BiStat
Installation and
Configuration Manual

BioLogic
Science **Instruments**

The equipment described in this manual has been designed in accordance with EN61010 and EN61326 and has been supplied in a safe condition. The equipment is intended for electrical measurements only. It should be used for no other purpose.

To avoid injury to an operator the safety precautions given below, and throughout the manual, must be strictly adhered to, whenever the equipment is operated. Only advanced user can use the instrument.

Bio-Logic SAS accept no responsibility for accidents or damage resulting from any failure to comply with these precautions.

GROUNDING

To minimize the hazard of electrical shock, it is essential that the equipment be connected to a protective ground through the AC supply cable. The continuity of the ground connection should be checked periodically.

ATMOSPHERE

You must never operate the equipment in corrosive atmosphere. Moreover if the equipment is exposed to a highly corrosive atmosphere, the components and the metallic parts can be corroded and can involve malfunction of the instrument.
The user must also be careful that the ventilation grids are not obstructed on the right and left sides and under the chassis. An external cleaning can be made with a vacuum cleaner if necessary.
Please consult our specialists to discuss the best location in your lab for the instrument (avoid glove box, hood, chemical products, …).

AVOID UNSAFE EQUIPMENT

The equipment may be unsafe if any of the following statements apply:
- Equipment shows visible damage,
- Equipment has failed to perform an intended operation,
- Equipment has been stored in unfavourable conditions,
- Equipment has been subjected to physical stress.

In case of doubt as to the serviceability of the equipment, don't use it. Get it properly checked out by a qualified service technician.

LIVE CONDUCTORS

When the equipment is connected to its measurement inputs or supply, the opening of covers or removal of parts could expose live conductors. Only qualified personnel, who should refer to the relevant maintenance documentation, must do adjustments, maintenance or repair

EQUIPMENT MODIFICATION

To avoid introducing safety hazards, never install non-standard parts in the equipment, or make any unauthorised modification. To maintain safety, always return the equipment to Bio-Logic SAS for service and repair.

GUARANTEE

Guarantee and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use of the device,
- Improper installation, operation or maintenance of the device,
- Operating the device when the safety and protective devices are defective and/or inoperable,
- Non-observance of the instructions in the manual with regard to transport, storage, installation,
- Unauthorized structural alterations to the device,
- Unauthorized modifications to the system settings,
- Inadequate monitoring of device components subject to wear,
- Improperly executed and unauthorized repairs,
- Unauthorized opening of the device or its components,
- Catastrophic events due to the effect of foreign bodies.

IN CASE OF PROBLEM

Information on your hardware and software configuration is necessary to analyze and finally solve the problem you encounter.

If you have any questions or if any problem occurs that is not mentioned in this document, please contact your local retailer. The highly qualified staff will be glad to help you.
Please keep information on the following at hand:

- Description of the error (the error message, mpr file, picture of setting or any other useful information) and of the context in which the error occurred. Try to remember all steps you had performed immediately before the error occurred. The more information on the actual situation you can provide, the easier it is to track the problem.
- The serial number of the device. You will find it on the rear panel device.
- The software and hardware version you are currently using. On the Help menu, click About. The displayed dialog box shows the version numbers.
- The operating system on the connected computer.
- The connection mode (Ethernet, LAN, USB) between computer and instrument.

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1. Introduction

Historically, the first of our multi-channel instruments was designed to study intercalated compounds with long experiment times because of slow diffusion coefficients. It worked in either galvanostatic mode or potentiostatic mode (each channel was devoted to one of either modes). Then the interest for multichannel potentiostats increased with battery testing, corrosion study and, recently, biosensors development. Now our multichannel product range has four different very modular instruments that are all potentiostats/galvanostats. They can be used for most electrochemical applications from battery testing and intercalated compounds study to corrosion and multipitting. We can also mention electrochromics, fuel cells, capacitors, and biosensors study.

The BiStat consists of single computer board associated with potentiostat channel boards. The BiStat has its own operating system included on the computer board. When started, the on-board computer has full control of the experiment. The bipotentiostat can receive two independent channel boards. It is designed to provide very flexible use with one or two different users. One or two computers can perform full remote monitoring of the system. These computers connect to the BiStat through an Ethernet connection. With the Ethernet connection, each one of the users is able to monitor his own channel from his computer. Our aim is to design the most modular, versatile and flexible instruments as possible.

This instrument is very modular. It can be provided with low current board channel. All the channels can be coupled with current amplifiers (2, 5, 10, 20 A). Moreover, the BiStat can control auxiliary instruments (like a rotating electrode or thermostatic bath).

The aim of this manual is to guide the user in the instrument installation and configuration. This manual is composed of several chapters. The first one is an introduction. It explains the abilities of the instrument. The second part describes the technical specifications. The third and fourth parts concern the installation and configuration of the instrument and the configuration of the computer. The fifth chapter is dedicated to the explanation of advanced features. Finally the BiStat's accessories are described in the last part.

This manual will guide you through the hardware installation of your BiStat (chapter 3 and 4).

WHEN AN USER RECEIVES A NEW UNIT FROM THE FACTORY, THE SOFTWARE AND FIRMWARE ARE INSTALLED AND UPGRADED. THE INSTRUMENT IS READY TO BE USED. IT DOES NOT NEED TO BE UPGRADED.

Fig. 1: BiStat.

1.1 General description

Each channel can be set, run, paused or stopped, independently of each other, using identical or different protocols. Any settings of any channel can be modified during a run, without interrupting the experiment.

The two channels can be interconnected and run synchronously, for example to perform multi-pitting experiments using a common counter-electrode in a single bath.

Simultaneous measurements of the current and potential of the working electrode are performed continuously, using two 16-bit Analog to Digital Converters. This allows the user to make true power or noise measurements.

Once the protocols have been loaded and started from the PC, the experiments are entirely under the control of the BiStat's on-board computer. The BiStat temporarily buffers data and regularly transfers it to the PC, which is used for data storage, on-line visualization, on-line and off-line data processing, and display. This architecture ensures a very safe operation since a shut down of the monitoring PC does not affect the experiments in progress on the BiStat.

1.2 Software features

Any electrochemical experiment is a set of open circuit sequences and galvanic sequences, measuring the potential in both cases, and imposed potential sequences, measuring the current.

Usual electrochemical techniques, such as Cyclic Voltammetry, Chronopotentiometry, etc.., are obtained by associations of elementary sequences, and appear as flow-diagrams combining these sequences.

The user can find more information about EC-Lab$^®$ software in the **EC-Lab$^®$ software user's manual.**

Conditional tests can be performed at various levels of any sequence either on the working electrode potential or current, the counter electrode potential, or on the external parameters. These conditional tests either force the experiment to go to the next step, loop to a previous sequence, or end the sequence.

The application software package provides useful protocols for general electrochemistry, corrosion, batteries, super-capacitors and custom applications.

Standard graphic functions such as re-scaling, zoom, linear and log scales are available.

Standard processed files can be created at the user's convenience upon running an experiment, for purpose of real time display of the experiments in progress.

Post processing is also possible using built-in options to create variables at the user's convenience, such as derivative or integral values, etc...

Raw data and processed data can be exported as standard ASCII text files.

This design makes the BiStat a very versatile potentiostat. It can support most of the electrochemical applications from corrosion experiments to research on batteries, super-capacitors or electrochromics. It is also a very well adapted tool for sensors and actuators applications.

It is assumed that the user is familiar with Microsoft Windows$^©$ and knows how to use the mouse and keyboard to access the drop-down menus.

2. BiStat cables connection

2.1 Connections

Depending on your local installation, you can use a direct connection (1 PC to 1 BiStat) or a network connection (1 or several PCs to 1 or several BiStats).

2.1.1 Direct connection

Ethernet crossed cable
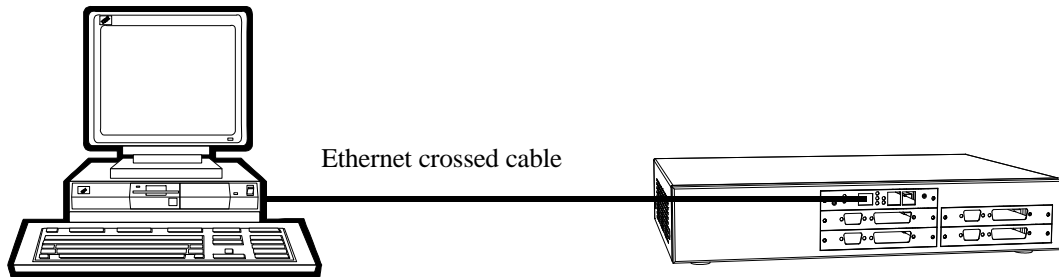
Fig. 2: Ethernet crossed cable for direct connection.

2.1.2 Network connections

Several PCs can be connected to the same BiStat through the network.
WARNING: check IP addresses before connecting to avoid conflicts (see TCP/IP configuration chapter).
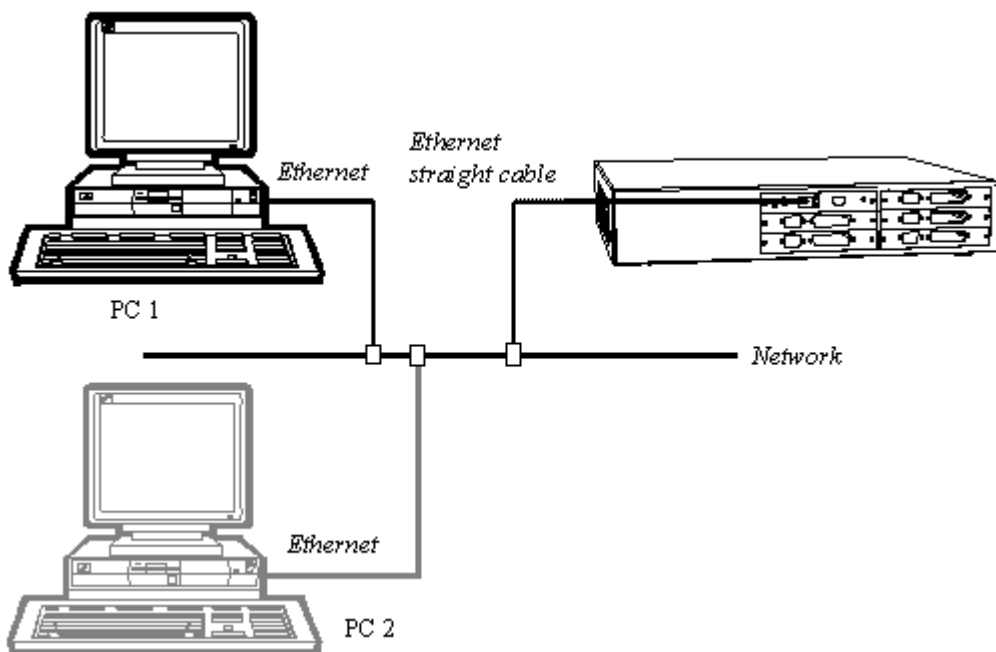
Fig. 3: Ethernet straight cable for network connection (1 BiStat, several PCs).

