ADINSTRUMENTS
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Animal Bio Amp

Owner's Guide

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Contents

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.

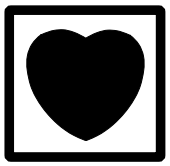
The choice to meet IEC 60601-1 is in no way to be interpreted to mean that a product:

- 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 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.

CHAPTER 1

Overview

The ML136 Animal Bio Amp is a modular device, in a family called front-ends, designed to extend the capabilities of the PowerLab® system. The Animal Bio Amp is designed to allow the PowerLab system to record bioelectrical signals, such as ECG (EKG), EOG, ERG, EMG, and EEG, from animals or isolated tissues, or action potentials from isolated nerves. ***It is not intended for human use and should never be connected to a human subject!*** This chapter provides an overview of the Animal Bio Amp, and describes its basic features.

How to Use This Guide

This owner's guide describes how to set up and begin using your Animal Bio Amp. The chapters give an overview of front-ends in general and the Animal Bio Amp in particular, and discusses how to connect the hardware, install the driver software, and perform a simple power-up test. The use of the Animal Bio Amp with the LabChart and Scope applications is also described. The appendices provide technical information about the Animal Bio Amp, and take a look at some potential problems and their solutions.

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

Checking the Animal Bio Amp

Before connecting the Animal Bio Amp 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 Animal Bio Amp casing.

2. Check that there is no obvious sign of internal damage, such as rattling. Pick up the Animal Bio Amp, 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 PowerLab representative immediately, and describe the problem. Arrangements can be made to replace or repair the Animal Bio Amp.

Front-End Fundamentals

Your Animal Bio Amp is one of a family of integrated front-ends for your PowerLab system. Front-ends provide additional signal conditioning and other features, needed for specialized work, that are not available using the PowerLab by itself.

All PowerLab front-ends are fully compatible with your PowerLab system, and can be used to extend the types of experiments you can conduct and the data you can record. All PowerLab front-ends are designed to be operated under full software control. No knobs, dials or switches are needed.

The PowerLab controls the Animal Bio Amp through a special expansion connector called the I^2C (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. This makes it easy to add front-ends to your system or to transfer them between PowerLab units. Each front-end requires at least one input channel of the PowerLab.

PowerLab front-ends are automatically recognized by the PowerLab system and the LabChart or Scope software. Any front-end feature such as gain or filtering is combined with the appropriate features of the application 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 Animal Bio Amp

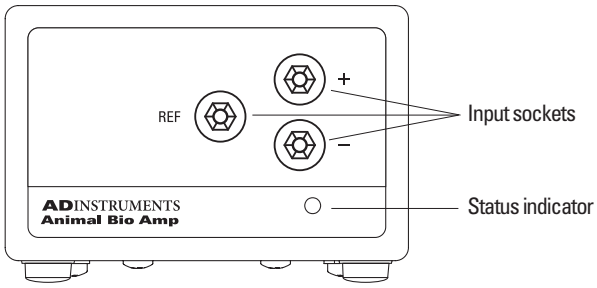
WARNING
The Animal Bio Amp must never be connected to a human subject

This rest of this chapter contains general information about the features, connections, and indicators of the Animal Bio Amp. More detailed information can be found in the technical appendices.

The Front Panel

The front panel of the Animal Bio Amp has three input connectors and one indicator light.

Figure 1–1
The front panel of the Animal Bio Amp



The Input Sockets

Connections are made to the Animal Bio Amp are made using the three 2 mm pin sockets on the front panel. A separate socket is provided for each of the positive (+), negative (–) and ground (GND/REF) cables.

Three cables are provided and each is terminated with a miniature alligator clip suitable for use with a wide variety of electrodes (not supplied).

The Status Indicator

Located at the bottom right of the front panel of the Animal Bio Amp is the status indicator light. When lit, it indicates that the PowerLab software (such as LabChart or Scope) has found the Animal Bio Amp and that it is ready to use. If the light does not go on, then the Animal Bio Amp is not connected properly, or there is a software or hardware problem.

The Back Panel

The back panel of the Animal Bio Amp provides all the sockets for connection of the Animal Bio Amp to the PowerLab and to other front-ends.

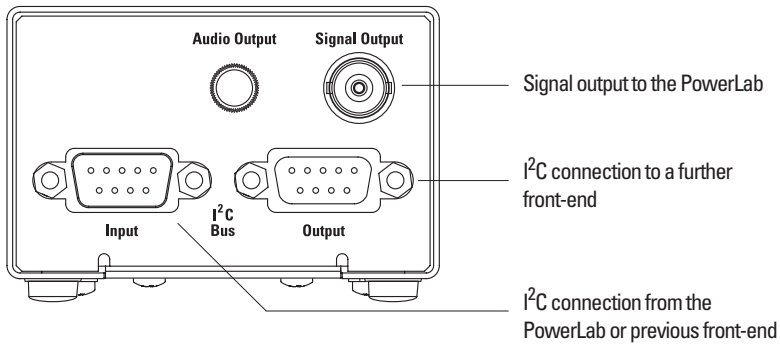


Figure 1–2
The back panel of the Animal Bio Amp

I²C Input and Output Sockets

Two nine-pin sockets are used to communicate with the PowerLab (they are marked 'I²C Bus': a 'bus' is simply an information transmission connection such as connectors and cabling). These sockets in conjunction with the proper cables allow multiple front-ends to be used independently with one PowerLab: power and control signals to connected front-ends come from the PowerLab. Multiple front-ends are connected to each other in series, 'output to input'. This is discussed in detail in the next chapter.

