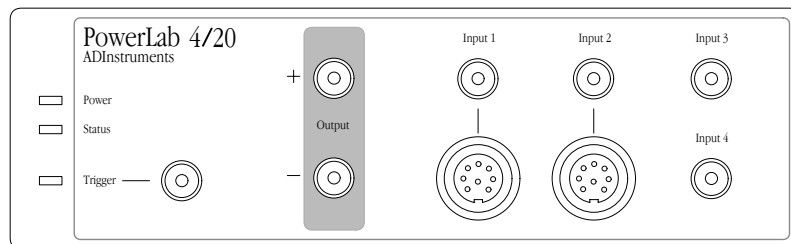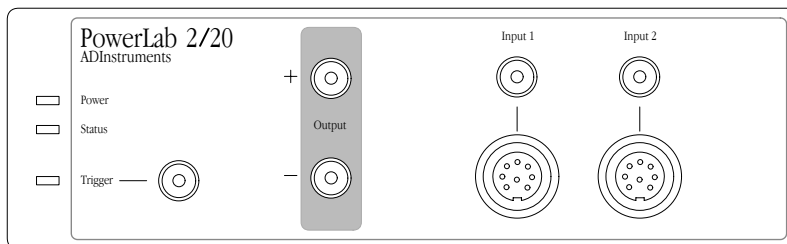# PowerLab /20 Owner's Guide

for PowerLab 2/20 and PowerLab 4/20 models

This document was, as far as possible, accurate at the time of printing. Changes may have been made to the software and hardware it describes since then, though: ADInstruments reserves the right to alter specifications as required. Late-breaking information may be supplied separately.

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Contents

Safety Notes

Product Intention

PowerLab systems have been designed only for use in teaching and research applications. They are not intended for clinical or critical life-care use and should never be used for these purposes, nor for the prevention, diagnosis, curing, treatment, or alleviation of disease, injury, or handicap.

Applicable Safety Standards

When used with insulated transducers or ADInstruments isolated front-ends, PowerLab systems are safe for human connection. The ML132 Bio Amp, ML135 Dual Bio Amp, ML408 Dual Bio Amp/Stimulator, ML116 GSR Amp, ML117 BP Amp and ML180 front-ends conform to international safety requirements. Specifically, these requirements are IEC601-1 and its addenda (Table S–1), and various harmonised standards worldwide (UL2601.1 in the USA, and AS/NZS3200.1 in Australia and New Zealand). In accordance with European standards they also comply with the electromagnetic compatibility requirements under EN60601-1, which encompasses the EMC directive. Further information is available on request.

Table S–1
Applicable safety standards met by ADInstruments isolated front-ends

EC Standard No.	International Standard — Medical electrical equipment
IEC601-1:1988	General requirements for safety
IEC601-1-1:1992	Safety requirements for medical electrical systems
IEC601-1-2:1993	Electromagnetic compatibility

General Safety Instructions

- Since the PowerLab is used in conjunction with a computer (which has much higher leakage currents) the subject must be at least 1.83 metres (6 feet) away from any of the equipment, to avoid contact with the computer. The Bio Amp or BP Amp cable provides enough distance. Alternatively, an isolation transformer can be used to supply power to both the PowerLab and the computer.

- The PowerLab 2/20 and PowerLab 4/20 are classified as Class I medical equipment, which means that protection against electric shock in the event of a fault relies on a direct connection through the power cable to your building's earth conductor. The power cable supplied with your PowerLab provides the required ground connection to the power outlet. If your building does not have power outlet sockets with a good ground connection, then you may use the ground connection on the rear of the PowerLab to provide the equipotential connection to the building's earth conductor. A ground connection is an essential part of this equipment's safety. Never use the PowerLab without a ground connection.

Safety Symbol Explanation

Every ADInstruments device designed for connection to humans, including the Bio Amp, BP Amp, GSR Amp and Stimulus Isolator, carries one or more of three safety symbols, as shown in Figure S–1. These symbols appear next to those input and output connectors that can be directly connected to human subjects.
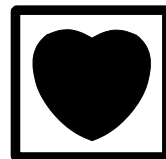
Figure S–1
Equipment safety symbols on ADInstruments devices designed for safe connection to humans

BF symbol: Body-protected equipment

Warning symbol: see documentation

CF symbol: Cardiac-protected equipment

The three symbols are:

- **BF (body protected) symbol**. This means that the input connectors are suitable for connection to humans provided there is no direct electrical connection to the heart.

- **Warning symbol**. The exclamation mark inside a triangle means that you should consult the supplied documentation (you're reading it) for operating information or cautionary and safety information before using the device.

- **CF (cardiac protected) symbol**. (Appears on some models of Bio Amp, and every BP Amp.) This means that the input connectors are suitable for connection to humans even when there is direct electrical connection to the heart.

Cleaning and Sterilisation

This system is not supplied with materials or components likely to need sterilisation. If you need to clean peripherals likely to be in contact with different subjects, they can be cold-sterilised with an appropriate sterilising agent. No part of the system can be autoclaved.

Storage

It is recommended that the hardware be kept below 40 °C and above 0 °C in a moisture-free or low-humidity environment when not in use (storage only). Electronic components are susceptible to corrosive substances and atmospheres, so it is also advisable to keep the system away from laboratory chemicals.

Preventative Inspection and Maintenance

Both PowerLab systems and ADInstruments front-ends are maintenance free and do not require periodic calibration or adjustment to ensure medical safety. Internal diagnostic software performs system checks during power up and will report errors if a significant problem is found.

There is no need to open the instrument for inspection or maintenance, and doing so within the warranty period will void the warranty.

If you so wish, your PowerLab system can be periodically checked for basic medical safety by using an appropriate medical safety testing device. Tests such as earth leakage, earth bond, insulation resistance, patient leakage and auxiliary currents and power cable integrity can all be performed on the PowerLab system without having to remove the covers. You should follow the instructions for the testing device if performing such tests.

If the PowerLab system is found not to comply with such testing you should contact your PowerLab dealer to arrange for the equipment to be checked and serviced. You should not attempt to service the device yourself.

1 Overview
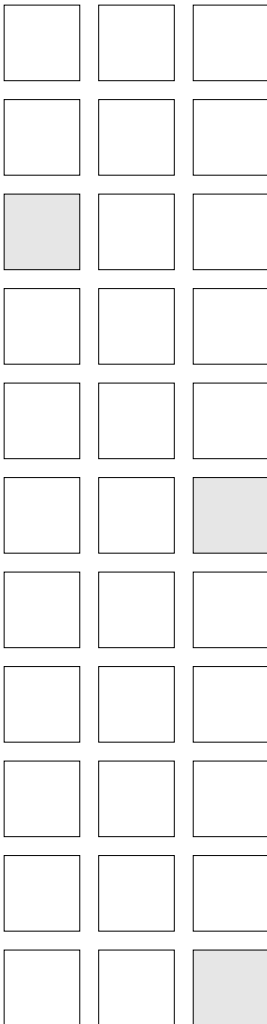
Your PowerLab recording unit, together with a range of specialised application programs, provides a versatile data recording and analysis system when used with a Windows or Macintosh computer. This chapter provides an overview of the PowerLab system and describes the basic features, connectors, and indicators of the /20 series PowerLabs: the PowerLab 2/20 and PowerLab 4/20.