Alternatively, a single PC can control several BiStats through the network.
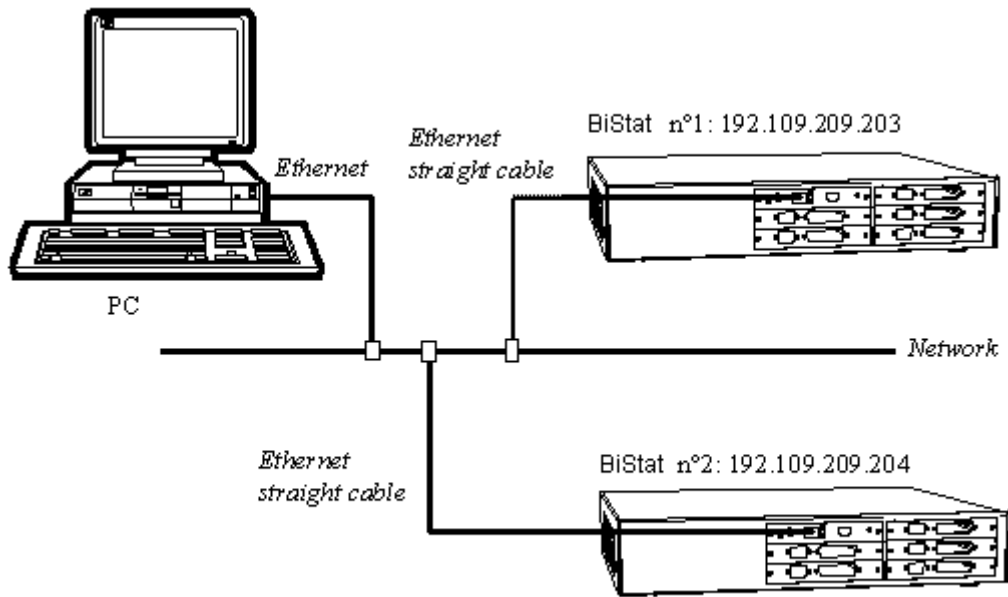
Fig. 4: Connection of 1 PC to several BiStats.

2.2 BiStat amplifier and cell connections

One or two cables are used for the connections depending on the use of a booster or not.

2.2.1 Connection of the standard channel board to the electrochemical cell
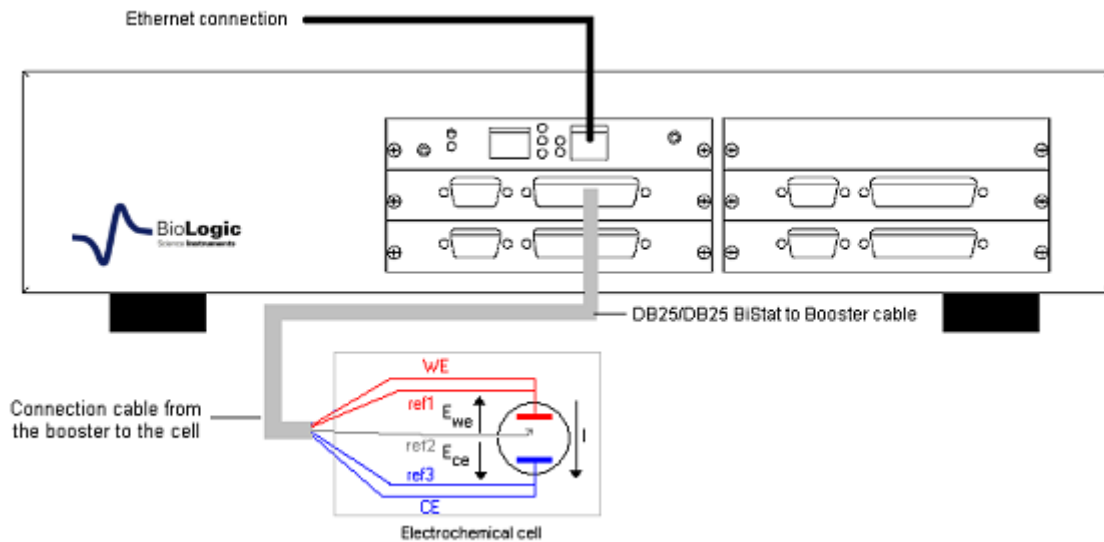
Fig. 5: BiStat channel board connection to the cell.

The cable is 1.5 m long with a DB25 connector on the BiStat channel board side and 5 terminals (2 mm plugs) to connect to the cell.

2.2.2 Connection of the standard channel board to the cell through a booster
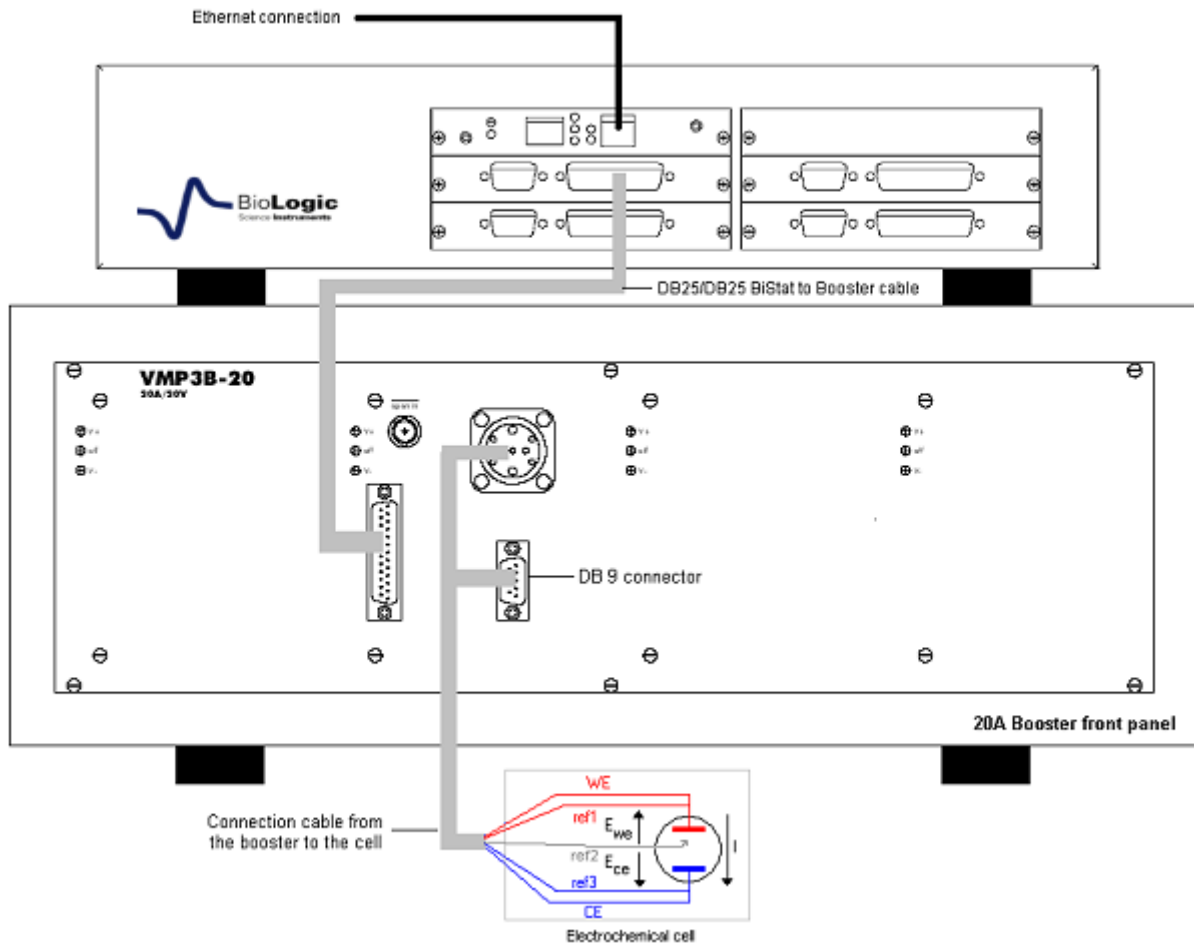
Fig. 6: BiStat to amplifier and amplifier to cell connections.

The BiStat to amplifier cable is 0.6 m long with a DB25 connector on each side.
The amplifier to cell cable is 1.5 m long with a DB9 connector on the amplifier side and 5 terminals to connect to the cell: 2 for the current (4 mm banana plugs) and 3 for the potential (2 mm banana plugs).

2.3 "p" low current option

One of the channel of the BiStat is equipped with the 'p' low current option providing a sub-pA resolution. This extends the current ranges down to 1 nA with a resolution better than 0.1 pA. A BiStat unit contains a mixture of standard channels and channels equipped with the 'p' low current option.

A BiStat standard channel with the "p" low current option features 10 current measurements ranges in fixed or auto-ranging mode. The "p" low current option inherits all the standard board benefits: impedance measurements, simultaneous recording of the potential and current, high speed acquisition, DSP technology, 20 V adjustable control range, 2 auxiliary inputs per channel, up to 5 terminal measurements.

Fig. 7: The "p" low current option.

The "p" option improves some of the specifications like the electrometer's input bias current which is typically less than 100 fA or the input impedance at least 10^{14} Ω in parallel with no more than 1 pF. All these performances makes a BiStat with the "p" low current option best suited for research on insulators, coatings, thin film electrodes, dielectric materials, microelectrodes, sensors, low conductive medium, biological interfaces.

2.3.1 Installation

The "p" low current option physically consists of a board, a probe that is a small box to be placed close to the cell and cables.
The connection between the standard channel and the 'p' low current option is performed using a supplied ribbon cable.

Fig. 8: Standard channel installed.

Fig. 9: Standard channel connected to a "p" low current.

2.3.2 Calibration

Once installed and connected to its adjacent standard channel, the "p" low current option must be calibrated using EC-Lab® (V8.0 or higher). Note that this operation is necessary only once.

WHEN THE "P" LOW CURRENT BOARD IS PROVIDED WITH A NEW INSTRUMENT, IT IS NOT NECESSARY TO DO THE CALIBRATION. IT HAS BEEN ALREADY DONE AT THE FACTORY.

Note: 1) The supplier recommends to calibrate the channel boards and the "p" low current boards two or three times an year especially if the room where the instrument is located is sensitive to temperature variations.
2) A new instrument is delivered with calibrated channel boards and calibrated "p" low current boards.

