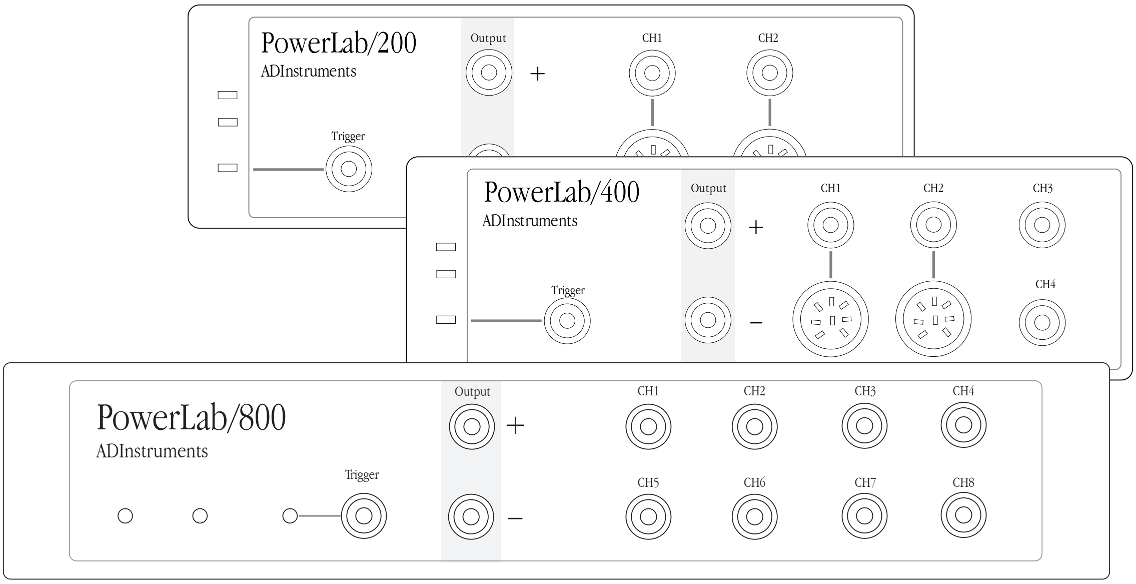
ADInstruments

# PowerLab Owner's Guide

## for PowerLab/200, PowerLab/400, and PowerLab/800 models




MacLab® System PowerLab® System

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PowerLab
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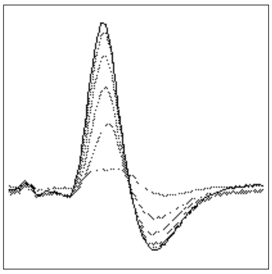


# Contents

CHAPTER ONE

# 1 Overview

Your PowerLab recording unit, together with a range of specialised application programs, provides a versatile data recording and analysis system when used with a computer running either the Mac OS, or Windows 95 or NT 4 or later. This chapter provides an overview of the PowerLab system and describes the basic features, connectors, and indicators of the E series PowerLabs: the PowerLab/200, PowerLab/400, and PowerLab/800.

# How to Use this Guide

This owner's guide describes how to set up and begin using your PowerLab recording unit. The chapters provide an overview of the PowerLab system (the combined software and hardware package), and a more detailed look at the features of your recording unit and its connection to your computer. The appendixes provide technical information about the recording unit, and solutions to problems. At the end of this guide is a glossary of hardware terms, an index, and warranty information.

The specifications and diagrams included in the appendixes are there to help the more technically minded to understand what the PowerLab can and cannot do, but this is not a service manual: only an authorised ADInstruments distributor should attempt repairs. If you modify the recording unit yourself, you void any rights you have under warranty.

The user's guides for the Chart and Scope application programs provide detailed information on the software side of the PowerLab system and its uses in acquiring, storing, and analysing data. Read them after you have connected the PowerLab to your computer.

## First, Check Your PowerLab!

Please do not attempt to connect the PowerLab to a power outlet or computer or turn it on until you have read the first two chapters of this owner's guide, and have checked it as described below.

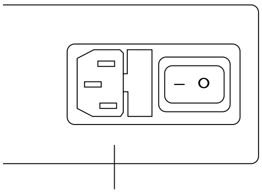
1. Check that all items in the accompanying packing list are included in the box.

2. Check that there are no obvious signs of external damage to the PowerLab.

3. Check that there are no obvious signs of internal damage, such as rattling. Pick the PowerLab up, tilt it gently from side to side, and listen for anything that appears to be loose.

4. Check that the correct voltage for your country is shown on the back of the unit. Your PowerLab should be delivered with the

**Figure 1–1**
The voltage rating on the back panel of the PowerLab



Check the voltage rating beneath the power switch

appropriate mains power voltage set, at either 100–120 volts or 220–240 volts. The setting is indicated at the right of the back panel of the unit, beneath the power switch.

If anything is missing, or the PowerLab seems to be damaged in any way, or if no voltage, or the wrong voltage, is shown on the back panel of the unit, contact your authorised ADInstruments distributor immediately, and describe the problem. Arrangements can be made to replace or repair the PowerLab. (Up-to-date contact addresses are available in the software — see Appendix B in one of the software user's guides for details.)

# The PowerLab System

The PowerLab system is an integrated system of hardware and software designed to record, display, and analyse experimental data. The hardware consists of the PowerLab recording unit and possible ancillary devices (front-ends); the software consists of the application programs (such as Chart and Scope) that run on the computer to which the PowerLab is connected.

Your E series PowerLab has considerable computing power of its own and performs many tasks that are necessary during data recording. Once the PowerLab transfers the data to the computer, the data are available for display, manipulation, printing, storage, and retrieval. The PowerLab/200 has two inputs for recording external signals, the PowerLab/400 has four, and the PowerLab/800 has eight.

# Computer Requirements: Macintosh

**Minimum**: a Macintosh computer or computer running the Mac OS with at least a 68020 CPU and a hard disk, SCSI, System 7, 4 MB free RAM, and a 14-inch or larger monitor.

**Recommended**: a Macintosh computer or computer running the Mac OS with a PowerPC microprocessor and a hard disk, SCSI, System 7.6 or later, 8 MB free RAM, and a 16-inch or larger monitor.

The computer requirements of the PowerLab system mainly depend on the software, except for connections. Any Macintosh from an LC onwards should be adequate. The software should still do most things on the minimum-grade computers, but the faster the computer, the better the overall performance.

The E series PowerLabs need SCSI to connect to a computer. Most Macintosh computers should have SCSI built in or available through a card. (The PowerLab/800 can also connect to early Macintosh computers through its serial port.) Not all SCSI cards are suitable, especially high-end ones (ultra-wide SCSI and the like). SCSI cards and cables with which the PowerLab should work reliably are sold by ADInstruments. If your computer does not have SCSI available (like an iMac, for instance) then you cannot connect to it. (At the time of writing there were no suitable SCSI-to-USB adapters available.)

## Computer Requirements: Windows

**Minimum**: a reliable computer with a Pentium-level CPU and a hard disk, Windows 95 or NT 4 or later operating system, 16 MB RAM (32 for NT), SCSI, a colour VGA card, and a 14-inch or larger monitor.

**Recommended**: a reliable, name-brand computer with a Pentium-level or faster microprocessor and a hard disk, Windows 95 or NT 4 or later operating system, 32 MB RAM (48 for NT), SCSI, an accelerated colour Super VGA card (or equivalent), and a 16-inch or larger monitor.

The computer requirements of the PowerLab system mainly depend on the software, except for connections. Slower computers with only an 80486DX CPU or those with less RAM may be adequate. The software should still do most things on the minimum-grade computers, but the faster the computer, the better the performance.

The E series PowerLabs need SCSI to connect to a computer. Most PC computers should have SCSI built in or available through a card. Not all SCSI cards are suitable, especially high-end ones (ultra-wide SCSI and the like). SCSI cards and cables with which the PowerLab should work reliably are sold by ADInstruments.

## The Application Programs

Two main application programs and their documentation are provided with each PowerLab. Scope emulates a two-channel storage oscilloscope. Chart emulates a multi-channel chart recorder (up to 16 channels, depending on the PowerLab model). Both provide many other powerful features in addition, including computed functions, triggering options, software-controlled stimulus generation, and automated recording and analysis. Their user's guides describe them in full; their quick start guides give summaries. You must install the software to use your PowerLab. Installation instructions are included in the user's guides for the software.

## ADInstruments Front-Ends

Front-ends are optional ancillary devices that can be connected to the PowerLab to extend the system's capabilities. They afford additional signal conditioning and other features, and extend the types of experiments you can conduct and the data you can record. For instance, the Bio Amp is available if you need to perform electrically isolated measurements of biological signals (PowerLabs should *never* be connected to humans directly, unless it is through connections marked as safe). A PowerLab can have as many front-ends connected to it as it has analog inputs, roughly speaking. Front-ends are easily added to or transferred between PowerLabs. They are automatically recognised by the PowerLab system and seamlessly integrated into its programs, operating under full software control.

Your ADInstruments distributor will have full information on available front-ends and their uses and specifications, and will be happy to discuss your requirements.

# The PowerLab

It is a good idea to get familiar with some of the external features of your PowerLab before connecting it to a power source. The rest of this chapter discusses the different features, connectors, and indicators of the PowerLab/200, PowerLab/400, and PowerLab/800.

## The Front Panel

The front panel of your PowerLab provides most of the connectors for interfacing with external signals, and indicators for various functions. This section describes each of the front panel features.

The PowerLab / 200 has three indicators at the left of the front panel, one BNC connector for the external trigger, two BNC connectors for output, and two BNC connectors (marked CH1 and CH2), with two alternative Pod (DIN) connectors, for recording external signals.

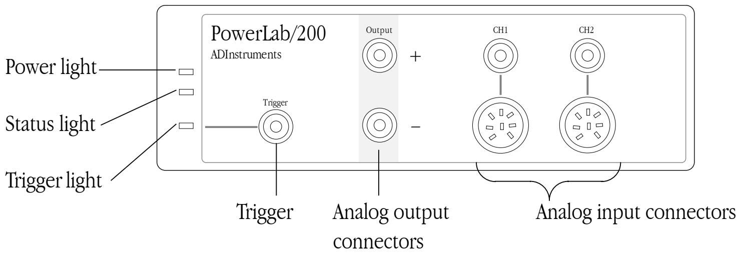



**Figure 1–2**
The front panel of the PowerLab/200

The PowerLab / 400 has three indicators at the left of the front panel, one BNC connector for the external trigger, two BNC connectors for output, and four BNC connectors (marked CH1 to CH4), with two alternative Pod (DIN) connectors, for recording external signals.

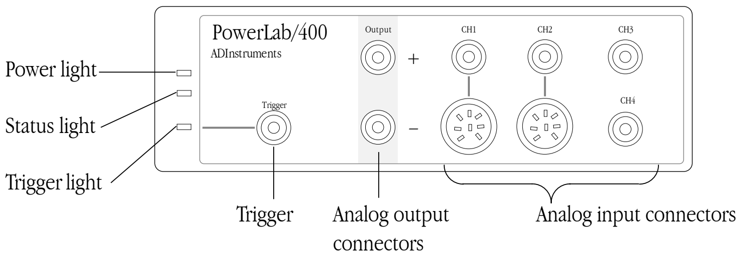



**Figure 1–3**
The front panel of the PowerLab/400

The PowerLab / 800 has three indicators at the bottom left of the front panel, one BNC connector for the external trigger, two BNC connectors for output, and eight BNC connectors (marked CH1 to CH8), for recording external signals.

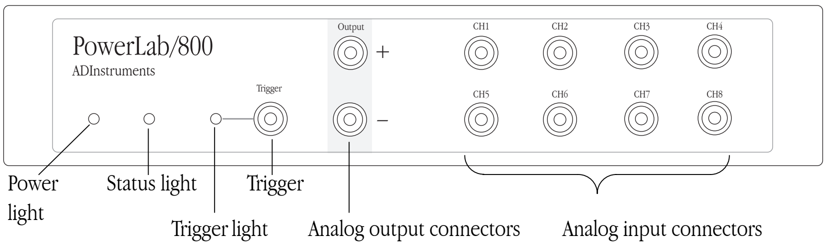



**Figure 1–4**
The front panel of the PowerLab/800

## Power and Status Indicators

The Power indicator on the front panel is a green light, which simply shows that the PowerLab is getting power. The indicator next to it, the Status indicator, provides a visual indication of what the PowerLab is doing, and will flash different patterns and colours depending on the state of the PowerLab.

**Table 1–1**
Status indicator states (don't worry too much about these)

| Status Indicator | Meaning |
|---|---|
| Off | Idle and not yet initialised by the software. |
| Yellow flash then one or more green flashes | When the PowerLab is powered up, the indicator flashes once yellow, then green a number of times equal to the SCSI ID. For example, 4 green flashes would indicate a SCSI ID number of 4. |
| Green constant | Idle, initialised, and waiting for a command from the computer. |
| Yellow constant | Communicating with the computer. |
| Yellow flashing | Sampling (may show green between flashes). |
| Yellow flash then one or more red flashes | This indicates that the PowerLab has detected an internal fault during the power-up test. The number of red flashes after the yellow flash indicates the type of error that has been detected. This display will keep repeating until the power to the PowerLab is turned off. |

## Analog Input Channels

▲ ***Caution***
*PowerLab inputs and outputs are not electrically isolated. Human subjects must not be connected directly to the PowerLab. If such measurements are to be made, an isolated front-end must be used, such as the Bio Amp.*

The analog inputs used to record external signals can handle signals from ±10 V down to the microvolt (µV) range without the need for additional external amplification. Each PowerLab analog input has an independently programmable gain amplifier with its own filtering, and AC/DC coupling. You can set up each channel independently to suit your requirements using the software. Note that applying more than ±15 V to the analog inputs can damage the circuitry.