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.

If anything is missing, or the PowerLab seems to be damaged in any way, 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), and from the ADInstruments web site.

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, pods, and so on); the software consists of the application programs (such as Chart and Scope) that run on the computer to which the PowerLab is connected.

Your /20 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 2/20 has two inputs for recording external signals, the PowerLab 4/20 has four.

Computer Requirements

Windows

- A computer with a Pentium processor or better

- 32 MB free RAM (48 MB for Windows 2000)

- Windows 98, Me, 2000 or later operating system

- USB built in or available through a PCI card

Macintosh

- A Power Macintosh computer (or computer with a PowerPC microprocessor)

- 32 MB free RAM (64 MB recommended)

- Mac OS 8.6 or later (Mac OS 9.0 or later recommended)

- USB built in or available through a PCI card.

The Application Programs

Two main programs and their documentation are provided with each PowerLab. Chart emulates a multi-channel chart recorder (up to 16 channels, depending on the PowerLab model). Scope emulates a two-channel storage oscilloscope. 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; the Getting Started with PowerLab manual gives summaries. You must install the software to use your PowerLab. Installation instructions are included in the user's guides for the software.

Other ADInstruments Hardware

ADInstruments has a range of optional ancillary devices that can be connected to the PowerLab to extend the system's capabilities. They afford extra signal conditioning and other features, and extend the types of experiments you can conduct and the data you can record. Front-ends are advanced signal conditioners (the Bio Amp front-end, for instance, lets you perform electrically isolated measurements of biological signals). They are automatically recognised by the PowerLab system and integrated into its programs, operating under full software control. Pods are basic signal conditioners, more limited (but cheaper) than front-ends. Various transducers can plug into a PowerLab, front-end, or pod, depending on their type. A PowerLab can usually have as many front-ends, pods, stand-alone instruments, or transducers connected to it as it has appropriate connectors. All are easily added to or transferred among PowerLabs. Full information on such hardware should be available from your local ADInstruments distributor or from the ADInstruments web site.

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 2/20 and PowerLab 4/20.

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 2/20 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 Input 1 and Input 2) with two alternative pod (DIN) connectors, for recording external signals.

Figure 1–1
The front panel of the PowerLab 2/20.
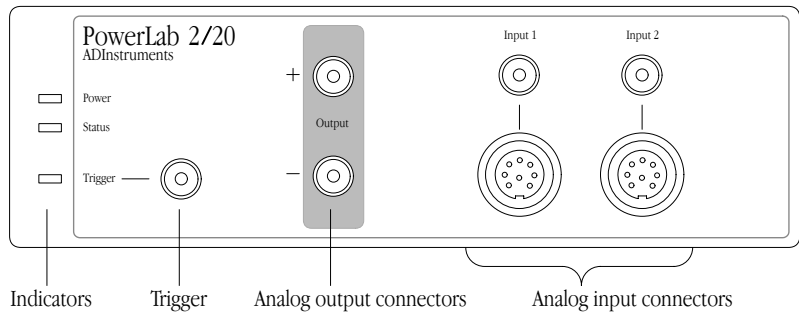
The PowerLab 4/20 has three indicators at the left of the front panel, one BNC connector for the external trigger, two BNC connectors for output, and four BNC connectors (marked Input 1 to Input 4) with two alternative pod (DIN) connectors for Input 1 and Input 2, for recording external signals.

Figure 1–2
The front panel of the PowerLab 4/20.

Indicators

All three labelled indicators on the front panel should turn on at least briefly while the PowerLab is started up. In normal circumstances, the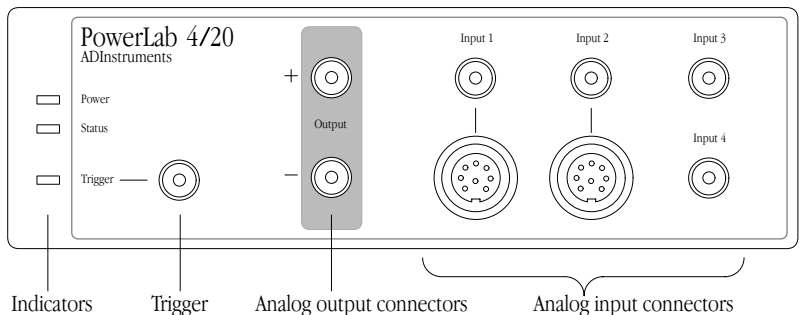 Power indicator should glow blue and then stay lit, the Status indicator should flash yellow and then stay green, and the Trigger indicator should flash yellow and then turn off. The Power indicator is a blue light, which simply shows that the PowerLab is getting power. When an external trigger signal is received, the Trigger indicator will glow yellow. The Status indicator provides some 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.

Status Indicator	*Meaning*
Off	Idle and not yet initialised by the software.
Green	Idle, initialised, and waiting for a command from the computer.
Yellow	Sampling, or communicating with the computer.
Four red flashes and one yellow one	The PowerLab has detected a low-level software or firmware fault. It will repeat until the power to the PowerLab is turned off.
Red flashes	The PowerLab has detected an internal fault during the power-up test. It will repeat until the power to the PowerLab is turned off.

Analog Inputs

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 input 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 2/20 has two independent analog inputs (marked Input 1 and Input 2), each of which has alternative connectors. The PowerLab 4/20 has four independent analog inputs (marked Input 1 to Input 4), the first two of which have alternative connectors. In either case, the top BNC connector for Input 1 and Input 2 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. Do not attempt to record from both the BNC and pod connectors for an input 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. The pod connectors on the PowerLabs 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.

Analog Output

The PowerLab can generate a stimulus voltage through its analog output sockets (marked Output), giving positive, negative, or differential (complementary) stimuli, depending on the sockets used. The negative output is always the opposite of positive output. This means that if the positive output gives a +5 V signal, then the negative output will simultaneously give a –5 V signal. The outputs cannot be run independently. If only 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.

