

CIO-EXP32/16

User's Manual

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We, ComputerBoards, Inc., declare under sole responsibility that the product:

CIO-EXP32/16

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.

Carl Haapaoja, Director of Quality Assurance

For your notes.

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For your notes.

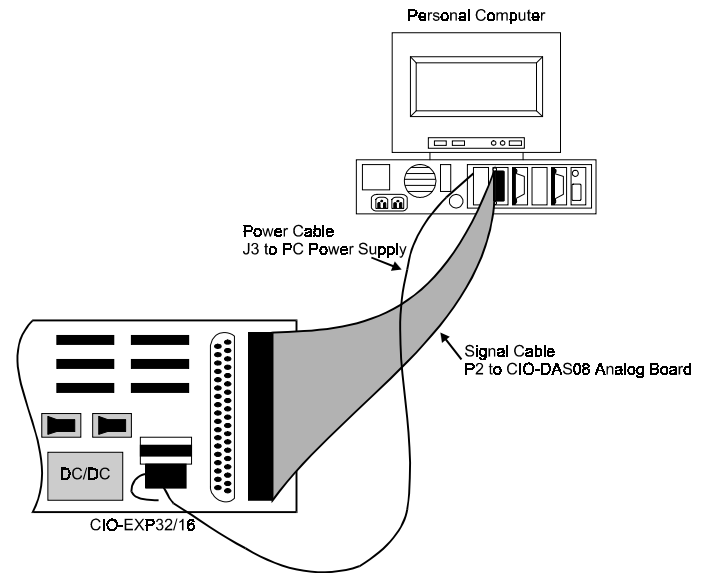
The CIO-EXP is easy to use. Here is the quick start procedure for those who own a CIO-DAS08 and are familiar with its software and signals. If you are using a CIO-EXP with any CIO-DAS16 series board, please turn to Installation.

The CIO-EXP is setup at the factory with:

BASE ADDRESS	None, this is an external peripheral to be used with a plug in board such as the CIO-DAS08
INPUTS	32 or 16 Differential input channels standard
GAIN	Gain = 1 selected

POWER: The +5 Volt power to the EXP may be supplied via the 37 conductor cable from the PC or via an optional power cable to the PC power supply.

If you have purchased a C-PCPOWER-10, open your PC (after turning off the power) and connect the black cable with the white MOLEX type connectors to one of the unused PC expansion power connector from the PC power supply. They are keyed so the cable will plug into the expansion connector easily when they are aligned.



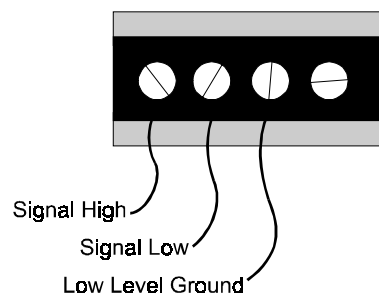
Run the power cable out the back of the PC through an expansion slot or other orifice.
DO NOT run the cable in such a way that it is pinched when the case is closed. If this cable is cut, the resulting short circuit may damage the computer.

Connect the other end of the black cable to the CIO-EXP. This end is keyed also. Put the CIO-EXP board switch +5 in the EXT position.

Connect a 37 conductor cable, such as the C37FF-2, to the CIO-EXP J1 connector and to the CIO-DAS08 family board installed in your computer.

SIGNAL CONNECTION

The CIO-EXP inputs are differential. Differential inputs require 3 connections be made from the signal source to the CIO-EXP. These are SIGNAL HIGH, SIGNAL LOW & GROUND.



TYPICAL CHANNEL - Differential Input

You may test the installation with InstaCal, supplied with your data acquisition board. For program control of your EXP board, refer to UniversalLibrary functions which work in combination with the DAS board installed in your computer to which the EXP board is connected.

TEMPERATURE COEFFICIENT

Gain = 1	+/- 20ppm / Deg C
Gain = 10	+/- 20ppm / Deg C
Gain = 100	+/- 40ppm / Deg C
Gain = 200	+/- 60ppm / Deg C
Gain = 500	+/- 100ppm / Deg C
Offset	+/- 15uV / Deg C

COLD JUNCTION COMPENSATION

CJC Output Voltage	24mV / Deg C
CJC Zero Crossing	0.0 Volts @ 0.0 Deg C
Deg C / Bit @ +/-5V	0.1 Deg C / Bit.

