PowerLab /25 Series

Owner's Guide

ADINSTRUMENTS
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Safety Notes

Statement of Intended Use

All products manufactured by ADInstruments are intended for use in teaching and research applications and environments only. ADInstruments products are NOT intended to be used as medical devices or in medical environments. That is, no product supplied by ADInstruments is intended to be used to diagnose, treat or monitor a subject. Furthermore no product is intended for the prevention, curing or alleviation of disease, injury or handicap.

Where a product meets IEC 60601-1 it is under the principle that:

- it is a more rigorous standard than other standards that could be chosen, and
- it provides a high safety level for subjects and operators.

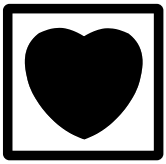
The choice to meet IEC 60601-1 is in no way to be interpreted to mean that a product:

- is a medical device,
- may be interpreted as a medical device, or
- is safe to be used as a medical device.

Safety Symbols

Devices manufactured by ADInstruments that are designed for direct connection to humans are tested to IEC 601-1:1998 (including amendments 1 and 2) and 60601-1-2, and carry one or more of the safety symbols below. These symbols appear next to those inputs and output connectors that can be directly connected to human subjects.

BF symbol: Body-protected equipment



CF symbol: Cardiac-protected equipment

Warning symbol: 'see documentation'

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.
- CF (cardiac protected) symbol. This means that the input connectors are suitable for connection to human subjects even when there is direct electrical connection to the heart.
- Warning symbol. The exclamation mark inside a triangle means that the supplied documentation must be consulted for operating, cautionary or safety information before using the device.

Further information is available on request.

Bio Amp Safety Instructions

The Bio Amp inputs displaying any of the safety symbols are electrically isolated from the mains supply in order to prevent current flow that may otherwise result in injury to the subject. Several points must be observed for safe operation of the Bio Amp:

- All Bio Amp front-ends (except for the ML138 Octal Bio Amp) and PowerLab units with a built-in Bio Amp are supplied with a 3-lead or 5-lead Bio Amp subject cable and lead wire system. The ML138 Octal Bio Amp is supplied with unshielded lead wires (1.8 m). Bio Amps are only safe for human connection if used with the supplied subject cable and lead wires.
- All Bio Amp front-ends and PowerLab units with a built-in Bio Amp are not defibrillator-protected. Using the Bio Amp to record signals during defibrillator discharges may damage the input stages of the amplifiers. This may result in a safety hazard.
- Never use damaged Bio Amp cables or leads. Damaged cables and leads must always be replaced before any connection to humans is made.

Isolated Stimulator Safety Instructions

The Isolated Stimulator outputs of a front-end signal conditioner or PowerLab with a built-in isolated stimulator are electrically isolated. However, they can produce pulses of up to 100 V at up to 20 mA. Injury can still occur from careless use of these devices. Several points must be observed for safe operation of the Isolated Stimulator:

- The Isolated Stimulator output must only be used with the supplied bar stimulus electrode.
- The Isolated Stimulator output must not be used with individual (physically separate) stimulating electrodes.
- Stimulation must not be applied across the chest or head.
- Do not hold one electrode in each hand.
- Always use a suitable electrode cream or gel and proper skin preparation to ensure a low-impedance electrode contact. Using electrodes without electrode cream can result in burns to the skin or discomfort for the subject.
- Subjects with implantable or external cardiac pacemakers, a cardiac condition, or a history of epileptic episodes must not be subject to electrical stimulation.
- Always commence stimulation at the lowest current setting and slowly increase the current.
- Stop stimulation if the subject experiences pain or discomfort.

- Do not use faulty cables, or those that have exhibited intermittent faults.
- Do not attempt to measure or record the Isolated Stimulator waveform while connected to a subject using a PowerLab input or any other piece of equipment that does not carry the appropriate safety symbol (see Safety Symbols above).

Always check the status indicator on the front panel. It will always flash green each time the stimulator delivers a current pulse. A yellow flash indicates an 'out-of-compliance' (OOC) condition that may be due to the electrode contact drying up. Always ensure that there is good electrode contact at all times. Electrodes that are left on a subject for some time need to be checked for dry contacts. An electrode impedance meter can be used for this task.

- Always be alert for any adverse physiological effects in the subject. At the first sign of a problem, stimulation must be stopped, either from the software or by flicking down the safety switch on the front panel of any built-in Isolated Stimulator or the ML180 Stimulus Isolator.
- The ML180 Stimulus Isolator is supplied with a special transformer plug pack. The plug pack complies with medical safety requirements. Therefore, under no circumstances should any other transformer be used with the Stimulus Isolator. For a replacement transformer plug pack please contact your nearest ADInstruments representative.

General Safety Instructions

To achieve the optimal degree of subject and operator safety, consideration should be given to the following guidelines when setting up a PowerLab system either as stand-alone equipment or when using PowerLab equipment in conjunction with other equipment. Failure to do so may compromise the inherent safety measures designed into PowerLab equipment. The following guidelines are based on principles outlined in the international safety standard IEC60601-1-1: *General requirements for safety - Collateral standard: Safety requirements for medical systems*. Reference to this standard is required when setting up a system for human connection.

PowerLab systems (and many other devices) require the connection of a personal computer for operation. This personal computer should be certified as complying with IEC60950 and should be located outside a 1.8 m radius from the subject (so that the subject cannot touch it while connected to the system). Within this 1.8 m radius, only equipment complying with IEC60601-1 should be present. Connecting a system in this way obviates the provision of additional safety measures and the measurement of leakage currents.

Accompanying documents for each piece of equipment in the system should be thoroughly examined prior to connection of the system.

While it is not possible to cover all arrangements of equipment in a system, some general guidelines for safe use of the equipment are presented below:

- Any electrical equipment which is located within the SUBJECT AREA should be approved to IEC60601-1.
- Only connect those parts of equipment that are marked as an APPLIED PART to the subject. APPLIED PARTS may be recognized by the BF or CF symbols which appear in the Safety Symbols section of these Safety Notes.
- Only CF-rated APPLIED PARTS must be used for direct cardiac connection.
- Never connect parts which are marked as an APPLIED PART to those which are not marked as APPLIED PARTS.
- Do not touch the subject to which the PowerLab (or its peripherals) is connected at the same time as making contact with parts of the PowerLab (or its peripherals) that are not intended for contact to the subject.
- Cleaning and sterilization of equipment should be performed in accordance with manufacturer's instructions. The isolation barrier may be compromised if manufacturer's cleaning instructions are not followed.
- The ambient environment (such as the temperature and relative humidity) of the system should be kept within the manufacturer's specified range or the isolation barrier may be compromised.
- The entry of liquids into equipment may also compromise the isolation barrier. If spillage occurs, the manufacturer of the affected equipment should be contacted before using the equipment.
- Many electrical systems (particularly those in metal enclosures)

depend upon the presence of a protective earth for electrical safety. This is generally provided from the power outlet through a power cord, but may also be supplied as a dedicated safety earth conductor. Power cords should never be modified so as to remove the earth connection. The integrity of the protective earth connection between each piece of equipment and the protective earth should be verified regularly by qualified personnel.

- Avoid using multiple portable socket-outlets (such as power boards) where possible as they provide an inherently less safe environment with respect to electrical hazards. Individual connection of each piece of equipment to fixed mains socket-outlets is the preferred means of connection.

If multiple portable socket outlets are used, they are subject to the following constraints:

- They shall not be placed on the floor.
- Additional multiple portable socket outlets or extension cords shall not be connected to the system.
- They shall only be used for supplying power to equipment which is intended to form part of the system.

Cleaning and Sterilization

ADInstruments products may be wiped down with a lint free cloth moistened with industrial methylated spirit. Refer to the Data Card supplied with transducers and accessories for specific cleaning and sterilizing instructions.

Preventative Inspection and Maintenance

PowerLab systems and ADInstruments front-ends are all maintenance-free and do not require periodic calibration or adjustment to ensure safe operation. 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.

Your PowerLab system can be periodically checked for basic safety by using an appropriate safety testing device. Tests such as earth leakage, earth bond, insulation resistance, subject leakage and auxiliary currents and power cable integrity can all be performed on the PowerLab system without having to remove the covers. 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 representative to arrange for the equipment to be checked and serviced. Do not attempt to service the device yourself.

Environment

Electronic components are susceptible to corrosive substances and atmospheres, and must be kept away from laboratory chemicals.

Storage Conditions

- Temperature 0–40 °C
- Non-condensing humidity in the range 0–95%.

Operating Conditions

- Temperature 0–35 °C
- Non-condensing humidity 0–90%.

Disposal

- Forward to recycling center or return to manufacturer.

CHAPTER 1

Overview

Your PowerLab recording unit, together with a range of specialized 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 /25 PowerLabs: the PowerLab 4/25 and PowerLab 4/25T.

Note that you need to have installed the software from the Software Installer CD before you connect the PowerLab to your computer.

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 appendices provide technical information about the recording unit, and solutions to problems. At the end of this guide is a glossary of hardware terms and an index.

The specifications and diagrams included in the appendices 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 authorized ADInstruments representative 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 analyzing data. Read them after you have connected the PowerLab to your computer.

The PowerLab System

The PowerLab system is an integrated system of hardware and software designed to record, display and analyze 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 /25 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 4/25 and 4/25T have four inputs for recording external signals.

First, Install the Software

Two main application programs and their documentation are provided with each PowerLab. The Chart application 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 provides summaries.

You must install the software to use your PowerLab. Full installation instructions are included in the *Getting Started with PowerLab* manual.

Next, 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 authorized ADInstruments representative 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 the appendices of one of the software user's guides for details), and from the ADInstruments website.

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 recognized 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 representative or from the ADInstruments website.

The PowerLab

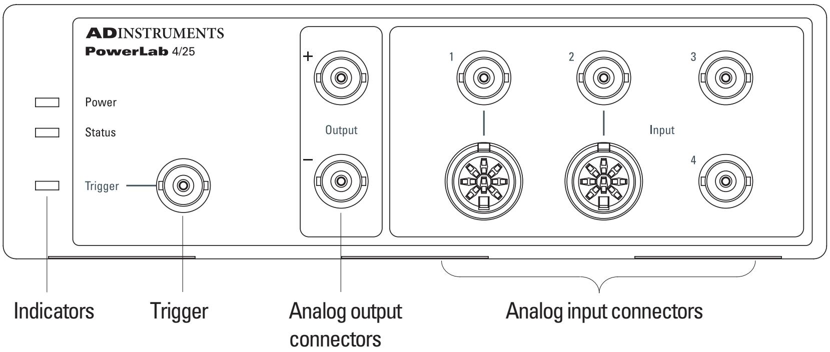
It is a good idea to get familiar with some of the external features of your PowerLab before connecting it to a power source. The rest of this chapter discusses the different features, connectors and indicators of the PowerLab 4/25 and PowerLab 4/25T.

