

# DataShuttle and DynaRes User's Manual

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for Data Acquisition and Control



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## DataShuttle and DynaRes Users Manual

*for Data Acquisition and Control*

p/n 1051-0901 Rev. 2.0



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In this manual, the book symbol always precedes the words "Reference Note." This type of note identifies the location of additional information that may prove helpful. References may be made to other chapters or other documentation.



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Specifications are subject to change without notice. Significant changes will be addressed in an addendum or revision to the manual. As applicable, IOtech calibrates its hardware to published specifications. Periodic hardware calibration is not covered under the warranty and must be performed by qualified personnel as specified in this manual. Improper calibration procedures may void the warranty.

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## Introduction

Thank you for selecting the DataShuttle for your project.

Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to furnish the performance you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your budget.

We manufacture the DataShuttle as an enhancement product that readily plugs into the parallel port of an IBM, or compatible, desktop or portable computer.

The product's high noise rejection, input protection to withstand as much as 50 Volts, and guaranteed long term stability make it ideal both for the laboratory and for harsh industrial environments. With its parallel port interface, built-in terminal panel, and compact, light size, the DataShuttle is also completely portable, providing for a quick and easy set-up in both in-house labs and remote test sites.

Using the DataShuttle together with our graphical interface application software (such as DASyLab<sup>®</sup> or QuickLog<sup>™</sup>), you can easily and very quickly implement a broad spectrum of research and commercial tasks, in a variety of settings. You can, for example,

- **Display, and log data** to disk for later analysis,
- **Measure temperature, pressure, flow** and most other analog inputs from sensors and instruments,
- **Capture maximums, minimums, averages, or differences** of measurements,
- **Monitor and control processes,**
- **Set alarm limits** on any input,
- **Control devices at preset levels** (fans, pumps, heaters, etc.),
- **Control devices from digital input** (from switches or TTL signals), and
- **Gather data unattended.**

You can use the system interactively, operating controls or modifying your setup while the system is running.

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## General Information

### Development System

People who write their own software (rather than using an off-the-shelf application) can employ the Analog Connection Windows Development System<sup>™</sup> hardware driver. This can address all features of the unit from within a program they design and code for their specific purpose.

### Expandability

All DataShuttles have eight differential analog input channels and 8 digital input/output lines. You can add one DataShuttle at a time to your computer, for as many as 15 units with a total of 120 analog input channels and 120 digital I/Os.

### Ranges/ Units of Measure

The six input ranges of the DataShuttle span from 50 milliVolts through 10 Volts DC, making it capable of accepting data from almost any sensor. In addition, You can install a resistor, making the DataShuttle capable of DC current measurements.

Its high accuracy makes the DataShuttle ideal for precise evaluations in the laboratory or field.

The DataShuttle together with our software – such as DASYLab or QuickLog PC – make it easy to specify engineering units (degrees, volts, milliAmperes, etc.) for measurements, as well as which ranges to use.

(You can measure temperature, for example, by selecting from among 11 different thermocouple types, or from a variety of resistance temperature devices – RTDs. With the application software, the process simply consists of selecting the type of sensing device from a menu – the driver itself automatically handles cold junction compensation and linearization.)

## Data Presentation

The combination of hardware and application software (DASYLab or QuickLog PC) enables both the display of data on the screen, and the logging of data to disk for later analysis.

The system is capable of showing data on the monitor in a variety of formats. On-screen meters can provide accurate readings of any parameter on any channel. Chart displays can indicate trends for comparison of actual measurements on several channels, or for setting data points or alarms.

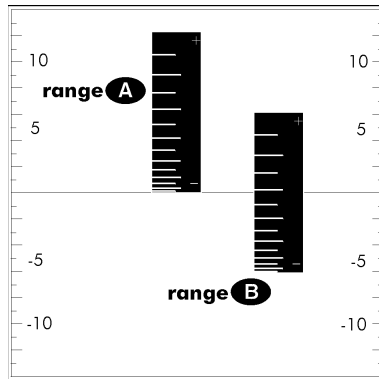
## Dynamic Resolution

All DataShuttles incorporate “Dynamic Resolution,” which improves the unit’s accuracy.

With this feature, resolution is greater at the lower (negative) end of any range than at the higher end. As your readings approach the low end of any given range, the resolution becomes finer (that is, the increments of the signal you can distinguish become smaller).

Dynamic resolution improvement is most noticeable when the signal remains below a 10% of full-scale threshold (approximately). Our products, consequently, are the best available for taking accurate measurements of low-level signals, as you would using a thermocouple sensor.

Dynamic resolution is always best toward the negative end of any range:



*Dynamic Resolution for Dissimilar Ranges*

Two vertical black “rulers” (range A and range B) portray the impact of Dynamic Resolution. Their graduations – representing their ability to resolve – are always finer at the lower (more negative) ends of their ranges, regardless of the spectrum of values the ranges are measuring.

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## Features and Configurations

<b>Analog Input Channels</b>	DataShuttle-16 can achieve 16 bit resolution (.0015% of signal).
<b>Resolution Selections</b>	<p>The DataShuttle-16 has eight differential analog input channels.</p> <p>The resolution of the DataShuttle is selectable in software. With the DataShuttle-16, it extends from 10 through 16 bits.</p> <p>(These products also feature advanced “dynamic resolution.” See page 1 – 2 for further explanation.)</p>
<b>Data Acquisition Speed</b>	The data acquisition rate for the DataShuttle reaches as high as 6 kHz at 9 bits, in burst mode.
<b>Ranges</b>	DataShuttle has six voltage ranges, all selectable individually for each analog input channel.
<b>Noise Rejection</b>	The DataShuttle features a high noise rejection integrating converter (in “low noise mode” it helps reject 50/60 Hz AC power line interference).
<b>Sensors</b>	The DataShuttle supports accurate cold junction compensation and linearization for thermocouple devices, and signal conditioning for resistance temperature devices (RTDs).
<b>Accuracy</b>	Calibration constants are stored in non-volatile memory on each DataShuttle.
<b>Input Protection</b>	Built-in circuitry assures protection of analog input channels for $\pm 50$ Volts continuous.
<b>Digital I/O</b>	All DataShuttles feature eight digital input/output channels that the user can configure individually to be input or output.
<b>Counter/Timer</b>	<p>Every DataShuttle includes a counter/timer for precise timing (for counting pulses or other events) which you can also use as a pulse output.</p> <p>Counter/Timer controls analog pacing and is therefore, unavailable for use with DASyLab software.</p>
<b>Isolation</b>	<p>The digital I/O lines on all models may be isolated with optional ODC (opto 22) family modules.</p> <p>The 5B models also accept optional –5B family isolation modules for analog inputs and/or analog outputs.</p>
<b>Analog Output Channels</b>	All DataShuttle-AO models feature two optional 12-bit analog output channels with one current (4-20mA) and six voltage ranges, software selectable

## For More Information

For more information about the capabilities of your DataShuttle, please see the “Product Specifications” in Chapter 2.

For instructions on controlling the unit with our interface software (such as DASyLab or QuickLog), refer to that particular software manual.

To learn more about data acquisition and process control in general, and how to use our systems together to accomplish everyday tasks, consult our Applications manual.

If you’re creating your own program to address the unit for a custom purpose, please see the Analog Connection Development System help section.

## System Requirements

Before installing the DataShuttle, make sure the computer system fulfills these minimum requirements:

### Hardware

- IBM PC AT (or higher) or -compatible, with at least 640k system RAM,
- Floppy disk drive, CD-ROM drive and a hard drive.

### Software Environment

- Windows 3.1/95/98/NT,
- Application software (DASyLab, QuickLog PC, the Analog Connection Development System, or other compatible proprietary software; please see your software manual for directions for using it with the DataShuttle). QuickLog for Windows 3.1, 95/98 only.

### Package Contents

Your DataShuttle package should include:

- One DataShuttle
- One 6V 1A AC Adapter; or 5VDC, ~2.5A Adapter for DS-5B models (for U.S. market; may differ for international markets)  
(Polarity  $\oplus$  —  $\ominus$ )
- One parallel cable (DB-25 M-F) IEEE 1284 Compliant.
- This manual, including DataShuttle, QuickLog PC, and Applications
- One QuickLog for Windows Disk
- One Quickstart card

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## DataShuttle Model Variations

The DataShuttle family line offers 4 basic models, plus versions with 2 optional analog outputs.

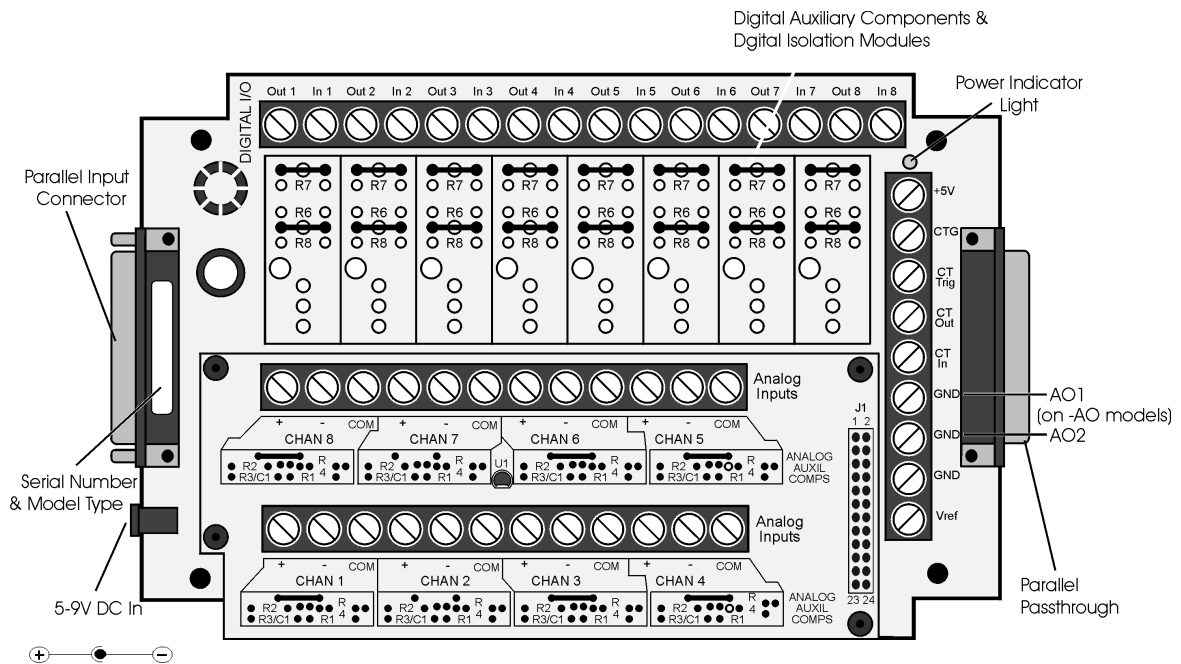
### DataShuttle-GP

The DS-16-8-GP and DS-16-8-GP-AO are general purpose units designed for all types of inputs. The DS-GP features terminals for 8 differential analog inputs and 8 digital I/O lines, with room for up to 8 high-power optically isolated models.

## DataShuttle-RTD

The DataShuttle RTD models are specifically designed for high accuracy RTD measurements. The DS-16-8-RTD-115e version is suited for  $-200^{\circ}\text{C}$  to  $115^{\circ}\text{C}$  measurements, and the DS-18-8-RTD-750C version is suited for  $-200^{\circ}\text{C}$  to  $750^{\circ}\text{C}$  measurements. Both have signal conditioning set resistors pre-installed at the factory for use with two or three wire RTDs. This model also features terminals for 8 digital I/O lines, with room for up to 8 optically isolated modules. Two analog outputs are available on the -AO models: DS-16-8-RTD-115C-AO and DS-16-8-RTD-750C-AO.

The DataShuttle-RTD can also measure non-RTD inputs. For channels that are required to measure other signals, remove the pre-installed resistors at R3 and R4. See example in the Analog Auxiliary Components section of Chapter 2 for a more detailed illustration.

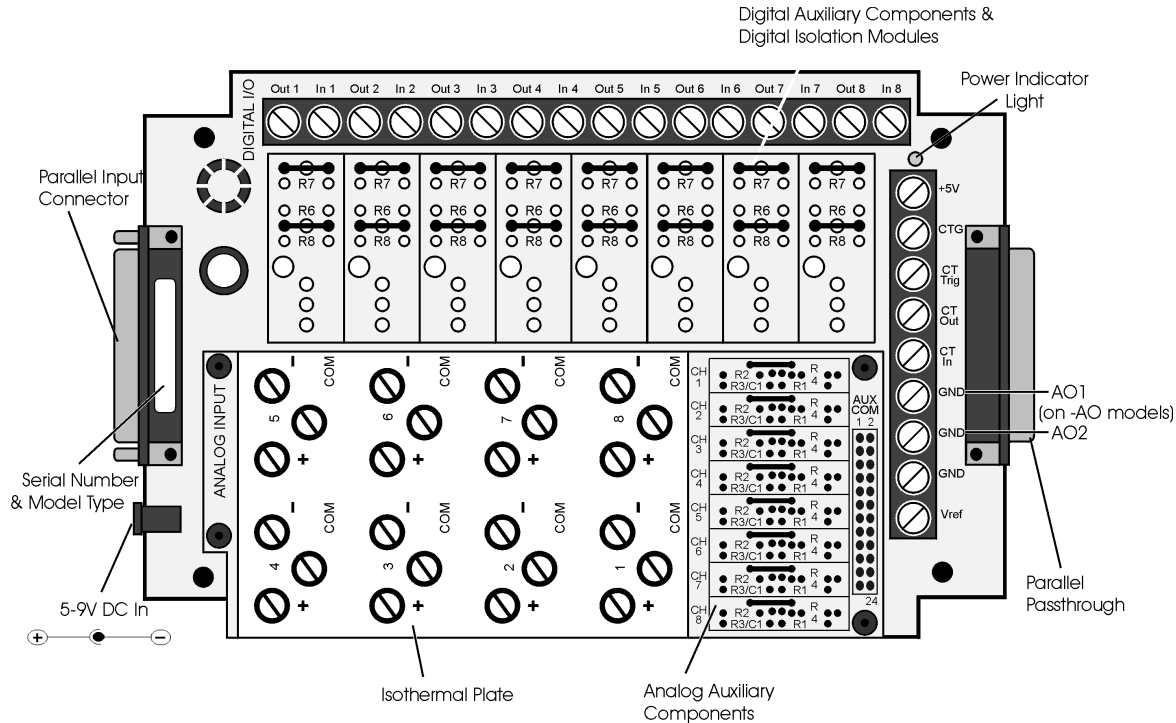


*Illustration of the DataShuttle-GP and DataShuttle-RTD*

## DataShuttle-TC

The DS-16-8-TC is the best model for thermocouple measurement. The DS-TC has a large aluminum isothermal plate with screw terminals for 8 analog inputs. This isothermal plate improves accuracy by attenuating temperature differences at the cold junction connector. Without this plate, the connectors can vary in temperature by 5°C or more, causing a similar error in the reading reported by the DataShuttle .

The plate, however, does not prevent measurement of other signals, such as voltage or current. In addition, the DataShuttle-TC features 8 digital I/O lines, with room for up to 8 optically isolated modules.



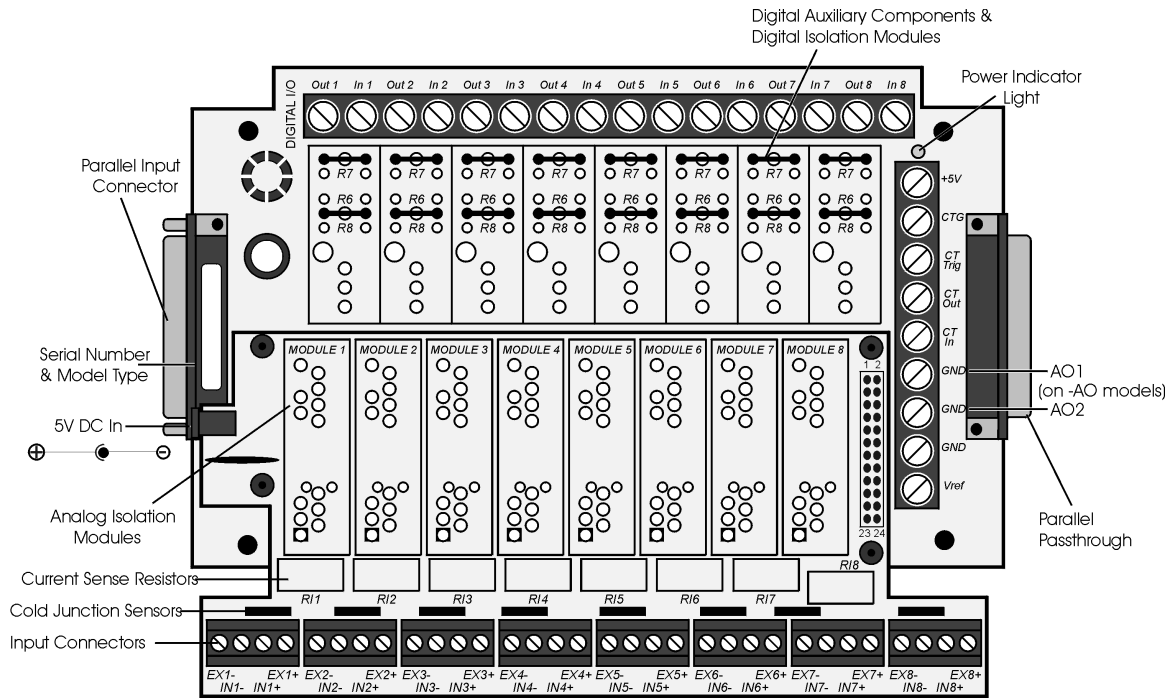
*Illustration of the DataShuttle-TC*

## DataShuttle-5B

The DS-16-8-5B-AO offers the most compact solutions available for electrically isolating analog inputs, analog outputs, and digital I/Os—all in one package. Up to 1500V isolation is available when installed with the optional 5B modules for analog channels and/or opto22 modules for digital channels. The DS-5B's encasement is custom-designed to support the installation of these 5B modules.

The DS-5B features terminals for 8 differential analog inputs and 8 digital I/O lines; two analog outputs are available on the -AO models. For maximum accuracy, each channel has a temperature sensor for thermocouple cold junction compensation. Excitation terminals for driving strain gauges are also included on each channel. In addition, each channel can accept current sense resistors for 4-20mA measurements.

Before installing 5B or opto22 isolation modules, it will be necessary to remove jumpers. Note also that if two output isolation modules are installed, only six analog inputs are available for isolation. Odd-numbered channels (1, 3, 5 or 7) should be used to track Analog Output 1 (AO1) and even-numbered channels for Analog Output 2 (AO2).



*Illustration of the DataShuttle-5B*

## Installing Your DataShuttle

Getting your DataShuttle up and running is a straightforward process; you only need to:


- Connect the DataShuttle to the parallel port of a computer, and
- Connect power to the DataShuttle.

Guidelines for loading the software, and for starting up, depend on the application program you are going to use (such as DASyLab<sup>®</sup> or QuickLog<sup>™</sup>, or a package by a third party developer who has our authorization).

The program you are going to use with the DataShuttle might even be unique and proprietary, a product of your organization. (The Analog Connection Windows Development System is a powerful set of utilities making it possible for software engineers to design and develop their own programs to exploit the DataShuttle's many features).

In any event, please refer to the software provider's installation manual, or user guide, for specific information on how to load and run the particular program.

Troubleshooting – If you have any difficulty getting your unit to work, refer to the “Troubleshooting” section in Chapter 2.

<b>WARNING</b>	
	<p><b>Be sure to turn the power to the DataShuttle and computer off before making or removing connections.</b></p> <p><b>Always remove the AC adapter from the power line before disconnecting it from the DataShuttle.</b></p>

---

## **Physical Installation**

Installation very simply consists of plugging the DataShuttle's DB-25 cable into the parallel port outside your computer. The DataShuttle may be used in combination with any of our data acquisition products.

### **To Install a DataShuttle**

#### **Single Unit Installation**



1. **TURN THE COMPUTER OFF.** Never plug anything into the computer's parallel port without first turning its power switch to the “off” position.
2. Connect the parallel input connector, on the left side of the DataShuttle, to the parallel port on your computer with the provided DB-25 cable. The parallel port on the PC has 25 pins and is often labelled “Printer” or “LPT.” Computers may have up to four parallel ports; the DataShuttle may be connected to any one of these.
3. Connect the provided AC Adapter to the 6-9V DC input just to the side of the parallel port of the DataShuttle. Plug the AC Adapter into an AC power line.
4. Connect the sensors needed for your application: Remove the top cover of the DataShuttle by removing the four screws in the corners of the unit. Connect the sensors needed for your application to the DataShuttle screw terminals. Replace the cover. You may wish to refer to the Applications Reference Manual for examples of particular applications.

#### **Multiple Unit Installation**

To install more than one DataShuttle– Follow the steps above to install the first DataShuttle. Then for every additional DataShuttle you wish to install, simply connect the parallel input port of that DataShuttle to the passthrough port of the previously installed DataShuttle. You may use the additional DB-25 cables to do this, or you can plug the next DataShuttle directly into the previous one. If you prefer to keep the units separate, you may also connect additional DataShuttles directly to any or all of the other parallel ports on your computer.

In any of these ways, you may connect up to 15 DataShuttles to one computer.

Please note, however, that only two DataShuttles, may be powered off the same 6V, 1 amp AC Adapter. Therefore, you must connect a new AC Adapter (see Step 3 above) to every third DataShuttle in a series. This number may vary outside the U.S.

<b>CAUTION</b>	
	<p><b>The DS-16-8-5B models are shipped with a 5V DC, ~2.5A regulated adapter instead of the standard 6V adapter. If you are using DS-16-8-5B model(s) in your installation, note that each of those units will require its own adapter.</b></p> <p><b>Polarity</b> </p>

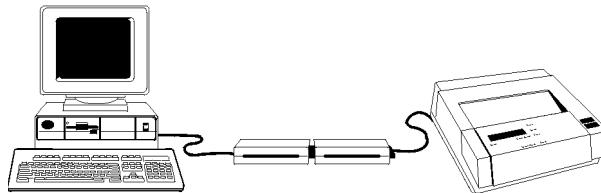


A Note on Board Numbers– When you are using multiple units in your installation, each unit needs to have an identity, or “board number,” for the software to recognize it as “individual.”

When the software is loaded, it will conduct a search for all installed hardware, scanning first for in-system boards and then for any DataShuttles connected to the parallel ports. Any plug-in boards that you have installed will be assigned a board number first. Then the DataShuttle connected at LPT1 nearest to the computer will be assigned the next available board number. Additional DataShuttles on LPT1 will be assigned sequentially higher board numbers following the connection order. This process will be repeated on LPT2, LPT3, and LPT4 until all units have received a board number.

## Printer Installation

If you wish to use a printer on the same parallel port as a DataShuttle– Connect the printer cable to the passthrough port of the last DataShuttle in the series. Printing can only take place when the DataShuttle is powered and the data shuttle is not collecting data.



*Figure 4. Installation with multiple DataShuttles and printer*

## Keyboard Adapter Installation

For field applications where no AC power line is available– The Keyboard Adapter power cable (available optionally) may be used instead of the AC Adapter. To install, simply connect one end of the cable to the keyboard port on the computer. (This connector must be the six-pin mini DIN style found on IBM PS-2s and most portable computers.) Plug the other end of the cable into the DataShuttle’s DC input jack.

We recommend that only one DataShuttle be powered off a keyboard adapter; this may vary depending on the computer used. (See the “Multiple Unit Installation” section for instructions on installing multiple DataShuttles.)



**If you are using DS-5B model(s) in your installation, it is recommended that you use an external power source. The keyboard adapter might not meet the power requirements of some DS-5B experiment setups.**

## Next Steps

Installing the Software – For information on loading and configuring DASyLab, QuickLog PC, or other software please refer to the user guide for that software package.

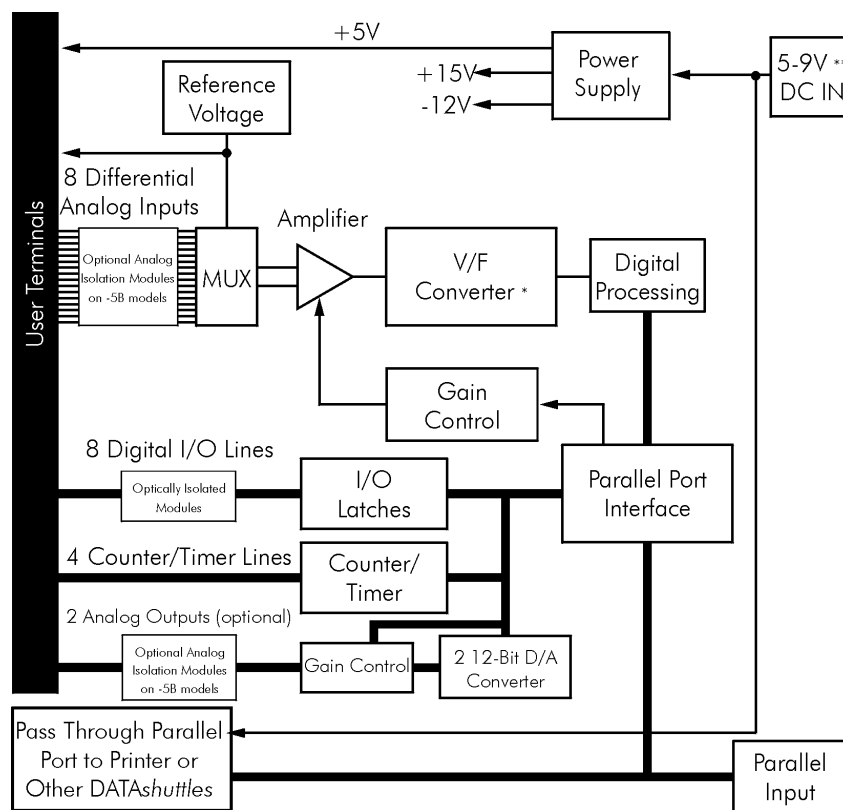


Notes

Although the technical notes presented in the following pages should seldom be needed, you may find one or more of them to be of use, on occasion. The technical notes are:

- Block diagram (of the DataShuttle showing on-unit processing)
- Editing calibration numbers to accommodate changes to your installation, or to restore missing files
- Auxiliary analog and digital components
- Counter/Timer
- Use with AC Development System software
- Troubleshooting: possible problems and solutions after installing, and during operation of your unit
- DataShuttle Specifications

## Block Diagram



\*V/F Converter: 16 bits  
 \*\*5V DC in for DS-5B models

*Block Diagram of DataShuttle-16*

---

## EDITCAL



**DataShuttles are calibrated at the factory prior to shipment, and should not need re-calibration when you receive your order. The recommended calibration period is 2 years. Note that changing calibration numbers affects the accuracy of the analog measurements.**

EDITCAL.EXE (or EDITCAL, for short) is our utility program that allows the modification of calibration numbers. Steps for starting and using EDITCAL follow.

1. Make sure the EDITCAL.EXE program file is located in the same sub-directory as the application programs.
2. Load the EDITCAL.EXE program from the keyboard.
3. At the DOS prompt, enter EDITCAL, then press the [ENTER] key. This invokes the utility.

Once EDITCAL is up and running you can use the arrow keys to navigate back and forth among the following menu selections:

**Data Files:** To merge calibration files supplied from the factory into a single file for systems that have multiple units, or to update existing calibration files.

**AC EEPROM:** To view or modify calibration data on Analog Connection units that have non-volatile on-unit EEPROMS.

**DS EEPROM:** To view and/or modify the calibration numbers of DataShuttle EEPROMs, or to perform an analog calibration

**QUIT:** Ends the EDITCAL session.

4. Move the arrow keys until **DS EEPROM** is flashing.
5. Press [ENTER].
6. Proceed according to the on-screen instructions that appear after making your selection.



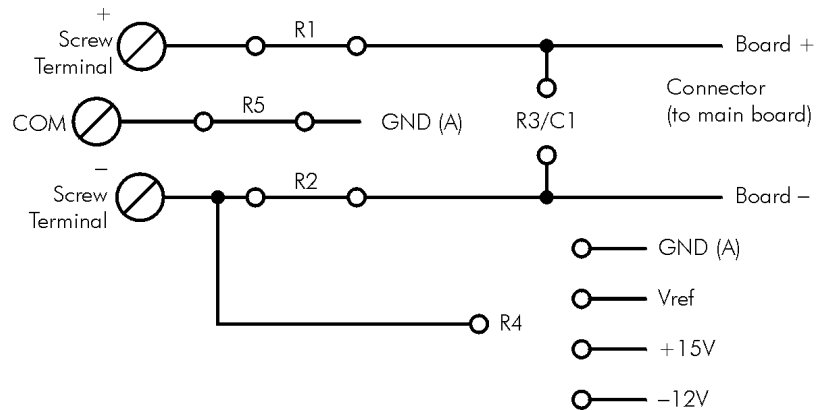
**At any time during your use of EDITCAL, you can press the [F1] key to display help-text regarding a highlighted field.**

---

## Auxiliary Components

### Starting EDITCAL

Auxiliary Components are required by some sensors, are used to protect digital signals, or are used to pull digital outputs to a set level. There are two areas (one digital and one analog) on the DataShuttle for installing auxiliary components. Schematics of Analog auxiliary components are shown in detail on page 2-3. Schematics of Digital auxiliary components are shown in detail on page 2-6.



Analog Auxiliary Components, each channel

#### *Schematic for Analog Auxiliary Components*

Each channel on the DataShuttle has room for its own separate set of auxiliary components. Examples of their use can be found in the following pages and in the Applications Reference Section.

## Analog Components

### **Instructions for Installing Components**

Most common sensors can be connected without the use of auxiliary components. Some of the sensor installations (bridges, RTD circuits, voltage dividers and current sensors), however, require auxiliary components. These components can be installed on the DataShuttle for convenience. This requires soldering and some familiarity with electronics. In the examples in the *Applications Reference Manual*, and the following, the component locations are shown but not the component values; you must calculate the values if they are not supplied with the sensor.

The first step is to remove the daughterboard from the unit, as you will need full access to it for soldering on the auxiliary components. To do this, simply remove the four screws in the corners of the daughterboard and lift it off of the DataShuttle.

When using analog auxiliary components R1, R2, and R5 you must cut the shorting metal trace that connects the two ends of the line together before installing any of the components in these locations. Use a sharp knife to carefully slice through the trace without cutting additional traces. In the case of R5 this is a plastic covered metal wire. Diagrams of the auxiliary component area, hole functions, and connection possibilities are shown on the following page.

