**PowerLab**C

Front End Interface and Instrument Interface

Owner's Guide

ADINSTRUMENTS

making science easier

This document is, as far as possible, accurate at the time of release. However, changes may have been made to the software and hardware it describes since then. ADInstruments NZ Limited reserves the right to alter specifications as required. Late-breaking information may be supplied separately.

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# Chapter 1

# 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. ADInstruments products are intended to be installed, used and operated under the supervision of an appropriately qualified life-science researcher. The typical usage environment is a research or teaching lab or hospital. ADInstruments equipment is not intended for use in domestic environments.

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

- this is a more rigorous standard than other standards that could be chosen.
- 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 and Quality Standards

In accordance with European standards PowerLab C and C Series devices also comply with the electromagnetic compatibility requirements under EN61326-1, which encompasses the EMC directive.

**Quality Management System ISO 9001:2015**

ADInstruments manufactures products under a quality system certified as complying with ISO 9001:2015 by an accredited certification body.

# Regulatory Symbols

Devices manufactured by ADInstruments that are designed for direct connection to humans and animals are tested to IEC60601-1:1998 and IEC60601-1:2005 (including amendments 1 and 2) and EN61326-1:2006, and carry one or more of the safety symbols below.

**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.

**CE Mark.** All front-end amplifiers and PowerLab systems carry the CE mark and meet the appropriate EU directives.

**UKCA Mark.** All front-end amplifiers and PowerLab systems carry the UKCA mark and meet the appropriate UK directives.

**Refer to booklet symbol.** This symbol specifies that the user needs to refer to the Instruction manual or the booklet associated with the device.

**Date of Manufacture/ Manufacturer's name symbol.** This symbol indicates the date of manufacture of the device and the name of the manufacturer

**WEEE directive symbol.** Unwanted equipment bearing the Waste Electrical and Electronic Equipment (WEEE) Directive symbol requires separate waste collection. (See disposal section at the end of this chapter)

Further information is available on request.

# Safety Standards

**IEC Standard - International Standard - Medical Electrical Equipment**

IEC 60601-1:2012          General requirements for safety

# 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 C 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 IEC 60601-1: *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. The user is responsible for ensuring any particular configuration of equipment complies with IEC60601-1-1.

The PowerLab C (and many other devices) requires the connection of a personal computer for operation. This personal computer should be certified as complying with IEC 60950 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 IEC 60601-1 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 IEC 60601-1.
- 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, ADInstruments should be contacted before using the equipment.
- The PowerLab depends on the presence of a Protective Earth for it's electrical safety requirement. This is usually provided from the power outlet through a power cord. Before connecting the equipment to mains power, ensure that the power socket has a protective earth circuit capable of carrying the fault current (see bullet point below). Note the POAG terminal on the rear of the PowerLab C is not rated as a Protective Earth.
- The Protective Earth must be cable of carrying the maximum current allowed by the circuit breaker and must be electrically insulated. It must be connected to

**WARNING:**

This equipment is not intended to be modified or serviced by the user. No user serviceable parts inside. Refer servicing to authorized ADInstruments service center.

**WARNING:**

Use only with ADI supplied power cords appropriate for your region.

an equi-potential source (a metal stake drive into the soil is a typical situation). A licensed electrician must perform this installation.

- 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.
- PowerLabs are compatible with electrical safety devices (sometimes known as Safety Switches, Ground fault circuit interruptor, Residual Current Devices or Earth-leakage Circuit Breaker). ADInstruments recommends the use of such devices supplied in fixed wiring installations.
- 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.
- When used in ambient temperatures of 38 degrees Celcius and above, do not touch PowerLab enclosure or the USB cable continuously for more than a minute.
- To safely shut down the PowerLab, press the stop button and then close LabChart. Turn the PowerLab off at the inlet switch.

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.

# 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.

The 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 ADInstruments representative to arrange for the equipment to be checked and serviced.

# Environment

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

**Transport and 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 labeled 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 2
# Overview

The PowerLab C and C Series devices are ADInstruments' range of modern, high quality, research grade laboratory data acquisition hardware. They work seamlessly with LabChart 8 and LabChart Lightning to provide a reliable foundation on which to integrate a variety of input and output devices suitable for a range of life science applications.

**Figure 2–1**

Front End Interface, Instrument Interface and PowerLab C

# How to Use This Guide

This owner's guide describes how to set up and begin using the PowerLab C, the Front End Interface and the Instrument Interface. The chapters provide an overview of the entire system (the combined software and hardware package), and a more detailed look at the features of each unit and its connections to other recording devices as well as to your computer. There are also chapters that provide technical information and solutions to problems. At the end of this guide is a glossary of hardware terms.

# Software Installation

The ADInstruments application software should be installed before connecting or using a PowerLab C or any C Series device.

The Getting Started with PowerLab manual provides full installation instructions for the LabChart software.

# PowerLab Check

Please do not attempt to connect a PowerLab C or any C Series device to a power outlet or computer or turn it on until you have checked it as described below.

1. Check that all items in the accompanying packing list are included in the box.
2. Check that there are no obvious signs of external damage to the unit.
3. Check that there are no obvious signs of internal damage, such as rattling. Pick up the unit, tilt it gently from side to side, and listen for anything that appears to be loose.

If anything is missing or the unit seems to be damaged in any way, contact your authorized ADInstruments representative immediately. Up to date contact addresses are available from the ADInstruments website.

Connection information is in the next chapter.

# Power-on Self Diagnostics

The PowerLab C and C Series devices perform a self test during power up. The software will run a number of system checks to verify functionality of the internal circuitry. None of these tests calibrate or change the performance of the devices in any way, they are used only to determine the operability of the device.

Any faults found during this procedure may be indicated in two ways.

1. As long as USB communication is functional, errors may be reported by LabChart when communication to the device is established.
2. The PowerLab will also give a Red status LED if the test detects a hardware fault.

The devices contain no user-serviceable parts inside. If a hardware fault is reported by a PowerLab C or any C Series device, an ADInstruments representative should be contacted.

# Chapter 3
# Setting Up

This chapter describes:

- Connecting the Hardware.
- Installing the software

**Figure 3-1**

C Series
devices
connected

# Connecting the Hardware

The PowerLab C and C Series devices use USB-C to communicate with either a host computer, or a PowerLab C.

## With a PowerLab C

The PowerLab C should be connected to the host computer using either the included USB-C to USB-A cable, or the USB-C to USB-C cable depending on port availability. The PowerLab C can be powered in one of 3 ways:
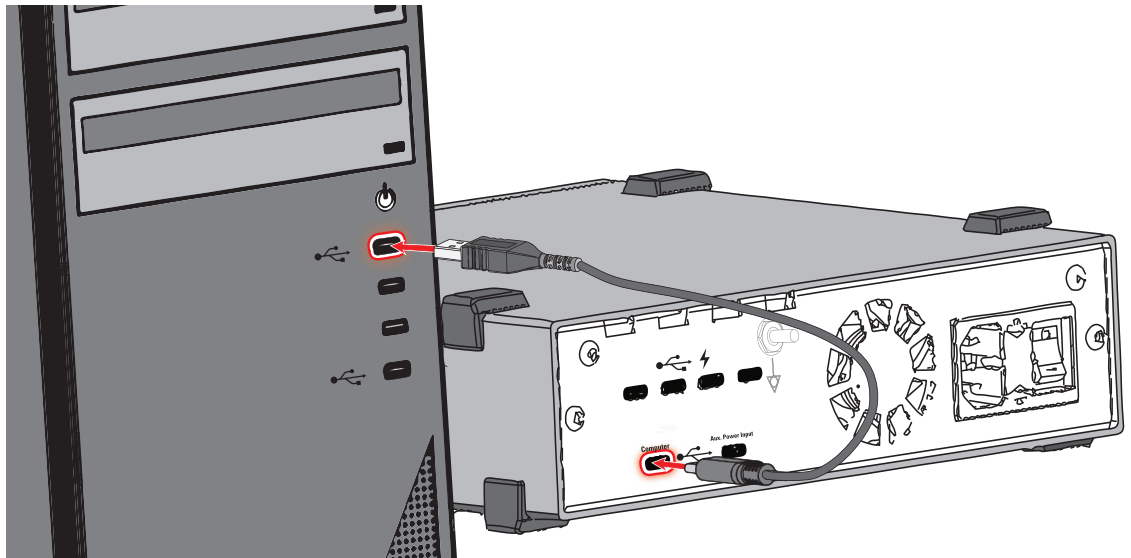
- Using the included mains power cable: This is the recommended approach as it ensures that the system has its full 310W power budget available.

- Host-Powered: If the host computer supports the USB-PD standard on the USB-C port that the PowerLab is connected to the PowerLab can draw power directly from the host computer. Note that the power budget of the downstream facing ports will be limited by the power available from the host computer.

- Auxiliary Power Input: A second power-only USB-C connector on the back of the PowerLab can be used to power it from a USB-PD compliant power supply, such as battery packs, laptop chargers or car chargers. Note that the power budget of the downstream facing ports will be limited by the power available from the selected power supply.

Other C series devices (such as the Front End Interface) should be connected to the downstream facing ports of the PowerLab C using the included USB-C to USB-C Cable. This will provide both power and a data connection to the device.

## Without a PowerLab C

C Series devices can be connected directly to a host computer. Specific host requirements are detailed in the following chapters. This configuration is only recommended if using one C Series device. If using multiple devices a PowerLab C should be used.