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.

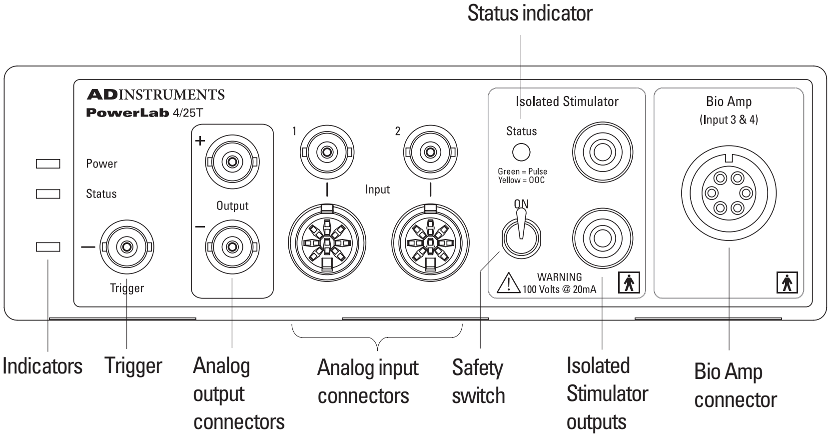
The PowerLab 4/25 has three indicators at the left of the front panel, one BNC connector for the external trigger, two BNC connectors for output and four BNC connectors (marked Input 1 to 4) with two alternative pod (DIN) connectors for Input 1 and 2, for recording external signals.

Figure 1–1
The front panel of the PowerLab 4/25



The PowerLab 4/25T 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 (Input 1 and 2) with two alternative pod (DIN) connectors, for recording external signals. It also has a safety switch, status light and two connectors for the Isolated Stimulator and a connector (Input 3 & 4) for the Bio Amplifiers.

Figure 1–2
The front panel of the PowerLab 4/25T



Indicators

All three labeled indicators on the front panel should turn on at least briefly when 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 colors depending on the state of the PowerLab.

Table 1–1
Status indicator states

Status Indicator	*Meaning*
Off	Idle and not yet initialized by the software.
Green	Idle, initialized, 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 4/25T has two independent analog inputs (marked Input 1 and 2), each of which has alternative connectors. The PowerLab 4/25 has four independent analog inputs (marked Input 1 to 4), the first two of which have alternative connectors. In either case, the top BNC connector for Input 1 and 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 labeled (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.

▲WARNING
PowerLab inputs and outputs are not electrically isolated (except for the Bio Amp input and Isolated Stimulator outputs on the PowerLab 4/25T). Human subjects must not be connected to the PowerLab outputs and inputs either directly or with uninsulated transducers. If such measurements are to be made, an electrically isolated ADInstruments front-end, insulated transducer or other approved electrically isolated device must be used

Analog Output

The PowerLab can generate a stimulus voltage through its analog output sockets (Output + and –), 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 synchronize 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 1.2 volts for the /25 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 Bio Amp Inputs (Inputs 3 and 4)

The PowerLab 4/25T also has one common connector for two Bio Amp inputs marked Bio Amp (Input 3 & 4). These biological amplifiers are needed to perform electrically isolated measurements of biological signals, such as electrocardiograms and electromyograms. The two Bio Amp inputs are internally configured to use Channels 3 and 4 of the PowerLab 4/25T.

The Bio Amps have a common six-pin connector with a shared ground signal. The PowerLab 4/25T is supplied with a 5-lead Bio Amp cable and lead wires for connection. These inputs should only be used with the supplied Bio Amp cable and approved leads. Other cables may not meet safety requirements.

Isolated Stimulator

The PowerLab 4/25T has a built-in, isolated, constant-current pulse stimulator that can be used for any general-purpose stimulation. The Isolated Stimulator section of the front panel has two output sockets, a Status indicator light and a safety switch. You can use either the analog output or the isolated stimulator, but not both at once.

The stimulus output is supplied via two 4 mm shrouded banana sockets; the top (red) socket is positive, the bottom (black) socket is negative. These are similar to the sockets found on many digital multimeters, and designed for use with shrouded male 4 mm plugs (the shrouding is to prevent accidental stimulation while fitting or removing the plugs). The bar stimulus electrode supplied with the PowerLab 4/25T uses such plugs. The output is capable of supplying 100 V pulses at currents up to 20 mA, so it should be treated with caution.

The Isolated Stimulator Status indicator is a multi-colored light that is used to indicate the current status or operating condition of the Stimulator. The indicator light will flash green for every stimulus pulse, and may seem to glow green constantly at higher stimulus frequencies. A yellow color indicates that the output is overloaded or out of compliance (compliance is the ability to supply voltage to meet the required current). This means that the impedance of the tissue being stimulated is too high, or there is a poor electrical connection (possibly due to electrode drying), and that the Isolated Stimulator can no longer supply constant current stimulation. If this should happen, try reducing the output current amplitude, and check all connections.

To provide an additional level of safety, a safety switch has been placed on the front panel to allow the output to be switched on and off as needed. The switch should be in the up position when the output is turned on, and should be flicked down to turn it off: that disconnects the output sockets from the internal circuitry, allowing connections to be made in safety while the PowerLab is on.

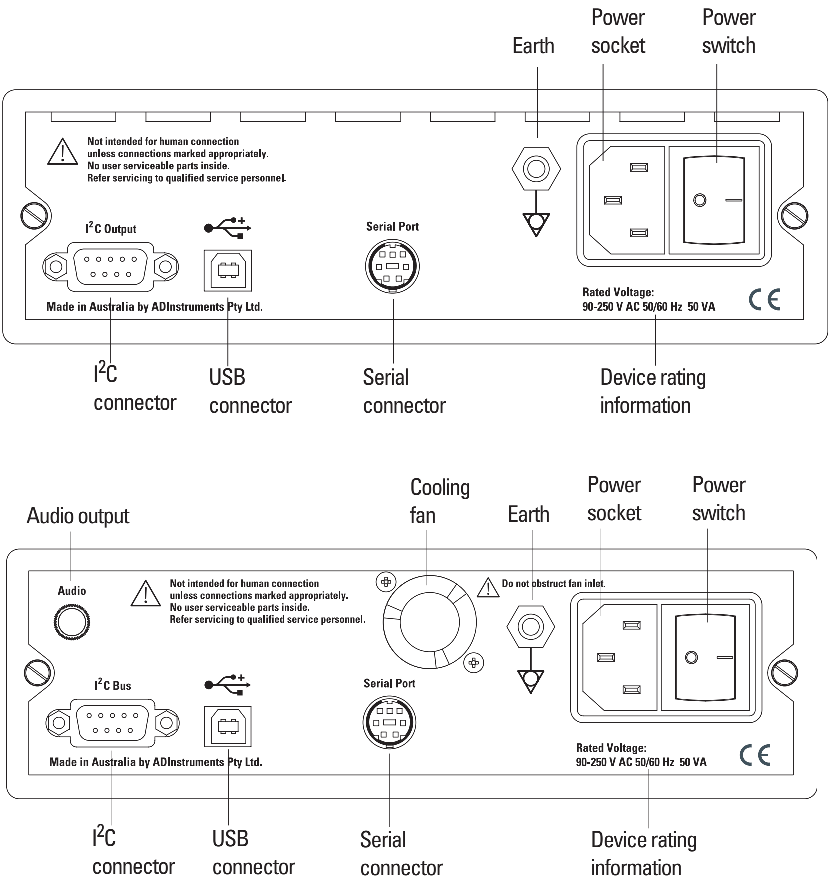
The Back Panel

The PowerLab back panel (Figure 1–3) 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.

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 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 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 1–3
The back panels of the PowerLab 4/25 (above) and the PowerLab 4/25T (below)



USB Port

The PowerLab connects to your computer using a USB (universal serial bus) port. This requires 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, Me, 2000 or XP. Note that the PowerLab is capable of sampling at rates of 200 kHz when connected to computers that support USB 2.0.

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 you do this, though. Read the details on USB in Appendix A 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 specialized devices controlled from the PowerLab system.

Earth 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 earth 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 earth 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.

Audio Out (for Bio Amp Channels)

The PowerLab 4/25T has an audio output to monitor the Bio Amp channels. It provides stereo sound (using signals from Inputs 3 and 4). The 3.5 mm stereo socket can be used with a wide range of headphones or externally powered speakers. The audio output is of particular use when monitoring nerve firings to control the placement of electrodes, for instance.

Power Connections

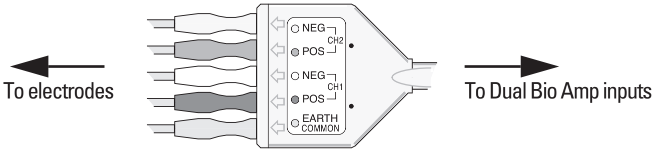
The power switch on the back right of the PowerLab turns the PowerLab on and off; the 3-pin IEC power socket is used to connect your PowerLab to a 3-pin earthed (grounded) power cable. The power supply is universal, and can use all common international mains power supplies (auto-switching, 90–250 V AC, 50/60 Hz).

The /25 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.

The Bio Amp Cable

Connections are made to the Bio Amp inputs using the supplied Bio Amp cable and leads. The cable plugs into the six-pin input socket on the front panel: a notch in the plug ensures that polarity is correct. Only the supplied Bio Amp cable and leads should be used. Other cables may not meet safety requirements. The PowerLab 4/25T is supplied with a 5-lead Bio Amp cable and lead wires; it uses a shared ground signal for its Bio Amp channels. The supplied cable is of the sort often used for ECG or EMG work, a Tronomed D-1540 cable, which has a cable yoke with five holes for the leads.

Figure 1–4
The Dual Bio Amp cable yoke, with 5 leads attached



The leads supplied are of the sort often used for ECG work. They click into place in the cable yoke, and have snap connectors at the other end to connect to typical ECG electrodes. The leads are color-coded for ease of identification. The labels on the Bio Amp cable also have color spots to help sort out which cables connect where and what they are measuring. (The colors are arbitrary, since the PowerLab system is for general-purpose recording, and 'standard' color assignments tend to change with the type of recording.)