The PowerLab/200 has two independent analog input channels (marked CH1 and CH2), each with alternative connectors. The top BNC connector can be used for single-ended input, and the 8-pin DIN Pod connector below can be used for either single-ended or differential input. Single-ended inputs record the difference between signal and ground, and differential ones record the difference between positive and negative input signals.

The PowerLab/400 has four independent analog input channels (marked CH1 to CH4). Channels 1 and 2 have alternative inputs. The top BNC connector can be used for single-ended input, and the 8-pin DIN Pod connector below can be used for either single-ended or differential input. Single-ended inputs record the difference between signal and ground, and differential ones record the difference between positive and negative input signals. The inputs for Channels 3 and 4 are single-ended, and have only positive connectors.

The Pod connectors on the PowerLab/200 and PowerLab/400 allow the connection of ADInstruments Pods — small, low-cost units that provide alternatives to front-ends for specific tasks, for use with precalibrated transducers and so on. (Pods are supported by Scope v3.6.3 and later, Chart for Macintosh v3.6.3 and later, and Chart for Windows v3.4.7 and later.) Pod connectors do not handle transducers directly unless the transducers are so labelled (unsuitable transducers will give a very weak signal). Transducers designed for direct connection can be provided with power and control, since the Pod connectors provide some functions of the $I^2C$ output as well as alternative analog inputs to the BNC connectors. When recording, do not attempt to use inputs from both the BNC and Pod connectors for a channel at the same time, or the signals will compete.

The PowerLab/800 has eight independent analog input channels (marked CH1 to CH8). All inputs are single-ended (with the signal referenced to ground), and have only positive connectors.

## Analog Output

The PowerLab can generate a stimulus voltage through its analog output sockets (marked Output), giving positive, negative, or differential stimuli, depending on the sockets used. When the positive output socket is used, a positive stimulus voltage (set up in the software) will give a positive voltage output, and a negative voltage a negative one. When the negative output socket is used, the voltage outputs are inverted. When both output sockets are used, the stimulus is the difference between the voltages at the positive and negative outputs: you could generate up to a 20-volt pulse, given a ±10 V stimulus.

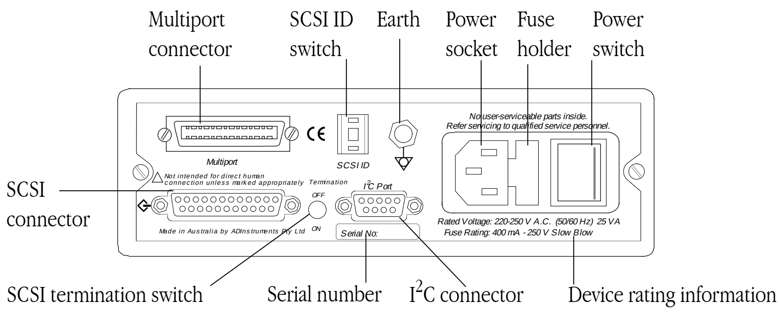
## Trigger

The external trigger connector allows you to use a digital signal level to synchronise recording to an external event. This input can handle voltages of up to ±12 V. The threshold voltage (the voltage above which the trigger circuit activates) is 3.0 volts for the PowerLab/200 and PowerLab/400, 2.5 volts for the PowerLab/800. When the trigger threshold is crossed, the indicator beside the external trigger connector will glow yellow. The external trigger is described in more detail in Appendix A, and the software documentation covers its practical use in normal recording.

# The Back Panel

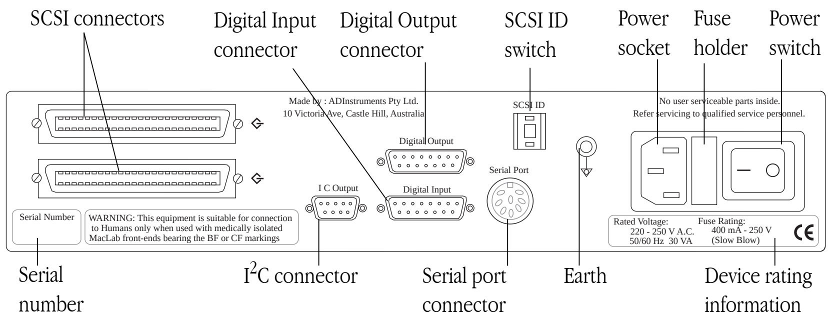
The PowerLab back panel provides the sockets to connect the PowerLab to the computer, front-ends, the power outlet, and so on. This section describes each of the back panel features. The back panels for the PowerLab/200 and PowerLab/400 are identical.

**Figure 1–5**
The back panel of the PowerLab/200 and PowerLab/400




The back panel for the PowerLab/800 has a few differences in layout and function, with digital input and output connectors rather than a Multiport connector, and different SCSI connectors.

**Figure 1–6**
The back panel of the PowerLab/800



## The SCSI Port

The PowerLab can connect to your computer using the SCSI port (SCSI is an acronym for small computer system interface and is pronounced 'scuzzy' — which shows that engineers have no taste in acronyms). SCSI provides fast data transfer, but requires that specific rules be followed in order for it to work correctly: it is the most complex aspect of setting up a PowerLab system. Please read the details on SCSI in Chapter 2 of this guide before connecting your PowerLab to your computer using SCSI.

The PowerLab/200 and PowerLab/400 have a single 25-pin connector for connecting SCSI cables, so these PowerLabs have to be used at the end of a SCSI chain. They are terminated internally, but the termination can be switched on and off using the SCSI Termination switch beside the SCSI connector (it should be on).

The PowerLab/800 has two 50-pin connectors for connecting SCSI cables. These connectors allow the PowerLab to be used anywhere in the SCSI chain, as well as allowing the use of external terminators. The PowerLab is not internally terminated: an external terminator is supplied with it instead (it should be terminated).

## The SCSI ID Switch

The SCSI ID switch is there if you need to change the SCSI ID number of your PowerLab. The PowerLab is factory-set to an identification number of 4. The SCSI ID can be changed simply by pressing the control buttons while the PowerLab is turned off. The new ID takes effect when the PowerLab starts up again. Only some numbers are valid: they depend on the type of computer, whether it has built-in SCSI or a SCSI card, and the number of built-in and peripheral SCSI devices in the SCSI chain. This is discussed in the next chapter.

## $I^2C$ Output

The $I^2C$ output is a special port designed to connect to front-ends made by ADInstruments. It supplies power and communications. A PowerLab can have as many front-ends connected to it as it has analog inputs, roughly speaking. *Note*. Do not attempt to run other external devices from the $I^2C$ port: it is designed for use only with

ADInstruments front-ends, which draw a low current. The PowerLab can not supply a great deal of power, and so devices drawing a lot of current should not be used.

## Ground Connection

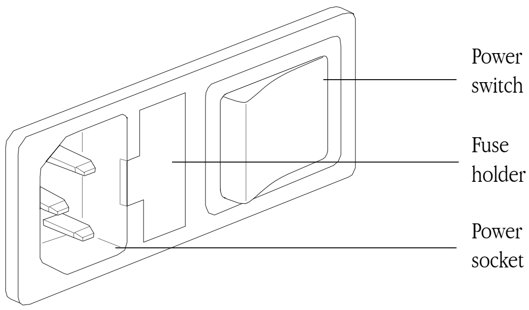
A special earthing (grounding) stud has been provided on the rear of the PowerLab. This is an equipotential bonding connection post compatible with the DIN 42801 standard. If the ground connector post is used, the power cord ground connection should not be used: a power cord with no ground connection should be used instead.

The ground connector post on the rear panel is used as a primary earth connection (equipotential connection point) in situations that require this type of connection, or if there is no ground provided via the power cord. Safety standards in laboratories and similar environments may require additional grounding protection when connecting equipment to human subjects. In such cases, an equipotential connection may be used for all linked equipment to prevent ground loops, and power cords with no ground connections should be available.

## Power Connections

The power switch on the back right of the PowerLab turns the PowerLab on and off; the 3-pin IEC power socket is used to connect your PowerLab to a 3-pin earthed (grounded) power cable.

**Figure 1–7**
The power switch, fuse holder, and power socket



## Fuse Replacement

The fuse holder is located beside the power socket, and can only be opened when the power cable is removed. To check the fuses, remove the power cable from the PowerLab, and lever the fuse holder out using the tab at its left, which is recessed in the power socket. The fuse holder contains two 'slow-blow' fuses, which protect your PowerLab from power surges.

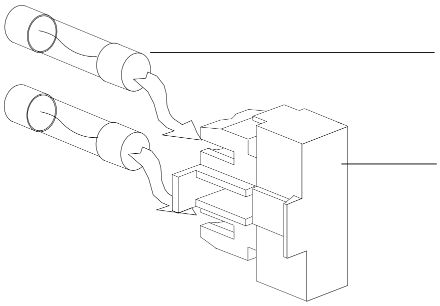



**Figure 1–8**
To change fuses in the PowerLab, remove blown ones from the fuse holder and slide new ones into place in the empty sockets

Replacement fuses must be of the correct type, as specified below for 100–120 volts or 220–240 volts operation:

- 100–120 V 1 Amp (5 × 20 mm) slow blow (voltage rating 120 or 250 V)
- 220–240 V 400 mA (5 × 20 mm) slow blow (voltage rating 250 V only)

The correct voltage for your country is shown on the back of the PowerLab, by the power switch (see Figure 1–1, page 3).

## Multiport Connector

The PowerLab/200 and PowerLab/400 have a Multiport connector. This connector provides additional expansion for the PowerLab/200 and PowerLab/400, comprising:

- two digital input and two digital output control lines
- a secondary $I^2C$ control port
- a connection to the analog output channel
- a connection to the positive side of each input channel
- a connection to the external trigger input

The Multiport provides digital input and output ports as well as duplicate analog inputs and outputs, and can also be used with particular specialised front-ends. If you are using a Multiport channel input, do not attempt to use the same channel input on the front of the PowerLab at the same time, or the signals will compete.

The digital input and output lines let you monitor and control external devices respectively. These recording automation and control features are available in the Macintosh version of Chart, but not in the current version of Chart for Windows (v3.4), or in Scope.

The digital input monitors state changes: you can have a predefined comment automatically inserted during recording when a digital input changes to a particular state. The two lines in the Multiport allow monitoring of up to two devices. The digital output can turn on and off external devices, for example, pumps, relays, and indicator lights, or can signal to some other device. The two lines in the Multiport allow control of up to two devices.

The pin connections of the Multiport are described in detail later in this guide: please refer to the description before attempting to connect equipment to this port. More information on the use of digital inputs and outputs is given in the user's guide for the software.

## The Serial Port

The PowerLab/800 is fitted with a serial port. This works with early Macintosh computers and computers running the Mac OS, but not with Windows-based PC computers.

A serial connection is about 200 times slower than SCSI for data transfer, and so will limit sampling rates (in Chart) or increase delay times between sweeps (in Scope), but it is less fussy. You can turn on or off, or disconnect or reconnect, a serially connected PowerLab without problems (this is *not* the case with SCSI). Some Macintosh PowerBook computer models may have problems with serial connections because of power management, so you should use a SCSI connection if you intend to use your PowerLab with one.

## Digital Input and Output Ports

The PowerLab/800 is fitted with digital input and output ports. The digital input and output connectors let you monitor and control external devices respectively with the PowerLab/800. These recording automation and control features are available in the Macintosh version of Chart, but not in the current version of Chart for Windows (v3.4), or in Scope.

The digital input monitors state changes: you can have a predefined comment automatically inserted during recording when a digital input changes to a particular state. The eight lines of the connector allow monitoring of up to eight devices. The digital output can turn on and off external devices, for example, pumps, relays, and indicator lights, or can signal to some other device. The eight lines of the connector allow control of up to eight devices.

Technical details of the digital input and output connectors are given later in this guide: please refer to the descriptions before attempting to connect equipment to them. More information on the use of digital inputs and outputs is given in the user's guide for the software.

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CHAPTER TWO

# Setting Up

This chapter starts with the PowerLab's internal self-test, then looks at the SCSI connection in some detail, including connection and termination rules, and setting the SCSI ID number. It discusses how to connect up your PowerLab to a computer running either the Mac OS, or Windows 95 or NT 4 or later. It also looks at the serial connection (Macintosh only).

# Self-Test

Now that you are familiar with some of the features of your PowerLab, you should check that it is working properly before you connect it to your computer. The PowerLab performs a diagnostic self-test each time it is switched on, whether or not it is connected to a computer. To test that your PowerLab is functioning properly when you turn it on, follow the instructions below, and observe the effects.

1. Connect the PowerLab to a power outlet using the power cable that came with your unit. Turn the power on at the wall.

2. Turn on the power switch located on the rear of the unit.

   The Power indicator on the front panel should glow green while the PowerLab is on (see Figure 1–2, Figure 1–3, and Figure 1–4).

   The Status indicator should flash yellow and then green a number of times equal to the SCSI ID of the PowerLab (see Table 1–1). If the internal diagnostic check finds no problems, the Status indicator turns off (showing that the PowerLab is idle; it only goes green when the software is running).

If the indicators perform as described above, then your PowerLab has successfully performed its internal self-test, and it can be safely connected to your computer. If your PowerLab would not successfully complete its self-test, something is wrong. If the Power indicator does not glow green when the power switch is turned on, then either the fuse has blown or there is a problem with the power cable or PowerLab itself.