# Installing the Software

PowerLab C and C Series devices are compatible with both LabChart 8 software and LabChart Lightning on both Windows and Mac.

## LabChart 8

Install the latest version of LabChart 8 by visiting [adi.to/powerlabcstart](adi.to/powerlabcstart). Once installed LabChart will automatically detect PowerLab C and C Series devices during it's device detection process. Getting started videos and more information can be found at the link above.

## LabChart Lightning

Install the latest version of LabChart Lightning by visiting [adi.to/powerlabcstart](adi.to/powerlabcstart). Once installed LabChart Lightning will automatically detect PowerLab C and C Series devices. Getting started videos and more information can also be found at the link above.

## PowerLab Event Link (PEL)

A PowerLab C and all C Series devices can communicate with each other using a proprietary protocol implemented on USB-C Alternate Mode which is named the PowerLab Event Link (PEL). This allows these products to remain time synchronized and will enable additional advanced device synchronization features in the future.

Using USB cables supplied by ADInstruments is recommended. If using 3rd party cables with the PowerLab C or any C Series devices it is critical that cables used to connect between them meet the following requirements:

- USB3.1 5Gbps or 10Gbps speeds

# Chapter 4

# PowerLab C

The unit, together with a range of specialized application programs, provides a versatile data recording and analysis system when used with a Windows or Macintosh computer. This chapter provides an overview of the PowerLab® system and describes the basic features, connectors and indicators of the PowerLab.

Note that the software supplied with the PowerLab should be installed before connecting the PowerLab to the computer.

**Figure 4–1**

The PowerLab C

# The PowerLab C

The PowerLab C provides 4 downstream-facing USB-C (with Power Delivery) ports for connection to equipment with a USB-C interface (such as the Front-End Interface) and provides 2 upstream-facing ports for connection to a computer supporting USB-C with Power Delivery. The port marked "Computer" provides data and power connection from the host computer. The auxiliary port (marked "Aux. Power Input") provides a power-only input from an alternate power source. The auxiliary port may be useful in applications where battery power is desired.

The PowerLab provides adaptive mains filtering (when powered via the mains) and also provides advanced device synchronisation features.

Multiple PowerLab Cs' may be connected in series to provide extra ports if required.

## The Front Panel

The front panel (Figure 4–2) provides the indicators for various functions.

- The 'Power' LED illuminates as the following colours when the system is receiving power from one of the 3 possible power sources
    1. Blue  -  Mains power
    2. Cyan  -  Auxillary port powered
    3. Purple  -  Computer port powered
    4. Also Amber  -  While initial booting. This remains on if the boot failed.
- The 'Status' LED indicates the current state of the device
    1. White  -   PowerLab is idle
    2. Green  -  PowerLab is connected to LabChart
    3. Magenta - Power budget starts rolling back (internal temperature exceeds 40 °C)
    4. Orange - PowerLab shuts down due to over-temperature limit being reached (42 °C)

**Figure 4–2**
The front panel of the PowerLab C



Power indicator

Status indicator

# The Rear Panel

The rear panel of the PowerLab C (Figure 4-3) provides the sockets to connect the PowerLab to the computer, other devices and the power outlet. This section describes each of the rear panel features:
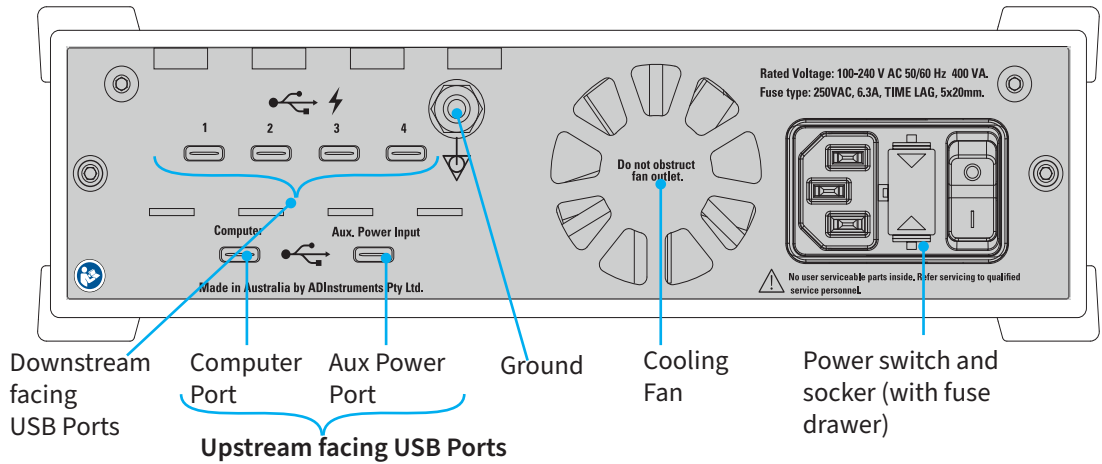
Downstream facing USB Ports — Computer Port — Aux Power Port — Ground — Cooling Fan — Power switch and socker (with fuse drawer)

**Upstream facing USB Ports**

## Upstream facing USB Ports

1. **Computer Port:** For connection to the host computer using either a USB-C to USB-C Cable or a USB-C to USB-A Cable. The host computer requires only USB2.0 to be compatible. If the host computer features a USB-C port that supports USB-PD the PowerLab can also be powered using this port. Note that the power budget of the downstream facing ports will be limited by the power available from the host computer.

2. **Aux Power Port:** This port can optionally be used to power the PowerLab from a USB-PD compliant power supply, such as battery packs, laptop chargers or car chargers. Note that the power budget of the downstream facing ports will be limited by the power available from the selected power supply.

## Downstream facing USB Ports

The downstream facing ports are primarily intended for connection to any ADInstruments C Series device. These devices should be connected using an ADInstruments supplied USB-C to USB-C Cable. If using a third party cable it must support both alternate mode and be capable of 100W USB-PD. Each of the 4 downstream facing ports function identically.

The downstream facing USB-C Ports do support standard USB-PD at up to 100W (depending on how the PowerLab is itself powered) meaning it can be used as a power source for other USB-PD compliant devices such as some laptops, tablets and mobile phones.

## Ground Connector

A special earthing stud is provided on the rear panel of the PowerLab. This is an equipotential bonding connection post compatible with the DIN 42801 standard. It

is used as an equipotential connection point in situations that require this type of connection or if there is no ground provided via the power cord. This connector is not rated as a Protective Earth and should only be used to provide functional earthing.

## Power Connector

The power switch on the back right of the PowerLab C turns the PowerLab on and off; the 3-pin IEC power socket is used to connect the PowerLab to a power cable. The power supply is universal, and can use all common international mains power supplies (100–240 V AC, 50/60 Hz).

The PowerLab C is fitted with replaceable fuses. If the Power LED on the PowerLab, does not illuminate with power applied, it may be that one or both of the replaceable fuses has blown. Fuses should only be of the rating and type as specified below:

- 250VAC Slo Blo (usually marked "T")
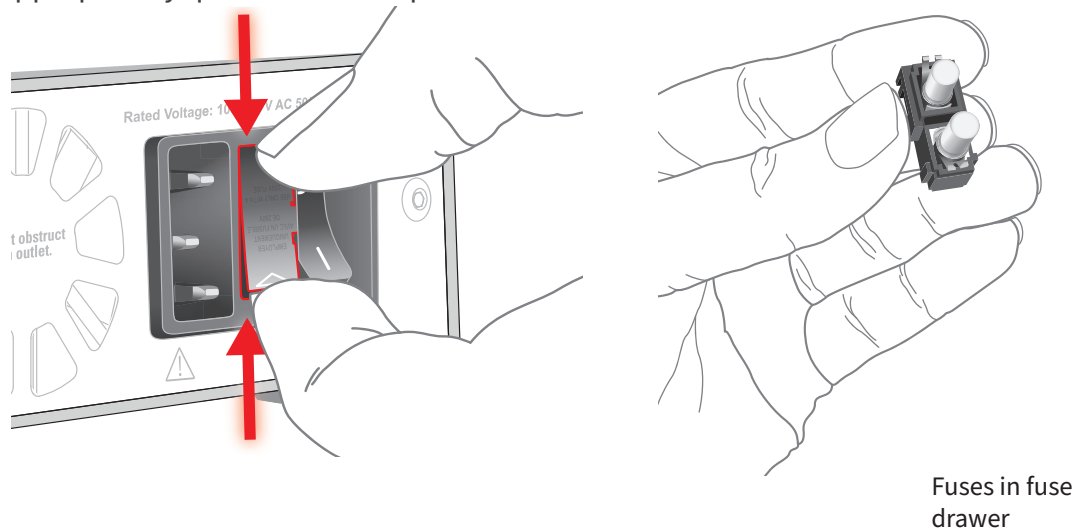- 6.3A
- 20 x 5mm

## Checking and replacing fuses

Ensure the power lead is disconnected before attempting to replace a fuse.

The fuses are contained in the fuse drawer. To remove the drawer, the top and bottom plastic tabs need to be squeezed simultaneously while pulling the drawer away from the PowerLab (a small flat-bladed tool is useful for this task). The old fuses should spring free of the drawer once removed from the inlet. Load the new fuses back into the drawer and carefully push back into the inlet. Note that the fuse drawer is polarized and can only be put back in one orientation. For further assistance please contact your nearest ADInstruments representative.

