ADINSTRUMENTS
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Neuro Amp EX

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.

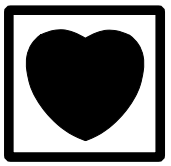
The choice to meet IEC 60601-1 is in no way to be interpreted to mean that a product:

- 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.

Neuro Amp EX Safety Instructions

The Neuro Amp EX has been designed for research use only. While it can be directly connected to humans using metal microelectrodes, it should not be used for clinical or health purposes.

The input amplifiers in the Neuro Amp EX headstage and front-end are electrically isolated from the mains supply in order to prevent current flow that could result in injury to the subject. The following points must be adhered to for the safe operation of this system:

- Intramuscular or neural recording from human subjects using microelectrodes must only be performed by suitably qualified personnel under the direct approval of institutional ethics review panels and with full adherence to universal precautions for prevention of contamination.
- The Neuro Amp EX is supplied with a headstage with integrated sockets for connecting to standard metal microelectrodes. Under no circumstances should the headstage be used if the input connectors, cable or front-end connections are damaged.
- The Neuro Amp EX is only safe for connection to humans when it is used with an ADInstruments headstage. Do not use any other headstage when directly connecting the Neuro Amp EX to human subjects.
- With human connections, the headstage must be securely attached to the subject so that the headstage is not able to move independently of the subject. It is recommended to tape the headstage to the subject.
- Under no circumstances should the headstage be removed from the subject while electrodes are still attached to a subject.

Isolated Stimulator Safety Instructions

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

- The Isolated Stimulator output must only be used with the supplied bar stimulus electrode.
- The Isolated Stimulator output must not be used with individual (physically separate) stimulating electrodes.
- Stimulation must not be applied across the chest or head.
- Do not hold one electrode in each hand.
- Always use a suitable electrode cream or gel and proper skin preparation to ensure a low-impedance electrode contact. Using electrodes without electrode cream can result in burns to the skin or discomfort for the subject.
- Subjects with implantable or external cardiac pacemakers, a cardiac condition, or a history of epileptic episodes must not be subject to electrical stimulation.
- Always commence stimulation at the lowest current setting and slowly increase the current.
- Stop stimulation if the subject experiences pain or discomfort.
- Do not use faulty cables or those that have exhibited intermittent faults.
- Do not attempt to measure or record the Isolated Stimulator waveform while connected to a subject using a PowerLab input or any other piece of equipment that does not carry the appropriate safety symbol (see Safety Symbols above).

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

- Always be alert for any adverse physiological effects in the subject. At the first sign of a problem, stimulation must be stopped, either from the software or by flicking down the safety switch on the front panel of any built-in Isolated Stimulator or the ML180 Stimulus Isolator.

- The ML180 Stimulus Isolator is supplied with a special transformer plug pack. The plug pack complies with medical safety requirements. Therefore, under no circumstances should any other transformer be used with the Stimulus Isolator. For a replacement transformer plug pack please contact your nearest ADInstruments representative.

General Safety Instructions

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

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

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

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

- Any electrical equipment which is located within the SUBJECT AREA should be approved to IEC60601-1.
- Only connect those parts of equipment that are marked as an APPLIED PART to the subject. APPLIED PARTS may be recognized by the BF or CF symbols which appear in the Safety Symbols section of these Safety Notes.
- Only CF-rated APPLIED PARTS must be used for direct cardiac connection.
- Never connect parts which are marked as an APPLIED PART to those which are not marked as APPLIED PARTS.
- Do not touch the subject to which the PowerLab (or its peripherals) is connected at the same time as making contact with parts of the PowerLab

(or its peripherals) that are not intended for contact to the subject.

- Cleaning and sterilization of equipment should be performed in accordance with manufacturer's instructions. The isolation barrier may be compromised if manufacturer's cleaning instructions are not followed.
- The ambient environment (such as the temperature and relative humidity) of the system should be kept within the manufacturer's specified range or the isolation barrier may be compromised.
- The entry of liquids into equipment may also compromise the isolation barrier. If spillage occurs, the manufacturer of the affected equipment should be contacted before using the equipment.
- Many electrical systems (particularly those in metal enclosures) depend upon the presence of a protective earth for electrical safety. This is generally provided from the power outlet through a power cord, but may also be supplied as a dedicated safety earth conductor. Power cords should never be modified so as to remove the earth connection. The integrity of the protective earth connection between each piece of equipment and the protective earth should be verified regularly by qualified personnel.
- Avoid using multiple portable socket-outlets (such as power boards) where possible as they provide an inherently less safe environment with respect to electrical hazards. Individual connection of each piece of equipment to fixed mains socket-outlets is the preferred means of connection.

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

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

Cleaning and Sterilization

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

Preventative Inspection and Maintenance

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

Internal diagnostic software performs system checks during power up and will report errors if a significant problem is found. There is no need to open the instrument for inspection or maintenance and doing so within the warranty period will void the warranty.

Your PowerLab system can be periodically checked for basic safety by using an appropriate safety testing device. Tests such as earth leakage, earth bond, insulation resistance, subject leakage and auxiliary currents and power cable integrity can all be performed on the PowerLab system without having to remove the covers. Follow the instructions for the testing device if performing such tests.

If the PowerLab system is found not to comply with such testing you should contact your PowerLab representative to arrange for the equipment to be checked and serviced. Do not attempt to service the device yourself.

Environment

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

Storage Conditions

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

Operating Conditions

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

Disposal

- Forward to recycling center or return to manufacturer.
- Unwanted equipment bearing the Waste Electrical and Electronic Equipment (WEEE) Directive symbol requires separate waste collection. For a product labelled with this symbol, either forward to a recycling center or contact your nearest ADInstruments representative for methods of disposal at the end of its working life.