Trigger

The external trigger connector allows you to use an external signal 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 2.9 volts for the /20 series PowerLabs. 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 are the same for the PowerLab 2/20 and PowerLab 4/20.
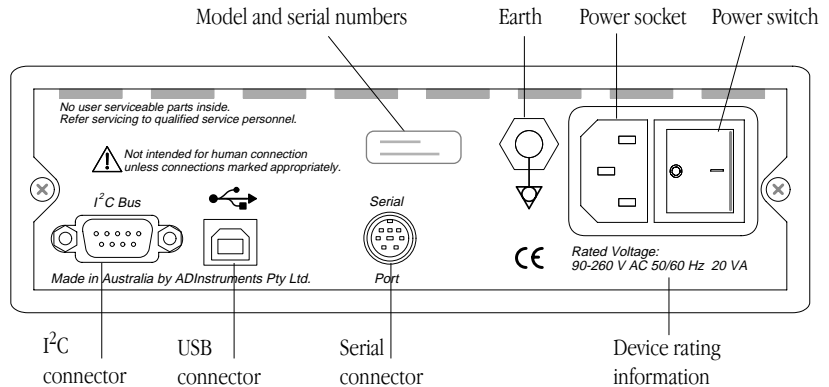
I²C Output

The I²C 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 appropriate connectors. All of them connect to this port in a simple daisy-chain arrangement. *Note*. You should not attempt to run other external devices from the I²C 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.

USB Port

The PowerLab connects to your computer using a USB (universal serial bus) port. This works with USB 1.1-compliant computers with USB connectors or a PCI USB card. To operate, USB needs a Power Macintosh running Mac OS 8.5 or later, or a PC running Windows 98 or 2000 or later.

You can safely turn on or off, or disconnect or reconnect, a USB-connected PowerLab while the computer remains on, in most cases. The application program (Chart or Scope) must not be running while this occurs, though. Read the details on USB in Chapter 2 of this guide before connecting your PowerLab to your computer using USB.

Serial Port

The PowerLab is fitted with an RS-485 serial communication port. It is not currently in use, but is meant for connection in the future to specialised devices controlled from the PowerLab system.

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. The power supply is universal, and can use all common international mains power supplies (auto-switching, 90–260 V AC, 50/60 Hz).

The /20 series PowerLabs are not fitted with replaceable fuses. The power supply is short-circuit protected, and should not damage the internal fuses unless a major fault develops. In that happens, the unit

must be returned for service by qualified service personnel. Do not attempt to replace internal power supply fuses yourself.

2

Setting Up
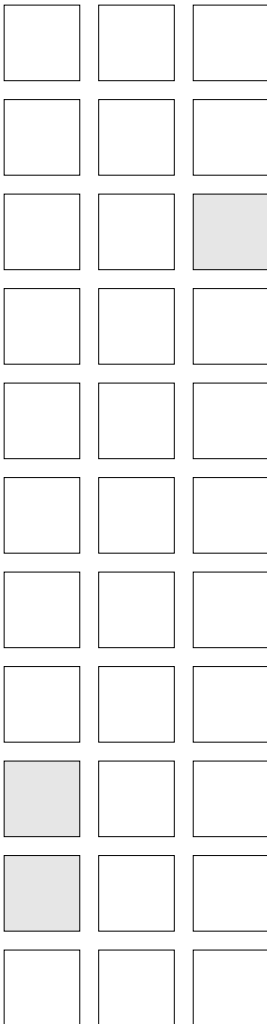
This chapter starts with the PowerLab's internal self-test, then looks at how to connect up your PowerLab to a computer. It discusses the USB connection in some detail.

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.

   All three labelled indicators on the front panel should turn on at least briefly while the PowerLab is started up. The Power indicator on the front panel should glow blue while the PowerLab is on (see Figure 1–1 and Figure 1–2). If the internal diagnostic check finds no problems, the Status indicator should flash yellow, and then stay green. The Trigger indicator should flash yellow, and then turn off.

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 blue when the power switch is turned on, then there is a problem with the power source, power cable, or PowerLab itself. Check connections and so on. If an error is detected during the self-test, the Status indicator will flash red. Flashing lights are used when the problem is one that prevents the PowerLab communicating with the computer, and so cannot be shown in the software. Four red flashes separated by a yellow flash means there is a low-level software or firmware fault. Red flashes means there is a hardware fault. Turn everything off, and then after at least five seconds turn the PowerLab back on again. This should clear a temporary problem. If it still continues to flash red, then the PowerLab may need repair.

If the PowerLab does not seem to be getting power, or the Status indicator flashes red even after restarting, contact your authorised ADInstruments distributor as soon as possible. Do not attempt to repair the PowerLab yourself.

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

The USB Connection

This section is essential reading before trying to use your PowerLab with USB. The PowerLab is fitted with a USB (universal serial bus) port, which provides its means of connection to a computer. This works with USB 1.1-compliant computers with USB connectors or a PCI USB card. On a PC, USB requires Windows 98, Me, 2000 or later (95 or NT 4 won't do). On a Macintosh, USB needs a Power Macintosh with Mac OS 8.5 or later (but note that the latest PowerLab software requires Mac OS 8.6).

USB devices are connected in a tree-like structure, with the host, the computer, forming the root of the tree, and hubs allowing multiple devices to connect to them, like the branches of the tree.

Figure 2–1
A USB tree: up to 126 devices can be linked to the computer.

Up to 126 linked USB devices

Computer: root hub for the USB tree
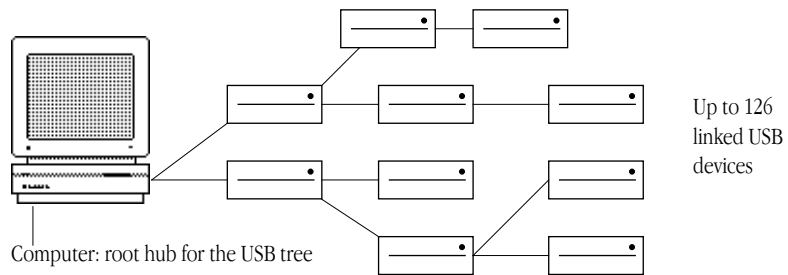
A hub is simply a device that lets you extend the USB tree. It connects to a USB device such as the computer, and multiple USB devices (including other hubs) can connect to it in turn. It provides power for those attached devices that need it. Up to five hubs can be connected between the computer and the furthest USB device. As many as 127 devices can be connected on one tree, counting the computer. The cable between any USB devices (including hubs) must allow a signal to be transmitted in a certain time; in practical terms this means it

must be no more than 5 metres (16 feet) in length. Thus, no device can be more than 30 metres (98 feet) from the computer.

USB lets one plug in and remove devices while the computer is on. It re-enumerates (provides addresses for) devices as they are connected and disconnected, rather than requiring fixed ID numbers.

USB still has some restrictions. Since all the devices on a USB tree have a common communication pathway, if you have many devices with a lot of information to transfer, they compete for capacity (bandwidth). Using a video camera and a scanner at the same time as a PowerLab may limit the sampling rates considerably (in Chart) or increase delay times between sweeps (in Scope).