Select the **Config, Boards calibration…** menu into EC-Lab® to load the next window:

Fig. 10: Boards calibration window.
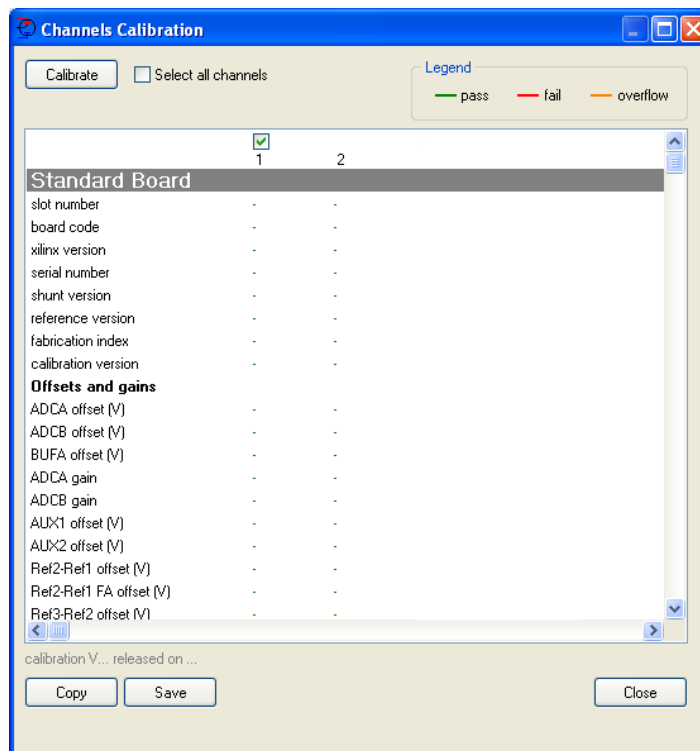
Select a channel and click on the **Calibrate** button and follow the instructions to calibrate the channel and the associated 'p' option. You will be asked to perform some specific actions (cell cables connections and disconnections) during the calibration procedure. Note new firmware is loaded on the channel during the calibration, causing the channel to reinitialize after calibration.

2.4 BiStatBiStat cable connection to the cell

This paragraph explains how to connect a Bistat channel to a cell using the standard 1.5 m cable provided with the instrument.

In the standard configuration, a Bistat channel has 6 lead connections to the electrochemical cell: four are used in the cell control loop (2 for the current and 2 for the potential) while the 5th lead permits simultaneous recording of a supplementary cell potential. Additionally, a 6th ground lead is provided for cell shielding purposes or for particular cell arrangement like in multi-pitting protocols. This lead is especially used in the CE to ground mode. To be easily identified, each lead has an associated color and label as follows:

- Ref1: RED – Reference 1 for the control and measurement of the working electrode potential.
- Ref2: WHITE – Reference 2 for the control and measurement of the Reference electrode potential.
- Ref3: BLUE – Reference 3 for the control and measurement of the Counter electrode potential.
- CA2: RED – Control Amplifier for the current control and measurement flowing through the working electrode (in standard mode).
- CA1: BLUE – Control Amplifier for the current control and measurement flowing through the counter electrode (in standard mode).
- GND: BLACK – Ground connected to REF1 in the CE to Ground mode.

The internal structure of the BiStat has led to the building of two different connection modes: "Standard" and "CE to Ground".

2.4.1 Standard connection

A BiStat channel has the possibility to link up with 2, 3 or 4 electrodes in different configurations depending on the electrochemical cell. In the standard mode E_{we} and E_{ce} are measured as follow:

$$E_{we} = Ref1 - Ref2$$
$$E_{ce} = Ref3 - Ref2$$

The current (defined in the positive direction) crosses the electrochemical cell from CA2 to CA1. Three typical standard configurations are explained below.

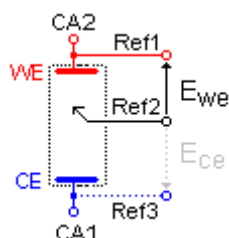#### 2.4.1.1 Standard three-electrode connection

Fig. 11: Standard three-electrode connection for a classical metal-solution interface.

In the standard three-electrode connection mode typically used in analytical electrochemistry or in corrosion experiments the working electrode is connected to Ref1+CA2. The counter-electrode is connected to Ref3+CA1, and the reference electrode is connected to Ref2.

Another three-electrode connection with a reference electrode can be done, for example in batteries application. This connection allows the user to record/control simultaneously the positive and the negative part of the battery. For this, the following connection (Fig. 12) has to be done:

- Connection of the positive electrode (WE) to Ref1+CA2,
- Connection of the negative electrode (CE) to Ref2+CA1,
- Connection of the reference electrode (REF) to Ref3.
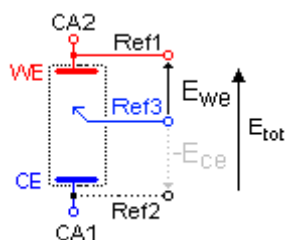
Fig. 12: Three-electrode connection with a reference electrode.

As the potential regulation is done between Ref1 and Ref2, the total potential of the battery will be displayed by default. The other parameters, such as the potential of the positive and the negative electrode versus the reference electrode, can be displayed by ticking the boxes E_{ce} and E_{we}-E_{ce} in the Cell Characteristics windows.

By this way, in the data file, the following rows will be displayed:

- E_{we} related to Ref1-Ref2 *i.e.* total potential of the battery,
- E_{ce} related to Ref3-Ref2 *i.e.* – negative electrode potential *vs.* Reference,
- E_{we} - E_{ce} related to Ref1-Ref3 *i.e.* positive electrode potential *vs.* Reference electrode.

It is then possible to plot change of potential (positive, negative, totality) as a function of time or state of charge (SOC).

2.4.1.2 Two electrode connection to a battery cell
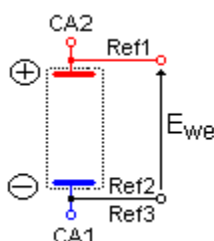
Fig. 13: Two-electrode connection to a battery cell.

In the two-electrode connection mode, the positive electrode of the battery is connected to Ref1+CA2. The potential control or measurement is performed between Ref1 and Ref2, and the controlled or measured current crosses the cell from CA2 to CA1. Therefore, the negative electrode has to be connected to Ref2+Ref3+CA1. In order to study the battery positive and negative electrode materials, the user inserts a reference electrode. Then a three-electrode assembly is required (refer to the previous part).

2.4.1.3 Four-electrode connection for liquid-liquid interfaces
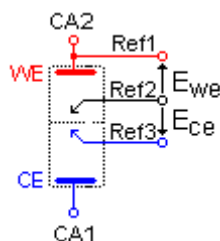
Fig. 14: Four-electrode connection for a liquid – liquid interface.

In the four-electrode connection mode the user will have the possibility to record the liquid-liquid interface potential (E_{ce}).

In the standard connection mode, Ref1 should always be connected to WE (or to the positive electrode) for proper cell isolation. However, to avoid IR drop in connections it is recommended to connect Ref1 directly on the cell electrode and not on the CA2 cable.

Note: Connecting Ref3 to CA1 adds parallel impedance. It is better to avoid it for accurate impedance measurement. So for impedance measurement, it could be better to disconnect Ref3 from the cell if E_{ce} measurement is not required. Notice that in that case, it is recommended to connect Ref3 to the ground cable.

2.4.2 CE to Ground (N'Stat) connection mode

This connection mode is chosen in EC-Lab$^{®}$ software "Advanced settings" window.
It is possible to work with several working electrodes, one counter and one or several reference electrodes into the same bath. That is the "N'Stat" configuration. Then the connections must be done in a special way, in connecting the CA1 (CE) cable to the WE of the cell and the ground cable to the CE electrode of the cell, as shown below:
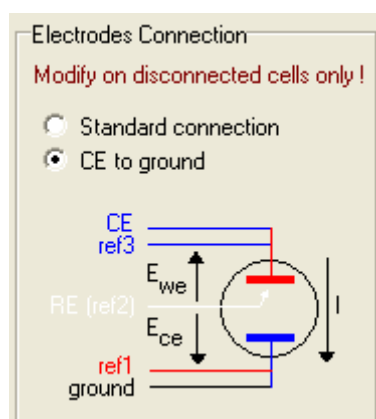
Fig. 15: CE to Ground connection mode.

Note: for the low-current board the Ground cable has to be connected to the black connector of the electrometer.

2.5 BiStat channel DB25 front panel connector

Front view

Ew_ctrl (output)
Cell WE current lead

Ew_guard (output)
Guard of Ew_ctrl and Ew_m leads

Ew_m (input)
Cell WE voltage measure lead

Ref_guard (output)
Cell reference guard lead

Ref (input)
Cell reference voltage lead

Ec_m (input)
Cell CE voltage measure lead

Ground (two pins)
Cell return current lead

Shunt_1, Shunt_2, Shunt_3 (output)
Booster shunt selectors leads

Amp_ctrl (output)
Booster control point lead

C/d_ext (output)
Booster cell open circuit relay command

Amp_status (input)
Booster status

Out_on (output)
Booster cell analog open circuit command

Shunt-, Shunt+ (input)
Booster current image leads

Amp_0, Amp_1, Amp_2, Amp_3 (input)
Booster identificator

Fig. 16: BiStat DB25 connector.

2.6 Power supply

Power supply connections are on the rear panel of the BiStat and current amplifier units.

2.7 BiStat auxiliary inputs/outputs (DB9)

The following figure shows the structure of the DB9 connector and the different pins that can be used as auxiliary inputs/outputs.

1 - Analog In1
2 – Analog Out
3 - OPEN In
4 – Trigger Out
5 - I monitor
6 – Analog In2
7 - Ground
8 - Trigger In
9 - E monitor
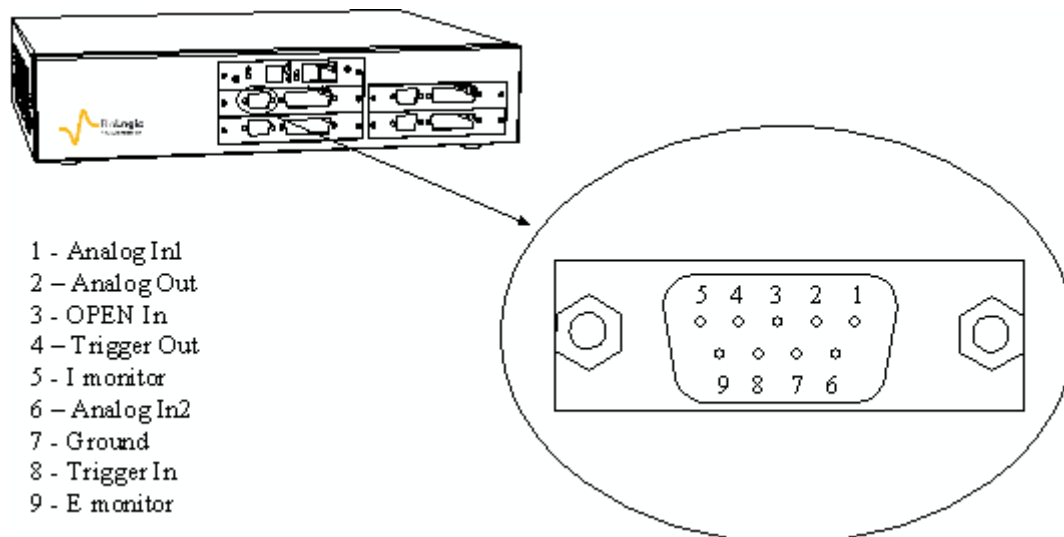
Fig. 17: Structure of a BiStat DB9 connector.