WEEE Directive symbol

CHAPTER 1

Overview

The Neuro Amp EX is one of a family of modular devices called front-ends, designed to extend the capabilities of the PowerLab® system. It differs from other front-ends by including an additional piece of hardware, the headstage. The Neuro Amp EX allows the PowerLab system to record single-unit or multi-unit extracellular action potentials from single neurons or axons. The front-end is fully isolated for human use, in addition to being suitable for extracellular recordings from experimental animals.

How to Use This Guide

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

There is an index at the end of this guide. Technical terms are defined in the glossary of terms included with the owner's guide for your PowerLab or as they appear in this guide.

Checking the Front-end

Before connecting the Neuro Amp EX 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.

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. The Neuro Amp EX 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^2C (pronounced 'eye-squared-sea') bus. Each new front-end added to the system connects to the back of the previous front-end, in a simple daisy-chain structure. This makes it easy to add front-ends to the system or to transfer them between PowerLabs. In general, each front-end requires at least one analog input channel 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.

The Front-end

The Neuro Amp EX is designed to allow the PowerLab system to perform isolated measurements of single-unit or multi-unit extracellular action potentials from single neurons or axons, from human or animal subjects. It consists of an electrically isolated differential input AC amplifier with an isolated ground connection.

It is possible to 'daisy-chain' multiple Neuro Amp EXs to record from separate subjects, using separate grounds. It is not recommended to use more than one Neuro Amp EX to record from a single subject or to use a Neuro Amp EX with an ADInstruments' Bio Amp to record from a single subject (this is discussed in more detail in the next chapter).

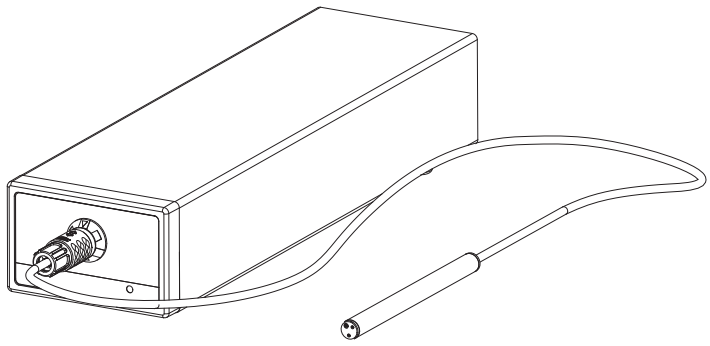
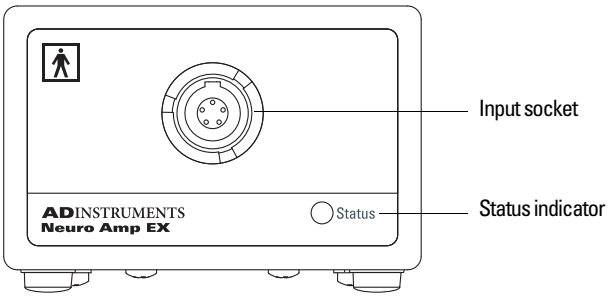


Figure 1–1
The Neuro Amp EX front-end with headstage attached

The Front Panel

The front panel of a Neuro Amp EX has an input socket and a status indicator light.

Figure 1–2
The front panel of the Neuro Amp EX



The Input Socket

The headstage output cable is coupled to the front-end using a five-pin socket on the front panel: the pin arrangement ensures that the polarity is correct. The socket is physically and electrically isolated from the low-voltage mains-supply circuitry of the PowerLab and the input connections are isolated internally by isolation circuitry. The socket provides 7.5 V supply lines to the headstage, a protected earth and differential input lines.

The Status Indicator

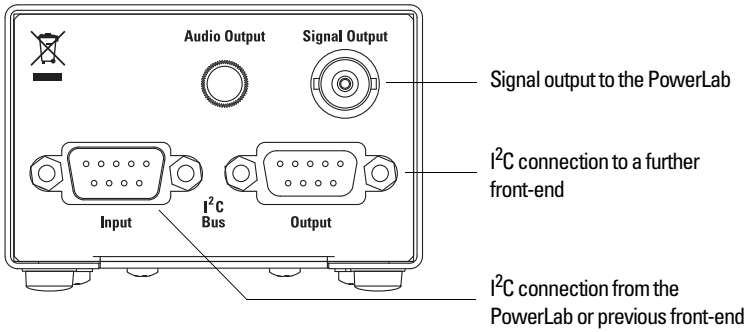
The status indicator light of a Neuro Amp EX is located at the bottom right of the front panel.

When an ADInstruments application such as LabChart starts, the status indicator should flash briefly and then remain green, indicating that the program has found the front-end, checked and selected it, and is ready to use it. If the status indicator does not turn on and stay on when the application starts, it is most likely that the front-end is not connected properly.

The Back Panel

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

Figure 1–3
The back panel of the Neuro Amp EX



I²C Input and Output Sockets

Two nine-pin sockets are used to communicate with the PowerLab (they are marked 'I²C Bus': a 'bus' is simply 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).

Analog Out Socket

The BNC socket labeled Analog Out on the back panel provides the signal output and a connection is made to an analog input socket on the front of the PowerLab with a BNC-to-BNC cable (supplied).

If you are connecting to an earlier model PowerLab with differential inputs, only connect the analog output to the positive analog input of the PowerLab. ADInstruments applications do not find a front-end on start up if the negative input is used.