Signal Output Socket

The BNC socket labeled Signal Output is used to connect the Animal Bio Amp to one of the analog input channel sockets on the front of the PowerLab. The supplied BNC-to-BNC cable is used for this purpose.

Audio Output Socket

The Animal Bio Amp has an audio monitor output that can be used with a wide range of headphones or externally powered speakers. The 3.5 mm stereo socket is wired to provide mono sound (the same signal to a set of stereo speakers or headphones. This audio output is of particular use when monitoring bursts or nerve activity.

CHAPTER

2 Setting Up

This chapter describes connecting your Animal Bio Amp 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 Animal Bio Amp with PowerLab software programs.

Connecting to the PowerLab

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

If you have a PowerLab with differential inputs (+ and – channels), then you must connect the BNC cable to one of the positive analog input channels. PowerLab applications will not find the front-end on starting up if a negative input is used. If you have a PowerLab with single-ended inputs (none of the channel sockets is marked + or –), then you can connect to any of the inputs.

Single Front-end

Connect the I^2C output of the PowerLab to the I^2C input of the front-end using the I^2C cable provided. Figure 2–1 shows how to connect up a single front-end to your PowerLab.

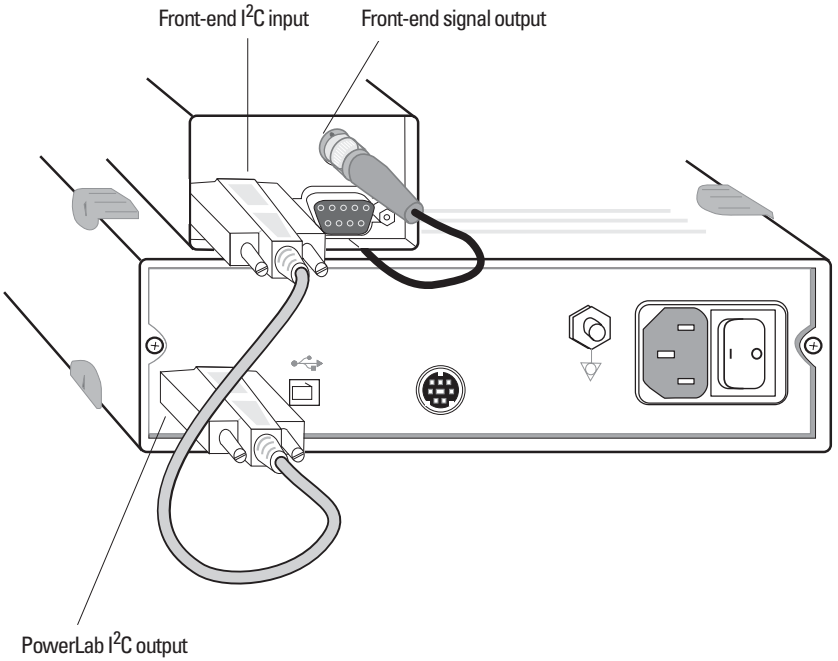


Figure 2–1
Connecting a front-end to the PowerLab: there will be only one I^2C socket on the PowerLab even if the back panel layout is different

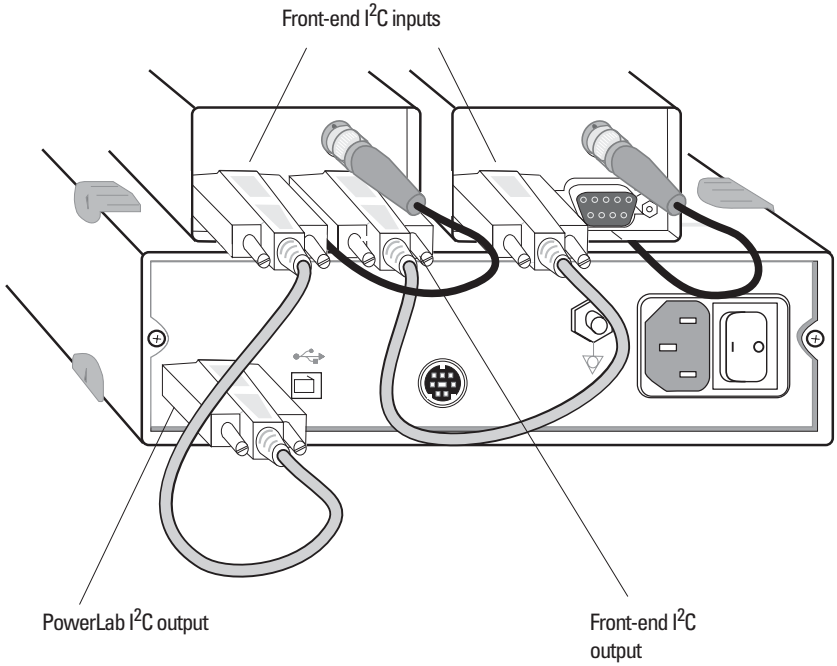
Check that the plugs for the I^2C bus are screwed in firmly. Check the BNC cable for firm connections as well.