The Trigger signals have high and low levels:
$$+\ 3.5\ \text{V} < \text{Trigger high level} < +\ 5\ \text{V}$$
$$0\ \text{V} < \text{Trigger low level} < 0.8\ \text{V}$$

Trigger In and ***Trigger Out*** are programmed in the experiment protocol. The Trigger In can be used to start or stop the experiment of electrochemistry. In that case another instrument send a trigger to the BiStat. The Trigger Out can be sent at the beginning or at the end of the experiment. It is used to start or stop an experiment on another instrument.

E monitor and ***I monitor*** are outputs to visualize I and E on a scope. The output variables are opposite to the real measured values.

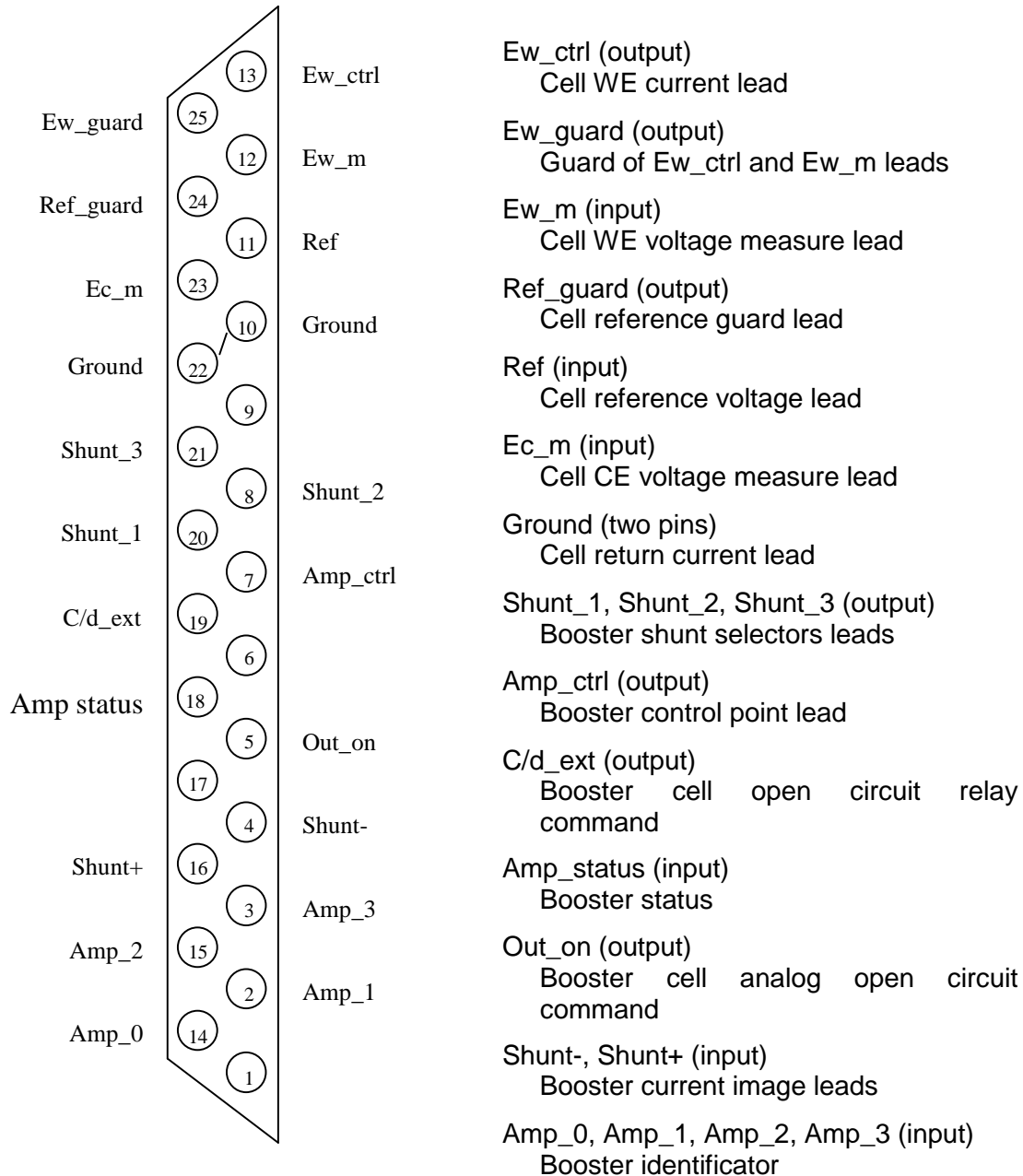***OPEN In*** is an external Trigger signal (active high) that can open the relays providing 0 A current in the cell. For example, an emergency stop may come from an external event.

Ground is tied to the earth.

Analog Out is used for rotating electrode control.

Analog In1 and ***Analog In2*** are general analog inputs used for auxiliary signal (voltage) recording. Activate Record Aux1 and Record Aux2 in the cell characteristics window to record these variables in the data file.

For convenience we have designed a 50 cm cable that connects to the DB9 connector of a channel on one end and with 8 BNCs on the other end.
The available signals are: E monitor, I monitor, Trigger In, Trigger Out, Analog In1, Analog In2 and Analog Out

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Fig. 18: BiStat DB9 cable.

3. Software installation on the computer

Before to turn on the instrument, it is recommended to install the software EC-Lab and/or EC-Lab express. For this operation, insert the CD-Rom in the computer. The installation is automatically launched with the "Autorun" function. The first software to be installed is EC-Lab.

