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Bridge Amp

Owner's Guide

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ML228 Octal Bridge Amp

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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.

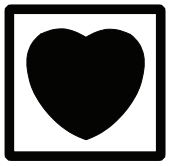
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Safety Symbols

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:

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- 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.

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- 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.

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- 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.

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CHAPTER 1

Overview

The Bridge Amp is a modular device, in a family called front-ends, designed to extend the capabilities of the PowerLab® system. The Bridge Amp is designed to allow the PowerLab to connect to most DC bridge transducers, including commonly available force transducers, temperature probes, light meters, displacement transducers, pressure transducers, and similar devices. This chapter provides an overview of the various Bridge Amps, describes their basic features, and looks at which transducers can be used with them.

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How to Use This Guide

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

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

Checking the Front-end

Before connecting the Bridge 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 Bridge 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.

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The PowerLab controls front-ends through an 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 very easy to add front-ends to the system or to transfer them between PowerLabs. In general, each front-end requires one analog input of the PowerLab. (Note that the Quad Bridge Amp acts as if it were four individual Bridge Amps and the Octal Bridge Amp, as if it were eight.)

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 software and presented as a single set of software controls. This seamless integration of front-ends greatly increases the flexibility and ease of use of the PowerLab system.

The Front-end

The Bridge Amp is designed to allow the PowerLab to connect to most DC bridge transducers, including commonly available force transducers, temperature probes, light meters, displacement transducers, pressure transducers, and similar devices. There are several models of Bridge Amp. The Bridge Amp provides just one connection for a bridge transducer, the Quad Bridge Amp provides four connections for bridge transducers and the Octal Bridge Amp provides eight connections for bridge transducers.

Grass transducers can connect to any ADInstruments Bridge Amp using a Grass adapter cable available from ADInstruments. Use the MLAC11 Grass Adapter Cable to connect a Grass transducer to the ML221, ML224 or ML228 Bridge Amp.

The rest of this chapter contains general information about the features, connections and indicators of the Bridge Amps. More detailed information can be found in the technical appendices.

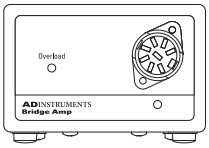
The Front Panel

The front panel of a Bridge Amp has a single socket for a transducer connection, a status indicator light and an overload indicator light. The front panel of a Quad or Octal Bridge Amp has four or eight transducer connections, respectively, each of which has a status indicator light and an overload indicator light.

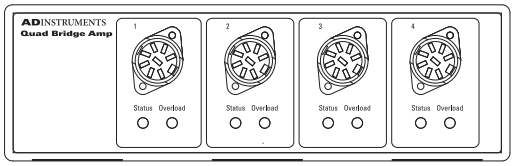
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Figure 1–1
The front panels of the Bridge Amps

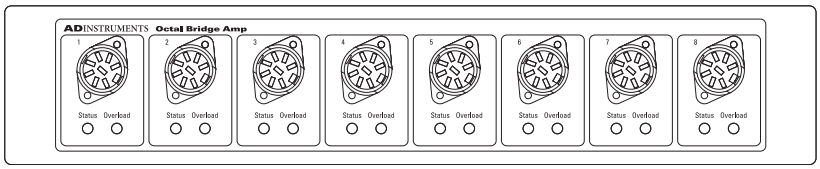
ML221 Bridge Amp



ML224 Quad Bridge Amp



ML228 Octal Bridge Amp



The Input Socket

Transducers are connected to a Bridge Amp using the eight-pin DIN sockets on the front panel. The sockets provide terminals for supplying a transducer with power and for receiving the transducer output. Front-ends are supplied with DIN plug kits (one per connection) to be fitted to those transducers that lack them. The connection is discussed in more detail later.

The Status Indicator

The Status indicator of the Bridge Amp is located at the bottom right of the front panel, and the Status indicators of the Quad Bridge Amp and Octal Bridge Amp are located beneath each connector on the front panel. When an ADInstruments program such as LabChart starts up, the Status indicator light should glow green, indicating that the program has found the front-end, checked and selected it, and is ready to use it. If the light does not glow when the program is running, this indicates either that the front-end is not connected properly or that there is a software or hardware problem.

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The Overload Indicator

The Overload indicator is located on the left side of the front panel of the Bridge Amp and to the right of the Status indicator on the Quad and Octal Bridge Amps.

The Overload indicator is normally off. If the indicator lights when a transducer is attached, it indicates an out-of-compliance condition (meaning that the excitation voltage drops because too much current is being drawn by the load). When the Bridge Amp detects a problem with the transducer (for instance a wiring fault with a transducer causing a short-circuit), the overload indicator will glow yellow or amber and will remain on until the fault is rectified.

If the overload indicator remains on with a transducer attached, the transducer should be removed immediately to minimize the risk of damage to the transducer. Check the transducer wiring carefully before re-attaching the transducer. If the fault persists, refer to the Troubleshooting section of this Owner's Guide.

For the overload indicator to function, power must be applied to the Bridge Amp via a PowerLab. LabChart software does not need to be loaded.

When a software application is running and a channel is being zeroed, the Status indicators for the other channels should temporarily be off.

The Back Panel

The back panel of the Bridge Amp provides all the sockets required to connect the Bridge Amp to the PowerLab and to other front-ends.

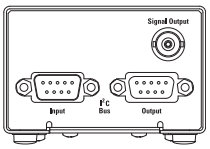
I^2C Input and Output Sockets

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

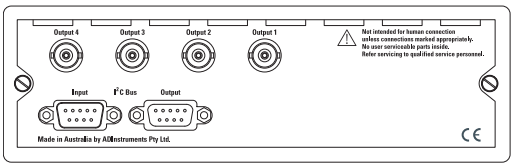
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Figure 1–2
The back panels of the Bridge Amps

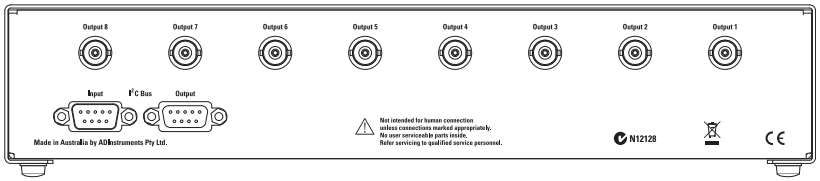
ML221 Bridge Amp



ML224 Quad Bridge Amp



ML228 Octal Bridge Amp



Analog Output Sockets

BNC sockets on the back panel of the Bridge Amp provide the signal outputs to connect to the analog input sockets on the front of the PowerLab. The sockets are labelled Signal Output on a Bridge Amp and Output 1 to Output 4 or 8 on Quad or Octal Bridge Amps. You don't have to match the channel numbers when connecting outputs to inputs, but it helps to prevent confusion if you do. A BNC-to-BNC cable is supplied for each connection.