Loose connectors can cause erratic front-end behavior, or may cause the front-end to fail to work at all. The BNC cable can be tucked under the front-end to keep it out of the way if desired.

Multiple Front-ends

Multiple front-ends can be connected up to a PowerLab; up to sixteen, depending on the number of input channels (positive sockets) on the PowerLab. The initial front-end should be connected as shown in Figure 2–1. The remainder are daisy-chained via I^2C cables, connecting the I^2C output of the last connected front-end to the I^2C input of the front-end to be added. The BNC cable for each front-end is connected to one of the positive analog inputs of the PowerLab. Note that signal degradation can be expected if multiple Bio Amps are connected to a single subject.

Figure 2–2
Connecting multiple front-ends to the PowerLab



The Front-end Driver

There are several front-end drivers for the various front-ends made by ADInstruments (a driver is a piece of software the computer uses to drive a peripheral device). For example the Bio Amp front-end driver is used with the Bio Amp and Animal Bio Amp; and the Stimulus Isolator front-end driver is used with the Stimulus Isolator.

In order for the Animal Bio Amp to be recognized by PowerLab applications, the Bio Amp front-end driver must be present. It should have been installed when the LabChart and Scope applications were installed on your computer. If it is not present, then you may need to reinstall the software or obtain a software update.

A Power-up Test of the Animal Bio Amp

Once the Animal Bio Amp is properly connected to the your computer, and when the proper software is installed, a quick check can be performed on the Animal Bio Amp. To perform the power-up test:

1. Turn on the PowerLab and check that it performs its normal diagnostic tests, as described in the owner's guide that was supplied with the PowerLab.
2. Once the PowerLab is ready, open either LabChart or Scope.
3. While the chosen program is opening, keep a close eye on the Animal Bio Amp's online indicator. During initialization, you should see this indicator flash briefly and then remain lit. This tells you that the Animal Bio Amp has been found by the PowerLab and is ready for use.

If the indicator is lit, the Animal Bio Amp is working properly, and you can quit the application. If the indicator does not light, check your cable connections and repeat the procedure. If this does not solve the problem, contact your PowerLab representative.

Using LabChart and Scope

When the Animal Bio Amp is connected to a channel and successfully installed, the **Input Amplifier**... menu command from the Channel Function pop-up menu in LabChart is replaced by the **Bio Amp**... menu command. In Scope, the **Input Amplifier**... button in the Input A (or Input B) panel is replaced by the **Bio Amplifier**... button.

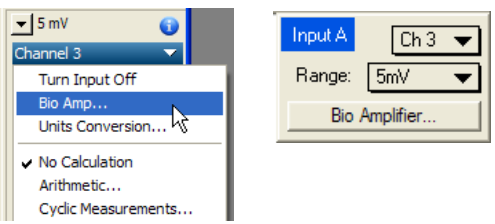


Figure 2–3
A Channel Function pop-up menu in LabChart, and an Input panel in Scope, with the Animal Bio Amp connected

If the application fails to find a front-end attached to a channel, the normal **Input Amplifier**... command or button remains. If you were expecting a connected front-end, you should close the program, turn everything off, check the connections, then start things up again. Note that leaving the PowerLab on while changing connections can damage the PowerLab, the Animal Bio Amp, or both.

Choosing the **Bio Amp**... menu command or clicking the button will bring up the Bio Amp dialog, which replaces the Input Amplifier dialog for the channel (the LabChart Help Center and *Scope User's Guide* have details on the Input Amplifier dialog, and explain some of the software terms used here).

Setting Up the Animal Bio Amp

The Bio Amp dialog is similar for LabChart and Scope. It allows software control of the various amplifiers and filters in the Animal Bio Amp (and PowerLab) for a channel. The signal present at that channel's input is displayed so that you can immediately see the effects of any changes. Once you have changed the settings in the dialog, click **OK** to apply the changes to the Chart or Scope window. The channel that the dialog applies to is shown next to the arrows, and the channel title or axis label (if any) is shown along the vertical Amplitude axis.