3.1 EC-Lab software installation
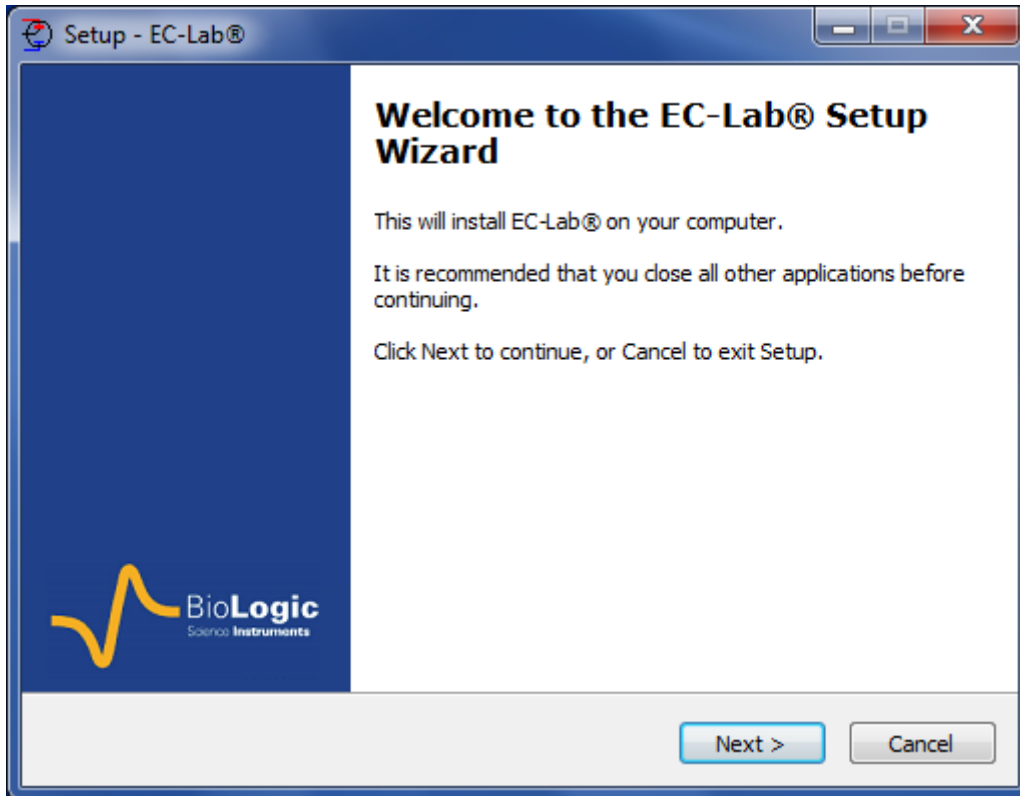
Fig. 19: EC-Lab software installation (1).
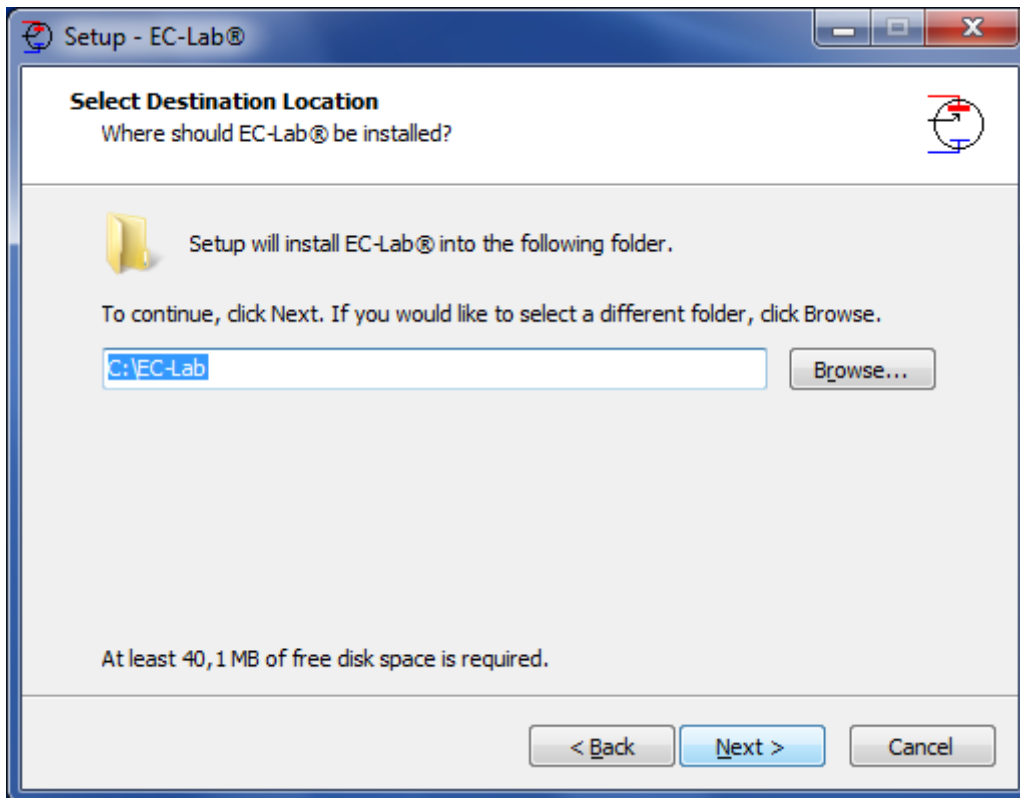
Fig. 20: EC-Lab software installation (2).
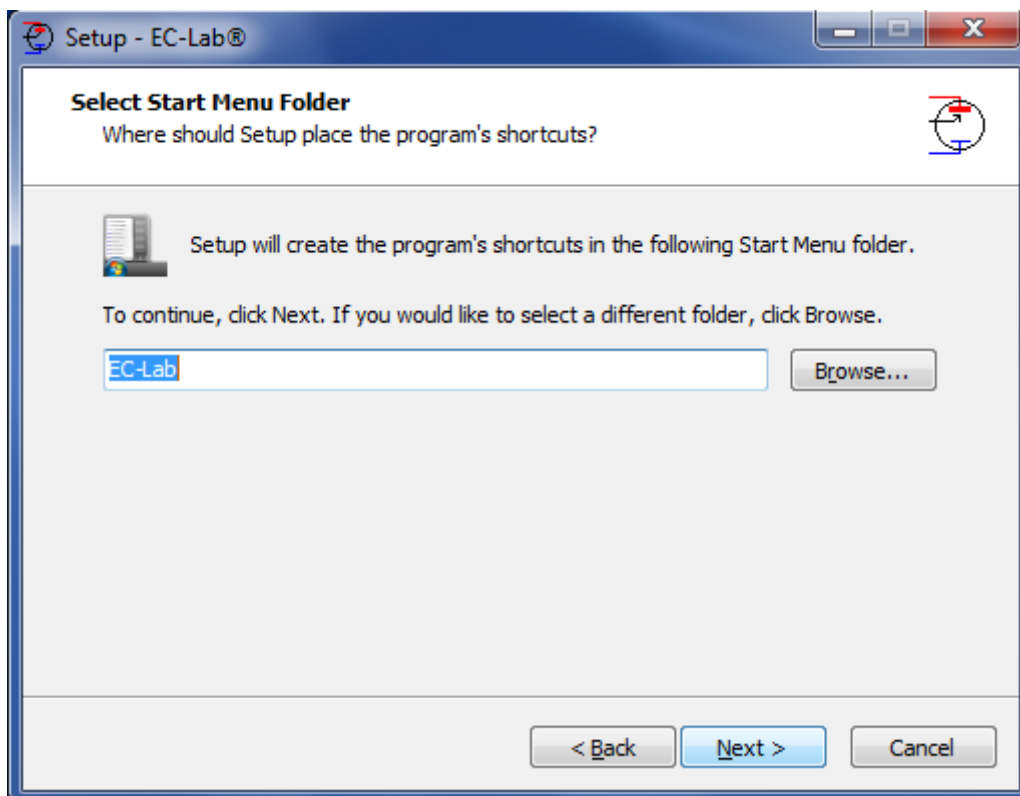
Fig. 21: EC-Lab software installation (3).
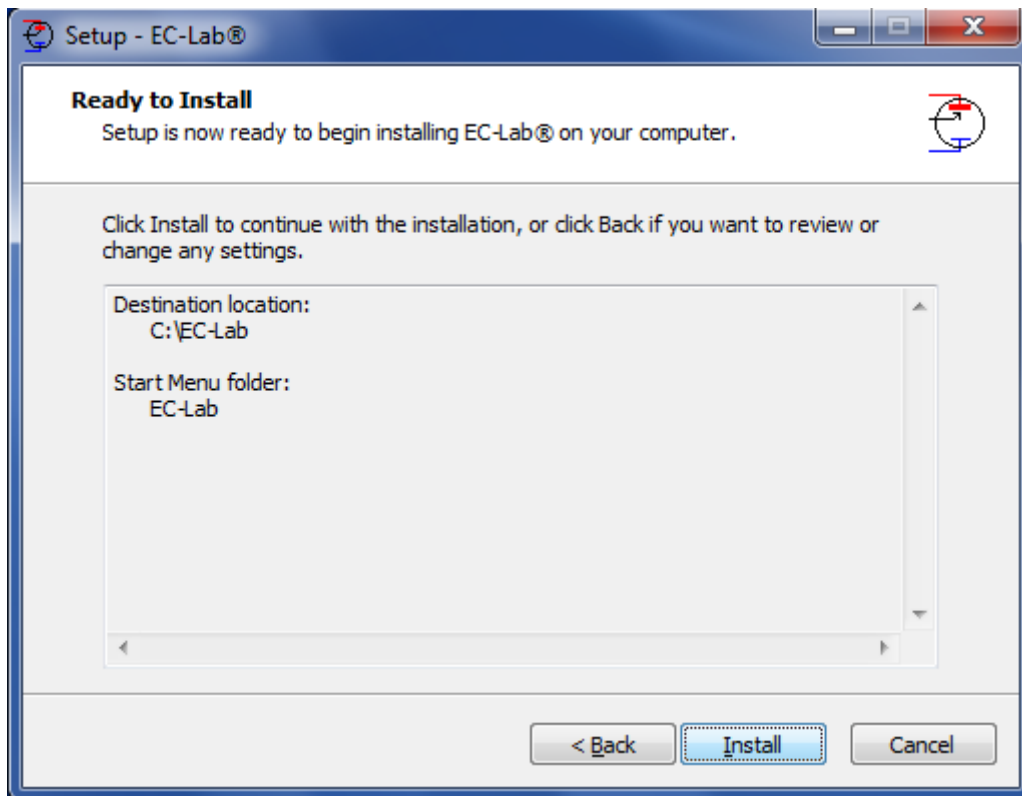
Fig. 22: EC-Lab software installation (4).
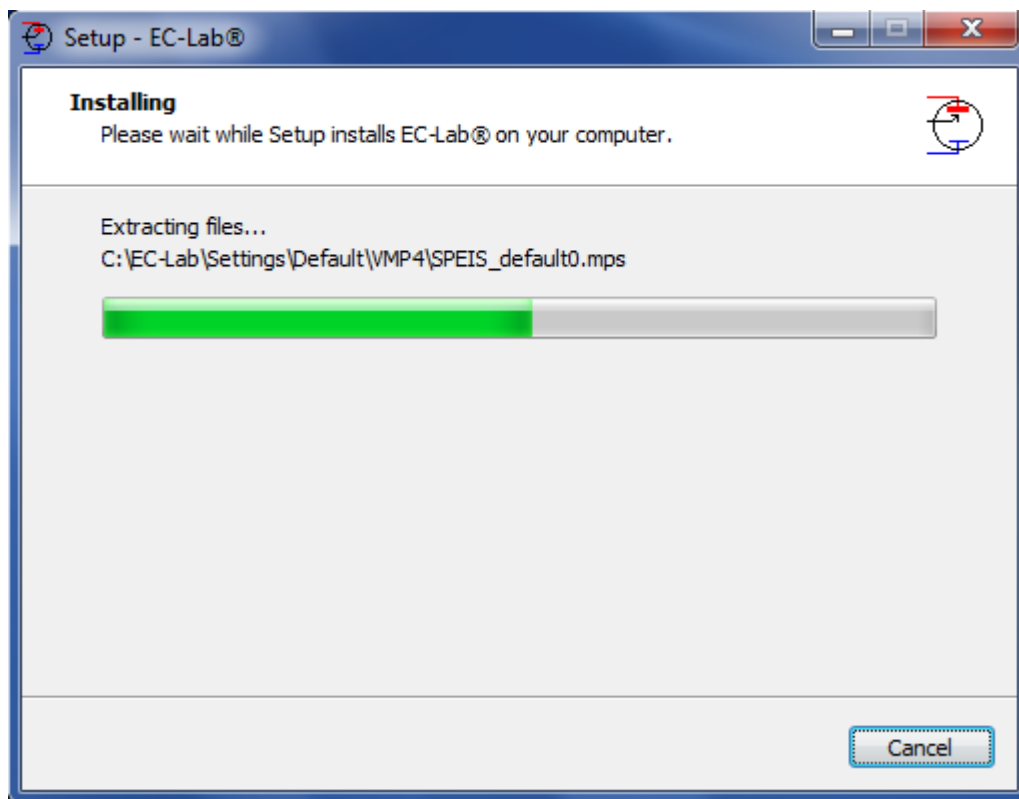
Fig. 23: EC-Lab software installation (5).
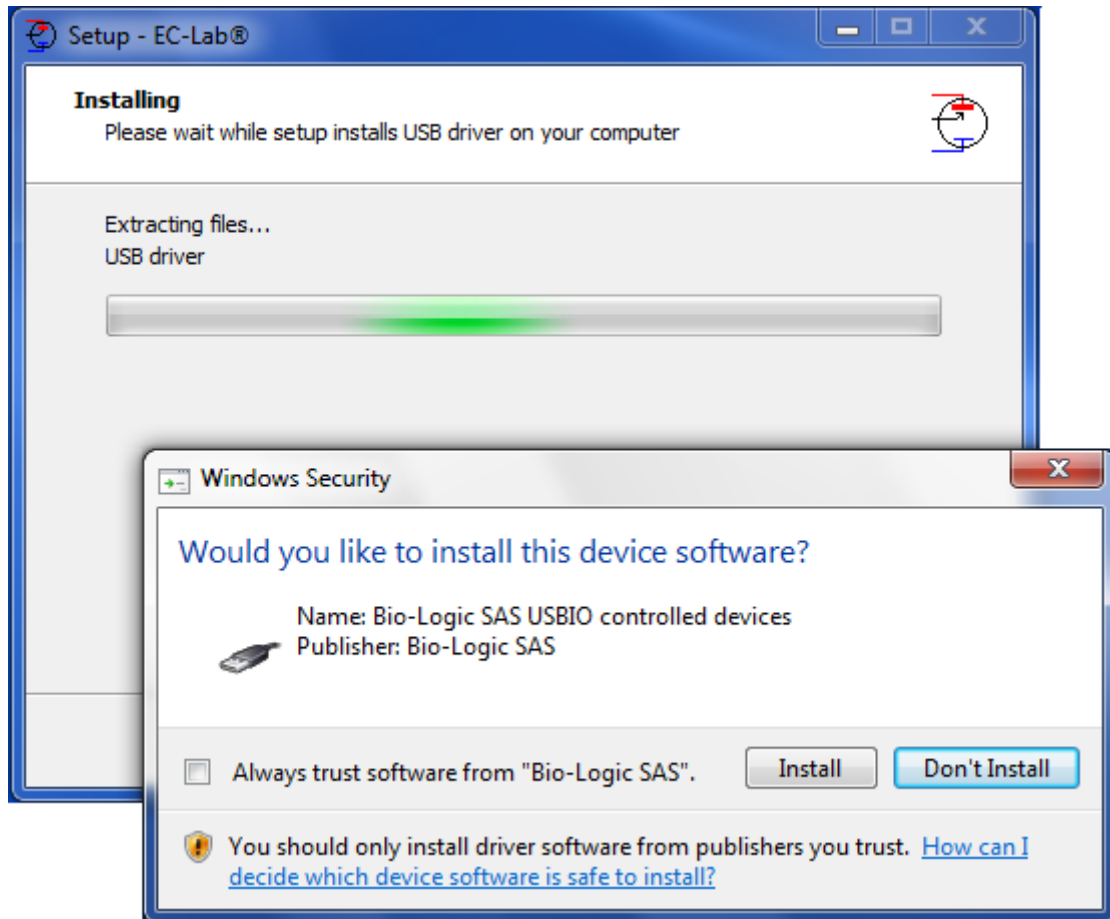
Fig. 24: EC-Lab software installation (6).
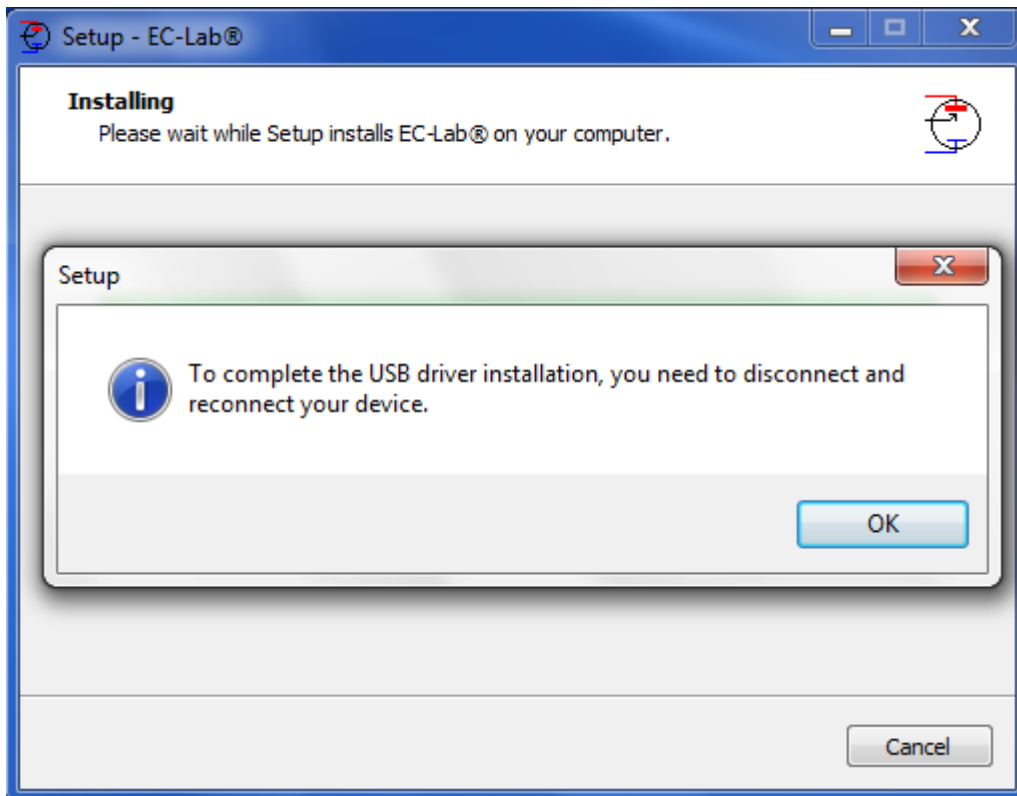
Fig. 25: EC-Lab software installation (7).
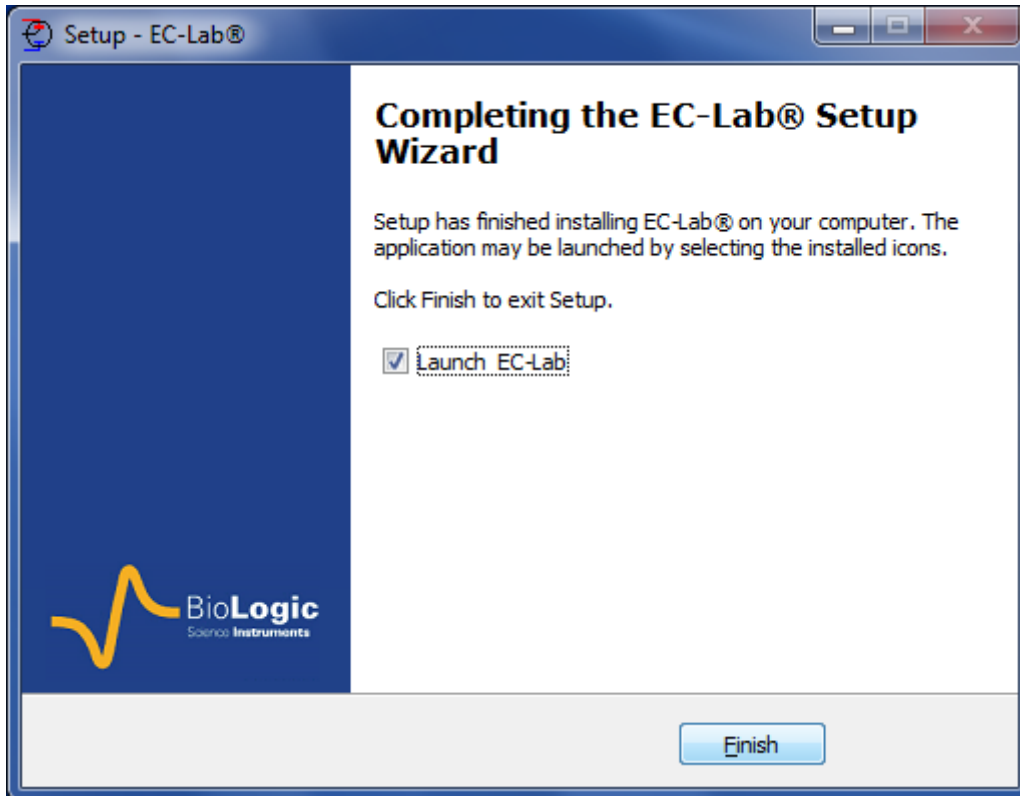
Fig. 26: EC-Lab software installation (8).

