



# **BP Amp**

## Owner's Guide



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# Safety Notes

## Statement of Intended Use

All products manufactured by ADInstruments are intended for use in teaching and research applications and environments only.

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

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

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

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

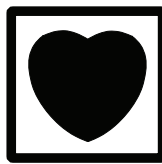
- is a medical device,
- may be interpreted as a medical device, or
- is safe to be used as a medical device.

## Safety Symbols

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



BF symbol: Body-protected equipment



CF symbol: Cardiac-protected equipment



Warning symbol: 'see documentation'

The three symbols are:

- BF (body protected) symbol. This means that the input connectors are suitable for connection to humans provided there is no direct electrical connection to the heart.
- CF (cardiac protected) symbol. This means that the input connectors are suitable for connection to human subjects even when there is direct electrical connection to the heart.
- Warning symbol. The exclamation mark inside a triangle means that the supplied documentation must be consulted for operating, cautionary or safety information before using the device.

Further information is available on request.

## Bio Amp Safety Instructions

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

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

## Isolated Stimulator Safety Instructions

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

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

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

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

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

## General Safety Instructions

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



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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.

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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.



# Overview

The BP Amp is a modular device, in a family called front-ends, designed to extend the capabilities of the PowerLab® system. The BP Amp is a blood pressure measurement amplifier for use with economical disposable blood pressure transducers. It provides full electrical isolation.

This chapter provides an overview of front-ends, describes the basic features of the BP Amp and discusses some aspects of its use.

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# How to Use This Guide

This owner's guide describes how to set up and begin using your BP Amp. The chapters give an overview of front-ends in general and the BP Amp in particular, and discusses 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. The index is at the end of this guide.

## Checking the Front-end

Before connecting the BP 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 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 BP Amp 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 I<sup>2</sup>C (eye-squared-sea) bus.

Each additional front-end connects to the back of the previous front-end, in a simple daisy-chain structure. 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 of the PowerLab (as does the BP Amp), although the Stimulus Isolator 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 BP Amp

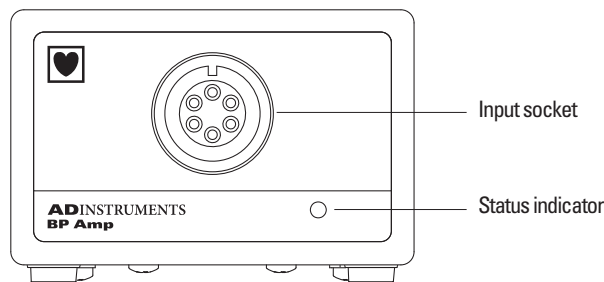
The BP Amp is designed to provide a fully subject-isolated blood pressure measurement amplifier for use with economical disposable blood pressure transducers. The BP Amp measures blood pressure directly in mmHg (millimeters of mercury): units conversion is done for you. It is precalibrated for use with the MLT0670 disposable blood pressure transducer. The pre-calibration can be overridden if you want to use another kind of transducer.

The rest of this chapter contains general information about the features, connections, and indicators of the BP Amp. It also looks at the disposable blood pressure transducer. More detailed information can be found in the technical appendices.

### The Front Panel

The front panel of the BP Amp (Figure 1–1) is simple, with one input connector and a small indicator light.

**Figure 1–1**  
The front panel of the  
BP Amp



## The Status Indicator

The status indicator light is located at the bottom right of the front panel. When an ADInstruments program such as LabChart starts up, the status indicator should flash briefly and then remain green, indicating that the program has found the front-end, checked and selected it, and that it is ready for use. If a status 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.