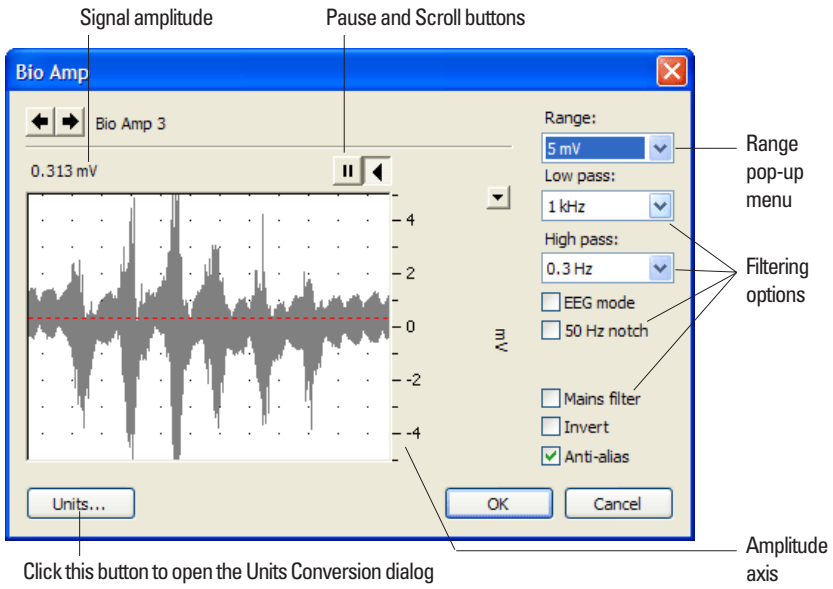


Figure 2–4
The Bio Amp dialog (for LabChart for Windows; the Macintosh version and the Scope version are similar)

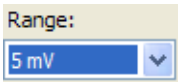
Signal Display

The input signal is displayed so that you can see the effect of changing the settings — no data is actually recorded when setting up the Animal Bio Amp. The average signal value is displayed at the top left of the display area. 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.

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. On the Macintosh this changes to the Scroll button. Click the Scroll button to start scrolling again.

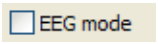
Shift and stretch the vertical Amplitude axis to make the best use of the available display area. Apart from being at the right rather than the left, it functions the same as the Amplitude axis in the Chart or Scope window, controls are identical and any change made here is applied to the Chart or Scope 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 Animal Bio Amp and the PowerLab. Changing the range in the Bio Amp dialog is equivalent to changing it in the Chart or Scope window (all dialog changes are made in the main window after clicking **OK**). The default setting is 100 mV rather than 10 V, and the ranges go down to 5 μV in 14 steps.

EEG Mode



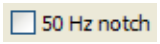
The **EEG Mode** checkbox changes the available filters of the Animal Bio Amp to suit EEG applications. When this checkbox is on, the **High Pass** pop-up menu gives filter settings of 0.03, 0.1, 0.3 and 1 seconds, and the **Low Pass** pop-up menu gives filter settings of 3, 10, 30, 60, and 120 Hz. It is a convention in EEG to deal with high-pass filter settings in terms of seconds (giving the time constant of the first-order filter).

Filtering

The Animal Bio Amp provides signal filtering options that can be adjusted to suit your requirements; they are appropriate to the signals usually measured, which tend to be of lower frequency.

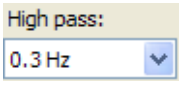
The notch filter and the mains filter are used to remove excessive mains frequency interference. The high-pass filter limits the bandwidth of low-frequency signals and the low-pass filter limits the bandwidth of high-frequency signals.

Not all possible combinations of high-pass and low-pass filters are available, for instance, if the 5 kHz low-pass filter is selected, then high-pass filtering cannot be below 1 Hz.

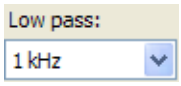


Notch Filter. Click the **Notch** checkbox to turn the notch filter on and off (it is on when checked). The notch filter is set to either 50 or 60 Hz depending on the power line voltage (mains) frequency being used to remove electrical interference. It provides 32 dB of attenuation, thus reducing the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

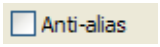
Note that if you are using LabChart with a /20 series PowerLab, there will also be a **Mains Filter** checkbox available, as shown in Figure 2–4. This is an adaptive filter and should only be used when the signal to mains noise ratio is less than 36 dB, and the mains frequency is varying over time — otherwise the notch filter will give better results. More details on the mains filter can be found in the LabChart Help Center.



High-Pass Filtering. There are normally five options in the **High Pass** pop-up menu: 0.1, 0.3, 1, 3 and 10 Hz. When the **EEG Mode** checkbox is on, four options are provided in the **High Pass** pop-up menu: 0.03, 0.1, 0.3 and 1 seconds. (Units of seconds give the time constant of the first-order filter.) When any of the options is chosen, a high-pass filter removes any DC components and attenuates those frequency components below the AC filter frequency from the signal. This is useful to remove slowly changing baselines, such as motion or respiration artifacts, particularly in ECG (EKG) recordings.



Low-Pass Filtering. The **Low Pass** pop-up menu normally gives a choice of six low-pass filters to remove high-frequency components from an input signal: 50, 100, 200 and 500 Hz, and 1 and 5 kHz. When the **EEG Mode** checkbox is on, five options are provided in the **Low Pass** pop-up menu: 3, 10, 30, 60 and 120 Hz. These settings are useful to eliminate high-frequency components, such as noise, and to prevent aliasing in the recorded signal.

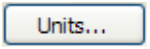


Anti-alias. Click the **Anti-alias** checkbox to turn anti-aliasing on and off. If the frequency of the incoming signal is more than half the sampling frequency, the recorded waveform may be quite different from the actual signal. This filter helps to eliminate this distortion. See "Aliasing" on page 29 for more details on this potential problem.

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 rewire a circuit or reconnect to the signal. Select the **Invert** checkbox to change the signal polarity.