CIO-EXP SWITCHING HI-507

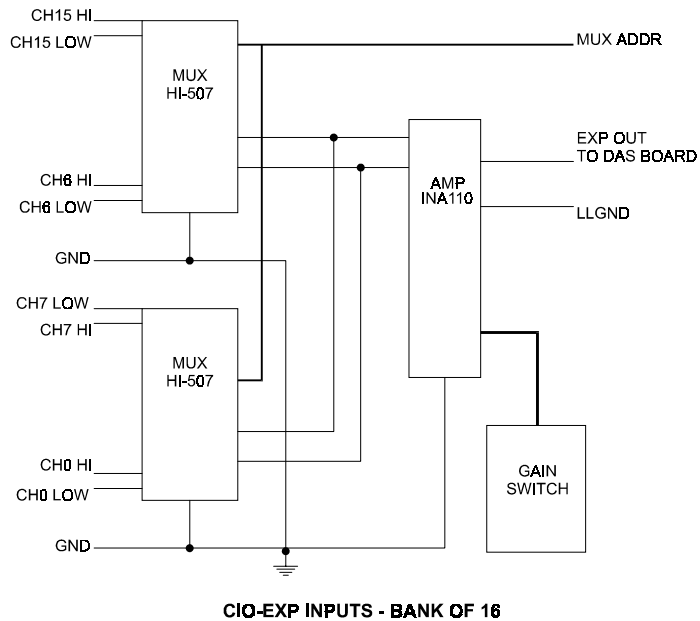
Settling Time to .1%	1.2 μ s Typ.
Settling Time to 0.1%	3.5 μ s Typ.
Channel Access Time	1.0 μ s Max., 0.5 μ s Typ.

On each CIO-EXP, each bank of 16 inputs is multiplexed into one output. This output from the CIO-EXP board is connected to one analog input of the CIO-DAS board.

Both CIO-EXP boards also have a semiconductor temperature sensor on board to measure the temperature of the board in the region of the screw terminals. The temperature at the screw terminals is needed when thermocouples are used with the CIO-EXP. The temperature at the screw terminals is called the Cold Junction temperature and is needed to accurately calculate thermocouple temperature. This is known as Cold Junction Compensation.

When the CIO-EXP is used with thermocouples, the INPUT CJC jumper should be installed, otherwise, do not install it.

Here is a simple schematic of one bank of 16 CIO-EXP inputs. The one of sixteen inputs is selected by the state of the digital control lines. The digital control lines are controlled by the CIO-AD board.



The output of the CIO-EXP selected channel is an input to the CIO-DAS board.

The CIO-EXP is configured at the factory with CIO-EXP channels 0-15 connected to A/D board channel 0, CIO-EXP channels 16-31 connected to A/D channel 1 and CIO-EXP CJC connected to A/D channel 7.

This table shows the maximum readable temperature for thermocouple types at a given gain.

Type	Output uV/Deg C	Min Temp Deg C	Max Temp Deg C	Gain Settings and Deg C/bit				
				100	200	300	500	800
J	51	0	760	760	463	307	186	117
K	40	0	1370	3.29	166	107	66	45
T	40	-160	400	400	400	400	214	140
E	62	-100	1000	656	348	244	152	98
S	7	0	1760	1760	1760	1760	1019	703
R	7	0	1760	1760	1760	1760	948	663

Gains of 1 or 10 will allow full scale readings of type K and E thermocouples if desired.

AMPLIFICATION & THERMOCOUPLES

The voltage from a thermocouple is very low and must be amplified in order to take advantage of the A/D board's full resolution. The amplification of a bank of 16 inputs may be set by switch on the CIO-EXP board.