USB has two sorts of cables, which it should not be possible to interchange. Low-speed cables are cheaper, and suitable for mice and so on. They are either captive (one end is permanently fixed to the device) or use a custom connection, not a standard USB one. All detachable USB cables are high speed, with fully shielded twisted-pair cables, and standard USB connections: a narrow rectangular A plug at one end and a squarer B plug with a bevelled top at the other. All devices that can act as hubs have high-speed connections. The PowerLab needs a high-speed connection, and is provided with a suitable cable.

Connecting the PowerLab Using USB

Use the USB cable supplied with your PowerLab to connect the USB port on its back panel to the USB port on the computer, or to an active USB hub connected to the computer. USB ports and cables should be marked with a trident-like icon (some might have the letters 'USB' instead). USB cables are directional, and can only be connected one way: the narrow rectangular A plug connects to a hub (including the computer), and the squarer B plug with the bevelled top connects to a USB device, such as the PowerLab.

Connecting Macintosh or Windows computers should be much the same in this case: just look for the icons. If the connection is to a USB card installed in the computer, there might not be any icons on the card. The narrow rectangular sockets for the USB A plug are distinctive, though. Any USB icons on the plugs should be on top.

Figure 2–2
Connecting a PowerLab to a
computer with USB.

PowerLab
connection

USB icon

Computer or
hub connection

B plug

A plug
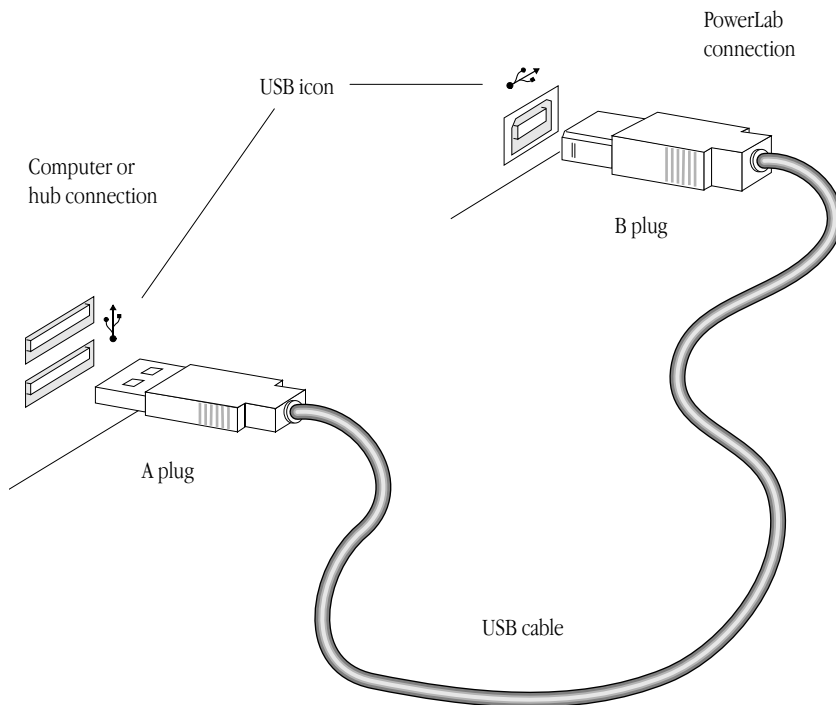
USB cable

USB Connection Rules

1. *Cable length should be less than 5 metres (16 feet) between devices.*
    Devices include USB hubs. There are a maximum of five hubs on
    any branch, so the maximum distance between the computer and
    the PowerLab is 30 metres (98 feet). Do not use extension cables,
    use hubs between approved high-speed cables.

2. *Never attempt to make your own USB cable, or modify one.*
    USB is sensitive to cable impedances and cable lengths. Only use
    a certified USB cable from a reliable supplier, never a cheap brand
    or 'something the workshop whipped up'. Your PowerLab is
    supplied with the proper USB cable. If you need additional USB
    cables, you should buy high-speed cables (fully shielded, twisted-
    pair, and with standard USB connections) for reliable results.

3. *Don't disconnect the PowerLab while a program is using it.*
    Disconnecting a PowerLab while it is sampling is a bad idea and
    may cause problems in some circumstances. It is better to be safe
    than sorry, and not even disconnect a PowerLab while Chart or

Scope is open. Stop sampling and quit the program first before disconnecting a PowerLab from USB.

You can safely turn on or off, or disconnect or reconnect, a USB-connected PowerLab while the computer remains on, as long as the application program (Chart or Scope) is off when you do it. (Although USB is a hot-pluggable standard, Windows 2000 may complain, bringing up an alert. The alert lets you install a control in your taskbar to avoid potential problems in future.)

Technical Aspects

This appendix describes some of the important technical aspects of the PowerLab 2/20 and PowerLab 4/20, 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 and Figure A–2 show the essential elements of each PowerLab.

All sampling, output, and communication functions are controlled by an internal PowerPC microprocessor running at 60 MHz. This microprocessor has access to 4 MB of internal dynamic RAM for data storage and buffering. The PowerLab uses USB (universal serial bus) to communicate with the computer. This provides data transfer rates of up to 800 kB per second, possibly more in some cases.

The PowerLab 2/20 has two and the PowerLab 4/20 has four analog inputs, used to record external signals prior to digitising. The outputs of these input amplifiers are multiplexed to a 16-bit ADC (analog-to-

digital converter). The ADC can sample at a maximum rate of 100,000 samples per second. The sampling process is handled independently of the processor core through a sampling control engine using direct memory access. The CPU assembles groups of samples into blocks and then transmits them to the computer, where the software receives, records, and displays the data.

The external trigger input (marked 'Trigger' on the front panel) allows either a voltage level or a contact closure to trigger recording.