If an error is detected during the self-test, the Status indicator will flash yellow and then a certain number of red flashes depending on the fault. Flashing lights are used when the problem is one that prevents the PowerLab communicating with the computer (such as a hardware fault), and so cannot be shown in the software. The error pattern will continue to be displayed, allowing you to take note of the type of error that occurred. The number of red flashes indicates the probable problem area, as detailed in Table 2–1. If any of these error patterns is shown, switch off your PowerLab, wait about ten seconds and switch it back on. If it still continues to flash the error pattern, then the PowerLab needs repair. Contact your authorised ADInstruments distributor as soon as possible. Do not attempt to repair the PowerLab yourself.

**Table 2–1**
PowerLab self-test error patterns (red flashes)

| Number of Flashes | Test that Failed | Probable Cause |
|---|---|---|
| 1 | ROM checksum error | Internal memory fault |
| 2 | RAM checksum error | Internal memory fault |
| 3 | VIA Test | Faulty VIA or bus problem |
| 5 | SCSI Test | SCSI controller problem |
| 6 | ADC Test | Faulty ADC or analog power supply |
| 8 | No Line Frequency | Faulty power supply |

If your PowerLab has successfully performed its internal self-test, read on to find out how to connect it to your computer.

# The SCSI Connection

This section is essential reading before trying to use your PowerLab with SCSI. The user's guide for your computer may have a section on connecting SCSI devices, in which case you should read that as well.

The PowerLab is fitted with a SCSI port. SCSI (small computer system interface) is simply a communication standard for connecting a single chain of SCSI devices together on a common high-speed bus (information-carrying pathway). A SCSI connection can easily handle the 200 kilobytes per second maximum data transfer rate of the PowerLab, although the speed of your computer may limit this.

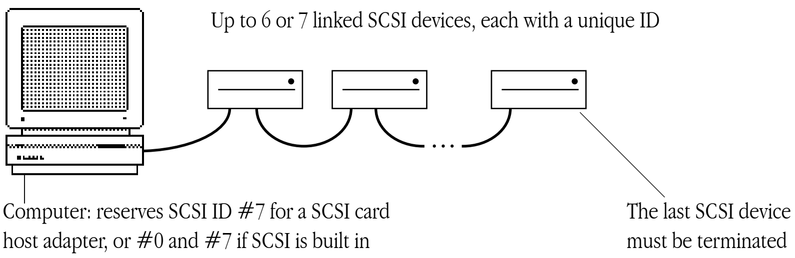



**Figure 2–1**
A SCSI chain: up to six (or seven) devices can be linked to the computer

The PowerLab is supplied with a SCSI cable to communicate with your computer. The PowerLab/800 can be placed anywhere in a SCSI chain; the PowerLab/200 or PowerLab/400 must be placed at the end of the SCSI chain (if it is the only device, then connected directly to the SCSI port of, or to an installed SCSI card in, the computer).

## SCSI Connection Rules

1. *Never alter the SCSI chain while any SCSI devices are on.*
   Disconnecting a SCSI device while there is SCSI hard disk activity may cause data loss or electrical damage. Switch all devices off, including the computer, before adding or removing SCSI devices.

2. *Each SCSI device must have its own unique SCSI ID number.*
   No two SCSI devices can have the same SCSI ID number or malfunctions may result. SCSI ID numbers are discussed later.

3. *Total cable length should be less than 6 metres (20 feet).*
   The SCSI circuits can only transmit data reliably over short lengths of cable. The total length of the chain is important, including short lengths of cable inside the computer and other SCSI devices. Internal cabling can be from 10 to 30 cm (4 inches to 1 foot), depending on the device.

4. *The SCSI chain must be terminated correctly.*
   Failure to terminate the chain properly can result in intermittent communication, no communication, or failure of the computer to boot up. The correct way of terminating is discussed later.

5. *Turn SCSI devices on and off in the right sequence.*
   Turn on all external SCSI devices before the computer: this ensures that the SCSI bus is stable before your computer tries to use it. Turn off the computer before turning off other devices. This prevents external SCSI devices from 'hanging' the SCSI bus and preventing further access. Never operate with some devices in a chain turned off, as this degrades performance and signal quality.

6. *Avoid mixing cable types, brands, and styles.*
   A common source of trouble is mixing poor-quality SCSI cables with approved high-quality SCSI cables. Different cable types or brands may have different types of construction, impedance, and wire placement, and this can result in problems when they are used together. Also, whenever possible, avoid using cable joiners and junctions to extend cable lengths.

7. *Never attempt to make your own SCSI cable, or modify one.*
   SCSI is sensitive to cable impedances and cable lengths. Only use an approved SCSI cable from a reliable supplier, never 'something the workshop whipped up'. If you need additional SCSI cables, you should buy cables that are double-shielded (foil and braid), with twisted pairs and shielded connector hoods for the most reliable results. ADInstruments sells approved SCSI cables

# Setting the SCSI ID Number

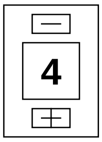



**Figure 2–2**
The SCSI ID switch

Your PowerLab was set to a SCSI ID number of 4 at the factory before shipping. To change its SCSI ID, turn off the PowerLab, and all other connected devices in the SCSI chain, before changing the SCSI ID number. The SCSI ID switch is located on the back panel of the PowerLab. A small panel with push buttons above and below it displays the SCSI ID number. Press the [–] button above the indicator to decrease it or the [+] button below the indicator to increase it.

Do not set the SCSI ID to numbers already used by other SCSI devices in the chain. The maximum number of devices within the same SCSI chain is eight. Each device in the chain must have a unique SCSI identification number assigned to it. The numbers range from 0 to 7, with 7 the highest priority device. A computer with built-in SCSI usually reserves the values 0 and 7. On the Macintosh, 7 is used for the computer and 0 may be used for an internal SCSI hard disk (an internal SCSI CD, if there is one, usually takes ID 3, as well). On a PC, SCSI ID number 7 is usually reserved by a SCSI card host adapter or built-in SCSI controller, and SCSI ID number 0 is used by an internal SCSI hard disk, if there is one.

Externally connected devices should have readable SCSI ID switches you can check, although some may have ID switches that are difficult to see or read. Internally connected devices should be described in the manual that came with your computer. If you are unsure about the SCSI devices connected to a Macintosh computer, you can use tools such as SCSIProbe (a free utility available from the Internet and user groups), which lists all SCSI devices attached, what they are, and which SCSI ID they use. If you are unsure about the SCSI devices connected to a Windows computer (particularly internal ones), your PC technical support person or IS manager may be able to help.

To confirm that you have set the right SCSI ID number, turn on the PowerLab and watch to see if the Status indicator flashes green a number of times equal to its SCSI ID number.

## SCSI Termination Rules

Terminating the SCSI bus is essential to preserve the integrity of the high-speed signals present on the bus. Termination helps keep these signals free from noise and prevents unwanted signal reflections up and down the bus. Without correct termination, the SCSI signals could be swamped by reflections from previous signals, resulting in a jumble of meaningless electronic noise. The way in which you terminate the SCSI chain will depend on the number of SCSI devices you wish to connect to your computer along with the PowerLab. The SCSI connection between your PowerLab and computer is a very good way to provide safe and reliable high-speed data transfer, provided that you follow the rules for proper termination.

A SCSI chain is correctly terminated by placing terminators at each end of the chain. The computer is terminated internally, so forming one end of the chain. (A SCSI host adapter will be terminated: if the SCSI controller and internal SCSI hard disk are both terminated, you may have to alter things — see the documentation that came with the card or computer.) The last device in the chain should be terminated. A PowerLab/200 or PowerLab/400 must be last device in the chain, with its SCSI termination switch on. A PowerLab/800 can be anywhere in the chain. If it is the last SCSI device in the chain, it must have an external terminator connected to its free SCSI connector.

# Connecting the PowerLab: Macintosh

Many Macintosh computers have SCSI built in or available through a card. If your computer does not have SCSI available (like an iMac, for instance) then you cannot connect to it via SCSI. Not all SCSI cards are suitable, especially high-end ones (ultra-wide SCSI and the like). SCSI cards and cables with which the PowerLab should work reliably are sold by ADInstruments. Make sure that you have the correct SCSI cable to connect up your PowerLab. You need a 25-pin to 25-pin SCSI cable to connect a PowerLab/200 or PowerLab/400, or a 25-pin to 50-pin SCSI cable to connect the PowerLab/800. If the supplied cable is the wrong one, contact your ADInstruments distributor for a replacement. (Most PowerBooks and Duo Docks have a special space-saving square 29-pin SCSI connector, which requires another connector or adapter. This can be purchased separately from your Apple dealer.)

If the PowerLab is the only SCSI device to connect to the computer, then simply connect the two together with the correct SCSI cable. Turn on the SCSI termination switch of the PowerLab/200 or PowerLab/400, or connect the supplied external terminator to the free SCSI connector of the PowerLab/800.

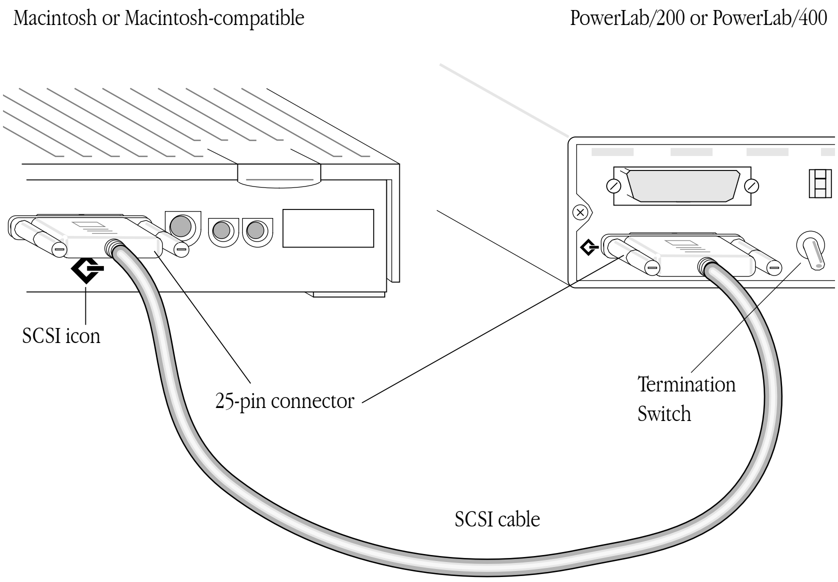
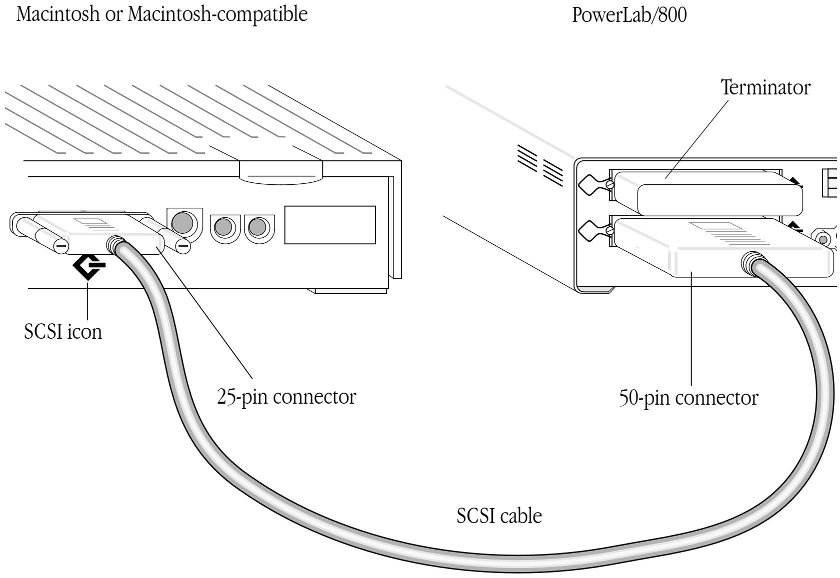



**Figure 2–3**
Connecting a PowerLab/200 or PowerLab/400 to the computer (look for the SCSI icon if the back panel is different)

**Figure 2–4**
Connecting a PowerLab/800 to the computer (look for the SCSI icon if the back panel is different)




If you wish to use multiple SCSI devices with the computer, the first and last devices in the chain should be terminated. You can connect a PowerLab/800 anywhere in the chain, but a PowerLab/200 or PowerLab/400 must be at the end of the chain, since it has only one SCSI connector, and its internal terminator must be switched on.

# Connecting the PowerLab: Windows

Most modern PC computers should have SCSI available through a card (some have it built in). Not all SCSI cards are suitable, especially high-end ones (ultra-wide SCSI and the like). ADInstruments sells SCSI cards and cables with which the PowerLab should work reliably. (It may not be possible to find a cable to fit all connections, though.)

Make sure that you have the correct SCSI cable to connect up your PowerLab. It requires either a 25-pin connector for the PowerLab/200 or PowerLab/400, or a 50-pin connector for the PowerLab/800. If you have a portable computer with a PC card SCSI adapter, then the card probably needs the specific cable that came with that particular card. You may have to purchase separately a cable adapter to connect the end of your SCSI cable to the 25-pin connector for the PowerLab.

The card should have full instructions on installation with it. The SCSI adapter card will usually be terminated, and at one end of the chain (this is always the case for PC card SCSI adapters), although if the computer has built-in SCSI, you may have an internal SCSI device in your PC that is terminated, with the host adapter in the middle of the chain. If there is a problem with cables, or you are unsure about any devices, such as a hard disk, connected to your computer on SCSI internally, your PC technical support person or IS manager should be able to help you.