Type	Output uV/Deg C	Min Temp Deg C	Max Temp Deg C	Gain Settings and Deg C/bit				
				100	200	300	500	800
J	51	0	760	0.5	0.25	0.16	0.09	0.05
K	40	0	1370	0.5	0.34	0.2	0.122	0.07
T	40	-160	400	0.5	0.34	0.2	0.122	0.07
E	62	-100	1000	0.5	0.2	0.13	0.07	0.05
S	7	0	1760	3.0	2.0	1.15	0.69	0.43
R	7	0	1760	3.0	2.0	1.15	0.69	0.43

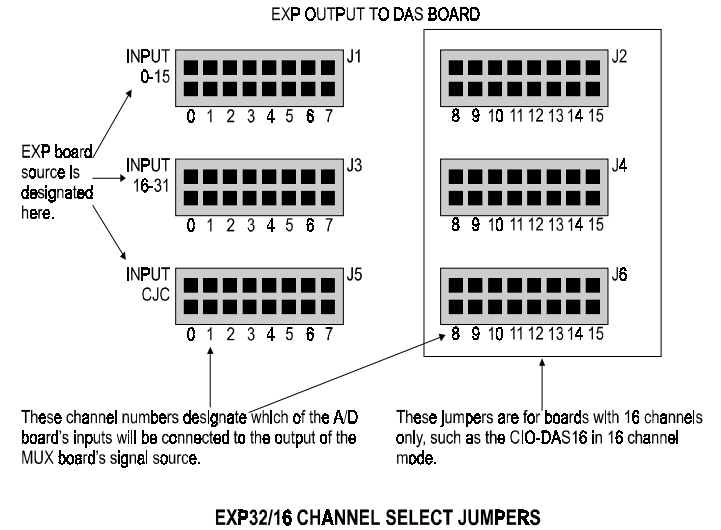
The chart below shows some common thermocouples and their output voltage ranges along with suggested gain settings. The chart may be used to suggest a gain for a thermocouple that you plan to use, or to choose the thermocouple that matches the temperature range of your application.

Let's take some time to look at this chart and what it means to us. The J type thermocouple is common and is a good example to start with. A J thermocouple outputs 51 micro volts per degree centigrade over the range of 0 to 760 degrees C. At a gain of 100 the A/D is resolving to 0.0000242 volts per bit (24.42 micro volts/ bit). For the J type thermocouple with an output of 51 μ V/bit that represents about 1/2 of a degree C per bit. Look under the gain of 100 for J type and you will find 0.5 Deg C/ bit.

The table is repeated below with different information about the effect of gain settings. Here, the thermocouple output voltage at maximum temperature for each gain is shown. Where the output voltage exceeds 5V, the reading is clipped. To see the temperature at which the reading is clipped, see the next table.

Type	Output uV/Deg C	Min Temp Deg C	Max Temp Deg C	Gain Settings and Deg C/bit				
				100	200	300	500	800
J	51	0	760	3.90	7.75	11.63	19.38	31.00
K	40	0	1370	5.48	10.96	16.44	27.40	43.84
T	40	-160	400	1.60	3.20	4.80	8.00	12.80
E	62	-100	1000	6.20	12.40	18.60	31.00	49.60
S	7	0	1760	1.23	2.46	4.00	6.16	9.86
R	7	0	1760	1.23	2.46	4.00	6.16	9.86

This diagram corresponds to the layout of the jumper blocks on the CIO-EXP32. The CIO-EXP16 lacks the second row (Ch 16-31).



JUMPER CONFIGURATION WITH CIO-DAS08 FAMILY OF BOARDS

The CIO-DAS08 family of boards has 8 channels of input so only CIO-EXP outputs 0-7 are valid. The CIO-DAS08 family of boards has single ended inputs which is the correct type to connect to a CIO-EXP. Up to 8 banks of 16 CIO-EXP inputs may be connected to a CIO-DAS08 family of boards for a total of 128 inputs.

JUMPER CONFIGURATION WITH CIO-DAS16

The CIO-DAS16 is switch selectable for either 8 differential or 16 single ended channels. The CIO-DAS16 must be placed in 16 channel single ended mode. The CIO-EXP outputs 8-15 may be used with the CIO-DAS16. Up to 16 banks of 16 CIO-EXP channels may be connected to a CIO-DAS16 for a total of 256 inputs.

POWER TO THE CIO-EXP

There are two ways to power the CIO-EXP board:

1. The CIO-EXP may be powered by the +5 volts present on the 37 conductor signal cable which connects the CIO-EXP to the CIO-DAS08 family of boards. Set switch +5 to INT.

This naming is somewhat confusing.

On the switch which controls the source of the +5 volts, EXT means the +5 volt power comes from the Molex connector while INT means the +5 volts is drawn from the 37 conductor signal cable.

2. A +5 volt power only cable may supply the CIO-EXP with +5 volts. A separate power cable is required when several CIO-EXP boards are used with one A/D board.