Units



Click **Units**... to display the Units Conversion dialog, with which you specify the units for the channel and, using waveform measurements, calibrate the channel. Units conversion is not normally required for measurements taken using the Animal Bio Amp, but is provided just in case.

When the button is clicked, the waveform currently 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 any specific signal that you want to use.) 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, as it does not allow the conversion of individual blocks or pages of data. For more information about units conversion, see the LabChart Help Center and *Scope User's Guide*.

CHAPTER

3 Using the Animal Bio Amp

This chapter looks at the use of the Animal Bio Amp for measurements, describes the input connection in detail, and looks at how to avoid some common problems when setting up. It is essential that you read the material in this chapter before you attempt to connect biological signal sources to the Animal Bio Amp, especially if you intend to use your own cables or are unsure about how to connect to the Animal Bio Amp.

Using the Animal Bio Amp

The Animal Bio Amp amplifies the signal from a biological signal source so it can be used by the PowerLab, and provides appropriate filtering. The tasks listed below, and the basics of setting up measurement, are covered in detail in standard electrophysiology texts. Note that signal degradation can be expected if multiple Bio Amps are connected to a single subject.

Some Suitable Uses

This version of the Animal Bio Amp (ML 136) has been designed to measure a wide variety of biological signal sources. Some of the tasks for which it is suitable include:

ECG. Electrocardiogram (also referred to as EKG); a recording of the electrical currents that constitute the cardiac action potential.

EOG. Electro-oculogram; a recording of the electrical activity of the muscles which control movement of the eyeball. For bilateral measurement, an ML408 Dual Bio Amp is recommended, although two ML136 Animal Bio Amps can be used. The lowest possible high-pass filter setting is recommended for EOG measurements.

ERG. Electroretinogram; a recording of the electrical currents produced in the retina by a light stimulus. Two Animal Bio Amps are required for bilateral measurement.

EMG. Electromyography (surface electrode electromyography); a recording of the electrical activity of a muscle, using surface or needle electrodes: voluntary, M-wave (nerve stimulation), and so on.

EEG. Electroencephalogram; a recording of the electrical activity of the brain. The Animal Bio Amp is suitable for both 'biofeedback' and clinical types of EEG recording, if the environment is electrically quiet.

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. This should be done with signal averaging, using Scope.

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

Slow Waves. For some smooth muscle studies; recording the long-term electrical activity involved in involuntary muscle contractions.

Some Unsuitable Uses

The Animal Bio Amp is not recommended for work requiring high-impedance electrodes or using a high bandwidth. Some of the tasks for which it is not really suitable include:

- Intracellular micropipette recordings. Recordings from a very fine, electrolyte-filled tube inserted into a nerve or muscle cell. These require an electrometer amplifier.
- Any biopotential recordings requiring low input capacitance and a driven guard circuit.

The Animal Bio Amp Input

Connections are made to the Animal Bio Amp using the three 2 mm sockets on the front panel. The socket is of a sort commonly used with life science connection leads, and is shown in Figure 1–1.

The sockets provide two pins for a differential input signal (+ or red, – or black), and an isolated ground (GND or green).

The Animal Bio Amp should never be used on humans. For human connection use the ML132 Bio Amp or ML135 Dual Bio Amp with the associated approved subject cables.

Preventing Problems

Several problems can arise when using the Animal Bio Amp for recording biological signals. It is important to understand the types of problems that can occur, how they manifest themselves, and what can be done to remove them or to minimize their effect. These are usually problems of technique, and should be addressed before you set up.

Aliasing

Aliasing occurs when the highest frequency of an analog signal is greater than half of the sampling frequency. The Nyquist–Shannon sampling theorem states that an analog signal that has been digitized can be perfectly reconstructed if the sampling rate is at least twice the highest frequency in the original signal. An example of aliasing would be the cinematic 'wagon-wheel effect', whereby a spoked wheel appears to rotate too slowly or even backwards, relative to the movement of the wagon.

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.

Frequency Distortion

Frequency distortion will occur if the bandwidth of the Bio Amp is made smaller than the bandwidth of the incoming signal. For example, if an ECG was measured with a bandwidth of 100 Hz and the Animal Bio Amp had its low-pass filter set to 50 Hz, the fast-changing sections of the waveform (the QRS complex) would be smaller, while the slower T-wave sections would remain relatively unchanged. This overall effect is called frequency distortion. It can be eliminated by increasing the low-pass frequency of the Animal Bio Amp to obtain an undistorted waveform. Similarly, if the high-pass filter were set too high, the amplitude of the T-wave sections could be reduced. The Bio Amp dialog lets you examine ECGs and similar slowly changing waveforms and fine-tune filter settings without recording.

Saturation

Saturation occurs when the range of the Animal Bio Amp is set too low for the signal being measured (the amplification, or gain, is too high). Since the signal amplitude exceeds the allocated range, the recorded waveform appears as if part of the waveform had been cut off, an effect referred to as clipping.

Clipping can also be caused by excessive baseline offset: the offset effectively moves the whole waveform positively or negatively to an extent that causes all or part of it to be clipped.