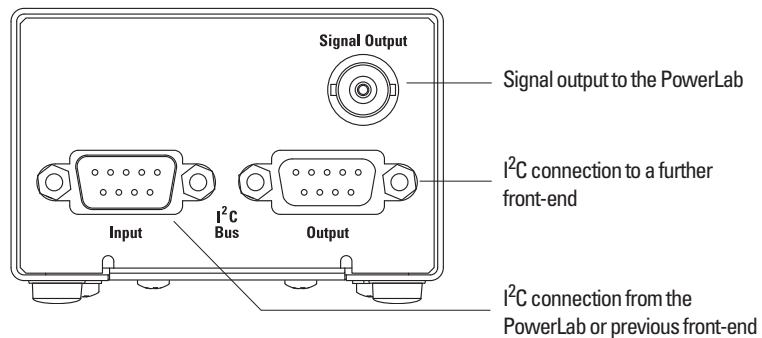
## The Input Socket

Connections are made to the BP Amp using the six-pin socket on the front panel. The Utah Medical transducer cable, supplied with the BP Amp, has a 4-pin transducer connection at the other end, suitable for the MLT0670 blood pressure transducer. The input connection has internal isolation circuitry. The socket and connections to it are discussed in more detail later (The Disposable BP Transducer, p. 17).

## The Back Panel

The back panel of the BP Amp (Figure 1–2) provides all of the sockets that are required to connect the front-end to the PowerLab and to other front-ends.

**Figure 1–2**  
The back panel of the  
BP Amp



## I<sup>2</sup>C Input and Output Sockets

Two nine-pin sockets are used to communicate with the PowerLab (they are marked 'I<sup>2</sup>C Bus': a 'bus' is simply information-transmission circuitry such as cables and connectors). 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. ADInstruments front-ends are connected to each other in series, output to input (this is discussed in more detail in the next chapter).

### The Signal Output Socket

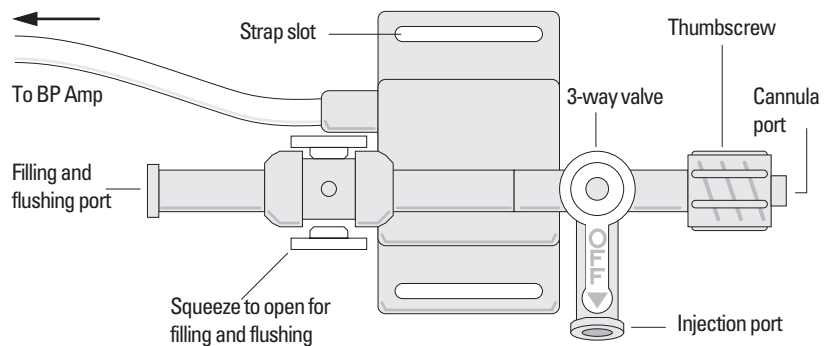
The BNC socket labeled Signal Output on the back panel of the BP Amp provides the signal output to connect to an analog input socket on the front of the PowerLab. A BNC-to-BNC cable is supplied for this connection. If you are using a PowerLab with differential inputs, remember to connect the cable only to a positive analog input. ADInstruments applications will not find the front-end on starting up if a negative input is used.

## Equipment and Technique

### The Disposable BP Transducer

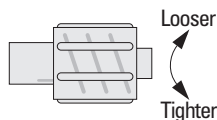
The MLT0670 Disposable BP Transducer is reliable and economical. Its components and functions are described below.

**Figure 1–3**  
The MLT0670 Disposable  
BP Transducer



The 4-pin connection from the transducer slots into the end of the Utah Medical 650-208 cable that is supplied with the BP Amp. The transducer may be attached to a subject or support frame using a strap through the strap slots.

The transducer has three ports, up to two of which can be open at one time. The cannula port is the one that connects a pressure line (cannula or catheter) to the subject.