Note: Fuse replacement should only be attempted by appropriately qualified service personnel. If the fuse is suspected as blown, please contact ADI service representative or appropriately qualified service personnel.

**WARNING:**

Ceramic replacement fuses should be used in preference to glass fuses. Glass fuses are fragile and are prone to breakage, potentially leading to injury.

**Figure 4–4**
Removing and replacing fuses



Fuses in fuse drawer

# Using Multiple PowerLabs

Multiple PowerLab C units can be connected in one of two ways:

1.  Daisy Chained: The 'Computer' port of the second PowerLab C is connected to one of the downstream facing ports on the first PowerLab C. This allows the second PowerLab to be powered by the first, allows full use of the PowerLab Event Link (PEL) between devices but comes at the cost of using one of the available downstream facing ports on the first PowerLab.
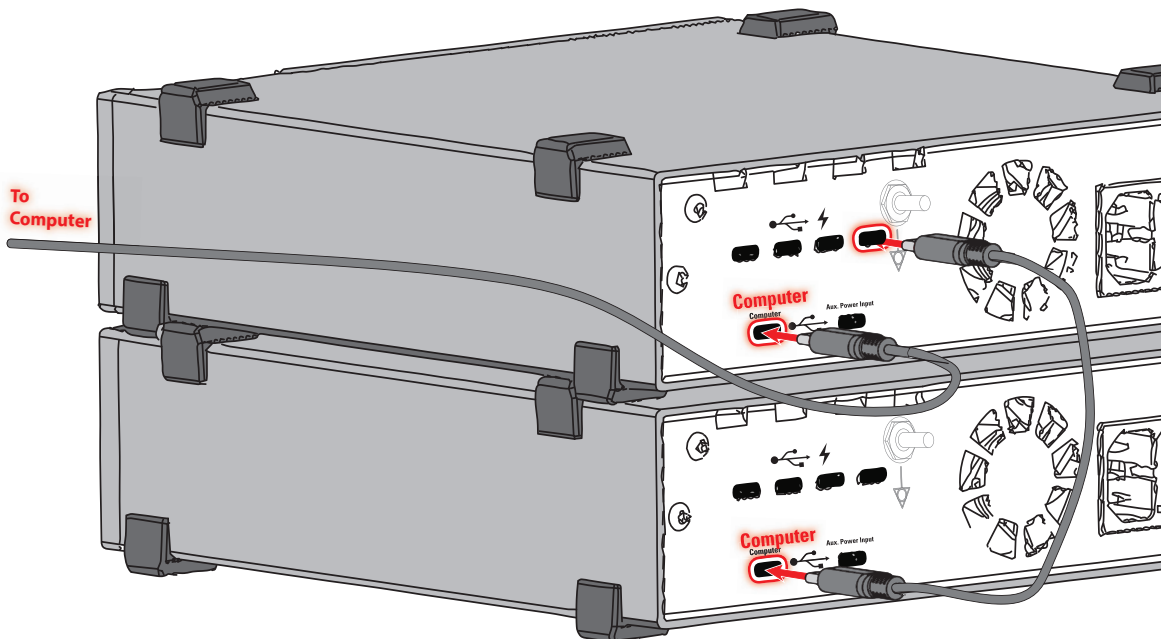
To Computer

2.  Connect both PowerLabs to the host computer: This maximizes the number of downstream facing ports for other C Series devices but comes at the cost of not allowing PEL communications between C Series devices connected to the different PowerLabs.

**Figure 4–6**
PowerLabs con-
nected to host
computer
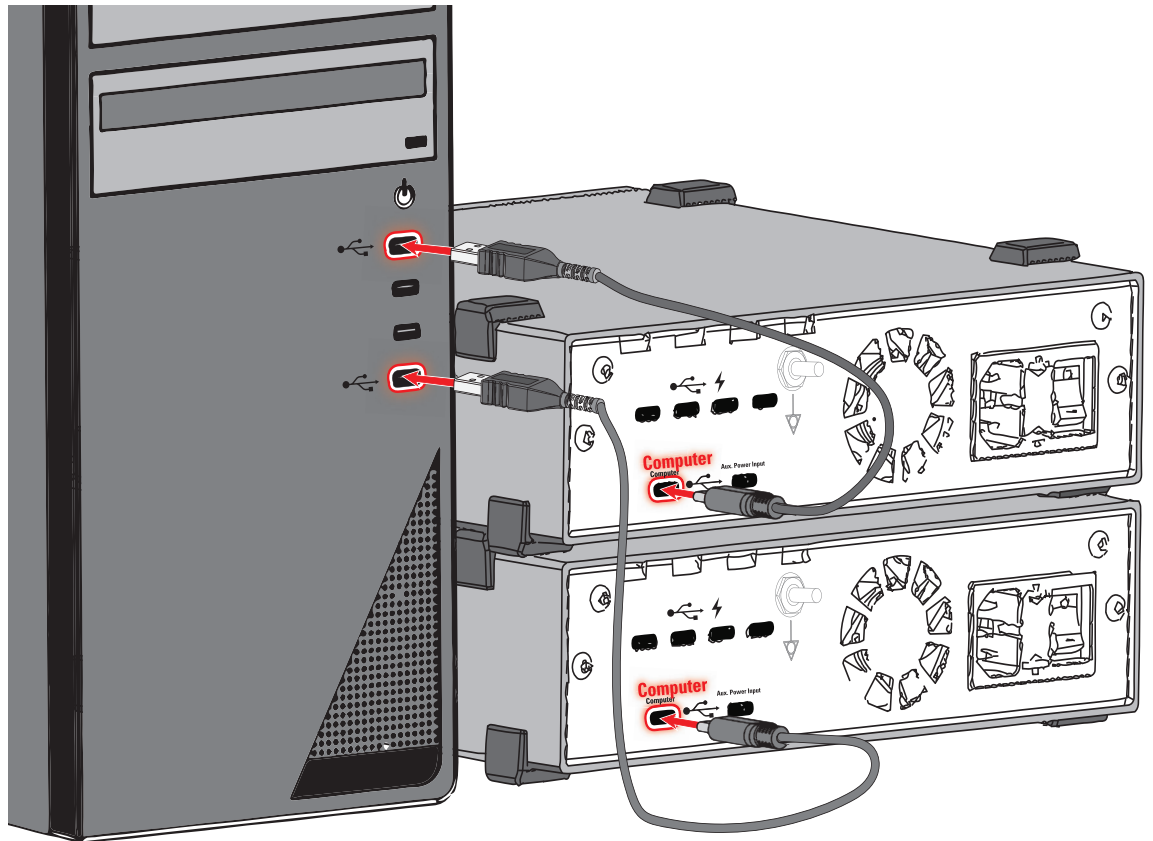
## Supplied Accessories

| Accessory |
| --- |
| MLAC89/2 USB-C to USB-C cable (1m) |
| MLAC89/3 USB-C to USB-A cable (1m) |

## Power Budgets with PowerLab C

PowerLab C can provide power to up to 4 downstream devices while itself being powered in a variety of different ways. PowerLab C and C Series devices utilise sophisticated USB-PD technology to manage and negotiate power between devices.

USB-PD allows power 'source' devices to advertise the amount of power they are able to provide and for 'sink' devices (i.e devices that need power) to request a particular amount of power from the source they are connected to. This leads to a negotiation between the source and sink devices occurring every time a connection is made. If the source is able to supply the power the sink requires then power is supplied. This negotiation can reoccur if circumstances at either the source or sink change.

PowerLab C acts as a USB-PD source on its 4 Downstream Facing Ports (DFPs). The amount of power PowerLab C is able to advertise depends on how much power it has available itself, which is known as its 'power budget'. PowerLab C can be powered via one of 3 different connectors on the rear panel: the mains inlet, the 'Auxiliary' power port or the 'Computer' port.

When powered via the mains inlet PowerLab C has a power budget of 310W available to divide up between its 4 downstream facing ports. Each port can deliver a maximum of 100W, which is much more than most typical devices need. When connected via mains PowerLab C will show a blue 'Power' LED and will draw almost no power from the 'Computer' Port, which means it will work with both legacy type-A ports and type-C ports

When no mains power is connected PowerLab C also acts as a USB-PD sink device on the Auxiliary Power Port and/or the Computer Port. PowerLab C will request power from whichever connected device advertises the highest amount of available power. The power LED colour will indicate which power source is being used. Regardless of how it is powered PowerLab C will always have the 'Computer' Port connected either directly to the host PC, or to another PowerLab C which is in turn connected to the host PC for communication with LabChart.

At a minimum PowerLab C reserves 1.5W of power to run itself, as well as 2.5W for each of the 4 downstream facing ports. This 2.5W is required to allow connected devices to initiate the USB-PD negotiation process, or to power any older USB devices (i.e devices not capable of USB-PD negotiation) that are connected. This means PowerLab C requires a minimum of 12.5W to be available in order to start up (PowerLab C will not power on if not enough power is available). Each device connected to a DFP on PowerLab C is guaranteed 2.5W at startup and can then negotiate more power up to either 100W, or the remaining power budget (whichever is lower). This is in line with USB standards. Note that PowerLab C also budgets an extra 10% to account for any losses. It is also worth noting that not all USB-C cables are created equal. Higher powers (>60W) require a cable capable of handling higher currents. These cables contain a small chip (known as an e-marker) in the plug that takes part in the USB-PD negotiation process. All ADI branded cables contain an e-marker and are capable of 100W of power. Other brand cables may be labelled as '5A' or '100W' cables.