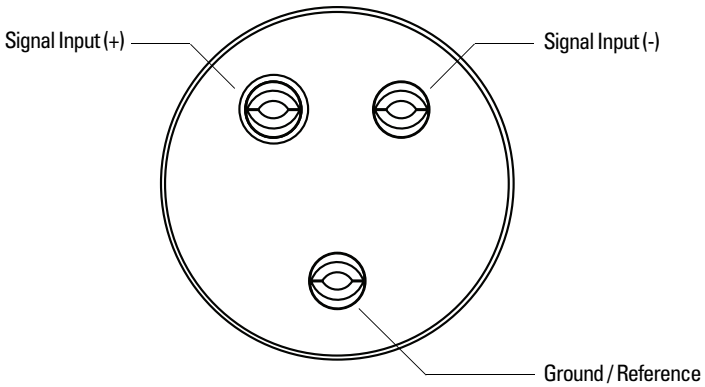
Audio Out Socket

The Neuro Amp EX has an audio monitor output on the back panel that can be used with a wide range of headphones or externally powered speakers. The 3.5 mm socket provides mono sound that may be of use when monitoring nerve firings, to control the placement of electrodes for instance.

The Neuro Amp EX Headstage

The headstage can be mounted in a micromanipulator for animal use or taped directly to the skin of a human subject. The casing of the headstage is connected to the shielding of the cable, thereby providing shielding up to the input terminals. Three female Amphenol sockets provide inputs for the headstage. The positive and negative terminals are adjacent, while the ground terminal is further away. The positive terminal is distinguished by a slightly recessed surround.

Figure 1–4
Input sockets for the Neuro Amp EX headstage



Six male Amphenol connectors or pins are supplied and can be crimped to standard metal microelectrodes, such as tungsten, stainless steel or platinum, to allow you to construct electrodes to suit your requirements.

Connections are made to the Neuro Amp EX front-end using the supplied Neuro Amp EX headstage and connectors (microelectrodes are not supplied). The headstage cable plugs into the five-pin input socket on the front panel: the pin arrangement ensures that polarity is correct. Only use the supplied Neuro Amp EX headstage as others may not meet safety requirements.

Figure 1–5
Neuro Amp EX headstage with male connectors attached

Types of Measurement

The low noise and high gain of the Neuro Amp EX makes it suitable for all recordings that require a high bandpass (300 Hz – 5 kHz) and a high signal to noise ratio. Such recordings may include extracellular recordings from single cells or groups of cells, or from single nerve fibres (split-nerve preparation or human microneurography). The headstage provides a gain of 100x and the cable shielding is directly connected to the casing, limiting the need for additional shielding at the input terminals. The Neuro Amp EX is not suitable for intracellular recording with glass microelectrodes.

Recording Technique

When conducting research using the Neuro Amp EX, it is important to ensure that you use correct preparation and recording techniques. It is important to understand the types of problems that can occur, how they manifest, and what can be done to remove them or to minimize their effect. Potential problem areas include aliasing, frequency distortion, saturation, ground loops, electrode contact, motion artifacts, electromagnetic fields, and data display.

It is recommended that the LabChart and Scope Guides be read prior to recording neurological signals using the Neuro Amp EX. More information can also be obtained from your ADInstruments representative.

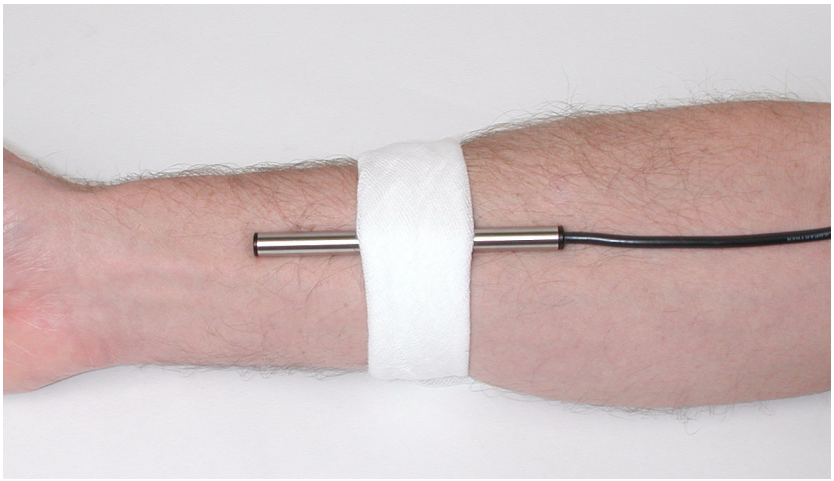
For microneurography studies, it is normal that the subject is passive during the procedure. The headstage must be attached to the Neuro Amp EX before and during the procedure. Not having the headstage attached to the Neuro Amp EX before and during the procedure may result in static shocks being delivered to the subject through the microelectrodes.

During the procedure, an operator securely attaches the headstage to the subject (using tape or a bandage), grounds the subject using the Ground/Reference socket of the headstage, and connects the active and reference mocroelectrodes to the headstage. The active microelectrode is inserted into the skin overlying the nerve, while the reference electrode is inserted under the adjacent skin. Under no circumstance should the headstage be disconnected from the Neuro Amp EX while the electrodes are still attached to the subject. The ground lead can be attached to a surface electrode using a press stud or snap fitting. See Figure 1–6 for an example.

Figure 1–6
An example of a lead wire with press stud or snap fitting at one end

The headstage must be securely attached (Figure 1–7) to the limb of the subject under investigation. This ensures that the headstage is in contact with the subject and helps to minimize artifacts from movement. Microelectrode needles (Figure 1–8) should be positioned using examination gloves to minimize the risk of infection.