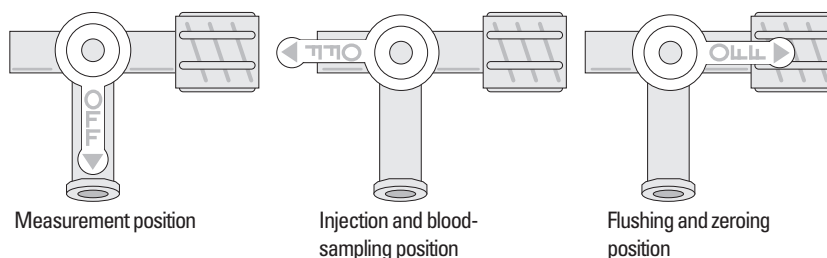


The thumbscrew by the cannula port turns anticlockwise to tighten the connection to the port, and clockwise to loosen it and unscrew the pressure line. Either or both of the other ports can be used.

The flushing port helps to get rid of air bubbles, if the transducer is arranged with this port at the top. The squeeze valve is squeezed to open it for filling and flushing; it is closed in the rest position. The injection port is used to fill the device and pressure line with saline solution and to draw blood from the subject if necessary.

The three-way valve controls which ports remain open (although the filling and flushing port requires the squeeze valve to be squeezed in addition). Point the valve handle at the port to be turned off.

**Figure 1–4**  
Three-way valve positions  
on the blood pressure  
transducer



## Sterilization of MLT0670 Disposable BP Transducer

If using the MLT0670 Disposable BP Transducer (stopcock) for measuring blood pressure in human subjects, the transducer must be sterilized prior to use. The MLT0670 is supplied in sterile packaging. However, ADInstruments cannot guarantee its sterility, and advise the user to gas sterilize the transducer prior to use.

## Zeroing

When zeroing the BP Amp, close the cannula port (Figure 1–4, right), leaving the central area of the transducer and its pressure sensor open to the atmosphere.

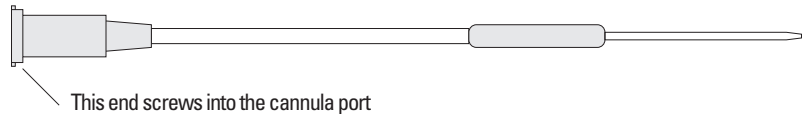
## Connecting a Subject

Note. Only appropriately qualified and experienced personnel should attempt to connect the device to a human subject.

Before connecting up a subject, the transducer, pressure line, and so on should be filled with sterile 'heparinized' saline (saline solution containing heparin to prevent blood clots). After this is done, make sure the setup is free of air bubbles, insert the cannula or catheter into the vein or artery, and secure the insertion point.

For animal monitoring, the catheter or pressure line to the cannula is kept as short as possible. When monitoring humans, there are usually extra safety devices, and the transducer will likely be part of an infusion set. A pressure line, if used, should be short and rigid, to avoid losing measurements of fast changes in pressure. The catheter or cannula should lie flat where it enters the blood vessel, to prevent obstruction of the tip.

**Figure 1–5**  
A typical cannula for  
animal use



If the pressure line back-fills with blood, the blood may clot, since it is not circulating. To prevent this, sterile 'heparinized' saline is injected or infused as required to keep the pressure line clear of clottable blood. In a transparent pressure line, diffusing blood can be seen, and the onset of clotting is also indicated by waveform amplitude attenuation in the blood pressure signal. It is important to keep blood out of the transducer itself.



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This chapter describes connecting the BP 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 front-end with ADInstruments application programs.