Figure A–1
Block diagram of the PowerLab 2/20.
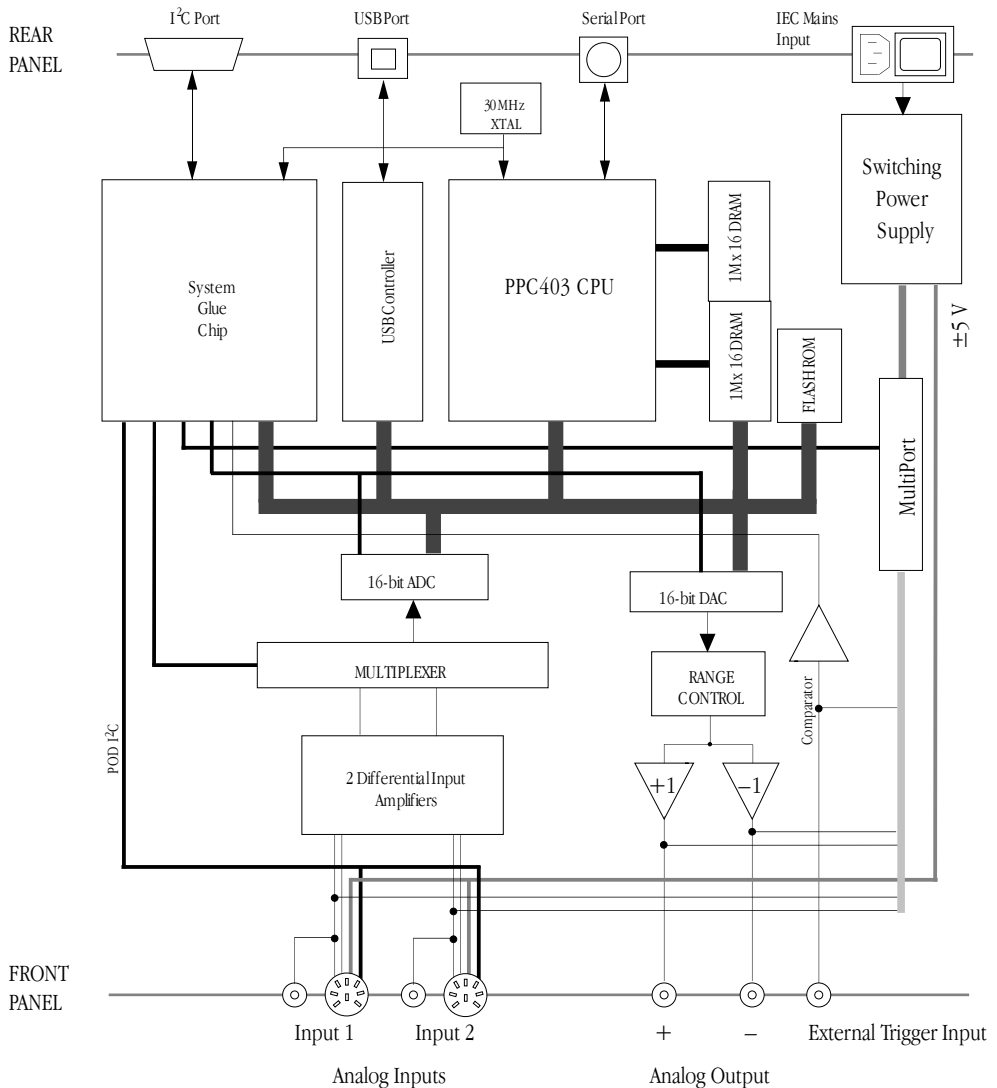
Note that for either mode the trigger signal must be present for at least 5 μs to register as an event. When a trigger event occurs, the trigger indicator light will glow yellow.

When set up through software to use a voltage level, a trigger event is registered when the voltage exceeds 2.9 volts. The trigger input is optically isolated when set up for a voltage level. In the external contact closure mode, the trigger input will respond to a direct short between the centre pin and outer ring of the BNC. This can be

Figure A–2
Block diagram of the PowerLab 4/20.
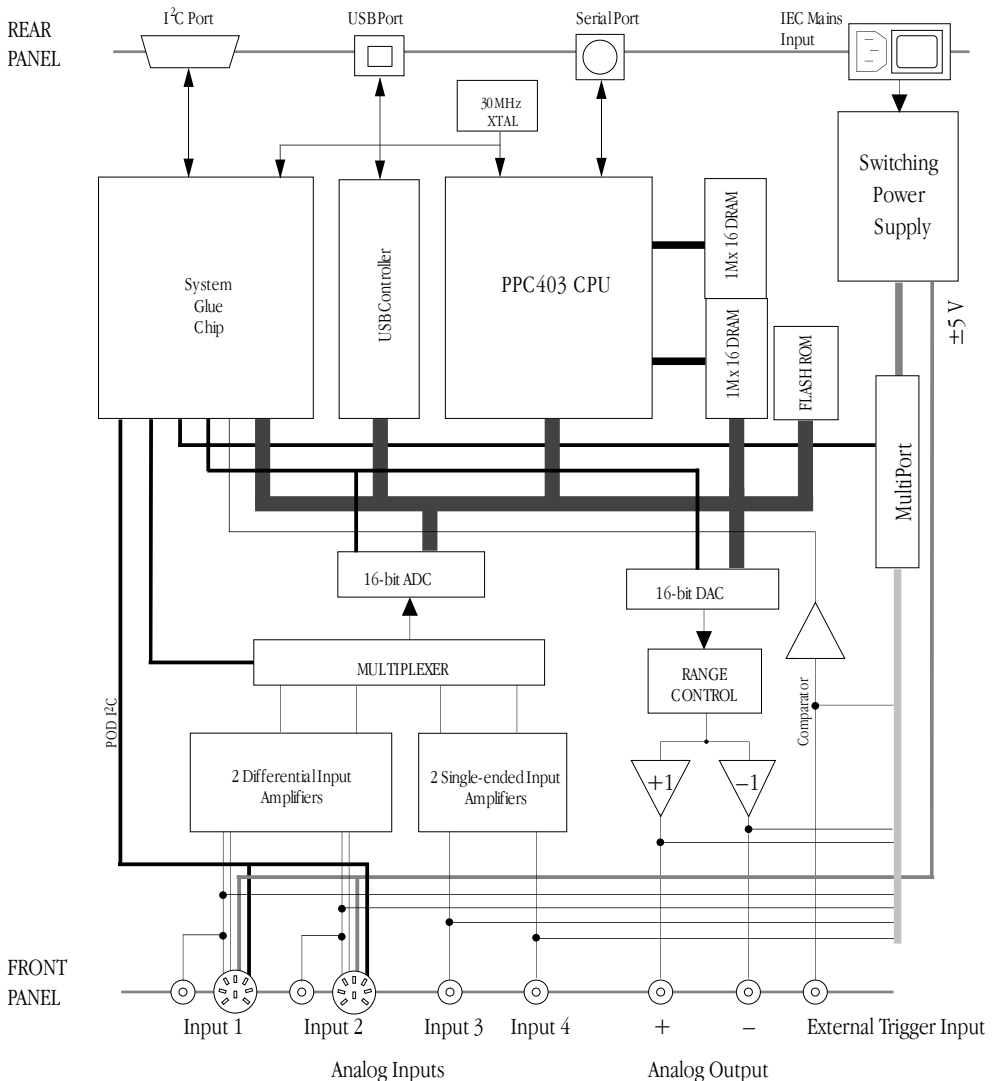
achieved with an external relay contact, a manual push-button, or a microswitch. The trigger input is not electrically isolated when set up for contact closure.