Figure 1–7
The headstage securely attached to the forearm using a firmly fitting bandage to prevent movement

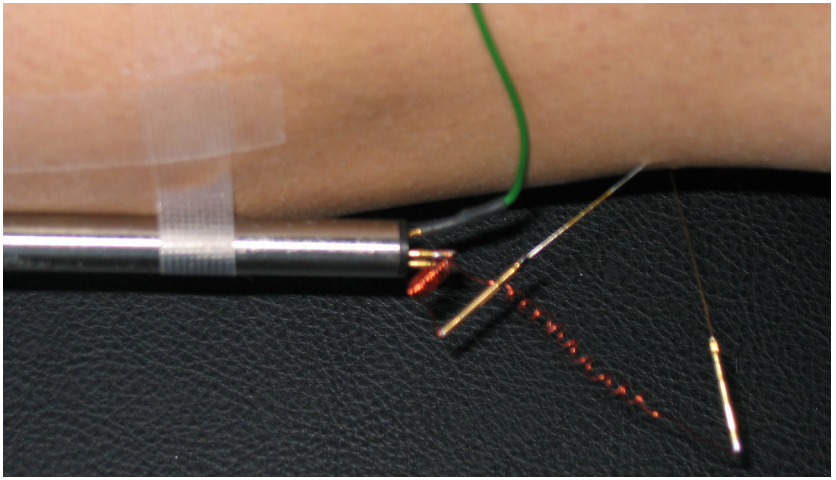


Electrode Contact

Occasionally during measurement of a neurological signal, one of the lead wires connecting the source to the front-end may become disconnected, or electrode contact may become poor. If this should happen, relatively high voltages (potentials) can be induced in the open wire, due to electric fields caused by the power line or other sources close to the front-end or to the subject.

This induced potential results in a constant amplitude disturbance of the recorded waveform, at the mains frequency, and loss of the desired signal. If the problem is a recurring one, one of the leads may be faulty. Check connections and replace faulty leads, if necessary.

Figure 1–8
The active microelectrode (normal to the skin) is inserted into the common peroneal nerve at the fibular head. The reference microelectrode (oblique to the skin) is inserted under the skin. The ground electrode (AgAgCl) is attached to the surface of the skin with the green lead.



Motion Effects

A common source of artifacts when recording neurological signals is motion of the subject or equipment. For example, muscular activity generates its own electrical signals, which may interfere with the neuronal signal, depending on the location of the electrodes.

If the subject is going to move during recording, then special care needs to be taken when positioning electrodes and securing leads.

CHAPTER

2 Setting Up

This chapter describes how to connect the Neuro Amp EX to your PowerLab and perform 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 to the PowerLab, first ensure that the PowerLab is turned off. Failure to do this may damage the PowerLab, the front-end, or both.

Connect the signal output on the rear panel of the Neuro Amp EX to an analog input on the front panel of the PowerLab using a BNC cable. If the PowerLab has differential (rather than single-ended) inputs, the BNC cable must connect to a positive analog input of the PowerLab. ADInstruments applications will not find the front-end on start-up if a negative input is used.

Single Front-end

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

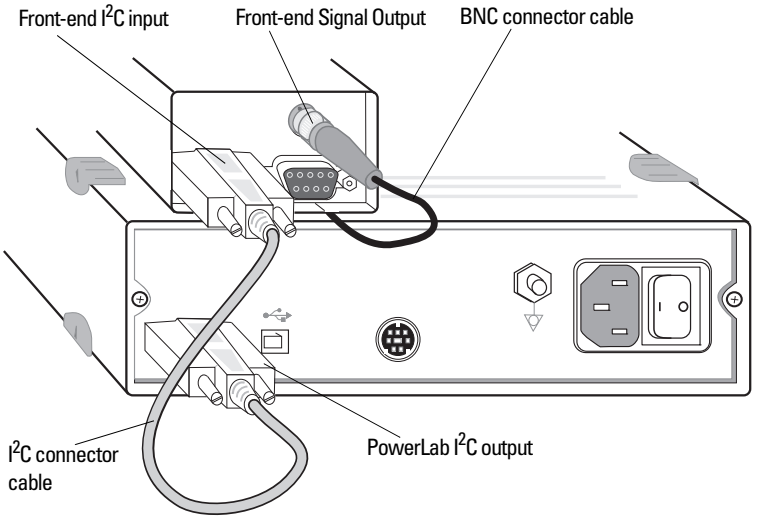


Figure 2–1
Connecting a front-end to the PowerLab: a PowerLab has only one I^2C output, and each front-end has one I^2C output and one I^2C input

Check that the plugs for the I^2C bus are screwed in firmly. Check the BNC cable for firm connections as well. Loose connectors can cause erratic front-end behavior, or may cause the front-end to fail to work at all. The BNC cable can be tucked under the front-end to keep it out of the way if desired.

Multiple Front-ends

Multiple separate front-ends can be connected to a PowerLab. The number of normal front-ends that can be connected depends on the number of input channels on the PowerLab, since each signal output from the front-ends is connected to one of the 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^2C cable, as shown in Figure 2–1. The remainder are daisy-chained via I^2C cables, connecting the I^2C output of the last connected front-end to the I^2C input of the front-end to be added, as shown in Figure 2–2. Note that signal degradation may occur if multiple front-ends share a common ground, such as by being connected to a single subject.

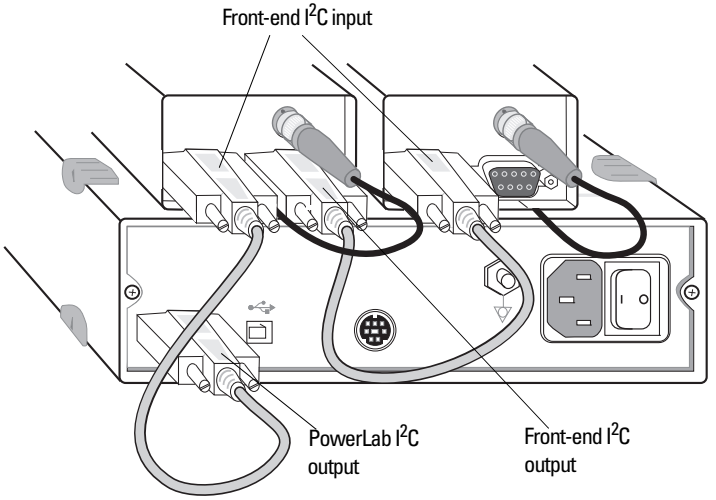


Figure 2–2
Connecting two front-ends to the PowerLab: a connection is made from the I^2C output on the first front-end to the I^2C input on the second front-end

Using More Than One Neuro Amp EX

Although you can record with more than one channel using a common ground, such as recording from a single subject, it is not recommended. When using two or more front-ends, some interaction can take place between them, causing up to 10 μV of induced low-frequency signal, through slight differences in frequency between the isolated power supplies. This should not affect most biopotential measurements, especially if using signal averaging. Narrowing the signal pass band may also reduce the effect.

