Dual Bio Amp/ Stimulator
Owner’s Guide
This document was, as far as possible, accurate at the time of release. However, changes may have been made to the software and hardware it describes since then. ADInstruments Pty Ltd reserves the right to alter specifications as required. Late-breaking information may be supplied separately.

**Trademarks of ADInstruments**

PowerLab®, LabTutor® and MacLab® are registered trademarks of ADInstruments Pty Ltd. The names of specific recording units, such as PowerLab 8/30, are trademarks of ADInstruments Pty Ltd. LabChart, Chart and Scope (application programs) are trademarks of ADInstruments Pty Ltd.

**Other Trademarks**

Apple, Mac and Macintosh are registered trademarks of Apple Computer, Inc.

Windows, Windows XP and Windows Vista are either registered trademarks or trademarks of Microsoft Corporation.

All other trademarks are the property of their respective owners.

Product: ML408 Dual Bio Amp/Stimulator

Document Number: U-ML408-OG-003B
Part Number: 4391

Copyright © February 2008 ADInstruments Pty Ltd.
Unit 13, 22 Lexington Drive, Bella Vista, NSW 2153, Australia

All rights reserved. No part of this document may be reproduced by any means without the prior written permission of ADInstruments Pty Ltd.

Web: www.adinstruments.com
Technical Support: support.au@adinstruments.com
Documentation: documentation@adinstruments.com
**Contents**

### Safety Notes

### 1 Overview

- How to Use This Guide ................................................. 14
- Checking the Front-end ............................................... 14
- Front-end Fundamentals ............................................. 14
- The Front-end .......................................................... 15
  - The Front Panel ..................................................... 16
    - Dual Bio Amp ..................................................... 16
    - Audio Out .......................................................... 17
    - Isolated Stimulator ............................................. 17
  - The Back Panel ...................................................... 18
    - I²C Input and Output Sockets ................................. 18
    - Analog Out Sockets ............................................. 18
    - Signal Input Socket ............................................ 19
- The Bio Amp Cable .................................................... 19
- Types of Measurement ............................................... 20
- Recording Technique ................................................ 21

### 2 Setting Up

- Connecting to the PowerLab ........................................ 24
- Using ADInstruments Programs .................................... 26
  - The Front-end Driver ............................................. 26
  - The Dual Bio Amp / Stimulator Self-test ....................... 26
  - Software Behavior ................................................ 27
- The Bio Amp .......................................................... 27
  - Signal Display ..................................................... 27
  - Setting the Range .................................................. 29
  - Filtering ............................................................. 29
  - Inverting the Signal .............................................. 30
  - Units ................................................................. 30
- The Isolated Stimulator .............................................. 31
  - Marker Channel ..................................................... 32
  - Setting the Controls ............................................. 32
  - Number of Pulses .................................................. 32
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.

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 manufacturer’s guidelines or 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 in the range 0–40 °C
- Non-condensing humidity in the range 0–95%.

**Operating Conditions**

- Temperature in the range 5–35 °C
- Non-condensing humidity in the range 0–90%.

**Disposal**

- Forward to recycling center or return to manufacturer.
The Dual Bio Amp/Stimulator is a modular device, in a family called front-ends, designed to extend the capabilities of the PowerLab® system. The Dual Bio Amp/Stimulator allows the PowerLab system to record biological signals, such as ECGs (EKGs) and EMGs, from humans and other sources, with full electrical isolation, and can also be used for any general-purpose stimulation work. This chapter provides an overview of the front-end, describing its basic features, and discusses the Bio Amp cable and the measurement of signals.
How to Use This Guide

This owner’s guide describes how to set up and begin using your Dual Bio Amp/Stimulator. The chapters give an overview of front-ends in general and the Dual Bio Amp/Stimulator in particular, and discuss how to connect the hardware, perform a simple power-up test, and use the front-end with some ADInstruments programs. The appendices provide technical information about the front-end, and take a look at some potential problems and their solutions.

At the end of this guide, you’ll find an index. Technical terms that are not defined in the glossary of terms included with the owner’s guide for your PowerLab are defined as they appear.

Checking the Front-end

Before connecting the Dual Bio Amp/Stimulator to anything, check it carefully for signs of physical damage.

1. Check that there are no obvious signs of damage to the outside of the front-end casing.
2. Check that there is no obvious sign of internal damage, such as rattling. Pick up the front-end, tilt it gently from side to side, and listen for anything that appears to be loose.

If you have found a problem, contact your authorized ADInstruments representative immediately, and describe the problem. Arrangements can be made to replace or repair the front-end.

Front-end Fundamentals

The PowerLab system consists of a recording unit and application programs that run on the computer to which the unit is connected. It is an integrated system of hardware and software designed to record, display, and analyze experimental data. Your Dual Bio Amp/Stimulator is one of a family of front-ends meant for use with your PowerLab system.