The power cable has two connectors, one male and one female. The male end has metal pins, the female end, metal sockets

The male connector will mate with any of the unused PC power supply power expansion plugs inside your PC. There are extra of these plugs attached to wires which come from the PC power supply. Several of these are plugged into the PC disk drives. Plug the male end of the CIO-EXP power cable into one of the unused ones.

Run the CIO-EXP power cable out the back of the PC. It may be run out and expansion slot or other orifice. The newer machines have several DB25 connector locations in the back of the PC which may be used for this purpose.

Under no circumstance should the CIO-EXP power cable be pinched by the PC case. If the cable were severed, a serious short circuit would result, possibly damaging your computer.

The optional power cable, C-PCPOWER-10 may be used to draw power directly from the PC power supply.

The power cable is black with two white MOLEX connectors. One end mates with the P27 connector on the CIO-EXP and the other mates with any one of the available PC power expansion plugs inside the PC.

The signal cable is a 37-conductor cable with 37D female connectors at each end. One end plugs into the P2 connector of the CIO-EXP, the other plugs into the CIO-DAS08 family of boards.

OPEN THERMOCOUPLE DETECT

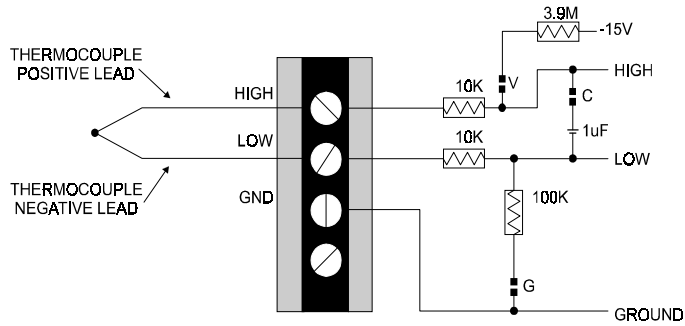
Open thermocouple detect (OTD) is implemented by closing the 'V' pad with a solder bridge. OTD provides the high side of the thermocouple signal with a reference to the full scale negative voltage of the CIO-EXP board. If a thermocouple opens then it ceases to produce a voltage. When that happens the 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. The CIO-EXP will accurately measure thermocouples without the 'V' pad closed but you should close it.

LOW PASS FILTER

A low pass filter is implemented by closing the 'C' pad. The bandwidth of this filter is 7 Hz. This means that a signal that swings full scale up to 7 times per second will 'pass' through the filter. Faster signals will be damped. This is good because temperature variables, especially with thermocouples, just don't change very fast but thermocouple wires being long and carrying a low voltage can pick up noise. The low pass filter helps to reject noise. The CIO-EXP will accurately measure thermocouples without the 'C' pad closed but the measurements may appear to fluctuate a few degrees from reading to reading as the result of noise on the thermocouple wire.

GROUND REFERENCE

The CIO-EXP inputs are fully differential which will help reject noise on thermocouple wires. If thermocouples connected to the CIO-EXP inputs are to work properly, the 'G' pad must be closed. The 'G' pad provides a reference from ground to the analog low input via a 100K 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.



CIO-EXP INPUT - One channel. Typical thermocouple hookup. C = Filter capacitor, pad open. V = Open TC detect, pad open. G = Ref to ground, pad open. Pads are located on circuit side. All pads must be closed when thermocouples are used.

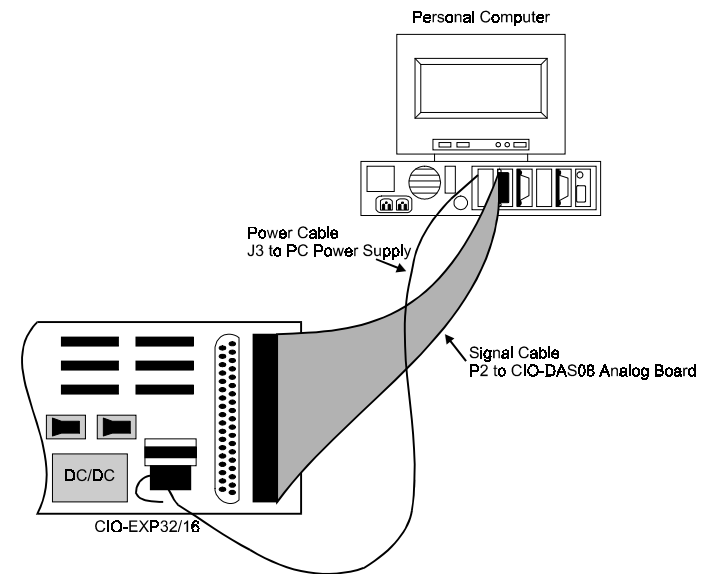
Other important thermocouple connection issues are discussed below.