Using Transducers

Bridge Amps are designed to allow the PowerLab to connect to most DC bridge transducers, including commonly available force, pressure, and displacement transducers, temperature probes, light meters, and similar devices. They are capable of supporting various powered transducers, and certain low-impedance unpowered (or self-powered) transducers.

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However, because transducers vary in sensitivity and suitability, you should read the following sections before connecting a transducer to a Bridge Amp.

Compatibility

Transducers which operate with the ML110, ML112, ML118, ML119 will operate with the ML22x Bridge Amps. The ML110 and ML112 amplifiers had provision for increasing offsetting resolution via an optional resistor installed in the transducer connector. Transducers which have this offsetting resistor fitted will operate with the ML22x Bridge Amps without modification.

Suitable Transducers

The Bridge Amps are designed to connect to transducers that require DC excitation voltages, such as DC strain-gauge or semiconductor transducers.

If you are uncertain about the suitability of your transducer, please provide ADInstruments with an accurate circuit of the transducer and a sample, and we will see about testing the device for compatibility. Half-bridge transducers will need to be wired up with compensating resistors before they can be used with any of the Bridge Amps (see Chapter 3).

DC Strain-gauge. These are full-bridge or half-bridge transducers requiring a DC excitation voltage, and output voltages of less than 200 mV full scale. They include strain-gauge force transducers, temperature transducers and pressure transducers.

Semiconductor. These are powered transducers typically used for light, displacement, and temperature measurements, giving output voltages less than 200 mV full scale.

Generally, a Bridge Amp can be used with transducers that:

- require DC excitation voltages, not AC
- have transducer output voltages less than 5 V full scale
- have transducer impedances less than 10 kΩ.

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Unsuitable Transducers

Some transducers are not supported and should not be used with the Bridge Amp. These include LVDT, capacitive bridge, piezoelectric and high-voltage transducers.

LVDT (linear variable differential transformer). This type of transducer requires AC excitation voltages. The Bridge Amp is for use with transducers requiring DC excitation. Connecting an LVDT transducer to the Bridge Amp may damage the transducer.

Capacitive Bridge. These transducers require AC excitation. The Bridge Amp is for use with transducers requiring DC excitation.

Piezoelectric. These transducers are not recommended owing to the relatively low input impedance of the single Bridge Amp (piezoelectric transducers typically need amplifiers with input impedances of tens of megohms), and their half-bridge configuration.

High-voltage. Transducers generating more than ±5 V full scale will exceed the input range of the Bridge Amp. A high-voltage powered transducer may require some signal attenuation.

How Transducers Work

The Bridge Amp can connect to most bridge-type transducers, hence its name. The term 'bridge' refers to the circuit configuration that is normally called a Wheatstone bridge. These transducers come in two forms: full-bridge and half-bridge. Some explanation is given here of bridge-type transducers, although there are of course other types that work differently, such as the semiconductor transducer.

The full-bridge circuit is fairly versatile, in that the circuit elements, shown as the rectangular boxes in Figure 1–3, can be resistive, capacitive, or thermal circuit elements, allowing the bridge to measure force, pressure, temperature, and so forth. This circuit produces an electrical output in proportion to an appropriate stimulus applied to one or more of the four elements. Because of the balancing effect of the four elements, high precision is possible. Full-bridge transducers should work without problems.

A half-bridge transducer only uses half of the full-bridge circuit. It consists of two elements of equal value with an excitation voltage applied across them. The output of the transducer is taken at the junction of the two elements.

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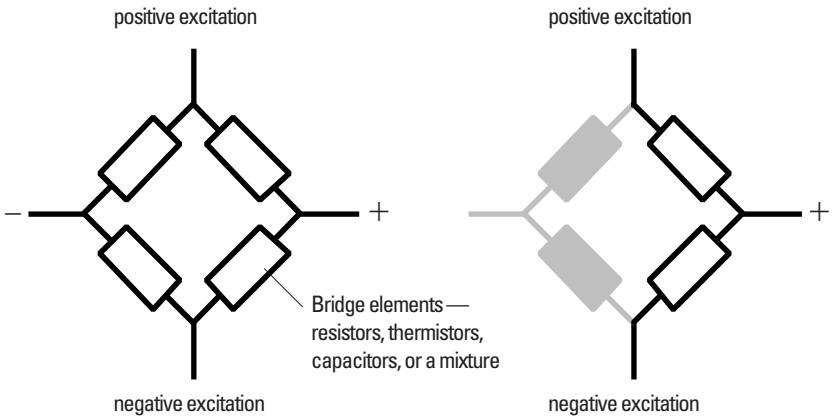


Figure 1–3
Left, a full-bridge transducer; right, a half-bridge transducer

The circuit forms a simple voltage divider. If one of the elements changes value owing to an external stimulus, the output voltage will also change. In practice, this configuration is not often used. Half-bridge transducers will require adapting with compensating resistors before use with a Bridge Amp.

Checking the Transducer

Before attempting to connect any transducer to a Bridge Amp, you will need to determine the three things listed below. (This information is normally supplied with the transducer; if not, you should consult the manufacturer or supplier of the transducer.)

1. If the transducer requires an excitation voltage, and if so, what the maximum excitation voltage, or recommended range, is for the transducer.
2. The configuration of the transducer wiring connections.
3. If the transducer is a bridge-type transducer, and whether it has a full-bridge or half-bridge configuration.

Transducers supplied by ADInstruments are supplied pre-adjusted, and need no adjustment.

Do not attempt to connect the signal leads from the transducer to the Bridge Amp if the wiring configuration is not known. Connecting an incorrectly wired transducer to an excitation source is likely to damage both the transducer and Bridge Amp.