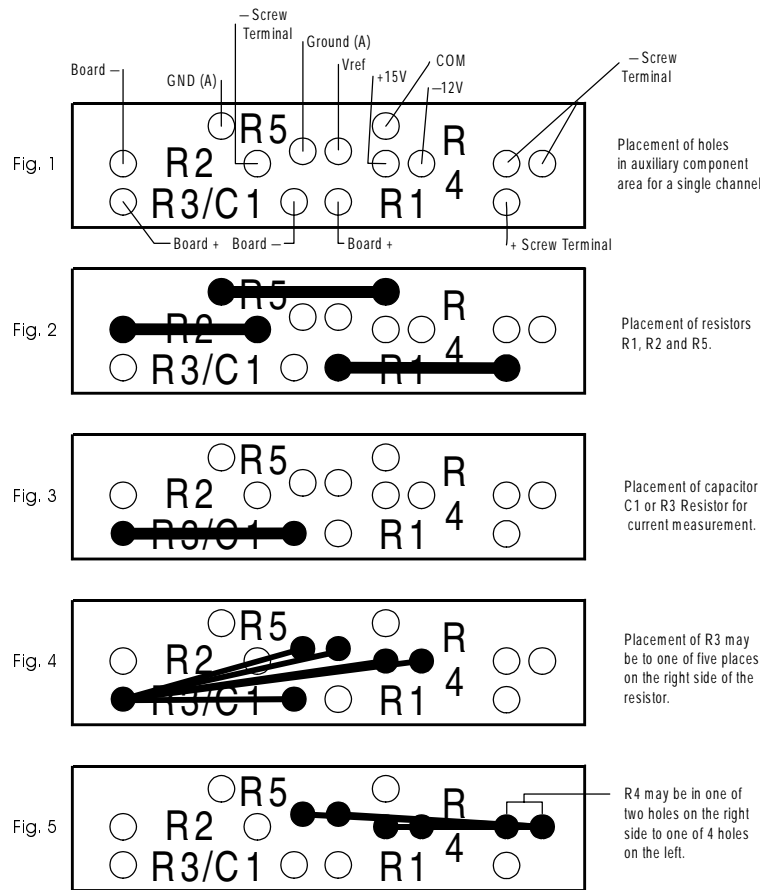
**Note:** Analog auxiliary components are not available on DS-5B models.

## Power Supplies

A Note on Power Supplies – The DataShuttle supplies the following voltages to power transducers, strain gauges, etc. The currents available to the user are limited as follows:

Voltage	Tolerance	Maximum Current (mA)	Output Impedance (ohms)
Vref(6.9V)	±5%	10	<1
+5V	4.5 to 5.0V	100	<50
+15V	±3%	10	100
-12V	±3%	10	100

Users of the open collector digital outputs and buffer amplifiers should be careful not to exceed these limits. Any power used from these supplies will add to the specified supply current used by the DataShuttle.



\*Except DS-5B models

### Analog Auxiliary Component Area on the DataShuttle

## Examples

### Example 1: Current Sense Resistor

The DataShuttle can measure currents up to 50 mA directly. A 24.9 Ohm precision resistor needs to be installed in the auxiliary component area to do so. This connection for current measurement is shown below. (To see how this connection adds to the circuit, refer to Figure on page 2-3.) R3 is used as a shunt resistor across the positive and negative lines of the channel in use. To install this resistor, push the resistor ends through the holes for R3 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes, and then clip off the extra wire with pliers. This connection does not require any additional traces to be cut. Be sure to select current measurement in the software package that you are using. This installation allows the measurement of voltage across the resistor and the conversion of this measurement to current using the equation  $V=IR$ . Observe the power rating of the resistor you install at R3. Space is provided for a 1/4 Watt resistor.

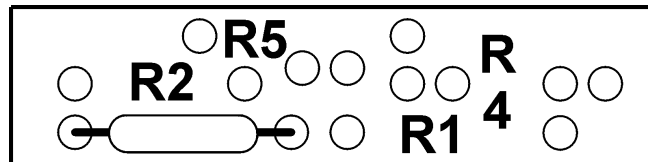
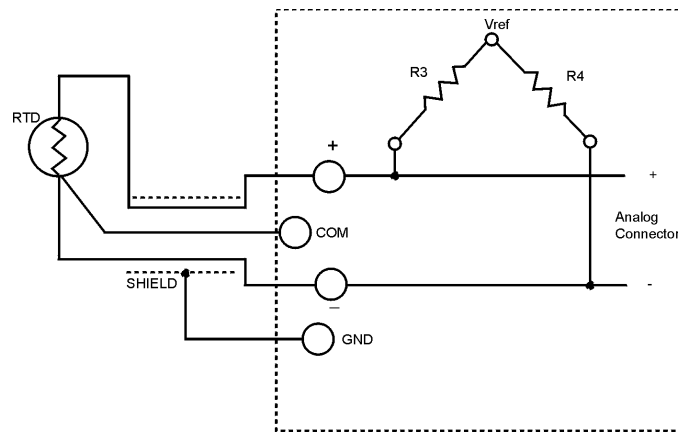


Figure 6. Current Measurement Connection

### Example 2: 3-Wire RTD Components

The most popular connection for RTDs is the three-wire type. This sensor requires the installation of resistors R3 and R4 except for these DataShuttle RTD model, where both resistors are already installed. Consult Set Resistor Values on page 2-14 for R3 and R4 values.



3- Wire RTD

Figure 7. 3-Wire RTD Components

However, if you need to install these resistors yourself then do the following: Figure 4 and Figure 5 show the possible locations of R3 and R4. Figure 1 will show you that R3 and R4 need to be connected as in Figure 14. R5 is already in place and should not be removed. To install these resistors push the resistor ends through the holes for R3 and R4 as shown in Figure 4 (from the terminal side) until the resistor lies flat with the panel surface. If two wires cannot fit into the Vref hole then one wire may be soldered to another that is already inserted. On the back side solder the wires to the holes. Then clip off the extra wires with pliers. The auxiliary component area in question will now look like Figure 8. This connection does not require any additional traces to be cut.

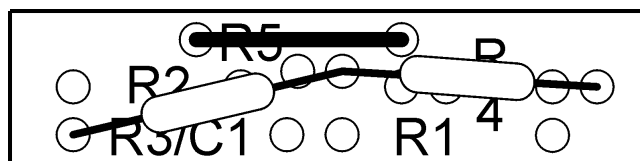


Figure 8. 3-Wire RTD Connection

### Example 3: Ground loops

Occasionally there is an installation where the ground connection is made at the sensor, but it is not reliable. The solution to this “intermittent” ground is to replace the COM to GND(A) jumper wire at R5 (Figure on page 2-3) with a 10 Megohm, 5%, 1/4 Watt resistor. This provides a ground reference for the analog inputs in question, but allows very little ground current to flow. In very noisy environments with intermittent grounds, a smaller resistor may be used if the readings are erratic.

To install this resistor the wire at R5 must first be removed. After R5 has been removed push the resistor ends through the holes for R5 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes. Then clip off the extra wire with pliers. The auxiliary component area in question will now look like Figure 9. This connection does not require any additional traces to be cut.

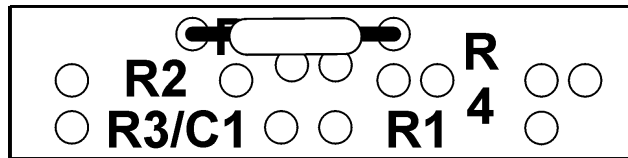


Figure 9. Ground Loop Connection

### Wiring Analog Outputs on the DataShuttle

#### Voltage Outputs

Voltage outputs can drive a wide variety of controllers, amplifiers, and other devices. Figure 9a shows the standard way in which the Data Shuttle analog output terminals are connected to a load when the “Voltage Output” option has been selected in the software.

**Note:** The load resistance should be at least 1000 ohms to guarantee that the output will not have to source more than 10 mA.

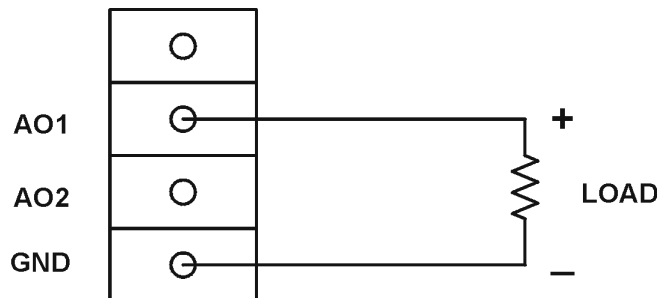


Figure 9a. Voltage Output



## Current Outputs

Most current outputs connect to current loop devices, such as controllers. If you select the “Current Output” option in the software then, the output current loop will be in the 4 to 20 mA range. A 4 to 20 mA current device has the advantage of running the power and signal over the same pair of wires. Also, current signals are much less susceptible to noise pickup than are voltage signals.

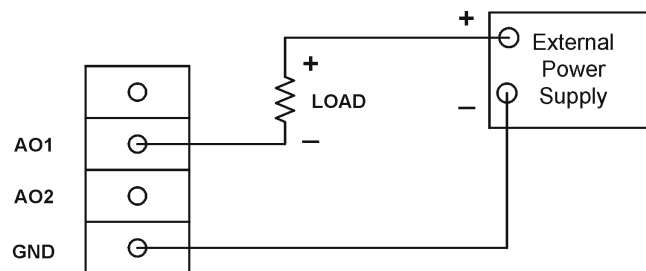
**Note:** The current loop connection on the Data Shuttle must be powered by a + 12V source. Since no such source is available on the Data Shuttle itself, an external power supply must be used

### Ungrounded Load

Several loads can be powered from a single supply, as long as the negative side of the supply is connected to the Data Shuttle ground. The circuit in Figure 9b is the most common way to connect a current loop to the Data Shuttle. In this case, the load is not grounded but is floating above ground level.



**If there are multiple loads, then the negative terminal of each load must be connected to a separate Analog Output (AO) terminal on the DataShuttle.**

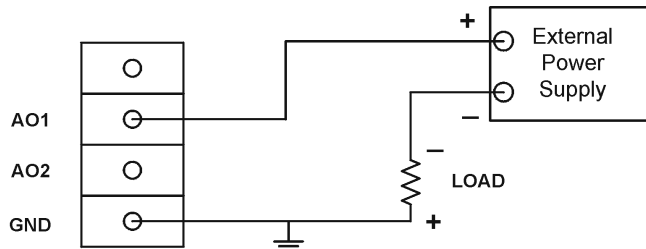


*Figure 9b. Current Output, Ungrounded Load*

For the current output option to work properly, the voltage from each AO terminal to ground must be at least 2.6 volts. Therefore, since the voltage source may vary by +/- 1 V, the maximum load resistance that can be used in this circuit is 420 ohms.

### Grounded Load

If one side of the load must be grounded for some reason, use the circuit shown in Figure 9c. The disadvantage of this circuit is that each load requires its own power supply. The same maximum load resistance applies, i.e., 420 ohms.



*Figure 9c. Current Output, Grounded Load*

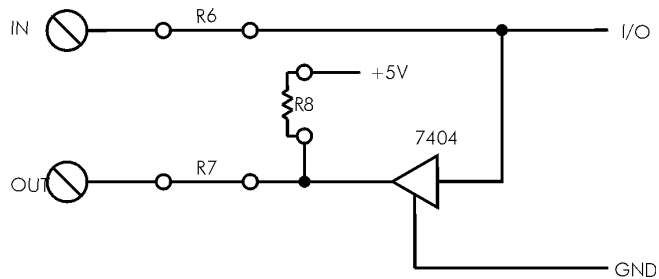
## CAUTION



**Inadvertent damage to the Data Shuttle’s Analog Output is possible! Some situations can occur in which the software could start up in a default voltage mode [instead of the selected current mode]. To avoid this possibility, physically disconnect the current loops from the Data Shuttle prior to shutting down or disabling the software, or prior to rebooting the PC.**

## Digital Components

### Installing Digital Modules



Digital Auxiliary Components, each channel

### Schematic for Digital Auxiliary Components

Opto22 modules are available to safely connect the digital I/O lines to high voltage AC and DC sources. There are four basic types:

- AC output: to switch AC power (relay)
- DC output: to switch DC power (relay)
- AC input: to sense AC voltage
- DC input: to sense DC voltage

The output types are used to switch loads on and off. The input types are used to sense the high/low status of a signal. All of the modules provide optical isolation between the high voltage and terminations.

These modules may be installed on any DataShuttle. First, remove the jumpers labeled R6 and R7. This disconnects the digital I/Os from the terminals. The module will not fit into the panel until these jumpers are removed. Then, simply insert the module and fasten the retention screw.

The terminals for that I/O have now changed their function from low voltage I/O to high voltage isolated I/O. The two terminals become one input channel (high and low lines), or one output channel (like relay contacts), depending on the type of module you have installed.



**When using these terminals as input lines, be sure to connect the positive line to the old OUT terminal and the negative line to the old IN terminal. Failure to do this will result in the module not switching.**

## Installing Pull-up Resistors

As noted in the Applications Reference Manual and previously in this manual, the digital outputs are open collector and must have a power source connected in order to drive loads. Merely connecting the output terminal through a load (such as a bulb) and then to digital ground will not work. In this case, a pull-up resistor connecting the output terminal to a power supply will complete the circuit.

This pull-up resistor is installed in position R8, as shown in the figure on page 2-6, which connects the output to the unit's +5 volt power supply. Figures in Chapter 1 show the physical location of R8 on the DataShuttle. Note that R8 must be installed manually between the +5 volt supply and the output terminal in question. To install this resistor, push the resistor ends through the holes for R8 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes. Clip off the extra wire with pliers. This connection does not require any additional traces to be cut. Use a 4.7K resistor to give 1mA current flow or a 2.3K resistor to give 2mA current flow.

## Installing Current Limiting Resistors

To limit the current in the digital input line, install a resistor in the R6 position (remove the corresponding jumper first).

Install a resistor in the R7 position (after removing the jumper) to limit the current in the digital output line.

---

## Counter/Timer

The DataShuttle features one 16 bit counter/timer that may be used to count up to 216 (65,535) events. The maximum rate of pulses it can measure is 3MHz. The counter/timer is connected to an internal 2MHz clock, allowing it 0.5µS resolution.

There are four dedicated terminals for the counter/timer:

Counter/Timers lines available on the DataShuttle		
Label	Name	Function
CTG	Gate	Input/output functions may operate when this line is high and stop when it is low
CT Trig	Trigger	Initiate input or output functions on rising edge
CT Out	Output	Output pulses or square waves
CT In	Input	Measure frequency of pulses, count pulses, or time events

All of these lines are TTL compatible. Please note that they may not be optically isolated with modules.

For more information and examples about the uses of the counter/timer please see the Applications Reference or QuickLog chapters.

---

## Troubleshooting: Installation

If you experience difficulty in getting your DataShuttle up and running, please check to see that the installation is according to the descriptions in Chapter 1.

If the software reports a unit failure, or that it cannot find a DataShuttle, then try these remedies:

1. Make sure the cable is securely connected from the DataShuttle input connector to the parallel port on the computer.
2. Make sure the DataShuttle is connected to a power source, either an AC Adapter or Keyboard Adapter. A red light on the board will indicate that power is present.
3. Verify that the software is up to date (a version compatible with the unit you are using). Contact us, or your software provider.

4. Disconnect additional DataShuttles and printers in your setup.
5. Connect the DataShuttle to another parallel port.
6. Remove any additional data acquisition cards from the computer.
7. If possible, install the DataShuttle with another computer to verify its correct operation.
8. Remove other terminate and stay resident (TSR) programs from your system's AUTOEXEC.BAT file, temporarily. Also REM out any AUTOEXEC.BAT and CONFIG.SYS lines that relate to a PCMCIA port, such as device drivers, as these have been known to cause conflicts.
9. Make sure that you plug the DataShuttle in and that power is connected before starting your computer. Many laptops will deactivate the parallel port at the start-up if nothing is attached to it.
10. Make sure that the Print Manager is not active in the Windows environment when attempting to start the DataShuttle. Some computers automatically load the Print Manager at startup, and it can interfere with DASyLab's ability to communicate with the hardware. Printing is possible while using the DataShuttle but not during the initial loading of the DASyLab software. Likewise check for lack of interrupt assignment on parallel port in device manager.
11. Erratic behavior can occur when a parallel port is in ECP modes under early Windows 95 versions. Change parallel port protocol in BIOS.
12. QuickLog checks for [386Enh]  

```
DEVICE=C:\QLFWASTIDATAQ.386
```

  
in System.ini file
13. Increase Minimum Interrupt Timing setting. (consult software manual)

## If You Need Customer Support

***To help us serve you better, please have the following information ready:***

1. Have the part number of your DataShuttle ready.
2. Have the type and version number of the software you're using.
3. Have your computer's type, model, and the version of the operating system.

---

## Troubleshooting: Operation

### Hints

It's essential to have exactly one ground reference per channel. This single connection to ground makes sure you don't exceed the common mode range of input.

(More than one connection per channel can lead to ground loops, causing errors or erratic readings. Connecting the – to the Com terminal provides a single ground. Your sensor might also provide another ground. If you're not sure that your sensor is grounded, try connecting the – to Com, and not, and see which works best.)


Remember that if speed is not critical, selecting the "low noise mode" in software always provides the best accuracy and resolution with your data acquisition unit.

### Operating Qs and As

1. Problem: My unit reads analog inputs wrong.  
Action: Make sure the calibration numbers in the non-volatile memory are non-zero (run EDITCAL to check this). If the figures are correct, try shorting + to – to Com: the unit should return a reading around 0V.
2. Problem: My unit reads the thermocouple as a very negative temperature.  
Action: Verify the connections are secure. Opens read as negative temperature. Make sure use lowest channel numbers first and scan only connected channels.
3. Problem: My board reads thermocouple input wrong.  
Action: Confirm that the CCAL number in the EEPROM matches the number on the terminal panel's calibration label.  
  
(If you need to use a general purpose terminal panel – one that doesn't have a factory CCAL number – with a thermocouple, you can achieve approximate results by entering a CCAL of 22000. Then change the figure by about 75 points for each degree C. that you want to raise the temperature.)
4. Problem: My readings are noisy.  
Action: Try using the low noise mode (see your software manual for more information).
5. Problem: My digital inputs are "high" with nothing connected to them.  
Action: This is normal. The digital inputs are pulled up to about 1.5 volts by leakage from the LS7407 chips. This is enough to read logic high. You can pull them low with a 470 ohm resistor to ground.
6. Problem: Can I get any output signal from the digital input terminals?  
Action: Yes, you can use an input terminal to drive light loads such as a TTL input.
7. Problem: What should I do with the jumpers connecting the analog input to COM?  
Action: In general, it is best to leave them connected as shipped.
8. Problem: My 5V terminal reads only 4.6V.  
Action: This is normal. Tolerance is 4.5 to 5V.
9. Problem: There is significant crosstalk  
Action: High impedance, greater than 1K, inputs, such as accelerometers require signal conditioning.
10. Problem: My analog output accuracy is poor.  
Action: From the DOS command line, or in GO.BAT, run GFIND -C. This calibrates analog outputs. Note, however, that calibration sends full scale outputs, so it may be necessary to remove any instruments connected to the outputs.
11. Problem: Errors in Thermocouples on multiple units.  
Action: If thermocouples are connected to metal, object, remove – to common strap on terminals.

## Before Calling Customer Support

Check the following key areas to validate whether or not the DataShuttle is operational:

1. Make sure the AC Adapter is not damaged. To do this, detach the adapter from the DataShuttle, while leaving it plugged in to the wall outlet. Then measure the voltage between the inside and outside surfaces of the cylindrical connector. In this no-load condition, the voltage should measure approximately 9V. If this is not the case, it is likely that the AC Adapter will need to be replaced. (Polarity )
2. Check the power section of the DataShuttle. After plugging the AC Adapter back into the DataShuttle, check to make sure the LED is functioning. If the LED is not lighting up, then there is likely a problem with the power section of the unit. Contact technical support for further assistance.
3. Check the DataShuttle's internal power supply. To do this, it is necessary to measure four voltage terminals on the unit itself: the +5V and Vref(6.9V) terminals, found at opposite ends of the terminal strip next to the passthrough connector, and the +15V and the -12V terminals, which can be found on the raised section of the DataShuttle called the terminal board. (Please consult the diagrams on pages 1–5 through 1–7 if you are unable to locate these terminals.)

If you have been installing resistors or capacitors on the analog input auxiliary section, then it is necessary to remove the terminal board and re-check the +5V and Vref voltages. If, after removal, these voltages return to normal, it is likely that there is a short-to-ground on the terminal board. Check the resistor/capacitor installations for such a short and reinstall the board.

If removal does not fix the +5 and -12 voltages, then there is a problem with the DataShuttle's internal power supply. Contact technical support for further assistance.

## If You Need Customer Support

***To help us serve you better, please have the following information ready:***

1. Have the part number of your DataShuttle ready.
2. Have the type and version number of the software you're using.
3. Have your computer's type, model, and the version of the operating system.

## Product Specifications

Accuracy DataShuttle-16 Accuracy & Resolution-				
Range		Typical Resolution at Full Scale	Absolute Accuracy, the larger of	
			% of Range:	% of Reading:
VOLTAGE	-5 to +50 mV	.8 $\mu$ V	0.04%	-
	-25 to +25 mV	.8 $\mu$ V	0.08%	-
	-50 to +500 mV	8 $\mu$ V	0.01%	0.05%
	-250 to +250 mV	8 $\mu$ V	0.01%	0.05%
	-1 to +10 mV	150 $\mu$ V	0.01%	0.05%
	-5 to +5 mV	150 $\mu$ V	0.01%	0.10%

General Conditions – From 15 to 35 degrees C, ambient at the interface unit, source resistance less than 1k Ohms. Includes linearity, drift, offset, resolution, and calibration error.

If you are using a DataShuttle-5B, be sure to add the uncertainty of the isolation modules being used to these specifications.

### DataShuttle- 16 Thermocouple Accuracy

Type	Range (°C.)	Resolution (°C.)	Accuracy (°C.)
<b>J</b>	-210 to -100	0.1 – 0.3	± 2.3
	-100 to 0	0.05	± 1.2
	0 to 880	0.05 – 0.2	± 1
<b>K</b>	-250 to -75	0.15 – 1.0	± 8
	-75 to 1260	0.07 – 0.3	± 1.4
	0 to 900	0.06 – 0.2	± 1.2
<b>E</b>	-250 to -70	0.1 – 0.5	± 4
	-70 to 100	0.04	± 1
	100 to 680	0.04 – 0.15	± 0.8
<b>T</b>	-250 to -50	0.15 – 0.8	± 6
	-50 to 10	0.02 – 0.8	± 1.4
	10 to 150	0.06	± 1.2
	150 to 400	0.06 – 0.1	± 1
<b>S</b>	-50 to 120	0.4	± 10
	120 to 380	0.3	± 5
	380 to 1770	0.2 – 0.6	± 4
<b>R</b>	-50 to 250	0.2 – 0.4	± 10
	250 to 800	0.2	± 4
	800 to 1770	0.2 – 0.4	± 3
<b>B</b>	200 to 300	0.7 – 1	± 20
	300 to 500	0.4 – 0.7	± 13
	500 to 1000	0.2 – 0.4	± 8
	1000 to 1820	0.2 – 0.4	± 4
<b>G</b>	25 to 200	0.2 – 1	± 15
	200 to 2315	0.15 – 0.8	± 4
<b>D</b>	-20 to 2315	0.2 – 1	± 4
	150 to 2000	0.15 – 0.6	± 3
<b>C</b>	-20 to 2315	0.15 – 1	± 4
	100 to 1500	0.15 – 0.4	± 3
<b>N</b>	-200 to -100	0.7 – 1.4	± 5
	-100 to 1300	0.4 – 0.7	± 3

Thermocouple Conditions – Same as General Conditions. Does not include the accuracy of the thermocouple itself (cold junction error must be added in; cold junction compensation with DataShuttle-TCs only). Resolution assumes 12 bit resolution in use for DataShuttle-12, 16 bit resolution for DataShuttle-16; it is approximate as resolution varies with temperature measured.

Thermocouples use the 50 mV range. For inputs below -5 mV (below approximately -100 degrees C), use the +/-25 mV range.

Cold Junction Compensation Error – For the best resolution while using the DataShuttle-TCs, use the 50 mV range above -5 mV. Cold Junction Compensation Error (degrees C) at terminal temperature of:

<b>Cold Junction Compensation Error</b>			
<b>Type</b>	<b>25°C</b>	<b>15° &amp; 35°C</b>	<b>5° &amp; 45°C</b>
<b>J</b>	0	< 0.25	< 0.6
<b>K</b>	0	< 0.3	< 0.7
<b>E</b>	0	< 0.3	< 0.8
<b>T</b>	0	< 0.4	< 1.2
<b>S</b>	0	< 0.6	< 1.3
<b>R</b>	0	< 0.4	< 1.6
<b>B</b>	0	< 1.0	< 2.0
<b>G</b>	0	< 0.7	< 1.7
<b>C</b>	0	< 0.5	< 1.2
<b>D</b>	0	< 0.6	< 1.8
<b>N</b>	0	< 0.6	< 1.2

Cold junction compensation error is in reference to the temperature of the terminals. For types B and G the above error applies for measured temperatures above 200 degrees C only. The cold junction sensor can be re-calibrated at any temperature from 0°C to 50°C to improve the accuracy if it will not be used at 25°C.

### Cold Junction Temperature Differential

For the DataShuttle-TC only, the temperature gradient in the air adjacent to the cold junction plate is attenuated 15 times when AWG #22 gage or smaller thermocouple wire is used. The wires are bundled together for at least one foot from the cold junction terminals. The error is usually less than 0.1 degree C.

For the DataShuttle-GPs there is no isothermal plate. The cold junction compensation error consists of the above table plus the difference between the terminal temperature and the cold junction sensor.

This difference can be several degrees. The above table applies only after user calibration of the cold junction.

### DataShuttle-16 RTD Accuracy

<b>Set Resistor</b> <b>Ω</b>	<b>RTD</b> <b>Ω</b>	<b>Range</b> <b>°C</b>	<b>Resolution</b> <b>°C</b>	<b>Accuracy</b> <b>°C</b>
10 k	50	-200 to 115	0.005	0.8
20 k	50	-200 to 525	0.01	0.9
20 k	100	-200 to 115	0.005	0.8
50 k	50	-200 to >850	0.03	1.4
50 k	100	-200 to 750	0.01	1.0
50 k	200	-200 to 115	0.005	0.8
100 k	100	-200 to >850	0.03	1.4
100 k	200	-200 to 750	0.01	1.0
100 k	500	-200 to 115	0.005	0.8
200 k	200	-200 to >850	0.03	1.4
200 k	500	-200 to 525	0.01	0.9
200 k	1000	-200 to 115	0.005	0.8
500 k	500	-200 to >850	0.03	1.4
500 k	1000	-200 to 750	0.01	1.0
1000 k	1000	-200 to >850	0.03	1.4



RTD Conditions – Same as General Conditions. Does not include the accuracy of the RTD sensor itself. Includes linearization and signal conditioning errors.

Assumes 16-bit resolution is in use for the DataShuttle-16.

RTD measurements are on the 0-50 mV range.

## Input Impedance

All analog inputs have an impedance rating of  $>20M\Omega$

## Noise Rejection

Important: All noise measurements are in low noise mode, with inputs shorted to COM.

CMRR – Common Mode Rejection Ratio (CMRR) is  $>80\text{dB}$  under these conditions: DC to 100 Hz, common mode input  $\pm 7.0$  Volts channel to ground. This specification applies even when one or more nonmeasured channels exceeds the operating common mode range.

## DataShuttle Noise Rejection

Range	Typical Internal Noise (RMS)
50 mV	0.5 $\mu\text{V}$
$\pm 25$ mV	0.5 $\mu\text{V}$
500 mV	4 $\mu\text{V}$
$\pm 250$ mV	4 $\mu\text{V}$
10 V	50 $\mu\text{V}$
$\pm 5$ V	50 $\mu\text{V}$

## Common Mode Range

Operating, channel-to-ground –  $\pm 7$  Volts

Nonoperating –  $\pm 50$  Volts continuous.

## Input Protection

On analog input channels: 50 Volts continuous; 150 Volts momentary.

## Resolution/Scan Rate

Both resolution and scan rate are selectable in software

### ***DataShuttle-16 Resolution And Scan Rate\****

Resolution	Scan Rate
low noise mode: 0.0015 %	45 / 55 Hz
16 bits: 0.0015 %	200 Hz
15 bits: 0.003 %	330 Hz
14 bits: 0.006 %	500 Hz
13 bits: 0.012 %	700 Hz
12 bits: 0.024 %	900 Hz
10 bits: 0.1 %	1400 Hz

\* Rates describe an IBM PC 486DX2 running at 66 MHz under Windows 3.1; tolerate error = 1 in DASyLab. Rates are somewhat faster in faster computers. Also see the discussion of “Dynamic Resolution,” on page 1-2.

## Analog Input

Scan Rate – Scan rate is the rate in Hertz (or, samples per second) to read data into memory, including the time it takes to switch channels and ranges. To calculate the total scan time for all channels, divide the rate by the number of channels.

### ***For the Analog Input Terminals on the DataShuttle***

- Maximum voltage on any terminal: 150 volts.
- Maximum voltage on DS-5B models: 1500 volts.
- Maximum current on any terminal: 1 Amp.

## Digital Input/Output

### ***For the Digital Input/Output Termination on the DataShuttle***

- Each line is individually selected to be an input or output.
- Inputs are TTL and MOS compatible
- Outputs are high voltage open collector:
- Low Level: 50 mA max, < 0.7 volts at 40 mA (sink)
- High Level: 30 volts max, <250  $\mu$ A (source)
- TTL outputs are available at the input terminals when an I/O is set to an output:
  - Low Level: < 0.4 volts at 2 mA (sink)
  - High Level: > 2.4 volts at 100  $\mu$ A (source)
- Maximum voltage on any terminal with digital isolation modules installed: up to 300 VAC, depending on module.

## Counter/Timer

The DataShuttle has one on-unit 16-bit counter/timer with 2 MHz internal clock. It can count pulses as fast as 3 MHz.

- Low Level: <0.4 volts at 2mA (sink)
- High Level: >2.4 volts at 100  $\mu$ A (source)

## Analog Output

For the analog output terminals on the DataShuttle-AO –

- Voltage compliance: will drive up to 1K load positive or negative
- Current compliance: 3 to 30V, sinking current only
- Maximum output speed: 2KHz (preliminary)

<b><i>DataShuttle-AO Resolution And Accuracy</i></b>		
<b>Output Range</b>	<b>Nominal Resolution</b>	<b>Accuracy</b>
0 to 10V	2.4mV	$\pm$ 10mV
0 to 5V	1.2mV	$\pm$ 5mV
0 to 2V	0.48mV	$\pm$ 3mV
$\pm$ 5V	2.4mV	$\pm$ 10mV
$\pm$ 2.5V	1.2mV	$\pm$ 5mV
$\pm$ 1V	0.48mV	$\pm$ 3mV
4 to 20mA	3.9 $\mu$ A	$\pm$ 50 $\mu$ A

## General Information

### ***General Specifications of the DataShuttle***

- Analog input operating ambient temperature: 0 to 50 degrees C, 5 to 90% RH, noncondensing
- Input power voltage range: 5.0 to 9.0 VDC
- Maximum input voltage before damage: 10.0VDC
- Supply current consumed with no external loads: <450mA
- Polarity of DC input connector: Outer surface +, inner surface –

### ***General Specifications of the DS-5B Models***

- Analog input operating ambient temperature: 0 to 50 degrees C, 5 to 90% RH, noncondensing
- Input power voltage range: 5.0 VDC,  $\pm 5\%$
- Maximum input voltage before damage: 7.0 V
- Supply current consumed: <450mA with no modules installed, <2.5A with worst case modules installed
- Polarity of DC input connector: Outer surface +, inner surface –



Thank you for selecting the DynaRes board for your project.

Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to furnish the performance you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your budget.

We manufacture the DynaRes as an enhancement board that readily mounts in an expansion slot in an IBM PC, or compatible, computer.

This product's high noise rejection, its input protection to withstand as much as 150 Volts, and its guaranteed long term stability make it ideal both for the laboratory and for harsh industrial environments.

Using the DynaRes board together with our graphical interface application software (such as DASyLab<sup>®</sup>, or QuickLog PC), you can easily and very quickly implement a broad spectrum of research and commercial tasks, in a variety of settings. You can, for example,

- Display and log data to disk for later analysis,
- Measure temperature, pressure, flow and most other analog inputs from sensors and instruments,
- Perform scale, offset, or complex calculations on a measurement,
- Monitor and control processes,
- Set alarm limits on any input,
- Control devices at preset levels (fans, pumps, heaters, etc.),
- Control devices from digital input (e. g., from switches or TTL signals), and
- Gather data unattended.

You can use the system interactively, operating controls or modifying your setup while the system is running.

---

## **General Information**

### **Development System**

People who decide, to write their own software (rather than using an off-the-shelf application) can employ the Analog Connection Windows Development System hardware driver. This addresses all features of the DynaRes board from within a program they design and code for their specific purpose.

### **Expandability**

A DynaRes product, depending on the model, has either eight or 16 differential analog input channels. You can add one board at a time to your computer, up to as many as 15 boards, up to 240 analog input channels and 240 digital input/output lines.

### **Ranges/Units of Measure**

The six input ranges of the DynaRes span from 25 milliVolts through 10 Volts, capable of accepting data from almost any sensor. Its high accuracy also makes the DynaRes ideal for precise measurement in the laboratory.

The DynaRes together with our software – such as DASyLab<sup>®</sup> and QuickLog PC – make it easy to specify engineering units (degrees, Volts, milliAmperes, etc.) for measurements, as well as which ranges to use.

You can measure temperature, for example, by selecting from among 11 different thermocouple types, or from a variety of resistance temperature detectors – RTDs. With our application software, the process simply consists of selecting the type of sensing device from a menu – the driver automatically handles cold junction compensation and linearization.

## Data Presentation

The combination of our hardware and application software (DASYLab® or QuickLog PC) enables both the display of data on the screen, and the logging of data to disk for later analysis.

The system is capable of showing data on the monitor in a variety of formats, including graphical meters. Charts can indicate trends for comparison of actual measurements on several channels, or for setting data points or alarms.

## Dynamic Resolution

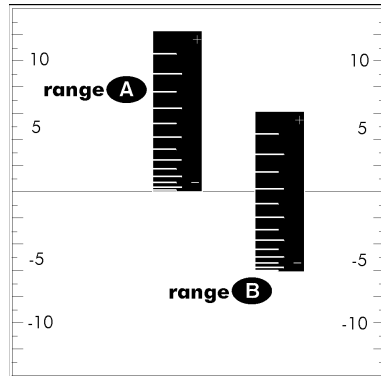
Your DynaRes incorporates “Dynamic Resolution,” improving the board’s accuracy.

With this feature, resolution is greater at the lower (negative) end of any range than at the higher end. As your readings approach the low end of any given range, the resolution becomes finer (that is, the increments of the signal you can distinguish become smaller).

This feature allows you to obtain the same advantages of an integrating converter, with the speed of a sample and hold converter, but without its susceptibility to noise.

Dynamic resolution gives a resolution that is a fixed percentage of the input voltage (not full-scale voltage) down to about 10% of full scale. Our products, consequently, are the best available for taking accurate measurements of low-level signals, as you would using a thermocouple sensor.

Dynamic resolution is always best toward the negative end of any range:



*Dynamic Resolution for Dissimilar Ranges*

Two vertical black “rulers” (range **A** and range **B**) portray the impact of Dynamic Resolution. Their graduations – representing their ability to resolve – are always finer at the lower (more negative) ends of their ranges, regardless of the spectrum of values the ranges are measuring.

---

## Features and Configurations

The DynaRes line consists of two models: the DynaRes 8 and the DynaRes 16.

<b>Analog Input Channels</b>	A DynaRes board can have two possible analog input configurations, also depending on the model of the product: The DynaRes 8 features eight differential analog inputs, and the DynaRes 16 model offer 16 differential analog inputs.
<b>Resolution Selections</b>	The resolution of your DynaRes is selectable in software, ranging from 10 through 16 bits, or 0.0015% of full scale. (The DynaRes also features advanced “dynamic resolution.” See page 1 – 2 for further explanation.)
<b>Data Acquisition Speed</b>	Maximum acquisition rates for the DynaRes 8/16 range up to 1700 Hz.
<b>Ranges</b>	DynaRes products have six voltage ranges, all selectable individually for each analog input channel
<b>Noise Rejection</b>	All DynaRes models feature a high noise rejection integrating converter (in “low noise mode” it helps reject 50/60 Hz AC power line interference).
<b>Sensors</b>	Each DynaRes provides accurate cold junction compensation and linearization for thermocouple devices, and signal conditioning for resistance temperature detectors (RTDs).
<b>Accuracy</b>	We guarantee the factory calibration of the DynaRes. See the Warranty Card for the exact guarantee. (If it is ever necessary, the user can recalibrate the board with precision through the use of software utilities we provide with every product.)
<b>Input Protection</b>	Built-in circuitry assures protection of analog input channels for 50 Volts, continuous , or 150 Volts, momentary.
<b>Digital I/O</b>	There are 8 digital input/output channels on the DynaRes 8 models; 16 digital I/Os are available on the DynaRes 16.
<b>Counter/Timer</b>	Every DynaRes board includes a counter/timer for precise timing (for counting pulses or other events) which you can also use as a pulse output. ( <i>NOTE: If you are using DASyLab, the counter/timer of the first board installed will not be available for use.</i> )
<b>Terminal Panels</b>	Available accessories for the DynaRes include your choice of screw terminal panels for connecting sensors. They include general purpose, thermocouple, and resistance temperature detector (RTD) device terminal panels, all of which accept digital opto-isolators.

### For More Information

For more information about the capabilities of your DynaRes, please see “Product Specifications” in Chapter 3.

For instructions on controlling the board with our interface software (such as DASyLab or QuickLog PC), refer to the appropriate software manual.

Consult our Applications manual to learn more about data acquisition, process control in general, and how to use our products together to accomplish everyday tasks.

If you're creating your own program to address the DynaRes for a custom purpose, please see the Analog Connection Development System Manual.

## **DynaRes System Requirements**

Before installing the DynaRes, make sure the computer system fulfills these minimum requirements:

### ***Hardware***

- IBM PC AT (or higher) or -compatible, with at least 640k system RAM,
- Floppy disk drive, CD-ROM drive and a hard drive.

### ***Software Environment***

- Windows 3.1/95/98/NT,
- Application software (DASYLab, QuickLog PC, the Analog Connection Windows Development System, or other compatible proprietary software; please see your software manual for directions for using it with the DataShuttle). QuickLog for Windows 3.1, 95/98 only.



## Overview

Getting your DynaRes data acquisition and process control board up and running is a straightforward process; you only need to:

- Verify the board's switch settings that control board identity and system addressing (see page 4 – 1),
- Physically insert the board into a slot of the personal computer (page 4 – 2; and illustration on 4 – 2),
- Connect a terminal panel to the board (to attach sensing devices and for digital outputs from the DynaRes; see page 4 – 2), and
- Load and start up the software to be used for the project.

As the scope of this manual focuses on the DynaRes board, this chapter discusses board's switch settings, and the physical insertion of the board.

Please see your terminal panel manual for full instructions regarding its attachment to the DynaRes, as well as for how to connect sensors to the panel.

Guidelines for loading the software, and for starting up, depend on the application program you are going to use (such as DASyLab<sup>®</sup> or QuickLog PC, or a package by a third party developer who has our authorization).

The program you are going to use with the DynaRes might even be unique and proprietary, a product of your organization. (The Analog Connection Development System is a powerful set of utilities making it possible for software engineers to design and develop their own programs to exploit the DynaRes' many features.)

In any event, please refer to the software provider's installation manual, or user guide, for specific information on how to load and run the particular program.

Troubleshooting – If you have any difficulty getting your board to work, refer to the “Troubleshooting” section in Chapter 5.

---

## Verifying DynaRes Switch Settings

### Single Board

When you purchase a data acquisition board new from our company, the product's switch settings already are correct to operate a single board with our software (DASyLab, QuickLog PC, the Analog Connection Development System, and all others).

This means the factory switch settings are right for the purpose of using only one board, and you can skip the task of confirming them. You can go directly to the “Physical Board Installation” section on page 4 – 2 in this chapter, and begin to follow the steps there.

### Multiple Boards

If you are using more than one board at a time, set the individual boards' Board Number Switch first (refer to “Setting the Board Number Switch” on page 4 – 4), then go on to perform the physical installation.

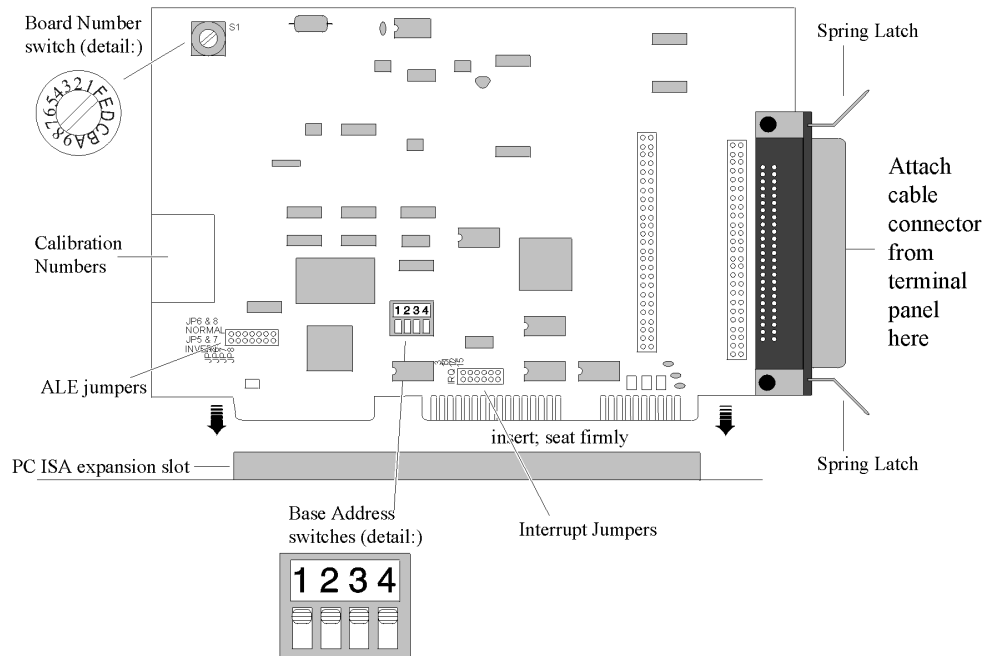
Otherwise, there's no reason to be concerned about the board's switch settings, except in the unlikely event you encounter a problem in getting your product to operate. (If you experience a problem, refer to “Troubleshooting” in Chapter 5).

## Previously in Use

If, on the other hand, your board has been in use previously in another computer, or if your company uses its own proprietary software, the present switch positions might differ from the factory settings.

If your company uses such a program, making changes to factory switch settings might be necessary to accommodate it. Please consult the administrator of your internal system, or the provider of third party software, to determine their recommendations for any unusual switch setting.

To check and restore the factory values, please read “Board Number Switch Settings” on 4 – 4 in this chapter.



*Illustration of DynaRes Data Acquisition Board, Showing Physical Installation*

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## Physical Board Installation

Installation consists of inserting the board into an open peripheral (expansion) slot inside your computer.

(There are, for example, five available slots in the IBM PC, and eight in the IBM XT or AT. IBM and other companies sell expansion chassis that can accept even more analog cards. Our software supports as many as 15 boards at one time.)

## Terminal Panel Connections

When using a terminal panel with the DynaRes (to connect external devices: sensors and digital input/output) you are going to use the provided Centronics cable.

Each cable can conduct eight analog input channels and eight digital I/O lines from your DynaRes to a single terminal panel.

**One Terminal Panel, One Cable** – A DynaRes 8, using eight analog input channels, requires one Centronics cable for connection to one terminal panel (this also allows the use of eight digital I/O lines).

**Two Terminal Panels, Two Cables** – A DynaRes 16, using 16 analog input channels, requires two Centronics cables for connection to two terminal panels (to handle two “banks” of eight analog inputs: Analog Input Channels 1- 8, and Analog Input Channels 9-16).

(Refer to “Pinouts,” in Chapter 5 of this manual, for a description of the signals at the connectors.)

## Physical Installation

### To Install the DynaRes Board

1. **TURN THE COMPUTER OFF.** Never remove the cover of the computer without first turning the power switch off.
2. **Open the Computer** Remove the cover of the computer. (If appropriate, refer to the computer's owner's manual for more information about removing the cover and installing enhancement boards.)
3. **Ground Yourself** While holding the board, before installing it, touch the metal chassis of the computer to discharge any static electricity that might be on the surface of your body.

This is important, as static electricity can damage electronic parts. (Likewise, if you ever remove the board from the computer, always store it in its protective shipping bag.)

4. **Remove Plate** At the back panel of the computer, unscrew and remove the narrow dust cover plate that is directly behind the expansion slot you want to use. (Keep this screw handy.)
5. **Insert the Board** Push the edge of the DynaRes board having "gold fingers" down and into the expansion slot (socket) on the chassis, making sure that the contacts align with the socket and the spring latches are through the socket. Then plug it in by pushing the board straight down. (NOTE: If you are using a DynaRes 16, a second expansion slot is required for the second cable connector.)
6. **Fasten the Board to the Chassis** Install the "left over" screw from step 4. Place it in the original hole, through the DynaRes board's bracket, so that it fastens the top of the bracket to the computer's back panel.
7. **Connect the Cable to the Terminal Panel** Plug the cable's connector into the socket on the terminal panel (please refer to your terminal panel's manual, if you are unsure about the correct position).

### CAUTION



**Incorrect installation of these cables can damage the data acquisition board or the terminal panel. If you are uncertain about proper placement, please see "Terminal Panel Connections" at the beginning of this discussion, and inspect the diagram on page 4 – 2 .)**

### Next Steps



**If you are going to measure current, please see "Measuring Current" on the next page.**

**Single Board Usage** – If you intend to run with a single data acquisition board in your system, you are now ready to install your application software and to connect sensors to your terminal panel.

**Multiple Board Usage** – If you are going to use more than one data acquisition board, now it's time to set each Board Number Switch to a unique number. Follow the steps in the "Setting the Board Number Switch" section in this chapter on page 4 – 4.

**Installing the Software** – For information on loading and configuring our DASyLab or QuickLog PC please refer to the user guide for that application package.

**Installing the Terminal Panels** – To learn how to connect experiments to the terminal panel see your terminal panel owner's manual, or our Applications manual (which discusses data acquisition and control in general and provides examples of uses for the products).

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## Measuring Current

If you are going to connect a current, rather than a voltage, to one or more of the analog input channels, then make certain to set the “Current/Volt” switch for that channel on the terminal panel. These switches are located under the daughterboard on the T71 terminal panel (*see Terminal Panels manual for illustration*).

Moving a switch to the “Current” position selects current, placing a precision 24.9Ω, 0.1% resistor in the circuit for that channel.

### CAUTION



Two kinds of misuse can burn out the board’s input sense resistors:  
Do not apply a voltage to a channel whose setting is for current.  
Also, do not apply more than 50 mA to a channel set for current.

---

## Setting the Board Number Switch

### Multiple Boards

When you are using multiple boards in your installation, each board needs to have an identity for the software to recognize it as an “individual.”

The Board Number switch on a board accomplishes this, as it enables you to set an identifying number for the board (see the illustration on page 4 – 2).

This number determines, among other things, the sequence in which the software reads multiple boards (application programs can address as many as 15 boards).

When using more than one DynaRes product in your installation, every board’s Board Number switch needs to have a different number setting, and all switches are to be in number sequence, starting with 1. For example, if you are using three boards, the board number sequence would be 1, 2, 3. Set the address and interrupt on all boards to the same settings.

### Single Board

If your system includes just a single data acquisition board, then you don’t need to have much concern about the Board Number switch.

When your DynaRes leaves our manufacturing facility, we set the Board Number switch to 1, and this is the setting we recommend for most purposes when you are using only one board in your installation.

### Disabling Boards

If you want to disable the board, for any reason, set its Board Number switch to 0. This is handy if you want to use fewer boards: that way you don’t have to remove them from the computer. Remember, however, that all remaining boards must have their board numbers in a continuous sequence.

## Setting the Switch

### To Set the Board Number Switch

1. **Locate the Switch** With the cover of your computer removed, examine the illustration on page 4 – 2 in this chapter and find the “Board Number Switch” on the DynaRes.

On the printed circuit board, this is a rotary switch with the label “BRD SEL.”

2. **Make the Setting** Note that the switch has 16 possible positions: numbers on the detents are 0 through 9 and A through F.

Determine which is to be the First Board. (This is easy, if it is the sole board.) Then turn its dial to 1.

Determine which is to be the Second Board, then set its switch to 2.

Continue to set the switches for all boards in your installation to unique numerical values in an unbroken sequence.

(As various models of our boards use different kinds of switches, please see their owner's manuals for an explanation of how to set switches on other boards.)

---

## Setting the Base Address

The Base Address determines the logical system address where the personal computer expects to find all data acquisition boards. Base Addresses must be the same on all boards.

The factory setting for all of our data acquisition products is 300H (in hexadecimal format).

It is rarely necessary, but if you have difficulty getting the board to work, you can change these switches to values different from the factory settings. (Another device in your PC, for example, might be trying to use the same Base Address.)

Indications of this are: if the program reports it cannot find your board, or if it reports fewer boards than you really have, or if another board starts to work improperly after you install the DynaRes.

These problems indicate interference with another board using the same base address as the DynaRes product.

Remedy the problem by changing the switches of all data acquisition boards to an address that has no conflict. (If you have boards other than DynaRes in your system, please refer to their owner's manuals for instructions on how to change their settings.)

## Setting DynaRes Base Address

### To Set the Base Address

1. Locate the Address Switches Remove the cover of your computer over the data acquisition board, and find the location of the Base Address switches. Refer to the board illustration on page 4 – 2 in this chapter and find “Base Address Switches” on the DynaRes diagram.

On the printed circuit board itself, this is a block of four DIP switches.

**Note:** Depending on the space available in your installation, it might be necessary to remove the board to reach the Base Address Switches. If so, please follow the same precautions as in “Physical Installation” on page 4 – 3.)

2. Change the Setting 300H is the normal base address. It consists of all four DIP switches' being in the “up” position (when the board is sitting in the computer's expansion slot).

The DIP switches have the labels “1” through “4.” Sliding a switch to the “down” position adds a value to 300H:

<i>DynaRes Base Address Switch Additive Values*</i>		
Switch	Position	To 300H Add
1	Down	10H
2	Down	20H
3	Down	40H
4	Down	80H

\* As the switches are additive, your sliding Switches 1 and 4 down, for example, is going to add 10H and 80H to the 300H, equalling 390H.

## Base Address Settings

<i>Possible DynaRes Base Address Settings</i>					
Value	Switch Positions*				Comments
	1	2	3	4	
300H	U	U	U	U	Factory setting
310H	D	U	U	U	-
320H	U	D	U	U	May interfere with hard disk drive
330H	D	D	U	U	-
340H	U	U	D	U	Recommended alternative
350H	D	U	D	U	-
360H	U	D	D	U	-
370H	D	D	D	U	May interfere with parallel printer
380H	U	U	U	D	-
390H	D	U	U	D	-
3A0H	U	D	U	D	-
3B0H	D	D	U	D	-
3C0H	U	U	D	D	-
3D0H	D	U	D	D	May interfere with graphics adaptor
3E0H	U	D	D	D	-
3F0H	D	D	D	D	May interfere with floppy disk drive

\* U = Up D = Down

---

## Changing Hardware Interrupts

For users of Windows programs that employ hardware interrupts, the DynaRes board provides for changing the interrupt number, if necessary.

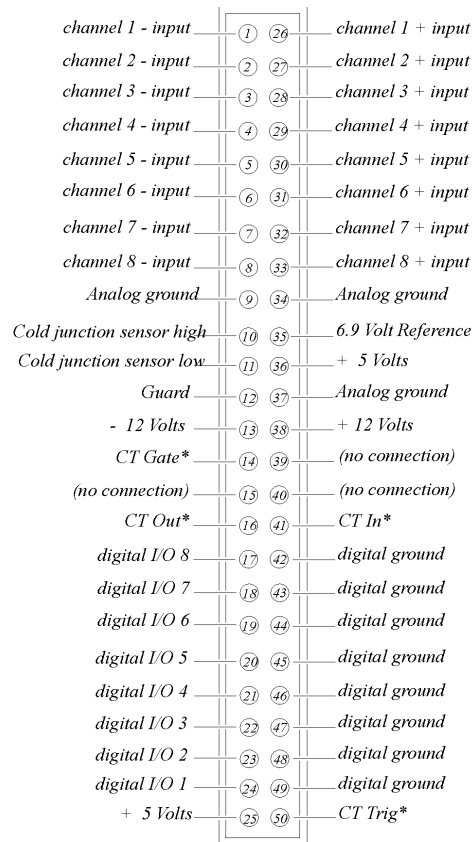
Refer to page 4 – 2 to locate the interrupt jumper block on the DynaRes board. By repositioning the jumper, which is a plug, to another socket on the block, you can select another of these interrupts: IRQ2, IRQ5, IRQ7, IRQ11, IRQ12, or IRQ15. (Remember that on AT computers the IRQ2 selection is actually the IRQ9 line.)

## Overview

Although operations in this chapter are seldom necessary during everyday data acquisition, you might want to refer to them at certain times during operation of the DynaRes. They are

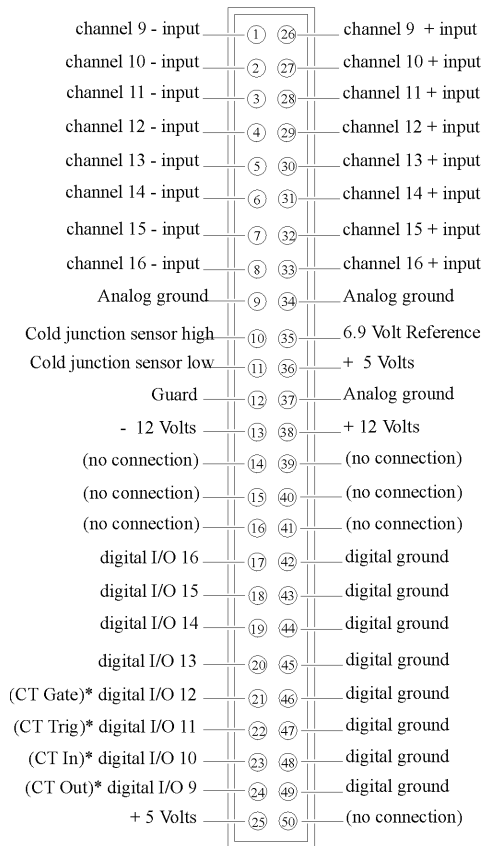
- Pinouts (at the board's connectors in the event you want to connect analog or digital signals directly, without using a terminal panel; refer to pages 5 – 1);
- Block diagram of the DynaRes showing on-board processing (see page 5 –2);
- Recalibration of all DynaRes on-board references to bring the accuracy of the product to factory specifications (see page 5 – 3);
- Using EDITCAL to edit calibration files on EEPROM to accommodate changes to your installation, or to restore missing files (on page 5 –3);
- Note for DOS users with respect to the Analog Connection Development System (see page 5 – 4);
- Troubleshooting: some possible problems and solutions after installing, and during operation of the DynaRes (starting on page 5 – 4).

## Pin Assignments



*\* Note: When two terminal panels are used, the one spare counter/timer on the board can be accessed from both terminal panels. Access to the CT lines is through pins 14, 16, 41, and 50 on Terminal Panel 1 or through pins 21-24 on Terminal Panel 2 (pins 14, 16, 41, and 50 will have no connection on this panel). If one of these CT lines is used, then that pin number on the other terminal panel cannot be used.*

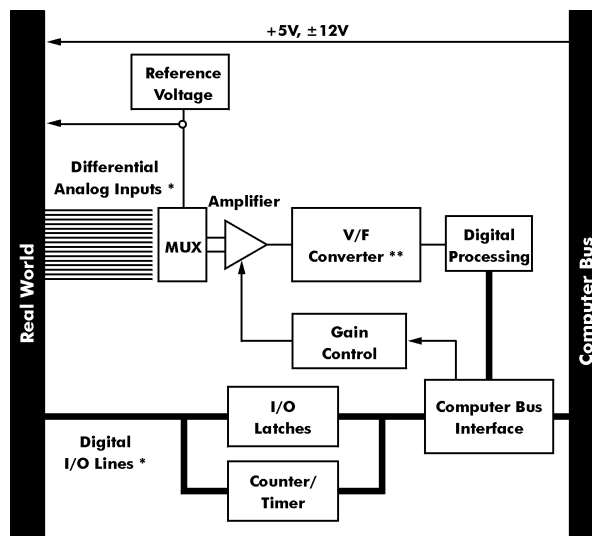
### **Pinouts of the DynaRes 8 and Channels 1-8 on the DynaRes 16 (at Back Panel Connector)**



\* *Note:* See the note on counter/timer lines on page 3-2.

**Pinouts of Channels 9-16 on the DynaRes 16  
(at Back Panel Connector)**

**Block Diagram**



\* **Analog Inputs and Digital I/Os:** 8 channels for DynaRes 8  
16 channels for DynaRes 16

\*\* **V/F Converter:** 12 bits for WB-DynaRes 8  
and WB-DynaRes 16

**Block Diagram of the DynaRes (All Models)**



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## **Recalibration**

Your DynaRes uses an exclusive calibration technology to achieve great stability, typically requiring no adjustment for years. Please see the Warranty Card for your exact guarantee of calibration.

### **Factory Methods**

Instead of employing adjustment potentiometers to calibrate the board, our technicians test and calibrate each DynaRes after assembly. They then enter that board's unique calibration number values into EEPROMs on the board; we also print the same numbers on a label on the board itself.

Whenever you use our software with the board thereafter, the programs read the factory's calibration numbers from the EEPROM, and automatically make minor compensations for real-world conditions (for instance, for cold junction properties of a thermocouple).

### **Recalibration**

Under normal conditions, no full recalibration of the DynaRes is necessary.

(If you ever suspect that your DynaRes is out of tolerance, please call Technical Support for advice. If it requires recalibration, we can perform the work for you at our facility using the same high accuracy test equipment we use during the manufacturing quality assurance process.)

Only if your organization is proficient in such techniques, and only if you have the necessary equipment, do we encourage you to proceed with recalibration (and please contact our Technical Support Department for guidelines).

For most customers, we recommend returning the board to our Technical Services Department, instead.

---

## **EDITCAL Utility**

EDITCAL.EXE (or EDITCAL, for short) is the utility program that simplifies the modification of values in the EEPROM.

### **Starting Editcal**

Make sure the EDITCAL.EXE program file is in the same sub-directory as the application programs.

At the DOS prompt, enter EDITCAL, then press the [ENTER] key. (This invokes the utility.)

### **EDITCAL Selections**

#### ***To Select a Function***

1. Use the arrow keys to navigate back and forth among these menu selections:

DATA FILES - To merge calibration files supplied from the factory into a single file for systems that have multiple boards, or to update existing calibration file (not for use with DynaRes boards).

AC EEPROM - To view or modify calibration data on Analog Connection boards (including DynaRes boards) that have non-volatile on-board EEPROMS.

QUIT - Ends this EDITCAL session.

2. Move the arrow keys until the selection you want is flashing.
3. Press [ENTER].

---

## Troubleshooting: Installation

If you experience difficulty in getting your data acquisition board up and running, please check to see that the installation is according to the descriptions in Chapter 4.

If the software reports a board failure, or that it cannot find a board, then try these remedies:

1. Confirm that the board is seated properly in the PC expansion slot (reseat it, if necessary; see the illustration on page 4 – 2).
2. Verify the Board Number switch is not set to “0.” (See page 4 – 4).
3. Use a different Base Address. It is possible that another device in your installation is trying to use the same Base Address (see the explanation on page 4 – 5). You may optionally specify this new number in the STI\_DRV.INI.
4. If there is more than one data acquisition board in your installation, make sure they all have the same Base Address and interrupt, but sequential Board Numbers, starting with 1.
5. Install the board in another open slot in the PC (follow the instructions on page 4 – 2).
6. Remove other devices from expansion slots in your PC to check whether they are conflicting with your DynaRes board.
7. Verify that the software is up to date (a version compatible with the board you are using. Contact your software provider or us).
8. Try different IRQ levels. If you are operating under our Windows software, change the IRQ level on the jumpers on your data acquisition board (see illustration on page 4 – 2 to locate these jumpers). You may want to specify this new number in your STI\_DRV.INI file. Alternatively, you may change the IRQ levels of other hardware in your computer. If using QuickLog, check for

[386Enh]

DEVICE=C:\QLFW\STIDATAQ.386

in System.ini file

9. Remove other software drivers that may conflict with ours.
10. If possible, install the board in another computer to verify its correct operation.
11. Try alternate bus timing jumpers. On some models of computers, the Address Latch Enable (ALE) timing is not compatible with our data acquisition boards.

To try the alternate (falling edge) timing, locate jumpers JP5 through JP8 on the data acquisition board. The normal (rising edge) timing position is JP6 and JP8. To change this, you need to cut these traces with a sharp knife, then solder a wire across JP5 and JP7.

(NOTE: This alternate connection may not work in all models of computers.)

## If You Need Customer Support

### *What to do before calling technical support, to help us serve you better:*

1. Have the part numbers of your boards and terminal panels ready.
2. Have the type and version number of the software you're using.
3. Have your computer's type, model, and the version of the operating system.

---

## Troubleshooting: Operation

### Hints

During operation, it's good practice to short all analog input channels you're not using; to do this, connect + to – to Com.

It's essential to have exactly one ground reference per channel. This single connection to ground makes sure you don't exceed the common mode range of input.

(More than one connection per channel can lead to ground loops, causing errors or erratic readings. Connecting the – to the Com terminal provides a single ground. Your sensor might also provide another ground. If you're not sure that your sensor is grounded, try connecting the – to Com, and not, and see which works best.)

Remember that if speed is not critical, selecting the "low noise mode" in software always provides the best accuracy and resolution with your data acquisition board.