Using ADInstruments Programs

The front-end is used with a PowerLab and ADInstruments application, such as LabChart and Scope. The amplification and filtering of the Neuro Amp EX is combined with that of the PowerLab and the application and presented as a single set of software controls, replacing the Input Amplifier dialog with the Neuro Amp EX dialog. The LabChart Help Center and *Scope User's Guide* describes the Input Amplifier dialog and explains 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 Neuro Amp EX front-end driver is used with the Neuro Amp EX. Front-end drivers are automatically installed when ADInstruments applications are installed on the computer.

On both Windows and Macintosh, LabChart and Scope front-end drivers are kept in an Essential Files folder in the LabChart and Scope folders, respectively. To replace the drivers, simply reinstall the ADInstruments application.

The Neuro Amp EX Self-test

Once the Neuro Amp EX is properly connected to the PowerLab, and when the correct software version is installed on the computer, the following quick check can be performed on the Neuro Amp EX:

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, start either LabChart or Scope. While the software is starting, watch the Neuro Amp EX's Status indicator. During initialization the indicator should flash briefly and then remain lit.

If the Status indicator illuminates, the Neuro Amp EX has been found by the PowerLab and is working. If the Status indicator doesn't illuminate, check the cable connections and repeat the procedure.

Software Behavior

When a Neuro Amp EX is properly connected to the PowerLab, the **Input Amplifier**… menu command is replaced with **Neuro Amp EX**… for the input to which the Neuro Amp EX is connected. If the application fails to find a front-end connected, the normal text remains. If the expected text is not displayed, quit the application, turn the PowerLab off and check the BNC and I^2C 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. Generally, dialogs for these applications are similar. The Neuro Amp EX dialog for LabChart for Macintosh and LabChart for Windows are very similar and are described here together.

Neuro Amp EX Dialog

The Neuro Amp EX dialog (Figure 2–3 and Figure 2–4) allows software control of the combined input amplifiers and filters in the PowerLab and Neuro Amp EX. The signal present at a channel's input is displayed in the preview area so that you can see the effects of changes in settings. After changing settings in the dialog, click the **OK** button to apply them.

The Neuro Amp EX dialog appears when you choose **Neuro Amp EX**… from a Channel Function pop-up menu (or click **Neuro Amp EX**… in the Input Settings column in the Channel Settings dialog). To set up many channels quickly, click the arrows by the dialog title, or press the right or left arrow keys on the keyboard, to move to the equivalent dialogs for adjacent channels. This skips channels that are turned off. The channel number is shown in the title of the dialog.

Signal Display

The input signal is displayed so you can see the effect of changing the settings — no data is recorded while setting things up. Slowly changing waveforms are represented quite accurately, whereas quickly changing signals are 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 above the display area.

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

On the 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.

You can 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.

Figure 2–3
The Neuro Amp EX dialog for Windows

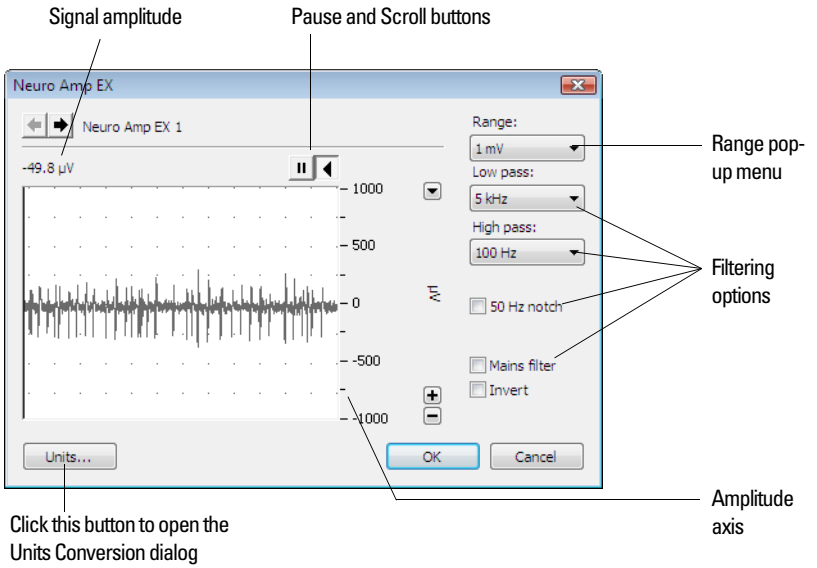
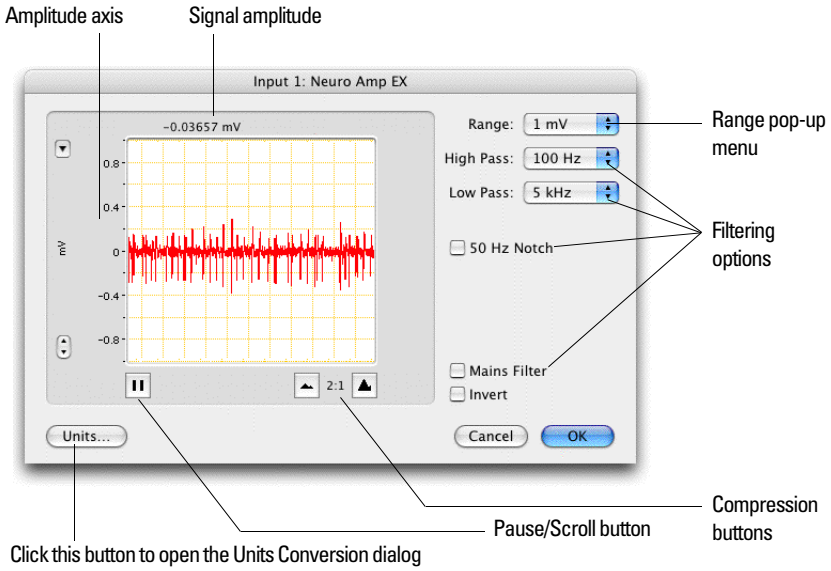
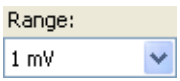