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Unpowered transducers, or those with their own power supply, do not have to be supplied with any excitation voltage from the Bridge Amp: they supply their own signal to it directly. The wiring connections should still be carefully checked before connection, along with transducer impedance and output voltage. Such transducers do not need the excitation range to be adjusted from the default setting. If they have low output voltages, though, then it is possible that their offset ranges require adjusting.

Using Grass Transducers with DIN Bridge Amps

Most Grass transducers should have an impedance of about 350 Ω or so. A few Grass and Grass-compatible transducers have a much lower impedance, of about 250 Ω.

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CHAPTER 2

Setting Up

This chapter describes connecting your Bridge 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 Bridge Amp with ADInstruments application software.

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PowerLab Requirements

The ML221, ML224 and ML228 Bridge Amps will only operate with newer models of PowerLabs, such as the /SP, /20, /26 and /30 series.

Software Requirements

The ML221, ML224 and ML228 Bridge Amps require the following versions of ADInstruments software applications:

- LabChart version 6, or later, for Windows or Macintosh
- Chart version 5.4.2, or later, for Windows or Macintosh
- Scope for Windows version 3.7.8, or later
- Scope for Macintosh version 4.0.3, or later.

Note: the Bridge Amps will not operate with earlier versions of these applications. Free updates are available from the ADInstruments website for users with earlier versions of Chart 5 and Scope. If you have queries regarding hardware and software requirements of the Bridge Amps, please contact your local ADInstruments representative.

Connecting to the PowerLab

Connect your Bridge Amp, to the PowerLab, as follows:

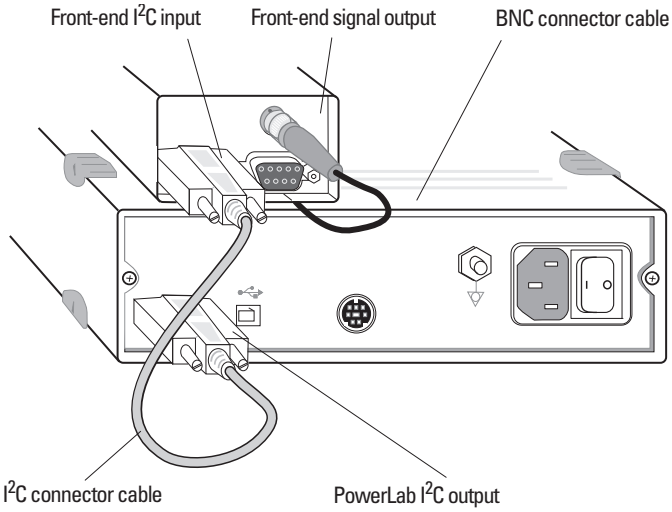
- Ensure that the PowerLab is turned off. Failure to do this may damage the PowerLab, the Bridge Amp, or both.
- Connect the I^2C output of the PowerLab to the I^2C input of the front-end using the I^2C cable provided.
- Connect a BNC cable from each signal output, on the rear of the Bridge Amp, to an input on the front panel of the PowerLab.

Note that the Quad Bridge Amp acts just as if it were four individual Bridge Amps; the Octal Bridge Amp, eight. The I^2C connections are internal, though, so there is only one I^2C cable needed to connect the Quad or Octal Bridge Amps to the recording unit.

Check that the plugs for the I^2C bus are screwed in firmly and the BNC cables have firm connections. Loose connectors can cause erratic front-end behavior, or may cause the front-end to fail to work at all. BNC cables can lie under the front-end to keep them out of the way.

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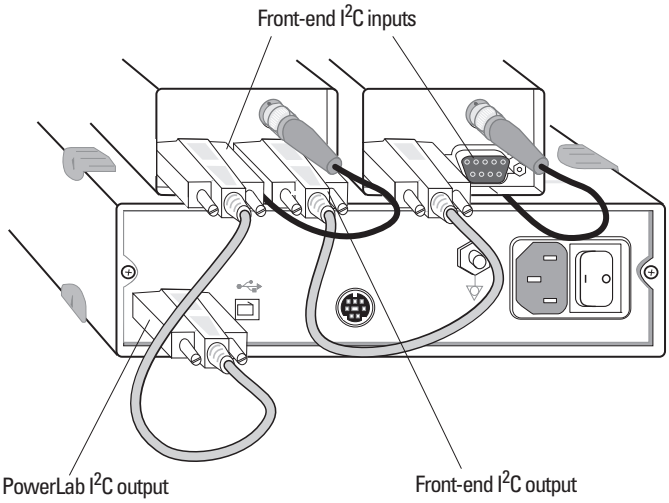
Figure 2–1
Connecting a front-end to the PowerLab: a PowerLab has only one I^2C output, and each front-end has one I^2C output and one I^2C input



Multiple Front-ends

Multiple front-ends can be connected up to a PowerLab. The number that can be connected depends on the number of inputs 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 next front-end to be added, as shown in Figure 2–2. The BNC cable for each front-end is connected to one of the inputs of the PowerLab (except where otherwise specified).

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



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Using ADInstruments Programs

Front-ends are used with PowerLabs and ADInstruments software applications such as LabChart and Scope (see Software Requirements, p. 24). The Bridge Amp's amplification and filtering is combined with that of the PowerLab and the program and presented as a single set of software controls, in this case replacing the Input Amplifier dialog with the Bridge Amp dialog. The LabChart Help Center and *Scope User's Guide* detail the Input Amplifier dialog, and explain relevant terms and concepts.

The Front-end Driver

A driver is a piece of software the computer uses to drive a peripheral device. In order for a front-end to be recognized by ADInstruments applications, the appropriate front-end driver must be present. The Bridge front-end driver is used with the Bridge Amp. Front-end drivers are installed when ADInstruments applications are installed on the computer.

LabChart and Scope for Macintosh keep separate drivers in the Essential Files folder in the LabChart or Scope folder. LabChart for Windows has them built in, and Scope for Windows has them in the Essential Files folder in the Scope folder. To replace the drivers, you generally need to reinstall the ADInstruments software.