If the PowerLab is the only SCSI device to connect to the computer, then simply connect the two together with the correct SCSI cable. Turn on the SCSI termination switch of the PowerLab/200 or PowerLab/400, or connect the supplied external terminator to the free SCSI connector of the PowerLab/800.

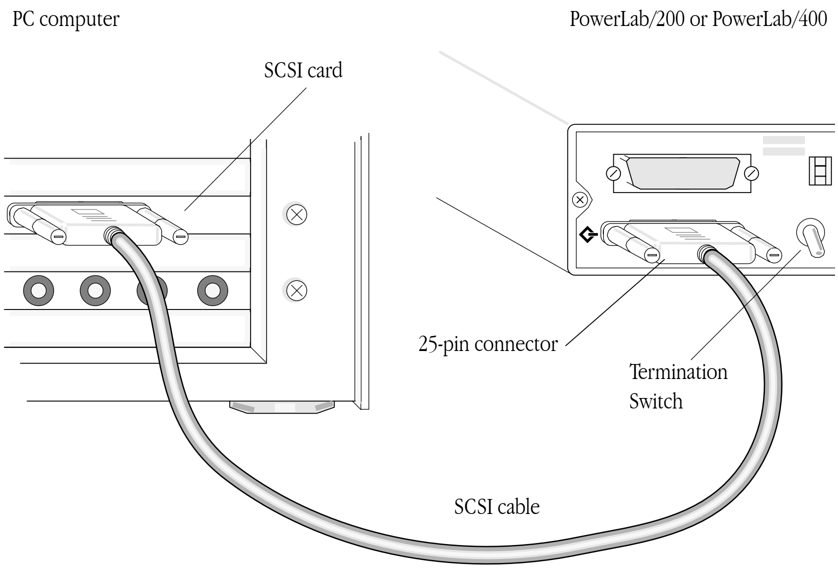
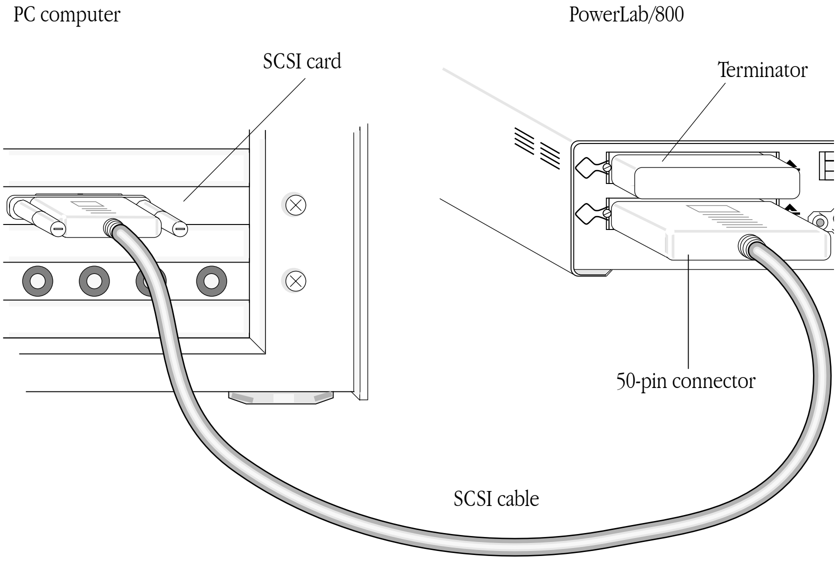



**Figure 2–5**
Connecting a PowerLab/200 or PowerLab/400 to the computer (25-pin connector shown)

If you wish to use multiple SCSI devices with the computer, the first and last devices in the chain should be terminated. You can connect a PowerLab/800 anywhere in the chain, but a PowerLab/200 or PowerLab/400 must be at the end of the chain, since it has only one SCSI connector, and its internal terminator must be switched on.

**Figure 2–6**
Connecting a PowerLab/800 to the computer (25-pin connector shown)




### SCSI Cards with Windows NT or Older Computers

Windows 95 and 98 both come with a number of generic SCSI drivers already installed that should work with most cards, including any that ADInstruments supplies. Windows NT may not have the right SCSI driver available, so the driver might have to be installed manually, perhaps from the original NT system CD. The SCSI card should have instructions on the driver it needs and how to install it.

Older, pre-PCI computers require a special ISA or ISO bus SCSI card. Such a card should come with its own manual, and may take some effort to set up. It will probably require assistance from a PC technical support person.

## SCSI Strikes Back

Not following the SCSI device connection and termination protocols can lead to more problems than you might think. The possible dangers include loss of data, intermittent communications, corruption of data on a SCSI hard disk, failure of the computer to boot from a SCSI drive, and failure of the computer to recognise SCSI devices connected to it. Such problems are very unlikely, however, if you follow the rules.

# The Serial Connection

The PowerLab/800 is fitted with a serial port. This works with early Macintosh computers and computers running the Mac OS, but not with Windows-based PC computers.

A serial connection is about 200 times slower than SCSI for data transfer, so it is only useful if you are sampling at slower speeds. It is easier to set up and use, however. You can turn on or off, or disconnect or reconnect, a serially connected PowerLab without problems (this is *not* the case with SCSI). The limitation on total cable length is also removed: rather than the 6 metres (20 feet) of SCSI, a serial cable can be several hundred metres long.

## Connecting the PowerLab Using the Serial Port

On some earlier computers, ADInstruments applications will not recognize the PowerLab if you connect the serial cable to the Printer port of the computer. This is less likely to occur with PowerPC computers. To be safe, use the serial cable supplied with your PowerLab/800 to connect the serial port on its back panel to the serial (modem) port on the computer. The serial (modem) port on the computer is marked with the icon of a telephone handpiece. Chart and Scope v3.6.3 and later allow you to choose, from the software, which serial port to use.

## Serial Killers

The serial connection has other limitations apart from speed. The Macintosh PowerBook and Duo computer models may have problems with serial connections (owing to sampling interruption by the power management chip). On slower computer models connected through LocalTalk, data loss may occur if there is heavy network use at the higher serial sampling speeds, since the same chip in the computer deals with network communication and PowerLab data. (This is less likely to occur with PowerPC computers.) Since integrity of data cannot be completely guaranteed under these circumstances, we recommend using SCSI in such cases unless you have specific reasons for using a serial connection.

A

APPENDIX A

# Technical Aspects

This appendix describes some of the important technical aspects of the PowerLab/200, PowerLab/400, and PowerLab/800, to give some insight into how they work. You do not need to know the material here to use your PowerLab. It is likely to be of especial interest to the technically minded, indicating what the PowerLab can and cannot do, and its suitability for particular purposes. You should not use it as a service manual: remember that user modification of the PowerLab voids your rights under warranty.

## How Does it Work?

The PowerLab is essentially a smart peripheral device specifically designed to perform the various functions needed for data acquisition, signal conditioning, and pre-processing. It contains its own microprocessor, memory, and specialised analog amplifiers for signal conditioning. The block diagrams in Figure A–1, Figure A–2, and Figure A–3 show the essential elements of each PowerLab.

All sampling, output, and communication functions are controlled by an internal 65C02 microprocessor running at 4 MHz (4 million cycles per second). The microprocessor has access to 47 kilobytes of RAM (random access memory) for data storage and buffering prior to transmission to the computer. The PowerLab uses SCSI (small computer system interface) to communicate with the computer, through built-in SCSI or via a SCSI card, at up to 200 kB per second. The PowerLab/800 provides a lower-speed serial interface as well, communicating at up to 1 kB per second (with a Macintosh only).

The PowerLab has two (PowerLab/200), four (PowerLab/400), or eight (PowerLab/800) input channels, used to record external signals. The outputs of their input amplifiers are multiplexed to a 12-bit (PowerLab/200) or 16-bit (PowerLab/400 and PowerLab/800) analog-to-digital converter. This ADC is capable of a maximum sampling rate of 100 kilohertz (100,000 samples per second). The CPU (central processing unit) assembles groups of samples into blocks and then transmits them via the SCSI bus (or serial line) to the computer, where the application program receives, records, and displays the data.

**Figure A–1**
Block diagram of the PowerLab/200

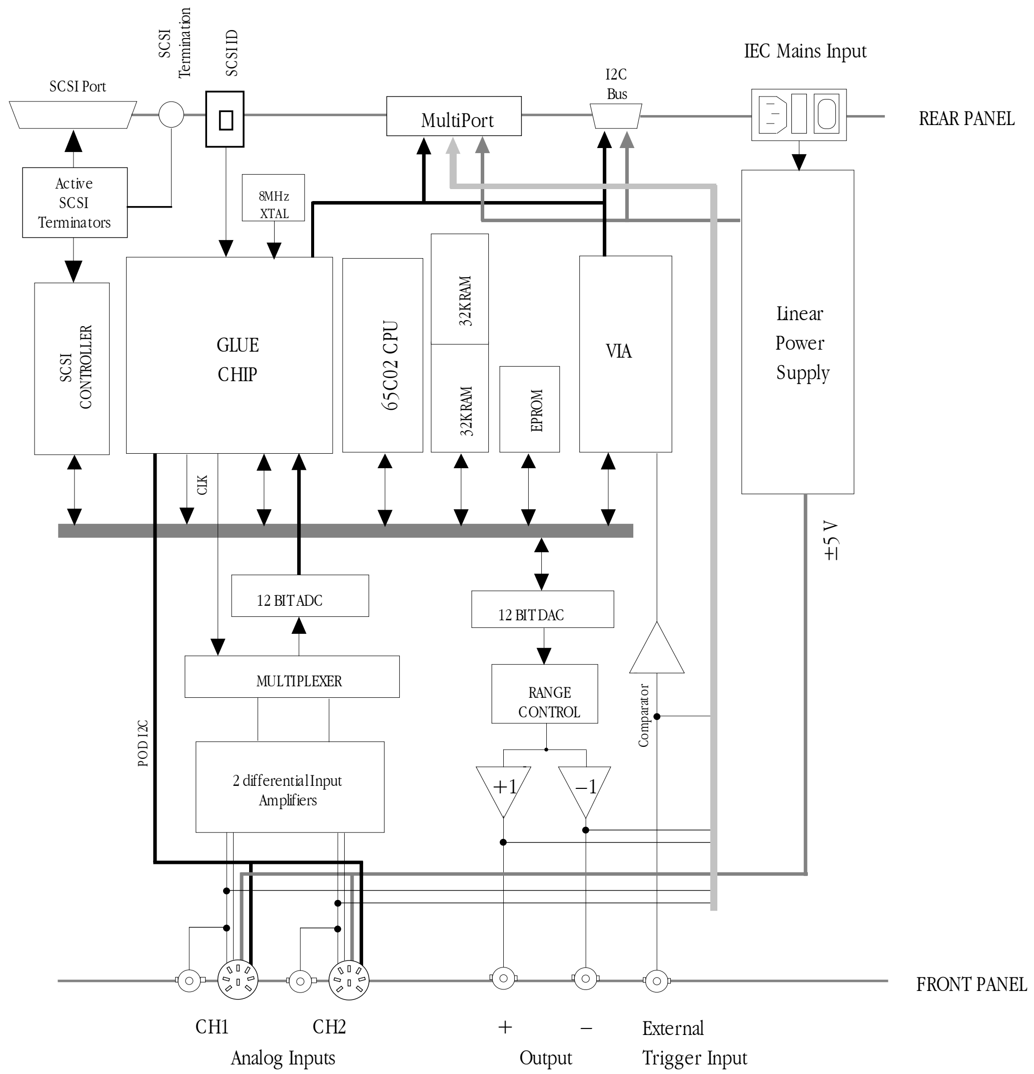
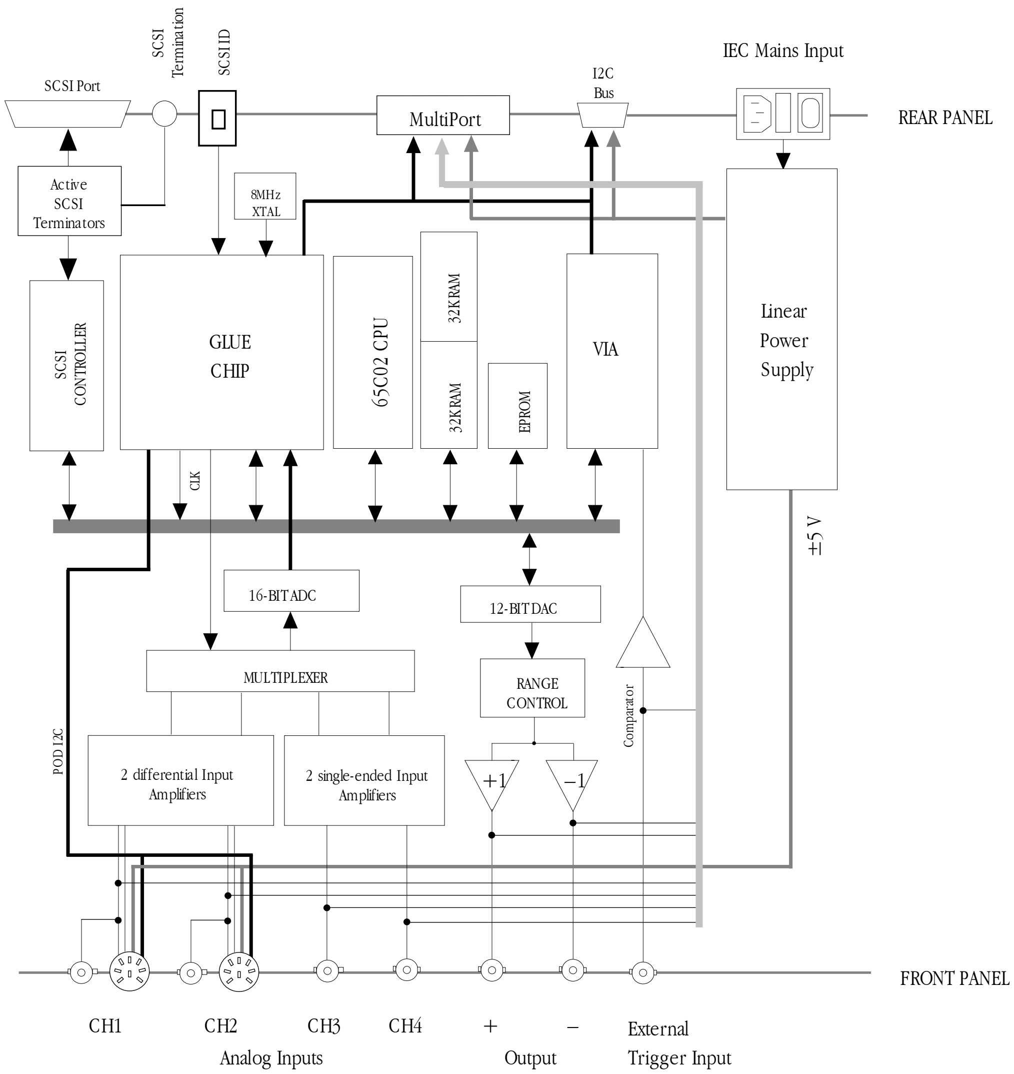