Front-ends are ancillary devices connected to the PowerLab recording unit to extend the system’s capabilities. They provide additional signal conditioning and other features, and extend the types of experiments that you can conduct and the data you can record.
All ADInstruments front-ends are designed to be operated under full software control. No knobs, dials, or switches are needed, although some may be provided for reasons of convenience or safety.

The PowerLab controls front-ends through an expansion connector called the I²C (eye-squared-sea) bus. Each new front-end added to the system connects to the back of the previous front-end, in a simple daisy-chain structure. (The three front-ends of the Dual Bio Amp/Stimulator are internally connected.) This makes it very easy to add front-ends to the system or to transfer them between PowerLabs. In general, each front-end requires a positive analog input channel of the PowerLab, although the Isolated Stimulator and similar front-ends use the positive analog output of the PowerLab.

Front-ends are automatically recognized by the PowerLab system. Any front-end feature such as gain or filtering is combined with the appropriate features of the program and presented as a single set of software controls. This seamless integration of front-ends greatly increases the flexibility and ease of use of the PowerLab system.

The Front-end

The Dual Bio Amp/Stimulator provides three front-ends in one useful package: the two Bio Amps (with a shared ground isolated connection and input socket) for electrically isolated measurements of biological signals, and the Isolated Stimulator for any general-purpose stimulation work. The front-end is designed to let the PowerLab system conveniently perform both stimulation of human or other sources, and isolated measurements of biological signals from them (such as ECGs (EKGs), EMGs, and EEGs). Note that signal degradation can be expected if multiple Bio Amps are connected to a single subject.

The rest of this chapter contains general information about the features, connections, and indicators of the Dual Bio Amp/Stimulator, the Bio Amp cable and signal measurement. More detailed information can be found in the technical appendices.
**The Front Panel**

The front panel of a Dual Bio Amp/Stimulator has two separate sections. The Dual Bio Amp section has a common input connector and two Status indicators, one for each Bio Amp input. The Isolated Stimulator section has two output connectors, a Status indicator, and a safety switch. The front panel also has an audio output.

**Figure 1–1**
The front panel of the Dual Bio Amp/Stimulator

---

**Dual Bio Amp**

The Dual Bio Amp/Stimulator also has one common connector for two Bio Amp inputs (marked Bio Amp Input 1 & 2). These biological amplifiers are needed to perform electrically isolated measurements of biological signals, such as electrocardiograms and electromyograms. The Bio Amps have a common six-pin connector with a shared ground signal. The socket is of a sort commonly used with ECG-type cables and leads, such as the Bio Amp cable and leads with which your front-end is supplied (Tronomed D-1540). These inputs should only be used with the supplied Bio Amp cable and leads. Other cables may not meet safety requirements. The socket and connections to it are discussed in more detail later on.

The indicator lights of the Dual Bio Amp are located beneath the input connector on the front panel. When an ADInstruments program such as LabChart starts up, the indicator lights should flash briefly and then remain green, indicating that the program has found the front-end, checked and selected it, and is ready to use it. If an indicator does not turn on and stay on when the program is run, this indicates either that the front-end is not connected properly or that there is a software or hardware problem.
Audio Out

The Dual Bio Amp/Stimulator has an Audio Out socket on the front panel, with which you can monitor the Bio Amp inputs. It can be used with a wide range of headphones or externally powered speakers. The 3.5 mm stereo socket provides two channels of sound, one for each data channel. The audio output may be of use when monitoring nerve firings to control the placement of electrodes, for instance.

Isolated Stimulator

The Dual Bio Amp/Stimulator 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.

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 front-end 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, reduce the output current amplitude and check 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 front-end is on.
The Back Panel

The back panel of the Dual Bio Amp/Stimulator provides all the sockets required to connect the front-end to the PowerLab and to other front-ends.

![Diagram of the back panel of the Dual Bio Amp/Stimulator]

**I^2C Input and Output Sockets**

Two nine-pin sockets are used to communicate with the PowerLab (they are marked \(\text{I}^2\text{C Bus}\): a ‘bus’ is simply information-transmission circuitry such as cables and connectors). These sockets allow multiple front-ends to be used independently with one PowerLab. Power and control signals to the front-ends come from the PowerLab. Many front-ends can be connected to the system, in series, output to input, providing there is the same number of channel inputs available on the PowerLab (this is discussed in more detail in the next chapter).

The Dual Bio Amp/Stimulator acts as if it were two Bio Amps and a Stimulus Isolator in series, with internal \(\text{I}^2\text{C}\) connections between the separate front-ends.