The Bridge Amp Self-test

Once the Bridge Amp is properly connected to the PowerLab, and when the proper software is installed on the computer, a quick check can be performed on the Bridge Amp. 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 the ADInstruments program such as LabChart or Scope.
3. While it starts up, keep a close eye on the Status and Overload indicators on the Bridge Amp. During initialization, the Status indicators glow green, flash briefly, and then remain lit.

If the indicator glows green, the Bridge Amp is working properly, and you can quit the application. If a light does not go on when the program is started, this indicates either that the front-end is not connected properly or that there is a software or hardware problem.

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If the overload light glows yellow (or amber) on any Bridge Amp, this indicates some fault such as a short circuit, a badly wired bridge transducer, or an excitation overload. In the first instance, check your cable connections and transducers, and repeat the self-test. If this does not solve the problem, contact your ADInstruments representative.

When a Bridge Amp is properly connected to the PowerLab, the **Input Amplifier**... menu command are replaced by **Bridge 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.

The documentation for LabChart and Scope does not cover front-end-specific features. These features are described in detail here for LabChart. For the most part, dialogs for LabChart and Scope should be much the same.

The Bridge Amp Dialog

The Bridge Amp dialog allows software control of the various amplifiers and filters in the Bridge Amp and PowerLab for an input. The signal present at a PowerLab input is displayed so that you can see the effects of changes straight away. Once the settings in the dialog are changed, click **OK** to apply them.

To set up many inputs quickly, click the arrows at the top of the dialog, or use the right or left arrow keys on the keyboard, to move to the equivalent dialogs for adjacent inputs. This skips channels that have their inputs turned off. The input number is shown at the top of the dialog, and the channel title (if any) is shown in the vertical Amplitude axis of the dialog.

Signal Display

The input signal is displayed so you can see the effect of changing the settings — no data are in fact recorded 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.

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

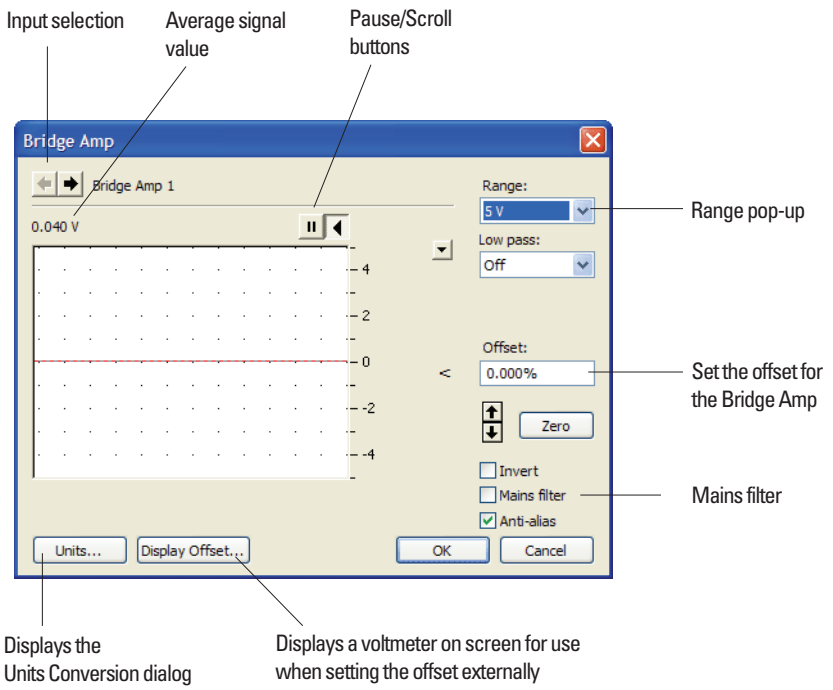
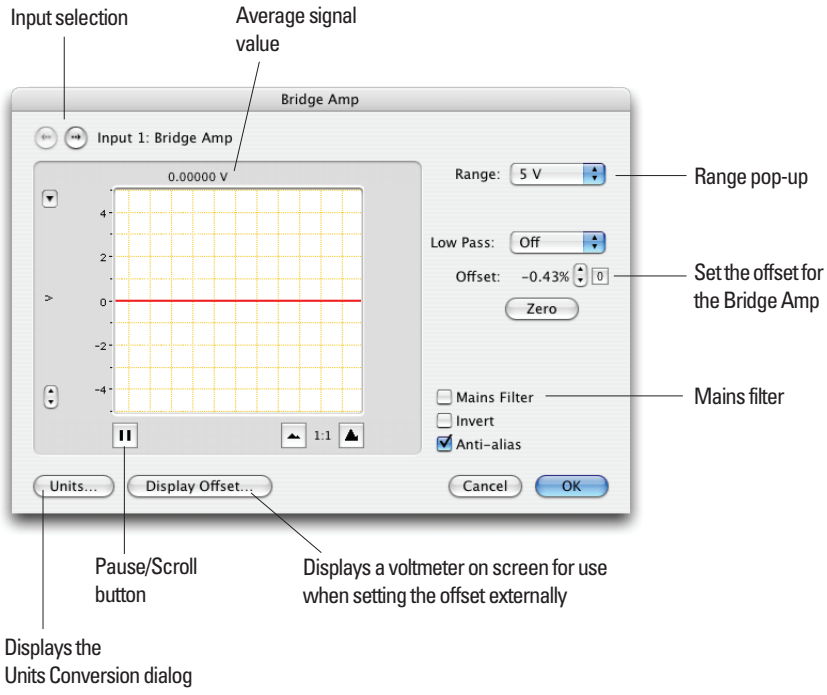


Figure 2–4
The Bridge Amp dialog for Macintosh (after zeroing)



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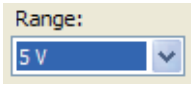
You can stop the signal scrolling by clicking the Pause button at the bottom left (Macintosh) or top right (Windows) of the data display area. On the Macintosh this changes to the Scroll button. Click the Scroll button to start scrolling again.

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.

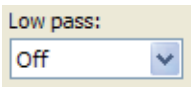
Setting the Range



The **Range** pop-up menu lets you select the input range or sensitivity of the channel (combined range of the PowerLab and Bridge Amp). Changing the range in the Bridge Amp dialog is equivalent to changing it in the Chart window. The default setting is 5 V and the ranges go down to 200 μV in 14 steps.