COLD JUNCTION COMPENSATION

A thermocouple is two dissimilar wires that react electrically when in contact with each other. The reaction produces a voltage which is dependent on the temperature at the point where the two metals touch. There is a reaction at every point where dissimilar metals (the thermocouple wire) touch including the screw terminal where the thermocouple wire is connected to the CIO-EXP board.

A semiconductor temperature sensor located on the CIO-EXP board provides a stable, accurate and linear output which is temperature dependent. This output must be mapped into one of the A/D boards inputs via the CJC jumper block. The CJC temperature reference is universally used by software to compensate for the voltage induced at the 'cold junction' (the screw terminal). Failure to supply a CJC reference will result in inaccurate temperature readings.

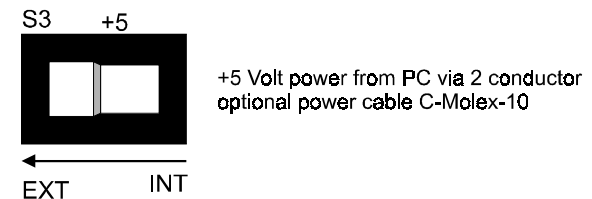
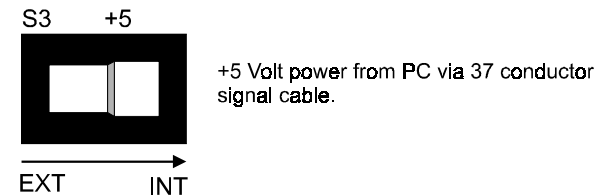
All software programs use a CJC reference. Labtech Notebook defaults to channel 7. Lablog2 is fixed at channel 4. Control EG defaults to channel 4. Computer Boards' example programs default to channel 7. Failure to supply the CJC reference by installing the jumper plug on the correct channel will result in inaccurate temperature calculations in the software. The CJC jumper block diagram is in section 3 of this manual.



A DC/DC converter on the CIO-EXP to supplies +/-15 volts power to the amplifier.

CIO-EXP POWER SOURCE SELECT SWITCHES

The power source select switch is shown here in each of the two possible configurations.



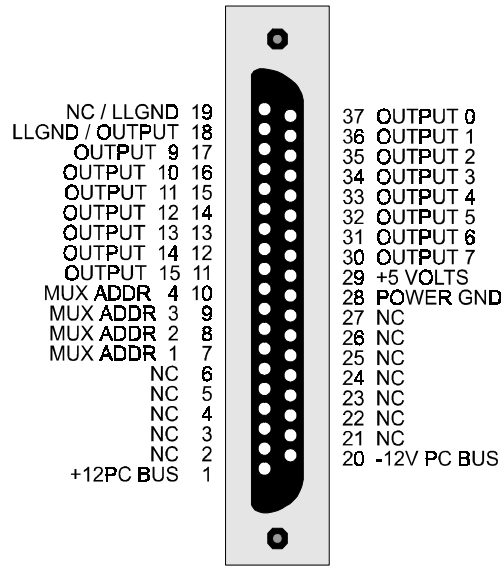
SIGNAL CABLE

The CIO-EXP signal connector is nearly a mirror of the CIO-DAS08 family of boards signal cable.

There are two 37D connectors on the CIO-EXP. The are wired 1:1. The second D37, P1, is provided to daisy chain CIO-DAS08 family of boards signals onto other signal conditioning boards.

Any 37 conductor ribbon cable with female D37 connectors will suffice to connect an CIO-EXP to a CIO-DAS08 family of boards. Length should not exceed 50 feet.

Connect one end of the signal cable to the CIO-DAS08 family of boards and the other to the CIO-EXP P2 connector.