A single 16-bit DAC (digital-to-analog converter) is used to provide an analog output or stimulation capability through the analog outputs of the PowerLab (marked 'Output' on the front panel). The DAC can produce constant DC voltage levels or waveforms under software control. Stimulation frequency is completely independent of the analog input sampling rate. The output of the DAC is fed through a programmable attenuation network to produce different output ranges. The signal is then split into a positive and negative output through buffer amplifiers. The outputs are capable of driving up to 12 mA into a load.

The PowerLab is also fitted with an I^2C front-end expansion port. This is a 9-pin port that allows ADInstruments front-ends to be attached to the system. It provides both power and communications to allow software control of the attached hardware.

The PowerLab uses an IEC601-1(medically) compliant switching power supply. This provides a universal input that handles all common international voltage supplies and frequencies without the need to change voltage ranges. This power supply is also internally protected in the case of a problem. It is important to note that the PowerLab has a limited amount of power available for external devices. Because of these power limitations, you should not use the PowerLab as a power source for external devices other than those produced by ADInstruments.

The Analog Inputs

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 analog 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). Inputs 1 and 2 of the PowerLab 2/20 and PowerLab 4/20 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. Differential signals can only be recorded using a pod connector; the BNC analog inputs on the PowerLabs are all single-ended. Inputs 3 and 4 of the PowerLab 4/20 are single-ended, but can be set by the software to be either positive or negative (inverting or non-inverting).

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–3
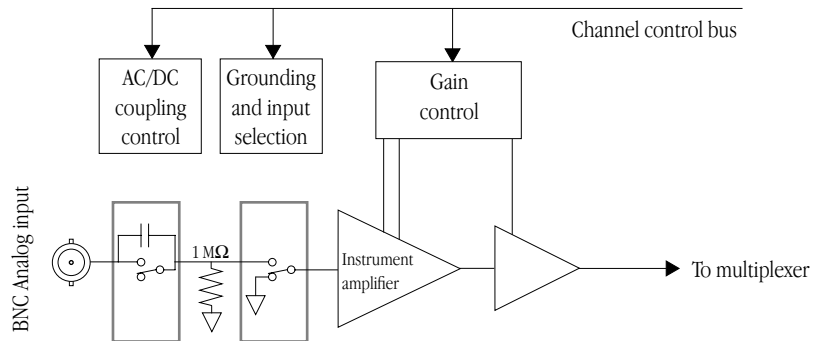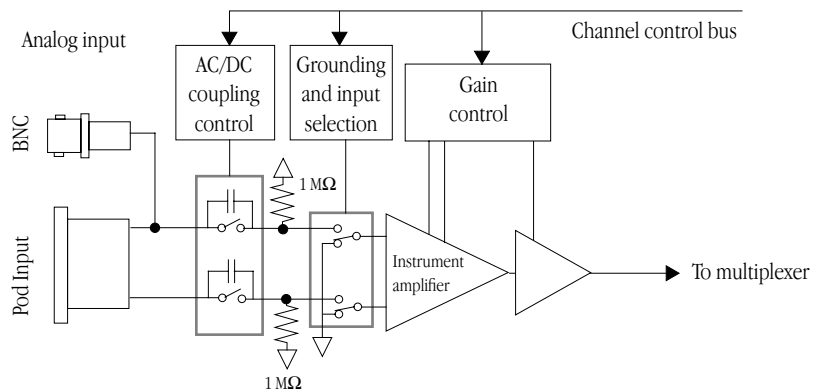Block/schematic diagram of the input amplifier circuitry for BNC-only inputs.

Figure A–4
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 analog input is fitted with a fixed 20 kHz low-pass filter. The unfiltered signal has an effective bandwidth of 45 kHz (within the Nyquist frequency when sampling at 100,000 samples per second).

PowerLab Accuracy

The 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 input 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 software 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 input (marked 'Trigger' on the front panel) provides a digital input for synchronising sampling to external devices. It allows either a voltage level or a contact closure to trigger recording. Note that for either mode the trigger signal must be present for at least 5 µs to register as an event. When a trigger event occurs, the trigger indicator light will glow yellow.

When set up through software to use a voltage level, the external trigger 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, above which a trigger event is registered, is

2.9 V ± 0.25 V; once on, the trigger turns off at 1.8 V ±0.25 V, giving a hysteresis voltage of 1.1 V. The external trigger input draws 2.2 mA at 5 V and 5.5 mA at 10 V.

The trigger input is optically isolated when set up for a voltage level, as shown in Figure A–5. There is no electrical connection between the external trigger ground and the ground of the trigger device. This removes ground noise and current loop problems, and improves static discharge immunity. In order for the external trigger to work, though, a voltage must be applied between the outer ring and the inner pin of the connector. Applying a voltage just to the centre pin will not work. The trigger source must be capable of supplying at least 1 mA of current to activate the trigger.

The equivalent circuit of the external trigger is basically an LED (light-emitting diode) in series with a resistor (the second diode shown below protects the optocoupler).

Figure A–5
The equivalent circuit of the external trigger input, when set up for a voltage level.
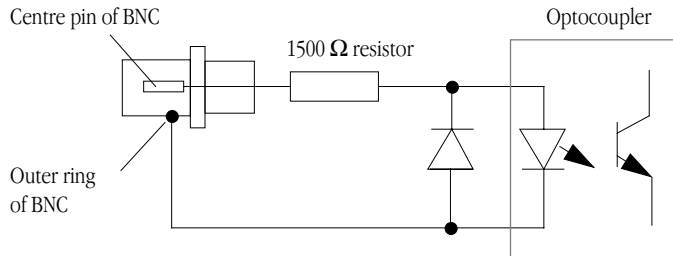
In the external contact closure mode, the trigger input will respond to a direct short between the centre pin and outer ring of the BNC. This can be achieved with an external relay contact, a manual push-button, or a microswitch. The trigger input is not electrically isolated when set up for contact closure.

Figure A–6
The equivalent circuit of the external trigger input, when set up for contact closure.
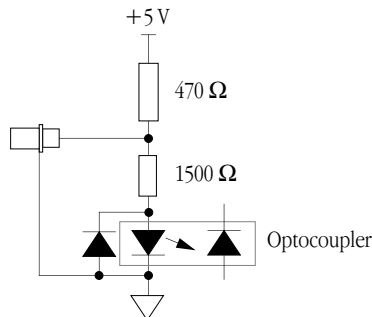
The Analog Output

The analog outputs provide computer-controlled variable outputs (±10 V) that can be used with the Chart and Scope applications either directly as a stimulator, or to control peripheral devices. All stimulation voltage is generated by the PowerLab via the output sockets on the front of the PowerLab (marked 'Output'), giving positive, negative, or differential stimuli, depending on the sockets used and the software settings.