### Operating Qs And As

1. Problem: My board reads analog inputs wrong.  
Action: Make sure the calibration numbers in the EEPROM are correct (see the discussion beginning on page 5 – 6 in this chapter). If the figures are correct, try shorting + to – to Com: the board should return a reading around 0V.
2. Problem: My board reads the thermocouple as a very negative temperature.  
Action: Verify the connections are secure. Opens read as negative temperature.
3. Problem: My board reads thermocouple input wrong.  
Action: Confirm that the CCAL number in the EEPROM matches the number on the terminal panel's calibration label.

(If you need to use a general-purpose terminal panel – one that doesn't have a factory CCAL number – with a thermocouple, you can achieve approximate results by entering a CCAL of 22000. Then change the figure by about 75 points for each degree C. that you want to raise the temperature.)

4. Problem: My readings are noisy.  
Action: Try using the low noise mode (see your software manual for more information).
5. Problem: My board used to work, but now the software cannot find it, or reports an error.  
Action: Check to make sure the Board Number switch is not set to "0."

### If You Need Customer Support

#### ***What to do before calling technical support, to help us serve you better:***

1. Have the part numbers of your boards and terminal panels ready.
2. Have the type and version number of the software you're using.
3. Have your computer's type, model, and the version of the operating system.

---

## Product Specifications: DynaRes 8/16

### Specifications of the DynaRes 8 and DynaRes 16

<i>Accuracy DynaRes 8/16 General Conditions</i>				
Range		Typical Resolution at Full Scale	Absolute Accuracy, the Larger of % of Range: % of Reading:	
VOLTAGE	-5 to +50 mV	0.8 $\mu$ V	0.04%	–
	-25 to +25mV	0.8 $\mu$ V	0.08%	–
	-50 to +500mV	8 $\mu$ V	0.01%	0.05%
	-250 to +250 mV	8 $\mu$ V	0.01%	0.05%
	-1 to +10 V	150 $\mu$ V	0.01%	0.05%
	-5 to +5 V	150 $\mu$ V	0.01%	0.10%

General Conditions – From 15 to 35 degrees C. ambient at the interface board, source resistance less than 1k Ohms. Includes linearity, drift, offset, resolution, and calibration error. 16 bit (0.0015%) resolution in use.

Thermocouple Conditions – Same as General Conditions. Does not include the accuracy of the thermocouple itself (cold junction error must be added in; cold junction compensation with T21 terminal panel only; please see your terminal panel manual's specifications for cold junction compensation error). Resolution assumes 16 bit resolution in use; it is approximate because resolution varies with temperature.

Thermocouples use the 50 mV range. For inputs below -5 mV (below approximately -100 degrees C.) use the +/-25 mV range. For the best resolution use the 50 mV range above -5 mV.

<b>DynaRes 8/16 Thermocouple Accuracy</b>			
<b>Type</b>	<b>Range (°C.)</b>	<b>Resolution (°C.)</b>	<b>Accuracy (°C.)</b>
J	-210 to -100	0.02 – 0.04	± 1.2
	-100 to 100	0.02	± 0.7
	100 to 880	0.01	± 0.5
K	-250 to -150	0.03 – 0.15	± 4
	-150 to -50	0.03	± 1
	-50 to 1260	0.02	± 0.7
E	-250 to -100	0.08 – 0.01	± 2
	-100 to 200	0.01	± 0.6
	200 to 680	0.01	± 0.4
T	-250 to -120	0.03 – 0.1	± 3
	-120 to -25	0.02 – 0.03	± 0.9
	-25 to 200	0.01 – 0.02	± 0.7
	200 to 400	0.01	± 0.5
S	-50 to 50	0.1 – 0.2	± 5
	50 to 300	0.1	± 3
	300 to 1770	0.08	± 2
R	-50 to 25	0.1 – 0.2	± 5
	25 to 200	0.1	± 3
	200 to 1770	0.08	± 2
B	200 to 300	0.25 – 0.4	± 10
	300 to 500	0.15 – 0.25	± 6
	500 to 1000	0.08 – 0.15	± 4
	1000 to 1820	0.08	± 2
G	25 to 200	0.08 – 0.3	± 8
	200 to 2315	0.08	± 2
D	-20 to 2315	0.04 – 0.08	± 2
	300 to 1500	0.04	± 1.3
C	-20 to 2315	0.04 – 0.08	± 2
	100 to 1500	0.05	± 1.5
N	-200 to -100	0.05 – 0.1	± 3
	-100 to 1300	0.02 – 0.05	± 1.5

<b>DynaRes 8/16 RTD Accuracy</b>				
<b>Set Resistor Ω</b>	<b>RTD Ω</b>	<b>Range °C.</b>	<b>Resolution °C.</b>	<b>Accuracy °C.</b>
10 k	50	-200 to 115	0.005	0.8
20 k	50	-200 to 525	0.01	0.9
20 k	100	-200 to 115	0.005	0.8
50 k	50	-200 to >850	0.03	1.4
50 k	100	-200 to 750	0.01	1.0
50 k	200	-200 to 115	0.005	0.8
100 k	100	-200 to >850	0.03	1.4
100 k	200	-200 to 750	0.01	1.0
100 k	500	-200 to 115	0.005	0.8
200 k	200	-200 to >850	0.03	1.4
200 k	500	-200 to 525	0.01	0.9
200 k	1000	-200 to 115	0.005	0.8
500 k	500	-200 to >850	0.03	1.4
500 k	1000	-200 to 750	0.01	1.0
1000 k	1000	-200 to >850	0.03	1.4

RTD Conditions – Same as General Conditions. It does not include the accuracy of the RTD sensor itself. RTD Conditions includes linearization and signal conditioning errors. Resolution assumes 16-bit resolution is in use. RTD measurements are on the 50 mV range.

## Stability

Accuracy specifications in this chapter already reflect these temperature drift errors for temperatures from 20° through 40° C.:

<b>DynaRes 8/16 STABILITY</b>		
<b>Range</b>	<b>% per °C.</b>	<b>% Over a Year</b>
50 mV	± 0.001	± 0.02
± 25mV	± 0.001	± 0.02
all other voltage ranges	± 0.0025	± 0.03

In many applications, stability and noise can be more important than absolute accuracy. This is “repeatability.” Calculate the repeatability of a reading by adding together the stability and noise for the range you want.

## Input Impedance

The DynaRes 8/16 Ultra has an input impedance of > 20 MΩ.

## Noise Rejection

Important: All noise measurements are in low noise mode.

CMRR – The Common Mode Rejection Ratio (CMRR) is >20 dB. Conditions for CMRR: DC to 400 Hz, common mode input ± 7.0 Volts channel to ground. This specification applies even when one or more nonmeasured channels exceeds the operating common mode range.

<b>DynaRes 8/16 Noise Rejection</b>	
<b>Range</b>	<b>Typical Internal Noise (RMS)</b>
50 mV	0.5 μV
± 25 mV	0.5 μV
500 mV	2.5 μV
± 250 mV	2.5 μV
10 V	50 μV
± 5 V	50 μV

## Common Mode Range

Operating, channel-to-ground – ±7 Volts

Nonoperating – 50 Volts continuous, 150 Volts for one second, nonrepetitive.

## Input Protection

50 Volts continuous. 150 Volts for one second, nonrepetitive.

## Resolution/Scan Rate

Selectable in software:

<b>DynaRes 8/16 Resolution And Scan Rate*</b>	
<b>Resolution at Full Scale</b>	<b>Scan Rate</b>
low noise mode: 0.0004%	45/55 Hz
16 bits: 0.0015%	200 Hz
15 bits: 0.003 %	300 Hz
14 bits: 0.006 %	500 Hz
13 bits: 0.012 %	700 Hz
12 bits: 0.024 %	900 Hz
* Rates describe an IBM PC 486DX2 66MHz running DASyLab under Windows 3.1 with Tolerate Error=0. Rates are somewhat faster in faster computers. Please also see "Dynamic Resolution" on page 3 – 2.	

Scan rate is the rate in Hertz (or, samples per second) to read data into memory, including the time it takes to switch channels and ranges. To calculate the total scan time for all channels, divide the rate by the number of channels.

## Digital I/O Channels

The DynaRes 8/16 has 8 or 16 digital I/O lines, with each line individually selectable as input or output. These channels are TTL- and MOS- compatible as they come out of the board.

Their outputs sinks are open collector and are 3 milliAmperes; as inputs they draw no current. (Please see the specifications in your terminal panel owner's manual for open collector output.)

## Counter/Timer

The DynaRes 8/16 has one on-board 16 bit counter/timer with 2 MHz internal clock. The counter timer is connected to Digital I/O lines 9–12 on Terminal Panel 2 or to CT Gate, CT Out, CT In, and CT Trig on Terminal Panel 1.

## General Conditions

Maximum Voltage on any terminal – 150V

Maximum Current on any terminal – 1A

Auxiliary Power Supplies – +5V, +12V, or -12V, direct from the computer's power supply. The +6.9V supply draws it's current from the +12V supply.

<b>Voltage</b>	<b>Maximum Current</b>
+6.9V	20mA
+12V	200mA
+5V	100mA
-12V	200mA

+6.9V Supply Tolerance –  $\pm 5\%$

- Temperature Coefficient:  $< 0.0005\%$  per °C
- Stability:  $< 0.01$  per year

Operating Temperature Ambient – 0 to 50 degrees Celsius.

Physical Dimensions– 6.7" x 4.0" (17.0cm x 10.2cm)

<b>DynaRes 8/16 Ultra Current Consumption*</b>		
<b>Voltage</b>	<b>Supply Current Consumed by</b>	
	<b>DynaRes 8 Ultra:</b>	<b>DynaRes 16 Ultra:</b>
+5V	317mA	335mA
+12V	10.5mA	13mA
-12V	1.6mA	2.5mA
Total	1.73 Watts	1.861 Watts
* Measurements are made after loading GDRV and GFIND, with no connection to terminal panel.		



For most data acquisition applications using a plug-in board, it is also necessary to install a terminal panel. Terminal panels serve as a convenient interface between the real-world and the computer, providing screw terminals for connections to sensor wires and a 50-pin ribbon cable connected to the data acquisition board inside the computer.

Multitudes of terminal panels are offered to assist you with all types of applications. This manual covers all of our general purpose and temperature panels for the WB series boards: the T31, T71-GP, T71-TC, and T71-RTD.

---

## General Information

### Features

All the terminal panels have connections for:

- eight differential analog inputs;
- at least 8 digital input and output inputs;
- the +5V, +12V, and -12V power supplies from the computer; and
- the reference voltage from the analog board.

### Package Contents

Your terminal panel package should include:

- a cold junction temperature compensation sensor; and
- a 50-pin, one meter cable for connection to the data acquisition board

### Types of Panels

There are three basic types of terminal panels:

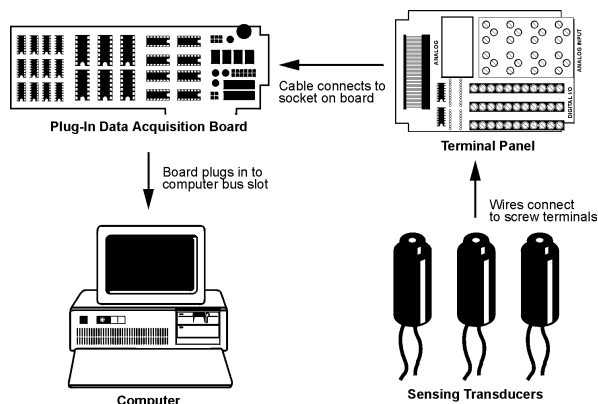
- General Purpose - -T31, T71-GP
- Thermocouple - -T71-TC
- RTD (resistance temperature detector) - -T71-RTD.

The features and benefits of the different types of terminal panels are discussed in the corresponding sections of this manual.

---

## Physical Installation

Installation very simply consists of attaching a cable connector to both the terminal panel and the data acquisition board installed in your computer, as shown below. You are then ready to begin connecting the sensors needed for your application.



*Terminal Panel Installation*

## To Install a Terminal Panel

1. Verify that the panel is compatible with the installed board Not all terminal panels are compatible with all data acquisition boards. Depending on the data acquisition board in use and on the type of data to be collected, different terminal panels should be used. The table below indicates the correct terminal panel under different conditions.

<i>Terminal Panel Cross Reference</i>			
Product Model	TC*	GP	RTD
ACAO-12	-	T31	-
DynaRes	T71-TC	T71-GP	T71-RTD

\* The general purpose terminal panels can read thermocouples, but do not provide the same high accuracy as the T71-TC.

2. Plug the terminal panel's cable into the board All terminal panels connect to the installed data acquisition board with one 50-pin cable.

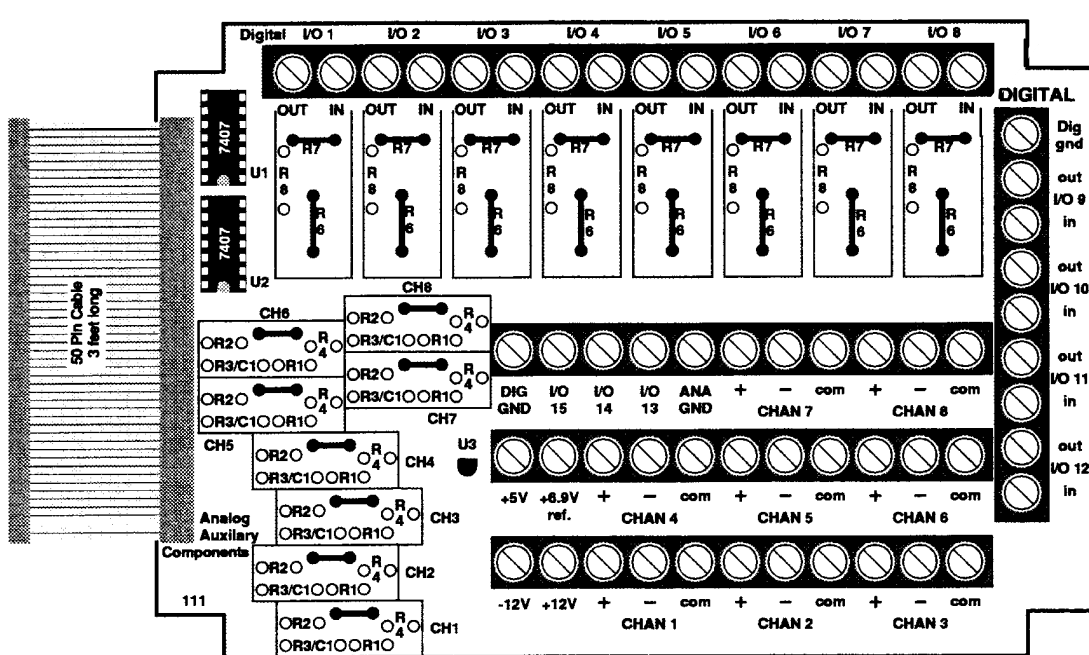
The T71 terminal panels use a 50-pin Centronics cable, shipped separately, to connect to the data acquisition board. To install, simply plug the cable into both the terminal panel's and board's connectors, making sure to secure the spring latches to hold the cable in place.

## Types of Terminal Panels

As was stated in the introduction, there are two basic types of terminal panels, each compatible with different models of data acquisition boards.

### T31 Terminal Panel

The T31 is a general-purpose terminal panel that provides screw-terminals for connecting up to eight analog outputs and up to 12 digital I/O lines.

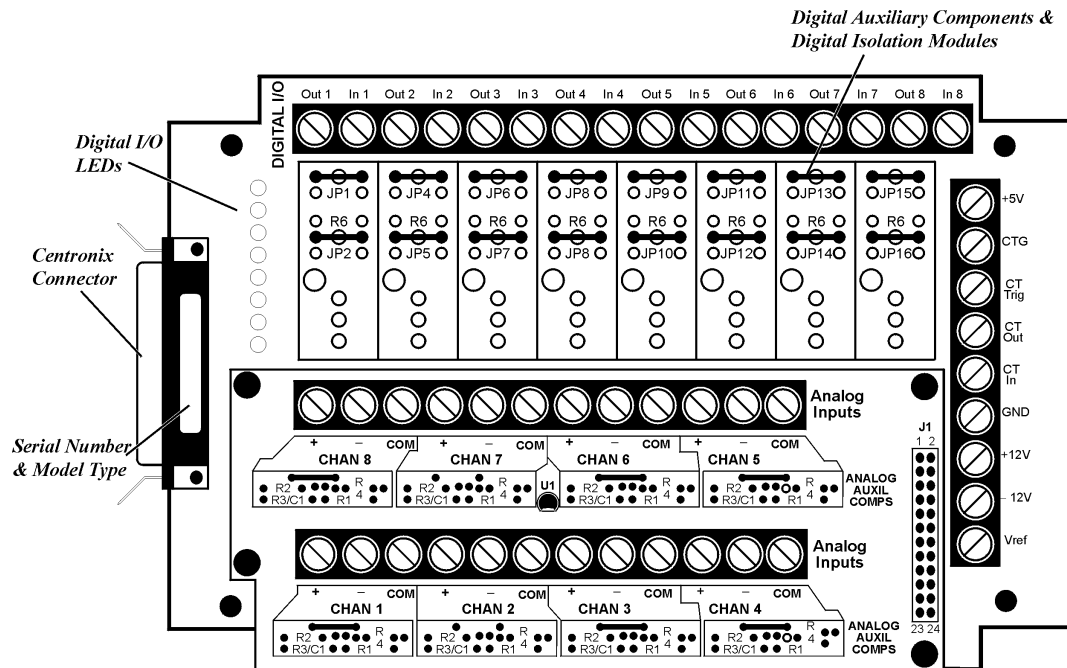


*Illustration of the T31 Terminal Panel*

## T71 Terminal Panel

Designed for use with the DynaRes data acquisition boards, the T71 terminal panel comes with a 3-ft., detachable M-M Centronics cable. The panel features terminals for eight analog inputs and eight digital I/O lines, with room for up to eight digital opto-isolation modules.

There are three different models of the T71 terminal panel. The T71-TC is optimized for thermocouple measurements, featuring a large aluminum isothermal plate with screw terminals for eight analog inputs. The T71-RTD, specifically designed for high accuracy RTD measurements, has signal conditioning set resistors pre-installed at the factory for use with two- or three-wire RTDs. The T71-GP model, pictured below, is available for general-purpose measurements.



*Illustration of the T71-GP Terminal Panel*

Using the Digital I/O Lines – On-unit LEDs show the state of the digital I/O lines. “On” indicates that the digital input or output is “low,” or that, if a digital output opto-isolator is installed on that channel, it is energized.

Note that the state of the digital inputs will be “high”, if there is nothing connected. To change a line’s default to low, a resistor (R1 for Channel1, R2 for Channel 2, etc.) must be moved to an alternate area (R1G for Channel 1, R2G for Channel 2, and so on).

To Measure Current – There are eight dip switches, marked “Current/Volt,” located under the analog input daughterboard. To measure current (4-20mA) on a channel, move the corresponding switch to the “Current” position. This will connect a 24.9Ω, 0.1% resistor across the + and – inputs for that channel.

**WARNING**



**Setting the switch to current may damage the resistors if a voltage in excess of 2.5V is applied.**

---

## Reference Tables

Each of the terminal panels differs from the others in some way, whether as a function of the signals to be connected or of the plug-in board in use. In addition, some screw terminals on the panels have different functions depending on which board is in use.

To assist you in making the proper connections, this section contains reference tables for the screw connectors of each type of terminal panel. The panels are grouped according to the similarities in pin connections and locations.

To use the following tables, first turn to the table for the terminal panel in use. Then find the function desired in the left hand column. Under the board used will appear the label for the screw performing that function

### T31 Pin Connectors

<b>Functions of the T31 Terminal Panels Pin Connectors</b>	
<b>Function</b>	<b>ACAO-12-XX</b>
Dig I/O 9	N/A
Dig I/O 10	N/A
Dig I/O 11	N/A
Dig I/O 12	N/A
An Out 1	Chan 1
An Out 2	Chan 2
An Out 3	Chan 3
An Out 4	Chan 4
An Out 5	Chan 5
An Out 6	Chan 6
An Out 7	Chan 7
An Out 8	Chan 8
CT Out	N/A
CT In	N/A
CT Trig	N/A
CT Gate	N/A
Vref	+ 6.9 V

1. Actual voltage is 10V

N/A = Not Applicable

### T71 Pin Connectors

<b>Functions of the T71 Terminal Panel Pin Connectors</b>		
<b>Function</b>	<b>DynaRes 8</b>	<b>DynaRes 16</b>
CT Out	CT Out	Dig I/O Out 9
CT In	CT In	Dig I/O In 10
CT Trig	CT Trig	Dig I/O In 11
CT Gate	CT Gate	Dig I/O In 12

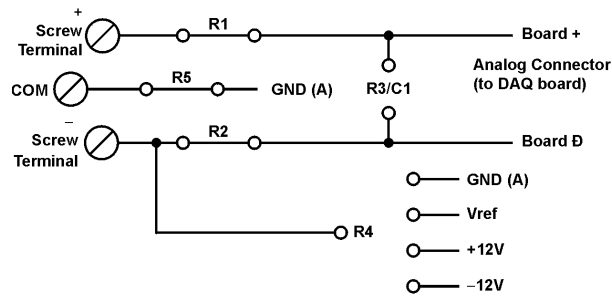
When two T71s are used with a 16-channel DynaRes, both terminal panels have access to the one counter/timer on the board. The first T71 will access the counter/timer through the lines shown in the first column above. The second T71 uses the lines shown in the second column. Both sets of lines cannot be used at the same time.

## Auxiliary Analog and Digital Components

### Auxiliary Components

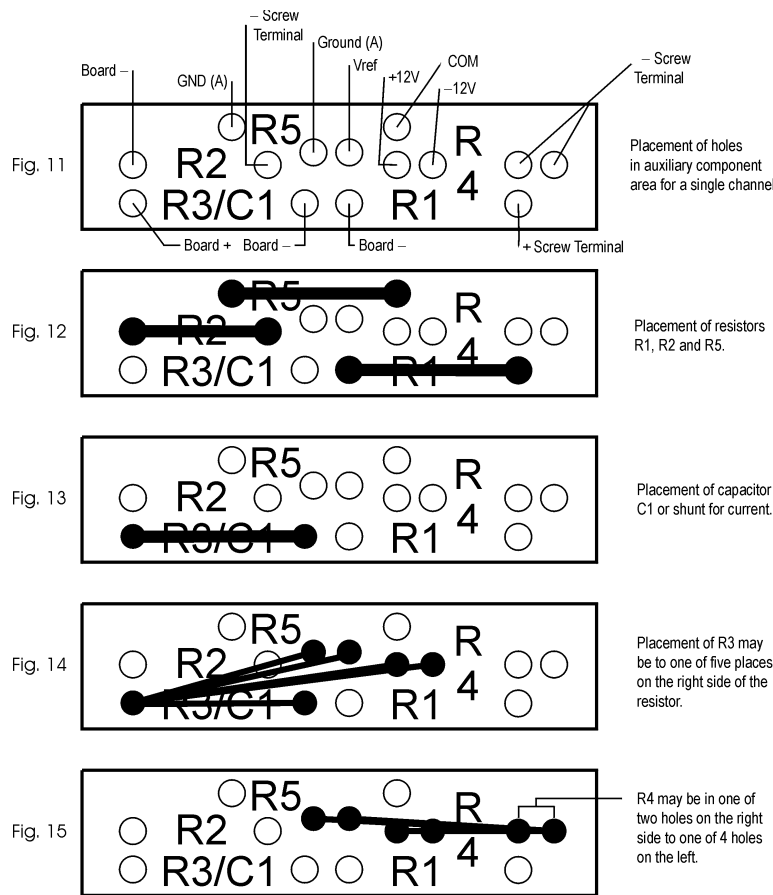
Auxiliary Components are required by some sensors, are used to protect digital signals, or are used to pull digital outputs to a set level. There are two areas (one digital and one analog) on the terminal panels for installing auxiliary components; schematics of both are shown in detail in Figures 10(a),(b), and (c) below and on page 6-8. Note that each channel on the terminal panel has room for its own separate set of auxiliary components.

When using analog auxiliary components R1, R2, and R5 you must cut the shorting metal trace that connects the two ends of the line together before installing any of the components in these locations. Use a sharp knife to carefully slice through the trace without cutting additional traces. In the case of R5 this is a plastic covered metal wire. Diagrams of the auxiliary component area, hole functions, and connection possibilities are shown on page 6-8.



a. Analog Auxiliary Components, each channel  
All Terminal Panels

Figure 10 Schematic for Analog & Digital Auxiliary Components

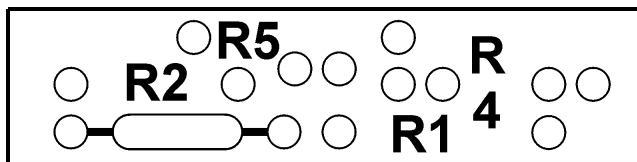


*Analog Auxiliary Component Area on Terminal Panel*

## Examples

### **Example 1: Current sense resistor**

The analog boards and terminal panels can measure currents up to 50mA directly. On the Analog Connection boards and T71 terminal panels there is a 25Ω precision resistor on the unit itself; dip switches allow users to selecting between voltage and current input. To measure current on any other type of board, however, it is necessary to install 25Ω precision resistor on the terminal panel. This connection for current measurement is shown below. (To see how this connection adds to the circuit, refer to Figure 10(a).)



**Figure 16. Current Measurement Connection**

R3 is used as a shunt resistor across the positive and negative lines of the channel in use. To install this resistor, push the resistor ends through the holes for R3 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes, and then clip off the extra wire with pliers. This connection does not require any additional traces to be cut. Be sure to select current measurement in the software package that you are using.

This installation allows the measurement of voltage across the resistor and the conversion of this measurement to current using the equation  $V=IR$ . Observe the power rating of the resistor you install at R3. Space is provided for a 1/4 Watt resistor.

## Example 2: 3-Wire RTD components

The most popular connection for RTDs is the three wire type. This sensor requires the installation of resistors R3 and R4 except for these DataShuttle RTD model, where both resistors are already installed. Consult Set Resistor Values on page 5-7 for R3 & R4 values. Both resistors are already installed in the T71-RTD panels.

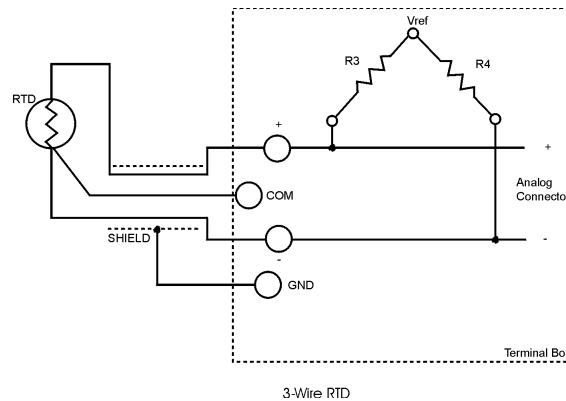


Figure 17. 3-Wire RTD Components

However, if you need to install these resistors yourself then do the following: Figure 14 and Figure 15 show the possible locations of R3 and R4. Figure 11 will show you that R3 and R4 need to be connected as in Figure 18. R5 is already in place and should not be removed. To install these resistors push the resistor ends through the holes for R3 and R4 as shown in Figure 14 (from the terminal side) until the resistor lies flat with the panel surface. If two wires cannot fit into the Vref hole then one wire may be soldered to another that is already inserted. On the backside, solder the wires to the holes. Then clip off the extra wire with pliers. The auxiliary component area in question will now look like Figure 18 below. This connection does not require any additional traces to be cut.

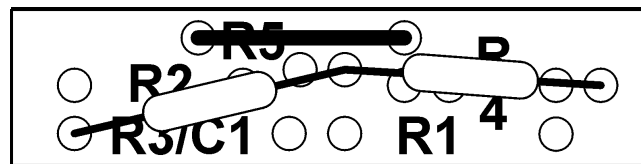


Figure 18. 3-Wire RTD Connection

## Example 3: Ground loops

Occasionally there is an installation where the ground connection is made at the sensor, but it is not reliable. The solution to this “intermittent” ground is to replace the COM to GND(A) jumper wire at R5 (Figure 10(a)) with a 10 MW, 5%, 1/4 Watt resistor. This provides a ground reference for the analog inputs in question, but allows very little ground current to flow. In very noisy environments with intermittent grounds, a smaller resistor may be used if the readings are erratic. This connection is shown in Figure 19 below.

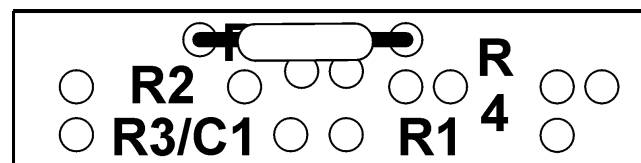


Figure 19. Ground Loop Connection

To install this resistor the wire at R5 must first be removed. After R5 has been removed, push the resistor ends through the holes for R5 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes. Then clip off the extra wire with pliers. The auxiliary component area in question will now look like Figure 19. This connection does not require any additional traces to be cut.

## Digital Auxiliary Components

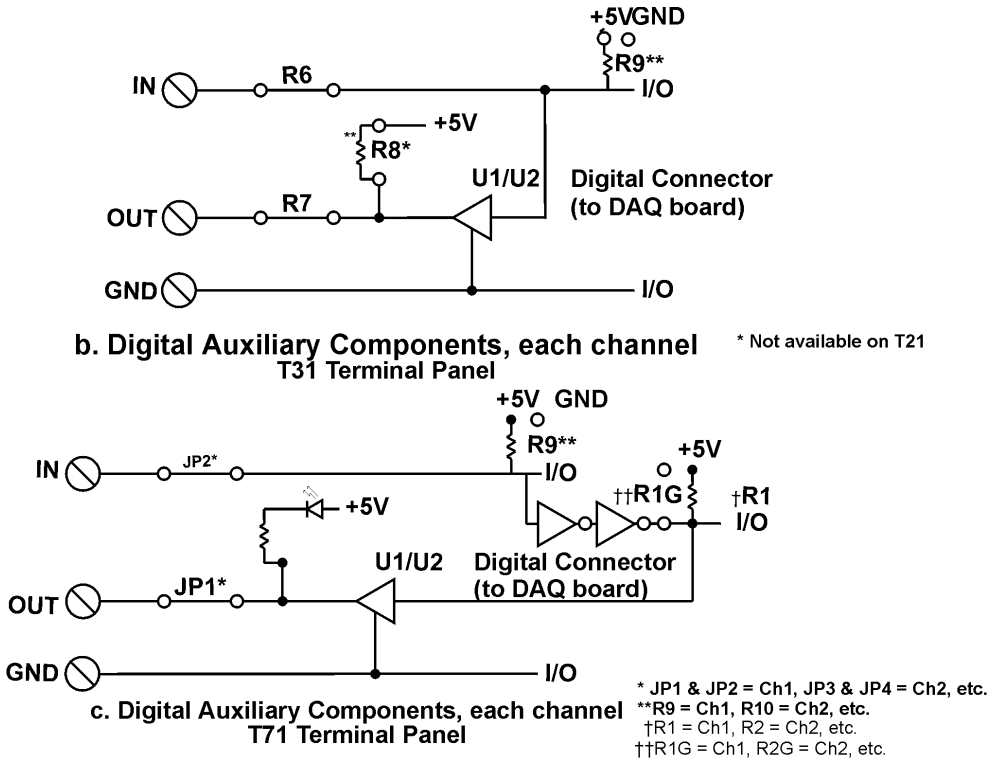


Figure 10 (Cont.) Schematics for Digital Auxiliary Components

### Installing Digital Modules

Modules are available to safely connect the digital I/O lines to high voltage AC and DC sources. There are four basic types:

- AC output: to switch AC power (relay)
- DC output: to switch DC power (relay)
- AC input: to sense AC voltage
- DC input: to sense DC voltage

The output types are used to switch loads on and off. The input types are used to sense the high/low status of a signal. All of the modules provide optical isolation between the high voltage and terminations.