ADInstruments supplies other types of lead that connect to the Bio Amp cable yoke, such as EEG/EMG leads and dry earth straps. Also available are disposable and reusable electrodes, electrode cream (for reusable electrodes), and abrasive pads, for lightly abrading the skin before the electrodes are attached.

Types of Measurement

The basics of measurement of various standard signals with the PowerLab 4/25T, in a series of step-by-step student experiments in electrophysiology, are detailed in the Teaching Experiments available from the ADInstruments Teaching Resources website; more are covered in standard electrophysiology texts. ADInstruments also produces materials describing specific uses of the Bio Amp inputs, such as Application Notes and Instructor's Notes that can be downloaded from the ADInstruments website or obtained from your ADInstruments representative.

Just as the built-in isolated stimulator can be used for many general stimulation tasks, the Bio Amp inputs can measure a wide variety of biological signal sources. Some of these measurements include:

ECG. Electrocardiogram (also referred to as EKG); a recording of surface potentials due to electrical currents associated with the heartbeat.

EEG. Electroencephalogram; a recording of the electrical activity of the brain. Scalp electrodes record potential waves (10–100 μV) representing the summed activity of cortical neurones.

EMG. Electromyography; a recording of the electrical activity of a muscle, using surface electrodes. The recorded activity may be a voluntary contraction, or evoked by motor nerve stimulation.

EOG. Electro-oculogram; a recording of the potential difference between the front and back of the eyeball, as projected on to the face.

ERG. Electroretinogram; a recording of the electrical signals produced in the retina by a light stimulus.

Cortical Evoked Potentials. Averaged recordings of the electrical activity of the brain when subject to stimulation: visual evoked response, auditory evoked response, and somatosensory response. These should be done with signal averaging, using Scope.

SNAP. Sensory nerve action potential; a recording of evoked responses in stimulated nerves. This is usually done with signal averaging, using Scope.

The built-in PowerLab 4/25T Bio Amps are unsuitable for work requiring high-impedance electrodes or using a high bandwidth. Such tasks include intracellular micropipette recordings, which are made from a very fine, electrolyte-filled tube inserted into a nerve or muscle cell, and require an electrometer amplifier; and needle electromyography, the intramuscular recording of the electrical activity of a muscle, which requires low input capacitance and a driven guard.

Recording Technique

Several problems can arise when using the Bio Amp inputs to record signals. These are basically problems of technique, and should be addressed before setting up. It is important to understand the types of problems that can occur, how they manifest, and what can be done to remove them or to minimize their effect. Potential problem areas include aliasing, frequency distortion, saturation, ground loops, electrode contact, motion artifacts, electromagnetic fields and data display.

There is a good introduction to data acquisition provided in the documentation for Chart and Scope. This information is also available in one of the Application Notes (AGB01 Basics of Data Acquisition) that can be downloaded from the ADInstruments website or obtained from your ADInstruments representative. It is highly recommended reading for anyone recording biological signals using the Bio Amps. Apart from the general areas covered in that material, two things particularly affect the kind of measurements made with Bio Amp inputs, and can cause ‘artifacts’ (spurious readings) in the recorded waveform: electrode contact and motion effects.

Electrode contact. Occasionally during measurement of a biological signal, one of the lead wires connecting the source to the front-end may become disconnected, or an electrode contact may become poor. If this should happen, relatively high voltages (potentials) can be induced in the open wire, owing to electric fields caused by the power line or other sources close to the front-end or to the subject. This induced potential results in a constant amplitude disturbance of the recorded waveform at the power line frequency, and loss of the desired signal. If the problem is a recurring one, one of the leads may be faulty. Check connections and replace faulty leads, if necessary.

Make sure that skin is cleaned and lightly abraded before attaching electrodes to it. Ensure that there is sufficient electrode cream to maintain a good contact: if it dries out, the contact will be poor, and the recorded signal may be degraded or lost.

Motion effects. A common source of artifacts when recording biological signals is motion of the subject or equipment. For example, muscular activity generates its own electrical signals, which may be recorded along with an ECG, say, depending on the location of the electrodes. If an electrode is not firmly attached, impedance (and hence the recorded signal) may vary as the contact area changes shape owing to movement. Movement of Bio Amp cables and leads, particularly bending or rubbing together (triboelectric effects) may generate artifacts in a signal.

Subject respiration can also generate a signal: breathing can result in a slowly changing baseline corresponding to inspiration and expiration. If the subject is liable to move during recording, then special care needs to be taken when attaching the electrodes and securing the leads.

CHAPTER 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.

The PowerLab 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 labeled 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 authorized ADInstruments representative 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.

Connecting the PowerLab using USB

Use the USB cable supplied with your PowerLab to connect the USB port on the back panel to the USB port on the computer, or to an active USB hub connected to the computer (see Figure 2–1). 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. Further detail about USB connections are provided on page 57 of Appendix A.

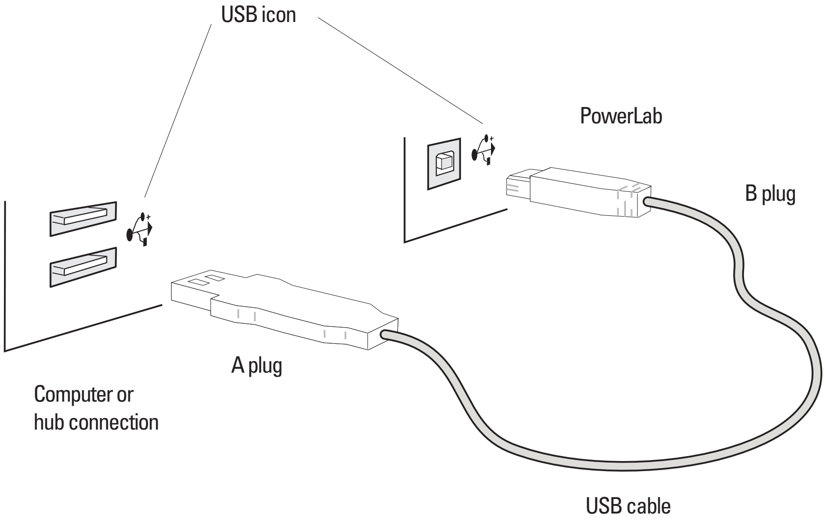
Connecting Macintosh or Windows computers should be much the same in this case: just look for the icons. If the connection is to a USB card installed in the computer, there might not be any icons on the card. The narrow rectangular sockets for the USB A plug are distinctive, though. Any USB icons on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

USB Connection Rules

1. *Cable length should be less than 5 meters (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 meters (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

Figure 2–1
Connecting a PowerLab to a computer with 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.)

CHAPTER 3

Using the Software

This chapter describes the Chart software features specific to the built-in Bio Amplifier and Isolated Stimulator front-ends of the PowerLab 4/25T. Software features for Windows and Macintosh computers are covered separately. Features for Scope are not described but are generally similar.

ADInstruments Front-ends

ADInstruments front-ends interact with the Powerlab and the application software to extend the capabilities of the PowerLab system.

In order for a front-end to be recognized by ADInstruments application software such as Chart and Scope, the appropriate front-end driver must be present. A driver is a piece of software the computer uses to drive a peripheral device. Front-end drivers are installed when ADInstruments applications are installed on the computer. To replace the drivers, you generally need to reinstall the ADInstruments software.

The PowerLab 4/25T has some front-ends built in: two Bio Amps and an Isolated Stimulator:

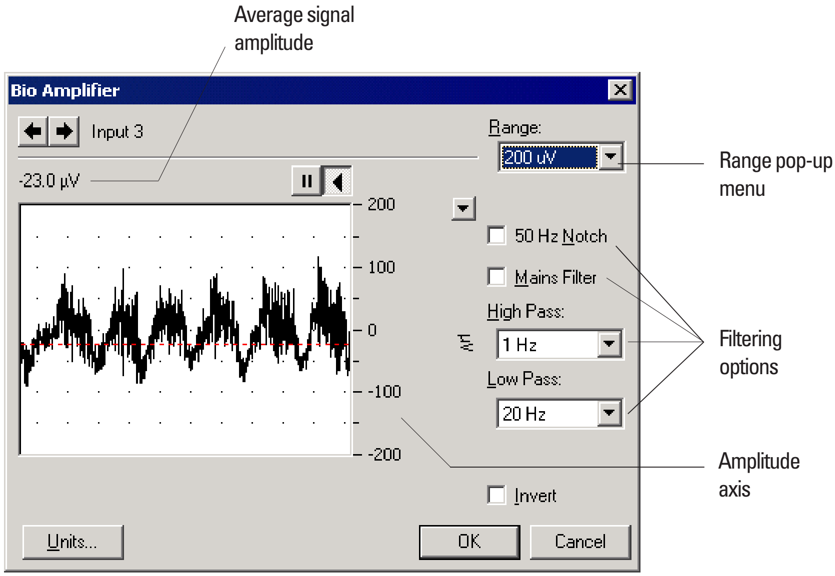
- The Bio Amp's amplification and filtering is combined with that of the PowerLab, and the standard Input Amplifier controls for Channels 3 and 4 in Chart are replaced by the Bio Amplifier controls.
- The PowerLab 4/25T has both normal and isolated outputs, and you can switch between them in software. When the isolated output is used, the functions of the Isolated Stimulator are combined with those of the PowerLab and the program, and the standard Stimulator controls in Chart are replaced by the Isolated Stimulator controls.

The documentation for Chart and Scope describes in detail the standard software features of those applications. However, features that are specific to the front-ends built into the PowerLab 4/25T, such as the Bio Amplifier and Isolated Stimulator controls, are described in detail in the following sections. Differences between Chart and Scope should be fairly obvious from perusing the user's guide for Scope. For the most part, dialogs and so on for the different application programs should be much the same.

The Bio Amplifier: Windows

The Bio Amplifier dialog appears when you choose the **Bio Amp**… command from a Channel Function pop-up menu (or click a **Bio Amp**… row in the Input Settings column in the Channel Settings dialog). The Bio Amplifier dialog allows software control of the combined input amplifiers and filters in the PowerLab and Bio Amp. The signal present at a channel's input is displayed so that you can see the effects of changes straight away.

Figure 3–1
The Bio Amplifier dialog for Windows



Once the settings in the dialog are changed, click **OK** to apply them.

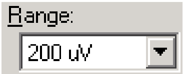
To set up many channels quickly, click the arrows below the dialog title, or press the right or left arrow keys on the keyboard, to move to the equivalent dialogs for adjacent channels. This skips channels that are off. The channel number is shown below the title of the dialog, and the channel title (if any) should be shown in the vertical Amplitude axis of the dialog.