At the end of the installation, the instrument connected by USB is detected and ready to get used.

3.2 EC-Lab express software/OEM package installation

The installation of EC-lab express software and the OEM package is exactly done in the same way as for EC-Lab. Please see the above section for the installation

3.3 Errors during the installation

During the installation an error may occur if you are not administrator of the computer.
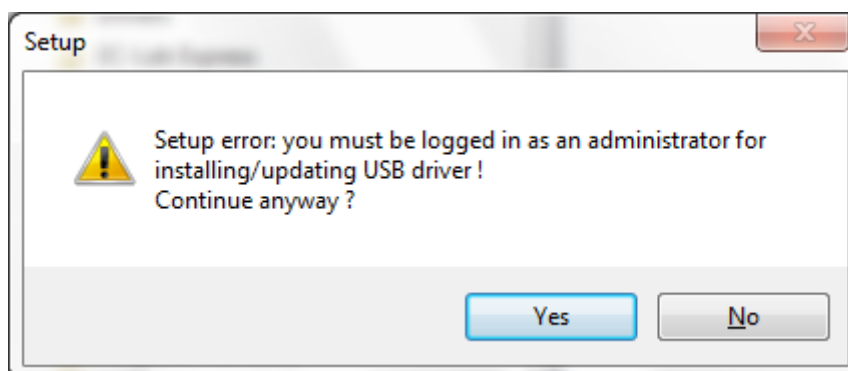
Fig. 27: EC-Lab software installation (8).

In this case it is necessary to contact your network administrator for the installation.

4. PC installation and configuration

IT IS HIGHLY RECOMMENDED TO ASK FOR ASSISTANCE FROM YOUR NETWORK ADMINISTRATOR.

4.1 TCP/IP installation and configuration

The BiStat uses the TCP/IP (Transfer Control Protocol / Internet Protocol) to exchange data with the PC. This protocol uses IP addresses to identify hosts on a network, so you will need 2 IP numbers, one for the BiStat and one for the PC. For direct connection between the BiStat and the PC, you can use the following numbers (default factory settings):

192.168.0.2   (PC)

192.168.0.1   (BiStat)

But, if you connect the PC and the BiStat to your local network, you need to ask your system administrator for 2 VALID IP NUMBERS FOR YOUR INTRANET (and the sub-net mask and the gateway numbers if necessary).

Note: before the TCP/IP protocol installation, your Ethernet board must be properly installed into your computer.

4.1.1 Windows© XP Pro configuration

The TCP/IP protocol must be installed on the PC computer to establish the connection with the BiStat.
If your computer is connected to a network, the TCP/IP protocol may be already installed. In that case the computer already has an IP address (obtained automatically). When the computer is connected directly to the instrument, it is necessary to give an IP address to the computer. The following part describes the way to give an IP address to the computer:

1- Into the **Control Panel**, double click on the **Network Connections** icon. Then the **Local Area Connection window** appears. Right click on the name and choose "**Status**" to see the computer IP address in the network. The windows below is displayed:
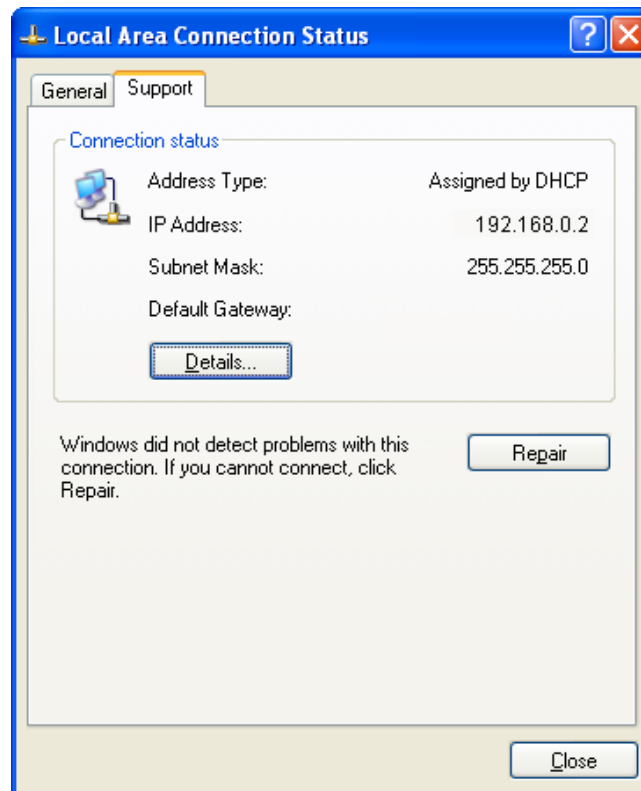
Fig. 28: Local Area connection status.