Some devices request both a minimum and 'nice to have' power allocation. For example a mobile phone may require a minimum of 5W in order to charge at all, but can charge more quickly at up to 30W if available. PowerLab C will also take this into account when allocating power.

PowerLab C will also handle changes to available power while running and attempt to keep as many downstream devices up as possible. This includes handling turning on and off mains power and connecting/disconnecting auxiliary USB-PD power sources. As long as enough power is always available from one source to satisfy the minimum requirement of all downstream devices the system should remain up. If not enough power is available PowerLab will disconnect some or all downstream devices.

A couple of examples:

**A PowerLab C powered only from a host Laptop.**

Most modern laptops have at least one USB-PD capable port. These are most commonly able to provide 15W of power, although some only provide 7.5W, while others provide 30W or more. In the case of the most common 15W port PowerLab C will request the full 15W, use 1.5W for itself and reserve an additional 2.5W for each of its downstream ports. This totals 11.5W, leaving only an additional 3.5W available for downstream devices that need more than their initial 2.5W allocation. An Instrument Interface requires <2.5W of power and thus 4 could be run from this PowerLab C. The Front End Interface, however, requires at least 7.5W, and sometimes more depending on the Front End connected (See Figure 5-8). Therefore no Front End Interfaces will work when connected to a PowerLab C running only off a 15W port. An auxiliary power source capable of supplying more than 15W, or mains power will be needed in this case.

**A Complex System:**

Let's take the example of a more complex system requiring 24 channels of Bio Amplifiers and 16 channels of Bridge Amplifiers. Within ADI's current product lineup this would require 3 Octal Bio Amps and 2 Octal Bridge Amps. These 5 Front Ends would require 5 Front End Interfaces and 2 PowerLab Cs to support them. Let's assume only one PowerLab C is connected to mains power, while the second PowerLab C is connected to one of the DFPs of the first. In this example the mains powered PowerLab C would have 310W of power budget available. The second PowerLab would negotiate reserving 100W of that power for its use. Each of the 5 Front End Interfaces connected to one of the Octal Amplifiers would request 15W from the PowerLab C it was connected to. Connecting 4 Front End Interfaces to the second PowerLab would use up 60W (4*15W) of its 100W of reserved power. Adding the 10% buffer and 1.5W for the PowerLab C itself uses would mean the second PowerLab is using 67.5W out of the 100W reservation from the first PowerLab C. The remaining Front End Interface would connect to one of the DFPs of the first PowerLab, also using 15W. This means the first PowerLab is using 100W (for the second PowerLab) + 15W (for the connected Front End) + 1.5W (for itself) + (2*2.5)W (reserved for the 3rd and 4th, currently unconnected DFPs). This adds to 133.5W out of the total 310W available power budget.

**Battery Powered example:**

Let's take a system including one PowerLab C, one Bridge Amp (with Front End Interface) and one Instrument Interface as an example. Let's assume we have a 100W USB-PD compliant battery bank to power this system via the Auxiliary power port. In this case the PowerLab would reserve the full 100W from the battery bank but would only be using 1.5W (for itself) + 2.5W (for the Instrument Interface) + 7.5W (for the Front End Interface connected to the Bridge Amp). The two remaining DFPs would each have 2.5W reserved. Adding in the 10% safety margin this means 17.5W is reserved, leaving 82.5W of remaining power budget. The user could decide to connect their Laptop's USB-PD compliant charge port to one of the DFPs so their entire system was powered off of one battery bank. The amount of power needed to power a laptop varies depending on the model but typically 30W is enough to keep a laptop running, while the 82.5W remaining in this example would be enough to charge all but the most high powered laptops.

# Chapter 5

# Front End Interface

The Front End Interface allows existing ADInstruments Front Ends with I²C and BNC connectors to be connected to the PowerLab C. The Front End Interface provides analog-to-digital conversion, USB-C/PD interface for connection to the PowerLab C and FE device detection.

**Figure 5–1**

The Front End Interface



Analog I/O

C Series
Front End Interface
Made in Australia by ADInstruments Pty Ltd.
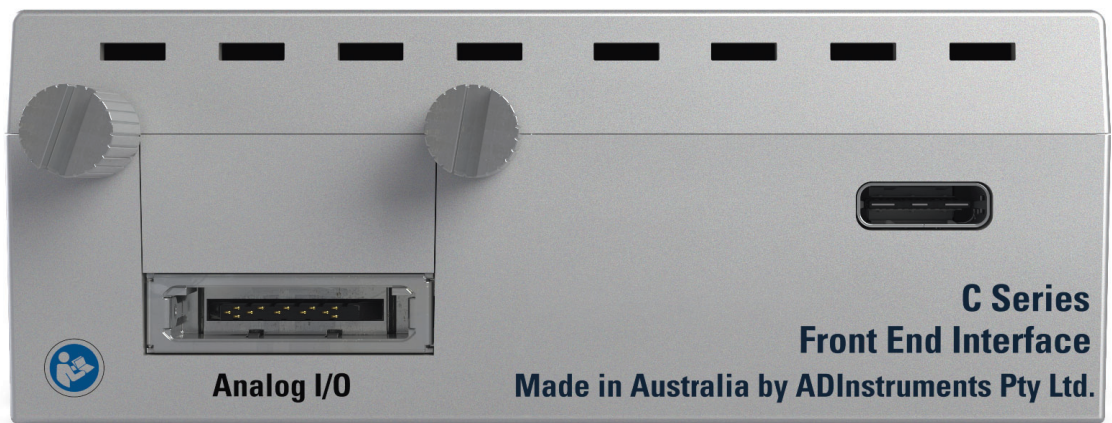
# The Front End Interface

This section describes the connectors and indicators of the Front End Interface.

## The Front View
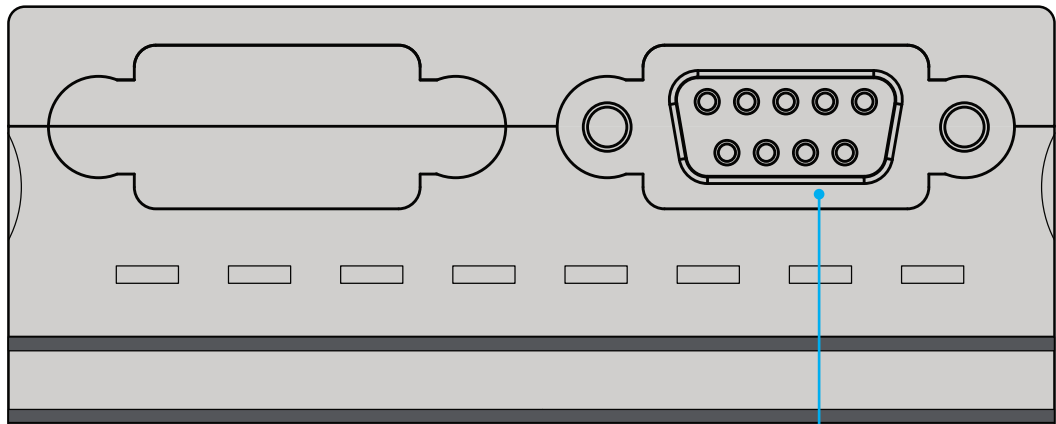
I²C Port

The front of the Front End Interface (Figure 5–2) provides an I²C port for connection to any ADInstruments Front End. The product is designed to connect directly to the rear of all current Front Ends. It can also be connected via the MLAC02 DB9M -DB9F Cable (sold separately) if required.

# The Rear View

The rear of the Front End Interface (Figure 5-3) has the following connectors/ features:

**Figure 5–3**
The rear view of
the
Front End
Interface
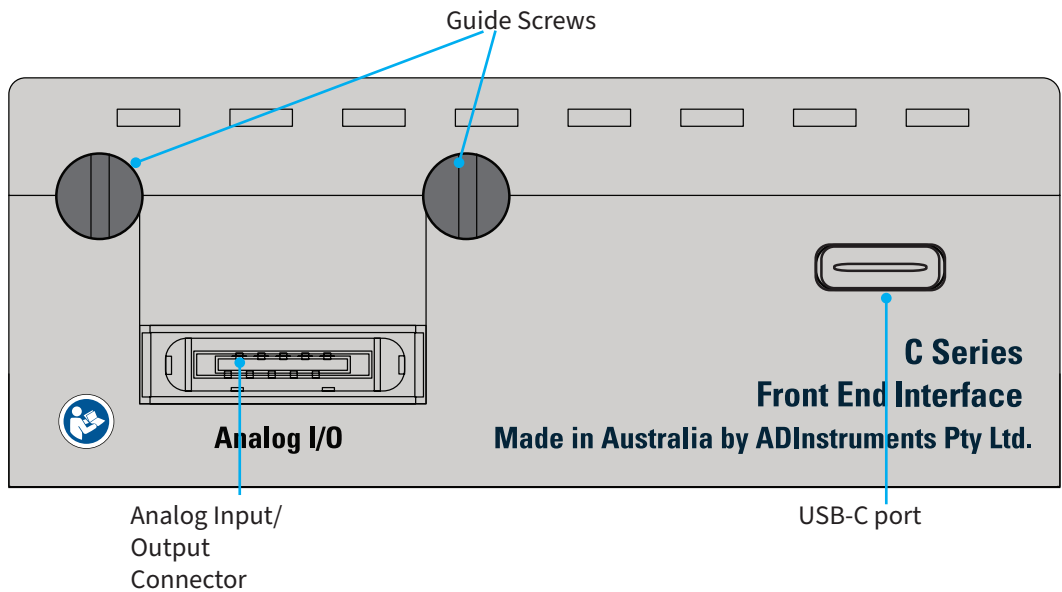
Guide Screws

Analog I/O

C Series
Front End Interface
Made in Australia by ADInstruments Pty Ltd.