This problem is overcome by selecting a higher Animal Bio Amp range from the Range menu, or, in the case of excessive baseline offset, selecting a higher frequency in the high-pass filters settings.

Ground Loops

Ground loop currents are caused by differences in potential between two earthed devices, and can cause 'artifacts' (spurious readings) in the recorded waveform, and present a safety hazard to a subject. To avoid ground loops, ensure that the subject is only connected to one grounded device. The Animal Bio Amp is not a grounded device.

Note that for safety reasons, no grounded devices should be used with a human subject.

Electrode Contact

Occasionally, during measurement of a biological signal, one of the lead wires connecting the source to the Animal Bio Amp 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 Animal Bio Amp 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.

Motion Artifacts

A common source of artifacts when recording biological signals is due to 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 patient cables, 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 patient leads. Make sure the skin is cleaned and lightly abraded before attaching the electrodes.

Electromagnetic Fields

A major source of artifacts when recording biological signals is related to power-line fluctuations. Most biological measurement equipment derives its power from a wall socket connected to the electrical power system, and thus power lines are frequently found close to both the biological source and the measurement equipment. The associated electric fields of these power lines can introduce interference at the line frequency into the recorded signal.

Electromagnetic fields from other sources can also cause interference: fluorescent tubes, apparatus with large transformers, computers, network cables, VDUs, x-ray machines, microwave ovens, electron microscopes, even cyclic air conditioning. Sources need not be in the same room: being in the path of a microwave link or directly above a room full of electrically noisy equipment can cause problems.

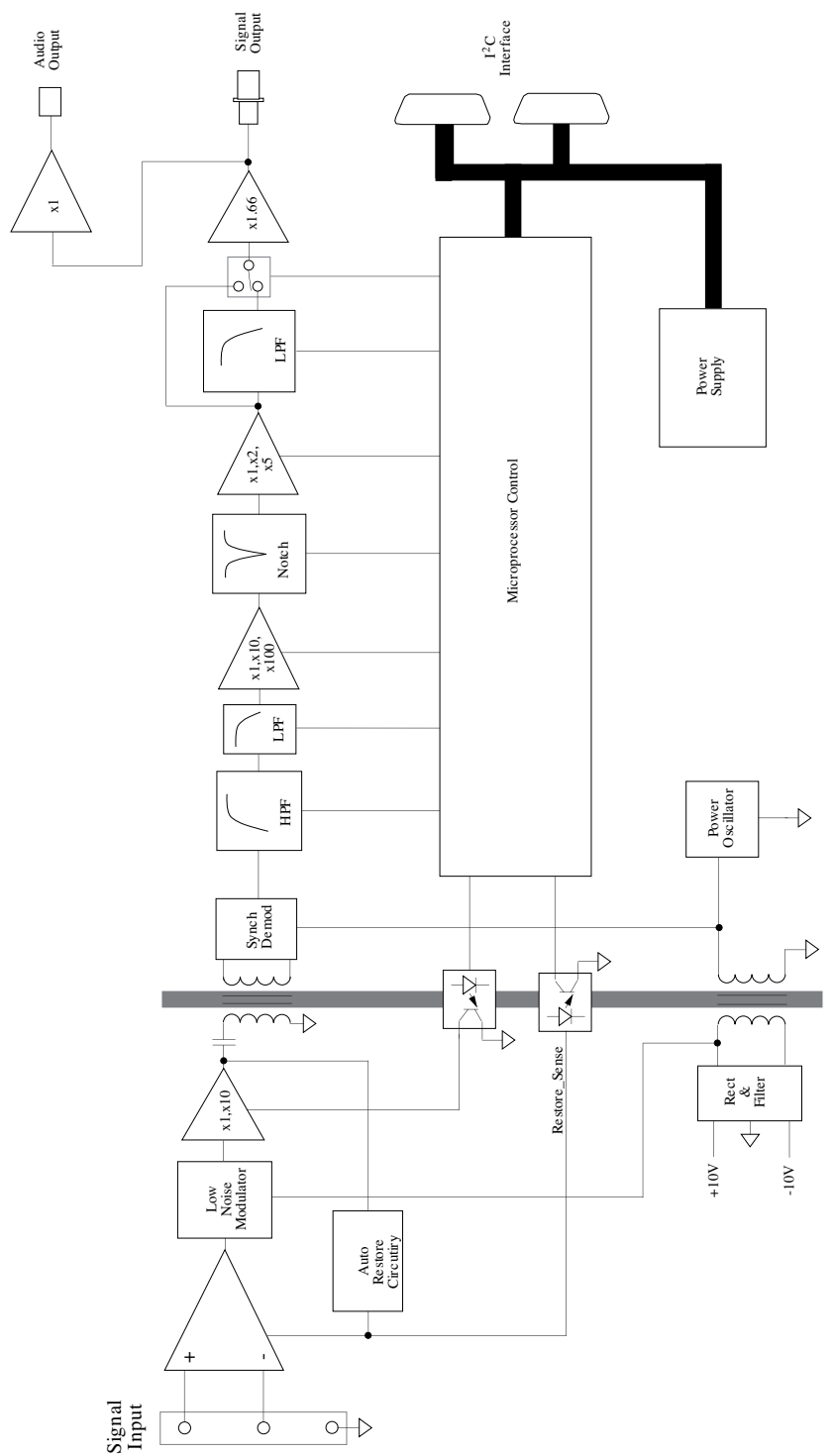
Interference can be minimized by using shielded cables and patient leads, and activating the notch filter in the Animal Bio Amp to remove excessive electrical frequency interference. Reasonable care in the arrangement and shielding of equipment can reduce interference from it. For very sensitive measurements, it may be necessary to place the subject (the biological source) and the Animal Bio Amp in a Faraday cage.