On the "**General**" tab click on **Properties**. This will load the following window:
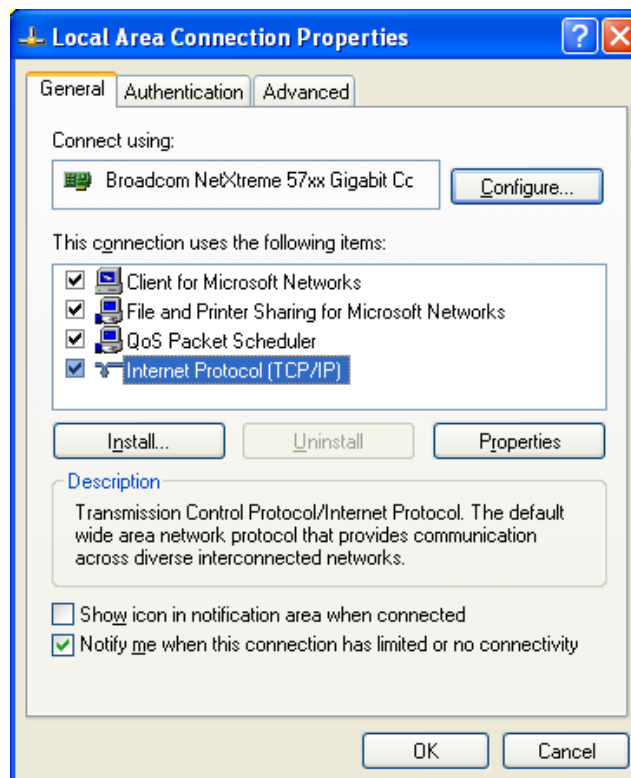
Fig. 29: Network window.

2- Select **Internet Protocol (TCP/IP)** and click on the **Properties** button. The following window appears:
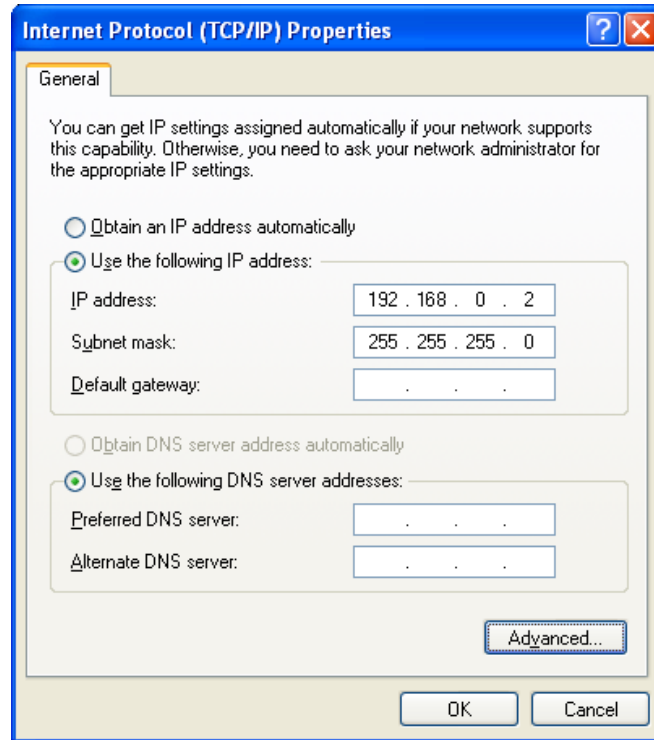
Fig. 30: TCP/IP properties window.

3- At this point of the installation, the user has to activate the "**Use the following IP address**" box.
WARNING: THERE MIGHT BE ANOTHER TCP/IP PROTOCOL INSTALLED CALLED "TCP/IP DISTANT ACCESS", DO NOT CLICK ON THIS LINE!

4- Enter the PC **IP address**, DO NOT ENTER A NETWORK MASK (it will automatically be added) and click on the OK button.
WARNING: IP ADDRESS MUST BE UNIQUE IN A NETWORK.

5- Restart the PC. Now the PC and the BiStat are in the same network.

4.2 USB driver installation

The BiStat can use an USB connection to exchange data with the PC. This connection requires USB drivers to be installed in the computer operating system. Installation of the drivers will vary depending upon the operation system of the computer.
We highly recommend that the user works with **at least** Windows© 2000 to control the potentiostat through an USB connection.

4.2.1 Windows XP installation

The way to proceed to install USB drivers is described below for Windows© XP Pro. After connecting the instrument to the computer with the USB cable power on the instrument. When the user powers on the instrument, Windows automatically detects a new USB device. Then the following installation window appears:

Fig. 31: USB device installation window (1).

In this window, select "**No, not this time**" and click on "**Next**". The following window is displayed:

Fig. 32: USB device installation window (2).

Check that the EC-Lab® installation CD is in the CD drive. If it is, Windows® XP will automatically search on the CD, find the USB driver and complete the installation.

Fig. 33: USB device installation window (4).

Fig. 34: USB device installation window (4).

Click on Finish. The potentiostat can now be connected to the computer through an USB connection.

Note: It is not necessary to restart the computer after this installation.

Note that it is possible to communicate with the instrument from another subnet with the following ports 23455 (broadcast), 23456, 23457 and 23458.

For other Windows® versions, the user will probably have to specify where to find the driver on the CD-Rom. In this window select the automatic installation of the software.

4.2.2 Windows Seven and Vista installation

With Windows seven and Vista systems, the USB driver is automatically installed when the instrument is detected. And the following message is displayed at the end of the installation:
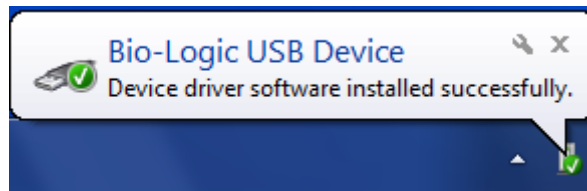
Fig. 35: USB device installation for Seven and Vista.

4.2.3 USB driver update

From EC-Lab® version 10.10, a new USB driver is available and installed automatically. This new USB driver is included in the installation CD. When the software is installed, the new USB driver replaces automatically the old one.

4.2.4 Uninstall USB drivers

For this operation, please open the folder: C:\Progrm Files\Bio-Logic\USBIO as described in the picture below. Double click on "uninstall" to proceed.
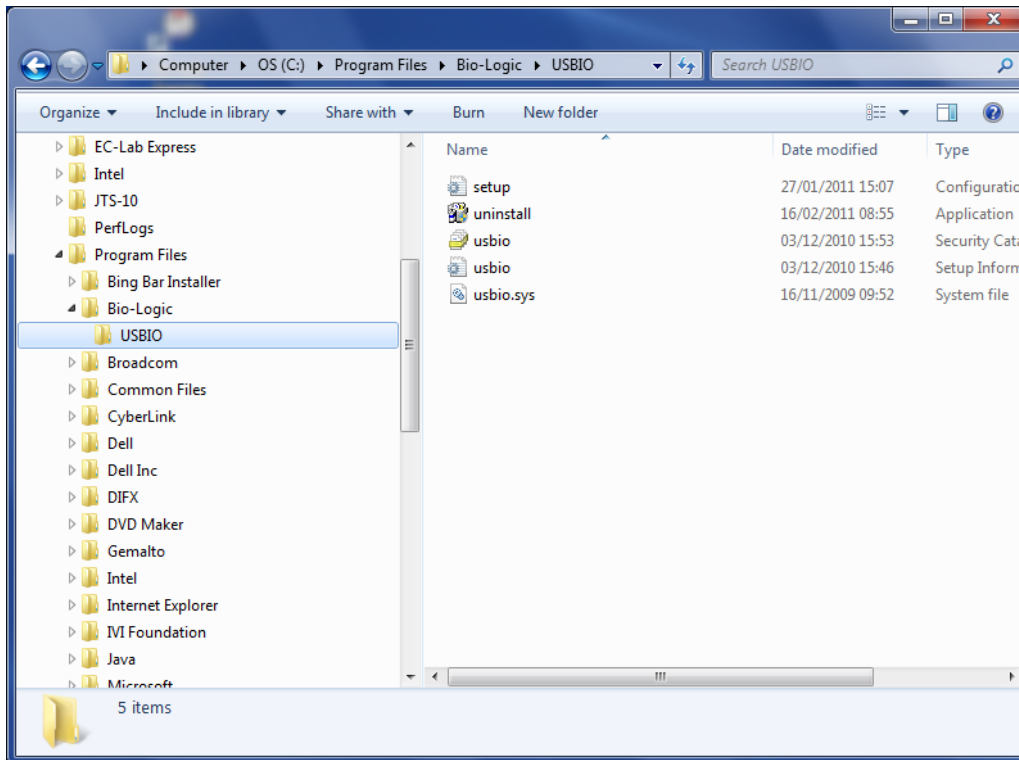
Fig. 36: Uninstall USB driver (1).