Analog Input/
Output
Connector

USB-C port

**NOTE:**

The Front End
Interface does not
support daisy
chaining Front Ends.
The 'I²C Output'
port on a Front End
should NOT be used
in conjunction with
the Front End
Interface.

- USB-C Port for connection to PowerLab C or computer
- Analog connector for connection to the analog outputs on the rear of the front End. 1, 2, 4 and 8 Channel cable variants are available. See the compatibility matrix below for details.
- Guide Screws for securely attaching to the rear of a supported ADInstruments Front End. These screws should be done up finger tight only. Note these screws are not necessary if connecting the device via an MLAC02 DB9 cable.

## Analog Cable

There are 4 variants of the analog cable assembly.

- MLAC871       1 Channel Analog Cable
- MLAC872       2 Channel Analog Cable
- MLAC874       4 Channel Analog Cable
- MLAC878       8 Channel Analog Cable

When using a multi channel analog cable the connection order does not matter except when using a device with a stimulator output. Please see the compatibility matrix (Figure 5-8) at the end of the chapter for details.

## Connecting a Front-End to the Front End Interface

A Front-End can be connected to the Front End Interface in the following ways:

1. Screwed directly using the guide screws: In this case, the I²C port on the front of the Front End Interface can be inserted into the corresponding port on the rear panel of the Front End. Once inserted, the guide screws on the Interface can be twisted clockwise to to engage with the threads on the nuts of the serial port on the Front- End.
2. Using a DB9M- DB9F cable: In this case, the MLAC02 DB9M - DB9F cable can be used to connect the Front End to the Interface directly. This maybe required in

**Figure 5–4**
Direct connection

**NOTE:**

The Front End Interface does not support daisy chaining Front Ends. The 'I²C Output' port on a Front End should NOT be used in conjunction with the Front End Interface.
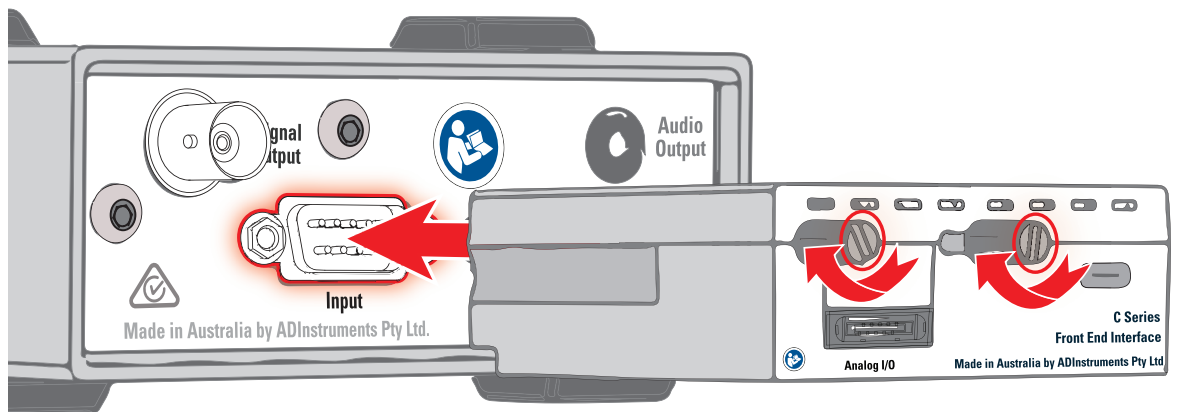


the case of some older Front-Ends like the ML138 Octal Bio Amp.

**Figure 5–5**
Connection
using a I²C cable
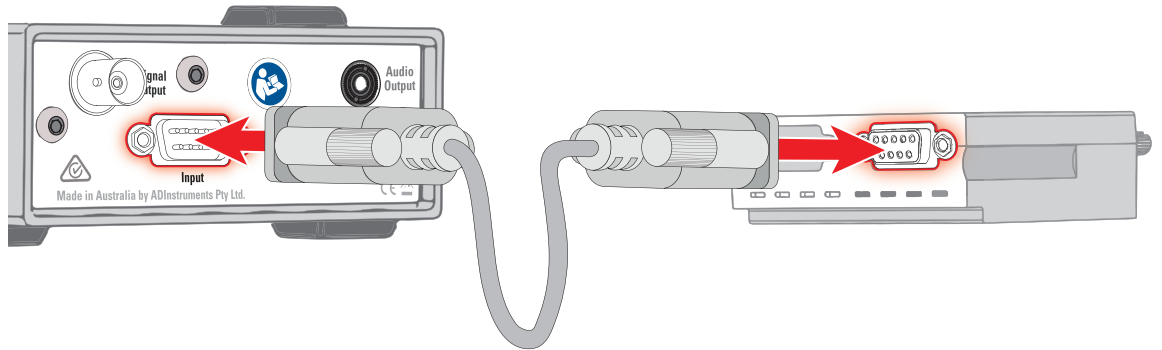
## Connecting a Front-End into a system

A Front-End can be connected using the Front End Interface in the following ways:

1. Through a PowerLab C: After screwing the Front End Interface into the I²C port of the Front End, the requisite Analog cable can be used to connect the two devices. Using the USB-C to USB-C cable, the Interface can be powered by connecting it to one of the 4 downstream facing USB ports on the PowerLab C. A USB-C to USB-C cable or USB-C to USB-A cable should be used to connect the PowerLab (using the 'Computer' labelled upstream facing port) to the appropriate USB port on the computer .

2. Directly to the Computer: After connecting the Front-End and the Front End

**Figure 5–6**
Connecting a
Front End using
a PowerLab C
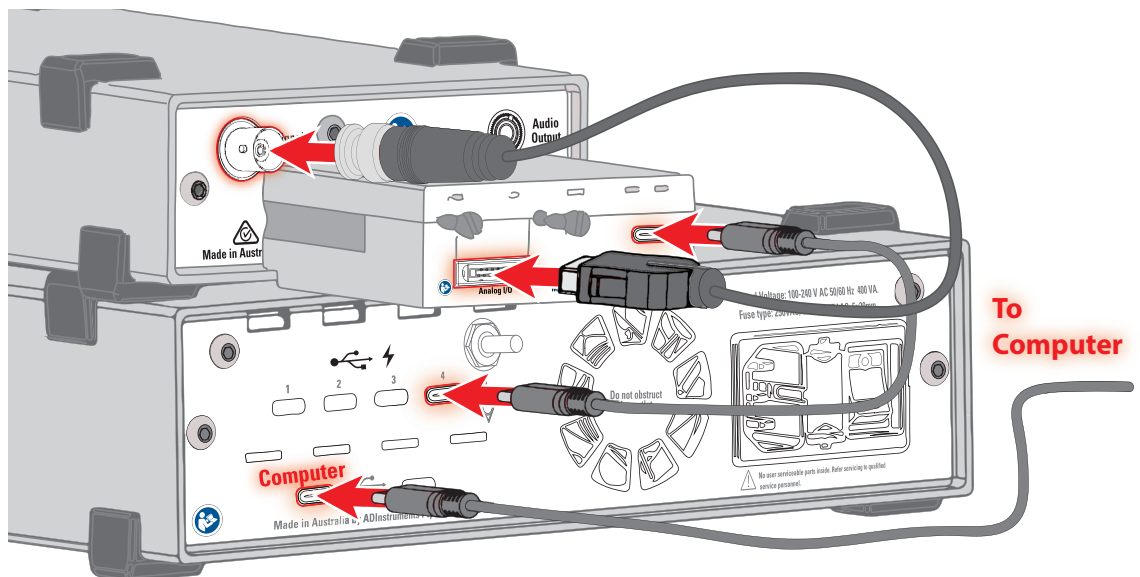
Interface using an analog cable, the Interface can be powered by directly connecting it to a computer. In this case, an ADInstruments supplied USB-C to USB-C cable must be used to connect the Interface to a USB-C port on the

computer. Please note that the USB port must be capable of delivering a minimum amount of power. (Refer Figure 5-8 for more details)
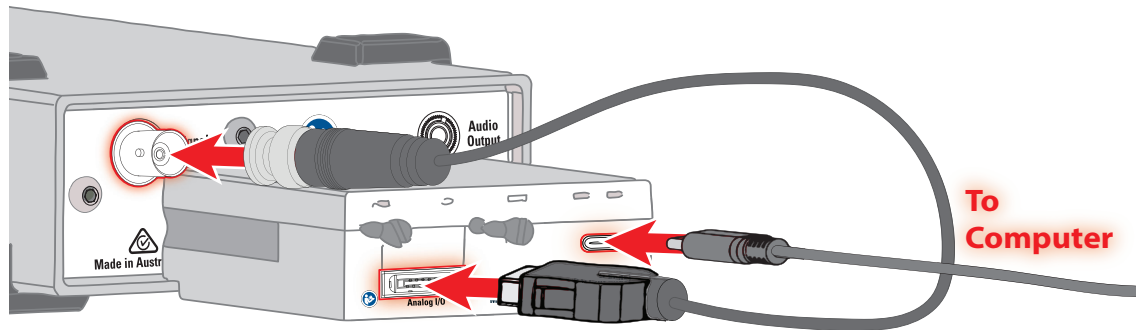
## Supplied Accessories

| Accessory |
|---|
| MLAC89/1 USB-C to USB-C cable (300mm) |
| MLAC871 Analog Cable (1 Channel) |
| MLAC872 Analog Cable (2 Channels) |
| MLAC874 Analog Cable (4 Channels) |
| MLAC878 Analog Cable (8 Channels) |

## Software

LabChart 8:

Front End Interface devices will be detected and listed during LabChart 8's device detection process. Channels can be enabled in the 'Devices and Channels' dialogue in the 'Setup' menu. There are no specific settings available for the Front End Interface itself. All settings for the connected Front End can be found in the Input Amplifier section of the channel drop down menu.