**Analog Out Sockets**

BNC sockets on the back panel of the Dual Bio Amp/Stimulator provide the signal outputs to connect to the analog input sockets on the front of the PowerLab. The sockets are labelled Output 1 and Output 2. You don’t have to match the channel numbers when connecting everything up, but it may help to prevent confusion if you do. A BNC-to-BNC cable is supplied for each connection.
If you are using a PowerLab with differential inputs, remember to connect the cable only to a positive analog input. ADInstruments applications will not find a front-end on starting up if a negative input is used.

**Signal Input Socket**

A BNC connector labelled Signal Input on the back panel of the Dual Bio Amp/Stimulator is used to connect the Isolated Stimulator in the front-end to the positive analog output on the front of the PowerLab. The positive output is labelled + on most PowerLabs and Output 1 on /30 series PowerLabs. A BNC-to-BNC cable is supplied for this connection. The PowerLab output is used to provide the trigger pulses for the Stimulator and to establish timing, as well as to check that the Stimulator is connected.

ADInstruments applications will not find the Stimulator on starting up if the negative output of the PowerLab is used.

**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 Dual Bio Amp/Stimulator 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.
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.)

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**

Standard electrophysiology texts describe various standard signals and how to measure them. ADInstruments also produces materials describing specific uses of Bio Amps, such as Application Notes that can be downloaded from the ADInstruments website or obtained from your ADInstruments representative. A series of step-by-step student experiments in electrophysiology that can be performed using one or two Bio Amps and an Isolated Stimulator is covered in the Physiology Experiments Manual. This is supplied with particular PowerLab teaching systems, or can be purchased separately 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 Bio Amp inputs 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 LabChart and Scope. 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.
This chapter describes connecting the Dual Bio Amp/Stimulator to your PowerLab and performing a quick test to make sure that it is working properly. The best way to configure your system for one or more front-ends is discussed, along with how to use the front-end with ADInstruments application programs.
Connecting to the PowerLab

To connect a front-end, such as your Dual Bio Amp/Stimulator, to the PowerLab, first ensure that the PowerLab is turned off. Failure to do this may damage the PowerLab, the front-end, or both.

The BNC cables from the Dual Bio Amp analog outputs must connect to positive analog inputs of the PowerLab, if the PowerLab has differential (rather than single-ended) inputs. ADInstruments applications will not find the front-end on starting up if a negative input is used. The BNC cable from the Stimulator analog input must connect to positive analog output of the PowerLab. The positive output is labelled + on most PowerLabs and Output 1 on /30 series PowerLabs. ADInstruments applications will not find the Stimulator on starting up if the negative output is used.

Connect the I²C output of the PowerLab to the I²C input of the front-end using the I²C cable provided. Figure 2–1 shows how to connect up a Dual Bio Amp/Stimulator to your recording unit.

Note that the Dual Bio Amp/Stimulator acts just as if it were two individual Bio Amps and a Stimulus Isolator. Its I²C connections are internal, though, so there is only one I²C cable needed to connect the front-end to the PowerLab. Three BNC cables are still used.

Check that the plugs for the I²C bus are screwed in firmly. Check the BNC cables for firm connections as well.
Loose connectors can cause erratic front-end behavior, or may cause the front-end to fail to work at all. The BNC cables can be tucked under the front-end to keep them out of the way if desired. You do not have to connect all the front-ends if you do not want to.

Multiple separate front-ends can be connected up to a PowerLab. The number of normal front-ends that can be connected depends on the number of (positive) input channels on the PowerLab, since the BNC cable for each front-end is normally connected to one of the positive analog input channels of the PowerLab. Only one front-end such as a Stimulator can be connected to the (positive) output of the PowerLab. The initial front-end should be connected with the I2C cable as shown in Figure 2–1. The remainder are daisy-chained via I2C cables, connecting the I2C output of the last connected front-end to the I2C input of the front-end to be added. Note that signal degradation can be expected if multiple Bio Amps are connected to a single subject.

The Stimulator of the Dual Bio Amp/Stimulator connects to and uses the analog output of the PowerLab as a source for producing pulses, so only one such front-end can be used per PowerLab. The I2C bus can control a maximum of sixteen front-ends. (Remember the Dual Bio Amp/Stimulator counts as three front-ends.) If you are using a PowerLab 16/30, therefore, which has sixteen input channels, you cannot use all the analog inputs for normal front-ends while the Stimulator is in use.
Using ADInstruments Programs

Front-ends are used with PowerLabs and ADInstruments programs such as LabChart and Scope. The amplification and filtering of the Bio Amp is combined with that of the PowerLab and the program and presented as a single set of software controls, replacing the Input Amplifier dialog with the Bio Amp dialog. The functions of the Isolated Stimulator are combined with those of the PowerLab and the program and presented as a single set of software controls, replacing the Stimulator dialog with the Isolated Stimulator dialog. The LabChart Help Center and Scope User’s Guide detail the Input Amplifier and Stimulator dialogs, and explain relevant terms and concepts.