APPENDIX

A Technical Aspects

This appendix describes some of the important technical features of the Animal Bio Amp. It describes the capabilities of the Animal Bio Amp, and its suitability for particular purposes. Be advised that user modification of the equipment voids the warranty agreement.

Figure A–1
Block diagram of the Animal Bio Amp



Animal Bio Amp Operation

The Animal Bio Amp and other PowerLab front-ends have been designed to integrate fully into the PowerLab system. The Animal Bio Amp is essentially an extension of the PowerLab's input amplifiers, so the amplification (and hence the ranges) you see offered in the LabChart and Scope software will be the combination of both pieces of hardware.

The Animal Bio Amp provides:

- 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 or EEG signals and so on.

Technical Description

As with other ADInstruments front-ends, all internal functions of the Animal Bio Amp are controlled from the PowerLab through a special communications connector called the I^2C (eye-squared-sea) bus. This connection also supplies power to the Animal Bio Amp. Front-ends are also connected to the analog input channels of the PowerLab via a BNC-to-BNC cable, through which the amplified and filtered signal is sent to the PowerLab. The overall operation of the Animal Bio Amp can be better understood by referring to Figure A–1.

The input amplifier of the Animal Bio Amp starts with an electrically isolated differential amplifier. The output of this amplifier is fed into a low-noise demodulator and then to a programmable gain stage, before being fed across an isolation transformer to the non-isolated circuitry. Control of the isolated gain is provided via a high-isolation-voltage optocoupler. An auto-restore circuit monitors the level of the input signal and restores the input before the signal produces amplifier 'blocking'. Isolated power comes from a second isolation transformer driven by a power oscillator circuit running at about 38 kHz.

The signal from the isolated input amplifier is synchronously demodulated and then fed to a programmable, switched-capacitor, high-pass filter. Any switching clock noise is filtered by the low-pass filter following this stage.

The signal then passes to the first non-isolated gain stage, where it is amplified 1, 10 or 100 times. A switched-capacitor notch filter follows (this is automatically set to 50 or 60 Hz depending on the mains frequency of your power supply). After this, the signal passes to the final programmable gain stage, where it is amplified 1, 2 or 5 times. The last part of the signal-conditioning circuitry is the low-pass filter.

The output of the Animal Bio Amp is buffered with an amplifier with a fixed gain (nominally × 1.66), to compensate for gain differences through the previous stages of the device. An audio signal output, capable of driving headphones or powered speakers, is provided by tapping off the output stage and buffering it.

The control for the various filters and gain stages in the Animal Bio Amp is provided by on-board microprocessors, which also communicate with the PowerLab over the I^2C bus.

Note that the Animal Bio Amp is an extremely sensitive instrument, and it is important that in no circumstances should you try to repair or adjust it yourself. If you experience problems with the Animal Bio Amp, it should be returned to your ADInstruments representative for repair or calibration under the terms of your Warrant & Licensing Agreement.

APPENDIX

B Troubleshooting

This appendix describes some problems that may arise when using the Animal Bio Amp with the PowerLab. If you have any trouble getting the Animal Bio Amp to work with the PowerLab, use this section to try and isolate and cure the problem. If the solutions here do not work, earlier chapters, the LabChart Help Center, and the guide to your PowerLab may contain possible solutions. If none of the solutions here or elsewhere are of help, then consult your ADInstruments representative.

Although the PowerLab and the Animal Bio Amp are designed to be very reliable, there may be occasions when they do not appear to function correctly. In the majority of cases, the problem can be fixed by checking connections and starting up the application again. Very rarely will there be an actual problem with the Animal Bio Amp or the PowerLab itself. This appendix will help you determine what kind of fault you have and the appropriate solution.

The online indicator fails to light when the application is opened

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.

The BNC-to-BNC cable from the Animal Bio Amp to the analog input channel of the PowerLab is not connected, has been connected incorrectly, or is loose.

- Check that the cable is firmly connected at the back of the front-end and to the PowerLab input.

The I^2C cable from the Animal Bio Amp to the PowerLab is not connected, has been connected incorrectly, or is loose.

- Check to see that the I^2C cables are firmly seated and screwed in. Start up again to see if this has fixed the problem.

You are using an early version of LabChart or Scope.

- Upgrade to the current version of the software — contact your ADInstruments representative.

The BNC or I^2C 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 Animal Bio Amp is faulty.

- This is the least likely event. If you have tried the above suggestions and still cannot get the Animal Bio Amp to work properly, then try using it on another PowerLab if you have access to one. If the online indicator fails to light on the second PowerLab, the unit may be faulty and should be returned for repair.