Filtering

The filtering options provided are appropriate to the type of transducers used with the Bridge Amp, and the signals usually measured, which tend to be of lower frequency. Low-pass filters allow you to remove high-frequency components, such as noise, from an input signal. The Mains filter allows you to remove interference at the mains frequency (typically 50 or 60 Hz).



Low-Pass Filtering. The **Low Pass** pop-up menu provides a choice of filters to remove high-frequency components from the signal. They are: 1, 2, 10, 20, 100, and 200 Hz, and 1 kHz. (The highest frequency you can actually record is limited by the transducer you use: such information should be in the documentation supplied with it.)



Mains Filter (/20, /25 and /30 series PowerLabs only). The **Mains filter** checkbox allows you to filter out interference at the mains frequency (typically 50 or 60 Hz). Note that in general it is better to prevent interference at its source than to filter it. The mains filter is an adaptive filter which tracks the input signal over approximately 1 second. It analyzes the signal and creates a template of any interference due to the mains frequency (see Appendix C). Subtraction of the template from the incoming signal cancels most of the interference.

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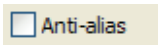
In comparison with a notch filter, this method produces little waveform distortion and attenuates harmonics of the mains frequency as well as the fundamental; it effectively removes non-sinusoidal interference, such as that commonly caused by fluorescent lights.

The filter should not be used when:

- the interference changes rapidly. The filter takes about 1 second to adapt to the present level. If interference is present, and then is suddenly removed, interference in the filtered signal will temporarily be increased.
- your signal contains repetitive components at frequencies close to the mains frequencies.
- your signal is already free from interference. If the signal-to-noise ratio is greater than about 64 the mains filter introduces more noise than it removes.
- you are recording at close to maximum sampling rates. The mains filter uses some of the PowerLab's processing power and therefore reduces the maximum rate at which you can sample.

The template is not fully generated until about 1 second after sampling starts and so the mains filter is not fully effective in the first second of each data block.

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 can be seen in older Western films: spoked wagon wheels appear to stop or even go backwards when their rate of rotation matches the film frame speed – obviously not an accurate record of the wheels' motion.

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

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Inverting the Signal



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

For example, you might be recording from a force transducer where an increase in force downwards gives a negative signal, but you want to have a downwards force shown as a positive signal on the screen. Checking the Invert checkbox will change the display to do this.

Offset Adjustment

Transducers almost always produce some amount of signal, usually small, when in the equilibrium or rest state. Offset from a zero reading need to be removed, in a process called zeroing. Commonly, the user also wants to remove a constant term, for example baseline blood pressure or initial tension in a muscle, from a measurement of interest. This enables more accurate measurement of the changes in the signal under stimuli. The offset controls in the Bridge Amp dialog can be used to zero the reading manually or automatically.



Figure 2–5
The Offset controls, Windows (left) and Macintosh (right)

Manual Zeroing. The up and down arrows near the **Zero** button allow manual adjustment of the signal offset. Click the up arrow to shift the signal positively and the down arrow to shift it negatively. The shift by clicking the arrow buttons depends on the range setting. At high ranges the increments are larger to adjust the offset efficiently.

Automatic Zeroing. To perform automatic zeroing, click **Zero**: the program works out a corrective DC voltage that cancels, as closely as possible, the output voltage from the transducer. Auto-zeroing may take about 20 seconds to work out the best zeroing value at all ranges. A dialog with a progress bar appears: click the Cancel button or type Command-period to stop the zeroing process. If there is still offset after auto-zeroing, then Option-click the up and down arrow buttons to adjust the zeroing slightly, by the smallest increment at any range.

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Note. Variations in the transducer signal during the auto-zeroing operation will cause the software to fail to zero the offset properly, if it zeroes at all. Make sure that the transducer is kept still and that no varying signal is applied during the operation.

The offset display, a small numeric indicator above the **Zero** button, shows the corrective voltage used to adjust for transducer offset. The offset is given in the units of the channel. When the Bridge Amp is first powered up, the software sets the offset circuit to its default position (no offset adjustment of the transducer) and the offset display value is zero. When either **Zero** or the manual offset controls are clicked, this value will change to indicate the positive or negative corrective adjustment.

On a Macintosh, click the small **0** button to restore the offset circuit to its initial, non-zeroed position (and the offset display value to zero). This can be used to determine the offset generated by a transducer.

Display Offset

Click **Display Offset**... to display the Input Value dialog (Figure 2–6). A voltmeter displays the voltage currently being measured for an input (the input channel is indicated at the top of the dialog). If a transducer or some other external equipment has offset adjustment capabilities, you can use this to zero it.

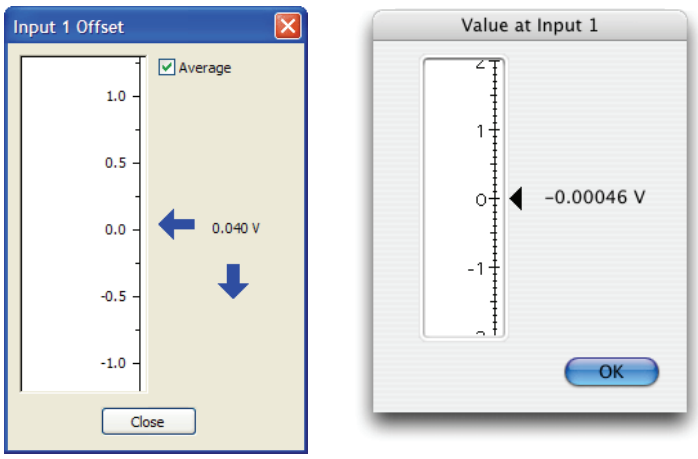


Figure 2–6
The Input Value dialog, Windows (left) and Macintosh (right)

Because the dialog allows for such fine adjustment, a vertical arrow appears indicating the zero point if the offset is substantial. This dialog is not a control, simply an indicator that acts like a voltmeter.

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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. The waveform in the data display area of the Bridge Amp dialog is transferred to the data display area of the Units Conversion dialog. (Use the Pause button to capture a specific signal.) The units conversion only applies to subsequently recorded signals, so it is more limited than choosing **Units Conversion**... from a Channel Function pop-up menu, as it does not allow conversion of individual blocks or pages of data.