Signal Display

The input signal is displayed so you can see the effect of changing the settings — no data are in fact recorded while setting things up. Slowly changing waveforms will be represented quite accurately, whereas quickly changing signals will be displayed as a solid dark area showing only the envelope (shape) of the signal formed by the minimum and maximum recorded values. The average signal value is shown at the top left of the display area.

You can stop the signal scrolling by clicking the Pause button at the top right of the data display area (it looks like the pause button on a CD player). Click the Scroll button beside it to start scrolling again (like the play button on a CD player). You can shift and stretch the vertical Amplitude axis to make the best use of the available display area. Apart from being at the right rather than the left, it is the same as the Amplitude axis in the Chart View, and the controls, such as the Scale pop-up menu, function identically. Changes made here are reflected in the Chart View.

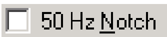
Setting the Range



The Range pop-up menu lets you select the input range or sensitivity of the channel — the combined range of the PowerLab and Bio Amp. Changing the range in the Bio Amplifier dialog is equivalent to changing it in the Chart View. The default setting (if you have not loaded settings files) is 50 mV rather than 10 V, and the ranges go down to 20 μV in 11 steps.

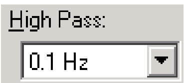
Filtering

Each of the Bio Amps in the PowerLab 4/25T has low-pass, high-pass and notch-filter circuitry that can be adjusted to suit the recording. The notch filter removes excessive mains-frequency interference. The high-pass and low-pass filters provide bandwidth limiting of low-frequency and high-frequency signals respectively; the settings for one filter type may restrict the possible settings for the other.

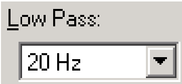


Notch filter. Click in the **Notch** checkbox to turn the notch filter on and off (it is on when checked). The notch filter is automatically set to either 50 or 60 Hz depending on the power line voltage frequency being used by the PowerLab (the mains frequency). It provides approximately 32 dB of attenuation, thus reducing the effect of the 50 or 60 Hz signals that can easily be picked up by long leads.

Mains Filter. Select the **Mains Filter** to turn on the Mains Filter. This is an adaptive filter and should only be used when the signal to mains noise ratio is less than 36 dB, and the mains frequency is varying over time — otherwise the notch filter will give better results. More details on the mains filter can be found in your *Chart User's Guide*.



High-Pass filtering. The **High Pass** pop-up menu gives the choice of four high-pass filters: **0.1**, **0.3**, **1** and **10** Hz. The high-pass filter allows high frequencies in the signal to pass, and removes frequency components below the filter frequency (including any DC signal). These filters are useful for removing slowly moving baselines, such as motion or respiration artifacts, particularly in ECG (EKG) recordings.



Low-Pass filtering. The **Low Pass** pop-up menu gives the choice of eight low-pass filters: **20**, **50**, **100**, **200** and **500** Hz, and **1**, **2** and **5** kHz. The low-pass filter allows low frequencies in the signal to pass, and removes frequency components above the filter frequency. These filters are useful for removing high-frequency signals, such as noise. However, Digital Filters available in Chart v4.2 or later provide more options and sharper cut-offs.

Inverting the Signal

Selecting **Invert** allows you to invert the signal on the screen. It provides a simple way to change the polarity of the recorded signal without having to swap the connections to the recording electrodes.

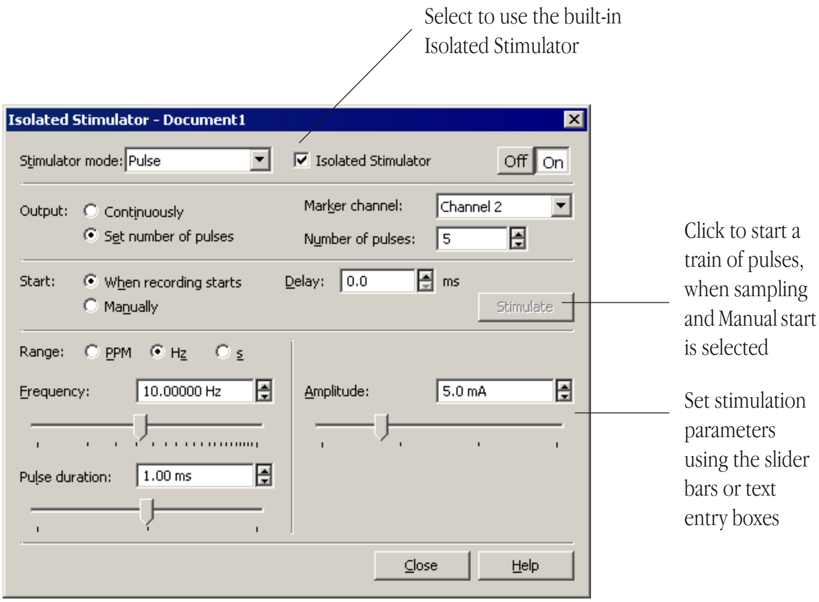
Units

Clicking the **Units**… opens the Units Conversion dialog, letting you specify the units for a channel, and, using waveform measurements, to calibrate the channel. A waveform in the data display area of the dialog is transferred to the data display area of the Units Conversion dialog. (Use the Pause button to capture a specific signal.) The units conversion only applies to subsequently recorded signals, so it is more limited than choosing units conversion directly, as it does not allow conversion of individual blocks of data.

The Isolated Stimulator: Windows

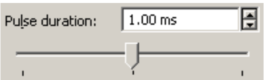
The Isolated Stimulator lets you generate a pulse or series of pulses, using the outputs on the front of the PowerLab 4/25T. To set it up, choose **Stimulator**… from the **Setup** menu and select the **Isolated Stimulator** checkbox in the Stimulator dialog that appears (Figure 3–2). To toggle between the Isolated Stimulator and Stimulator, just select or deselect the checkbox. The two stimulators use different outputs on the front panel of the PowerLab. The settings are independent of the sampling rate, but stimuli can only be generated while sampling. The Stimulator dialog is used both to set up stimulation, and to control and change it while sampling.

Figure 3–2
The Isolated Stimulator dialog for Windows

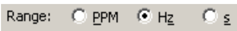


The Stimulator dialog can be moved around the screen or left in the background while the Chart View is active. By default, the stimulator is **Off**, **Pulse** is selected in the **Stimulator mode** drop-down list and the controls are active. The isolated stimulator can only stimulate in **Pulse** mode, although this may be **Continuously** or for a **Set number of pulses**. Each pulse is a rectangular stimulus that starts at zero current, is raised to the set current amplitude for the pulse duration, and then falls to zero current again

Setting the Controls

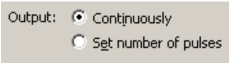


The slider bars are used to set values for the various stimulation parameters in the normal way, by dragging the sliding handles. The value is displayed in the text entry box above the slider bar. You can enter a value directly by typing in the text entry boxes.

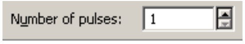


Select the Range **PPM**, **Hz** or **s** radio buttons to set the pulse frequency in pulses per minute, hertz or seconds respectively. The **Frequency** (or **Interval**, for the seconds range) controls are used to set the pulse frequency (or period between pulses) within these ranges, from **0.1** to **2000** Hz in the hertz range, from **1** to **200** pulses per minute in the PPM range (about 0.017 Hz to 3.3 Hz), and from **500** μs to **10** s in the seconds range.

The Pulse Duration controls set the time for which the pulse lasts. For safety reasons, duration is limited to from 10 μs to 2000 μs (0.01 ms to 2.00 ms). The Amplitude controls are used to set the exact amplitude of the stimulus current, from 0 to 20 mA.



If the **Continuously** radio button is selected, the stimulator will give a continuous train of pulses, starting when sampling starts. Stimulation stops when the **Off** button is clicked.

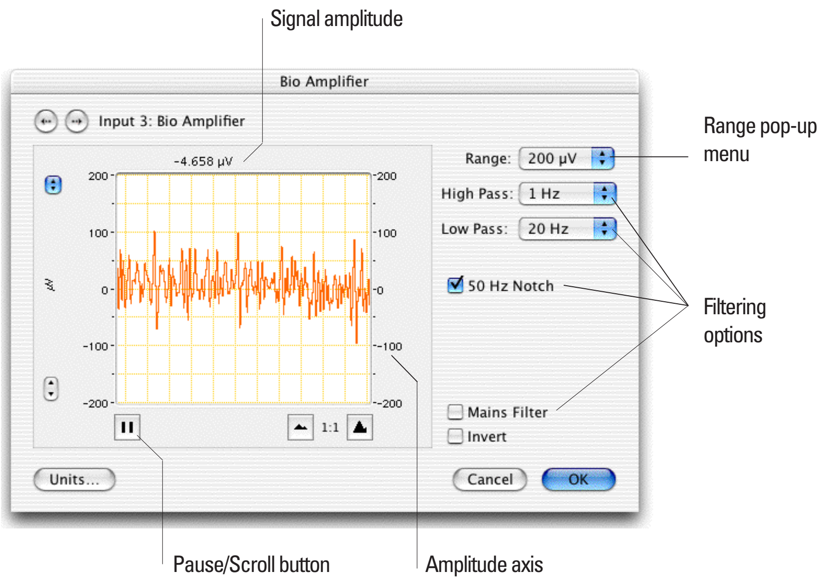


If the **Set number of pulses** radio button is selected, then the **Number of pulses** controls are enabled to its right, with which you can specify the number of pulses to be produced by the stimulator, from **1** to **2000**. Click the up or down arrows to increment or decrement the number, or type a value in the text box directly.

The Bio Amplifier: Macintosh

The Bio Amplifier dialog appears when you choose the **Bio Amplifier**… command from a Channel Function pop-up menu (or click a **Bio Amplifier**… row in the Input Settings column in the Channel Settings dialog). The Bio Amplifier dialog allows software control of the combined input amplifiers and filters in the PowerLab and Bio Amp. The signal present at a channel's input is displayed so that you can see the effects of changes straight away.

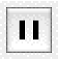
Figure 3–3
The Bio Amplifier dialog for Macintosh

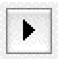


Once the settings in the dialog are changed, click the **OK** button to apply them. To set up many channels quickly, click the arrows by the dialog title, or press the right or left arrow keys on the keyboard, to move to the equivalent dialogs for adjacent channels. This skips channels that are turned off. The channel number is shown in the title of the dialog, and the channel title (if any) is shown in the vertical Amplitude axis of the dialog.