The Front-end Driver

A driver is a piece of software the computer uses to drive a peripheral device. In order for a front-end to be recognized by ADInstruments applications, the appropriate front-end driver must be present. The Bio Amp front-end driver is used with the Bio Amp. The Stimulus Isolator front-end driver is used with the Isolated Stimulator. Front-end drivers are installed when ADInstruments applications are installed on the computer. To replace the drivers, you need to reinstall the ADInstruments software.

The Dual Bio Amp / Stimulator Self-test

Once the Dual Bio Amp/Stimulator is properly connected to the PowerLab, and the proper software is installed on the computer, a quick check can be performed on the Bio Amp parts of the front-end. To perform the self-test:

1. Turn on the PowerLab and check that it is working properly, as described in the owner’s guide that was supplied with it.
2. Once the PowerLab is ready, open either LabChart or Scope.
3. While the program is opening, keep a close eye on the Status indicators for the Dual Bio Amp (at the bottom right of the front panel). During initialization, you should see the indicator or indicators flash briefly and then remain lit.

If the indicator or indicators light correctly, the Bio Amp has been found by the PowerLab and is working properly, and you can quit the application or carry on as appropriate. If the indicator or indicators don’t light, check your cable connections and repeat the procedure.
The Isolated Stimulator Status indicator does not light during this procedure. It is only used to indicate pulses, and whether they are valid stimuli or show an out-of-compliance (OOC) condition.

**Software Behavior**

When a Bio Amp is properly connected to a channel, the Input Amplifier... menu commands and so on are replaced by Bio Amp... where they appear. When the Isolated Stimulator is properly connected to the output, the Stimulator... menu commands are replaced by Isolated Stimulator... where they appear. If the application fails to find a front-end connected, the normal text remains. If you were expecting a connected front-end and see the normal text, you should quit the program, check the connections, then open it again to see if the front-end commands appear. You do not have to connect all the front-ends if you do not want to.

The documentation for LabChart and Scope does not cover front-end-specific features. These features are described in detail here for LabChart. Differences between LabChart and Scope should be fairly obvious from perusing the Scope User’s Guide. For the most part, dialogs for these two application programs should be much the same.

**The Bio Amp**

The Bio Amp 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. Once the settings in the dialog are changed, click OK to apply them.

The Bio Amp dialog appears when you choose Bio Amp... from a Channel Function pop-up menu (or click Bio Amp... in the Input Settings column in the Channel Settings dialog). 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 next to the arrows, 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 when 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 (Macintosh) or top right (Windows) of the data display area. This changes to the Scroll button on the Macintosh. Click the Scroll button to start scrolling again.
Shift and stretch the vertical Amplitude axis, by clicking and dragging it in various ways, to make the best use of the available display area. It functions the same as the Amplitude axis of the Chart Window, controls are identical and any change is applied to the Chart Window.

**Setting the Range**

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

**Filtering**

Each of the Bio Amps in the Dual Bio Amp/Stimulator has low-pass, high-pass and notch-filter circuitry that can be adjusted to suit the application. 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.

**Notch Filter.** Select or deselect the Notch checkbox to turn the notch filter on and off. 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.

**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.
Mains Filter. Select or deselect the Mains filter checkbox to turn the mains filter on and off. The mains filter allows you to remove interference related to the mains frequency (both fundamental and harmonic frequencies). This is an adaptive filter. It adjusts to filter the interference by tracking the input signal for a second. Because of this, in general, using the mains filter is better than using the notch filter but the mains filter does have some limitations. More details on the mains filter can be found in the LabChart Help Center.

Click the Anti-alias checkbox to turn anti-aliasing on and off. Aliasing is distortion caused by frequencies of the incoming biological waveform that are more than half the sampling frequency. If you monitor physiological signals with a low-pass filter setting of 100 Hz, but you are only sampling at 100 Hz, aliasing may cause the recorded waveform to be quite different from the actual signal. An analogy can be seen in older Western films: spoked wagon wheels appear to stop or even go backwards when their rate of rotation matches the film frame speed – obviously not an accurate record of the wheels’ motion.

To prevent aliasing, the sampling rate must be at least twice the rate of the highest expected frequency of the incoming waveform. For example, if monitoring an ECG with maximum frequency components of 100 Hz, the sampling rate needs to be at least 200 Hz to provide an accurate signal. The sampling rate could be increased further if fast spikes or peaks (such as in the QRS complex of an ECG) must be accurately recorded. A high sampling rate, however, will use more computer memory and may limit recording time.

Inverting the Signal

The Invert checkbox 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

Click Units... to display the Units Conversion dialog, with which you can set the units for the channel and, using waveform measurements, calibrate the channel. A waveform in the data display area of the Bio Amp 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... from a Channel Function pop-up menu (does not convert individual blocks of data).
The Isolated Stimulator

The Isolated Stimulator lets you generate a pulse or series of pulses, using the outputs on the front of the Dual Bio Amp/Stimulator. To set it up, choose **Isolated Stimulator**... from the Setup menu: the Isolated Stimulator dialog appears. The Isolated Stimulator dialog is used both to set up stimulation, and to control and change it while sampling. The settings are independent of the sampling rate, but stimuli can only be generated while sampling.