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CHAPTER 3

Adapting Transducers

This chapter describes the modifications that may be required to connect third-party transducers to the Bridge Amp. Transducers supplied by ADInstruments should connect directly without modification, so if using those you need not read this chapter.

If you are using powered third-party transducers with your Bridge Amp you may need to adapt them using the information provided here.

NOTE: Please ensure that any modifications made to transducers are carried out by experienced technical staff, as incorrect wiring may damage the transducer or Bridge Amp. If you are unsure, please contact your nearest ADInstruments representative for further assistance.

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Introduction

Conventional amplifiers usually have controls on the front to adjust for the connected transducer: this means making adjustments each time you change transducers or amplifiers.

Front-ends controlled by ADInstruments software are designed to be easily transferred between recording units, and to be quick to disconnect and reconnect, so it makes more sense to adapt the transducer. The change needs only be done once for any third-party transducer, which can then be used with any Bridge Amp with the same connector. Once set up, multiple transducers will work with the same Bridge Amp without needing further adjustment, and one can simply change connected transducers as required.

Some soldering of components is required to adapt third-party transducers for use with your Bridge Amp. If you have little experience with electronics and no technician to assist you, your ADInstruments representative should be able to help.

Types of Bridge Amp and Adaptation

The ML118 Quad and ML119 Octal Bridge Amps have a fixed excitation voltage of 8 V (±4 V with respect to ground). You cannot adjust the offset voltage range of the zeroing circuit for these front-ends. Adapting powered transducers for them is relatively simple.

Transducer Adaptations

This section covers adapting transducers for use with the ADInstruments Bridge Amps.

To connect transducers that require some form of power supply from the Bridge Amp, first read this section carefully. The requirements of the transducer should be determined before attempting to connect it.

To adapt a transducer for use with the Bridge Amp, you need to:

- set the excitation voltage for the transducer
- wire the transducer to use the eight-pin DIN plug.

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You will need the following equipment:

- a soldering iron and resin-cored solder (ONLY resin-cored solder)
- an eight-pin DIN-style male plug with 45-degree pin spacing (supplied with your Bridge Amp)
- common E12 resistors: 0.25 or 0.125 Watt, 2% or 1% metal film.

Setting the Excitation Voltage

The first step in preparing a powered transducer for use with the Bridge Amps is to set the required excitation voltage. Two of the pins in the Bridge Amp's DIN socket can provide up to 20 volts DC as excitation voltage to power the transducer. The voltage is varied by a resistor fitted between the two corresponding pins of the transducer's DIN plug. When no resistor is present, the Bridge Amp's internal circuitry cuts off all voltage to prevent mishaps. Once a resistor is fitted, the correct excitation voltage is provided automatically when the transducer is plugged into the Bridge Amp.

Table 3–1
Transducer excitation voltage and resistance

Excitation voltage (DC volts)	Excitation resistance (Ω)	Excitation voltage (DC volts)	Excitation resistance (Ω)
20	Short circuit	5	470 k
18	12 k	4	560 k
15	47 k	3.5	680 k
12	100 k	3	820 k
10	150 k	2.5	1 M
8	220 k	2	1.2 M
6	330 k		

To program the excitation voltage for a particular transducer, choose a value of resistance from Table 3–1 to match the required excitation voltage for your transducer. In most cases, you should be able to get close to the required excitation voltage by selecting one of those values. We recommend that the excitation resistor be 0.25 or 0.125 Watt, 2% or 1% metal film. Larger resistors may not fit in the confined space of the transducer's DIN plug.

In general, the output voltage from the transducer is directly proportional to the excitation voltage placed across it. The greater the excitation voltage, the more sensitive the transducer becomes.

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However, transducers have a limit to the level of excitation voltage that can be applied before they are damaged. Some resistive elements may start to heat at high excitation voltages, causing their resistance to change. This degrades the accuracy of the transducer. High voltages may also damage capacitive bridge transducer elements. To avoid problems, the excitation voltage should be set according to the manufacturer's recommendation for that transducer.

To set the excitation voltage for a transducer, you will need to solder the chosen resistor between pins 5 and 8 of the eight-pin DIN plug, as shown in Figure 3–1. Mount the resistor as shown for maximum clearance within the plug.

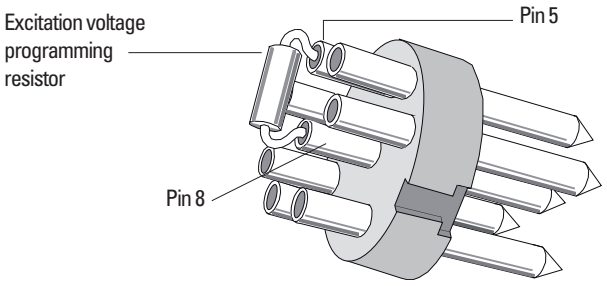


Figure 3–1
Installing the programming resistor (the pins are labeled on the plug)

Wiring Up the Transducer

The second step in preparing a powered transducer for use with the Bridge Amp is to wire the transducer to the DIN plug.

There are several things to note when wiring up transducers:

1. Make sure that the transducer wiring passes through the casing before soldering the wires to the plug.
2. The transducer wires should be cut, stripped and tinned prior to soldering, to ensure a good connection.
3. The pin numbers shown in the diagrams are the numbers marked on most standard DIN plugs. If the plug has no numbers or different ones, go by the layout shown here.

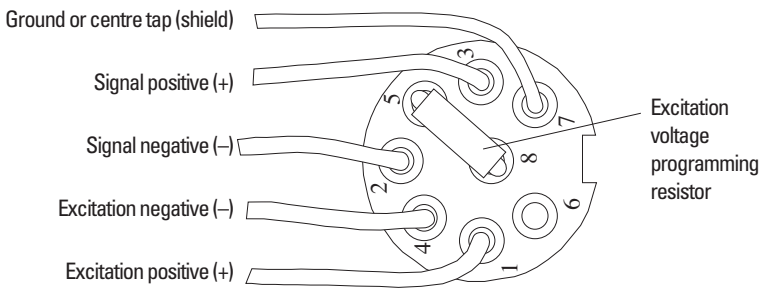
Wiring Up a Full-Bridge Transducer

This procedure should be used to wire full-bridge transducers only, not half-bridge transducers. The transducer lead wires should be soldered to the pins of the DIN plug as shown in Figure 3–2.