## Connecting to the PowerLab

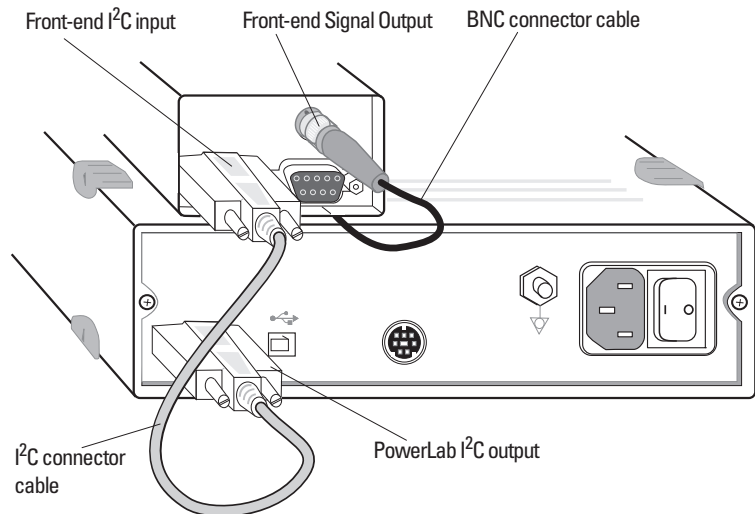
To connect a front-end, such as your BP Amp to the PowerLab, first ensure that the PowerLab is turned off. Failure to do this may damage the PowerLab, the front-end, or both.

The BNC cable from the BP Amp signal output must connect to a positive analog input 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 positive output is labelled + on a /25 series PowerLab and Output 1 on a /30 series PowerLab.

### Single Front-ends

Connect the I<sup>2</sup>C output of the PowerLab to the I<sup>2</sup>C input of the front-end using the I<sup>2</sup>C cable provided. Figure 2–1 shows how to connect up a single front-end to your recording unit.

**Figure 2–1**  
Connecting a single front-end to the PowerLab

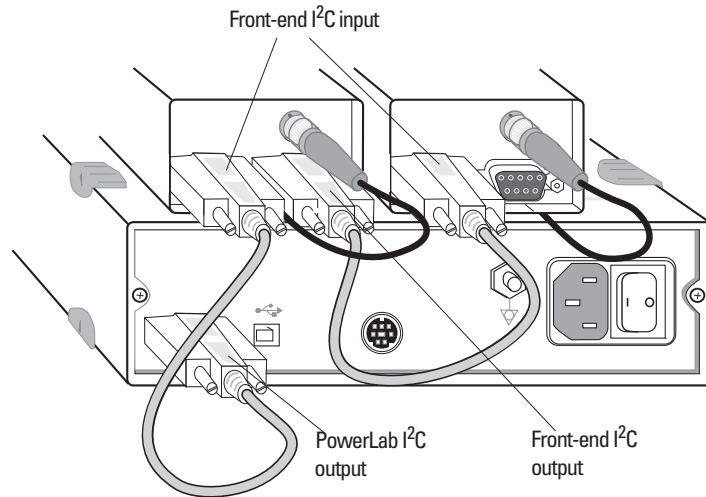


Check that the connectors for the I<sup>2</sup>C bus are screwed in firmly. Check the BNC cable for firm connections as well. Loose connectors can cause erratic front-end behavior, or may cause the front-end to fail to work at all.

## Multiple Front-ends

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 Stimulus Isolator can be connected to the (positive) output of the PowerLab. The initial front-end should be connected with the I<sup>2</sup>C cable as in Figure 2–1. The remainder are daisy-chained via I<sup>2</sup>C cables, connecting the I<sup>2</sup>C output of the last connected front-end to the I<sup>2</sup>C input of the front-end to be added.

**Figure 2–2**  
Connecting multiple front-ends to the PowerLab (two single front-ends are shown for simplicity)



## Using ADInstruments Programs

Front-ends are used with PowerLabs and ADInstruments programs such as LabChart and Scope. The amplification and filtering of the BP 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 BP Amp dialog. The LabChart Help Center and *Scope User's Guide* detail the Input Amplifier dialog, and explain relevant terms and concepts.

The documentation for LabChart and Scope does not cover front-end-specific features. These features are described in detail here for LabChart. Generally, the features are similar for Scope.