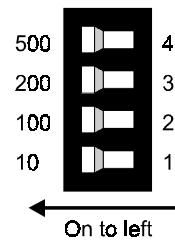


CIO-EXP SIGNAL CONNECTOR

GAIN SWITCH

The CIO-EXP has one bank of four switches per bank of 16 inputs located in a single DIP switch near the bank it is associated with. The four switches control the gain of the differential amplifier. The gains are additive so a total of 16 different gains are possible.

The gain associated with a switch is 'on' when the switch is to the left and 'off' when the switch is to the right.



GAIN SWITCH - Gains are additive ie:
500
+200
700

A floating differential hookup is handy when the signal source is floating with respect to ground, such as a battery, 4-20mA transmitter or thermocouple and the lead lengths are long or subject to EMI interference.

A thermocouple is an example of a floating differential. Instead of using an external 100K resistor, solder the 'G' pad.

The floating differential input will reject up to 10V of EMI energy on the signal wires.

WARNING!

Is the signal source really floating? Check it with a voltmeter before risking the CIO-EXP and PC!

DIFFERENTIAL

A differential signal is three wires from the signal source. The signals are Signal High (CH# HI), Signal Low (CH# LO) and Signal Ground (LLGND).

A differential connection allows you to connect the CIO-EXP to a signal source with a ground that different than the PC ground, but less than 10V difference, and still make a true measurement of the signal between CH# HI and CH# LO.

EXAMPLE:

A laboratory instrument with its own wall plug. There are sometimes differences in wall GND between outlets.

THERMOCOUPLES

The CIO-EXP32 and CIO-EXP16 are ideal for thermocouple signal conditioning. Features such as cold junction compensation (CJC), open thermocouple detect (OTD) and amplification provide the signal conditioning required for accurate temperature measurements with thermocouples.

A thermocouple is connected to one channel of the CIO-EXP. Note that the thermocouple does have a positive and negative lead. If you're not sure which is which, make a test hookup and use a match to stimulate the thermocouple. Does the temperature go up? If not, switch the leads and try it again.

SIGNAL CONNECTIONS

Signal connection can be one of the most challenging aspects of applying a data acquisition board. If you are an Analog Electrical Engineer then this section is not for you, but if you are like most PC data acquisition people these simple examples should get you started. The objective here is to present 'how to connect' common signals while avoiding discussion of electrical theory and special symbols. If you need a connection we do not show, or invent one, please call and tell us so we can add it to this manual.

CONNECTOR DIAGRAM

The CIO-EXP inputs are screw terminals which will accept 12-22 AWG wire.

Each channel has a screw terminal for signal high, signal low and ground.

ANALOG INPUTS

Analog inputs to the CIO-EXP may be connected in two different configurations. In order of complexity, these are Floating Differential and Differential.

WARNING - PLEASE READ

Here is a good tip. Measure the voltage potential (difference) between the ground signal at the signal source and the PC. Use a volt meter and place the red probe on the PC ground and the black probe on the signal ground. If there is a difference of more the 10 volts, do not connect the CIO-EXP to this signal source because you will not be able to make any reading. If the difference is more than 30 volts, DO NOT connect this signal to the CIO-EXP because it will damage the board and possibly the computer.

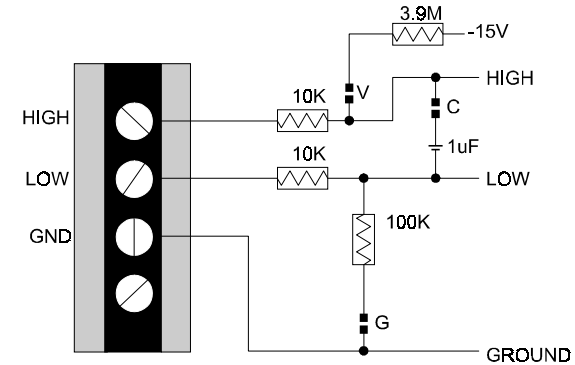
FLOATING DIFFERENTIAL

A floating differential input is two wires from the signal source and a 100K ground reference resistor installed at the CIO-EXP input. The two signals from the signal source are Signal High (CH# HI) and Signal Low (CH# LO).

The reference resistor is connected between the CIO-EXP CH# LO and LLGND pins.

CHANNEL CONFIGURATION

Each channel of the CIO-EXP may be configured in several ways by adding solder to three 'connect pads' on the circuit side (under side) of the CIO-EXP board. The connect pads connect resistors and capacitors to the input signals to achieve certain signal characteristics.



