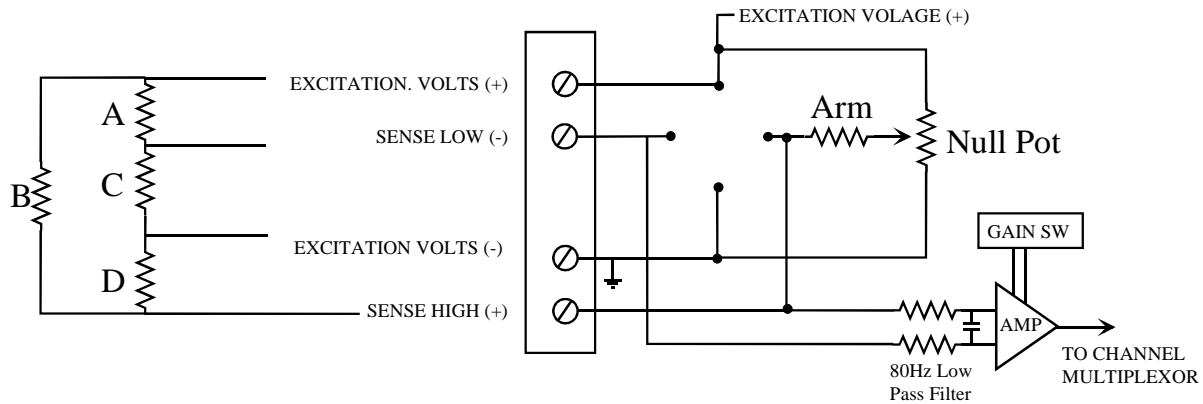

Figure 5-8. Full Bridge - Simplified Schematic

Full bridge 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.

6   SPECIFICATIONS

Power consumption

+5V (excludes any power to bridges)   250mA typical, 350mA maximum

Analog input section

Input amplifier type	INA102
Number of channels	16 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% typical, 0.15% maximum
Gain = 10, 25	0.02% typical, 0.35% maximum
Gain = 100, 250	0.05% typical, 0.40% maximum
Gain = 1000, 2500	0.20% typical, 0.90% maximum

Linearity
Gain = 1, 2.5	0.045% typical
Gain = 10, 25	0.045% typical
Gain = 100, 250	0.075% typical
Gain = 1000, 2500	0.15% 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/°Ctypical
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

Channel to channel settling time
5V step to .01%	250μs
Absolute maximum input voltage	±15V

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

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Analog Output

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 max
Miscellaneous	Output jumper selectable for one of 16 channels (P1 & P2 Output - to Output 15)

Digital Input / Output

Digital type	
DIn 0 through 2	HI508A multiplexer
DIn 3	2N2222 transistor inverter
Configuration	4 digital inputs for selecting multiplexer channel
Input low voltage	
DIn 0 through 2	0.8V max, -4V absolute min
DIn 3	1.0V max, -4V absolute min
Input high voltage	
DIn 0 through 2	2.4V min, 9V absolute max
DIn 3	1.27V min, 9V absolute max

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, 4V VEXC	333mA
12V source, 10V VEXC	833mA
15V external source, 10 VEXC	1333mA
Miscellaneous	Output jumper selectable for one of 16 channels (P1 & P2 Output - to Output 15)
	Voltage adjustable for zero error

Environmental

Operating temperature range	0 to 60°C
Storage temperature range	-40 to 100°C
Humidity	0 to 90% non-condensing

7.1   About Strain Gauges

7.1.1   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

7.1.2   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 CIO-EXP-BRIDGE16, 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.

7.2   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

The Art of Practical and Precise Stain Based Measurement

by James Pierson.

1992, 400 pages in 3-ring binder . ISBN: 1-895976-00-6

Available from Society for Experimental Mechanics, order # JP-001

Strain Gage and Transducer Techniques

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

CIO-EXP-BRIDGE16	Bridge inputs for ISA bus
Part Number	Description

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.

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