- **Figure 2–5** The Isolated Stimulator dialog, Windows
- **Figure 2–6** The Isolated Stimulator dialog, Macintosh

Click these radio buttons to choose continuous stimulation or a set number of pulses. If ‘Set number of pulses’ is selected, click these radio buttons to choose to stimulate when these buttons begin recording or when **Stimulate** is clicked.

Click to turn the Isolated Stimulator on or off. The stimulus will be delivered after the delay specified in this box. Set stimulation parameters using the slider bars, text boxes, or up/down buttons.

Turn stimulation on (Pulse) or off using this pop-up menu. Use this pop-up menu if you want to mark the stimulus event. Set the number of pulses with the arrows or text box.

Click to start a train of pulses, when sampling and manual start is selected. Use this pop-up menu to change the frequency range or change to PPM.
The Isolated Stimulator dialog 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. The isolated stimulator only offers the Pulse stimulation mode. This generates a rectangular pulse stimulus that starts at zero current, is raised to the set current amplitude for the pulse duration, and then falls to zero current again. On Macintosh, by default the stimulator is off and the controls are inactive: Off is selected in the Stimulator Mode pop-up menu.

In this case, Scope has a different dialog to LabChart: in the Stimulator dialog you can choose Pulse and Multiple in the Mode pop-up menu (for single or multiple pulses, respectively).

**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 that channel). The stimulus marker works at any sampling rate, up to a stimulus frequency of about 10 Hz.

**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, or clicking or pressing in the slider bar areas (click for a single increment, press to scroll). The value is displayed in the text box by the slider bar. Alternatively, you can click the up and down arrow buttons or enter a value directly by typing it in the text boxes.

**Number of Pulses**

By default, the stimulator gives a continuous train of pulses, and the Continuously radio button will be selected. In this case, stimulation starts when sampling starts and continues until sampling stops. The Stimulator Panel miniwindow has Off and On buttons though, so you can use them to turn the continuous stimulation off or on at will.

If the Set number of pulses radio button is selected, then the stimulator produces a set number of pulses. In this case, stimulation starts either When recording starts (or after a specified Delay) or Manually, that is, when the Stimulate button is clicked, depending on which option is selected. You can specify the number of pulses for the stimulator to produce, from 1 to 2000. Click or press the up or down arrows to increment or decrement the number, or type the number of pulses in the text box.
Range, Frequency, Pulse Duration and Amplitude

On Windows, the Range PPM, Hz or s radio buttons set the units of pulse frequency in pulses per minute, hertz or seconds, respectively. On Macintosh, the Range pop-up menu lets you select the range for the Frequency control; either 2 Hz or 20 Hz. You can also choose PPM. PPM can sometimes be more convenient than Hz (or s) as the pulse frequency is stated in terms of number of pulses in each minute.

On Windows, the Frequency (or Interval, for the s range) controls are used to set the pulse frequency (or period between pulses) within the ranges: 1 to 240 PPM (~0.017 to 4 Hz), 0.1 to 20 Hz, and 500 ms to 10 s. The Frequency controls have the same function on Macintosh, within the ranges: 2 to 200 PPM (~0.033 Hz to ~3.3 Hz), and 0.1 Hz to the selected Hz range (2 or 20 Hz).

The Pulse duration controls set the time for which the pulse lasts, from 50 μs to 200 μs (0.05 ms to 0.2 ms). The pulse duration is limited to 200 μs for safety reasons.

The Amplitude controls 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 dialog, 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.

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 selected, then the Panel will have Off and On buttons. If manual stimulation was selected, then the Panel will have a Stimulate button: click it to deliver the set number of pulses.

---

Figure 2–7

The Isolated Stimulator Panel miniwindow

Windows (upper): off/on continuous stimulation
Macintosh (lower): manual control of stimuli
This appendix describes some of the important technical aspects of the Dual Bio Amp/Stimulator to give some insight into how it works. You do not need to know the material here to use the front-end. It is likely to be of especial interest to the technically minded, indicating what the front-end can and cannot do, and its suitability for particular purposes. (You should not use it as a service manual: user modification of the equipment voids your rights under warranty.)