Figure A–2
Block diagram of the PowerLab/400

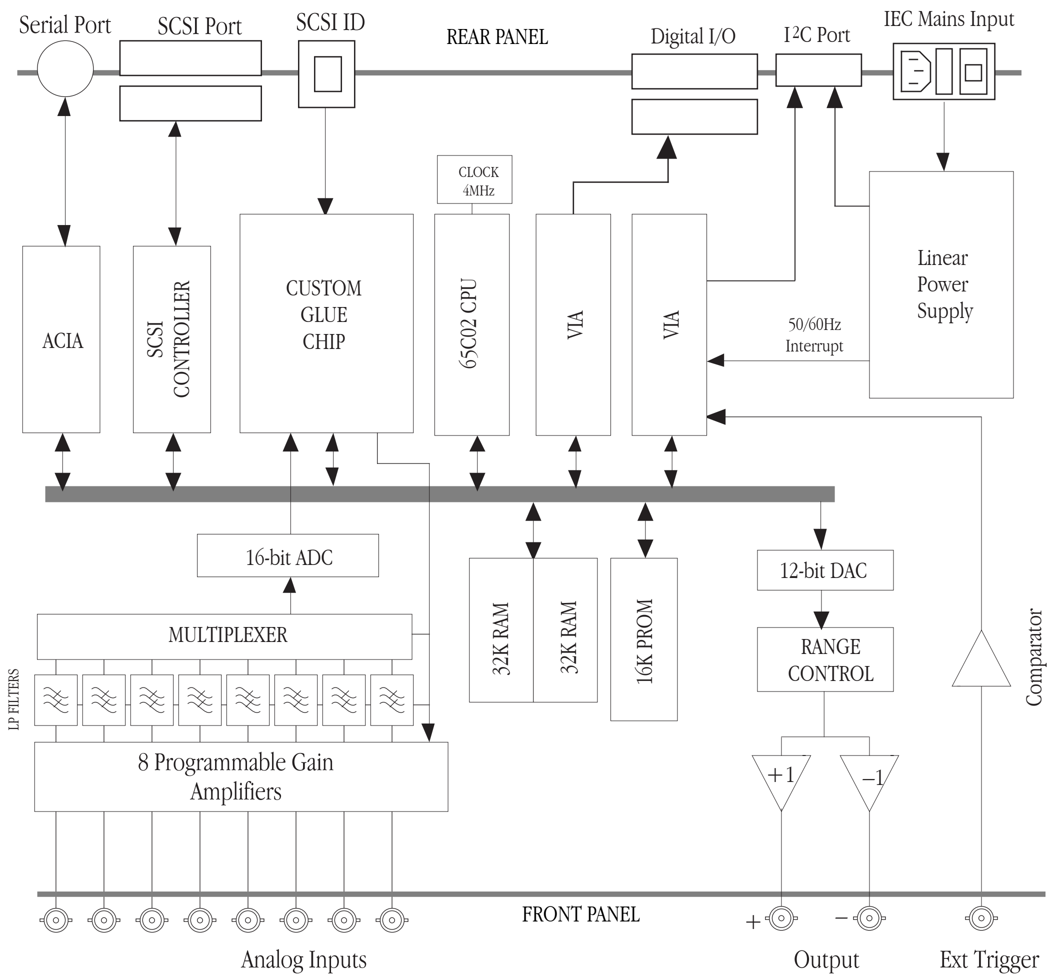
The external trigger input (marked ‘Trigger’ on the front panel) is connected to a comparator circuit that triggers when the input voltage exceeds 3.0 volts for the PowerLab/200 and PowerLab/400, 2.5 volts for the PowerLab/800. This signal is fed to circuitry that notifies the CPU that an external trigger event has been detected. The CPU then carries out the task for which the trigger is being used (such as pre-triggering or post-triggering). When the trigger



threshold is crossed, the indicator beside the trigger connector glows yellow.

A 12-bit DAC (digital-to-analog converter) is used to control the analog output of the PowerLab (marked ‘Output’ on the front panel). The DAC produces waveforms under software control that are fed through an attenuation network to produce different full-scale ranges. The signals are then buffered by a power amplifier to give them the capability to drive heavier loads.

**Figure A–3**
Block diagram of the PowerLab/800



▲ ***Caution***
*PowerLab inputs and outputs are not electrically isolated. Human subjects must not be connected directly to the PowerLab. If such measurements are to be made, an isolated front-end must be used, such as the Bio Amp.*

The PowerLab is also fitted with an $I^2C$ front-end expansion port. This 9-pin port supplies both power and control to ADInstruments front-ends using a 4-wire serial bus (two wires for standard $I^2C$ and two control lines).

The digital input and output connectors on the PowerLab/800 provide a means of using the PowerLab to monitor and to control external devices respectively. The digital input monitors state changes: the eight lines of the connector allow monitoring of up to eight devices. The digital output can turn on and off external devices or can signal to some other device. The eight lines of the connector allow control of up to eight devices. These recording automation and control features are available in the Macintosh version of Chart, but not in the current version of Chart for Windows (v3.4), or in Scope.

The PowerLab/200 and PowerLab/400 are fitted with a Multiport, which provides two digital inputs, two digital outputs, a second $I^2C$ interface port, connections to the analog input and output connectors on the front panel, and access to the external trigger input signal. It can also be used by particular specialised front-ends. The two digital input lines in the Multiport allow monitoring of up to two devices; the two digital output lines allow control of up to two devices. If you are using a Multiport channel input, do not attempt to use the same channel input on the front of the PowerLab at the same time, or the signals will compete.

The PowerLab uses an IEC601-1 compliant linear power supply, not a switching power supply, which makes it a little heavier, but a lot quieter electrically. It is important to note that the PowerLab has a limited amount of power available for external devices. Because of these power restrictions, you should not use the PowerLab as a power source for external devices other than front-ends produced by ADInstruments.

# The Analog Inputs

▲ ***Caution***
*Applying more than ±15 V to the input can damage the channel input circuits.*

PowerLab input amplifiers have been designed with a considerable amount of computer-controlled gain (up to × 5000). Thus it is possible to record a variety of signals without any external pre-amplification. Each channel input is a separate DC amplifier, with programmable gain able to be set independently (the gain is set through the software range control: the less the range, the more the gain). Differential signals can only be recorded using the Pod connectors; the BNC analog inputs on the PowerLabs are all single-ended. The input amplifiers of the PowerLab/800 are single-ended, but can be set by the software to be either positive or negative (inverting or non-inverting). The PowerLab/200 and PowerLab/400 input amplifiers for Channels 1 and 2 can be set by the software to be either single-ended — positive or negative — or differential. In the differential setting, the amplifier measures the difference between the positive and negative inputs of a Pod connector, irrespective of ground.

It is important to note that the PowerLab grounds the inputs to amplifiers not in use. It also grounds each amplifier and measures the DC offset voltage when the gain is changed. In this way, the software corrects for any DC drift or offset in the circuits that may develop over time or between readings. The operation of the input amplifiers is illustrated by the block diagrams below.

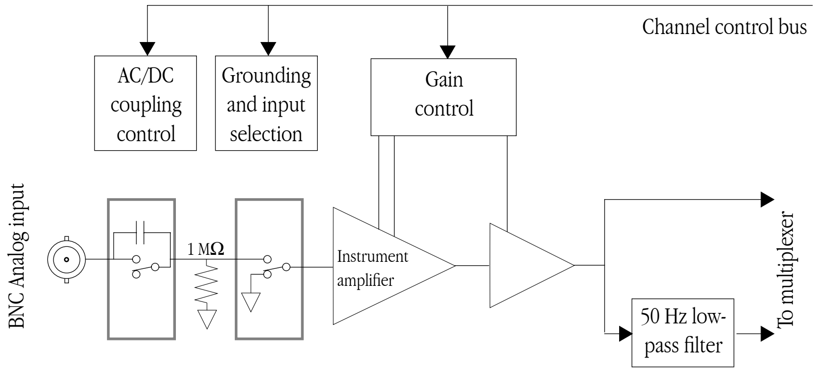



**Figure A–4**
Block/schematic diagram of the input amplifier circuitry for BNC-only inputs

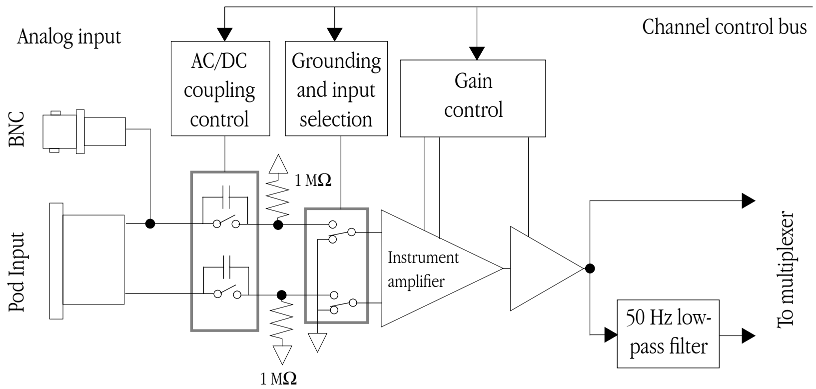



**Figure A–5**
Block/schematic diagram of the input amplifier circuitry for dual BNC and Pod inputs

The input amplifiers can be set to pass both DC and AC signals, or to pass only AC signals without passing DC signals. Input impedance is one megohm (1 MΩ).

Each channel produces two outputs filtered at different frequencies, only one of which is selected at any one time when running an ADInstruments application: a signal with bandwidth of DC to 20 kHz, and one with a bandwidth of DC to 50 Hz (DC is zero Hz).

## PowerLab Accuracy

Your PowerLab was calibrated at the factory to an accuracy of better than 0.1%. Some 'zero drift' or 'gain drift' can occur with time. This can affect the accuracy of measurements, especially at the highest input gains. The unit can be recalibrated, but in most circumstances this is not necessary in its lifetime. There are several reasons for this.

**DC drift compensation**. Each time that recording is started manually or by triggering or the gain is changed (that is, very often in most cases), the input to the amplifier is grounded and any DC due to the amplifier's drift with temperature and age is measured. The measured voltage is removed from the readings for that channel through software correction, in a process transparent to the user.

**Calibration facilities**. It is recommended and sound practice to calibrate a measuring system from the transducer to the output. After applying two known values to a transducer (say at 20% and 80% of full scale) and recording the signal, you can use the units conversion feature of ADInstruments applications to convert and display transducer readings in the appropriate units. This will compensate for any minor inaccuracies in amplifier gain and transducer calibration.

## The External Trigger

The external trigger provides a digital input for synchronising sampling to external devices. The external trigger input represents 1 TTL (transistor–transistor logic) load. The input is off for input voltages between –12 V and the external trigger level, and on between that and +12 V. The input will be overloaded if the voltage is outside the range –12 V to +12 V. The external trigger level for the PowerLab/200 and PowerLab/400 is 3.0 V ± 0.25 V; once on, the trigger turns off at 2.8 V ± 0.25 V, giving a hysteresis voltage of 0.2 V. The external trigger level for the PowerLab/800 is 2.5 V; once on, the trigger turns off at about 1.9 V, giving a hysteresis voltage of 0.6 V. When the external trigger input is on, the indicator beside it is on.

The PowerLab/200 and PowerLab/400 have optically isolated external trigger inputs, thus there is no direct connection between the external trigger ground and the ground of the device connected to it. This removes ground noise and current problems, and improves static discharge immunity. In order for these external triggers to work, though, a voltage must be applied between the outer ring and the inner pin on the connector. Just applying a voltage to the centre pin as you can on the PowerLab/800 won't result in triggering.

The equivalent circuit of the optically isolated external trigger is basically an LED (light-emitting diode) in series with a resistor, thus the device driving the external trigger must be capable of supplying at least 1 mA of current to cause the optocoupler to work. (The second diode shown below protects the optocoupler.)