Signal Display

The input signal is displayed so you can see the effect of changing the settings — no data are in fact recorded while setting things up. Slowly changing waveforms will be represented quite accurately, whereas quickly changing signals will be displayed as a solid dark area showing only the envelope (shape) of the signal formed by the minimum and maximum recorded values. The average signal value is shown at the top left of the display area.





You can stop the signal scrolling by clicking the Pause button at the bottom left of the data display area (it looks like the pause button on a CD player). It then changes to the Scroll button (like the play button on a CD player): click it to start scrolling again. You can shift and stretch the vertical Amplitude axis to make the best use of the available display area. Apart from being at the right rather than the left, it is the same as the Amplitude axis in the main window, and the controls, such as the Scale pop-up menu, function identically. Changes made here are reflected in the Chart window.

Setting the Range

The Range pop-up menu lets you select the input range or sensitivity of the channel — the combined range of the PowerLab and Bio Amp. Changing the range in the Bio Amplifier dialog is equivalent to changing it in the Chart window. The default setting (if you have not loaded settings files) is 50 mV rather than 10 V, and the ranges go down to 20 μV in 11 steps.

Filtering

Each of the Bio Amps in the PowerLab 4/25T has low-pass, high-pass and notch-filter circuitry that can be adjusted to suit the recording. The notch filter removes excessive mains-frequency interference. The high-pass and low-pass filters provide bandwidth limiting of low-frequency and high-frequency signals respectively. Note that the settings for one filter type may restrict the possible settings for the other.

High-Pass filtering. The **High Pass** pop-up menu gives the choice of four high-pass filters: **0.1**, **0.3**, **1**, and **10** Hz. The high-pass filter allows high frequencies in the signal to pass, and removes frequency components below the filter frequency (including any DC signal). These filters are useful for removing slowly moving baselines, such as motion or respiration artifacts, particularly in ECG (EKG) recordings.

Low-Pass filtering. The **Low Pass** pop-up menu gives the choice of eight low-pass filters: **20**, **50**, **100**, **200** and **500** Hz, and **1**, **2**, and **5** kHz. The low-pass filter allows low frequencies in the signal to pass, and removes frequency components above the filter frequency. These filters are useful for removing high-frequency signals, such as noise, and to prevent aliasing in the recorded signal.

Notch filter. Click in the **Notch** checkbox to turn the notch filter on and off (it is on when checked). The notch filter is automatically set to either 50 or 60 Hz depending on the power line voltage frequency being used by the PowerLab (the mains frequency). It provides approximately 32 dB of attenuation, thus reducing the effect of the 50 or 60 Hz signals that can easily be picked up by long leads.

Mains Filter. Select **Mains Filter** to turn on the Mains Filter. This is an adaptive filter and should only be used when the signal to mains noise ratio is less than 36 dB, and the mains frequency is varying over time — otherwise the notch filter will give better results. More details on the mains filter can be found in your *Chart User's Guide*.

Inverting the Signal

Selecting **Invert** allows you to invert the signal on the screen. It provides a simple way to change the polarity of the recorded signal without having to swap the connections to the recording electrodes.

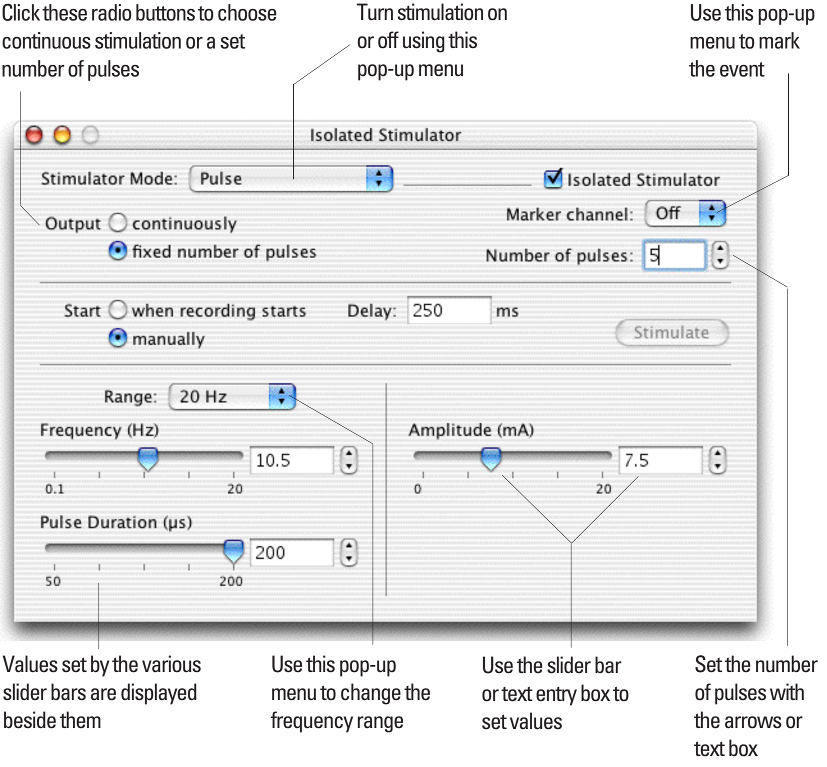
Units

Clicking **Units**… opens the Units Conversion dialog, letting you specify the units for a channel, and, using waveform measurements, to calibrate the channel. A waveform in the data display area of the dialog is transferred to the data display area of the Units Conversion dialog. (Use the Pause button to capture a specific signal.) The units conversion only applies to subsequently recorded signals, so it is more limited than choosing units conversion directly, as it does not allow conversion of individual blocks of data.

The Isolated Stimulator: Macintosh

The Isolated Stimulator lets you generate a pulse or series of pulses, using the outputs on the front of the PowerLab 4/25T. To set it up, choose **Isolated Stimulator** or **Stimulator** from the **Setup** menu (depending on the software version): the Isolated Stimulator or Stimulator window appears. Select or deselect **Isolated Stimulator** to toggle between the Isolated Stimulator and Stimulator windows. The two stimulators use different outputs on the front panel of the Powerlab.

Figure 3–4
The Isolated Stimulator window for Macintosh



The Isolated Stimulator window is a normal window with a close box and title bar, and can be moved around the screen or left in the background while the Chart window is active. By default, the stimulator is off: **Off** is selected in the Mode pop-up menu, and the controls are inactive. The isolated stimulator offers only one active stimulation mode, **Pulse**, in the **Mode** pop-up menu. The settings are independent of the sampling rate, but stimuli can only be generated while sampling.

(In this case, Scope is different to Chart: it has a dialog for the simulator rather than a window, and you can choose Pulse and **Multiple** in the **Mode** pop-up menu for single or multiple pulses.) Each pulse is a rectangular stimulus that starts at zero current, is raised to the set current amplitude for the pulse duration, and then falls to zero current again.

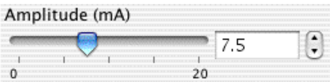
Marker Channel

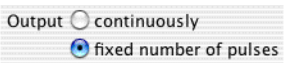
If you choose a channel from the **Marker channel** pop-up menu, then the point when a pulse stimulus starts is marked by a small data spike (this adds to any data in the channel). If you choose **Off**, no mark is added. The stimulus marker works at any sampling rate, up to a stimulus frequency of about 10 Hz.

Setting the Controls

The slider bars for various stimulation parameters can be used to set the value in the normal way, by dragging the sliding handle, or clicking or pressing the arrows or the slider bar area (click for a single increment, press to scroll). The selected value is displayed beside the slider bar. Alternatively, you can enter a value directly into the text entry box.

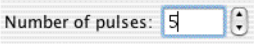
Figure 3–5
A typical slider bar





By default, the stimulator gives a continuous train of pulses, and the **continuously** radio button (near the top left of the window) will be on. In this case, stimulation starts when sampling starts. The Stimulator Panel miniwindow will have **Off** and **On** buttons, though, so you can use it to turn the continuous stimulation off or on at will. If the **fixed**

number of pulses radio button is selected, then the stimulator produces a set number of pulses. In this case, stimulation starts when the **Stimulate** button of the Stimulator Panel is clicked. The **Stimulate** button is only clickable once recording has started.



You can specify the **Number of pulses** that the stimulator is to produce, from **1** to **2000**, using the control. Click the up or down arrows to increment or decrement the number, or type a value in the text box directly.

The (frequency) **Range** pop-up menu lets you select the range for the Frequency control, from **2 Hz** or **20 Hz**. You can also choose **PPM** (pulses per minute), since it can sometimes be more convenient to have frequency stated in terms of minutes. The **Frequency** control is used to set the pulse frequency within these ranges, from 0.1 Hz to the maximum in each hertz range, and from 2 to 200 pulses per minute in the PPM range (about 0.033 Hz to 3.3 Hz). The **Pulse Duration** control sets the time for which the pulse lasts. For safety reasons, duration is limited to from 50 μs to 200 μs (0.05 ms to 0.2 ms). The Amplitude slider control is used to set the exact amplitude of the stimulus current, from 0 to 20 mA.

The Isolated Stimulator Panel

Once you have set up stimulation using the Isolated Stimulator window, you can easily start or stop stimulation or change settings while sampling, by using the Isolated Stimulator Panel miniwindow. Choose **Isolated Stimulator Panel** from the **Setup** menu to open it.

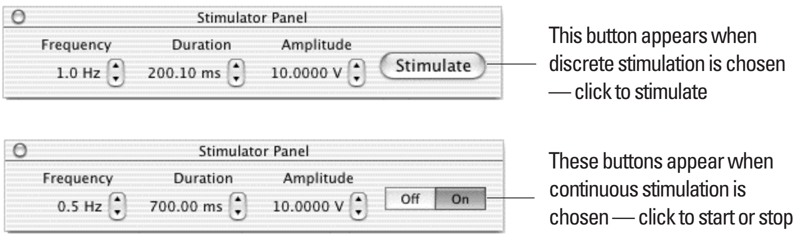


Figure 3–6
The Isolated Stimulator Panel miniwindow

The Isolated Stimulator Panel miniwindow 'floats' in front of the active window, can be moved around with its title bar, and can only be dismissed by clicking its close box. If continuous stimulation was chosen, then the Panel will have **Off** and **On** buttons, so you can turn stimulation off or on at will. If you have chosen discrete stimulation, then the Panel will have a **Stimulate** button: click it to deliver a set number of pulses.

Click the up or down arrows to increment or decrement the stimulus parameters during sampling — the currently measured value is shown beside the control.

APPENDIX

A Technical Aspects

This appendix describes some of the important technical aspects of the PowerLab 4/25 and PowerLab 4/25T, 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.