The Dual Bio Amp/Stimulator and other ADInstruments front-ends have been designed to integrate fully into the PowerLab system. Note that the Dual Bio Amp/Stimulator acts just as if it were two individual Bio Amps and a Stimulus Isolator. Its I²C connections are internal, and there is some common circuitry as well.
**Dual Bio Amp Operation**

The Bio Amp is essentially an extension of the PowerLab’s input amplifiers. The amplification and ranges you see offered in LabChart and Scope result from the combination of both pieces of hardware. The Dual Bio Amp in the front-end has a common power supply and isolated ground. It provides:

- full electrical isolation from power-line (mains) circuitry to guarantee subject safety
- a low-noise, high-gain differential amplifier specifically designed for biological signal measurements
- software-controlled low-pass, high-pass, and notch filters to remove unwanted signal frequencies for particular uses
- audio output for use with EMG signals and so on.

**Isolated Stimulator Operation**

The Isolated Stimulator in the front-end is essentially an extension of the PowerLab’s analog output. It provides:

- a constant-current, 100-volt compliance, pulsed output
- high-voltage subject isolation (4000 V rms)
- low leakage capacitance and low noise
- software-adjustable current amplitudes
- software-adjustable pulse duration.

**Technical Description**

The PowerLab provides control and low-voltage power to front-ends through a special expansion connector called the I²C (eye-squared-sea) bus. The Bio Amps in the Dual Bio Amp/Stimulator are also connected to the analog inputs of the PowerLab via a BNC-to-BNC cable, through which they send the amplified and filtered signals. The Isolated Stimulator in the Dual Bio Amp/Stimulator is not a signal conditioner, though, but produces stimulation voltage output, and so is connected to the positive analog output socket of the PowerLab. The overall operation of the Dual Bio Amp/Stimulator can be better understood by referring to Figure A–1.

**Dual Bio Amp**

The Dual Bio Amp/Stimulator has one common connector for the two Bio Amps (marked Bio Amp Input 1 & 2). These two independently controllable, electrically isolated, biological amplifiers are suitable for a range of basic physiological measurements.
Figure A–1
Block diagram of the Dual Bio Amp/Stimulator
The Bio Amps have a common six-pin connector with a shared ground signal. The front-end 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 leads. Other cables may not meet safety requirements.)

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 PowerLab input, where it goes through the standard PowerLab 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.

The control for the various filters and gain stages in the Bio Amp is provided by on-board microprocessors, which also communicate with the PowerLab over the I²C bus. The high-pass filters in the Dual Bio Amp are phase-matched to within 1° phase shift at the ~3 dB frequency to allow for accurate waveform arithmetic.

**Isolated Stimulator**

The output stage consists of a high-voltage constant-current source that can produce pulses of variable duration and amplitude under software control. The current source can deliver pulses up to 20 mA at 100-volt compliance levels; its amplitude is set by a digital attenuator network, which is in turn controlled by the I²C logic. The output to the subject is through high-isolation optical couplers.
Trigger pulses are delivered to the current source through optical isolation as well. During operation the Isolated Stimulator Status indicator light on the front panel lights green with every pulse (it will glow yellow if the Isolated Stimulator is out of compliance).

The digital interface that controls pulse width and current amplitude uses an I²C interface system, and provides a 4-wire serial communication bus to the PowerLab and other front-ends. Also present on the connector is a set of power supply rails derived from the PowerLab, used to provide power for the control circuitry of the Isolated Stimulator and for the stimulator current source.

The Bio Amp Input

The 5-lead Bio Amp cable plugs into the six-pin input socket on the front panel of the Bio Amp. 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 Dual Bio Amp has one common connector for two Bio Amp inputs, nominally inputs 1 and 2. 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.

![Figure A–2](image)

The pin assignments for the Dual Bio Amp input connector

- Reference/Common
- CH2 negative (–)
- CH2 positive (+)
- Polarising key (to fit notch in plug)
- CH1 positive (+)
- Shield
- CH1 negative (–)
This appendix describes most of the common problems that can occur when using the Dual Bio Amp/Stimulator 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, earlier chapters, the LabChart Help Center, and the guide to your PowerLab may contain possible remedies. If none of the solutions here or elsewhere are of help, then consult your ADInstruments representative.

Most of the problems that users encounter are connection problems, and can usually be fixed by checking connections and starting up the hardware and software again. Very rarely will there be an actual problem with the front-end or the PowerLab itself.
Problems

The Status indicators fail to light when the software is started, or the front-end commands do not appear where they should

The I2C cable or one or more BNC-to-BNC cables from the front-end to the PowerLab are not connected, have been connected incorrectly (to the wrong input or output, for instance), or are loose.

- Turn everything off. Check that all cables are firmly attached and screwed in. BNC cables from the Bio Amp must be connected to a positive input on the PowerLab: the input channel that you expect to use in the software. The BNC cable from the Isolated Stimulator must be connected to the positive output on the PowerLab (it is labelled + on a most PowerLabs, and Output 1 on a /30 series PowerLab). Switch the PowerLab on and start the software again.

You are using an early version of LabChart or Scope.

- Upgrade to the latest version of the software. Contact your ADInstruments representative for information.

The BNC or I2C cable is faulty.