LabChart Lightning:

Front End Interface devices will be detected during LabChart Lightning's device detection process.

# Front End Compatibility Table

**Figure 5–8**
Front End
Compatibility
Table

| Front End | Supported | Minimum Cable Requirement | Limitations | Supported without PowerLab C? |
|---|---|---|---|---|
| **'35 Series' Front-Ends** | | | | |
| FE231 Bio Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| FE232 Dual Bio Amp | Yes | 2 Channel MLAC872 | | Y (=> **15W** Port) |
| FE234 Quad Bio Amp | Yes | 4 Channel MLAC874 | | Y (=> **15W** Port) |
| FE238 Octal Bio Amp | Yes | 8 Channel MLAC878 | | N |
| FE285 Neuro Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| FE221 Bridge Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| FE224 Quad Bridge Amp | Yes | 4 Channel MLAC874 | | Y (=> **15W** Port) |
| FE228 Octal Bridge Amp | Yes | 8 Channel MLAC878 | | N |
| FE117 BP Amp | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| FE116 GSR Amp | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| FE165 pH Amp | Yes | 2 Channel MLAC872 | | Y (=>7.5W Port) |
| FE305 Pod Expander | Yes | 4 Channel MLAC874 | | Y (=> **15W** Port) |
| FE141 Spirometer | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| FE180 Stimulus Isolator | Yes | 1 Channel MLAC871 | If using a multi-channel analog cable the red cable MUST be used | Y (=>7.5W Port) |
| FE180/30mA Stimulus Isolator (30 mA) | Yes | 1 Channel MLAC871 | If using a multi-channel analog cable the red cable MUST be used | Y (=>7.5W Port) |

| Front End | Supported | Minimum Cable Requirement | Limitations | Supported without PowerLab C? |
|---|---|---|---|---|
| FE155 Stimulator HC | Yes | 1 Channel MLAC871 | If using a multi-channel analog cable the red cable MUST be used | Y (=>7.5W Port) |
| IN125/X NIBP Controller | Yes | 2 Channel MLAC872 | Trigger in/out not supported | Y (=> **15W** Port) |
| IN175 STH Pump Controller | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| FE132 Bio Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| FE135 Dual Bio Amp | Yes | 2 Channel MLAC872 | | Y (=> **15W** Port) |
| FE136 Animal Bio Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| FE185 Neuro Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| IN191 Blood Flow Meter | NA | - | | - |
| **'30 Series' Front-Ends** | | | | |
| ML206 Gas Analyzer | Yes | 2 Channel MLAC872 | | Y (=>7.5W Port) |
| ML180 Stimulus Isolator | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| ML155 Stimulator HC | Yes | 1 Channel MLAC871 | | Y (=>7.5W Port) |
| ML132 Bio Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| ML135 Dual Bio Amp | Yes | 2 Channel MLAC872 | | Y (=> **15W** Port) |
| ML136 Animal Bio Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |
| ML138 Octal Bio Amp | Yes | 8 Channel MLAC878 | | N |
| ML185 Neuro Amp | Yes | 1 Channel MLAC871 | | Y (=> **15W** Port) |

The ML408 Dual Bio/Stim does not support sampling at 100k/s.

| Front End | Supported | Minimum Cable Requirement | Limitations | Supported without PowerLab C? |
|---|---|---|---|---|
| ML408 Dual Bio/Stim | Yes | 4 Channel MLAC874 | The red cable MUST be used for connecting the 'Stim' connector | Y (=> **15W** Port) |
|  |  |  |  |  |

# Chapter 1

# Instrument Interface

The Instrument Interface is a 4 channel device providing analog input capability to the PowerLab C. The device is powered and controlled by a single USB-C/PD cable connecting to the PowerLab C, or to a host computer. Connection to the PowerLab C provides adaptive mains filtering (when PowerLab C is powered from mains) and enables advanced synchronization features.

**Figure 1–1**

The Instrument Interface

# The Instrument Interface

This section describes the connectors and indicators of the Instrument Interface.

## The Front Panel

The front panel (Figure 6–2) provides the connectors and indicators for various functions.

- The 4x BNC Input Ports for connection to analog instruments using a BNC-BNC Cable.
- The 'Power' LED illuminates blue when the system is receiving power
- The 'Status' LED illuminates green when communication with LabChart has been established.

**Figure 1–2**
The front panel of the Instrument Interface
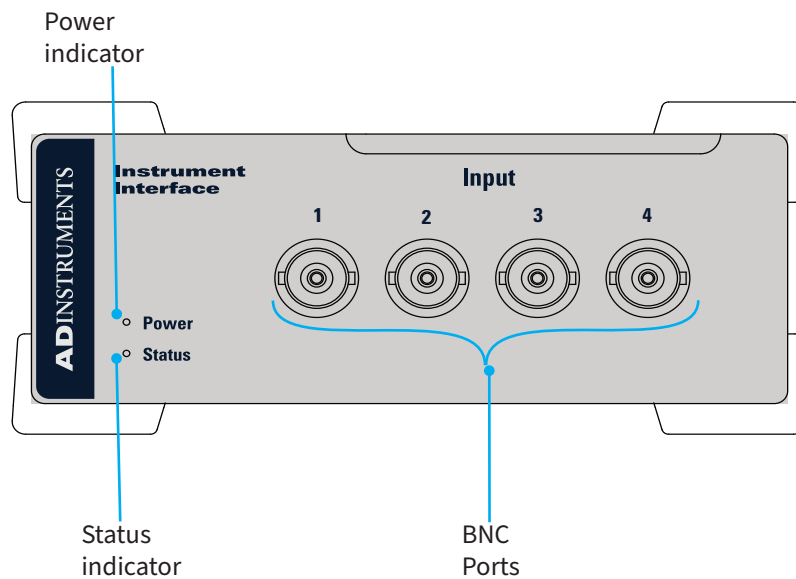
# The Rear Panel

The rear panel of the Instrument Interface is shown below (Figure 6-3).It provides the USB-C Port for connection to the PowerLab C or computer.

USB-C
Port
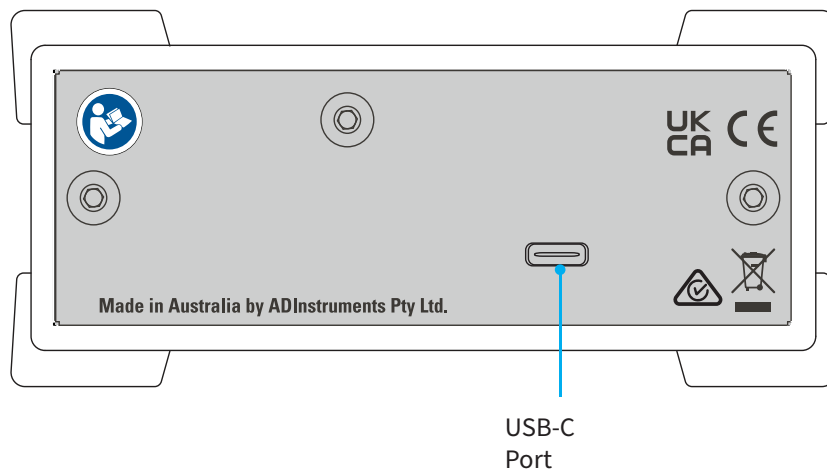
# Connecting an Analog Instrument into a system

An Analog Instrument can be connected using the Instrument Interface in the following ways:

1. Through a PowerLab C: The Analog instrument can be connected to the Instrument Interface by using the BNC sockets on the front panel. Using the USB-C to USB-C cable, the Instrument Interface can be powered by connecting it to one of the 4 downstream facing USB ports on the PowerLab C. A USB-C to USB-C cable or USB-C to USB-A cable should be used to connect the PowerLab (using the 'Computer' labelled upstream facing port) to the appropriate USB port on the computer .

**2.** Directly to the Computer: After connecting the Analog instrument and the Instrument Interface through the BNC sockets on the front panel, the Interface can be powered by directly connecting it to a computer. In this case, an ADInstruments supplied USB-C to USB-C cable or USB-C to USB-A cable can be used depending on port availability on the computer.