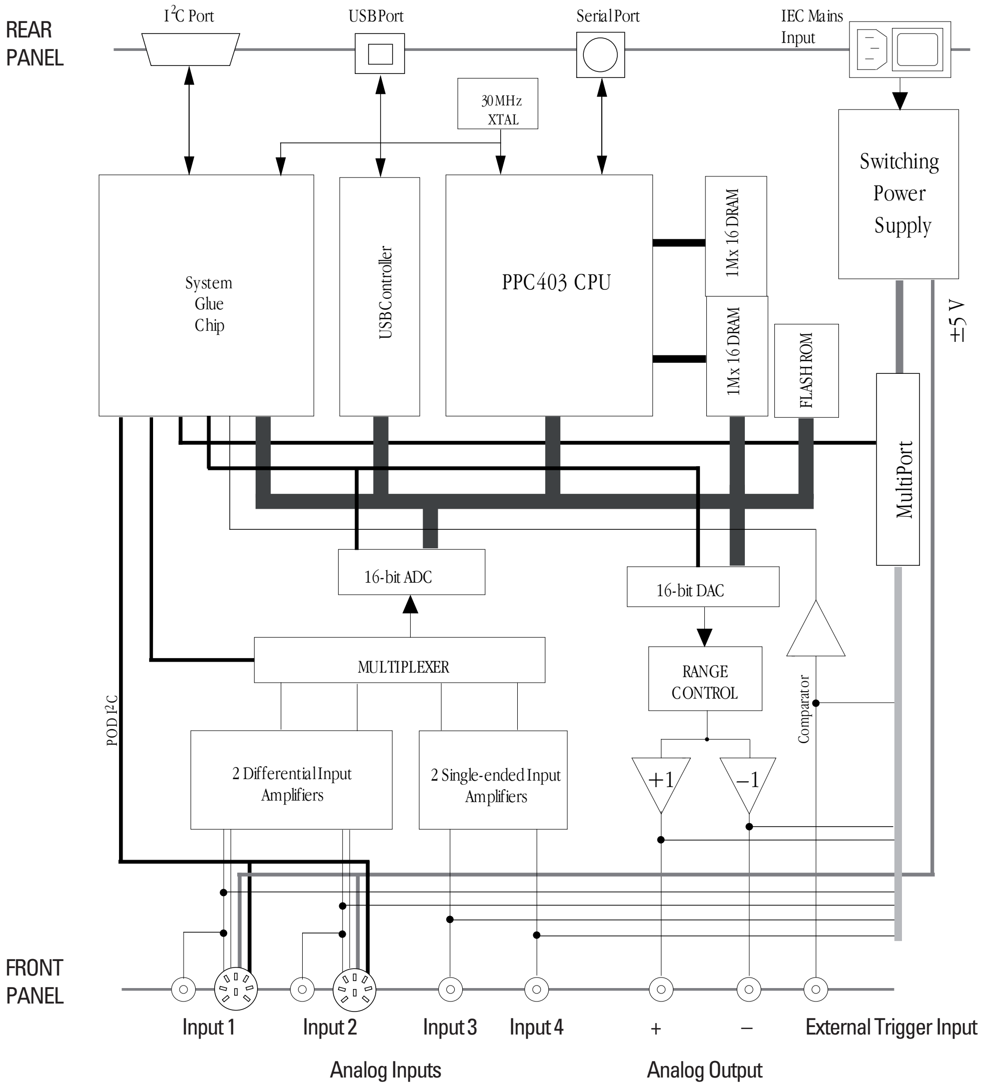
How Does it Work?

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 specialized 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 30 MHz. This microprocessor has access to 4 MB of internal dynamic RAM for data storage and buffering. The PowerLab uses USB 2.0 (universal serial bus) to communicate with the computer, if the computer is USB 2.0 compliant. This provides data transfer rates of up to 480 Mbits per second. If the computer supports USB 1.1 the data transfer rate will be slower.

The PowerLab 4/25 has four analog inputs, used to record external signals prior to digitizing. 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 200 000 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.

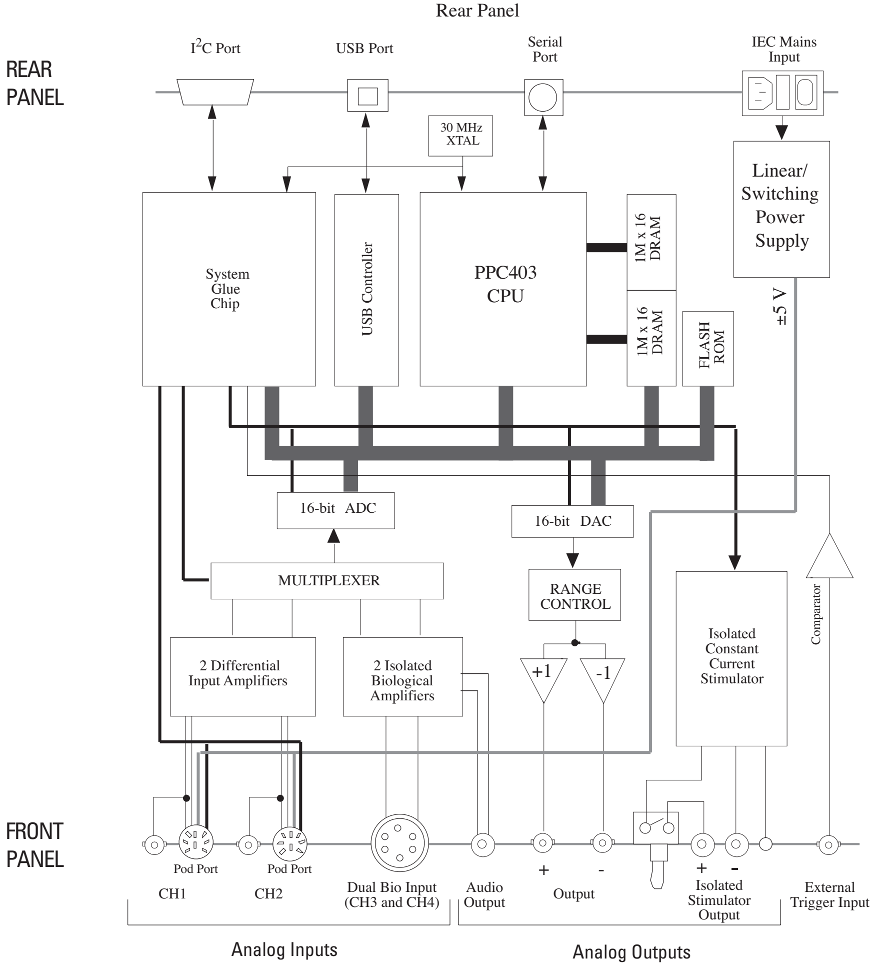
Figure A–1
Block diagram of the PowerLab 4/25



The external trigger input (marked ‘Trigger’ on the front panel) 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, a trigger event is registered when the voltage exceeds 1.2 V. The trigger input is 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 center pin and outer ring of the BNC. This can be achieved with an external relay contact, manual push-button or microswitch. The trigger input is not electrically isolated when set up for contact closure.

Figure A–2
Block diagram of the PowerLab 4/25T



▲***WARNING***

PowerLab inputs and outputs are not electrically isolated (except for the Bio Amp input and Isolated Stimulator outputs on the PowerLab 4/25T). Human subjects must not be connected to the PowerLab outputs and inputs either directly or with uninsulated transducers. If such measurements are to be made, an electrically isolated ADInstruments front-end, insulated transducer or other approved electrically isolated device must be used

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 100 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

▲***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 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 4/25 and PowerLab 4/25T 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 4/25 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.

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 25 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).

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

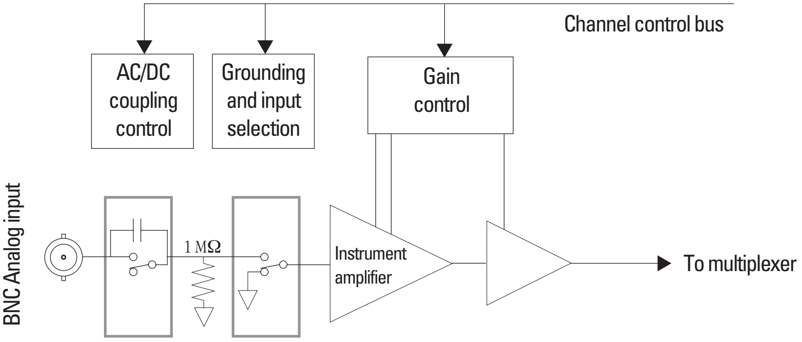
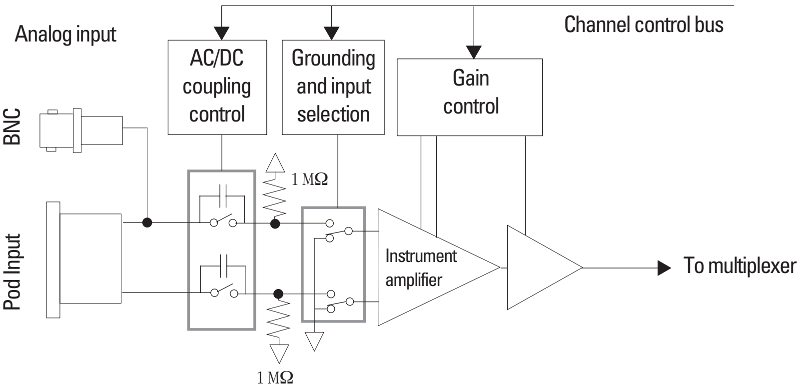


Figure A–4
Block/schematic diagram of the input amplifier circuitry for dual BNC and pod inputs



Bio Amp Inputs (Input 3 & 4)

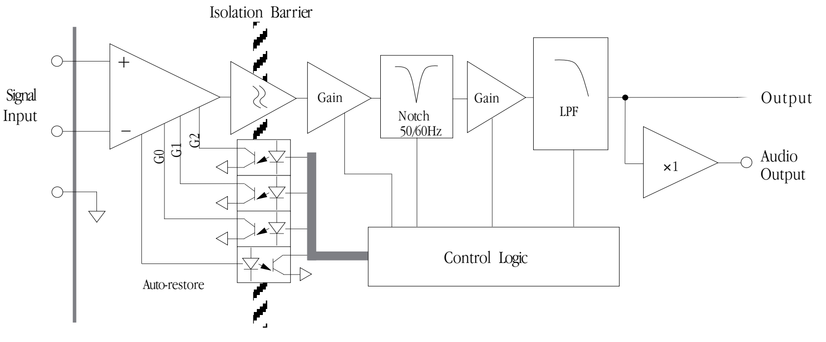
The PowerLab 4/25T has one common connector for two Bio Amp channels, marked Bio Amp (Inputs 3 & 4). These two independently controllable, electrically isolated, biological amplifiers are suitable for a range of basic physiological measurements. The two Bio Amp inputs are internally configured to use Channels 3 and 4 of the PowerLab 4/25T. The Bio Amps have a common six-pin connector with a shared ground signal.