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## The Front-end Driver

A driver is a piece of software that the computer uses to operate a peripheral device. In order for a front-end to be recognized by ADInstruments applications, the appropriate front-end driver must be present. The BP/GSR (Macintosh) or BP GSR Amp (Windows) front-end driver is used with the BP Amp. Front-end drivers are installed when ADInstruments applications are installed on the computer, so to replace the drivers, you generally need to reinstall the ADInstruments software.

## The Front-end Self-test

Once the front-end is properly connected to the PowerLab, and the proper software is installed on the computer, a quick check can be performed on 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, watch the front-end's status indicator (at the bottom right of the front panel). During initialization, you should see the indicator flash briefly and then remain lit.

If the indicator lights correctly, the front-end has been found by the PowerLab and is working properly. If the indicator doesn't light, check your cable connections and repeat the start-up procedure.

## Software Behavior

When a BP Amp is properly connected to the PowerLab, the **Input Amplifier...** menu command is replaced by **BP Amp...** for the input channel to which it is connected. 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 instead, you should quit the application, turn the PowerLab off and check the connections. Then restart the PowerLab and the application.

Note: you cannot start sampling in LabChart or Scope if a connected BP Amp is not zeroed. Therefore, the first step is to zero the amp.

The BP Amp dialog for LabChart for Macintosh and LabChart for Windows are very similar and are described here together.



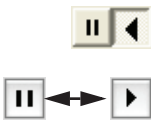
## The BP Amp Dialog

The BP Amp dialog allows software control of the combined filters and other circuitry in the PowerLab and BP Amp. The signal present at an input is displayed so that you can see the effects of changes straight away. The BP Amp is pre-calibrated and measures blood pressure directly in mmHg (millimeters of mercury). The dialog also allows you to zero the BP Amp. After changing settings in the dialog, click **OK** to apply them.

The BP Amp dialog appears when you choose the **BP Amp...** command from the Channel Function pop-up menu of the input channel it is attached to (or click **BP Amp...** in the Input Settings column of the Channel Settings dialog). To set up many channels quickly, click the arrows at the top left of the dialog 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.

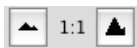
### Signal Display

The input signal is displayed to show you the effect of changing the settings — no data are 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.



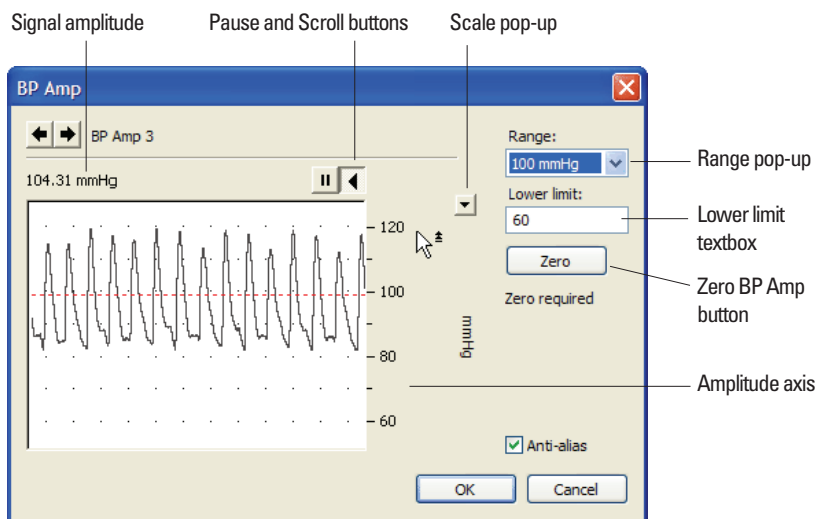
You can stop the signal scrolling by clicking the Pause button at the bottom left (Macintosh) or top right (Windows) of the data display area. On the Macintosh this changes to the Scroll button. Click the Scroll button to start scrolling again.

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.