**Figure 1–5**
Connecting an instrument to a computer

To
Computer
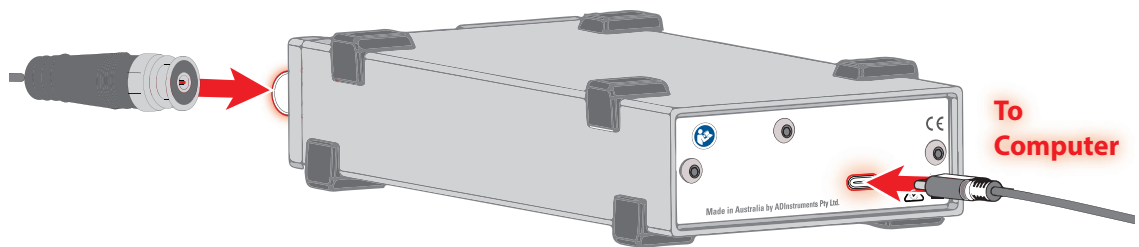
# Supplied Accessories

| Accessory |
| --- |
| MLAC89/1 USB-C to USB-C cable (300mm) |
| MLAC89/3 USB-C to USB-C cable (1m) |

# Software

LabChart 8:

Instrument Interface devices will be detected and listed during LabChart 8's device detection process. Channels can be enabled in the 'Devices and Channels' dialogue in the 'Setup' menu. Settings for the Instrument Interface can be found in the Input Amplifier section of the channel drop down menu.

LabChart Lightning:

Instrument Interface devices will be detected during LabChart Lightning's device detection process.

## Instrument Compatibility

The Instrument Interface is designed to work with most 3rd party instruments that feature an analog output between -10V and +10V. Many instruments feature a BNC output port, some may require an adapter cable.

# Technical Specifications

This chapter describes some of the important technical aspects of the PowerLab C and C Series devices. You do not need to know the material here to use these products. It is likely to be of special interest to the technically minded, however it should not be used as a service manual: user modification of the PowerLab voids your rights under warranty.

**Figure 7-1**
Instrument Interface
connected to a laptop
through a PowerLab C

# Specifications

## Common

### USB Standards

PowerLab C and all C Series devices support
- USB2.0 Full speed data
- USB Type-C 1.2 and USB-PD version 3.0
- Proprietary PowerLab Event Link (PEL)

### Regulatory Information

The PowerLab C and all C Series devices comply with the following

| | |
|---|---|
| Safety: | Complies with IEC 60601-1:2012 (tested by TÜV SÜD PSB, Singapore) |
| Classification: | Class I ME Equipment |
| EMC: | Complies with IEC 60601-1-2:2014 (tested by TÜV SÜD PSB, Singapore) |
| 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 center or return to manufacturer. |

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

## PLC01 PowerLab C

### Physical Configuration

Dimensions (h × w × d):      70 mm × 240 mm × 260 mm (2.8" × 9.4" × 10.2")

Weight:      2.9 kg (6 lb 6 oz)

### Operating Requirements

Operating voltage range:      100–240 V AC, 50/60 Hz

Rated Power:      400 VA

Earth Leakage Current:      <250µA

Touch Current:      <100µA

Operating conditions:      5–35 °C, 0–90% humidity (non-condensing)

Altitude:      <=2000m

Atmospheric Pressure:      70 kPa - 106 kPa

### Downstream facing Ports

Number of Ports:      4

Power supply (via USB-PD):      Supports 5V (up to 25W), 9V (up to 45W), 15V (up to 75W), 20V (up to 100W) per port

Total available power:      310W (when powered by internal power supply)

### Upstream facing Computer Port

Number of Ports:      1

Power capability:      100W

Supports power in, high-speed data, synchronisation

### Upstream facing Aux Port

Number of Ports:      1

Power capability:      100W

Supports power in only

## PLCF1 Front End Interface

### Analog Inputs

| | |
|---|---|
| Number of input channels: | 8 |
| Configuration: | Single-ended |

| Amplification ranges: | *Range* | *Resolution* |
|---|---|---|
| | ± 10 V | 313 µV |
| | ± 5 V | 156 µV |
| | ± 2 V | 62 µV |
| | ± 1 V | 31 µV |
| | ± 500 mV | 15 µV |
| | ± 200 mV | 6 µV |
| | ± 50 mV | 1.5 µV |
| | ± 20 mV | 625 nV |

| | |
|---|---|
| Maximum input over-voltage: | ± 13 V |
| Input impedance: | 1 MΩ |
| Input Coupling: | DC |
| Non-linearity (max): | 0.2 % |
| Low pass filters: | Off, 20, 50, 100, 200, 500, 1000, 2000 Hz |

(Only available when no front end device is detected)

### Sampling

| | |
|---|---|
| ADC sampling: | Simultaneous across channels |
| ADC resolution: | 18-bits (16-bit effective) |
| ADC linearity: | ±4 LSB |
| Available sampling rates: | Up to 100 000 samples/s per channel (max throughput 400 000 samples/s) , regardless of whether it is connected to a PowerLab C or directly to a computer. |

### Output Amplifier

| | |
|---|---|
| Number of output channels: | 1 |
| Maximum output current: | 5 mA |
| Output rise time: | <10µs |

| | |
|---|---|
| Output impedance: | 1 KΩ |
| Output level: | 4.5 V |

## Physical Configuration

| | |
|---|---|
| Dimensions (h × w × d): | 27.5 mm x 68 mm x 88 mm (1.1" x 2.7" x 3.5") |
| Weight: | 0.1 kg (0 lb 4 oz) |

## Operating Requirements

| | |
|---|---|
| Operating voltage range: | 5 - 15 V |
| Rated Power: | 15 W |
| Power requirements: | Front-end dependent (Refer Figure 5 - 8) |
| Operating conditions: | 5–35 °C, 0–90% humidity (non-condensing) |

# PLCI1 Instrument Interface

## Analog Inputs

| | | |
|---|---|---|
| Number of input channels: | 4 | |
| Configuration: | Single-ended | |
| Amplification ranges: | *Range* | *Resolution* |
| | ± 10 V | 313 µV |
| | ± 5 V | 156 µV |
| | ± 2 V | 62 µV |
| | ± 1 V | 31 µV |
| | ± 500 mV | 15 µV |
| | ± 200 mV | 6 µV |
| | ± 50 mV | 1.5 µV |
| | ± 20 mV | 625 nV |

| | |
|---|---|
| Maximum input over-voltage: | ± 13 V |
| Input impedance: | 1 MΩ |
| Input Coupling: | DC |
| Non-linearity (max): | 0.2 % |

| | |
|---|---|
| Frequency response: | 24K Hz (all ranges) |
| Crosstalk: | >90 dB (unused channels 1K terminated) |
| Low pass filters: | Off, 20, 50, 100, 200, 500, 1000, 2000 Hz |

## Sampling

| | |
|---|---|
| ADC sampling: | Simulaneous across channels |
| ADC resolution: | 18-bits (16-bit effective) |
| ADC linearity: | ±4 LSB |
| Available sampling rates: | Upto 100 000 samples/s |

## Physical Configuration

| | |
|---|---|
| Dimensions (h × w × d): | 55 mm x 120 mm x 260 mm (2.2" x 4.7" x 10.2") |
| Weight: | 1.2 kg (2 lb 10 oz) |

## Operating Requirements

| | |
|---|---|
| Operating voltage range: | 5 V |
| Rated Power: | <15 W |
| Power requirements: | <2.5 W |
| Operating conditions: | 5–35 °C, 0–90% humidity (non-condensing) |

## PowerLab Event Link (PEL)

| | |
|---|---|
| Time Sync accuracy between devices: | <1 µs |

## Electromagnetic Compatibility

The PowerLab C and C Series devices (the devices) have been tested to comply with IEC 60601-1-2:2014. The relevant basic EMC standards are IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-6, IEC 61000-4-8, IEC 61000-4-11 and CISPR 11.

## Emissions

- The devices are suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

## 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 devices are 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.

| Rated maximum output power of transmitter, P | Separation distance | |
| --- | --- | --- |
| | 150 kHz to 800 MHz $d = 1.17\sqrt{P}$ | 800 MHz to 2.7 GHz $d = 2.33\sqrt{P}$ |
| 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 |

| Immunity test | IEC 60601 test level | Compliance level | Electromagnetic environment guidance |
|---|---|---|---|
| Conducted RF<br>IEC 61000-4-6 | 3 Vrms<br>150 kHz to 80 MHz | 3 V | Recommended separation distance<br>(see TableB–2 p. 50) |
| Radiated RF<br>IEC 61000-4-3 | 3 V/m<br>80 MHz to 2.7 GHz | 3 V/m | Recommended separation distance<br>(see TableB–2 p. 50) |
| Electrostatic discharge<br>IEC61000-4-2 | ±8 kV contact<br>±15 kV air | ±4 kV contact<br>±8 kV air | Floors should be wood, concrete or ceramic tile.<br>If floors are covered with synthetic material, the relative humidity should be at least 30%. |
| Electrical fast transient/ burst<br>IEC61000-4-4 | ±2 kV for power supply lines | ±2 kV for power supply lines | Mains power quality should be that of a typical commercial or hospital environment. |
| Surge<br>IEC 61000-4-5 | ±0.5, 1 kV line-line<br>±0.5, 1, 2 kV line-ground | ±0.5, 1 kV line-line<br>±0.5, 1, 2 kV line-ground | Mains power quality should be that of a typical commercial or hospital environment. |
| Voltage dips, short interruptions and voltage variations on power supply input lines<br>IEC61000-4-11 | <5% UT (>95 % dip in UT) for 0.5 cycle<br><br>40% UT (60% dip in UT) for 5 cycles<br><br>70% UT (30% dip in UT) for 25 cycles<br><br><5% UT (>95% dip in UT) for 5 sec | <5% UT (>95% dip in UT) for 0.5 cycle<br><br>40% UT (60% dip in UT) for 5 cycles<br><br>70% UT (30% dip in UT) for 25 cycles | Mains power quality should be that of a typical commercial or hospital environment. If the user of the devices require continued operation during power mains interruptions, it is recommended that the devices be powered from an uninterruptible power supply or a battery. |
| Power frequency (50/60Hz) magnetic field<br>IEC 61000-4-8 | 3 A/m | 3 A/m | Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment. |

**Table 7-1** Immunity Test compliance

# Glossary

**Adaptive mains filtering.** An advanced signal processing technique that seeks to eliminate noise originating from mains power.