These modules may be installed on the T31 and T71 terminal panels. First, remove the jumpers labeled R6 and R7. This disconnects the digital I/Os from the terminals. The module will not fit into the panel until these jumpers are removed. Then, simply insert the module and fasten a #4-40 nut to the retention screw. Then, on the back of the terminal panel, solder the leads of the module to the panel.



The terminals for that I/O have now changed their function from low voltage I/O to high voltage isolated I/O. The two terminals become one input channel (high and low lines), or one output channel (like relay contacts), depending on the type of module you have installed.

## CAUTION



**When using these terminals as input lines, be sure to connect the positive line to the old OUT terminal and the negative line to the old IN terminal. Failure to do this will result in the module not switching.**

## Installing Pull-up Resistors

As noted in the Applications Reference Manual and previously in this manual, the digital outputs are open collector and must have a power source connected in order to drive loads. Merely connecting the output terminal through a load (such as a bulb) and then to digital ground will not work. In this case, a pull-up resistor connecting the output terminal to a power supply will complete the circuit.

This pull-up resistor is installed in position R8, as shown in Figure 10(b), which connects the output to the board's +5V power supply. The Figure on page 6-2 shows the physical location of R8 on the T31 terminal panel. Note that R8 is not available on the T71 and may have to be installed manually between the +5V supply and the output terminal in question.

To install this resistor, push the resistor ends through the holes for R8 (from the terminal side) until the resistor lies flat with the panel surface. On the backside, solder the wires to the holes. Clip off the extra wire with pliers. This connection does not require any additional traces to be cut. Use a 4.7K resistor to give 1 mA current flow or a 2.3K resistor to give 2mA current flow.

---

## Troubleshooting Q & A

1. Problem: Why can't I measure any voltage change with my voltmeter on my digital output?  
Action: With nothing but a voltmeter connected, this is normal (except on T71 panels, which have pull-ups installed). The digital outputs are termed "open collector." These kind of outputs do not supply any voltage, it must be supplied from another source. This allows the flexibility to use any supply voltage up to 30V. The easiest way to see the state of an output terminal is to check the state of the input terminal with a voltmeter.
2. Problem: My digital inputs are "high" with nothing connected to them.  
Action: This is normal. The digital inputs are pulled up to about 1.5 volts by leakage from the LS7407 chips. This is enough to read as a logic high. You can pull them down with a 470Ω resistor to ground. If you remove the LS7407 chips the inputs will be low, but the outputs will be disabled. (NOTE: On T71 panels, inputs will default to low if R10 is moved to GND.)
3. Problem: Can I get an output signal from the input terminals?  
Action: Yes, you can use an input terminal to drive light loads such as a TTL input (except on T71 panels).
4. Problem: What should I do with the jumpers connecting the analog input to COM?  
Action: In general, it is best to leave them connected as shipped. Unless using thermocouples connected to a common ground point on multiple units

---

## Product Specifications

### Accuracy

<b>Cold Junction Compensation Error</b>			
Type	25°C	15° & 35°C	5° & 45°C
J	0	< 0.25	< 0.6
K	0	< 0.3	< 0.7
E	0	< 0.3	< 0.8
T	0	< 0.4	< 1.2
S	0	< 0.6	< 1.3
R	0	< 0.4	< 1.6
B	0	< 1.0	< 2.0
G	0	< 0.7	< 1.7
C	0	< 0.5	< 1.2
D	0	< 0.6	< 1.8
N	0	< 0.6	< 1.2

Cold junction compensation error is in reference to the temperature of the terminals. For types B and G the above error applies for measured temperatures above 200°C only. The cold junction sensor can be recalibrated at any temperature from 0 to 50°C to improve the accuracy if it will not be used at 25°C. The above table applies only after user calibration of the cold junction.

#### **Cold Junction Temperature Differential**

For T21 and T71-TC terminal panels only, the temperature gradient in the air adjacent to the cold junction plate is attenuated 15 times when AWG #22 gage or smaller thermocouple wire is used. The wires are bundled together for at least one foot from the cold junction terminals. The error is usually less than 0.1°C.

For the T31, T35, T71-GP, and T71-RTD terminal panels there is no isothermal plate. The cold junction compensation error consists of the above table plus the difference between the terminal temperature and the cold junction sensor. This difference can be several degrees.

#### **Thermocouple Calibration Numbers**

The T21 and T71-TC terminal panels are marked near the 50-pin connector with a serial number (SN) and cold junction compensation number (CCAL). The terminal panel was calibrated with a matching analog input board at the factory. A change in CCAL by 75 changes temperature measurement 1°C.

For maximum accuracy, the panel should be used with the analog input board with the corresponding serial number. For boards with more than one terminal panel attached, the T71-TC with the matching serial number should be used for Channels 1 through 8.

### Digital Input/Output

#### **For the Digital I/O Termination on All Terminal Panel Types**

- Each line is individually selected to be an input or output.
- Inputs are TTL and MOS compatible.
- TTL outputs are available at the input terminals when an I/O is set to an output (except on T71):
  - Low Level: < 0.4 volts at 2 mA (sink)
  - High Level: > 2.4 volts at 100 µA (source)
- Maximum voltage on any terminal with digital isolation modules installed: up to 300 VAC, depending on module.

#### **On T31 Terminal Panels Only**

- Outputs are high voltage open collector:
  - Low Level: 50 mA max, < 0.7 volts at 40 mA (sink)
  - High Level: 30 volts max, <250 µA (source)

### On T71 Terminal Panels Only

- Outputs are high voltage open collector with pull-up to +5V through LED:  
Low Level: 40 mA max, < 0.7 volts at 30 mA (sink)  
High Level: 30 volts max, < 300  $\mu$ A (source);  
can drive > 300 $\mu$ A at 2.5V
- All inputs use Schmitt trigger to improve noise rejection.

### General Conditions

Maximum Voltage – 150 volts on any terminal.

Maximum Current – 1 Amp on any terminal.

Auxiliary Power Supplies – The +12 V, +5 V, and -12 V supplies are generated by the computer power supply. The Vref draws its current from the +12V supply.

Voltage	Maximum Current (One Board)
+5V	200 mA
+12V	200 mA
-12V	200 mA

Power, except for reference voltage, is supplied directly from the computer power supply. On the T71 terminal panel only, auxiliary supplies are protected by poly switches rated at one Amp. Switches automatically reset so that nothing is burnt.

Operating Ambient Temperature – 0 to 60° C for the terminal panel, 5 to 90% RH, noncondensing.

<b>Terminal Panel Power Supply Consumption</b>		
Voltage	Supply Current T31	Consumed by T71
+5V	50 mA	150 mA
+12V	0 mA	0 mA
-12V	0 mA	0 mA
-5V	0 mA	0 mA

The terminal panel consumes no current from the +5 volt supply if U1 and U2 are removed (except T71).



Thank you for selecting the ACAO for your project.

Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to furnish the performance you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your budget.

We manufacture the ACAO as an enhancement board that readily mounts in an expansion slot in an IBM PC, or compatible, computer.

This product's guaranteed long-term stability makes it ideal both for the laboratory and for harsh industrial environments.

Using the ACAO together with our graphical interface application software (such as DASyLab<sup>®</sup>, or QuickLog<sup>™</sup>), you can easily and very quickly implement a broad spectrum of research and commercial tasks, in a wide variety of settings. You can, for example,

- Ramp, hold, or step analog outputs,
- Control processes with proportional or on/off control,
- Set alarm on any digital input,
- Control devices at preset levels (fans, pumps, heaters, etc.),
- Control devices from digital input (e. g., from switches or TTL signals), and
- Control processes unattended.

You can use the system interactively, operating controls or modifying your setup while the system is running.

---

## **General Information**

### **Development System**

People who decide, to write their own software (rather than using an off-the-shelf application) can employ the Analog Connection Development System<sup>™</sup> hardware driver to address all features of the board from within a program they design and code for their specific purpose.

### **Expandability**

The ACAO has either two or eight analog output channels and eight digital input/output lines. You can add one board at a time to your computer, for as many as 15 boards with a total of 120 analog output channels and 120 digital I/Os. In addition, separate analog input cards may be used with the same software.

### **Ranges/Units of Output**

The ACAO features switch-selectable ranges of 0-10V, 0-5V, or  $\pm 5V$  for voltage output, and 4-20mA for current output. Self-calibration and self-diagnostics are built into the board to ensure that the output is always accurate.

### **Data Presentation**

The combination of our hardware and application software (DASyLab or QuickLog PC) enables both the display of data on the screen, and the logging of data to disk for later analysis.

---

## Features and Configurations

<b>Analog Output Channels</b>	The ACAO-12-2 has two output channels, while the ACAO-12-8 allows for up to eight analog outputs.
<b>Resolution</b>	The ACAO is capable of attaining 12 bit resolution (that is, .024% of signal).
<b>Data Acquisition Speed</b>	The ACAO is capable of attaining a data acquisition speed of 130 kHz, depending on the software being used. The maximum data acquisition rate supported by our software for the ACAO is 1 kHz.
<b>Accuracy</b>	The ACAO is factory-calibrated and very accurate. (If it is ever necessary, the user can recalibrate the board with precision using software utilities we provide with every product.)
<b>Digital I/O</b>	The ACAO features 8 digital input/output channels that the user can configure individually to be input or output.
<b>Terminal Panel</b>	An available accessory for the ACAO is the T31 general-purpose terminal panel, which includes terminals for eight analog outputs and eight digital I/Os.

## For More Information

For more information about the capabilities of your data acquisition board, please see the “Product Specifications” in this chapter.

For instructions on controlling the board with our interface software (such as DASyLab or QuickLog PC), refer to that particular software manual.

To learn more about data acquisition, process control in general, and how to use these systems together to accomplish everyday tasks, consult the Applications chapter.

If you’re creating your own program to address the board for a custom purpose, please see the Analog Connection Development System manual.

## System Requirements

Before installing the board, make sure the computer system fulfills these minimum requirements:

### Hardware

- IBM PC AT (or higher) or -compatible, with at least 640k system RAM.
- Floppy disk drive, CD-ROM drive and a hard drive.

### Software Environment

- Windows 3.1/95/98/NT.
- Application software (DASyLab, QuickLog PC, the Analog Connection Windows Development System, or other compatible proprietary software; please see your software manual for directions for using it with the DataShuttle). QuickLog for Windows 3.1, 95/98 only.

## Overview

Getting your ACAO data acquisition and process control board up and running is a straightforward process; you only need to:

- Verify the board's switch settings that control board identity and system addressing of these products
- Physically insert the board into a slot of the personal computer
- Set the voltage/current switches to suit the measurement you are making
- Connect a terminal panel to the board
- Use ACAO CAL to initialize ACAO in driver file. Consult software manual.
- Load and start up the software to be used for the project.

As the scope of this manual focuses on the ACAO board, this chapter discusses the board's switch settings, and the physical insertion of the board.

Please see your terminal panel manual for full instructions regarding its attachment to the ACAO, as well as for how to connect sensors to the panel.

Guidelines for loading the software, and for starting up, depend on the application program you are going to use (such as our DASyLab or QuickLog PC, or a package by a third party developer who has our authorization).

The program you are going to use with the ACAO might even be unique and proprietary, a product of your organization. (The Analog Connection Windows Development System is a powerful set of utilities making it possible for software engineers to design and develop their own programs to exploit the ACAO's many features.)

In any event, please refer to the software provider's installation manual, or user guide, for specific information on how to load and run the particular program.

**Troubleshooting** – If you have any difficulty getting your board to work, refer to the “Troubleshooting” section in Chapter 9.

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## Verifying ACAO Switch Settings

### Single Board

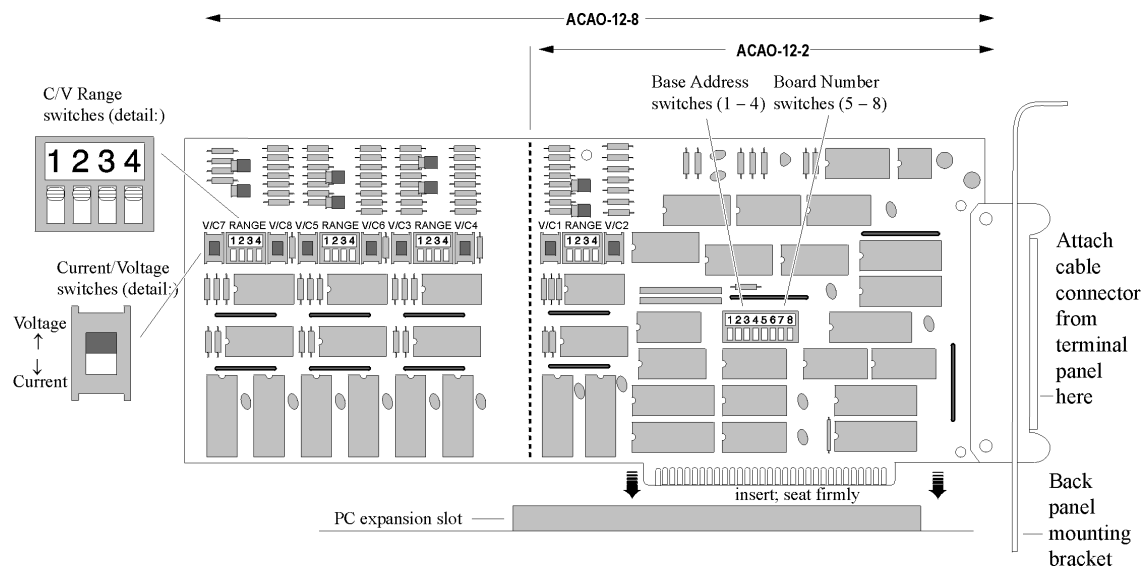
When you purchase a data acquisition board new from our company, the product's switch settings already are correct to operate a single board with our software (DASyLab, QuickLog, the Analog Connection Development System, and all others).

This means the factory switch settings are right for the purpose of using only one board, and you can skip the task of confirming them. You can go directly to the “Physical Board Installation” section on page 8 – 2 in this chapter, and begin to follow the steps there.

### Multiple Boards

If you are using more than one board at a time, set the individual boards' Board Number Switches first (refer to “Setting the Board Number Switches” on page 8 – 4), then go on to perform the physical installation.

Otherwise, there's no reason to be concerned about the board's switch settings, except in the unlikely event you encounter a problem in getting your product to operate. (If you experience a problem, refer to “Troubleshooting,” in Chapter 9).



*Illustration of ACAO Data Acquisition Board, Showing Physical Installation*

## Previously In Use

If, on the other hand, your board has been in use previously in another computer, or if your company uses its own proprietary software, the present switch positions might differ from the factory settings.

If your company uses such a program, making changes to factory switch settings might be necessary to accommodate it. Please consult the administrator of your internal system, or the provider of third party software, to determine their recommendations for any unusual switch setting.

To check and restore the factory values, please read “Setting the Board Number Switches” on 8-4 in this chapter.

---

## Physical Board Installation

Installation very simply consists of inserting the board into an open peripheral (expansion) slot inside your computer.

(There are, for example, five available slots in the IBM PC, and eight in the IBM XT or AT. IBM and other companies sell expansion chassis that can accept even more analog cards. Our software supports as many as 15 boards at one time.)

## Terminal Panel Connections

When using a terminal panel with the ACAO you are going to be using a single ribbon cable from the terminal panel. This cable plugs into a 50-pin connector at the back panel of the ACAO and, at its far end, plugs into a 50-pin connector at the terminal panel.

(Refer to the illustration on page 8 - 2; always check to confirm that the attachment of the cables is according to the diagram.)

Each 50-pin cable connector has a key on one side that mates with a socket on the device; be sure to observe polarity when attaching.



## Physical Installation

### To Install the ACAO Board

1. **TURN THE COMPUTER OFF!** Never remove the cover of the computer without first turning the power switch to the “off” position.
2. **Open the Computer** Remove the cover of the computer. (If appropriate, refer to your computer’s manual for more information about removing the cover and installing enhancement boards.)
3. **Ground Yourself** While holding the board, before installing it, touch the metal chassis of the computer to discharge any static electricity that might be on the surface of your body. This is important, as static electricity can damage electronic parts. (Likewise, if you ever remove the board from the computer, always store it in its protective shipping bag.)
4. **Remove the Dust Cover** At the back panel of the computer, unscrew and remove the narrow dust cover plate that is directly behind the expansion slot you want to use. (Keep this screw handy.)
5. **Insert the Board.** Push the edge of the ACAO board having “gold fingers” down and into the expansion slot (socket) on the chassis so that the contacts align with the socket, then plug it in by pushing the board straight down.
6. **Fasten the Board to the Chassis** Install the “left over” screw from step 4. Place it in the original hole, through the ACAO board’s bracket, so that it fastens the top of the bracket to the computer’s back panel.
7. **Connect the Cable to Board and Terminal Pane.** Plug the cable into the data acquisition board, and the connector on its far end into the socket on the terminal panel (please refer to your terminal panel’s manual, if you are unsure about the correct position).

### CAUTION



**Incorrect installation of these cables can damage the data acquisition board or the terminal panel. If you are uncertain about proper placement, please see “Terminal Panel Connections” at the beginning of this discussion, and inspect the diagrams on page 8-2 and 9-1.)**

---

## Setting the Voltage/Current Switches

The analog output channels of the ACAO (two on the ACAO-12-2 and eight on the ACAO-12-8) can be set to output in either voltage or current. There are five possible range settings – four voltage and one current – for each channel. These voltage/current ranges are set with series of switches on the hardware.

### Setting the Switches

#### To Set the Voltage/Current Switches

1. **Locate the Switches** With the cover of your computer removed, examine the illustration on page 8 – 2 in this chapter and find the “Voltage/Current Switches” and “V/C Range Switches” on the ACAO.

On the printed circuit board itself, the Voltage/Current is a single switch labeled “V/C”. The V/C Range is of a block of four DIP switches labeled “Range.”

Note that there are three switches for each analog output channel: one large V/C Switch (labeled V/C1 for Channel One, V/C2 for Channel Two, etc.) to set the output for voltage or current and two small DIP switches to set the voltage range.

2. **Set the V/C Switches** Determine whether the output for each channel is to be a voltage or current.

For voltage output, you must turn the V/C Switch up; leave it down for a current output.

Set the V/C Switch for each channel accordingly.

3. **Set the V/C Ranges for each channel** Note that the range switches for Channels One and Two are on the same switch module. Switches 1 and 2 select the ranges for Channel One, while 3 and 4 set the ranges for Channel Two.

(For ACAO-12-8 boards, Channels Three and Four are paired similarly, as are Channels Five and Six and Seven and Eight.)

The first range switch for each channel (Switch 1 or 3) selects unipolar or bipolar voltage outputs. Down selects unipolar; up will output bipolar.

The second range switch (Switch 2 or 4) will determine whether the output will be 5 or 10 Volts. An up setting selects 5 volts; down is 10 volts.

Note that the range switches do not effect current outputs. If you set a channel for current, it will automatically output in the 4-20mA range.

See the tables below for detailed V/C switch settings.

<b>V/C Switch Settings for Analog Output Channels</b>			
<b>Range</b>	<b>V/C Switch Position<sup>1</sup></b>	<b>V/C Range Switch Positions<sup>2</sup></b>	
		<b>Switch 1/3</b>	<b>Switch 2/4</b>
0 to 10V	U	D	D
0 to 5V	U	D	U
± 5V	U	U	U
± 10V*	U	U	D
4 to 20mA	D	–	–

1. U = Up D = Down

2. Switches 1 and 3 set the voltage ranges for Channels 1, 3, 5 and 7. Switches 2 and 4 set the ranges for Channels 2, 4, 6 and 8.

\* Selecting the ± 10V range is an error condition. This range can be used, but the output is not in ± 10V. Output ranges from -10V at 20% to +10V at 100% of full scale. It does not go below approximately -11V at 16%.

## Next Steps

Single Board Usage – If you intend to run with a single data acquisition board in your system, you are now ready to install your application software.

Multiple Board Usage – If you are going to use more than one data acquisition board, now it's time to set each board's Board Number Switches to an unique number. Follow the steps in the "Setting the Board Number Switches" section in this chapter on page 8 – 4.

Installing the Software – For information on loading and configuring DASyLab or QuickLog PC please refer to the user guide for that application package.

Installing the Terminal Panels – To learn how to connect experiments to the terminal panel see your terminal panel chapter, or the Applications chapter (which discusses data acquisition and control in general and provides examples of uses for the products).

ACAOCAL must be used to initialize driver file.

---

## Setting the Board Number Switches

### Multiple Boards

When you are using multiple boards in your installation, each board needs to have an identity for the software to recognize it as an "individual."

The Board Number Switches on a board accomplish this, as they enable you to set an identifying number for the board.

This number determines, among other things, the sequence in which the software reads multiple boards (application programs can address as many as 15 boards).

When using more than one of our product in your installation, every board's Board Number Switches need to have a different number setting. All settings are to be in number sequence (1, 2, 3, for example, if you are using three boards). Set the address and interrupt on all boards to the same settings

## Single Board

If your system includes just a single data acquisition board, then you don't need to be concerned with the Board Number Switches.

When your ACAO leaves our manufacturing facility, the Board Number switches are set to 1. We recommend this setting for most purposes when you are using only one board in your installation.

## Disabling Board

If you want to disable the board, for any reason, set its Board Number Switches to 0. (This is handy if you want to use fewer boards for a while: that way you don't have to remove them from the computer.)

## Setting the Switch

### ***To Set the Board Number Switches***

1. **Locate the Switches** With the cover of your computer removed, examine the illustration on page 8 – 2 in this chapter and find the "Board Number Switches" on the ACAO.

On the printed circuit board itself, these are located within a block of eight DIP switches; switches 5 through 8 represent the Board Number.

2. **Make the Setting** Note that the four switches have 16 possible setting combinations.

Determine which is to be the First Board. (This is easy, if it is the sole board.) Then set the switches for Board Number 1. (See the table below for board number settings.)

The software interprets Board 1 to use system installation digital I/O channels 1- 8 and analog output channels 1 through 8 (if it's an ACAO-12-8), or system installation analog output channels 1 through 2 (if it's an ACAO-12-2).

Determine which is to be the Second Board, then set the switches for Board Number 2.

The program then recognizes Board 2 to use system installation digital I/O channels 9 - 16 and analog output channels 9 to 16 (for an ACAO-12-8) or 3 - 4 (for an ACAO-12-2).

3. **Set All Switches** Continue to set the switches for all installed boards to unique numerical values in an unbroken sequence.

(As various models of our boards use different kinds of switches, please see their owner's manuals for an explanation of how to set switches.)

<b>ACAO Board Number Switch Settings</b>				
<b>Board Number</b>	<b>Switch Positions*</b>			
	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
0 (disabled)	D	D	D	D
1	U	D	D	D
2	D	U	D	D
3	U	U	D	D
4	D	D	U	D
5	U	D	U	D
6	D	U	U	D
7	U	U	U	D
8	D	D	D	U
9	U	D	D	U
10	D	U	D	U
11	U	U	D	U
12	D	D	U	U
13	U	D	U	U
14	D	U	U	U
15	U	U	U	U

\* U = Up D = Down

---

## Setting the Base Address

The Base Address determines the logical system address where the personal computer expects to find all data acquisition boards. Base Addresses must be the same on all boards.

The factory setting for all of our ACAO boards is B00H (in hexadecimal format). If you also have analog input boards installed in your system, note that they use the 300H base address. The two underlined digits must be the same for all installed boards: B00H for ACAO and 300H for analog input boards. (Please refer to the individual boards' owner's manuals for further instructions.)

It is rarely necessary, but if you have difficulty getting the board to work, you can change these switches to values different from the factory settings. (Another device in your PC, for example, might be trying to use the same Base Address.)

Indications of this are: if the program reports it cannot find your board, or if it reports fewer boards than you really have, or if another board starts to work improperly after you install the ACAO.

These problems indicate interference with another board using the same base address as the ACAO product. Remedy the problem by changing the switches of all ACAO boards to an address that has no conflict.

## Setting ACAO Base Address

### To Set the Base Address

**1. Locate the Address Switches** Remove the cover of your computer over the data acquisition board, and find the location of the Base Address switches. Refer to the board illustration on page 8 – 2 in this chapter and find “Base Address Switches” on the ACAO diagram.

On the printed circuit board itself, these are located within a block of eight DIP switches; switches 1 through 4 represent the base address.

(NOTE: Depending on the space available in your installation, it might be necessary to remove the board to reach the Base Address Switches. If so, please follow the same precautions as in “Physical Installation” on page 8 – 2 in this chapter.)

2. Change the Setting 300H is the normal base address. It consists of all four DIP switches being in the “down” position (when the board is sitting in the computer’s expansion slot).

The DIP switches have the labels “1” through “4.” Sliding a switch to the “up” position adds a value to B00H:

<b>ACAO Base Address Switch Additive* Values</b>		
<b>Switch</b>	<b>Position</b>	<b>To 300H Add</b>
1	Up	10H
2	Up	20H
3	Up	40H
4	Up	80H

\* As the switches are additive, your sliding Switches 1 and 4 up, for example, is going to add 10H and 80H to the B00H, equalling B90H.

## Base Address Settings

<b>Possible ACAO Base</b>		
<b>Value</b>	<b>Switch Positions*</b> <b>1 2 3 4</b>	<b>Comments</b>
B00H	D D D D	Factory setting
B10H	U D D D	-
B20H	D U D D	May interfere with hard disk drive
B30H	U U D D	-
B40H	D D U D	Recommended alternative
B50H	U D U D	-
B60H	D U U D	-
B70H	U U U D	May interfere with parallel printer
B80H	D D D U	-
B90H	U D D U	-
BA0H	D U D U	-
BB0H	U U D U	-
BC0H	D D U U	-
BD0H	U D U U	May interfere with graphics adaptor
BE0H	D U U U	-
BF0H	U U U U	May interfere with floppy disk drive

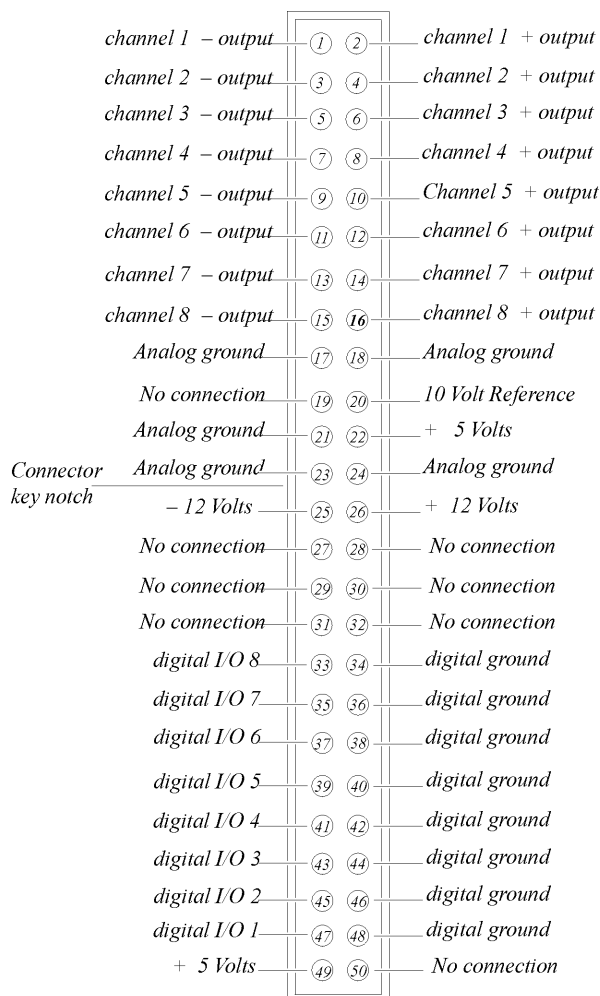
\* U = Up D = Down



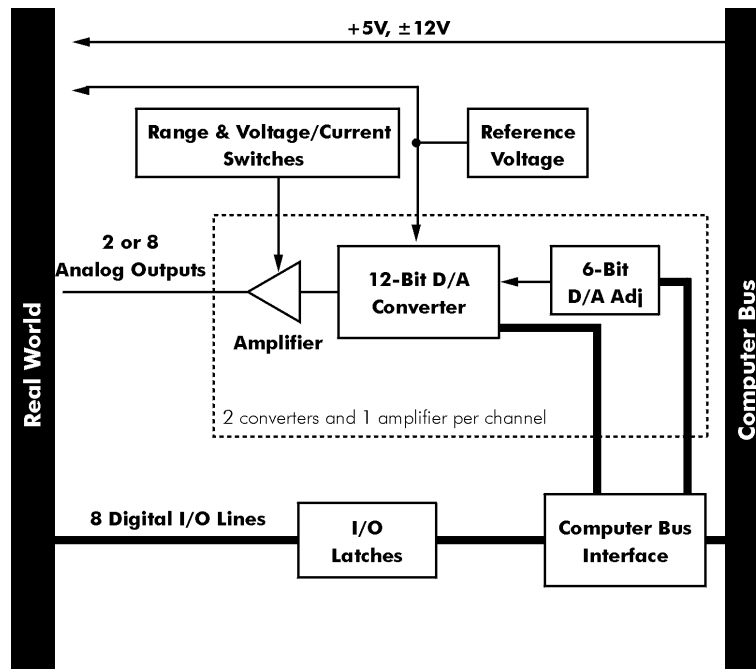
## Overview

Although operations in this chapter are seldom necessary during everyday data acquisition, you might want to refer to them at certain times during operation of the ACAO. They are

- Pinouts (at the board's connectors, in the event you want to connect analog or digital signals directly, without using a terminal panel; please refer below);
- Block diagram of the ACAO showing on-board processing (please see page 9 – 2);
- Recalibration of all ACAO on-board references to bring the accuracy of the product to factory specifications (see page 9 – 2);
- Editing calibration files to accommodate changes to your installation, or to restore missing files (on page 9 – 3),
- Troubleshooting: some possible problems and solutions after installing, and during operation of the ACAO (beginning at page 9 – 6).



**Board Pinouts for the ACAO**



*Block Diagram of the ACAO (All Models)*

## Recalibration

Your ACAO uses an exclusive calibration technology to achieve great stability, requiring no adjustment for years. (As a reflection of this, we guarantee the factory tolerances for two years from the date of purchase.)

## Factory Methods

Instead of employing adjustment potentiometers to calibrate the board, our technicians test and calibrate each ACAO after assembly. They then enter that board's unique calibration number values into a disk file that you receive with the product (CALOUT.DAT, for analog output channels; we also print the same numbers on a label on the back of the board itself).