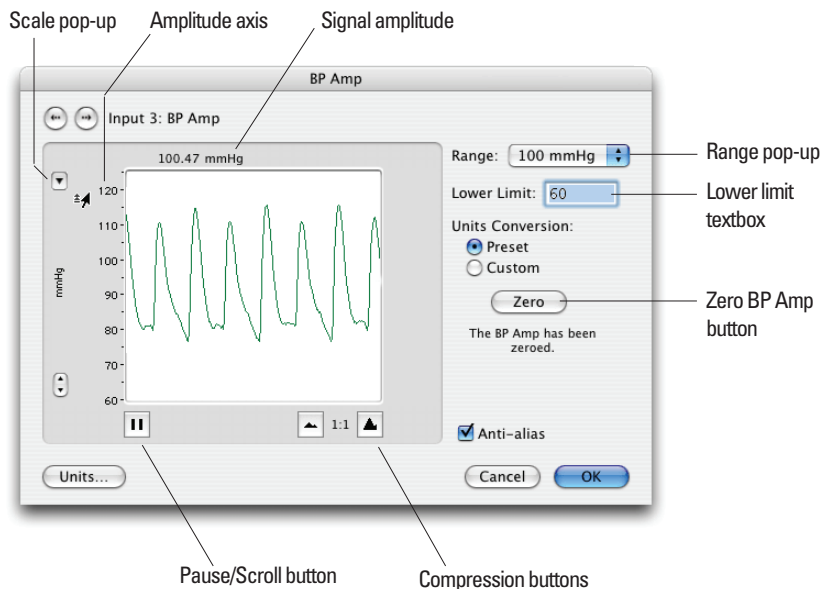


On a Macintosh, **Show Range Axis** in the Scale pop-up menu displays the range axis at the right of the display area, and the Compression buttons adjust the horizontal axis of the data display area.

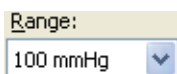
**Figure 2–3**  
The BP Amp dialog for Windows (before zeroing)



**Figure 2–4**  
The BP Amp dialog for Macintosh (after zeroing)



## 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 BP Amp). Changing the range in the BP Amp dialog is equivalent to changing it in the Chart Window. There are three ranges: 50, 100 and 250 mmHg.

Lower limit:

Zero required

☐ Anti-alias

## Lower Limit

The **Lower Limit** text entry box lets you set the lowest value for the displayed range, in mmHg. You can enter negative values. If you enter 70 with the range set to 50 mmHg, then the display will show values from 70 to 120 mmHg. The display adjusts after a second or so. The display can still be stretched and shifted afterwards.

## Zeroing

Before measurements can be made with the BP Amp, it must be zeroed. A note below the **Zero** button indicates its status. To zero the BP Amp, connect up the blood pressure transducer and leave it open to the atmosphere (arranging the transducer valve is described on page 18), then click **Zero** in the BP Amp dialog. If you start sampling before the BP Amp has been zeroed, you will receive an alert and the BP Amp dialog will appear, at which stage the amp must zeroed.

On a Macintosh, **Zero** will be highlighted if the BP Amp is not zeroed. After clicking **Zero**, the note below the **Zero** button changes to indicate that the BP Amp has been zeroed, and the **OK** button is highlighted.

## Anti-alias

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 to aliasing can be seen in older Western films: spoked wagon wheels may appear to stop or even go backwards when their rate of rotation matches the film frame speed — obviously not showing 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.

---

## Units

The BP Amp measures blood pressure directly in mmHg (millimeters of mercury), once the BP Amp is zeroed. The BP Amp is pre-calibrated for use with the MLT0670 Disposable BP Transducer, but most blood pressure transducers connecting to the 4-pin connection of the supplied cable should also work. In the Units Conversion dialog you can check the preset unit conversion or do your own calibration, if you prefer or if using another transducer (you can calibrate it against a pressure standard). To open the Units Conversion dialog, choose **Units Conversion...** from the Channel Function pop-up menu.

A small, rounded rectangular button with a light gray background and a thin black border. The text "Units..." is centered on the button in a black, sans-serif font.