- Replace the cable and try again. Immediately label all cables proved faulty so that you don’t use them again by accident.

The front-end, or a portion of it, is faulty.

- This is the least likely event. If the front-end will not work properly after the previous measures, then try using it on another PowerLab. If the same problems recur with a second PowerLab, the front-end may be faulty. Contact your ADInstruments representative to arrange for repairs.

The Stimulator Status indicator shows yellow

This means that the Stimulator is out of compliance (OOC). The impedance of the tissue could be too high for the Stimulator to supply constant current at the level requested, or there may be an inadequate electrical connection to the subject.

- Reduce the output current amplitude.
- Check the connections for proper contact and try again. Ensure the connection is not dry (apply electrode cream) and that the leads are properly connected.
You could be attempting stimulation while the output safety switch is turned off (in the down position).

- Turn the safety switch on (move to the up position).

**On starting up the software, an alert indicates that there is a problem with the front-end or driver**

The correct drivers are not installed on your computer (they should be in the Essential Files folder in the LabChart or Scope folder).

- Reinstall the software.

You are using an early version of LabChart or Scope.

- Upgrade to the latest version of the software. Contact your ADInstruments representative for information.

The BNC or I²C cable is faulty.

- Replace the cable and try again. Immediately label all cables proved faulty so that you don’t use them again by accident.

The front-end, or a portion of it, is faulty.

- This is the least likely event. If the front-end will not work properly after the previous measures, then try using it on another PowerLab. If the same problems recur with a second PowerLab, the front-end may be faulty. Contact your ADInstruments representative to arrange for repairs.

**The Bio Amp signal appears to display a constant amplitude oscillation**

Frequency interference from power lines can become superimposed on the biological signal being measured.

- You can use the internal notch filter in the Bio Amp to remove excessive line voltage frequency interference (use the checkbox in the Bio Amp dialog).

If you are using cables and leads that were not supplied with your Bio Amp, they may be unshielded or of low quality.

- Check to make sure that you are using high-quality shielded cables and high-quality leads. Only the supplied Bio Amp cable and leads should really be used.
The Bio Amp signal is noisy at lower ranges

This is probably the amplified noise from the electrodes, not a fault as such. There is, in addition, noise that cannot be avoided by any amplifier (called ‘thermal’ or ‘Johnson’ noise).

- Set the low-pass filter to remove the noise. (But be careful, since important components of the signal could also be attenuated.)

This could be due an electrically noisy environment, particularly if there is some equipment that produces a radio frequency that interacts with the Bio Amp modulator, giving a heterodyne effect.

- Turn off pieces of unnecessary equipment to try and isolate the cause, then either leave the equipment off, or, if possible, move the subject or equipment outside the area of any interfering field.
- At the lowest ranges you may have to shield, shorten, or even replace the Bio Amp leads, since they will tend to act as radio receptors.

The Bio Amp trace will not zero properly when adjusting high-pass filtering

The Bio Amp is receiving signals at a level that has saturated the input amplifier, resulting in a large offset. This is normally due to poor contact between the electrodes and the subject.

- Check the connections for proper contact and try again.

The Bio Amp signal appears to be unusual, very weak, clipped, or distorted in some way

This may be a problem of technique: the sampling rate, range, or filter settings may be inappropriate for the signal you are recording.

- Make sure the settings are appropriate for the expected signal.

You may be using the wrong Bio Amp. The 3-lead Bio Amp cable used with the single Bio Amp has a different pin arrangement, and cannot be used with the Dual Bio Amp/Stimulator front-end.

- Use the correct, supplied, 5-lead Bio Amp cable.

Refer
Recording Technique, p. 21
Dual Bio Amp Input

Input configuration: 2 differential channels with common isolated ground reference

Input impedance: 100 MΩ to ground (~200 pF per lead) using supplied Bio Amp cable and leads

Safety: Approved to IEC601-1 BF (body protection) standard

Isolation rating: 4000 V AC<sub>rms</sub> for 1 minute

Amplification ranges: ±20 μV to ±50 mV full scale in 11 steps (combined Bio Amp and PowerLab)

± 50 mV
± 20 mV
± 10 mV
± 5 mV
± 2 mV
± 1 mV
± 500 μV
± 200 μV
± 100 μV
± 50 μV
± 20 μV

Gain accuracy: ± 1% all ranges

Non-linearity: < 1% of full scale (better for ranges under 1 mV)