Whenever you use our software with the board thereafter, the programs read the factory's calibration numbers from the disk file, and automatically make minor compensations for real-world conditions (for instance, high external temperatures that marginally affect calibration).

## Recalibration

Under normal conditions, no full recalibration of the ACAO is necessary.

(If you ever suspect that your ACAO is out of tolerance, please call Technical Support for advice. If it requires recalibration, we can perform the work for you at our facility using the same high accuracy test equipment we use during the manufacturing quality assurance process.)

Only if your organization is proficient in such techniques, and only if you have the necessary equipment, do we encourage you to proceed with recalibration (and please contact our Technical Support Department for guidelines).

For most customers, we recommend returning the board to our Technical Services Department.



---

## Editing Calibration Files

Depending on your usage of the ACAO, your work might require a more common involvement with calibration: modifying values in the calibration file on disk.

This can be essential to accommodate occasional changes in your data acquisition setup.

It's necessary to edit calibration numbers (using ACAOCAL.EXE, the software utility we distribute with the ACAO, on the QuickLog PC disk) whenever you

- **Reconstruct CALOUT.DAT** if this disk file, which holds factory calibration numbers, is lost (the software tries to read these files upon startup); or
- **Change the quantity of boards** in your installation; that is, when you add data acquisition boards to, or remove them from your computer system.

### CALOUT.DAT

The CALOUT.DAT file maintains analog output channel calibration figures for all ACAO boards in the installation.

CALOUT.DAT is a simple text file containing lines of numbers, or values.

(Another calibration file, CALIB.DAT, contains the analog input channel numbers for all Analog Connection boards in the installation, and their thermocouple terminal panels. For more information on CALIB.DAT, see the owner's manual for any of the Analog Connection boards).

(Regarding DataShuttle: If your installation also includes any of these products, remember that they handle calibration values differently from the ACAO or Analog Connection boards. Their calibration figures reside on-board, in Electrically Erasable Programmable Read Only Memory – EEPROM – chips, rather than in disk files. As a result, their calibration numbers do not appear in either CALOUT.DAT or CALIB.DAT).

### Editcal Utility

EDITCAL.EXE (or EDITCAL, for short) is the utility program that simplifies the modification of values in CALOUT.DAT.

(Instructions for using the program are on page 9 – 5 in this manual; but please continue to read this discussion, which describes the format of the calibration file, before starting. Also note that it is possible, although more difficult, to modify numbers in the disk calibration files with a text editor. We recommend using EDITCAL.)

#### CAUTION



**If a calibration file's numbers are inaccurate or missing, this means the calibration of the cards is going to be in error. When you edit these files, take care to enter the numbers accurately.**

### Reconstructing Calibration Files

Reconstructing CALOUT.DAT – EDITCAL provides the capacity to reconstruct the calibration file for ACAO boards if the file happens to be lost entirely.

(If you still have the original distribution disk you can, of course, restore the original factory calibration numbers from disk).

As the CAL NO label on every ACAO board shows that individual board's values, it is a straightforward task to enter the figures into new calibration disk files through the use of EDITCAL. (The CAL NO label can be found on the back of the ACAO board; the calibration values are listed right after the serial number.)

## Multiple Boards/Panels

**Changing the Quantity of Boards** – A single CALOUT.DAT file maintains calibration numbers for all ACAO boards in your system.

When adding an additional ACAO board to the computer installation, it is essential to use EDITCAL to “merge” its numbers into the existing calibration disk files.

In like manner, if you remove an ACAO from the system, you need to run EDITCAL, removing that device’s calibration numbers from the file.

---

## Calibration File Format

### Analog Output Calibration File

The file CALOUT.DAT contains analog output channel calibration numbers for all ACAO boards.

CALIB.DAT Format – The file CALOUT.DAT looks like this:

<b>Content of CALIB.DAT</b>			
	<b>LINE</b>	<b>DATA</b>	<b>MEANING</b>
<b>HEADER</b>	1	ANALOG OUTPUT CALIBRATION	(identifier)
	2	0	
<b>GROUP A</b>	3 4 (and so on)	1000,1,2,3,4 1001,1,2,3,4 (this group continues for as many boards in your installation that have analog output channels)	Analog output board 1’s serial number, then its WCAL, XCAL, YCAL, ZCAL values*; next, analog output board 2’s serial number, and its WCAL, XCAL, YCAL, ZCAL values*, et al
	<b>GROUP B</b>	n n (and so on)	# RANGES 01,23,11,20 12,03,21,02 (this group continues for as many boards in your installation that have analog output channels)
<b>GROUP C</b>	n n (and so on)	@ CAL VALUES 8,36,42,32,40,40,34, 35,38 8,22,23,24,25,26,27,2 8,29 (this group continues for as many boards in your installation that have analog output channels)	After the @: cal values the number of AO channels, followed by calibration values for each analog output channel on board 1; next, calibration values for each analog output channel on board 2, et al

\* If your present CALOUT.DAT file is unusable, find WCAL, XCAL, YCAL, and ZCAL numbers on your board’s CAL NO label, and enter the values according to the format in this table

## CALOUT.DAT Notes

The third line in the file has the serial number followed by WCAL, XCAL, YCAL, and ZCAL for the first analog output card.

WCAL, XCAL, YCAL, and ZCAL are the gain calibration numbers for analog output channels for Analog Connection family products. They correspond to the 0-5V, 0-10V,  $\pm 5V$ , and 4-20mA ranges, respectively.

A second analog output card has its serial number and calibration numbers on the next line, and so on.

Following the “# ranges” sign are range settings. (These ordinarily result from calibrations of the ACAO when you start up the Analog Connection programs.)

Use ACAOCAL to read board settings and to write settings to STIDRV.INI

Following the “@” sign are the fine tuning calibration values that result from a recalculation taking place every time you use Analog Connection software. (There is no need to put numbers here. As with the range settings, the software is going to update them.) The values are in sequence, one for each channel, and one line for each card.

---

## Reconstructing A Lost Calibration File

In the event the calibration file CALOUT.DAT becomes corrupt, or is missing, it's first necessary to reconstruct a replacement text file before running EDITCAL. Use any text editor to create a new file, giving it the appropriate name (CALOUT.DAT).

Enter this text on the first line in the file:

```
ANALOG OUTPUT CALIBRATION
```

and then press [ENTER] ten times, to establish a total of 11 lines in the file. Save the file to the same subdirectory as your other applications programs.

Now you can use EDITCAL to read and restore the calibration numbers by using its **UPDATE** menu selection (please see “Using EDITCAL”).

---

## Using EDITCAL

Although the preceding tables might give the impression that editing calibration files is highly complex, the EDITCAL utility makes the task relatively easy.

### Starting EDITCAL

Make sure the EDITCAL.EXE program file is in the same sub-directory as the application programs and the CALOUT.DAT file.

Load the EDITCAL.EXE program from the keyboard:

#### **To Start Up EDITCAL.EXE**

At the DOS prompt, enter **EDITCAL**, then press the [ENTER] key. (This invokes the utility.)

## EDITCAL Selections

### To Select a Function

Once EDITCAL is up and running you can use the arrow keys to navigate back and forth among the following menu selections:

**Data Files:** To merge calibration files supplied from the factory into a single file for systems that have multiple units, or to update existing calibration files.

**AC EEPROM:** To view or modify calibration data on Analog Connection units that have non-volatile on-unit EEPROMS.

**DS EEPROM:** To view and/or modify the calibration numbers of DataShuttle EEPROMs, or to perform an analog calibration

**QUIT:** Ends the EDITCAL session.

4. Move the arrow keys until **DS EEPROM** is flashing.
5. Press [ENTER].
6. Proceed according to the on-screen instructions that appear after making your selection.



At any time during your use of EDITCAL, you can press the [F1] key to display help-text regarding a highlighted field.

---

## Troubleshooting: Installation

If you experience difficulty in getting your data acquisition board up and running, please check to see that the installation is according to the descriptions in Chapter 8.

If the software reports a board failure, or that it cannot find a board, then try these remedies:

1. Confirm that the board is seated properly in the PC expansion slot (reseat it, if necessary; see the illustration on page 8 – 2).
2. Verify the Board Number Switches are not set to “0.” (Refer to page 8 – 4).
3. Use a different Base Address. It is possible that another device in your installation is trying to use the same Base Address (please see the explanation on page 8 – 6).
4. If there is more than one data acquisition board in your installation, make sure they all have the same Base Address and interrupts, sequential Board Numbers, starting with 1.
5. Install the board in another open slot in the PC (follow the instructions on page 8 – 2).
6. Remove other devices from expansion slots in your PC to check whether they are conflicting with your data acquisition board.
7. If possible, install the board in another computer to verify its correct operation.
8. Verify that the software is up to date (a version compatible with the board you are using. Contact us, or your software provider).
9. Remove other terminate and stay resident (TSR) programs from your system’s AUTOEXEC.BAT file, temporarily.

---

## Troubleshooting: Operation

### Operating Qs And As

1. Problem: Initial startup of software; can see ACAO but software says can't connect to ACAO board number.  
Action: Run ACAOCAL to initialize ACAO in STIDRV.INI file.  
Proper installation will cure this.
2. Problem: After changing the switch settings on my board from voltage to current or to different voltage ranges, my outputs are inaccurate.  
Action: If you change any switch settings on the board, you must update the software as well. To do so, go back to DOS and rerun the GFIND command with the -c parameter.
3. Problem: I get a "Reference Error" message when I run GFIND.  
Action: This error occurs when the traces labeled F1 and F2 (found on the bottom right of the board) are burnt. In these cases, you must replace the burnt traces with a 1Amp maximum resistor fuse.
4. Problem: At start-up, I get a "Cannot Calibrate – check for short" message.  
Action: This error message occurs primarily when the channel in question is set to voltage. During start-up, calibration is performed on the board if the -c parameter is used with the GFIND command. Voltage calibration can only be completed if nothing is connected to the terminal panel. If there is a connection, you will usually receive this error.  
To correct this error, you can remove any connections to the terminal panel. Alternatively, you can rerun the GFIND command without the -c parameter.
5. Problem: At start-up, I get a "Cannot Calibrate – check for open" message.  
Action: This error message occurs primarily when the channel in question is set to current. During start-up, calibration is performed on the board if the -c parameter is used with the GFIND command. For current calibration to take place, the +12V terminal must be connected to the +ve terminal of the channel in question. If this connection is not made, you will usually receive this error.  
Ensuring this terminal connection will usually get rid of this message. Alternatively, you can rerun the GFIND command without the -c parameter.
6. Problem: My board used to work, but now the software cannot find it, or reports an error.  
Action: Check to make sure the Board Number Switches are not set to "0."
7. Problem: When my software starts, the outputs of the board momentarily go to full scale.  
Action: If the GFIND program is run with the -c parameter, the ACAO board will be calibrated by sending full scale outputs. Removing the -c will prevent this from happening at a slight loss of accuracy.

### If you Need Customer Support

What to do before calling technical support, to help us serve you better:

1. Have the part numbers of your boards and terminal panels ready.
2. Have the type and version number of the software you're using.
3. Have your computer's type, model, and the version of the operating system.

---

## Product Specifications

### Analog Outputs

The ACAO-12-2 features two analog outputs; the ACAO-12-8 includes eight analog output channels.

### Analog Output Ranges

The ACAO can output either voltage or current. Selectable voltage ranges include 0–5V, 0–10V, and  $\pm 5V$ ; current is output in the 4-20mA range only.

### Resolution

The ACAO can operate with resolution of up to 12 bits.

### Speed

The ACAO has a maximum output rate of 130kHz on a standard IBM PC running at 4.77MHz (rates are somewhat faster in faster computers).

For the multi-channel output rate, divide the maximum 130kHz rate by the number of channels using an assembly language program.

### Maximum/Minimum Output

#### *In Voltage Output Mode*

- Output Current:  $\pm 15\text{mA}$  minimum
- Output Protection: May be shorted to any voltage between +12 and -12V
- Output Impedance:  $<0.1\Omega$

#### *In Current Output Mode*

- Maximum Output Voltage: +50V
- Minimum Output Voltage: +2.6V
- Output may be shorted to any voltage between 0 and +50 volts

<b>Accuracy ACAO General Conditions Accuracy</b>		
<b>Range</b>	<b>Absolute Accuracy</b>	<b>Maximum Offset</b>
0 to 10V	0.02%	0.01%
0 to 5V	0.02%	0.02%
$\pm 5V$	0.07%	0.06%
4 to 20 mA	0.15%	0.04%

Relative accuracy for all ranges is a maximum of 0.01%.

There is a 0.01% maximum linearity for all ranges, guaranteed monotonic. The differential linearity is a maximum of 0.01%.

### Stability

#### *In Voltage Output Mode*

- Temperature Drift:
  - With self-calibration is 0.002% /  $^{\circ}\text{C}$  maximum
  - Without self calibration is 0.008% /  $^{\circ}\text{C}$  maximum
- Response time to 0.01% accuracy:
  - Small step is 2.5 $\mu\text{s}$
  - 5V step is 20 $\mu\text{s}$
  - 10V step is 35 $\mu\text{s}$

### ***In Current Output Mode***

- Temperature Drift:  
    With self-calibration is 0.006% / °C maximum  
    Without self calibration is 0.015% / °C maximum
- Response time to 0.01% accuracy:  
    Small step is 2.5µs  
    16mA step is 10µs

### **Digital I/O Channels**

The ACAO has eight digital I/O lines, with each line individually selectable as input or output. These channels are TTL- and MOS- compatible as they come out of the board.

Their outputs sinks are open collector and are 3 milliAmperes; as inputs they draw 5 milliAmperes when low. (Please see the specifications in your terminal panel owner's manual for open collector output.)

### **Auxiliary Power Output**

<b><i>Auxiliary Power Output For The ACAO</i></b>	
<b>Voltage</b>	<b>Maximum Current</b>
+10V	15mA
+12V	200mA
+5V	100mA
-12V	200mA

Power, except for 10 volts, is supplied directly from the computer power supply. The +10V supply draws its current from the +12V supply.

### ***10 Volt Reference***

- Output Current: 15mA maximum
- Initial Accuracy: 9.9 to 10.1 volts
- Temperature Drift: 0.0008% / °C maximum
- Drift with time: 0.003% / 1000 hours

### **General Conditions**

#### ***General Specifications of the ACAO***

- Operating Temperature Ambient: 0 to 50°C
- Board Dimensions:  
    The ACAO-12-2 is 4.2" x 5.25" (11.8 x 14.7 cm)  
    The ACAO-12-8 is 4.2" x 9.5" (11.8 x 14.7 cm)
- The supply current consumed by the ACAO varies according to number of analog output channels as well as voltage settings. (See table below for variations.)

<b><i>ACAO Power Consumption</i></b>		
<b>Voltage</b>	<b>Supply Current Consumed by</b>	
	<b>ACAO-12-2:</b>	<b>ACAO-12-8:</b>
+5V	320mA	320mA
+12V	40mA	65mA
-12V	15mA	15mA
Total	2.6 Watts	2.9 Watts



Notes



## General Information

Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to provide the performance and versatility you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your cost and time budgets.

QuickLog for Windows (QuickLog) is a menu-driven data acquisition software application that is supplied with all of our data acquisition hardware products. It has an easy-to-use tabular interface, which brings simplicity to the laboratory and industrial environments, allowing you to set up a typical data acquisition application in less than 30 minutes.

Using QuickLog, together with our plug-in data acquisition boards and/or parallel port DataShuttles, you can easily and quickly implement a broad spectrum of R&D or industrial tasks, in a variety of settings. You can, for example,

- Display data in meters and charts,
- Automatically linearize thermocouples and RTDs,
- Monitor processes and experiments,
- Log data to disk for later analysis,
- Control devices using digital outputs,
- Gather data unattended, and
- Exchange data with other Windows applications via DDE.

This chapter shows how to install the QuickLog software. Please refer to Chapter 11 for instructions on operation.

## What You Need

These are the items necessary to start using QuickLog:

- This manual
- The QuickLog disk, and
- Any of our data acquisition device (connected to your PC according to the Owner's Manual).

## System Requirements

QuickLog works with most Wintel personal computers (PCs with Intel, or Intel-like CPUs, running Windows) available today. The minimum software and hardware requirements your PC needs to run QuickLog successfully are listed below. To get the best performance from the software, especially when more than one Windows application is to be run, we recommend additional hardware resources.

## Minimum Requirements

A personal computer with a 386 processor, a standard keyboard, a mouse or similar pointing device, and

- 4 MB memory (RAM),
- 2 MB of free hard disk space
- 3.5" diskette drive,
- A monitor and a VGA display adapter supported by Windows,
- One parallel interface (Centronics) if using a DataShuttles, and
- Windows (v3.1or later) or Windows 95/98 (No NT support).

---

## Setting Up QuickLog

Make sure that your QuickLog package is complete. In addition to this printed document, it should contain a floppy disk, the Hardware Installation Manual, and the registration card.

Make sure that there is at least 2 MB of free space on the hard disk on which you intend to install QuickLog.

Insert the QuickLog disk into the floppy disk drive.

### Starting the Installation

#### ***For Computers Running Windows 3.x***

1. From the File menu in Windows Program Manager, choose Run. The Run dialog box will appear.
2. In the command line, type the drive letter of the drive you are using, followed by a colon and the QuickLog installation program file name, SETUP. (You may type upper or lowercase letters.) For example: A:SETUP
3. Press the Enter key. The QuickLog installation program will start.

#### ***For Computers Running Windows 95/98***

1. Open the Control Panel.
2. Select Add/Delete Programs.
3. Windows 95 will search for the installation disk. Select finish and the QuickLog installation program will start.

You can exit the installation procedure any time by clicking the Cancel button. However, QuickLog will not be completely and properly set up.

### Setup Summary

You will be asked to specify the drive and the directory where QuickLog is to be installed. The default is C:/QLFW. You may type a different path, but it must be a valid MS DOS path:

Drive:/ Directory/Directory

Then choose OK. The installation program will:

- Check if the specified directory exists, and create it if necessary.
- Check if there is enough free space on your hard disk. If not, you will be asked to enter another drive or to cancel setup.
- Copy all QuickLog program files to the drive and directory.
- Create a QuickLog program group in the Windows Program Manager. If the group already exists, it will be opened.
- Create various program items within that group.
- Add the command line DEVICE=DRIVE:/DIRECTORY/ DIRECTORY/.../STIDATAQ.386 to the [386Enh]section of the SYSTEM. INI file to install the virtual device drive needed to communicate with the hardware.

### Completing Setup

Restart Windows so that the changes made to your system can take effect, so that the driver will be loaded.

---

## Specifications

### Meter Display Screens

Types of I/O Supported – Analog In, Analog Out, Digital In, Digital Out, Counter/Timer pulse input, Counter/Timer frequency input, and Time.

Maximum Number of Data Acquisition Devices – 15

Maximum Number of Channels Per Board – 160. Channel name and/or units may be typed in.

Analog Input Ranges Supported – all that are supported by the data acquisition driver.

Analog Input Resolution Supported – all that are supported by the data acquisition driver.

Analog Output Ranges Supported – all that are supported by the data acquisition driver

Scaling of Any Input Type – linear,  $y = mX + b$ .

Outputs (analog or digital) may be changed by typing the value into the digital meter.

Size of Digital Meter Display – selectable height and width.

Number of Digital Meters – selectable from 1 to 100.

### Chart Display Screen

Single chart with selectable time scale. Y axis is % of specified range or user entered maximum and minimum range. Includes the scaling specified in the digital meter display.

Chart is a window that may be sized as desired.

Types of I/O Supported – Analog In, Digital In, Counter/Timer pulse input.

Number of Traces Displayed – 14 maximum.

### Logging

Data Type – ASCII characters, tab-delimited.

Maximum Number of Logged Channels – 256

Log Rate – same as sample rate

Types of I/O Supported – Analog In, Digital In, Counter/Timer pulse input.

### DDE

Any meters may be linked to another application using DDE.

Inputs can be sent, and outputs can be received, from the other source.

DDE Rate – same as sample rate, or same as rate requested by other application.

### General Configuration

The following settings are available for the general configuration of QuickLog:

- Sample rate: same for all channels, inputs and outputs,
- Polled or synchronous mode for all types: Analog In, Analog Out, Digital In, Digital Out, Counter/Timer pulse input, Counter/Timer frequency input,
- Polled mode: maximum speed is several samples/second,
- Interrupt mode: maximum speed is several hundred samples/second,
- Number of input meters,
- Input meter font size,
- Log file name, and
- Number of output meters.
- Output meter font size.

## I/O Configuration By Channel

The input and/or output of each channel can be configured using these options:

- Device (board)
- Channel
- Range (AI and AO only)
- Resolution (AI only)
- Scale (AI only):  $y = mx + b$  where m and b may be entered.
- Logging: yes/no.
- Display on chart: yes/no.

## Chart Configuration

Charts can be configured according to these available settings:

- Number of points on time axis (2 to 1000)
- Number of labels on time axis
- % of full scale on Y axis (0 to 100)
- Scaling of Y axis: -1e10 to 1e10
- Selectable options:
  - Color for each trace
  - Line type for each trace
  - Chart Colors
- Viewing Style: Color, monochrome, monochrome + symbols
- Plotting method: Line, Point, Points + Line, Points + Spline, Spline
- Graph or Table: Graph, Table, Both
- Grid Lines: Both, Y axis, X axis, None
- Grid in front
- UnZoom
- Font size: Large, Medium, Small

---

## General Information

QuickLog is entirely menu-driven. You control data acquisition, display, and disk logging by configuring QuickLog via the pull-down menu system.

QuickLog is based on one display screen of digital meters that are used to display all types of available inputs, and another screen for all types of available outputs. In addition, it displays input signals on a Y-t chart, as well as logs these inputs to disk.

You can change the name on each input or output meter to identify it.

When you first launch QuickLog, it searches for hardware devices, first on the ISA bus inside the PC, and then on all installed printer ports. It then creates Input, Output, and Chart windows that reflect the installed hardware.

QuickLog runs, and collects and displays input data, as soon as it is launched. It continues to run when you are configuring the various options. If you load a configuration file that does not match the installed hardware, it automatically adjusts the configuration file to match the hardware, and displays a warning message.

This chapter briefly explains the various menus, with a description of their functions. QuickLog also has an extensive on-line Help facility, which has more information than what is contained here.

---

## File Menu

Standard functions include those for creating, loading, and saving configurations. These are New, Open..., Save, and Save As. Select New to revert to the default configuration. Other file menu commands and their functions include:

<b>Save As Startup</b>	The Save As Startup command allows you to define your own startup configuration, using your desired settings.
<b>Print Window</b>	Print Window immediately prints the active top window, using the default Windows printer.
<b>Export Chart</b>	Export Chart to the Windows clipboard, a file, or to your printer.
<b>Exit</b>	Exit closes the program.

---

## Edit Menu

Cut, Copy, Paste, and Delete are standard editing functions.

<b>Paste Link</b>	Paste Link allows you to paste DDE links from another application into an output meter.
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## **Options Menu: General**

- Sample And Log Rate** You may select the Sample Rate, in Hz, which is the rate of reading and displaying inputs and logging to disk. The maximum rate depends on the Mode you have selected, the speed of your PC, and the data acquisition hardware installed.
- Mode** The Polled (or Asynchronous) mode samples at the rate set by the application, and is the slowest data acquisition rate. This mode does not use interrupts for most data acquisition devices. However, this mode is the simplest to use.
- The Interrupt (or Synchronous) mode samples at a precise rate set by the driver, and allows much faster sampling. Most data acquisition devices generate hardware interrupts to pace the driver, and thereby set the rate.
- Refer to the on-line help for more information about these modes.
- Input Meters** When first launched, QuickLog detects the hardware installed, and creates a default user interface made up of a table of windows, called Input Meters, which display the analog, digital, or Counter/Timer values being sampled. You may change the number of Meters being displayed, as well as the number of horizontal and vertical Meter windows, using the General Options menu. Color and font size are also selectable.
- Output Meters** You may set up the Output Meters in the same fashion as described above, if you have a device installed that has analog or digital outputs.

---

## ***Options Menu: Inputs***

	<p>This window allows you to define which readings will be displayed in the Meter window. You may select data acquisition Device 1 through 15, the input Function...None, Analog In, Digital In, Pulse In, Time, Date (from the PC clock), and which Channel on that device will be assigned that input function.</p>
<b>Window Label</b>	<p>The first column accepts a typed in label for that Input Meter window, in place of the default label.</p>
<b>Analog Input Range</b>	<p>When you select Analog In, you may select the input Range from a table that will depend on the ranges available on the device you have connected to your PC.</p>
<b>Resolution</b>	<p>The column Resolution allows selection of A/D resolution, again dependent on the device connected. Some devices allow for averaging the samples to reduce noise. Also, Low Noise mode is effective in greatly reducing AC line interference.</p>
<b>Scale</b>	<p>When you click on the radio button Scale = <math>mX + b</math>, a new field opens to allow you to enter coefficients for a linear scaling of the analog input readings into engineering units</p>
<b>Log &amp; Chart</b>	<p>Log and Chart columns allow you to select whether this channel will be logged to disk and/or displayed on the Chart. At least one channel must have the Log box checked to have logging to disk. At least one channel must have the Chart box checked to have a trace on the chart.</p>

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## ***Options Menu: Output Meters***

The functions in this menu are similar to the Input Meters Options menu described above but these selections operate on the output signals: Analog and Digital.

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## ***Options Menu: Chart***

	<p>This window allows you to customize the appearance of the Y-t Chart display. All of the parameters are available in one window, as opposed to the function of the Chart menu described below, where an abbreviated set of attributes are accessible separately in the menu.</p>
<b>Options Menu: Colors And Lines</b>	<p>Chart Colors and Lines can be used to select colors and line types on the chart.</p>

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## Chart Menu

Unlike the Options menu, these selections do not cause the Chart data to be erased.

<b>Undo Zoom</b>	Undo Zoom allows you to cancel a Chart zooming operation; alternatively, use the keyboard shortcut Ctrl+Z.
<b>Chart Zoom</b>	Chart Zoom allows you select a region of interest in the data, and expand it to fill the Chart display window. Place the cursor at one edge of the region of interest, and hold the left mouse button down. Move the cursor to draw a box around the region, and release the mouse button. The region will expand to fill the window. The X and Y scales will also expand to maintain the proper scale.
<b>Other Options</b>	The balance of the menu items, <i>Viewing Style</i> , <i>Font Size</i> , <i>Plotting Method</i> , <i>Grid Lines</i> , <i>Grid in Front</i> , and <i>Graph or Table</i> , are direct menu access to the same items as in Options, Chart. Refer also to the on-line Help.

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## Run Menu

To *Start* the acquisition, press F5; to *Stop*, press F6. When acquisition is running, a green *Running* indicator lights up at the left edge of the menu bar; when stopped, the indicator turns red

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## Window Menu

This menu allows you to pull the *Input* (F9), *Output Meter* (F11) displays, and the *Y-t Chart* (F12) to the foreground of the screen.

---

## Calibration Menu

<b>Calibrate Analog Inputs</b>	When you click on this entry, the analog input circuits of all devices are immediately calibrated against their respective internal precision voltage references, which compensates for drift and offset.
<b>Autocalibrate</b>	You may select the interval at which you wish to invoke the above calibration function.
<b>Calibrate Analog Outputs</b>	This selection calibrates analog outputs on some hardware <b>Note: Outputs are changed from minimum to maximum on all ranges during calibration.</b>
<b>Change Numbers</b>	This utility allows you to perform a complete recalibration of the device. If you follow the instructions given in the Help file, you can restore the device to the original factory accuracy. However, please observe the cautionary statement in the window, and in the Help file.

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## Help Menu

The Help menu provides on-line help for QuickLog. The on-line help is a complete guide to the use of QuickLog, with much more information than this manual.

<b>Installed Hardware</b>	Installed Hardware is very helpful when calling our Technical Support people. The information contained in this window will help speed the answers to your application and troubleshooting questions
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Our primary objective is to provide you with data acquisition systems that are easy to install, operate, and maintain. We also strive to furnish the performance you need at the lowest overall cost. The benefits for you are increased productivity, data you can count on, and, of course, meeting your budget.

Part of meeting that objective is contained herein. Because the PC is a general purpose tool for data acquisition applications, we think it helpful to provide you with information for your specific application. This Applications Handbook gives you a detailed description of how to use our products to complete a variety of data acquisition tasks.

Data acquisition is divided into two distinct types: ANALOG and DIGITAL. An example of analog data acquisition is temperature measurement. An example of digital data acquisition is observing the on/off state of a conveyor belt. Further, data acquisition usually refers to measurement (input) *and* control (output). Also, most data acquisition applications have a combination of inputs and outputs, analog and/or digital.

This Handbook covers all of the most common PC data acquisition applications, as well as a few uncommon applications. If your particular application is not covered here, and you need further assistance, please contact our technical support department.

We begin with a few generalities regarding sensor connections, followed by more specific examples for analog applications in Chapter 13, and digital applications in Chapter 14.

---

## ***Applications Reference***

Almost any type of sensor can be connected to Analog Connection data acquisition equipment. For each type of sensor, a detailed description of the connections and software setup is given. Sensors that are not listed may be connected as long as they have a voltage or current output.

### **Connection Types**

#### ***Analog Input & Output Applications***

- Thermocouples
- Strain Gages
- Current Input
- High Voltage Dividers
- RTD's (resistance temperature detectors)
- Piezoelectric Sensors
- Audio & Video
- Voltage Output
- Current Output

#### ***Digital I/O Applications***

- High Power Optically Isolated Digital Output
- High Power Optically Isolated Digital Input
- Low Power Optically Isolated Digital Output
- Low Power Optically Isolated Digital Input
- Non-Isolated Digital I/O
- Pulse Counting
- Cascaded Counter/Timers
- Frequency or Rate Measurement

## Sensor Connections

There are several general topics regarding sensor connections that must first be presented. These are single-ended vs. differential connections (for analog input), auxiliary power output and voltage reference, auxiliary components (sometimes needed to make certain sensors work), and digital line connections.

### Single-Ended vs. Differential Connections

This concept refers to how analog input sensor wires connect to the terminal panel. A single-ended input has only one wire from the sensor connected to each channel. The other wire from the sensor is connected to a common return for all channels. In this case, the A/D converter measures the voltage difference between the sensor wire and ground.

A differential connection means that there are two wires from your sensor that are connected to the terminal panel. Here, the A/D converter measures the voltage difference between the two wires.

When using boards in differential mode, analog inputs connect to the + and – terminals on the terminal panel. The reading is positive when the + terminal is positive with respect to the negative terminal. The COM terminal is ground. Often, the COM terminal is connected to the – input with a jumper plate. When the input voltage already has a ground reference, remove the connection to the COM terminal so that current won't flow between the two ground points, creating a voltage drop in the wire (a ground loop).

When using a data acquisition board in single-ended mode (if applicable), analog inputs 1 through 8 connect between the + terminal of channels 1 through 8, respectively, and GND on the terminal panel. The reading is positive when the + terminal is positive with respect to GND. The reading is negative when the positive terminal is negative with respect to GND. Channels 9 through 16 connect between the – terminal of channels 1 through 8 respectively, on the terminal panel and GND.