Figure 2–4
The Neuro Amp EX dialog for Macintosh



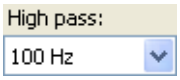


Setting the Range

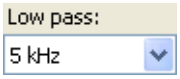
The **Range** pop-up menu lets you select the input range or sensitivity of the channel — the combined range of the PowerLab and the Neuro Amp EX. Changing the range in the Neuro Amp EX dialog is equivalent to changing it in the Chart or Scope window. The default setting (if you have not loaded a settings file) is 1 mV and the ranges go down to 20 μV in 6 steps.

Filtering

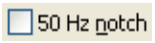
The Neuro Amp EX has low-pass, high-pass, notch and mains filter circuitry that can be adjusted to suit the application. The notch filter removes 50 or 60 Hz interference and the mains filter removes mains frequency related interference. Note that, in general, it is better to prevent interference at the source than to filter it. The high-pass and low-pass filters provide bandwidth limiting of low-frequency and high-frequency signals, respectively. Note that the settings for one filter type may restrict the possible settings for the other.



High-Pass Filtering. The **High pass** pop-up menu gives the choice of 100 Hz, 300 Hz and 500 Hz high-pass filters. The high-pass filter removes frequencies below the selected filter frequency and allows high frequencies in the signal to pass. Note, this amplifier is not suitable for DC recording.



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



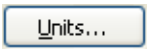
Notch Filter. Select or deselect the **Notch** checkbox to turn the notch filter on and off. The notch filter is automatically set to either 50 or 60 Hz, depending on the power line voltage frequency being used by the PowerLab (the mains frequency). It provides approximately 32 dB of attenuation, thus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

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

Inverting the Signal

The **Invert** checkbox provides a simple way to change the polarity of the recorded signal without having to swap the connections to the recording electrodes.

Units



Clicking the **Units**... button displays the Units Conversion dialog, with which you can set the units for a channel and, using waveform measurements,

calibrate the channel. The waveform in the data display area of the Neuro Amp EX 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. It is more limited than choosing units conversion directly as it does not allow conversion of individual blocks of data.

Setting up to Record From a Subject

This section provides a step-by-step guide to making a recording from a subject. After making the subject comfortable, a suitably qualified operator can use the following steps to attach the headstage. The operator should follow their institute's guidelines for making neurological recordings and use precautions to minimize the risk of infection:

1. Attach the headstage to the Neuro Amp EX.
2. Securely attach the headstage to the subject by taping or bandaging it to the limb or trunk.
3. Insert all the pins into the headstage.
4. Attach the ground electrode first. Take care to attach the correct electrode to either a positive or negative input on the headstage using Figure 1–4 as a guide.
5. To help locate the nerve site, stimulating techniques compatible with your institute's guidelines may be used. Stimulation may be made using the ADInstruments Stimulus Isolator, or another Isolated Stimulator. The Audio Output from the Neuro Amp EX can be connected to external speakers. Changes in signal output can be observed using the Neuro Amp EX dialog or by recording data using Scope or the Scope View in LabChart.
6. Remove stimulation leads from the headstage before recording: leaving them attached will introduce noise.

APPENDIX

A Technical Aspects

This appendix describes some of the important technical aspects of the Neuro Amp EX to give some insight into how it works. It is not necessary to know the material here to use the Neuro Amp EX. It is likely to be of interest to the technically minded, indicating what the front-end can and cannot do, and its suitability for particular purposes. (There are no user-serviceable parts inside the Neuro Amp EX; do not use this appendix as a service manual. User modification of the equipment voids the warranty.)

Neuro Amp EX Operation

The Neuro Amp EX and other ADInstruments front-ends have been designed to integrate fully into the PowerLab system. The Neuro Amp EX is essentially an extension of the PowerLab's input amplifiers. The amplification and ranges offered in LabChart and Scope result from the combination of both pieces of hardware.

The Neuro Amp EX provides:

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

Technical Description

The PowerLab provides control and low-voltage power to front-ends through a special expansion connector called the I^2C bus. Front-ends are also connected to the analog inputs of the PowerLab via a BNC cable, through which they send the amplified and filtered signals. The overall operation of the Neuro Amp EX can be better understood by referring to Figure A–1.

The headstage is a differential in/differential out with a fixed gain of ×100 and a 10 Hz high-pass filter. The amplifier drives a differential signal into the Neuro Amp EX. Power is supplied through the connector. A reference pin is a current-limited isolated ground return to protect against excessive auxiliary current. The overall operation of the Neuro Amp EX headstage can be better understood by referring to Figure A–2.