In addition, on a Macintosh, from the BP Amp dialog you can click **Units...** to open the Units Conversion dialog, and click **Preset** and **Custom** to change between the preset calibration and the one you set yourself in the Units Conversion dialog.



# Technical Aspects

■ This appendix describes some of the important technical aspects of the BP Amp, to give some insight into how it works. You do not need to know the material here to use a front-end. It is likely to be of special interest to the technically minded, indicating what a 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 BP Amp and other ADInstruments front-ends have been designed to integrate fully into the PowerLab system. Each requires connection to the PowerLab via a special communications connector called the I<sup>2</sup>C (eye-squared-sea) bus, and a BNC connector.

# BP Amp Operation

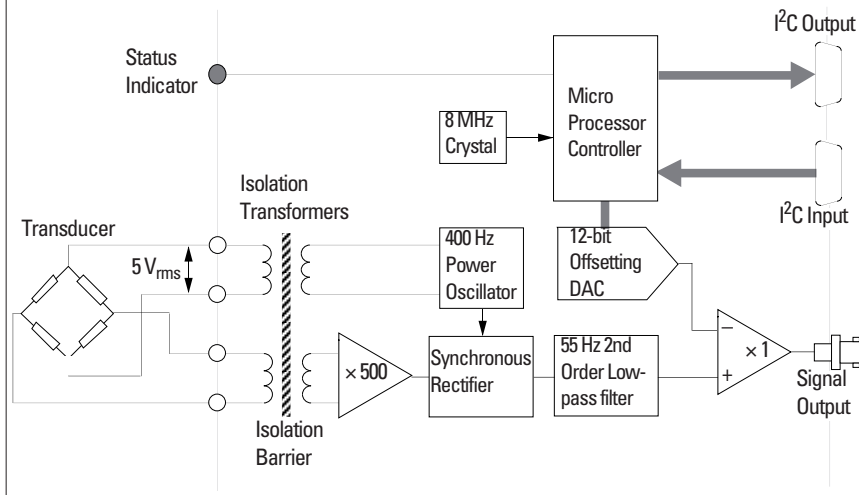
The BP Amp is essentially an extension of the PowerLab's analog input. The BP Amp provides:

- full electrical isolation from power-line (mains) circuitry to guarantee subject safety
- measurement of blood pressure directly in mmHg; units conversion is done for you
- precalibration with the MLT0670 blood pressure transducer, for convenient set-up
- the ability to override calibration when using other transducers.

The internal functions of the BP Amp are controlled from the PowerLab through the I<sup>2</sup>C bus, which also supplies power to the BP Amp. The front-end is also connected to an analog input channel of the PowerLab via a BNC-to-BNC cable, through which the signal is sent. The overall operation of the BP Amp can be better understood by referring to Figure A-1.

A power oscillator circuit running at 400 Hz is used to excite the transducer bridge. The BP Amp uses AC excitation for isolation, and for freedom from thermoelectric DC errors. The input signal from the connected transducer is fed across an isolation transformer into a stable, accurate, fixed-gain amplifier. The output of this amplifier is fed into a synchronous (phase-sensitive) rectifier to recover the DC content of the signal.

**Figure A-1**  
Block diagram of the  
BP Amp



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For the bridge used, each mmHg of the signal gives about  $25\ \mu\text{V}$  of signal for  $5\ \text{V}_{\text{rms}}$  excitation. The synchronous demodulation scheme is very effective at cancelling systematic and thermal (amplifier) noise.

The rectified signal then passes through a 55 Hz, second-order, low-pass filter, which provides output filtering of the data, and anti-alias filtering for the PowerLab input. A precision  $\times 1$  instrumentation amplifier finally compares the signal with the output of the 12-bit DAC. The DAC provides an exact offset voltage for zeroing and offsetting of the synchronously demodulated and filtered signal. This ensures maximum signal-to-noise ratio, good zeroing resolution, and maximum resolution in the displayed signal.