The reading is positive when the – terminal is positive with respect to GND and the reading is negative when the – terminal is negative with respect to GND.

### Auxiliary Power Output & Voltage Reference

Many sensors, such as RTD's, thermistors, strain gages, and pressure sensors, need a stable power source because the output is proportional to the power applied. For this reason, a stable voltage reference is available in all analog input and output boards (accessed via the terminal panel). Another advantage to the voltage reference is that it can be used for easy recalibration of analog inputs (see your hardware manual).

All other analog input boards have a 6.6-6.9 Volt reference with a low impedance that can supply 20mA of current (refer to the hardware manual for specifications). The ACAO-12 (analog output) has a 10 Volt reference, also with a low impedance that can supply 20mA of current.

Alternatively, you can use the +5 Volt or  $\pm 12$  Volt lines to provide power for your applications. These sources, however, are typically noisy, and may vary, so they do not make good reference voltages. Yet, they are an excellent source of relatively large amounts of power for sensor electronics.

### Auxiliary Components

For some sensors, it is necessary to install auxiliary components. These components provide signal conditioning and can easily be installed in the terminal panel for convenience.

Installing auxiliary components requires soldering and some familiarity with electronics. Most common sensors can be connected without the use of auxiliary components.

Refer to the your Terminal Panel manual for more information on installing these components.

### Digital Connections

Wires for digital signals connect to either the IN (+) or OUT (–) terminal and GND. Most software automatically changes each line to be either an input or an output when you use the line.

## **Special Note For Thermocouple Applications**

In addition to the thermocouple application instructions given in Chapter 13, Appendix I provides detailed information on common problems encountered with these sensors, along with specific instructions for solving such problems.



## *Analog Input & Output*

### **Thermocouples**

Thermocouples are the most widely used temperature sensor. They are rugged and available in a wide variety of types and configurations. Some types can be used in temperatures over 2000 degrees Celsius. Generally, thermocouples are not as accurate as thermistors or RTD's. Thermocouples output a voltage proportional to the temperature difference between two separate metal junctions. They require compensation of the reference, or cold junction, to measure absolute temperature. They are also nonlinear.

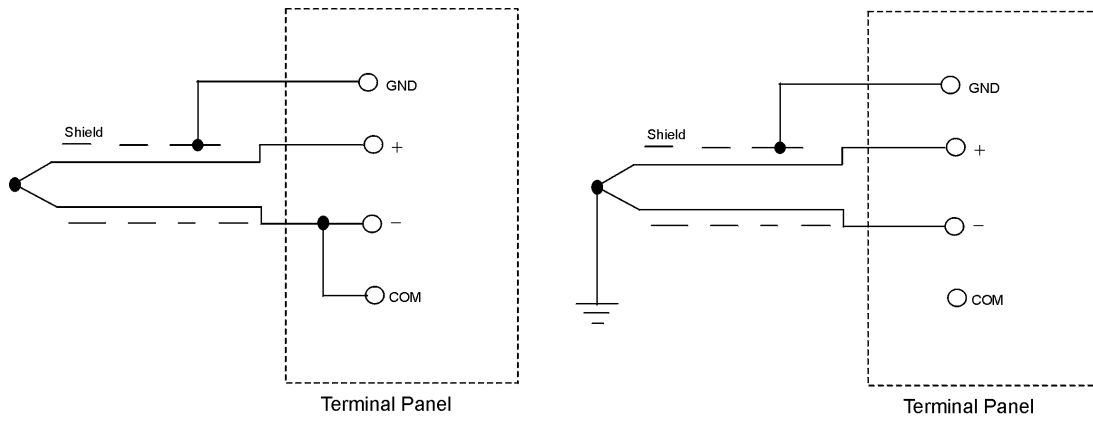
The T31 terminal panel has a cold junction sensor, but do not have the isothermal aluminum block. The thermocouple terminations are not held at exactly the same temperature as the cold junction sensor. The difference can be as much as several degrees, resulting in an error of several degrees.

Figure 13-1a shows the installation of an ungrounded thermocouple. The COM terminal connection provides the ground. Use this configuration for probes with isolated thermocouples or whenever the thermocouple probe is not in contact with grounded metal or other conductors such as water. The shield connects to one of the separate digital ground terminals on the digital terminal strips.

Thermocouples are commonly grounded as in Figure 13-4b. This is the case for probes with grounded thermocouples attached to grounded metal or other conductors such as water. Remove the COM connection for these installations.

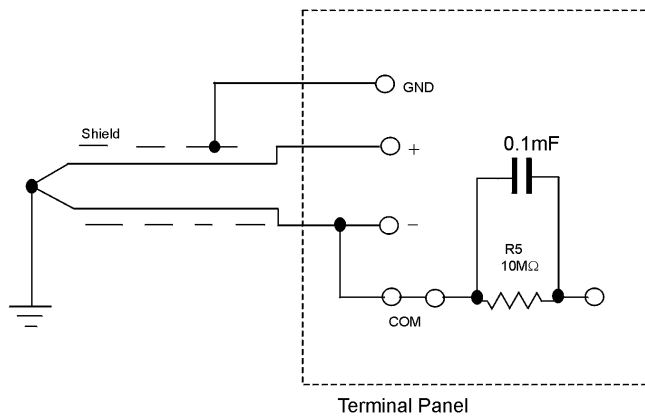
Although a properly installed thermocouple is grounded at some point, sometimes this requirement is hard to satisfy. Sometimes a thermocouple is not in good electrical contact with a conducting surface because of dirt or corrosion. Sometimes the material is only slightly conducting or the thermocouple may not always be in contact with it, as in a container of liquid that has been emptied.

For these situations use Figure 13-1c. It is the same as 13-1a except that a resistor has been installed in place of the jumper wire at auxiliary component location R5. Use a 1 M ohm, ¼ Watt, 5% resistor in parallel with a 0.1µ F capacitor. This connection provides a ground reference but doesn't allow large currents to flow in the signal wires. This prevents erroneous voltage drops. The modification may be left in place when you use either ungrounded or grounded thermocouples. The capacitor is optional.



a. Ungrounded thermocouple

b. Grounded thermocouple



c. Thermocouple with intermittent ground

**Figure 13-1. Thermocouple Connections**

When a resistor is installed at R5 and the thermocouple is grounded, there is a small current in the signal wire. With extremely long wires or extremely small thermocouples, there may be enough resistance in the wire to cause a small error. With long wires in a very noisy environment, large common mode signals can exceed the common mode range of the analog board. A smaller resistor or larger capacitor at R5 will rectify this problem.

Select the proper thermocouple for the temperature range and accuracy required using the table below. Use care in hostile environments especially at very high temperatures. Some thermocouples are durable only in certain atmospheres. They may fail very quickly in another type of atmosphere. In hostile environments, the thermocouple is usually placed in a sheath or thermowell.

<b>Thermocouple Types</b>		
<b>Type</b>	<b>Alloy Combination</b>	
	<b>+ Lead</b>	<b>- Lead</b>
E	Nickel-Chromium (Chromel)	Copper-Nickel (Constantan)
J	Iron	Copper-Nickel (Constantan)
K	Nickel-Chromium (Chromel)	Nickel-Aluminum (Alumel)
T	Copper	Copper-Nickel (Constantan)
C	Tungsten – 5% Rhenium	Tungsten – 26% Rhenium
D	Tungsten – 3% Rhenium	Tungsten – 25% Rhenium
G	Tungsten	Tungsten – 26% Rhenium
R	Platinum – 13% Rhodium	Platinum
S	Platinum – 10% Rhodium	Platinum
B	Platinum – 30% Rhodium	Platinum – 6% Rhodium
N	Nickel-Chromium-Silicon (Nicrosil)	Nickel-Silicon-Magnesium (Nisil)

<b>Supported Product Thermocouple Ranges</b>		
<b>Type</b>	<b>Degrees C</b>	<b>Degrees F</b>
E	-200 to 680	-76 to 1256
J	0 to 750	32 to 1382
K	-200 to 1250	-166 to 2282
T	-200 to 350	-184 to 662
C	0 to 2315	32 to 4200
D	0 to 2315	32 to 4200
G	0 to 2315	32 to 4200
R	0 to 1450	32 to 2642
S	0 to 1450	32 to 2642
B	100 to 1700	212 to 3092
N	-270 to 1300	-450 to 2372

## Strain Gages

Strain gages are made of a wire or resistor that changes resistance when stretched or compressed. They are normally bonded to the material in which the strain is being measured. They can be connected as a resistance type sensor, but they are usually used in bridge configurations. Load cells consist of a strain gage bridge arranged so it is temperature compensated and mounted on a load bearing support. Any analog input board with differential inputs can measure strain gage signals.

Connections: Figure 13-2a shows a bridge connection in which opposing pairs of strain gages are mounted so that one pair is in tension while the other is in compression. This gives the maximum sensitivity of any bridge configurations as well as providing temperature compensation

Figure 13-2b is a bridge configuration that uses fewer strain gages but requires R4 and R3 to be precision stable resistors. The bridge configuration of Figure 13-2c uses only one strain gage and has three precision stable resistors. The resistors may be mounted in the auxiliary component locations in the terminal panel. Often unmounted strain gages are used in place of resistors because they match the active strain gages in resistance and in temperature coefficient.

All strain gage circuits require a stable supply voltage, since the signal is proportional to the supply. The stable 6.6-6.9 voltage supply available on our data acquisition boards can provide the necessary power for strain gage circuits that draw current of 20mA or less. Due to the 20mA maximum current, the circuit must provide at least 345 Ohms of resistance. To determine the amount of resistance in your circuit, use the following Ohms formulas:

For a pair of resistors wired in series:

$$\text{Total Ohms} = R1 + R2$$

For a pair of resistors wired in parallel:

$$\text{Total Ohms} = [R1 \times R2] \div [R1 + R2]$$

For circuits that have less than 345 Ohms of resistance, another power supply, preferably 5V or less, providing ample current, must be used.

Keep the common mode voltage to the analog board within the common mode range of the board for proper operation ( $\pm 7.5$  volts).

Current from other sensors may create a voltage drop in the wires between the analog board and the terminal panel. Be careful that this does not reduce your accuracy.



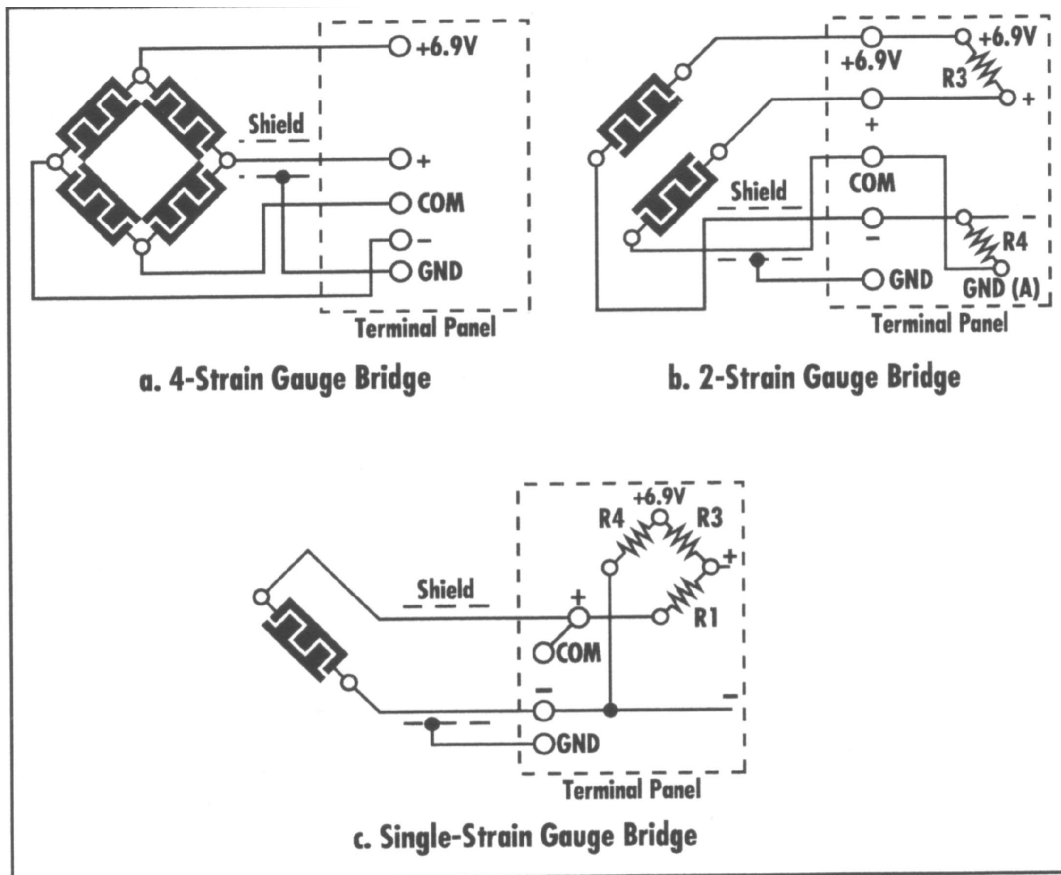


Figure 13-2. Strain Gage Connections

## Piezoelectric Sensors

Our data acquisition boards can be used with piezoelectric sensors to monitor vibration, audio and other mechanical and acoustic effects. Piezoelectric sensors rely on the piezoelectric effect, where a crystal generates a voltage when it is subjected to stress or strain. Piezoelectric sensors are a good, inexpensive sensor for the monitoring of acoustic, mechanical and audio disturbances provided an accurate quantitative reading is not required.

Figure 13-3a shows a simple DC-coupled piezoelectric sensor configuration. In this configuration, the piezoelectric sensor is connected to the terminal panel, either using a coaxial cable or twisted pair cable. R3 is the termination resistor, which is used to terminate the piezoelectric sensor signal. In many cases, the termination resistor is not needed. In some cases, the termination resistor is the characteristic impedance of the cable, often 50, 75 or 150 ohms. Refer to the technical manual for your piezoelectric sensor for selection of R3.

Figure 13-3b shows an AC-couple piezoelectric sensor example, which is the most common implementation. An AC-couple piezoelectric sensor is easier to measure because any DC offset in the piezoelectric sensor signal is automatically removed for you. The capacitor C and the resistor R3 form a high-pass filter network, which specifies the lowest frequency signal, which will be transmitted, to your analog input board. This lowest frequency point is given by:

$$F = 1 \div (2\pi R3C)$$

Install capacitor C in location R1 or R2. You must select R3 to be large compared to the output impedance of your piezoelectric sensor, then select C to set the lowest frequency which you wish to digitize via the data acquisition board. Refer to your piezoelectric sensor manual for details.

Figure 13-3c shows an amplified piezoelectric sensor configuration. Many piezoelectric sensors provide only a few millivolts of signal, so they need a preamplifier. The power for this preamplifier can be taken directly from the power supply terminals on your terminal panel. The output of the preamplifier can then be read directly with your data acquisition board as shown in Figure 13-3c.

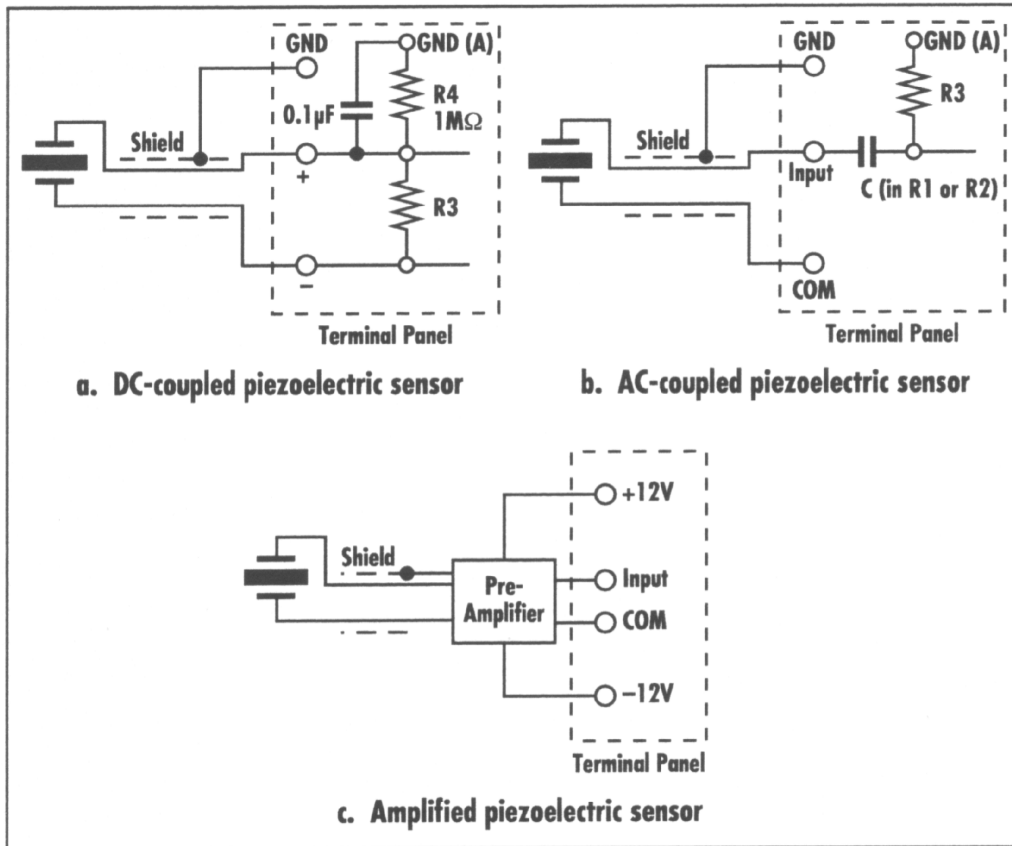


Figure 13-3. Piezoelectric Sensor Configurations

## Audio

Figure 13-4a shows a simple DC-coupled audio configuration. In this configuration, an audio source is connected to the terminal panel, using either coaxial cable or twisted pair cable. R3 is the termination resistor, which is used to terminate the audio signal. In many cases, the termination resistor is not needed. In some cases, the termination resistor is the characteristic impedance of the cable, often 50, 75, or 150 ohms. Refer to the technical manual of your audio transducer or microphone for the selection of the termination resistor.

Figure 13-4b shows an AC-coupled audio example, which is the most common implementation. AC-coupled audio is easier to measure because any DC offset in the audio signal is automatically removed for you.

The capacitor C and the resistor R3 form a high-pass filter network, which specifies the lowest frequency audio signal, which will be transmitted to the data acquisition board. The lowest frequency point is given by the equation:

$$F = 1 \div (2\pi R3C)$$

Install capacitor C in location R1 or R2. Select R3 to be large in comparison to the output impedance of your audio transducer, and then you select C to set the lowest frequency which you wish to digitize with your data acquisition board. Refer to your audio transducer manual for details.

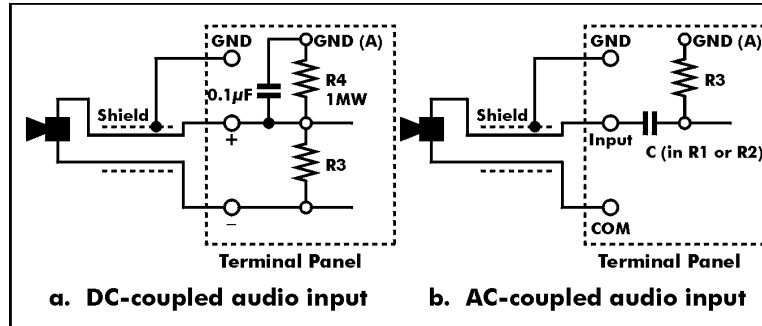


Figure 13-4. Audio Input Configurations

## RTDs

An RTD (Resistance Temperature Detector) changes resistance with temperature. The most common type is made of platinum because it is highly stable and its resistance change is linear. RTDs are connected like resistors, but there are some variations for three wire and four wire types. The most common resistance for platinum RTDs is 100 ohms at 0°C. There are other popular values ranging from 50 to 1000 ohms.

Figure 13-5a is an example of the connections for a two-wire RTD. This is the simplest connection. The precision voltage reference can be used as a power source. Auxiliary component R3 must be a precision, stable resistor. R4 has no effect with a two wire RTD. Install the lead of R3 that is near the analog terminals, in the reference voltage hole. This circuit can suffer from errors in long sensor wires because of wire resistance.

Figure 13-5b overcomes the wire resistance problem with a three wire RTD. R3 and R4 are equal so the currents in the signal wires (connecting to the + and – terminals) are equal. The voltage drops in the two signal wires are equal (so they cancel each other) because the signal wires have equal resistance. Only R3 must be high precision and stable. Consult tableset resistor values on page 13-6.

Figure 13-5c uses a four wire RTD for the highest precision. It does not rely on the signal wires being of equal resistance. R is a precision stable resistor. The resistor R does not install on the panel. The values for R3, the set resistor, are shown below. Keep the voltage drop across the RTD below 50 millivolts. This keeps heating less than 50 microwatts and subsequent temperature errors negligible.

Accuracy and resolution are shown for 16-bit boards in the following tables.

<b>RTD Ranges &amp; Resolution</b>			
<b>Current Set Resistor</b>	<b>RTD</b>	<b>Temperature Range</b>	<b>16-Bit Resolution</b>
(Ohms)	(Ohms)	(Degrees C)	(Degrees C)
10K	50	-200 to 115	0.005
20K	50	-200 to 525	0.01
20K	100	-200 to 115	0.005
50K	50	-200 to >850	0.03
50K	100	-200 to 750	0.01
50K	200	-200 to 115	0.005
100K	100	-200 to >850	0.03
100K	200	-200 to 750	0.01
100K	500	-200 to 115	0.005
200K	200	-200 to >850	0.03
200K	500	-200 to 525	0.01
200K	1000	-200 to 115	0.005
500K	500	-200 to >850	0.03
500K	1000	-200 to 750	0.01
1,000K	1000	-200 to >850	0.03

<b>RTD Accuracy</b>		
<b>Current Set Resistor</b>	<b>RTD</b>	<b>16-Bit Accuracy</b>
(Ohms)	(Ohms)	(Degrees C)
10K	50	0.8
20K	50	0.9
20K	100	0.8
50K	50	1.4
50K	100	1.0
50K	200	0.8
100K	100	1.4
100K	200	1.0
100K	500	0.8
200K	200	1.4
200K	500	0.9
200K	1000	0.8
500K	500	1.4
500K	1000	1.0
1,000K	1000	1.4

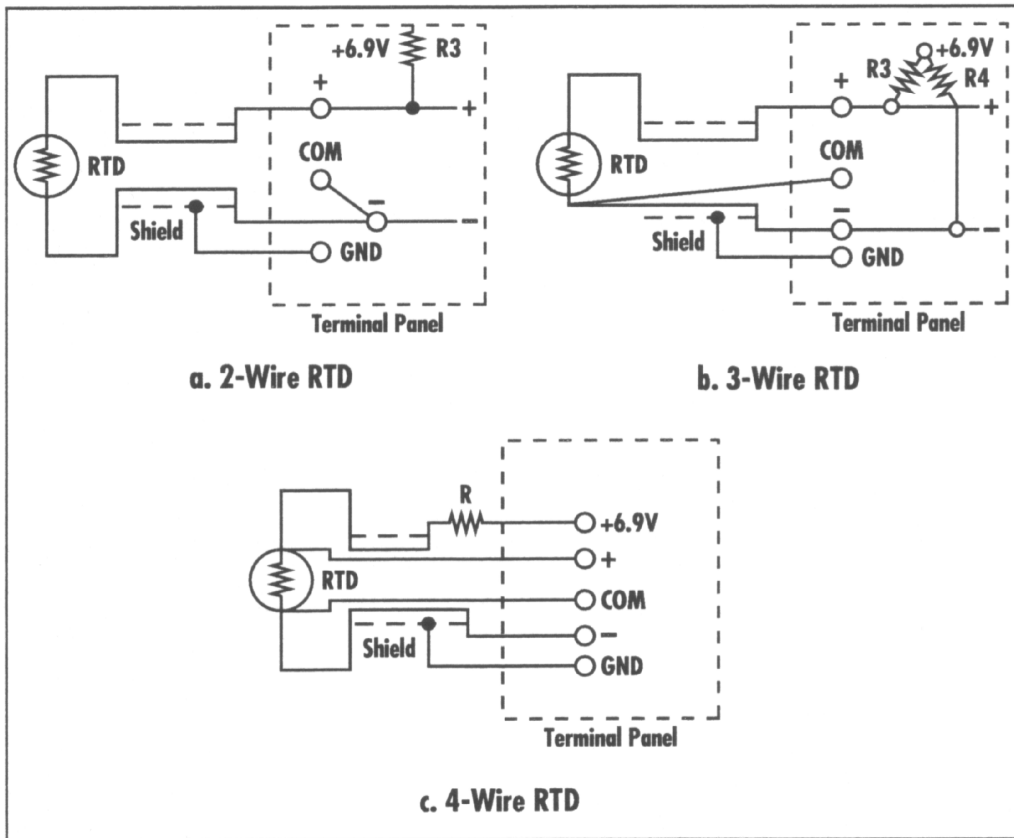


Figure 13-5. Connections for RTDs

## Current

Figure 13-6 shows the connections for current measurement. R3 is used as a shunt resistor. Since these analog input boards are configured to measure voltage, use the following equation to measure current:

$$\text{Current} = \text{Voltage} \div R3$$

Do not run currents higher than 1 Amp into the terminal panel or you risk melting the circuit board traces. Observe the power rating of the resistor you install at R3. Space is provided for a ¼ Watt resistor. To measure 1 Amp it can be no larger than 0.25 ohm.

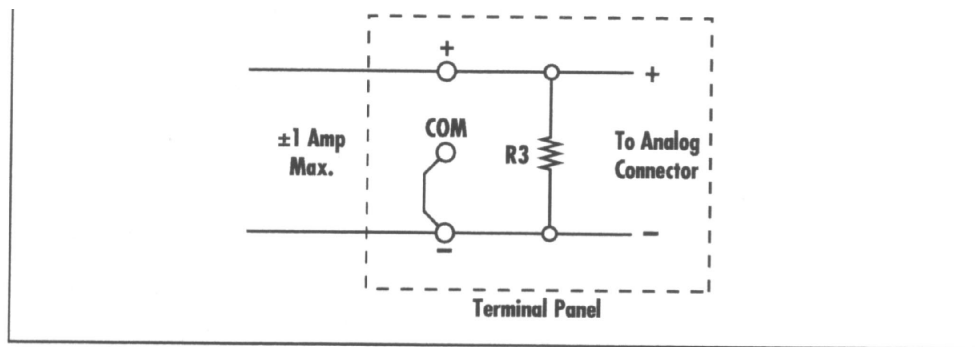


Figure 13-6. Current Connections

## High Voltage Divider

Our data acquisition boards and terminal panels are limited to measuring voltage up to 10 Volts directly. Although this is sufficient for most sensors, provision has been made for measuring voltages up to  $\pm 150$  Volts.

Figure 13-7 shows the connections for high voltage measurement. R3 and R1 are used as a voltage divider. Do not connect voltages higher than 150 Volts into the terminal panel or you risk arcing between the circuit board traces. Observe the power rating of the resistor you install at R1. Space is provided for a  $\frac{1}{4}$  Watt resistor. To measure 150 Volts it can be no smaller than 100k ohms.

One side of the analog input should be connected to ground to minimize the common mode voltage. In all cases the common mode voltage must be kept within the specifications of the board (refer to the user manual that accompanies the board).

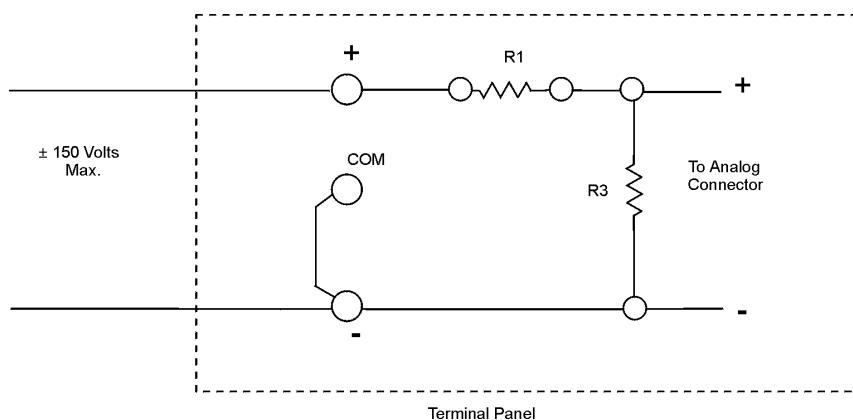


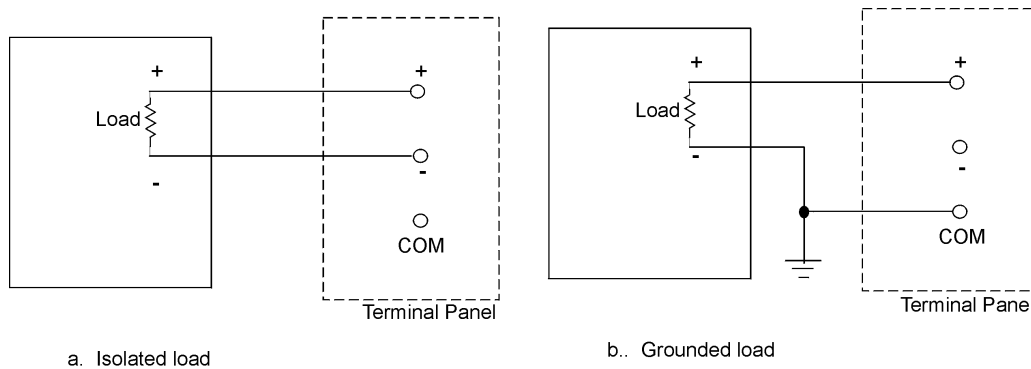
Figure 13-7. High Voltage Connections

## Voltage Output

Voltage outputs can drive a variety of controllers, amplifiers, and other devices. Figure 13-8a shows typical connections for voltage output.

The voltage output is on the “+” terminal. The negative terminal of the driven devices is returned to the “-” terminal of the same channel. This is the ground for the computer. By using the “-” terminal, maximum precision is achieved. Although the “COM” terminal is also ground, it may have small variations induced by other channels or by digital signals. Notice that the load is not connected to ground except by the “-” return wire. This is a normal situation.

Figure 13-8b shows a connection that may be used where the load is already connected to ground. This connection is not recommended, however. Voltage drops in the ground between the computer and the load will appear as error voltages in the signal. This means that for maximum accuracy you should have a load that is isolated from ground. In some cases this is not possible. If you have to use the connection of Figure 13-8b, make the ground return wire a large gauge, such as AWG 18 or larger. This will minimize errors due to current flowing in the wire.



**Figure 13-8. Voltage Output**

## Current Output

Most current outputs connect to current loop devices, which are often controllers. Almost all current loops are 4 to 20mA. If you have a device with another range, refer to Figure 13-9d.

A 4-20mA current device has the advantage of running the power and signal over the same pair of wires. Also, current signals are much less susceptible to noise pickup than voltage signals.