Figure A–7
The analog output stage, set up for a differential stimulus.
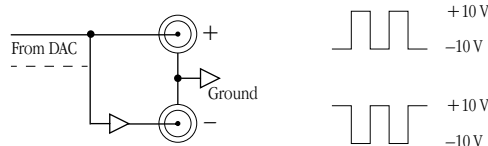
The outputs produce complementary (differential) stimulation. When the positive (+) output is used, a positive stimulus voltage (set up in an application) gives a positive voltage output, and a negative voltage a negative one. When the negative (–) output is used, the voltage outputs are inverted. When 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.

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.

USB Port

The PowerLab is fitted with a USB (universal serial bus) port, which is used to connect to a computer with built-in USB or a PCI USB card installed. USB needs a Power Macintosh with Mac OS 8.5 or later, or a PC with Windows 98 or 2000 or later.
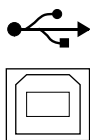
Your PowerLab is supplied with a proper high-speed USB cable. If you need additional USB cables, you should buy high-speed cables (fully shielded, twisted-pair, and with standard USB connections) for reliable results.

I^{2}C Expansion Port

The I^{2}C 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^{2}C 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 appropriate connections. You should not attempt to run other external devices from the I^{2}C 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^{2}C port.

Front-end power | **I^{2}C control signals**

DGND
UNREG–20 V
UNREG +10 V
UNREG +20 V
SCL
DSC
SDA
DSD
INT

5 ○ ○ ○ ○ ○ 1
9 ○ ○ ○ ○ 6
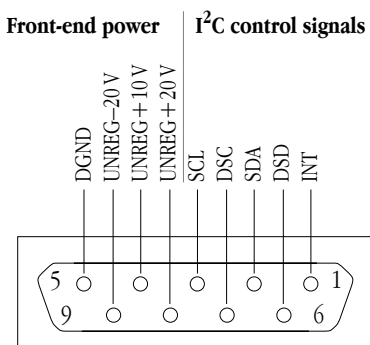
Pod Connectors

The pod connectors on Inputs 1 and 2 of the PowerLab 2/20 and PowerLab 4/20 are 8-pin DIN connectors. 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. The Pod connectors on 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. Do not attempt to record from both the BNC and pod connectors for an input at the same time, or the signals will compete.

[2] Input (−)

[4] Negative 5 V   [5] SDA

[1] Positive 5 V   [3] Input (+)

[6] Input (+) ref.   [7] Analog ground

[8] SCL   [*] Digital ground (metal ring)

Serial Port

The PowerLab is fitted with an RS-485 serial communication port. It is not currently in use, but is meant for connection in the future to specialised devices controlled from the PowerLab system. The serial port provides a differential, bidirectional serial connection for external devices supporting the RS-485 standard. The port also provides three power supplies and a ground signal.

[6] +7.5 V

[7] Ground   [5] Serial out

[4] RS-485 low   [3] RS-485 high

[2] −5 V   [1] +5 V

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

Most problems that users encounter are connection problems. Improper connections can result in a loss of all or some of a signal.

The PowerLab Status indicator light flashes red, or red and yellow, when the PowerLab is turned on

▼ **Refer**
Self-Test, p. 12

Either there is a low-level software or firmware problem (if there are red and yellow flashes), or an internal hardware problem has been discovered by the diagnostic self-test (performed by the PowerLab each time it powers up).

• Turn everything off, and then after at least five seconds turn the PowerLab back on again. This should clear a temporary problem. If not, then the software may have a serious fault, and may need to be reinstalled, or the PowerLab may need repair. 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.

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.

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

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

The connected computer does not properly support USB.

• USB needs a Power Macintosh with Mac OS 8.5 or later; it simply will not work with earlier hardware, such as a 68K Macintosh, or earlier operating systems, such as System 7.

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.

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.

Signals seem weak or interacting on Input 1 or 2

You may be using both the BNC connector and the Pod connector for an input at the same time, with resultant signal competition.

- Make certain that you use only *one* of the alternative connectors (BNC or Pod) for an input when recording.

Problems: Windows

Most problems that users encounter are connection problems. Improper connections can result in a loss of all or some of a signal.

The PowerLab Status indicator light flashes red, or red and yellow, when the PowerLab is turned on

Either there is a low-level software or firmware problem (if there are red and yellow flashes), or an internal hardware problem has been discovered by the diagnostic self-test (performed by the PowerLab each time it powers up).

- Turn everything off, and then after at least five seconds turn the PowerLab back on again. This should clear a temporary problem. If not, then the software may have a serious fault, and may need to be reinstalled, or the PowerLab may need repair. 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.

The computer refuses to boot with the PowerLab connected

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.

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

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

There is an alert when the PowerLab is disconnected or turned off

USB is a hot-pluggable standard, meaning that you should be able to turn on or off, or disconnect or reconnect, a USB-connected PowerLab safely while the computer remains on, as long as the application program (Chart or Scope) is off when you do it. Windows 2000 may complain, though, bringing up an alert.

- The Windows 2000 alert lets you install a control in your taskbar to deal with this. Install the control, and use it before you disconnect or turn off the PowerLab, to avoid the alert.

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.

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

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

The connected computer does not properly support USB.

- USB needs a USB 1.1-compliant PC with Windows 98, Me, 2000 or later; it simply will not work with earlier operating systems, such as Windows 95 or Windows NT 4.

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.

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.

Signals seem weak or interacting on Input 1 or 2

You may be using both the BNC connector and the Pod connector for an input at the same time, with resultant signal competition.

- Make certain that you use only *one* of the alternative connectors (BNC or Pod) for an input when recording.

PowerLab Owner's Guide

C

Specifications

PowerLab 2/20 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
                                     ± 5 V
                                     ± 2 V
                                     ± 1 V
                                     ± 0.5 V
                                     ± 0.2 V
                                     ± 0.1 V
                                     ± 50 mV
                                     ± 20 mV
                                     ± 10 mV
                                     ± 5 mV
                                     ± 2 mV

Maximum input voltage: ±15 volts

Input impedance: ≈ 1 MΩ || 47 pF @ DC

Low-pass filtering: 20 kHz fixed second-order filter
                                     Further digital filtering in software

AC coupling: DC or 0.1 Hz (software-selectable)

Frequency response (–3 dB):   20 kHz @ ±10 V full scale, all ranges

DC drift:	Software-corrected
CMRR (differential):	96 dB @ 50 Hz (typical)
Input crosstalk:	–110 dB typical
Input noise:	<2.4 μV_{rms} referred to input, DC to 20 kHz
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 (150 μV resolution at 10 V range)
Linearity error:	±2 LSB (from 0 °C to 70 °C)
Maximum sampling rates:	100 kHz on one channel; 40 kHz on two channels.
Available sampling rates:	100 kHz down to 0.003 Hz using Chart 100 kHz down to 2 Hz using Scope 100 kHz to 1 Hz using Chart for Windows

Output Amplifier

Output configuration:	Single-ended or differential (complementary)
Output resolution:	16 bits (150 μV resolution at 10 V range)
Maximum output current:	±15 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
	± 5 V
	± 2 V
	± 1 V
	± 500 mV
	± 200 mV

External Trigger

Trigger threshold:	+2.9 V ±0.25 V or contact closure (software-selectable)
Hysteresis:	1.1 V (turns off at +1.8 V ±0.25 V)
Input load:	2.2 mA at 5 V, 5.5 mA at 10 V
Maximum input voltage:	±12 V
Minimum trigger time:	5 µs

Microprocessor and Data Communication

Processor:	PPC403 GCX (60 MHz internal)
Memory:	4 MB DRAM
Data communication:	USB (up to 800 kilobytes/s, possibly greater dependent on setup)

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.