The control for offsetting and zeroing functions in the BP Amp is provided by an on-board microcontroller, which also communicates with the PowerLab over the I<sup>2</sup>C bus.

The good reproducibility of the blood-pressure transducers ensures good overall accuracy without the need for the user to apply units conversion. The only operations required are selection of pressure-range and an optional baseline pressure (zero is the default), then clicking on the **Zero** button with the pressure transducer open to the atmosphere (before connection to the subject).





# B

## Troubleshooting

■ This appendix describes most of the common problems that can occur when using the BP Amp 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 indicator fails to light when the software is started, or the front-end commands do not appear where they should*

The I<sup>2</sup>C cable or the BNC-to-BNC cable from the front-end to the PowerLab is not connected, has been connected incorrectly (to the wrong input or output, for instance), or is loose.

- Turn everything off. Check to see that all cables are firmly seated and screwed in. BNC cables from the BP Amp must be connected to a positive input on the PowerLab. Make sure the input is the same channel from which you expect to use the front-end in the software. Start up again to see if this has fixed the problem.

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 I<sup>2</sup>C 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 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.

*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 I<sup>2</sup>C 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 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.

*Some software settings don't resemble those in this guide*

You are using an early version of the front-end driver, or of LabChart or Scope. Some changes may have been made since then.

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



# C

## Specifications

### Input

Connection type:	6-pin Utah Medical 650-208 transducer cable with a 4-pin transducer connection cable
Safety:	Approved to IEC601-1 CF (cardiac protection) standard
Input impedance:	> 10 k $\Omega$ at 400 Hz AC
Input isolation:	Transformer isolation (AC bridge operation)
Isolation rating:	4000 V AC <sub>rms</sub> for 1 minute
Amplification ranges:	50 to 250 mmHg full scale in 3 steps (combined PowerLab and BP Amp)  0–250 mmHg 0–100 mmHg 0–50 mmHg
User offset:	Arbitrary scale offset (for example, –50 with 100 mmHg range gives –50 to 50 mmHg range)
Frequency response:	–3 dB at 50 Hz
Sensitivity:	Correct for 5 $\mu$ V/V/mmHg transducer standard (~350 $\Omega$ bridge)
Accuracy:	$\pm 2\%$ ( $\pm 0.2$ mmHg) all points, after zero correction
Input leakage current:	< 3 $\mu$ A <sub>rms</sub> at 240V, 50 Hz < 2 $\mu$ A <sub>rms</sub> at 120V, 60 Hz

Zeroing and offset: Automatic software-controlled fast zeroing, controlled by internal 12-bit DAC; resolution =  $\pm 0.2$  mmHg (with supplied transducer)

## Transducers

Transducer type: Precalibrated for use with MLT0670 Disposable BP Transducer: no further calibration needed for normal clinical applications

Excitation:  $\sim 5$  V<sub>rms</sub> AC at 400 Hz  $\pm 5\%$

Alternative types: Transducers up to 1 k $\Omega$  with  $\sim 5 \mu\text{V/V/mmHg}$  sensitivity, with a 4-pin transducer connection cable: they will need calibration.

## Filters

Low-pass filtering: Fixed 55 Hz ( $-3$  dB) two-pole Bessel filter (limited by PowerLab setting)

## Output

Signal:  $\pm 2.0$  V full scale: suitable for PowerLab

## Control Port

I<sup>2</sup>C port: Provides control and power. Interface communications rate of  $\sim 50$  kbits/s.

## Physical Configuration

Dimensions (h  $\times$  w  $\times$  d): 50 mm  $\times$  76 mm  $\times$  260 mm  
(1.97"  $\times$  3.0"  $\times$  10.2")

Weight: 750 g (1 lb 10.5 oz)

Power requirements: 2.5 W max

Operating temperature range: 5–35 °C

Operating humidity range: 0–90% (non-condensing)

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

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