The input amplifier of the Neuro Amp EX starts with an electrically isolated differential amplifier. The output of this is fed into a low-noise demodulator and then to a programmable gain stage, before being fed across an isolation transformer to the non-isolated circuitry.

Figure A–1
Block diagram of the Neuro Amp EX

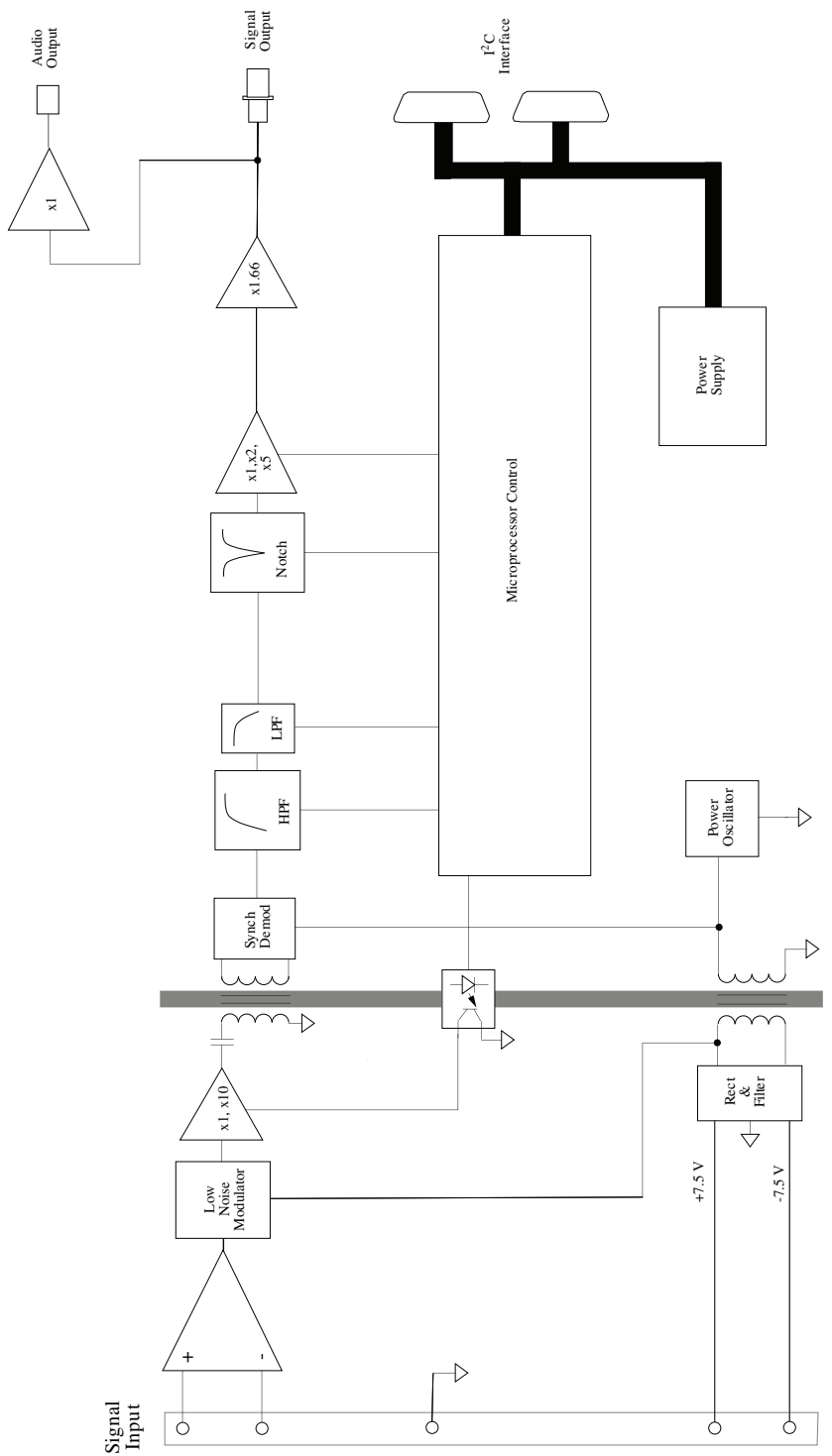
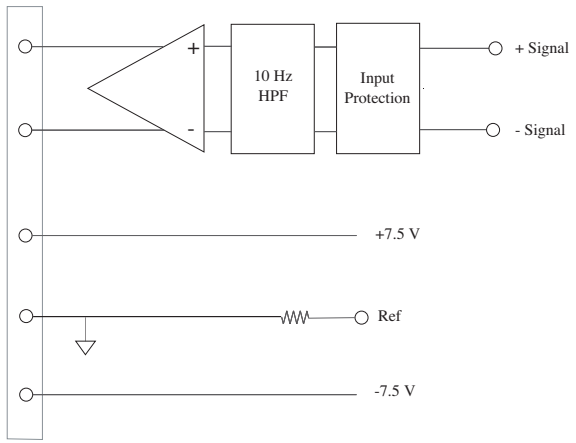


Figure A–2
Block diagram of the Neuro Amp EX headstage



Control of the isolated gain is provided via a high-isolation-voltage optocoupler. Isolated power comes from a second isolation transformer driven by a power oscillator circuit running at about 38 kHz.

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

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

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

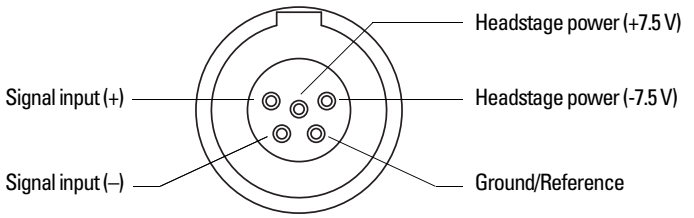
The control for the various filters and gain stages in the Neuro Amp EX is provided by on-board microprocessors, which also communicate with the PowerLab over the I^2C bus.