Physical Configuration

Dimensions (w × h × d):	200 mm × 65 mm × 250 mm (7.9″ × 2.6″ × 9.8″); excludes connectors
Weight:	2.0 kg (4 lb 6 oz)
Operating voltage:	90–260 V AC 50/60 Hz
Nominal power needs:	6 VA (25 mA @ 240 V or 52 mA @ 115 V); no front-ends or pods attached

Maximum power needs:	18 VA (full complement of front-ends and pods)
Operating temperature range:	0 to 35 °C, 0 to 90% humidity (non-condensing)

PowerLab 4/20 Specifications

Input

Number of inputs:	4
Input configuration:	Single-ended or differential (the latter only through the pod connectors on Inputs 1 & 2)
Amplification ranges:	±2 mV to ±10 V full scale in 12 steps
	± 10 V ± 5 V ± 2 V ± 1 V ± 0.5 V ± 0.2 V ± 0.1 V ± 50 mV ± 20 mV ± 10 mV ± 5 mV ± 2 mV
Maximum input voltage:	±15 volts
Input impedance:	≈ 1 MΩ ‖ 47 pF @ DC
Low-pass filtering:	20 kHz fixed second-order filter Further digital filtering in software
AC coupling:	DC or 0.1 Hz (software-selectable)
Frequency response (–3 dB):	20 kHz @ ±10 V full scale, all ranges
DC drift:	Software-corrected
CMRR (differential):	96 dB @ 50 Hz (typical)
Input crosstalk:	–110 dB typical
Input noise:	<2.4 μV_{rms} referred to input, DC to 20 kHz

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 (150 µV resolution at 10 V range)

Linearity error:	±2 LSB (from 0 °C to 70 °C)

Maximum sampling rates:	100 kHz on one channel; 40 kHz on two channels; 20 kHz on three or four channels.

Available sampling rates:	100 kHz down to 0.003 Hz using Chart 100 kHz down to 2 Hz using Scope 100 kHz to 1 Hz using Chart for Windows

Output Amplifier

Output configuration:	Single-ended or differential (complementary)

Output resolution:	16 bits (150 µV resolution at 10 V range)

Maximum output current:	±15 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
± 5 V
± 2 V
± 1 V
± 500 mV
± 200 mV

External Trigger

Trigger threshold:	+2.9 V ±0.25 V or contact closure (software-selectable)
Hysteresis:	1.1 V (turns off at +1.8 V ±0.25 V)
Input load:	2.2 mA at 5 V, 5.5 mA at 10 V
Maximum input voltage:	±12 V
Minimum trigger time:	5 µs

Microprocessor and Data Communication

|	
Processor:	PPC403 GCX (60 MHz internal)
Memory:	4 MB DRAM
Data communication:	USB (up to 800 kilobytes/s, possibly greater dependent on setup)

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.

Physical Configuration

Dimensions (w × h × d):	200 mm × 65 mm × 250 mm (7.9″ × 2.6″ × 9.8″); excludes connectors
Weight:	2.4 kg (5 lb 3 oz)
Operating voltage:	90–260 V AC 50/60 Hz
Nominal power needs:	6 VA (25 mA @ 240 V or 52 mA @ 115 V); no front-ends or pods attached
Maximum power needs:	18 VA (full complement of front-ends and pods)
Operating temperature range:	0 to 35 °C, 0 to 90% humidity (non-condensing)

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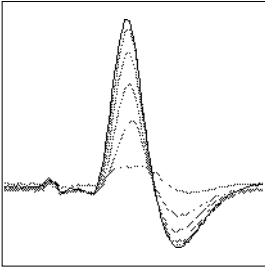
Glossary

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 connectors on the front of the PowerLab marked 'Input'. 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 (bayonet nut connector). 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. The input connector on the front of the PowerLab marked 'Trigger'. This lets one start recording from an external source. The trigger level (the voltage needed to have an effect) depends on the hardware and cannot be changed. The /20 series PowerLabs can also be triggered by contact closure if this is set up in the software.

filter. An electronic device or a program that alters data in accordance with specific criteria. Filters in hardware and software 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 /20 series and 200 kHz for SP and ST 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 value (the cutoff, or –3 dB, frequency).

I²C. 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, attenuating frequencies above a certain value (the cutoff, or –3 dB, frequency).

Macintosh. A family of Apple computers with built-in graphics and an elegant user interface. A Power Macintosh and Mac OS 8.5 or later are needed to use USB, and thus needed to use the /20 series PowerLabs.

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

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

PCI (peripheral component interconnect). A protocol for connecting peripheral devices (such as USB cards) to computers and so on.

Pod connector. A special 8-pin DIN connector on some PowerLabs giving differential or single-sided connections for some analog inputs (Inputs 1 and 2 on the PowerLab 2/20 and PowerLab 4/20). 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 PowerLab's pod connectors. They give alternatives to front-ends for specific tasks, for use with precalibrated transducers etc.

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. (Macintosh and Windows versions are very similar.)

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 Windows or Macintosh computer. 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 preserve signal integrity. Not used by the /20 series PowerLabs.

serial. A connection protocol for sending information sequentially, one bit at a time, over a single wire.

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

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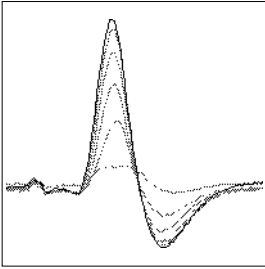
trigger. A signal such as a voltage pulse, used to determine when sampling will begin. Sampling can be made to begin when the trigger level is reached, after it, or even prior to it. See also external trigger.

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 new PowerLabs, such as the /20 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. Windows 98, Me, 2000 or later is needed to use USB, and thus to use the /20 series PowerLabs.

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PowerLab Owner's Guide