**ADC (analog-to-digital converter).** A device that converts analog information into some corresponding digital voltage or current.

**amplitude**. The maximum vertical distance of a periodic wave from the zero or mean position about which the wave oscillates.

**analog.** Varying smoothly and continuously over a range. An analog signal varies continuously over time, rather than changing in discrete steps.

**applied part.** A part which necessarily comes into physical contact with the subject during use.

**BNC (bayonet nut connector).** A type of cable or connector; a BNC-to-BNC cable connects two BNC connectors.

**bridge transducer.** A type of transducer using a Wheatstone bridge circuit. In its basic form, the bridge consists of four two-terminal elements (usually strain gauges) connected to form a quadrilateral. An excitationacross the other.

**connector.** A plug, socket, jack or port used to connect one electronic device to another (via a cable): a PowerLab to a computer, say.

**CPU (central processing unit).** A hardware device that performs logical and arithmetical operations on data as specified in the instructions: the heart of most computers.

**DAC (digital-to-analog converter).** A device that converts digital information into some corresponding analog voltage or current.

**DC offset.** The amount of DC (direct current) voltage present at the output of an amplifier when zero voltage is applied to the input; or the amount of DC voltage present in a transducer in its equilibrium state.

**DFP.** Downstream-Facing Port. A port that allows the connection of a peripheral such as a front-end, mobile phone, etc.

**filter.** An electronic device or a program that alters data in accordance with specific criteria. Filters in hardware and software can be used to reduce or to eliminate electronic noise or drift from data readings.

**frequency.** The number of complete cycles per second of a waveform. Frequency is usually expressed in hertz: Hz (cycles per second), kilohertz: kHz (thousands of cycles per second), or megahertz: MHz (millions of cycles per second).

**frequency response.** The bandwidth in which a circuit passes a signal without too much attenuation. A low-pass filter's frequency response is the frequency where the output voltage becomes 0.707 (1/√2) of the input voltage or has been attenuated by 3 decibels. If a low-pass filter has a frequency response of 200 Hz, say, then the signal is effectively unattenuated up to 150 Hz, and is 0.707 of the original value at 200 Hz.

**front-end.** An ancillary device that extends PowerLab capabilities, providing additional signal conditioning and features for specialized work. Front-ends are recognized automatically by the PowerLab system and seamlessly integrated into its applications, operating under full software control.

**gain.** The amount of amplification of a signal.

**I²C ('eye-squared-sea').** This connection is used by the PowerLab to control front-ends. It provides power and communications using a 4-wire serial bus (two wires for standard I²C and two control lines).

**IEC.** International Electrotechnical Commission.

**LabChart.** An application supplied with a PowerLab that emulates a multi-channel chart recorder, with other powerful options. (Macintosh and Windows versions differ slightly.)

**PD.** Power Delivery. An industry standard regulating the flow of power between devices which use USB-C standard.

**port.** A socket where you plug in a cable for connection to a network or a peripheral device. Also, any connection for transferring data, for instance between the CPU and main memory.

**PowerLab Event Link (PEL).** A communication protocol supported by USB-C which allows vendor-defined data transmission between devices.

**range.** In LabChart and Scope, the range is the greatest positive and negative voltage that can be displayed, usually from ±5 mV to ±10 V, in 11 steps. (Range is inversely proportional to gain, the extent of amplification.)

**transducer.** A physical device that converts a mechanical, thermal or electrical stimulus into a proportional electrical output. For example, there are common transducers to measure force, displacement, temperature, pressure, and similar parameters.

**UFP.** Upstream-Facing Port. A port that is intended for connection of a controlling device such as a computer.

**USB.** Universal Serial Bus.

**USB-C.** Universal Serial Bus with Type-C connector. An industry standard specifying providing high-speed data and power.

**waveform.** The shape of a wave; a graph of a wave's amplitude over time.

# Warranty

## Product Purchase and License Agreement

This Agreement is between ADInstruments NZ Ltd ['ADI'] and the purchaser ['the Purchaser'] of any ADI product or solution — software, hardware or both — and covers all obligations and liabilities on the part of ADI, the Purchaser, and other users of the product. The Purchaser (or any user) accepts the terms of this Agreement by using the product or solution. Any changes to this Agreement must be recorded in writing and have ADI's and the Purchaser's consent.

## Responsibilities

The Purchaser and any others using any ADI product or solution agree to use it in a sensible manner for purposes for which it is suited, and agree to take responsibility for their actions and the results of their actions. If problems arise with an ADI product, ADI will make all reasonable efforts to rectify them. This service may incur a charge, depending on the nature of the problems, and is subject to the other conditions in this Agreement. ADI does not separately warrant the performance of products, equipment or software manufactured by third parties which may be provided to Purchaser as part of an overall solution. However, as further noted below, ADI will pass through to Purchaser all applicable third party warranties to the extent it has the right to do so.

## ADI Product Hardware Warranty

ADI warrants that PowerLab Data Acquisition Units (PL prefix)1 and Front-ends (FEprefix)2 shall be free from defects in materials and workmanship for five (5) years from the date of purchase. Other PowerLab Data Acquisition Units3, Front-ends4 and Pods5 shall be free of defects in material and workmanship for three (3) years from their date of purchase. ADI also warrants that ADI Specialized Data Recorders6 and Instruments7 shall be free of defects in material and workmanship for one (1) year from their date of purchase. If there is such a defect, as Purchaser's sole remedy hereunder, ADI will repair or replace the equipment as appropriate, and the duration of the warranty shall be extended by the length of time needed for repair or replacement.

To obtain service under this warranty, the Purchaser must notify the nearest ADI office, or Authorized Representative, of the defect before the warranty expires. The ADI or Representative office will advise the Purchaser of the nearest service center address to which the Purchaser must ship the defective product at his or her own expense. The product should be packed safely, preferably in its original packaging. ADI will pay return shipping costs.

## Hardware Warranty Limitations

This warranty applies only to the ADI hardware specified in this document and used under normal operating conditions and within specification. Consumables, electrodes and accessories are not covered by this warranty. Third party equipment may be covered by the third party manufacturer's warranty. To the extent that ADI has the right to pass through any third party manufacturer warranties to Purchaser it will do so to the extent it is able to do so. Copies of applicable third party manufacturer warranties, to the extent they exist, are available upon request. The warranty provided hereunder does not cover hardware modified in any way, subjected to unusual physical, electrical or environmental stress, used with incorrectly wired or substandard connectors or cables, or with the original identification marks altered. Tampering with or breaking of the Warranty Seal will also void the warranty.

## Product Types & Warranty Term

### ADI manufactured products covered by a five (5) year warranty

[1] Data Acquisition Units: PowerLab C, C Series devices & 35 series with PL prefix
[2] Front-ends: ADI Front-end Signal Conditioners with FE prefix.

### ADI manufactured products covered by three (3) year warranty

[3] Data Acquisition Units: PowerLab 26 series with ML prefix
[4] Front-ends: ADI Front-end Signal Conditioners with ML prefix.
[5] Pods: The entire range of ADI Pod Signal Conditioners.

### ADI manufactured products covered by one (1) year warranty

[6] Specialized Data Recorders: Metabolic Systems (e.g., ML240 PowerLab/8M Metabolic System)
[7] Instruments: Blood FlowMeter, Gas Analyzers, NIBP System (excluding transducers), STH Pump Controller.

### Third Party Products (Including Transducers)

Products not manufactured by ADI are covered by the manufacturer's warranty.

### Accessories and Consumables

Accessories and Consumables are not covered by any type of warranty.

## General Limitations

ADI products are produced to high standards, and should perform as described in the supplied documentation. There is a limited hardware warranty, and technical support is provided for all ADI products. Nevertheless, since ADI products could be affected by external factors (for instance, the computer system on which they run and other hardware and/or software provided by third parties), absolute performance and reliability of products and the overall solution cannot be guaranteed. No warranty, either expressed or implied or statutory, other than that expressly contained in this Agreement, is made in respect to ADI products or software, third party products or software, the overall solution or otherwise. The Purchaser therefore assumes all risks as to the performance and reliability of the products, the software, the solution and the results gained using them. ADI neither assumes or authorizes any person to assume on its behalf any liability in connection with the sale, installation, service or use of its products. ADI shall not be held responsible for special, consequential or punitive damages of any kind aris-

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## Technical Support

The Purchaser is entitled to free technical support for any ADI product for one year from its date of purchase. Our technical support staff can provide advice concerning installation and operation of ADI products. Services outside of this may incur a charge. Technical support staff will not provide experimental protocols or procedural instructions for conducting experiments. However, information of this type may be provided in the supplied product documentation, or on ADI web sites.

## Inquiries

For additional information or service inquiries please contact the nearest ADInstruments office or Authorized Distributor. For contact details see www.ADInstruments.com