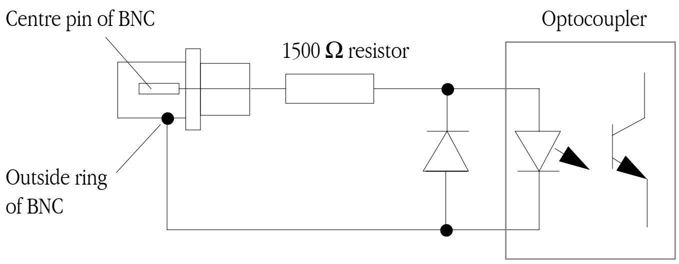



**Figure A–6**
The equivalent circuit of the optically isolated external trigger for the PowerLab/200 and PowerLab/400

# The Analog Output

The analog output provides a computer-controlled variable output (±10 V) that can be used with the Chart and Scope applications either directly as a stimulator, or to control peripheral devices.

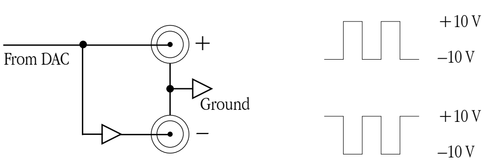



**Figure A–7**
The operation of the analog output stage

All stimulation voltage is generated by the PowerLab via the output sockets on the front of the PowerLab, giving a positive, negative, or differential stimulus, depending on the sockets used. When the positive output socket is used, a positive stimulus voltage will give a positive voltage output, and a negative voltage a negative one. When the negative output socket is used, the voltage outputs are inverted. When both output sockets are used, the stimulus will be the difference between the voltages at the positive and negative outputs: you could generate up to a 20-volt pulse, given a ±10 V stimulus. The output amplifier can deliver up to ±25 mA (PowerLab/200 and PowerLab/400) or ±50 mA (PowerLab/800).

# Connections

This section of the appendix contains 'pinout' and electrical details of some of the connectors fitted to the PowerLab. You should read it carefully before attempting to connect cables other than those supplied with the unit to the PowerLab. Using cables that are wired incorrectly can cause internal damage to the PowerLab and will void your rights under warranty.

## SCSI Port

The PowerLab/200 and PowerLab/400 use a single 25-pin D-type female connector for the SCSI port. The PowerLab/800 uses two 50-pin IEEE-488 style (sometimes called Centronics style) connectors. The connections are functionally equivalent, but require different cables. (If you are using a Windows PC, the connection at the other end of the cable depends on your set-up.)

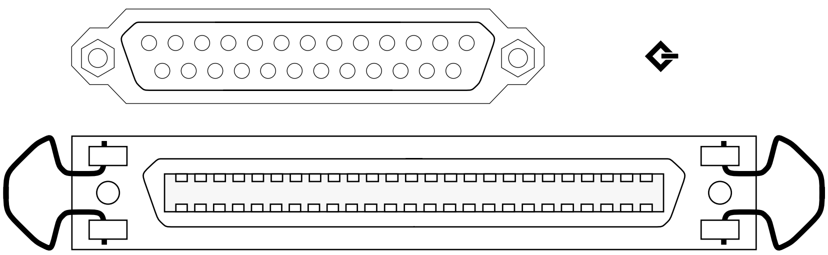


**Figure A–8**
The 25-pin and 50-pin SCSI connectors

SCSI is sensitive to cable impedances and connection lengths. The incorrect wiring of a SCSI cable can result in damage to the SCSI circuitry, or random SCSI activities being performed. You should, therefore, use only approved SCSI cables such as the ones available from ADInstruments, and never attempt to make your own.

# $I^2C$ Expansion Port

The $I^2C$ port on the back panel of the PowerLab provides expansion support for ADInstruments front-ends. This port provides both power and control signals for these front-ends. The $I^2C$ bus has a daisy-chain structure that allows simple connection of additional front-ends to the system. A PowerLab can have as many front-ends connected to it as it has analog inputs, roughly speaking. You should not attempt to run other external devices from the $I^2C$ port: it is designed for use only with ADInstruments front-ends. Only 50 mA maximum current can be provided through this bus, so it should not be used for third-party devices drawing more current.

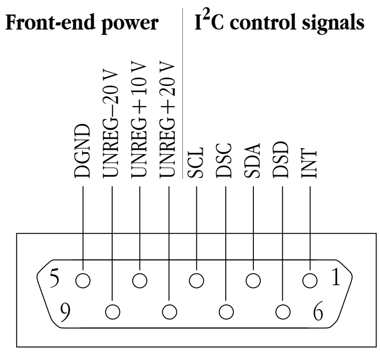



**Figure A–9**
The pin assignments for the $I^2C$ port

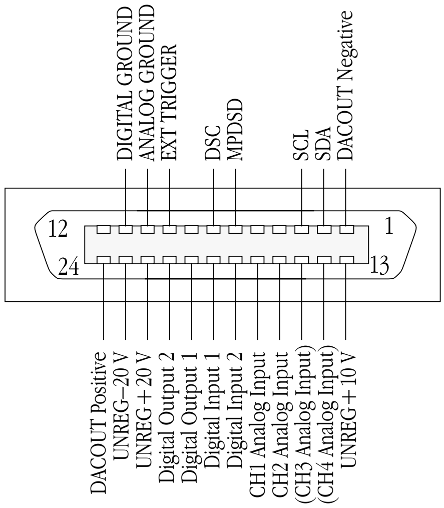
# The Multiport Connector

The Multiport connector is present only on the PowerLab/200 and PowerLab/400. It provides a special interface to the PowerLab/200 and PowerLab/400, with two digital inputs, two digital outputs, a second $I^2C$ interface port, duplicate analog input and analog output lines, access to the external trigger, and provision for particular specialised front-ends.

The Multiport provides two digital input and two digital output lines. The digital input lines respond to standard TTL level signals with a threshold of 2.2 V. The digital output lines are capable of driving two TTL loads (2 mA maximum load per line). These recording automation and control features are available in the Macintosh version of Chart, but not in the current version of Chart for Windows (v3.4), or in Scope.

The analog input lines are equivalent to the two (PowerLab/200) or four (PowerLab/400) positive input sockets on the front panel (the two are connected). They provide an alternative means of feeding in positive signals to a channel. If you are using a Multiport channel input, do not attempt to use the same channel input on the front of the PowerLab at the same time, or the signals will compete.

**Figure A–10**
The pin assignments for the Multiport connector (the CH3 and CH4 analog inputs are only present on the PowerLab/400)




The two analog output lines (DACOUT) are equivalent to the positive and negative output sockets (marked 'Output') on the front panel (the two are connected). This provides an alternative way to connect an external front-end to the output of the PowerLab (perhaps a front-end that increased the output voltage or drive current, say).

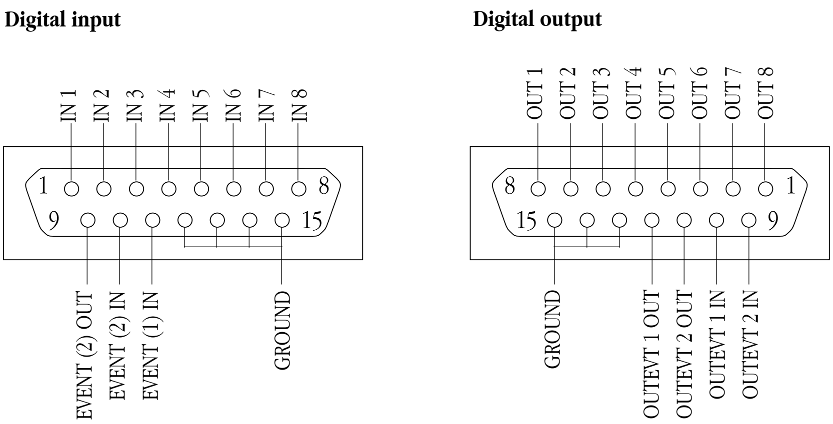
The external trigger input line is equivalent to the external trigger input (marked 'Trigger') on the front panel (the two are connected).

*Caution*. Use extreme care if wiring connectors for the Multiport. You need to ensure that shorts do not occur between channels, or between signal lines and power rails. Minimal power is available at this port, and it should not be used to power external equipment other than ADInstruments front-ends. Connection should be left to a technician if you have little experience with electronics.

# Digital Input and Output Ports

The digital input port and digital output port are present only on the PowerLab/800. They are 15-pin connectors situated on the back panel. The eight digital input lines respond to standard TTL signals with a threshold of 2.2 V. The eight digital output lines can turn on and off, or signal to, up to eight external TTL devices. The digital output lines are capable of driving five TTL loads overall (50 mA maximum load per line; 250 mA maximum total load).

**Figure A–11**
The pin assignments for the digital input and output connectors



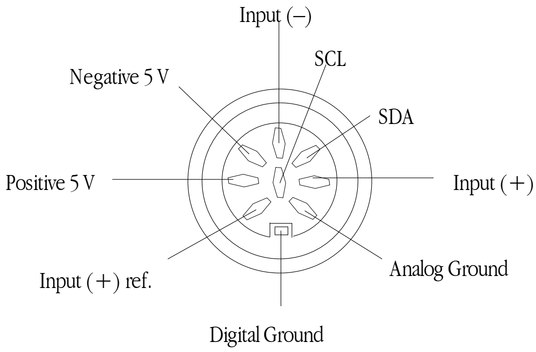

These recording automation and control features are available in the Macintosh version of Chart, but not in the current version of Chart for Windows (v3.4), or in Scope.

# Pod Connectors

The Pod connectors on the PowerLab/200 and PowerLab/400 are 8-pin DIN connectors. (The PowerLab/800 has single-ended BNC inputs only.) When recording, do not attempt to use inputs from both the BNC and Pod connectors for a channel at the same time, or the signals will compete.

Pod connectors allow the connection of ADInstruments Pods — small, low-cost units that provide alternatives to front-ends for specific tasks, for use with precalibrated transducers and so on. (Pods are supported by Scope v3.6.3 and later, Chart for Macintosh v3.6.3 and later, and Chart for Windows v3.4.7 and later.) The Pod connectors on the PowerLab/200 and PowerLab/400 do not handle transducers directly unless the transducers are so labelled (unsuitable transducers will give a very weak signal). Transducers designed for direct connection can be provided with power and control, since the Pod connectors provide some functions of the $I^2C$ output as well as alternative analog inputs to the BNC connectors.

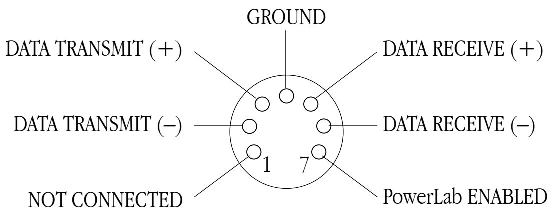
**Figure A–12**
The pin assignments for the Pod connector




# Serial Port

The PowerLab/800 is fitted with an RS-422 serial port. This works with early Macintosh computers and computers running the Mac OS, but not with Windows-based PC computers. The connector is a standard 7-pin DIN connector. Serial communication is at 19,200 baud (bits per second).

**Figure A–13**
The pin assignments for the serial port



B

APPENDIX B

# Troubleshooting

This appendix describes most of the common problems that can occur with your PowerLab recording unit. It covers how these problems are caused, and what you can do to alleviate them. If the solutions here do not work, your software guide may contain remedies for possible software problems. If none of the solutions here or in the software guide appears to help, then consult your ADInstruments distributor.

## Problems: Macintosh

Nearly all the problems that users encounter are connection problems and SCSI problems. Improper connections can result in a loss of all or some of a signal. SCSI difficulties can cause data loss, failure of the computer to recognise that SCSI devices are attached to it, and difficulties using other SCSI devices. Incompatible SCSI adapter cards and cables may also cause problems. (Obviously, the SCSI problems will not apply if you use a serial connection to the PowerLab/800.)

***The PowerLab Status indicator light flashes yellow then red when the PowerLab is turned on***

▼ ***Refer***
*Self-Test, p. 16*

An internal problem has been discovered by the diagnostic self-test (this is performed by the PowerLab each time it powers up).

- Turn everything off, and then after at least ten seconds turn the PowerLab back on again. This should clear a temporary problem. If not, then the PowerLab may need repair. Take note of the flashing pattern, and consult your ADInstruments distributor.

***The computer refuses to boot with the PowerLab connected, or the computer can't find the PowerLab***

The PowerLab is off or the power is switched off at the wall, the power cable is not connected firmly, or a fuse has blown.

- Check switches, power connections, and fuses.

If you are using a serial connection, the cable may be connected to the wrong port: the computer's printer port rather than its modem (serial) port, say.

- Ensure that the serial connection is correct.

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

The SCSI adapter card is incompatible with the computer or the PowerLab or both. We cannot guarantee that the PowerLab will work reliably with a card we did not supply.

- Try another card, preferably one we supplied.

The PowerLab has an internal problem or has 'hung'.

- Turn everything off, and then after at least ten seconds turn the PowerLab back on again. Turn on the computer and try using the software again.

***The computer hangs up while recording, or there is data loss***

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

If you are using a PowerBook or Duo with a serial connection, its power management circuitry could be interrupting sampling.

- Use a SCSI connection with these Macintosh models.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

***The PowerLab doesn't work or the program crashes after a short time***

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

The SCSI adapter card is incompatible with the computer or the PowerLab or both. We cannot guarantee that the PowerLab will work reliably with a card we did not supply.

- Try another card, preferably one we supplied.

Partitioning problems on the hard disk (while rare, this can happen even with new disks).

- Use disk-checking utility applications to check the SCSI driver and root directory on the hard disk. Partitioning programs may also have effective low-level disk checking. The programs will probably fix the problems, or otherwise indicate what needs to be done (such as reinstalling the SCSI driver), and their manuals should explain the technical details involved.