Each amplifier consists of an electrically isolated, AC coupled, differential 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). The gain is controlled by optically isolated digital control signals from the non-isolated section. The signal is then applied to an isolation amplifier which provides electrical isolation of the input stage from the supply.

The non-isolated stage consists of a series of filters and amplifiers. The first part of the stage is a high-pass filter designed to remove any DC components from the signal and the isolated stage. This is followed by amplification and an active notch filter. The notch can be turned on or off under software control as needed. The frequency of the notch filter is automatically set to either 50 or 60 Hz to match the frequency of the connected power supply.

The low-pass filter is an eighth-order, switched-capacitance, Bessel-type filter, with a software-selectable range of frequencies. The output of the biological amplifier is then passed to the standard PowerLab input amplifier circuit. An amplifier connected to the output of the biological amplifier is used to provide an audio output facility that can be used with headphones or powered speakers.

Figure A–5
Block diagram of one of the two PowerLab 4/25T Bio Amplifiers (Input 3 & 4)



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

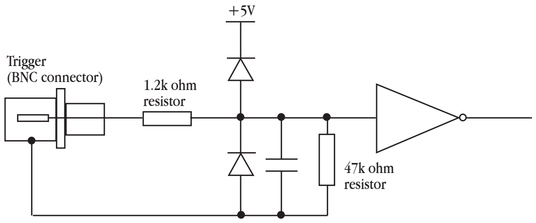
The external trigger input (marked 'Trigger' on the front panel) provides a digital input for synchronizing sampling to external devices. It allows either a voltage level or a contact closure to trigger recording. Note that for either mode the trigger signal must be present for at least 5 μs to register 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 1.2 V ± 0.5 V, with a hysteresis voltage of 0.5 V.

In order for the external trigger to work, a voltage must be applied between the outer ring and the inner pin of the connector. Applying a voltage just to the center pin may 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 shown in Figure A–6 and has two diode protection.

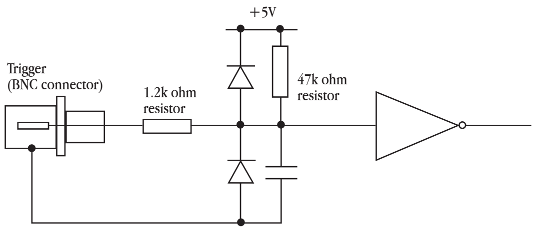
Figure A–6
The equivalent circuit of the external trigger input, when set up for a voltage level



In the external contact closure mode, the trigger input will respond to a direct short between the center 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.

The equivalent circuit for the external closure trigger is shown in Figure A–7. The BNC input connects to a TTL circuit via a resistor circuit and has two diode protection.

Figure A–7
The equivalent circuit of the external trigger input, when set up for contact closure

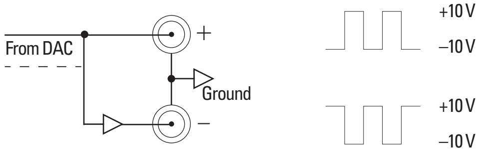


The Analog Output

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.

The outputs produce complementary (differential) stimulation. When the positive (+) output is used, a positive stimulus voltage (set up in

Figure A–8
The analog output stage, set up for a differential stimulus

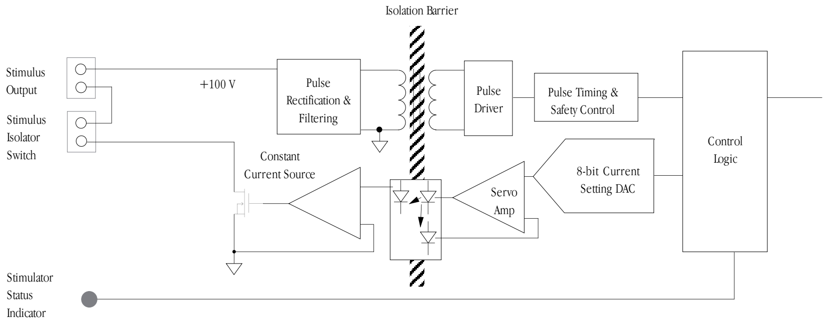


an application) gives a positive voltage output, and a negative voltage a negative one. When the negative (–) output is used, the voltage outputs are inverted. When both output sockets are used, the stimulus is the difference between the voltages at the positive and negative outputs: you could generate up to a 20-volt pulse, given a ±10 V stimulus.

The Isolated Stimulator Output

The Isolated Stimulator output provides a software-controlled, isolated, constant-current pulse stimulator that can be used for any general-purpose stimulation.

Figure A–9
Block diagram of the Isolated Stimulator



The output stage consists of a high-voltage, constant-current source that can produce pulses of variable duration and amplitude under full software control. The current source can deliver pulses up to 20 mA at 100 V maximum compliance levels; its amplitude is controlled by optically isolated digital control signals from the non-isolated section. The output to the subject is through high-isolation optical couplers.

Software and hardware safety features limit the energy delivered by the pulses to within international safety standards. The pulse duration of the stimulator can be set from 50 μs to 200 μs, and the pulse frequency can be adjusted between 1 pulse per minute and 20 pulses per second.

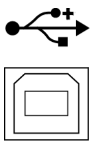
The Stimulator Status indicator is a multi-colored light on the front panel that indicates the status or operation of the Stimulator. The indicator light flashes green for each stimulus pulse, and may seem to glow green at high stimulus frequencies. A yellow color indicates that the output is overloaded or out of compliance (compliance is the ability to supply voltage to meet the required current).

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

Figure A–10
The USB connector



The PowerLab is fitted with a USB (universal serial bus) port, which is used to connect to a computer either 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, Me, 2000 or XP. The PowerLab is capable of sampling at 200 kHz when connected to a computer that supports USB 2.0.

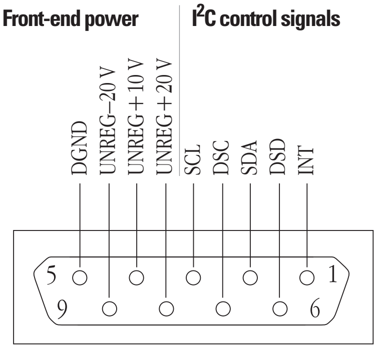
Your PowerLab is supplied with a proper high-speed USB cable. If you need additional USB cables, you should buy high-speed cables (fully shielded, twisted-pair, and with standard USB connections) for reliable results.

I^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 appropriate connections. 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.

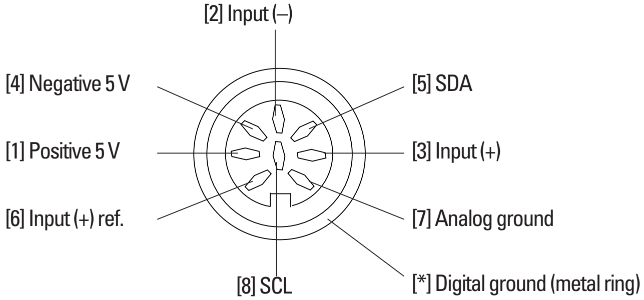
Figure A–11
The pin assignments for the I^2C port



Pod Connectors

The pod connectors on Inputs 1 and 2 of the PowerLab 4/25 and PowerLab 4/25T 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 labeled (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.

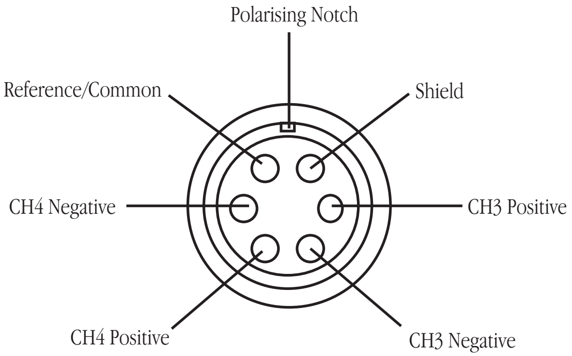
Figure A–12
The pin assignments for the pod connector



Bio Amp Input Connector

The PowerLab 4/25T also has one common connector for two Bio Amp channels, Channels 3 and 4. The biological amplifiers both have differential inputs, and have a common six-pin connector with a shared ground signal. The entire connector is physically and electrically isolated to ensure subject safety. The PowerLab 4/25T is supplied with a 5-lead Bio Amp cable and lead wires for connection. These inputs should only be used with the supplied Bio Amp cable and approved leads. Other cables may not meet safety requirements.

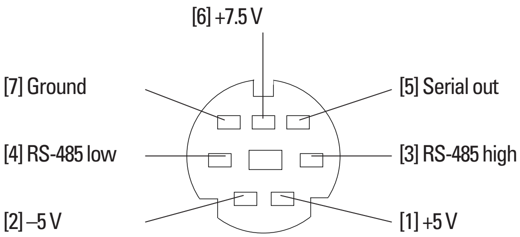
Figure A–13
The pin assignments for the Bio Amp input connector



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 specialized 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.

Figure A–14
The pin assignments for the serial connector

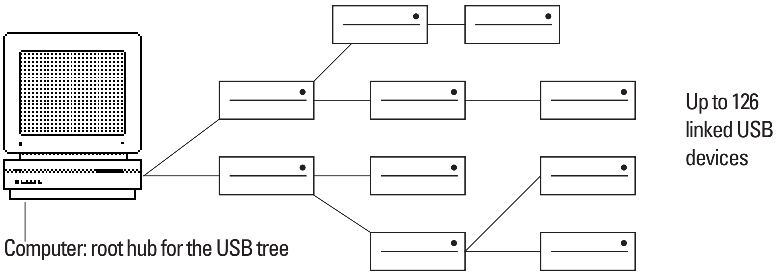


USB Connections

The PowerLab is fitted with a USB 2.0 (universal serial bus) port, which provides its means of connection to a computer. This allows high data transfer rates with USB 2.0-compliant computers, but also works with USB 1.1-compliant computers (with USB connectors or a PCI USB card). On a PC, Windows 98, Me, 2000 and XP all support USB 1.1 (but Windows 95 and NT 4 do not). On a Macintosh, USB needs a Power Macintosh with Mac OS 8.5 or later.