Notch-filtering: 50 or 60 Hz notch filter, automatically selected to match supply frequency
<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-pass filtering:</td>
<td>Single-pole 0.1, 0.3, 1, and 10 Hz (–3 dB) with accuracy of ±10%. The high-pass filters are phase-matched to within 1° phase shift at the –3 dB frequency to allow for accurate waveform arithmetic.</td>
</tr>
<tr>
<td>Low-pass filtering:</td>
<td>8th-order Bessel-type filters (linear time delay). Frequencies software-selectable at 20, 50, 100, 200, and 500 Hz, and 1, 2, and 5 kHz. Frequency accuracy is ±2%.</td>
</tr>
<tr>
<td>DC blocking:</td>
<td>± 0.5 V</td>
</tr>
<tr>
<td>Baseline restoration:</td>
<td>Automatic</td>
</tr>
<tr>
<td>Noise levels:</td>
<td>0.1 Hz to 5 kHz: 1.95 μV 0.1 Hz to 1 kHz: 1.25 μV 0.1 Hz to 50 Hz: 0.5 μV 0.1 Hz to 20 Hz: 0.2 μV</td>
</tr>
<tr>
<td>IMRR (isolation mode):</td>
<td>&gt; 130 dB (@ 50 to 100 Hz)</td>
</tr>
<tr>
<td>CMRR (common mode):</td>
<td>&gt; 75 dB (DC to 100 Hz)  &gt; 60 dB (@ 1 kHz)</td>
</tr>
<tr>
<td>Input leakage current:</td>
<td>&lt; 6 μA rms @ 240 V, 50 Hz  &lt; 4 μA rms @ 120 V, 60 Hz</td>
</tr>
<tr>
<td>Audio output:</td>
<td>Stereo output supplying signals from both Bio Amp channels. Suitable for earphones, headphones, or most externally powered speakers. Output is a 100 mV signal for any full-scale signal. Current limited to ± 5 mA.</td>
</tr>
</tbody>
</table>

**Isolated Stimulator Output**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output configuration:</td>
<td>Constant-current stimulator with hardware-limited repetition rate</td>
</tr>
<tr>
<td>Isolation rating:</td>
<td>4000 V&lt;sub&gt;rms&lt;/sub&gt; to ground as per IEC601-1  2000 V&lt;sub&gt;rms&lt;/sub&gt; (60 seconds) to Bio Amp inputs</td>
</tr>
<tr>
<td>Pulse duration:</td>
<td>50–200 μs (software-selectable)</td>
</tr>
<tr>
<td>Compliance voltage:</td>
<td>100–110 V typical</td>
</tr>
<tr>
<td>Output current:</td>
<td>0–20 mA in 0.1 mA steps (software-selectable)</td>
</tr>
<tr>
<td>Pulse rate:</td>
<td>Software-selectable, but hardware-limited to a maximum of 20 Hz for safety</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Safety switch:</td>
<td>Isolating On-off switch flicks down to disconnect quickly</td>
</tr>
<tr>
<td><strong>Control Port</strong></td>
<td></td>
</tr>
<tr>
<td>I²C port:</td>
<td>Provides control and power. Interface communications rate of ~50 kbits/s.</td>
</tr>
<tr>
<td><strong>Physical Configuration</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Dimensions (h × w × d): | 65 mm × 200 mm × 250 mm  
(2.56" × 7.9" × 9.8") |
| Weight:           | 1.52 kg (3 lb 5oz)                                                                                           |
| Power requirements: | ~6 W                                                                                                       |
| Operating conditions: | 5–35 °C, 0–90% humidity (non-condensing)                                                                     |

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

A
ADInstruments programs 26–33
aliasing 30
analog output 18
Application Notes 20
artifacts 21, 22
audio output 17

B
back panel 18–19
Bio Amp cable 19–20
Bio Amp inputs 16, 39
Bio Amp software 27–30
block diagram 37

C
checking the front-end 14
cleaning 10
connecting to the PowerLab
  multiple front-ends 25
  single front-end 24
continuous stimulation 32

differential inputs 19, 24

D
differential inputs 19, 24

F
filtering 29–30
front panel 16–17
front-end driver 26, 43
front-ends, general 14–15

I
indicator lights 16
Isolated Stimulator panel 33
isolated stimulator software 31–33
I2C bus 15, 18, 36

L
LabChart 26, 30

M
maintenance 10
manual stimulation 32
marker 32
measurements 20–21
  Cortical Evoked Potentials 21
  ECG (EKG) 20
  EEG 20
  EMG 20
  EOG 21
  ERG 21
  SNAP 21
motion effects 22

N
number of pulses 32

O
open lead wires 22
out of compliance 17
P
PowerLab system 14
problems and solutions 42–44
pulse properties 33

R
range 29, 33
recording technique 21–22

S
Safety Notes 5–11
safety switch 17
Scope 26
self-test 26
signal display 27–29
Signal Input 19
single-ended inputs 24
software 27–33
stimulator controls 32–33
stimulator output 17
Stimulator Status indicator 17
storage 10

T
technical description 36–39
technical specifications 45–47
triboelectric effects 22
troubleshooting 42–44

U
unit conversion 30
user modification 35
using ADInstruments programs 26–33
using this guide 14