***The PowerBook computer stops working normally, and instead shows a diamond with its SCSI ID number on screen***

The PowerBook is acting as a SCSI hard disk. This means that the wrong (30-pin) connector and cable were used to connect it to the PowerLab. You need a different (29-pin) cable and connector to make a normal SCSI connection to peripherals.

- Use the correct cable to connect your PowerBook to the PowerLab (the cable should be available from your Apple dealer).

***Signals seem weak or interacting on the PowerLab/200 or PowerLab/400***

You may be using two or three of the alternative analog inputs from the BNC connector, Pod connector, or Multiport for the same channel at the same time, with resultant signal competition.

- Make certain that you use only *one* of the alternative analog inputs (BNC connector or Pod connector or Multiport) for a channel when recording.

# Problems: Windows

Most problems that users encounter are connection problems and SCSI problems. Improper connections can result in a loss of all or some of a signal. SCSI difficulties can cause data loss, failure of the computer to recognise that SCSI devices are attached to it, and difficulties using other SCSI devices. Incompatible SCSI adapter cards and cables may also cause problems.

***The PowerLab Status indicator light flashes yellow then red when the PowerLab is turned on***

▼ **Refer**
*Self-Test, p. 16*

An internal problem has been discovered by the diagnostic self-test (this is performed by the PowerLab each time it powers up).

- Turn everything off, and then after at least ten seconds turn the PowerLab back on again. This should clear a temporary problem. If not, then the PowerLab may need repair. Take note of the flashing pattern, and consult your ADInstruments distributor.

***When Windows starts up, it doesn't recognise the PowerLab***

This should happen only the first time PowerLab hardware is connected to the computer. Windows may bring up the New Hardware wizard, and ask if you want to install a driver.

- Leave the wizard on its default settings and click the OK button. Insert the CD, or Disk 1 of the provided installation disks. The PowerLab setup information file should be selected in the dialog box that appears. Click the OK button, and continue.

***Windows complains about ASPI when Chart starts up***

Windows needs ASPI (advanced SCSI programming interface) in order for ADInstruments software to run. It is present by default in Windows 95 or 98, but not in Windows NT. It should have been installed along with the software if it could not be found, but may have been removed somehow.

- Re-install the ADInstruments software, or ask your PC technical support person or IS manager to install ASPI on the computer.

***The computer refuses to boot with the PowerLab connected***

The SCSI adapter card is incompatible with the computer or the PowerLab or both. We cannot guarantee that the PowerLab will work reliably with a card we did not supply, and some computers and SCSI adapter cards just won't work together.

- Try another card, preferably one we supplied. Ask your PC technical support person or IS manager to check compatibility.

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

The computer is running off a SCSI hard drive, and the PowerLab has an internal problem or has 'hung'.

- Turn everything off, and then after at least ten seconds turn the PowerLab back on again. Turn on the computer and try using the software again.

***The computer can't find the PowerLab***

The PowerLab is off or the power is switched off at the wall, the power cable is not connected firmly, or a fuse has blown.

- Check switches, power connections, and fuses.

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

The PowerLab has an internal problem or has ‘hung’.

- Turn everything off, and then after at least ten seconds turn the PowerLab back on again. Turn on the computer and try using the software again.

Windows NT may not have the right SCSI driver available (it does not have many already installed, as do Windows 95 and 98).

- The driver might have to be installed manually, perhaps from the original NT system CD. The SCSI card should have instructions on the driver it needs and how to perform the installation.

***The computer hangs up while recording, or there is data loss***

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

***The PowerLab doesn’t work or the program crashes after a short time***

The SCSI adapter card is incompatible with the computer or the PowerLab or both. We cannot guarantee that the PowerLab will work reliably with a card we did not supply, and some computers and SCSI adapter cards just won’t work together.

- Try another card, preferably one we supplied. Ask your PC technical support person or IS manager to check compatibility.

A poor connection between PowerLab and computer, or bad cable.

- Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

SCSI problems: two SCSI devices on the bus have the same SCSI ID, or termination is incorrect or unsuitable.

- Check that each device has a unique ID number and that the SCSI chain is terminated correctly. (As a last resort, if the PowerLab is the only connected SCSI device, try leaving it unterminated.)

***Signals seem weak or interacting on the PowerLab/200 or PowerLab/400***

You may be using two or three of the alternative analog inputs from the BNC connector, Pod connector, or Multiport for the same channel at the same time, with resultant signal competition.

- Make certain that you use only *one* of the alternative analog inputs (BNC connector or Pod connector or Multiport) for a channel when recording.

APPENDIX C

# C Specifications

## PowerLab/200 Specifications

### Input

| | |
|---|---|
| Number of inputs: | 2 |
| Input configuration: | Single-ended or differential (the latter only through the Pod connectors) |
| Amplification ranges: | ±2 mV to ±10 V full scale in 12 steps |
| | ± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 0.5 V<br>± 0.2 V<br>± 0.1 V<br>± 50 mV<br>± 20 mV<br>± 10 mV<br>± 5 mV<br>± 2 mV |
| Maximum input voltage: | ±15 volts |
| Input impedance: | ≈ 1 MΩ ‖ 47 pF @ DC |
| Low-pass filtering: | 20 kHz or 50 Hz (software-selectable) |
| AC coupling: | DC or 0.1 Hz (software-selectable) |
| Frequency response (–3 dB): | 20 kHz @ ±10 V full scale, all ranges (no 50 Hz low-pass filter) |

| | |
|---|---|
| DC drift: | Software-corrected |
| CMRR (differential): | 96 dB @ 50 Hz (typical) |
| Input crosstalk: | –110 dB typical |
| Input noise: | < 1 $\mu V_{rms}$ referred to input |
| Pod connectors: | Combine power, $I^2C$ and single-ended or differential analog input signals on one connector, support Pods, particular transducers, etc. |
| Supply voltage: | ±5 V regulated |
| Maximum current: | 50 mA per pod port |
| Communications: | 2-wire $I^2C$ |
| Signal input: | Positive and negative analog inputs |
| Connector type: | 8-pin DIN. |

## Sampling

| | |
|---|---|
| ADC resolution: | 12 bits |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |
| Maximum sampling rates: | 100 kHz on one channel;<br>40 kHz on two channels using Scope<br>1000 Hz multi-channel using Chart. |
| Available sampling rates: | 100 kHz down to 0.003 Hz using Chart<br>100 kHz down to 2 Hz using Scope<br>100 kHz to 2 Hz using Chart for Windows |

## Output Amplifier

| | |
|---|---|
| Output configuration: | Differential |
| Output resolution: | 12 bits |
| Maximum output current: | ±25 mA |
| Output impedance: | 0.1 Ω typical |
| Slew rate: | 6 V/µs |
| Settling time: | 2 µs (to 0.01% of FSR for LSB change) |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |

| | |
|---|---|
| Output ranges: | ±200 mV to ±10 V full scale in six steps |
| | ± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 500 mV<br>± 200 mV |

## External Trigger

| | |
|---|---|
| Trigger threshold: | +3.0 V ±0.25 V (TTL compatible) |
| Hysteresis: | 0.2 V (turns off at +2.8 V ±0.25 V) |
| Input load: | 1 TTL load |
| Maximum input voltage: | ±12 V |
| Minimum pulse width: | 10 µs |

## Microprocessor and Data Communication

| | |
|---|---|
| Processor: | 65C02 running at 4 MHz |
| Memory: | 47 K |
| ROM: | 16 K |
| Data communication: | SCSI (up to 200 kilobytes/s, maximum, dependent on computer) |

## Expansion Ports

| | |
|---|---|
| $I^2C$ expansion port: | Power and control bus for front-end units. Supports up to 16 front-ends, but limited to the PowerLab's free connectors. Interface communications rate of up to 10,000 bits/s. |
| Multiport: | Combines digital I/O, $I^2C$ and analog input and output signals on one connector. |
| Digital output: | 2 independent lines, TTL output level (2 mA maximum load per line) |
| Digital input: | 2 independent lines, TTL input level, threshold 2.2 V |
| External trigger: | Same as above |
| Analog input: | Same specs as input amplifier |
| Analog output: | Same specs as output amplifier |
| $I^2C$: | Same specs as above. |

## Physical Configuration

| | |
|---|---|
| Dimensions (w × h × d): | 200 mm × 65 mm × 250 mm (7.9″ × 2.6″ × 9.8″) |
| Weight: | 2.13 kg (4 lb 11 oz) |
| Operating voltage: | 220–240 V or 110–120 V (internally set) |
| Nominal power needs: | 6 VA (25 mA @ 240 V *or* 52 mA @ 115 V) (no front-ends attached) |
| Maximum power needs: | 15 VA (full complement of front-ends) |
| Replacement fuses: | 100–120 V: 1 Amp (5 × 20 mm) slow blow (voltage rating 120 or 250 V) |
| | 220–240 V: 400 mA (5 × 20 mm) slow blow (voltage rating 250 V only) |
| Operating temperature range: | 0 to 35 °C, 0 to 90% humidity (non-condensing) |

# PowerLab/400 Specifications

## Input

| | |
|---|---|
| Number of inputs: | 4 |
| Input configuration: | Single-ended or differential (the latter only through the Pod connectors) |
| Amplification ranges: | ±2 mV to ±10 V full scale in 12 steps |
| | ± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 0.5 V<br>± 0.2 V<br>± 0.1 V<br>± 50 mV<br>± 20 mV<br>± 10 mV<br>± 5 mV<br>± 2 mV |
| Maximum input voltage: | ±15 volts |
| Input impedance: | ≈ 1 MΩ ‖ 47 pF @ DC |

| | |
|---|---|
| Low-pass filtering: | 20 kHz or 50 Hz (software-selectable) |
| AC coupling: | DC or 0.1 Hz (software-selectable) |
| Frequency response (–3 dB): | 20 kHz @ ±10 V full scale, all ranges (no 50 Hz low-pass filter) |
| DC drift: | Software-corrected |
| CMRR (differential): | 96 dB @ 50 Hz (typical) |
| Input crosstalk: | –110 dB typical |
| Input noise: | < 1 $\mu V_{rms}$ referred to input |
| Pod connectors: | Combine power, $I^2C$ and single-ended or differential analog input signals on one connector, support Pods, particular transducers, etc. |
| Supply voltage: | ±5 V regulated |
| Maximum current: | 50 mA per pod port |
| Communications: | 2-wire $I^2C$ |
| Signal input: | Positive and negative analog inputs |
| Connector type: | 8-pin DIN. |

## Sampling

| | |
|---|---|
| ADC resolution: | 16 bits |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |
| Maximum sampling rates: | 100 kHz on one channel;<br>40 kHz on two channels using Scope<br>1000 Hz multi-channel using Chart. |
| Available sampling rates: | 100 kHz down to 0.003 Hz using Chart<br>100 kHz down to 2 Hz using Scope<br>100 kHz to 2 Hz using Chart for Windows |

## Output Amplifier

| | |
|---|---|
| Output configuration: | Differential |
| Output resolution: | 12 bits |
| Maximum output current: | ±25 mA typical |
| Output impedance: | 0.1 Ω typical |
| Slew rate: | 6 V/µs |

| | |
|---|---|
| Settling time: | 2 µs (to 0.01% of FSR for LSB change) |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |
| Output ranges: | ±200 mV to ±10 V full scale in six steps |
| | ± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 500 mV<br>± 200 mV |

## External Trigger

| | |
|---|---|
| Trigger threshold: | +3.0 V ±0.25 V (TTL compatible) |
| Hysteresis: | 0.2 V (turns off at +2.8 V ±0.25 V) |
| Input load: | 1 TTL load |
| Maximum input voltage: | ±12 V |
| Minimum pulse width: | 10 µs |

## Microprocessor and Data Communication

| | |
|---|---|
| Processor: | 65C02 running at 4 MHz |
| Memory: | 47 K |
| ROM: | 16 K |
| Data communication: | SCSI (up to 200 kilobytes/s, maximum, dependent on computer) |

## Expansion Ports

| | |
|---|---|
| $I^2C$ expansion port: | Power and control bus for front-end units. Supports up to 16 front-ends, but limited to the PowerLab's free connectors. Interface communications rate of up to 10,000 bits/s. |
| Multiport: | Combines digital I/O, $I^2C$ and analog input and output signals on one connector. |
| Digital output: | 2 independent lines, TTL output level (2 mA maximum load per line) |
| Digital input: | 2 independent lines, TTL input level, threshold 2.2 V |

| | |
|---|---|
| External trigger: | Same as above |
| Analog input: | Same specs as input amplifier |
| Analog output: | Same specs as output amplifier |
| $I^2C$: | Same specs as above. |

## Physical Configuration

| | |
|---|---|
| Dimensions (w × h × d): | 200 mm × 65 mm × 250 mm (7.9″ × 2.6″ × 9.8″) |
| Weight: | 2.16 kg (4 lb 12 oz) |
| Operating voltage: | 220–240 V or 110–120 V (internally set) |
| Nominal power needs: | 6 VA (25 mA @ 240 V *or* 52 mA @ 115 V) (no front-ends attached) |
| Maximum power needs: | 20 VA (full complement of front-ends) |
| Replacement fuses: | 100–120 V: 1 Amp (5 × 20 mm) slow blow (voltage rating 120 or 250 V) |
| | 220–240 V: 400 mA (5 × 20 mm) slow blow (voltage rating 250 V only) |
| Operating temperature range: | 0 to 35 °C, 0 to 90% humidity (non-condensing) |