The Bio Amp… command does not appear in LabChart or Scope

The BNC-to-BNC cable from the Animal Bio Amp to the analog input of the PowerLab might not be connected, has been connected incorrectly (to the wrong input, for instance), or is loose.

- Check that the cable is firmly connected at the back of the front-end and to a PowerLab input.

The I^2C cable from the Animal Bio Amp to the PowerLab is not connected, has been connected incorrectly, or is loose.

- Check to see that the I^2C cables are firmly seated and screwed in. Start up again to see if this has fixed the problem.

You are using an early version of LabChart or Scope.

- Upgrade to the current version of the software — contact your ADInstruments representative.

The BNC or I^2C 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 Animal Bio Amp is faulty.

- This is the least likely event. If you have tried the above suggestions and still cannot get the Animal Bio Amp to work properly, then try using it on another PowerLab if you have access to one. If the online indicator fails to light on the second PowerLab, the unit may be faulty and should be returned for repair.

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

The Animal 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 signal appears to display a constant amplitude oscillation

Frequency interference from power lines can become superimposed on the biological signal you are measuring.

- You can use the internal notch filter in the Animal 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 Animal Bio Amp, they of low quality.

- Check to make sure that you are using only high-quality cables, and that all soldered joints are in good condition.

Sometimes the alligator clips do not make good electrical contact with the electrodes.

- Check to make sure that the electrodes are clean and dry where they contact the alligator clips. Refresh the electrode surface by polishing with a fine abrasive cloth to remove any oxide layer, if necessary. Make sure there is no grease, oil or wax covering the electrodes.

The 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-Nyquist' 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 Animal 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 amplification ranges cables may have to be shortened, as long cables will tend to act as radio receivers.

Problems with the Front-end Driver

On starting up, LabChart or Scope presents a dialog indicating that it could not find the driver

The Bio Amp driver is not installed on the computer you are using.

- Reinstall the LabChart and Scope software from your PowerLab Installer CD.

On starting up, LabChart or Scope presents a dialog indicating that the driver is incompatible

You are probably trying to use the Animal Bio Amp with an old version of software.

- Reinstall the LabChart and Scope software from your PowerLab Installer CD. If you do not have a copy of the current version of software, please contact your ADInstruments representative.

APPENDIX C

Specifications

Amplification

Input amplifier:	High impedance, differential (floating), electrically isolated
Amplification range:	±5 μV to ±100 mV full scale in 14 steps (combined PowerLab and Bio Amp)

Full Scale	Resolution
± 100 mV	50 μV
± 50 mV	25 μV
± 20 mV	10 μV
± 10 mV	5 μV
± 5 mV	2.5 μV
± 2 mV	1 μV
± 1 mV	500 nV
± 500 μV	250 nV
± 200 μV	100 nV
± 100 μV	50 nV
± 50 μV	25 nV
± 20 μV	10 nV
± 10 μV	5 nV
± 5 μV	2.5 nV

Mid-band gain accuracy:	±1.5% (all ranges, within Bio Amp)
Non-linearity:	0.1% within range
Noise at various bandwidths:	
• 1 Hz to 5 kHz:	< 1.3 μV_{rms} (< 8 μV peak-to-peak)
• 0.3 Hz to 1 kHz:	< 0.6 μV_{rms}
• 0.1 Hz to 100 Hz:	< 0.35 μV_{rms} (@ 200 samples/second)
CMRR:	> 85 dB (typically, 1 – 60 Hz)
IMRR:	> 130 dB (to true earth, 50–100 Hz)

Input

Connection type:	Three 2 mm sockets
Input impedance:	200 MΩ differential
Input leakage current:	< 3 μA_{rms} @ 240 V, 50 Hz < 2 μA_{rms} @ 120 V, 60 Hz
DC blocking:	±1 V
Baseline restore:	Automatic

Filtering

Low-pass filter:	Fourth-order Bessel filter, ±3% accuracy
Low-pass options:	Software selectable. Standard: 50, 100, 200 and 500 Hz, and 1 and 5 kHz (all at –3 dB); EEG mode: 3, 10, 30, 60 and 120 Hz
High-pass filter:	First-order filter, ±0.25% accuracy
High-pass options:	Software selectable. Standard: 0.1, 0.3, 1, 3 and 10 Hz (all at –3 dB); EEG mode: 0.03, 0.1, 0.3 and 1 seconds
Notch filter:	Second-order filter, –32 dB attenuation; 50 or 60 Hz frequency (automatic sensing)

Output

Signal:	±2.0 V standard; (within ±4.0 V overrange)
Audio:	3.5 mm stereo jack; ±200 mV. Suitable for headphones or powered speakers

Control Port

I^2C port:	Provides control and power. Interface communications rate of ~50 kbits/s.

Physical Configuration

Dimensions (h × w × d):	50 mm × 76 mm × 260 mm (1.97" × 3.0" × 10.2")
Weight:	770 g (1 lb 11 oz)
Power requirements:	< 2 W
Operating conditions:	5–35 °C 0–90% humidity (non-condensing)

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

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