CIO-EXP INPUT - One channel. C = Filter capacitor, pad open. V = Open TC detect, pad open. G = Ref to ground, pad open. Pads are located on circuit side.

Shown above is a typical channel in the configuration as shipped from the factory. The connect pads 'V' and 'G' are open. The 'C' pad is closed placing a 1 μ F filter capacitor across the signal high and low inputs.

The V pad is for Open Thermocouple Detect. Open thermocouple detect means that if the thermocouple should open, and thereby have no valid signal coming from it, then the input for that channel would be driven to full scale negative volts. Negative FS corresponds to the lowest minus degree reading of the thermocouple, which in the real world is not likely or even possible. Software uses the presence of a lowest minus degree reading to alert the operator that a thermocouple has opened.

The G pad provides a reference to ground through a 100K resistor. A thermocouple is a floating source. Without the G pad's reference, the reading from the thermocouple would float meaninglessly. See the section of this manual on differential inputs.

The V, G, and C pad should be closed by a blob of solder whenever thermocouples are used.

The best way to close the pad is to get a blob of solder wet on the pad then pull the soldering iron perpendicular to the pads from the center of the two pads.

The best way to free a solder blob is to get it wet with the soldering iron then slide it toward one pad or the other.

CALIBRATION AND TEST

CIO-DAS08 FAMILY OF BOARDS SETUP

The range and gain settings of the CIO-DAS08 family of boards are additive to the gain setting of the CIO-EXP. For this reason, we suggest that the CIO-DAS08 family of boards be set to $\pm 5V$ bipolar or 0 to 10V unipolar, which is a gain of 1. Use the amplification on the CIO-EXP so a full scale signal is on the signal cable to the CIO-DAS08 family of boards.

There is no other CIO-DAS08 family of boards setup required.

CIO-DAS16 SETUP

The range and gain settings of the CIO-DAS16 are additive to the gain setting of the CIO-EXP. For this reason, we suggest that the CIO-DAS16 be set to $\pm 5V$ bipolar or 0 to 10V unipolar, which is a gain of 1. Use the amplification on the CIO-EXP so a full scale signal is on the signal cable to the CIO-DAS16.

The CIO-DAS16 may have either eight differential or 16 single ended inputs. When used with the CIO-EXP the CIO-DAS16 must be in 16 channel single ended mode.

There is no other CIO-DAS16 setup required.

CIO-DAS16 TO CIO-EXP CABLE

The CIO-EXP may be used with the CIO-DAS16, expanding the CIO-DAS16's 16 inputs to 256 inputs. The CIO-EXP connects to the CIO-DAS16 via a special 37 conductor cable. As you can see, the relationship of the CIO-EXP signals and CIO-DAS16 signals is not 1:1. A C37-CIO-EXPAD16 cable should be ordered to complete the connection between the CIO-DAS16 and the first CIO-EXP in the series.

The CIO-EXP is supplied with software for calibration and test. The calibration software supplied on the CIO-EXP utility disk is menu driven so is not explained here.

FREQUENCY OF CALIBRATION

Every board was fully tested and calibrated before being placed in finished goods inventory at the factory. For normal environments a calibration interval of 6 months to one year is recommended. If frequent variations in temperature or humidity are common then calibrate at least once every three months. It takes less than 30 minutes to calibrate the CIO-EXP.

REQUIRED EQUIPMENT

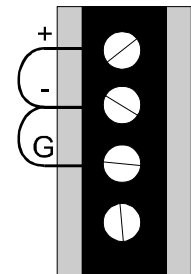
Ideally, you will need a precision voltage source, a 4 1/2 digit digital volt meter, a calculator and some pieces of wire. If you do not have a precision voltage source, you will need a non-precision source and have to make a few calculations.

CALIBRATING THE ANALOG INPUTS

The A/D is calibrated by applying a known voltage to any analog input channel and adjusting trimpot for offset.

The CIO-EXP should be calibrated for the range you intend to use it in. When the range is changed, slight variation in Zero may result. This variation can be measured and removed in software if desired.

Offset Adjust: Set the channel gain switch to the gain you will be using. Take two pieces of wire and tie G, -, and + of the channel being calibrated.



ZERO ADJUST - Ground all Inputs.

Using the calibration program, INSTACAL, adjust the potentiometer for a reading of zero.