# PowerLab/800 Specifications

## Input

| | |
|---|---|
| Number of inputs: | 8 |
| Input configuration: | Single-ended |
| Amplification ranges: | ±2 mV to ±10 V full scale in 12 steps |
| | ± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 0.5 V<br>± 0.2 V<br>± 0.1 V<br>± 50 mV<br>± 20 mV<br>± 10 mV<br>± 5 mV<br>± 2 mV |

| | |
|---|---|
| Maximum input voltage: | ±15 volts |
| Input impedance: | ≈ 1 MΩ \|\| 47 pF @ DC |
| Low-pass filtering: | 20 kHz or 50 Hz (software-selectable) |
| AC coupling: | DC or 0.1 Hz (software-selectable) |
| Frequency response (–3 dB): | 20 kHz @ ±10 V full scale, all ranges (no 50 Hz low-pass filter) |
| DC drift: | Software-corrected |
| CMRR (differential): | 96 dB @ 50 Hz (typical) |
| Input crosstalk: | –110 dB typical |
| Input noise: | < 1 $\mu V_{rms}$ referred to input |

## Sampling

| | |
|---|---|
| ADC resolution: | 16 bits |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |
| Maximum sampling rates: | 100 kHz on one channel;<br>40 kHz on two channels using Scope<br>1000 Hz multi-channel using Chart. |
| Available sampling rates: | 100 kHz down to 0.003 Hz using Chart<br>100 kHz down to 2 Hz using Scope<br>100 kHz to 2 Hz using Chart for Windows |

## Output Amplifier

| | |
|---|---|
| Output configuration: | Differential |
| Output resolution: | 12 bits |
| Maximum output current: | ±50 mA typical (±200 mA short circuit) |
| Output impedance: | 0.1 Ω typical |
| Slew rate: | 6 V/µs |
| Settling time: | 2 µs (to 0.01% of FSR for LSB change) |
| Linearity error: | ±1 LSB (from 0 °C to 70 °C) |

| | |
|---|---|
| Output ranges: | ±200 mV to ±10 V full scale in six steps<br><br>± 10 V<br>± 5 V<br>± 2 V<br>± 1 V<br>± 500 mV<br>± 200 mV |

## Microprocessor and Data Communication

| | |
|---|---|
| Processor: | 65C02 running at 4 MHz |
| Memory: | 47 K |
| ROM: | 16 K |
| Data communication: | SCSI (up to 200 kilobytes/s, maximum, dependent on computer)<br><br>Serial (up to 1 kilobytes/s, maximum, Macintosh only) |

## Expansion Ports

| | |
|---|---|
| $I^2C$ expansion port: | Power and control bus for front-end units. Supports up to 16 front-ends, but limited to the PowerLab's free connectors. Interface communications rate of up to 10,000 bits/s. |
| Digital output: | 8 independent lines, TTL output level (50 mA maximum load per line; 250 mA maximum total load) |
| Digital input: | 8 independent lines, TTL input level, threshold 2.2 V |

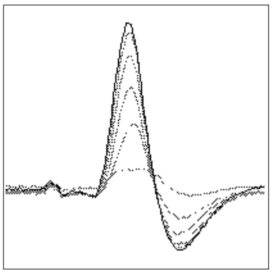
## External Trigger

| | |
|---|---|
| Trigger threshold: | +2.5 V (TTL compatible) |
| Hysteresis: | 0.6 V (turns off at +1.9 V) |
| Input load: | 1 TTL load |
| Maximum input voltage: | ±12 V |
| Minimum pulse width: | 10 µs |

## Physical Configuration

| | |
|---|---|
| Dimensions (w × h × d): | 300 mm × 60 mm × 300 mm (11.8″ × 2.4″ × 11.8″) |
| Weight: | 4.95 kg (10 lb 15 oz) |
| Operating voltage: | 220–240 V or 110–120 V (internally set) |
| Nominal power needs: | 10 VA (25 mA @ 240 V *or* 52 mA @ 115 V) (no front-ends attached) |
| Maximum power needs: | 40 VA (full complement of front-ends) |
| Replacement fuses: | 100–120 V: 1 Amp (5 × 20 mm) slow blow (voltage rating 120 or 250 V) |
| | 220–240 V: 400 mA (5 × 20 mm) slow blow (voltage rating 250 V only) |
| Operating temperature range: | 0 to 35 °C, 0 to 90% humidity (non-condensing) |

*ADInstruments reserves the right to alter these specifications at any time.*



# Glossary

This covers terms used in this owner's guide, those for ADInstruments front-ends, and the user's guides for ADInstruments software. General and specific computer terminology should be covered in the material that came with your computer, or in a recent dictionary.

**AC coupling**. A filter option. When AC coupling is chosen, a 0.1 Hz high-pass filter before the first amplification stage removes DC and frequency components below 0.1 Hz. This removes slowly changing baselines.

**ADC** (analog-to-digital converter). A device that converts analog information into some corresponding digital voltage or current.

**amplitude**. The maximum vertical distance of a periodic wave from the zero or mean position about which the wave oscillates.

**analog**. Varying smoothly and continuously over a range. An analog signal varies continuously over time, rather than changing in discrete steps.

**analog input**. This refers to the analog connectors on the front of the PowerLab marked 'CH1' and so on. These inputs are designed to accept up to ±10 volts. Inputs can be either single-sided or differential (the latter only in the case of the Pod connectors).

**analog output**. This refers to the connectors on the front of the PowerLab marked 'Output'. The analog output provides a software-controlled variable output (±10 V) that can be used with applications either directly as a stimulator, or to control peripheral devices.

**analysis**. When the PowerLab is not physically connected to the computer, then ADInstruments software can be used to analyse and manipulate existing files if the analysis option is chosen.

**BNC**. A sort of cable or connector; a BNC-to-BNC cable connects two BNC connectors.

**bridge transducer**. A type of transducer using a Wheatstone bridge circuit. In its basic form, the bridge consists of four two-terminal elements (usually strain gauges) connected to form a quadrilateral. An excitation source is connected across one diagonal, and the transducer output is taken across the other.

**bus**. A data-carrying electrical pathway.

**Chart**. An application supplied with a PowerLab that emulates a multi-channel chart recorder, with other powerful options. (Macintosh and Windows versions differ.)

**connector**. A plug, socket, jack, or port used to connect one electronic device to another (via a cable): a PowerLab to a computer, say.

**CPU** (central processing unit). A hardware device that performs logical and arithmetical operations on data as specified in the instructions: the heart of most computers.

**DAC** (digital-to-analog converter). A device that converts digital information into some corresponding analog voltage or current.

**DC offset**. The amount of DC (direct current) voltage present at the output of an amplifier when zero voltage is applied to the input; or the amount of DC voltage present in a transducer in its equilibrium state.

**differential input**. Input using both positive and negative inputs on a PowerLab. The recorded signal is the difference between the positive and negative input voltages: if both were fed exactly the same signal, zero would result. Can reduce the noise from long leads.

**digital**. Varying discretely. A digital signal changes to discrete values rather than varying continuously. A digital time display might read 2:57 instead of using the positions of a pair of hands on a clock face.

**DIN** (Deutsche Industrie Norm). A sort of cable or connector; there are various sorts with different numbers of pins.

**envelope form**. The overall shape of a signal, outlined by the minimum and maximum recorded values. Often used to display quickly changing signals.

**excitation voltage**. The voltage supplied to a bridge circuit from which the transducer output signal is derived. Manipulating the transducer changes the measurement elements of the bridge circuit, producing a change in its output voltage.

**external trigger**. Refers to the connector on the front of the PowerLab marked 'Trigger'. This input lets recording be started from an external source. The trigger level (the voltage necessary to have an effect) depends on the hardware and cannot be changed.

**filter**. An electronic device or a program that alters data in accordance with specific criteria. Filters in the PowerLab can be used to reduce or to eliminate electronic noise or drift from data readings.

**frequency**. The number of complete cycles per second of a waveform. Frequency is usually expressed in hertz, Hz (cycles per second), kilohertz, kHz (thousands of cycles per second), or megahertz, MHz (millions of cycles per second).

**frequency response**. The bandwidth in which a circuit passes a signal without too much attenuation. A low-pass filter's frequency response is the frequency where the output voltage becomes 0.707 ($1/\sqrt{2}$) of the input voltage or has been attenuated by 3 decibels. If a low-pass filter has a frequency response of 200 Hz, say, then the signal is effectively unattenuated up to 150 Hz, and is 0.707 of the original value at 200 Hz.

**front-end**. An ancillary device that extends PowerLab capabilities, providing additional signal conditioning and features for specialised work. Front-ends are recognised automatically by the PowerLab system and seamlessly integrated into its applications, operating under full software control.

**gain**. The amount of amplification of a signal.

**half-bridge transducer**. A bridge transducer only using half of the full-bridge circuit. It consists of two elements of equal value with an excitation voltage applied across them. The output of the transducer is taken at the junction of the two elements.

**hertz** (Hz). The unit of frequency of vibration or oscillation, defined as the number of cycles per second. The PowerLab's maximum sampling rate can be up to 100 kHz for E series and 200 kHz for S series PowerLabs.

**high-pass filter** (HPF). A filter that passes high-frequency signals, but filters low ones, by blocking DC voltages and attenuating frequencies below a certain frequency, called the cutoff, or –3 dB, frequency.

**$I^2C$**. The $I^2C$ (eye-squared-sea) connection is used by the PowerLab to control front-ends. It provides power and communications using a 4-wire serial bus (two wires for standard $I^2C$ and two control lines).

**IEC**. International Electrotechnical Commission.

**low-pass filter** (LPF). A filter that passes low-frequency signals and DC voltages, but filters high ones, by attenuating frequencies above a certain frequency, called the cutoff, or –3 dB, frequency.

**Macintosh**. A family of Apple computers with built-in graphics and an elegant user interface. Of the Mac OS (operating system) versions, System 7 is needed, and System 7.6 recommended, for ADInstruments programs.

**MacLab**. An earlier name for the PowerLab, before it became cross-platform.

**Peaks**. A simple chromatography analysis package. It reads acquired data from Macintosh Chart, Scope, or text files. (Available for Macintosh only.)

**Pod connector**. A special 8-pin DIN connector on some PowerLabs giving differential or single-sided connections for some analog inputs (Channels 1 and 2 on the PowerLab/200 and PowerLab/400). Pods can connect to them, and they can also provide power and control for some types of transducers.

**Pods**. Small, low-cost units that connect to the Pod connectors on the PowerLab. They give alternatives to front-ends for specific tasks, for use with precalibrated transducers and so on.

**port**. A socket in a computer where you plug in a cable for connection to a network or a peripheral device. Also, any connection for transferring data, for instance between the CPU and main memory.

**PowerChrom**. A versatile, flexible, and powerful chromatography program for use with a PowerChrom recording unit. (Available for Macintosh only.)

**PowerChrom System**. The system consists of a PowerChrom recording unit and the

PowerChrom program. It provides general-purpose manual or automatic recording and analysis of chromatographic peaks.

**PowerLab**. The PowerLab hardware unit is a self-contained data acquisition hardware unit that connects to a computer running the Mac OS, or Windows 95 or NT 4 or later. When used in conjunction with programs such as Chart and Scope, it functions as a versatile laboratory instrument.

**PowerLab system**. The system consists of a hardware unit and applications software (and possibly ancillary devices). It provides a multi-purpose data recording, display, and analysis environment for experimental data.

**range**. In Chart and Scope, the range is the greatest positive and negative voltage that can be displayed, usually from ±2 mV to ±10 V, in 12 steps. (Range is inversely proportional to gain, the extent of amplification.)

**Scope**. An application supplied with a PowerLab that emulates a two-channel storage oscilloscope, with added powerful options. (Macintosh and Windows versions are very similar.)

**SCSI** (small computer system interface). A connection protocol that provides a computer with fast access to peripheral devices, but has to be set up carefully. SCSI devices can be linked together in a chain, and require termination to prevent signal loss.

**serial**. A connection protocol for sending information sequentially, one bit at a time, over a single wire. (The PowerLab/800 has a slow serial connection, for use with early Macintosh computers.)

**TChart**. A simplified version of the Chart program once used for teaching. Its manual of experiments is now available for Chart.

**terminator**. A device used in a SCSI chain to maintain signal integrity. Some models of PowerLab have them built in.

**transducer**. A physical device that converts a mechanical, thermal, or electrical stimulus into a proportional electrical output. For example, there are common transducers to measure force, displacement, temperature, pressure, and similar parameters.

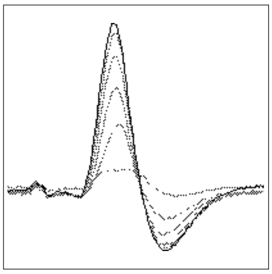
**trigger**. A signal such as a voltage pulse, used to determine when sampling will begin. Sampling can be made to begin when the trigger level is reached, after it, or even prior to it. See also external trigger.

**TTL** (transistor-transistor logic). A family of integrated circuits with bipolar circuit logic, used in computers and related devices. TTL is also a standard for interconnecting such ICs, defining the voltages used to represent logical zeroes and ones (binary 0 and 1).

**USB** (universal serial bus). A relatively new low-to-medium speed connection protocol, for linking multiple peripherals from mice to printers. (Available on newer S series PowerLabs, but not on E series PowerLabs.)

**waveform**. The shape of a wave; a graph of a wave's amplitude over time.

**Windows**. An operating system for PCs with a graphical user interface. Chart for Windows and Scope for Windows require Windows 95 or NT 4 or later.



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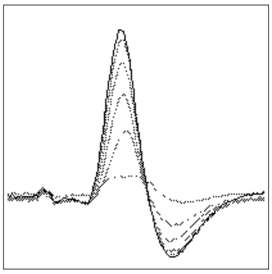

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