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 A–15
A USB tree: up to 126 devices can be linked to the computer



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 meters (16 feet) in length. Thus, no device can be more than 30 meters (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.

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 representative.

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

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). Refer to The PowerLab Self-test, p. 28.

- 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 representative.

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

▼***Refer***
The PowerLab Self-test, p. 28

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 representative.

When Windows starts up, it doesn't recognize the PowerLab

This is only likely to happen if PowerLab hardware is connected to the computer without first having installed the software. 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 either Software Installer CD and follow the wizard's instructions to complete the hardware installation.

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 2.0-compliant or USB 1.1-compliant PC with Windows 98, Me, 2000 or XP; 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.

APPENDIX

C Specifications

PowerLab 4/25 Specifications

Analog Inputs (Inputs 1 to 4)

Number of input channels: 4; 2 pod or differential (Inputs 1 & 2) and 2 single-ended (Inputs 3 & 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:

Range	Resolution
± 10 V	312.5 μV
± 5 V	156.25 μV
± 2 V	62.5 μV
± 1 V	31.25 μV
± 0.5 V	15.625 μV
± 0.2 V	6.25 μV
± 0.1 V	3.125 μV
± 50 mV	1.56 μV
± 20 mV	625 nV
± 10 mV	312.5 nV
± 5 mV	156.25 nV
± 2 mV6	2.5 nV

Maximum input voltage: ±15 volts

Input impedance: ~ 1 MΩ || 47 pF @ DC

Low-pass filtering: 25 kHz fixed second-order filter
Further digital filtering in software

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

Frequency response (–3 dB):	25 kHz @ ±10 V full scale, all gain ranges
DC drift:	Software-corrected
CMRR (differential):	96 dB @ 50 Hz (typical)
Channel crosstalk:	–80 dB typical
Input noise:	< 2.4 μV_{rms} referred to input

Pod Connectors

General features:	Combine power, I^2C and single-ended or differential analog input signals on one connector, support SmartPod 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:	±2 LSB (from 0 °C to 70 °C)
Maximum sampling rates:	200 kHz single channel 100 kHz /chan for 2 channels using Chart 40 kHz / chan for 4 channels using Chart
Available sampling rates:	200 kHz down to 0.2 Hz

Output Amplifier

Output configuration:	Complementary
Output resolution:	16 bits
Maximum output current:	100 mA (max)
Output impedance:	0.4 Ω typical

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 (software-selectable)

Range	Resolution
± 10 V	312.5 μV
± 5 V	156.25 μV
± 2 V	62.5 μV
± 1 V	31.25 μV
± 500 mV	15.625 μV
± 200 mV	6.25 μV

External Trigger

Trigger mode:	TTL Level (isolated) or contact closure (non-isolated), software selectable
Trigger threshold:	+1.2 V ±0.5 V (TTL compatible)
Hysteresis:	0.5 V
Input load:	1 TTL load
Maximum input voltage:	±12 V
Minimum event time:	5 μs

Microprocessor and Data Communication

CPU:	PPC403 GCX (30 MHz)
RAM:	4 MB DRAM
ROM:	2 Mbit FLASH ROM
Data communication:	Hi-speed USB 2.0 (max of 480 Mb/s transfer; compatible with USB 1.1 hosts)

Expansion Ports

I^2C expansion port:	Power and control bus for front-end units. Supports a number of front-ends equal to the number of PowerLab analog inputs. Interface communications rate of up to 10 Kbits/s.

Physical Configuration

Dimensions (w × h × d):	200 mm × 65 mm × 250 mm (7.9" × 2.6" × 9.8")
Weight:	~ 1.2 kg (dependent on power supply)

Operating Requirements

Operating voltage:	90–250 V AC 47–440 Hz
Maximum power needs:	50 VA (full complement of front-ends and pods)
Operating temperature range:	0–35 °C, 0–90 % humidity (non-condensing)

PowerLab 4/25T Specifications

Analog Inputs (Inputs 1 and 2)

Number of input channels: 2

Input configuration: Single-ended or differential (the latter only through the Pod connectors).

Amplification range: ±2 mV to ±10 V full scale in 12 steps

Range	Resolution
± 10 V	312.5 μV
± 5 V	156.25 μV
± 2 V	62.5 μV
± 1 V	31.25 μV
± 0.5 V	15.625 μV
± 0.2 V	6.25 μV
± 0.1 V	3.125 μV
± 50 mV	1.56 μV
± 20 mV	625 nV
± 10 mV	312.5 nV
± 5 mV	156.25 nV
± 2 mV	62.5 nV

Maximum input voltage:	±15 volts
Input impedance:	~ 1 MΩ || 47 pF @ DC
Low-pass filtering:	25 kHz fixed second-order filter. Further digital filtering in software
AC coupling:	DC or 0.1 Hz (software-selectable)
Frequency response (–3 dB):	25 kHz @ ±10 V full scale, all gain ranges
DC drift:	Software corrected
CMRR (differential):	96 dB @ 50 Hz (typical)
Channel crosstalk:	–80 dB typical

Input noise:	< 2.4 μVrms referred to input

Pod Connectors

General features:	Combine power, I^2C and single-ended or differential analog input signals on one connector, support SmartPod transducers, etc.
Supply voltage:	±5V 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

Bio Amp Inputs (Inputs 3 & 4)

Number of input channels:	2
Input configuration:	differential with common isolated ground
Amplification range:	±20 μV to ±50 mV full scale in 11 steps

Range	Resolution
± 50 mV	1.56 μV
± 20 mV	0.78 μV
± 10 mV	312 nV
± 5 mV	156 nV
± 2 mV	62.5 nV
± 1 mV	31.25 nV
± 500 μV	15.6 nV
± 200 μV	6.25 nV
± 100 μV	3.125 nV
± 50 μV	1.56 nV
± 20 μV	0.625 nV

Gain accuracy:	± 1 % all ranges
Non linearity:	< 1 % of full scale (better for ranges under 1 mV)
Noise levels:	<2.4 μV rms (0.1 Hz to 5 kHz bandwidth) <1.5 μV rms (0.1 Hz to 50 Hz bandwidth)
Maximum input voltage:	±10 volts
Input leakage current:	< 6 μA rms @ 240 V, 50 Hz < 4 μA rms @ 120 V, 60 Hz

DC blocking	± 0.5 V
Baseline restoration:	Automatic
Input impedance:	~ 100 MΩ to isolated ground (~200 pF per lead) using supplied Bio Amp subject cable and lead wires
Safety:	Approved to IEC601-1 BF (body protected) standard. Also approved to requirements of AS3200.1
Isolation rating:	4000 V ACrms for 1 minute
IMRR:	> 130 dB (@50 to 100 Hz)
CMRR:	> 75 dB (DC to 100 Hz) > 60 dB (@ 1 kHz)
Low-pass filtering:	8th order Bessel-type low pass filters (linear time delay). Frequencies are software selectable at 20, 50, 100, 200, and 500 Hz and 1,2, and 5 kHz. Frequency accuracy is ±2 %
High-pass filtering	Single pole 0.1, 0.3, 1 and 10 Hz (-3 dB) with an accuracy of ±10 %.
Notch filtering:	50 or 60 Hz notch filter, automatically selected to match mains frequency.
Audio output:	Stereo output socket supplying an analog audio signal from both bio amp channels. Suitable for earphones, headphones and most externally powered speakers. Output is 100 mV at full scale for any input range.

Sampling

ADC resolution:	16 bit
Linearity error:	±2 LSB (from 0 °C to 70 °C)
Maximum sampling rates:	200 kHz single channel 100 kHz/chan for 2 channels using Chart 40 kHz/chan for 4 channels using Chart
Available sampling rates:	200 kHz Hz down to 0.2 Hz

Isolated Stimulator Output

Output configuration:	Constant-current stimulator with hardware limited repetition rate
Isolation rating:	4000 Vrms to ground as per IEC601-1 2000 Vrms (60 seconds) to Bio Amp inputs
Pulse duration:	50–200 μs (software selectable)
Compliance voltage:	100–110 V typical
Output current:	0–20 mA in 0.1 mA steps (software adjustable)
Pulse rate:	Software-selectable, but hardware limited to a maximum of 20 Hz for safety
Safety indicators:	A single multi-color indicator displays the status. A green flash indicates delivery of a valid stimulus. A yellow flash indicates an out-of-compliance condition.
Safety switch:	Provides physical disconnection of the stimulator from the subject.

Output Amplifier

Output configuration:	Complementary
Output resolution:	16 bits
Maximum output current:	100 mA (max)
Output impedance:	0.4 Ω typical
Settling time:	2 μs (to 0.01% of FSR for LSB change)
Linearity error:	±1 LSB (from 0 °C to 70 °C)
Output range:	±200 mV to ±10 V (software-selectable)

Range	Resolution
± 10 V	312.5 μV
± 5 V	156.25 μV
± 2 V	62.5 μV
± 1 V	31.25 μV
± 500 mV	15.625 μV
± 200 mV	6.25 μV

External Trigger

Trigger mode:	TTL Level (isolated) or contact closure (non isolated), software selectable
Trigger threshold:	+1.2 V ±0.5 V (TTL compatible)
Hysteresis:	0.5 V
Input load:	1 TTL load
Maximum input voltage:	±12 V
Minimum event time:	5 μs

Microprocessor and Data Communication

CPU:	PPC403 GCX (30 Mhz)
RAM:	4 MB DRAM
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Data communication:	Hi-speed USB 2.0 (max of 480 Mb/sec transfer; compatible with USB 1.1 hosts

Expansion Ports

I^2C expansion port:	Power and control bus for front-end units. Supports a number of front-ends equal to the number of PowerLab analog inputs. Interface communications rate of up to 10 Kbits/s.

Physical Configuration

Dimensions (w x h x d):	200 mm x 65 mm x 250 mm (7.9" x 2.6" x 9.8")
Weight:	~1.2 kg dependent on type of power supply

Operating Requirements

Operating voltage:	95–250 V AC 47–440 Hz
Maximum power needs:	50 VA (full complement of front-ends and pods)
Operating temperature:	0–35 °C, 0–90% 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 analyze 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.

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 /25 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 specialized work. Front-ends are recognized 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 is 200 kHz for /25 PowerLabs if the computer is USB 2.0 compliant and 200 kHz for SP and ST PowerLabs using SCSI.

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 cut-off, 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, attenuating frequencies above a certain value (the cut-off, or –3 dB, frequency).

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

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 4/25 and PowerLab 4/25T). 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.

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 /25 PowerLabs.

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

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).

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

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