The Neuro Amp EX Input

The Neuro Amp EX headstage cable plugs into the five-pin input socket on the front panel of the Neuro Amp EX. The pin arrangement ensures that polarity is correct. Only the supplied Neuro Amp EX headstage should be used. Using other headstages invalidates the warranty and may not be as safe. ADInstruments are not responsible for damages incurred if using third party headstages.

The Neuro Amp EX has one connector: the socket provides two pins for a differential input signal, one pin for the ground, or reference, and two pins for power supply to the headstage. The entire connector is physically and electrically isolated to ensure subject safety.

Figure A–3
The pin assignments for the Neuro Amp EX input connector



APPENDIX B

Troubleshooting

This appendix describes most of the common problems that can occur when using the Neuro Amp EX 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 you may 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.

Problems

The status indicator fails to illuminate when the software is started, or the front-end commands do not appear where they should

The I^2C cable or the BNC cable from the front-end 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 seated and screwed in. The BNC cable from the Neuro Amp EX 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^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 Neuro Amp EX is faulty.

- This is the least likely event. If the front-end will not work properly after the previous measures, 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 driver is not installed on your computer (it 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^2C cable is faulty.

- Replace the cable and try again. Immediately label all cables that proved

faulty so that you don't use them again by accident.

The Neuro Amp EX is faulty.

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

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

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

- Check the connections for proper contact and try again.

The signal appears to display a constant amplitude oscillation

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

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

The leads you are using may be unshielded or of low quality.

- Check to make sure that you are using high-quality leads. Only the supplied Neuro Amp EX headstage cable should be used.

The signal is noisy at lower ranges

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

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

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

- Turn off pieces of unnecessary equipment to try and isolate the cause, then either leave the equipment off or, if possible, move the subject or equipment outside the area of any interfering field.

- At the lowest ranges you may have to shield, shorten, or even replace the leads, since they will tend to act as radio receptors.

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

Refer to
Recording Technique, p. 19

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

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

APPENDIX C

Specifications

Neuro Amp EX

Input

Connection type:	Five-pin Redel connector
Configuration:	One isolated differential channel with isolated ground reference
Impedance:	100 MΩ
Safety:	Approved to IEC601-1 BF (body protection)
Isolation:	4000 V_{rms} (50 Hz for 1 minute)
Amplification ranges:	± 20 μV to ± 1 mV full scale in 6 steps (combined PowerLab, Neuro Amp EX front-end and headstage)

Gain:

Range	Resolution
1 mV	500 nV
500 μV	250 nV
200 μV	100 nV
100 μV	50 nV
50 μV	25 nV
20 μV	10 nV

Filtering

Low-pass filtering:	Fourth-order Bessel filter, ± 3% accuracy. Frequencies software-selectable: 1 kHz, 2 kHz, 5 kHz.

High-pass filtering:	Fourth-order Bessel filter, ± 3% accuracy. Frequencies software-selectable: 100 Hz, 300 Hz, 500 Hz.
Notch filter:	Second-order filter, –32 dB attenuation; 50 or 60 Hz frequency (automatic sensing)

Output

Signal:	± 2.0 V standard
Audio:	Stereo jack with mono output; ± 200 mV full scale, current limited to ± 5 mA. Suitable for headphones or powered speakers.

Control Port

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

Physical Configuration

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

Safety

Safety:	Approved to IEC601-1:1988 including A1 & A2 BF rated (body protection)
EMC:	Approved to IEC60601-1-2:2001
Other approvals:	CSA/US
Equipment:	Class I
Operation:	Continuous
Unsuitable uses:	Do not use in the presence of flammable anaesthetic - air mixtures. Avoid operating near high voltage, RF or strong magnetic fields that may cause interference.
Method of disposal:	Forward to recycling centre or return to manufacturer.

Neuro Amp EX Headstage

Connection type:	Amphenol WPI 220-883-S02 To suit Male 220-P02
Configuration:	Differential
Impedance:	100 MΩ // ~100 pF
Gain:	×100
Input leakage current:	~1 pA
CMRR:	100 dB typical @ 50/60 Hz
Noise (rti):	$< 2\ \mu V_{rms}$, $< 14\ \mu V_{pp}$ (100 Hz – 5 kHz)
Power:	From the Neuro Amp EX front-end
Electrode type:	Suitable for metal microelectrodes (300 kΩ typical)
Dimensions:	8 mm OD, 100 mm long
Material:	Stainless steel
Cable length:	2.8 m

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

Electromagnetic Compatibility

The ML185 Neuro Amp EX (the device) has been tested to comply with the requirements of IEC 60601-1-2, IEC 61000-3-2, IEC 61000-3-3, IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-6, IEC 61000-4-8, IEC 61000-4-11 and CISPR 11.

Emissions

- The device uses RF energy for its internal function only. RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
- The device is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.

Immunity

- Mains power quality should be that of a typical commercial or hospital environment. If the user of the device requires continued operation during power mains interruptions, it is recommended that the device be powered from an uninterruptible power supply or a battery.
- Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
- Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.

Separation Distances

- The device is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled.
- Portable and mobile RF communications equipment should be used no closer to any part of the device, including cables, than the recommended separation distance in the table below.
- Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, should be less than the compliance level in each frequency range.

	Separation distance	
Rated maximum output power of transmitter, P	150 kHz to 800 MHz	800 Mhz to 2.5 GHz
	$d = 1.17\sqrt{P}$	$d = 2.33\sqrt{P}$
0.01 W	0.1 m	0.2 m
0.1 W	0.4 m	0.7 m
1 W	1.2 m	2.3 m
10 W	3.7 m	7.4 m
100 W	11.7 m	23.4 m

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