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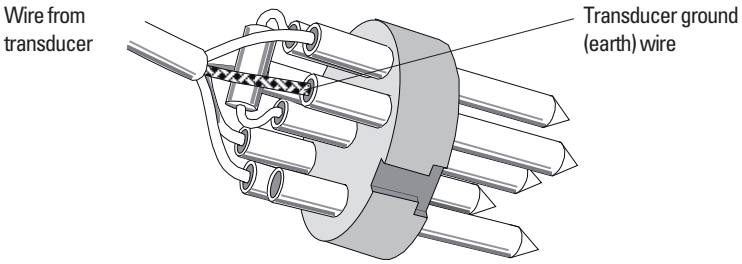
Any unused wires from the transducer should be cut and insulated to prevent shorting of signals or damage to the equipment.

Figure 3–2
The wiring connections for a full-bridge transducer, looking at the DIN plug from the cable side



The main insulation sheath of the transducer wiring should be clamped with the strain-relief device within the plug, so that it just clears the excitation voltage resistor. The transducer will normally have some sort of cable shield, which should be connected to pin 7 of the DIN plug. If the casing of the DIN plug is metal, it is recommended and good practice to ensure that the casing will also be connected to the shield.

Figure 3–3
The correct length of wiring to the DIN plug



The Finished Transducer

After connecting the excitation voltage programming resistor and wiring up the transducer to the DIN plug, the transducer should now be fully configured for your application. The excitation voltage will be set automatically when you plug the transducer into the Bridge Amp.

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APPENDIX

A Technical Aspects

This appendix describes some of the important technical aspects of the Bridge Amp to give some insight into how it works. You do not need to know the material here to use the Bridge Amp. It is likely to be of special interest to the technically minded, indicating what the Bridge Amp can and cannot do, and its suitability for particular applications. (You should not use it as a service manual: user modification of the equipment voids your rights under warranty.)

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Bridge Amp Operation

The Bridge Amp and other ADInstruments front-ends have been designed to integrate fully with the PowerLab system. The Bridge Amp is essentially an extension of the PowerLab's input amplifiers, so the amplification (and hence the ranges) offered in LabChart and Scope are the combination of both pieces of hardware. The Bridge Amp provides:

- the additional amplification necessary to deal with the low signal outputs of most transducers
- additional programmable filtering, to remove unwanted signal frequencies
- a stable DC excitation voltage supply for powering the transducer
- digitally-controlled transducer zeroing circuitry.

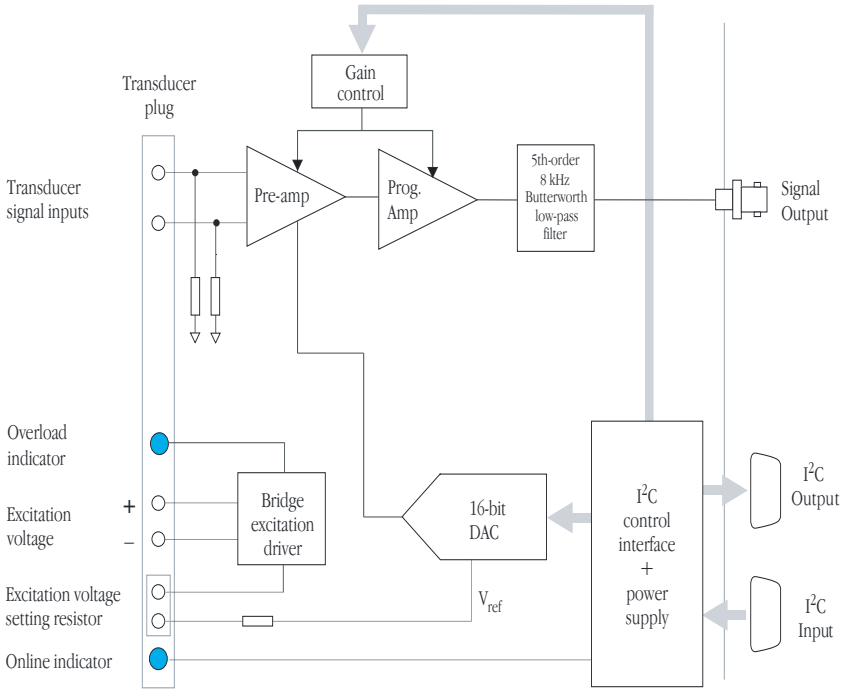


Figure A–1
Block diagram of the ML221 Bridge Amp. The ML224 and 228 Bridge Amps are similar but with four or eight inputs, respectively

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Technical Description

The PowerLab provides control and low-voltage power to front-ends through a special expansion connector called the I^2C (eye-squared-sea) bus. Front-ends are also connected to the analog inputs of the recording unit via a BNC-to-BNC cable. The overall operation of the Bridge Amps can be better understood by referring to Figure A–1.

The digital control interface used to control filter settings, gain, coupling, and zeroing circuits uses an I^2C interface system, which provides a 4-wire serial communication bus to the recording unit and other front-ends. All control of the Bridge Amp is through this bus. Also present on the I^2C connector is a set of power supply rails derived from the recording unit. The Bridge Amp has its own on-board regulators to ensure a stable power supply.

The input stage consists of a low-drift instrumentation amplifier with programmable gain (fully software-controlled). The gain of this stage is combined with the gain of the recording unit to give a total gain of up to 50 000 (at this amplification, 200 μV is full scale). From the input amplifier, the signal is passed to a fixed fifth-order, low-pass, filter. The filter allows a range of cutoff frequencies to be selected under software control.

The excitation voltage output circuit is a complementary output stage, derived from a stable internal voltage reference, capable of giving up to ±10 volts (20 volts DC) excitation. The excitation voltage for each channel is completely independent from other channels. The transducer excitation voltage can be adjusted by connecting a resistor between two pins on the plug that plugs into the Bridge Amp's input socket. This resistor is usually placed inside the transducer's DIN plug so that the transducer will always get the correct excitation voltage when it is connected.