The circuit in Figure 13-9a is the most common way to connect a current loop. The power is supplied from the +12 Volt source on the terminal panel. Many loads may be driven from one supply. The negative terminal of each load must be independently tied to the “+” output terminal. If the requirement cannot be met, the circuit of Figure 13-9c must be used.

The 12 Volt source connects to the computer’s power supply. If you are connecting a large number of current loops, you may want to use an external supply as in Figure 13-9b. This connection is otherwise identical to Figure 13-9a.

Figure 13-9b is advantageous when a load requires a large voltage. With a 12 Volt source, as in Figure 13-9a, the voltage drop across the load must be less than 9.4 Volts. The voltage at the analog output must be at least 2.6 Volts. The voltage at the analog output must be at least 2.6 Volts for the output to operate normally:  $12 - 2.6 = 9.4$  Volts. To be on the safe side you should allow for the +12 Volts supply to be low by as much as 1 Volt. This leaves only 8.4 Volts across the load. The load resistance must, therefore, be less than 420 Ohms:  $8.4 \text{ Volts} \div 20\text{mA} = 420 \text{ Ohms}$ . For loads with a higher resistance, the supply voltage must be higher. You can connect a power supply up to 50 Volts.

Use voltages higher than 12 Volts only when necessary. If the output is accidentally set to voltage instead of current with more than 12 Volts connected, the board will be damaged.

Use the connection of Figure 13-9c when the load is connected to ground. Unlike Figure 13-8b for voltage, the return wire to the “COM” terminal in Figure 13-9c is not necessary, and in fact, may degrade performance. Voltage drops in the ground wire do not affect the accuracy of the current supplied to the load. The connection to the “COM” terminal should be used only when the ground connection at the load is not reliably connected to the computer ground.

You must be careful not to have a large voltage drop between the computer ground and the ground of the load. If the difference in the two grounds is large it will either reduce or increase the voltage across the “+” and “-“ terminals of the board. If the voltage is less than 2.6 Volts, the current output won’t operate properly. If the voltage is more than 50 Volts, the current output may be damaged.

The disadvantage of this connection is that each load requires its own power supply. The power from the terminal panel may not be used because it does not have a separate negative return.



For currents other than 4-20mA, use the connection of Figure 13-9d. The channel must be set to output voltage. The current at zero percent output will be zero. The current at 100 percent output is determined by resistor R1, the load resistance, and the voltage range. To calculate R1 first determine the resistance of the load, RL, from its specifications. The maximum current, I, is determined by the formula below.

$$I_{max} = V_{max} \div (R_L + R_1)$$

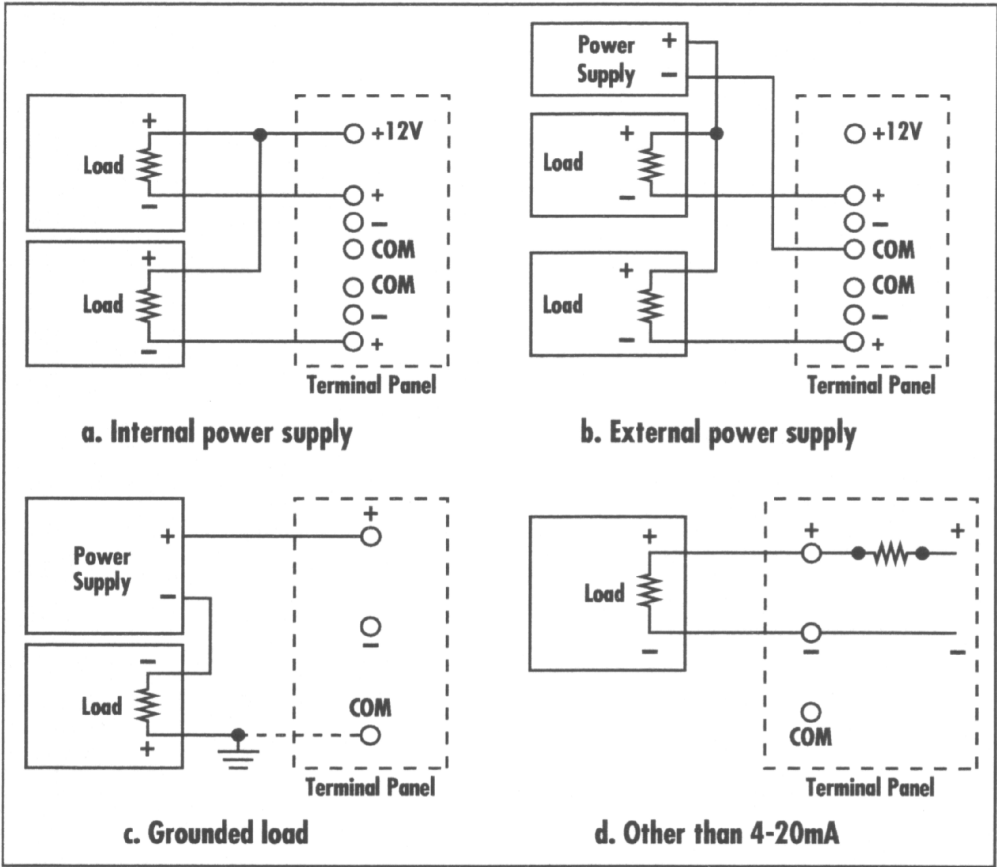


Figure 13-9. Current Output



## **Digital Input & Output**

This chapter provides instruction for digital I/O applications. Please note the implementation differences below for the various terminal panels.

The T31, terminal panel has provisions for high power optical isolation components or direct connection. Low power optical isolation components cannot be used with this terminal panel. This terminal panel also has open collector digital outputs ( a separate power supply must be provided).

## **Common Applications**

Digital I/O lines have two fundamental purposes: 1) to turn something on or off; or 2) to detect the state of an on/off device. All digital I/O applications are a variation of one of these two alternatives. The primary difference between variations is the electrical characteristics of the digital circuit, namely voltage.

There are two different ways to implement digital I/O applications: Isolated or Non-isolated. It is recommended to use isolation whenever possible. This protects most of the hardware from damage by unanticipated high voltage. Isolation also enables digital I/O operation for high-voltage applications, such as sensing the presence of a 120VAC source or switching a 50VDC circuit on and off.

Note: When making digital I/O connections without isolation, be certain there is no risk of an unanticipated high voltage. Such a situation can damage the data acquisition hardware, the computer, and also pose a risk of bodily injury.

Following are general instructions for implementing isolated digital I/O applications.

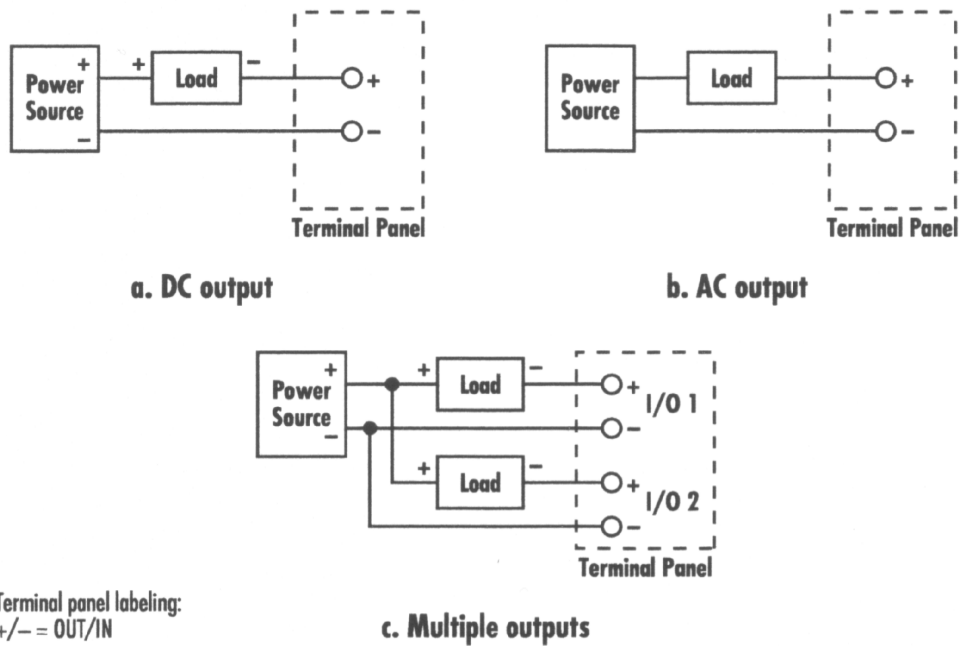
## **High Power Optically Isolated Digital Output**

(For T31 terminal panels)

Devices used for high power digital switching are called solid state relays (SSRs). The devices you want to control may be AC or DC and may have any of a large variety of voltage and current ratings. If you need to drive a device that has a higher rating than the high power SSRs, which are installed on the terminal panel, use the SSR to drive another solid state relay or mechanical relay with a higher voltage or current rating.

Mechanical relays and SSRs provide electrical isolation from the controlled device as well as the ability to switch large currents.

Connections to the screw terminals on the terminal panel are shown in Figure 14-1 for both AC and DC loads. They are almost identical. The loads indicated in the figure might be a heater, pump, light, or other device that you are turning on and off. Almost any type of load can be handled except inductive or capacitive loads, such as motors and fluorescent lights. These are best controlled by driving a relay which in turn switches the load. When the output is set low the SSR turns on.



**Figure 14-1. High Power Output Connections**

If the load is a DC load, such as motor, pump, or valve, it may have a polarity indication. Be sure to connect the terminals correctly (see illustrations) to avoid damage. Some DC loads, such as lights and heaters, often do not have polarity. You must still be careful to connect the power source correctly so that the SSR can switch the load.

There is no polarity to watch when connecting AC loads or power sources to the screw terminals. Ignore the terminal labels for AC loads.

The power source indicated in the figure might be 120 Volts AC to power heaters, lights, and pumps, 24 Volts DC to power pumps and relays, or 5 Volts DC to power relays and lights. The power source rating is determined by the requirements of the load. Be sure the output SSR can handle the current and voltage the load requires.

Figure 14-1c shows how to share a single power source among several loads. This occurs frequently. The number of loads that may be shared is limited by the current capability of the power supply. This only works, of course, if all the loads have the same voltage rating.

Be sure to set each line to the correct input or output condition in the software you are using.

These components require approximately 20 milliseconds to switch.

## High Power Optically Isolated Digital Input

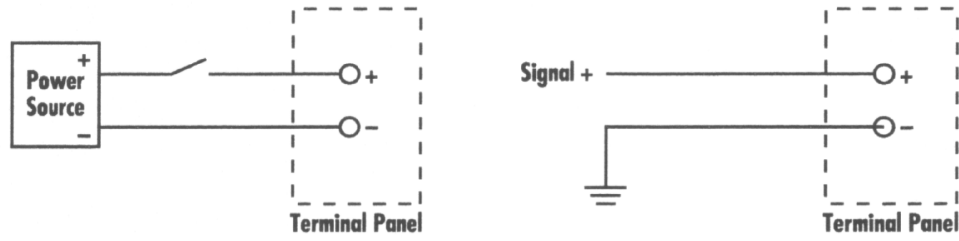
(For T31 terminal panels)

Digital input can be detected with any DynaRes board that has digital I/O capability.

Connections to the screw terminals for DC input signals are shown in Figure 14-2. There are two basic types, contact closure inputs shown in Figure 14-2a, and signal inputs shown in Figure 14-2b. AC input connections are shown in Figure 14-3. The connections are almost identical to Figure 14-2 for DC.

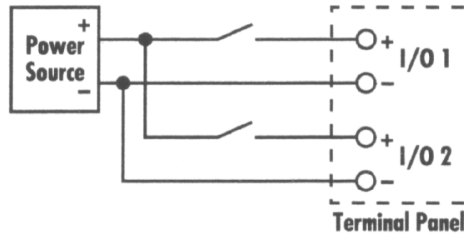
For contact inputs, a power source provides a voltage that, when connected to the screw terminals, is detected as a high level by the SSR. Because the SSR inverts the input, it appears as a low input to the data acquisition board. The switch interrupts the power source when it is open, resulting in a low level input to the SSR and a high level input to the data acquisition board.

Signal inputs connect directly to the screw terminals. They must be capable of driving the input SSR. The PSAC3-W detects a high level input for voltages greater than 90 Volts AC or DC. The maximum voltage you should apply is 140 Volts AC or DC. It draws 11 milliamps input current maximum. The PSAC1-W detects a high level input for voltages greater than 10 Volts AC or DC. The maximum voltage you should apply is 32 Volts AC or DC. It draws 25 milliamps maximum.



**a. DC contact closure input**

**b. DC signal input**

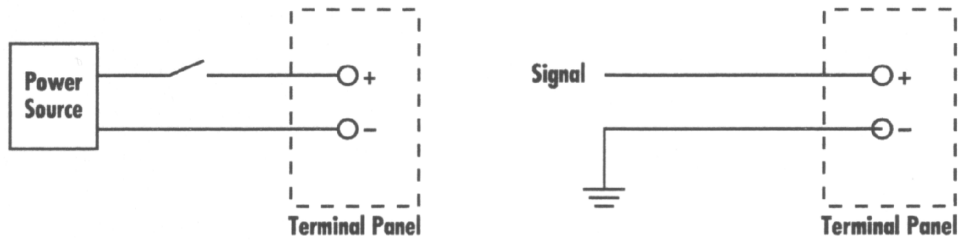


Terminal panel labeling:  
+/- = OUT/IN

**c. Multiple contact closure inputs**

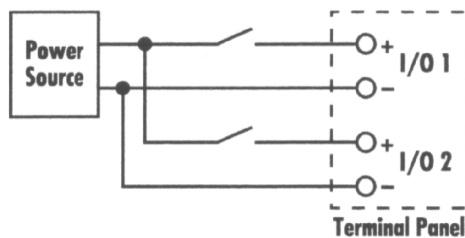
**Figure 14-2. High Power DC Input Connections**

DC inputs should be connected with the correct polarity or they may not be detected. There will be no damage to the board or boards if the polarity is reversed. When using an AC input you do not have to concern yourself with the polarity of the signals connected to the screw terminals.



**a. AC contact closure input**

**b. AC signal input**



Terminal panel labeling:  
+/- = OUT/IN

**c. Multiple contact closure inputs**

**Figure 14-3. High Power AC Input Connections**

Figures 14-2c and 14-3c show switches connected as in Figure 14-2a and 14-3a, except that they share a common power source. Since the input current requirements are minimal, you can connect almost an unlimited number of switches with a single power source.

Be sure to set each line to the correct input or output condition in the software you are using.

These components require approximately 10 milliseconds to switch. Because of this delay, they are not suitable for use with counter/timers.

## Pulse Counting

Counter/timers available on your data acquisition boards may be used for pulse counting, pulse output, frequency measurement, or timing. Each counter/timer has four I/O lines associated with it. They are used for inputs and outputs. The four I/O interface lines, the internal software line equivalents, and the various modes can all be used together to give a great deal of flexibility. A very simple but common example is that of counting pulses. (Note that the low and high power digital isolation modules should not be used in conjunction with the counter/timers, as these modules switch too slowly for counter/timer applications, and will likely result in erroneous counts.)

For pulse counting, only the input line of the counter/timer is used. You may make connections using the above diagrams for DC inputs. Do not use optical isolation components for this application.

In the software, you must set up the counter/timer. The external input line must be enabled. You should set the full count to 65,535, as high as possible (or to zero under certain circumstances). In most cases the output, gate, and trigger lines are not used. The software should gate and trigger the counter/timer

Internally, you might choose to use the gate, for instance, to block pulses during certain events signaled by another digital input. If so, connect that digital input to the gate and enable the external gate input.

You can set the counter/timer to count up from 0, or down to 0. The total number of pulses can be read from the counter at any time. You may have the software reset the count to 0 periodically to start over.

The counter/timer lines are labeled on the panel below the I/O numbers as "CT1", "CT2", and so on. Each external counter/timer line is also labeled as "IN", "OUT", "GATE", and "TRIG".

## Cascaded Counter/Timers

You may wish to count more than 65,535 pulses, the limit of one counter/timer. This can be done simply by cascading the output of one counter/timer into the input of another. The same thing would allow timing longer than 0.032 seconds in a timing application. This can be done by using more than one board with a counter/timer.

Figure 14-4a shows a pulse counting application with two counter/timers cascaded to count as high as 4,294,967,296. The output of CT1 is connected to the input of CT2 without using any I/O boards.

Set up both counter/timers as described in the previous section "Pulse Counting" above, except enable the output of CT1. See the next section for additional information.

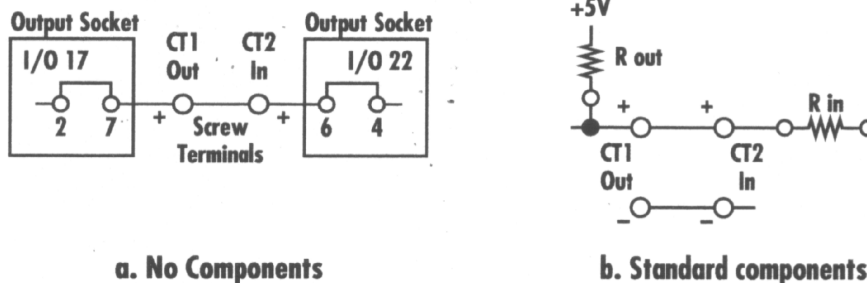


Figure 14-4. Cascaded Counter/Timers

## Frequency/Rate Measurement

Flow meters and tachometers put out pulses that are usually measured as a rate or frequency. You can measure rate or frequency by counting pulses in one counter/timer and measuring the time interval in another. The frequency is the number of pulses divided by the time interval. This can be done by using more than one board with a counter/timer.

Figure 14-5 uses three counter/timers. CT1 and CT2 are cascaded. CT1 gets its input from the internal clock. CT3 is gated by CT2. The pulses are counted by CT3. Figure 14-5a uses no boards.

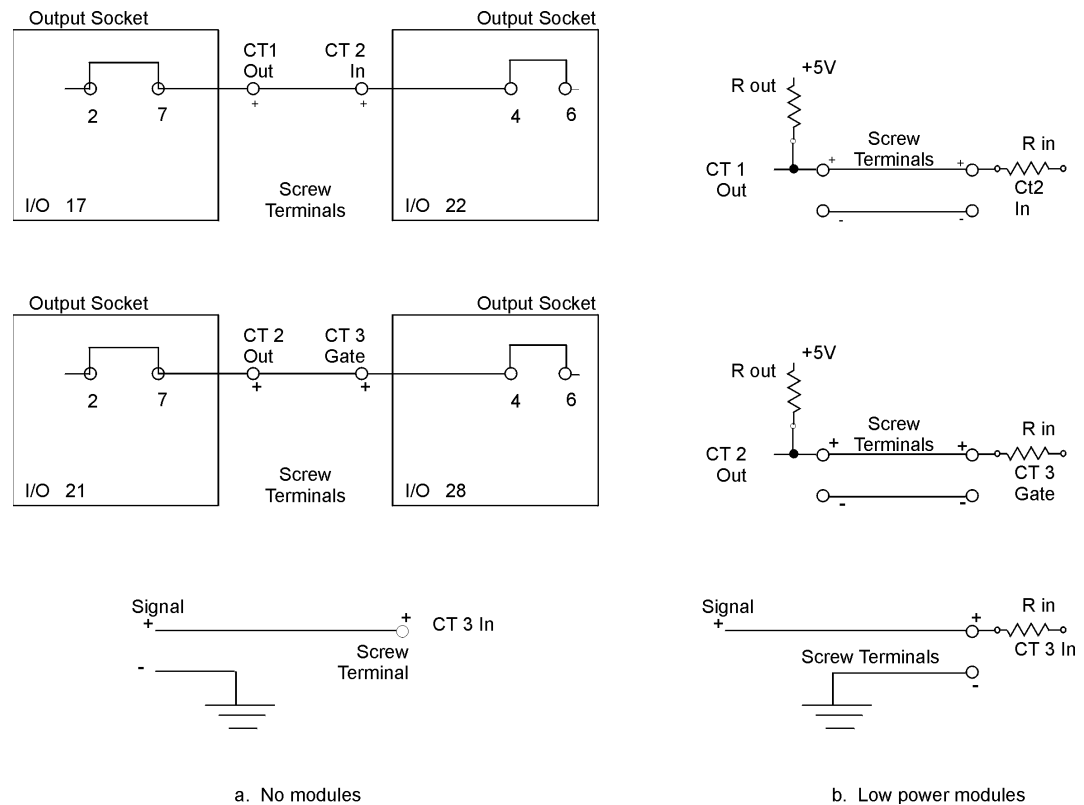
In the software, set up CT1 to use the internal input of 2 megahertz. Set it to a full count of 65,536. Enable its external output and put it in the one shot mode. Enable the input of CT2. Enable the external output of CT2 so it can gate CT3. Set the output mode of CT2 to pulse, and to single cycle (it only counts to full count once, then stops). Enable the input and the external gate of CT3. Set the full count of CT2 to give the output interval desired for the gating of CT3. It can count as long as 35.8 minutes.

The frequency is calculated as follows:

$$\text{Frequency} = (\text{CT3 count}) \div (\text{CT2 full count} \times 0.032768)$$

The gate interval for CT3 determines the resolution of the frequency measurement or how finely the frequency is measured. The resolution is calculated as follows.

$$\text{Resolution (\%)} = 100 \div (\text{gate interval} \times \text{frequency})$$



**Figure 14-5. Frequency/Rate**

If the gate interval is one second and pulses come in at the rate of 100 per second (100 Hertz frequency), the resolution is 1% or 1 Hertz. If the gate interval is reduced to 0.1 second to measure the frequency, the poorer the resolution.

Many applications require timing beyond the 32 milliseconds that one counter/timer can do with the internal 2 megahertz clock. This requires the cascading of two counter/timers as was done with CT1 and CT2. The first counter/timer, CT1, can be used to feed as many other counter/timers as desired. You can, for instance connect CT1 to several counter/timers, each timing different intervals. CT1 becomes a time base at a lower frequency than the built in 2 megahertz clock.

You can measure another frequency by adding only a single counter/timer and gating it with CT2. Just connect the additional counter/timer gate input as well as the gate input of CT3 to the output of CT2. You can gate almost an unlimited number of additional counter/timers, using only a single counter/timer for each frequency measurement. The only limitation is that the time interval (gate interval) is the same for all of them.



When implementing thermocouple applications, the following points will prove helpful if any problems are encountered.

- Ensure that the negative terminal is shorted to the ground (GND) terminal. Do not do this if the thermocouple is also grounded.
- Make sure that the type of thermocouple chosen in the software is the same as the one in use. Thermocouples can be identified by the colors of their wires.
- Check that the thermocouple is made from matched wires and not just any two bits of wire of the right composition. Non-matched wires will show errors due to resistance differences in the two wires.
- No wires should be connecting the ends of the thermocouple wires to the terminal panel. This leads to a change in the voltage drop due to the extra wire's different temperature/resistance characteristics. Extension wire that is specifically designed for a given thermocouple type can be used however. In this case only use extension wire at low temperatures and in regions of small gradients.
- Use the isothermal block terminal panels. Without it errors of up to 5°C can be seen in certain environments.
- Use sheathing to decrease the temperature gradient along certain sections of wire. If 90% of the temperature gradient is along a short section of wire, and that section has some small errors, then those errors will be significantly magnified.
- Ensure that there are no intermittent or solid grounds at the tip. This can occur in conducting solutions, or in high vibration or dirty environments. If there is an intermittent ground (seen as occasional spikes), use a high resistance resistor at R5 as shown in the manuals.
- If the cable is old, has been exposed to extreme temperatures or has been bent frequently, then the temperature characteristics may have been changed and will likely result in bad readings.
- Don't use very long, very thin wire as this can increase the resistance in the wires and lead to errors, especially at high temperatures.
- Check the connection at the end of the thermocouple, where the two wires have been joined. If this was not done properly then the wires may have been damaged or readings may be in error.
- Use the low noise mode, or at least the highest number of bits possible. This will help filter out unwanted noise.
- Ensure that calibration setup is engaged in DASyLab. This will prevent errors due to changing ambient temperatures.
- Make sure that QuickLog PC version 2.0.5 or QuickLog For Windows 1.14 or later is in use. Previous versions do not check the cold junction compensation.
- To check that the board, software, and terminal panel are functioning correctly, connect the positive and negative terminals of the channel in use to each other with copper wire. The software should read room temperature. If it does then the problem is with the thermocouple and the way it is placed in it's environment.
- To check that the thermocouple and cold junction compensation are working do the following: Heat the joined end of the thermocouple and check that the temperature reading increases. Heat the terminal ends and check that the temperature decreases. If the temperature movement is in the wrong direction then reverse the thermocouple leads. Heat the cold junction reference (only possible on non isothermal block boards) and check for temperature increase. Each can be cooled instead of heated, with the opposite temperature reaction occurring.
- When using Thermocouples connected to multiple units and a common metal surface remove – common connectors to eliminate ground loops.

- You can calibrate to your own temperature measurement by adjusting CCAL in the Calib.Dat file. Add 75 points to the number for every needed 1°C increase in the reading. Starting at 22,000 for CCAL is a good idea.
- If you see very negative temperatures (like -700 F) then you probably have an open thermocouple. The ends of the thermocouple must be re-attached, though care must be taken when doing this. If intermittent low temps are encountered then the source is probably noise. On a type K thermocouple 4 $\mu$ V can cause 0.1°C change. This means that 360mV will show up as  $\pm 9,000^\circ\text{C}$ .
- For long thermocouple or extension wire, a shield should be used. This will reduce noise. A shield consists of a conductive conduit, through which the thermocouple wire is passed. This conduit is in turn connected to ground (GND not GND(A)). In this way any noise is transmitted through the shield to ground instead of through the thermocouple wire.
- Thermocouple wire should not be excessively long. Instead of using long wires, attach extension wire matched to the type of thermocouple. If the extension wire is twisted pair, then noise reduction will be increased.

# Glossary

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## **Data Acquisition Glossary**

### **Accuracy**

In data acquisition applications, accuracy refers to how close reported data is to actual data. The difference in reported and actual data is known as the error. Data acquisition error has many components, including offset, gain, drift (repeatability), linearity, and noise. Reducing any of these error influences increases the accuracy.

### **Alias Frequency**

An erroneous frequency constructed from sampled data that was measured too slowly (slower than the actual frequency).

### **Analog**

A quantity that has a continuous range of values between the highest and lowest. Temperature and length are analog quantities. See “Digital.”

### **Analog to Digital Converter**

An electronic circuit that converts an analog quantity to a digital representation of it.

### **ASCII**

American Standard Code for Information Interchange. The standard file format for alphanumeric files (text, numbers, and special symbols). ASCII files are readable by virtually all word processing, spreadsheet, and database programs.

### **Bit**

Binary Digit. The smallest amount of data that is stored or processed by a computer (0 or 1).

### **Byte**

A sequence of eight bits. A byte is the most common unit of data storage.

### **Cold Junction**

The reference junction of a thermocouple. A thermocouple generates a voltage between two junctions where two dissimilar metals are in contact. The temperature of one of the junctions must be measured to calculate the absolute temperature of the other. This is cold junction compensation.

### **Common Mode**

The average of the voltage applied to both wires of a two wire (differential) input.

### **Common Mode Rejection**

A measure of how closely an A/D circuit measures identical common mode voltages generated by dissimilar differential voltages. For example, a 4 and 6 volt differential input and a 3 and 7 volt differential input both have a common mode of 5 volts. Any measurement deviation from 5 volts is common mode error. The metric for measuring common mode error is the common mode rejection ratio (CMRR). A low CMRR indicates better common mode rejection than a high CMRR.

### **Current Loop**

A technique for transmitting analog data accurately over two wires. The measured signal is the value of the changing current. The signal source or transmitter is powered from the signal current.

**Digital**

A quantity that has discrete levels. The number of people in a room is a digital quantity. See “Analog.”

**Drift Error**

The error that develops over time as physical properties of electronic circuits change.

**Gain Error**

The error in data which is the result of measurements being taken from different areas of the voltage range.

**Ground Loop**

A connection of ground wires such that current flows in them creating voltage drops that may interfere with the signal. This is usually avoided by connecting all ground wires to the same ground.

**Hardware**

The physical part of a computer. The case, integrated circuits, disk drives, monitor, etc. See “Software.”

**Linearity Error**

The resulting error when a transducer provides a signal that varies in a non-linear way with the measured phenomenon.

**Noise**

An external influence on electrical circuits. Noise can be random and unpredictable (such as that caused by electromagnetic interference), or systematic and predictable (such as that caused by the 110V power lines in a building).

**Normal Mode**

A voltage applied between the wires of a two wire (differential) input. The normal mode signal is the signal measured at the input.

**Normal Mode Rejection**

A measure of the rejection of unwanted normal mode signal, usually AC. The ratio of the normal mode input to the measured input due to the normal mode signal is the normal mode rejection ratio or NMRR. It is usually specified at 60Hz in a circuit that measures DC inputs.

**Offset Error**

The error observed when the measured quantity is higher or lower than zero, while the actual quantity equals zero.

**Open Collector**

A type of digital output in which the “off” state is nonconducting. In the “on” state, current can only flow into the output toward ground (conventional current flow, the opposite of electron flow). The load for this type of output is connected to a positive voltage. When the output is on, it goes low and current flows in the load.

**Peripheral Slot**

A connector inside a computer that accepts additional circuit boards to perform new functions.

**Pull-Up Resistor**

This is a resistor that is often connected from an open collector output to a positive voltage. It pulls the output high when it is off or nonconducting.

**Resolution**

The smallest increment that can be detected in a quantity. Resolution is often specified in bits (12-bit, 16-bit, etc.), but is most accurately specified in the same units as that of what is being measured, such as microvolts when measuring a voltage, or microamperes when measuring current.

**RTD**

Resistance temperature detector. A sensor that changes resistance with temperature. It is usually made of metal such as platinum or nickel.

**Sensor**

A device used to measure a physical parameter. In computer data acquisition, sensors convert the physical signal into an electrical signal. A sensor may generate the signal such as how a thermocouple generates a voltage, or the sensor may modify a signal such as how an RTD modifies the current that passes through it.

**Sink Current**

The current that flows into an output when it is low. Sink current flows into an open collector output when it is on or conducting.

**Software**

The programs and data that are stored in memory or on a diskette in a computer. See "Hardware."

**Source Current**

The current that flows out of an output when it is high. An open collector output cannot produce source current unless it is connected with a pull-up resistor.

**Thermistor**

A sensor that changes resistance with temperature. It is made of a semiconducting material that has a very large and very nonlinear change in resistance.

**Thermocouple**

A sensor that produces a voltage proportional to temperature. It consists of two dissimilar metals connected to form a junction.

**Transducer**

A sensor. This often refers to a sensor with some signal processing or power regulation built in.

**Transmitter**

A device that amplifies and transmits an input signal to another device. In a current loop it is the device that converts a sensor input into a current output.

**TTL**

A type of digital electrical signal. The low level is between 0 and 0.4 volts. The high level is between 2.4 and 5.0 volts.