To remove any offsets caused by an attached transducer or signal baseline, a DC offset circuit with a 16-bit DAC (digital-to-analog converter). This is internally connected to the input stage. Transducer offsets are zeroed by applying a corrective DC voltage to the input stage via the DAC, under software control.

The DAC is only capable of producing corrective voltages in discrete steps.

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APPENDIX B

Troubleshooting

This appendix describes most of the common problems that can occur when using the Bridge 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 solutions. 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 Bridge Amp or the PowerLab itself.

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Problems

The Status indicator fails to light when the software is started, or the Bridge Amp… command does not appear where it should

The I^2C cable or one or more BNC-to-BNC cables from the Bridge Amp to the PowerLab are not connected, have been connected incorrectly (to the wrong input, for instance), or are loose.

- Turn everything off. Check to see that all cables are firmly inserted and screwed in. Make sure the input is the same channel from which you expect to use the Bridge Amp in the software. Ensure no other equipment is attached to the particular channel of the Powerlab from which you expect to see the Bridge Amp. 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^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 Bridge Amp is faulty.

- This is the least likely event. If the Bridge Amp will not work properly after the previous measures, then try using it on another PowerLab. If the Bridge Amp's Status indicator fails to light with a second PowerLab, the Bridge Amp may be faulty. Contact your ADInstruments representative to arrange for repairs.

One or more overload indicators glow amber

If a light glows amber (yellow), it indicates some fault such as a short circuit, a badly wired bridge transducer, or an excitation overload.

- Check to see that all transducer connections are firm.
- Check for short circuits and badly wired bridge transducers, by changing them around, connecting new ones, and so on.
- Check transducer impedances. In particular, a low-impedance Grass transducer (250 Ω or so) may suffer overload if the excitation is too high.

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

The correct Bridge driver is not installed on your computer (it should be in the Essential Files folder, inside 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^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 Bridge Amp is faulty.

- This is the least likely event. If the Bridge Amp will not work properly after the previous measures, then try using it on another PowerLab. If the Bridge Amp's Status indicator fails to light with a second PowerLab, the Bridge Amp may be faulty. Contact your ADInstruments representative to arrange for repairs.

The trace will not zero properly when using the automatic or manual zeroing controls

Variations in the transducer signal during auto-zeroing may cause the software to fail to zero the offset properly, if it zeroes at all.

- Make sure that the transducer is kept still and that no varying signal is applied during auto-zeroing.

The transducer is defective or subject to excessive load, causing the offset range of the Bridge Amp's zeroing circuitry to be exceeded.

- Check the transducer with another Bridge Amp if possible and try again. Contact the supplier or manufacturer of the transducer if there still seems to be a problem.

You are using an unmodified half-bridge transducer.

- Half-bridge transducers may require rewiring with compensating resistors before they can be used with Bridge Amps.

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The signal from the transducer is noisy at lower ranges

This is usually the amplified noise from the transducer and its associated circuitry, not a fault as such.

- Set the low-pass filter to remove the noise.

The signal from the transducer is weak even at lower ranges

The connection to the transducer may be connected incorrectly, or may be loose or disconnected. Adaptations within the plug may be faulty or badly wired up.

- Check the connection and try again. If the transducer has been adapted for use with the Bridge Amp, check the wiring and soldering within the plug.
- Ensure that the particular channel in LabChart has been correctly recognized as a Bridge Amp (and not as Input Amplifier).

The transducer itself is faulty.

- Check the transducer with another Bridge Amp if possible and try again. Contact the supplier or manufacturer of the transducer if there still seems to be a problem.

The signal from the transducer drifts excessively.

- Both the Bridge Amp and transducer require time to reach thermal equilibrium. Allow 5 minutes of warm-up time with the transducer connected and then try to re-zero the transducer.
- The transducer itself may be of low quality.
- The excitation voltage may be too high and causing the transducer to self-heat and drift. Try reducing the excitation voltage.

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APPENDIX C

Specifications

Single, Quad and Octal Bridge Amps (ML221, ML224 & ML228)

Input

Number of inputs:	1 (single), 4 (Quad) or 8 (Octal); 8-pin DIN
Input configuration:	Differential
Amplification range:	±200 µV to ±5 V full scale in 14 steps (combined PowerLab and Bridge Amp)
	± 5 V ± 2 V ± 1 V ± 500 mV ± 200 mV ± 100 mV ± 50 mV ± 20 mV ± 10 mV ± 5 mV ± 2 mV ± 1 mV ± 500 µV ± 200 µV
Amplification accuracy:	±0.5% (combined PowerLab and Bridge Amp)
Maximum input voltage:	±10 volts
Input impedance:	2 × 1 MΩ (single-ended) 2 MΩ (differential)
Low-pass filtering:	1 Hz to 1 kHz in seven steps (software-selectable)

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Frequency response (–3 dB):	2 kHz maximum at all gains with the low-pass filter off
CMRR (differential):	100 dB @ 50 Hz (typical)
Input noise:	<1 μV_{rms} referred to input at highest gain

Excitation and Zeroing

Excitation voltage range:	0–20 volts DC (±10 V referred to ground), adjusted by external resistor
Transducer drive current:	±45 mA maximum
Zeroing circuitry:	Software-controlled, either manual or automatic
Internal offsetting range:	±10 V (1 V–5 V range) ±1 V (100 mV–500 mV range) ±100 mV (200 μV–50 mV)
Internal offset resolution:	16-bit (internal DAC) ±32 000 steps about 0 V. 1, 2, 5 V - 310 μ V/step 100 mV, 200 mV, 500 mV - 31 μ V/step 200 μV to 50 mV - 3 μV/step

Control Port

I^2C port:	Power and control bus for front-end units. Supports a number of front-ends dependent on the PowerLab. Interface communications rate of ~50 kbits/s.

Physical Configuration

Weight and Dimensions (h × w × d):

Single (ML221):	50 mm × 76 mm × 260 mm (1.97" × 3.0" × 10.2"); 710 g
Quad (ML224):	60 mm × 200 mm × 250 mm (2.36" × 7.9" × 9.8"); 1.5 kg
Octal (ML228):	60 mm × 300 mm × 300 mm (2.36" × 11.8" × 11.8"); 3.4 kg
Power requirements:	0.8 W (ML221); 2.5 W (ML224); 5.0 W (ML228) (without transducer attached)
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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