The uninstall wizard is launched. Click on the "Uninstall" button to proceed.
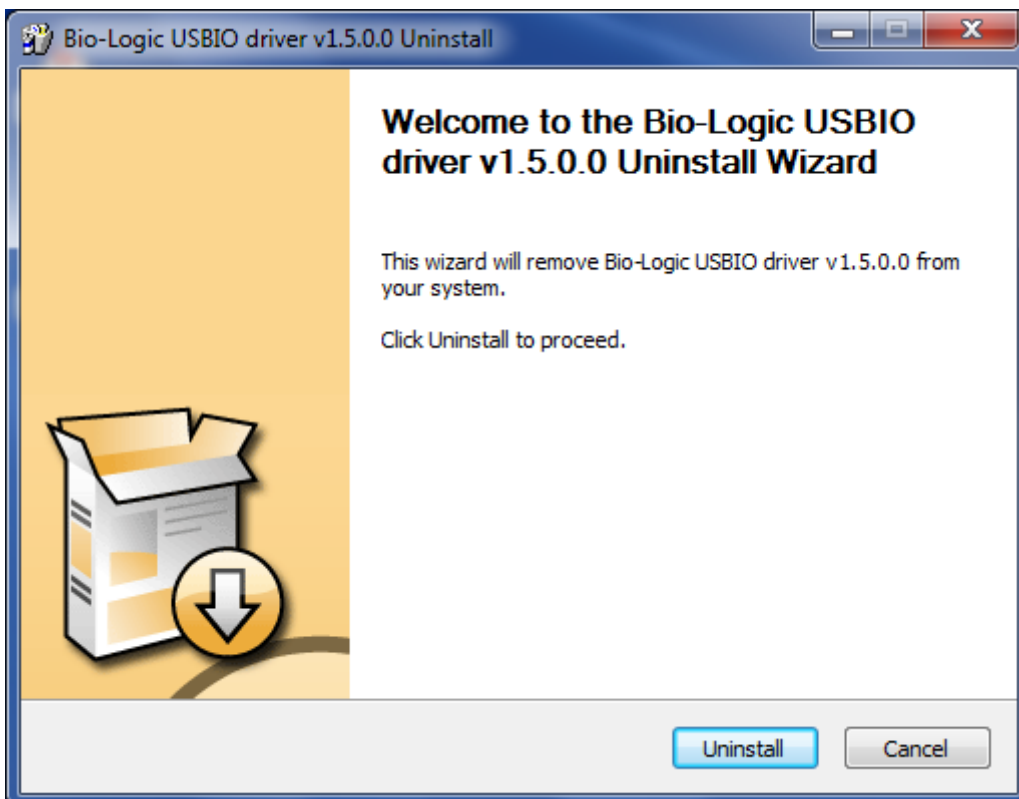
Fig. 37: Uninstall USB driver (2).
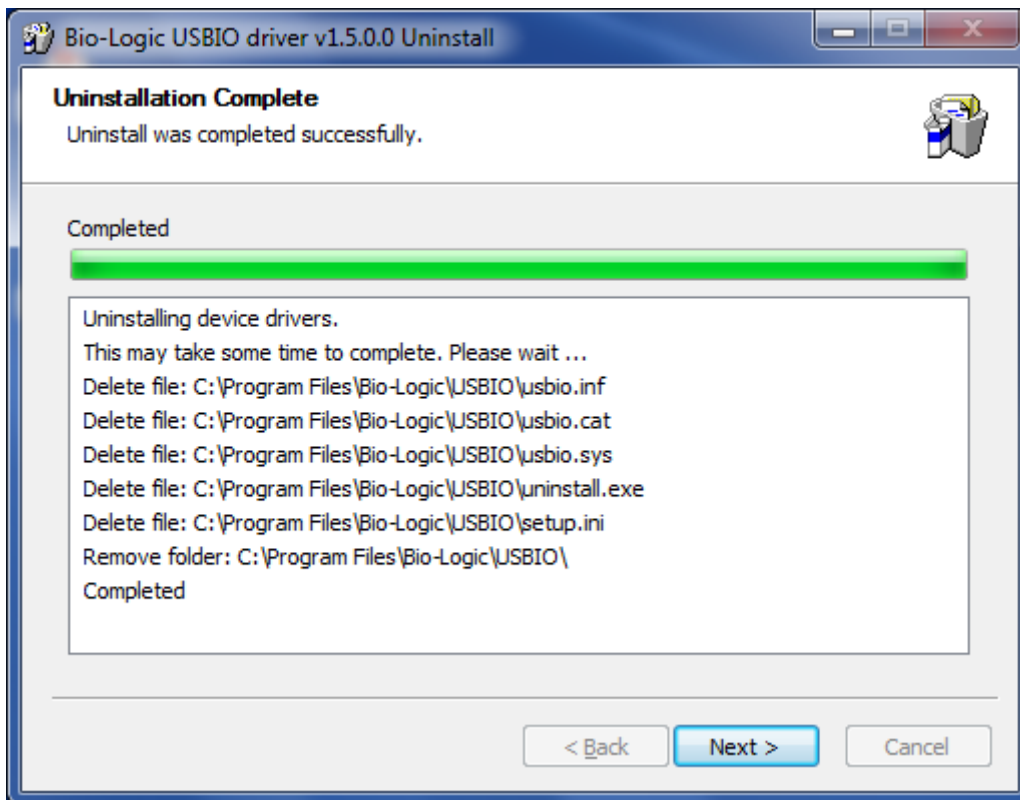
Fig. 38: Uninstall USB driver (3).
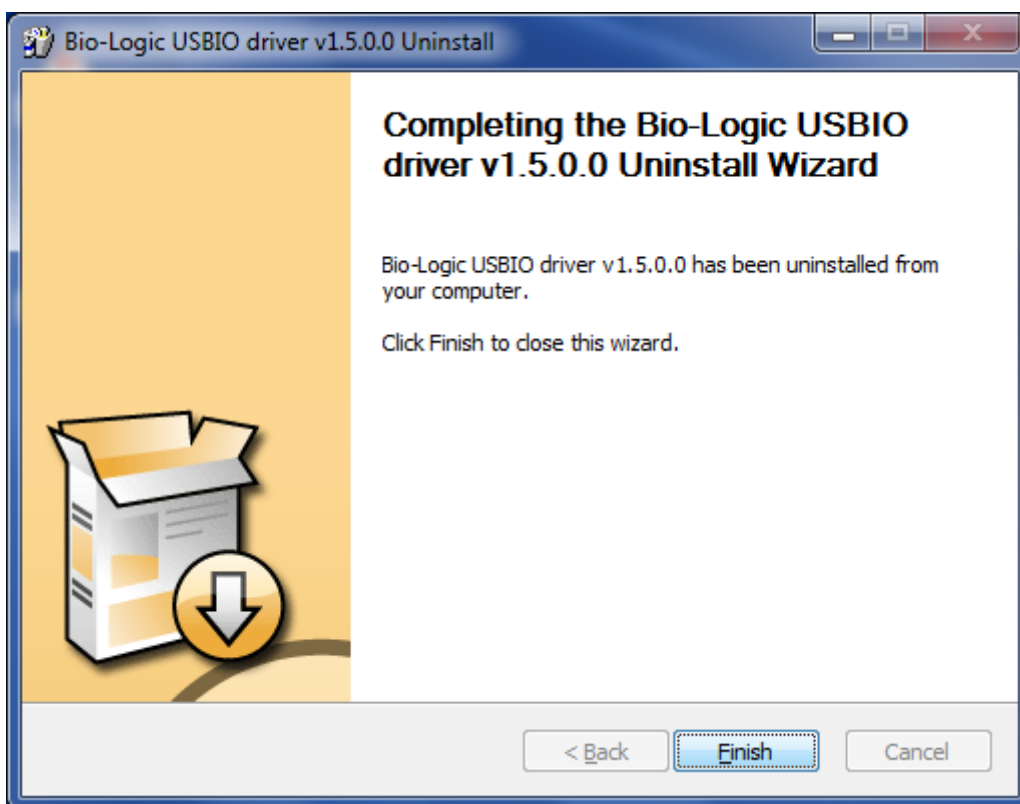
Fig. 39: Uninstall USB driver (4).

When you click on the "Finish" button the USB driver is completely uninstalled.

5. BiStat connection to the computer

When the user will try to find an instrument in the network or by USB, the software will use a broadcast that may be stopped by windows firewall. In this case click on the "Allow access" button:

5.1 Network parameter configuration with the Ethernet connection

Since September 2005, the instruments have been equipped with new communication boards. The serial port has been removed from this board. The Ethernet connection is now a 10/100 baseT compatible with every network. The **USB** connection has been integrated on this board. When it is installed in a Local Area Network (via the Ethernet connection), the instrument is automatically detected by the computers of the network. It becomes very easy to select an instrument in the network and modify its IP address via the Ethernet connection. This is possible with a MAC Address (set at the factory on the communication board) even if the instrument is not in the same network as the computer (before being connected together). Now new instruments are delivered with the following IP address commonly used as default: **192.168.0.1**. You can either manage your instrument directly with the computer (direct connection with the crossed cable) or change the instrument's IP address to add the instrument in your local network. The way to proceed is the same in both cases. The first step is the detection of the new instrument by a computer (directly or via the network). The second step is the IP address change before the connection, either to have both the instrument and the computer in the same LAN or to make a small network including the instrument and the PC.

5.1.1 BiStat Connection to the computer with EC-Lab® software: direct connection

The procedure to connect your computer directly or via the network to the instrument is as follows. Use the crossed Ethernet cable for a direct connection and a straight cable for the network connection.

1) Launch EC-lab® software V9.00 or more. In the menu bar click on "**Config\Connection**". You will see the following window showing the connection status "Off line":
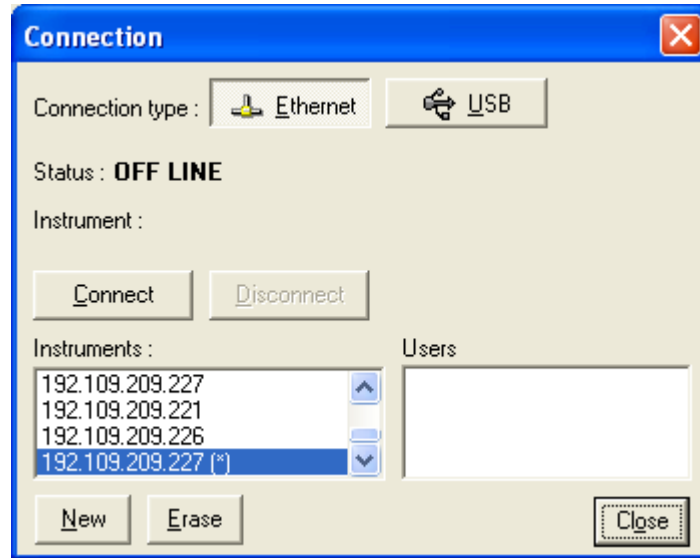
Fig. 40: "Connection" window for the connection between the computer and the instrument.

Note: The user can work with EC-Lab® software off-line (without to be connected). The software will work as if it was connected to a virtual potentiostat. The user just has to define the device he wants to simulate.

2) Select the connection type (Ethernet in this case or USB).

3) Click on "New" to see the following window without any instrument found in your network. Click on "Find" to see the instruments present on your network. A new instrument has been detected with its IP Address (IP:192.168.0.1). The automatic search frame shows the Name of the instruments detected with their serial number (#). A Mac address is given to each instrument at the factory. The Mac address is used to detect the instrument in a LAN even if its IP Address is not valid in the network. It is also used for the detection of instruments connected by USB.
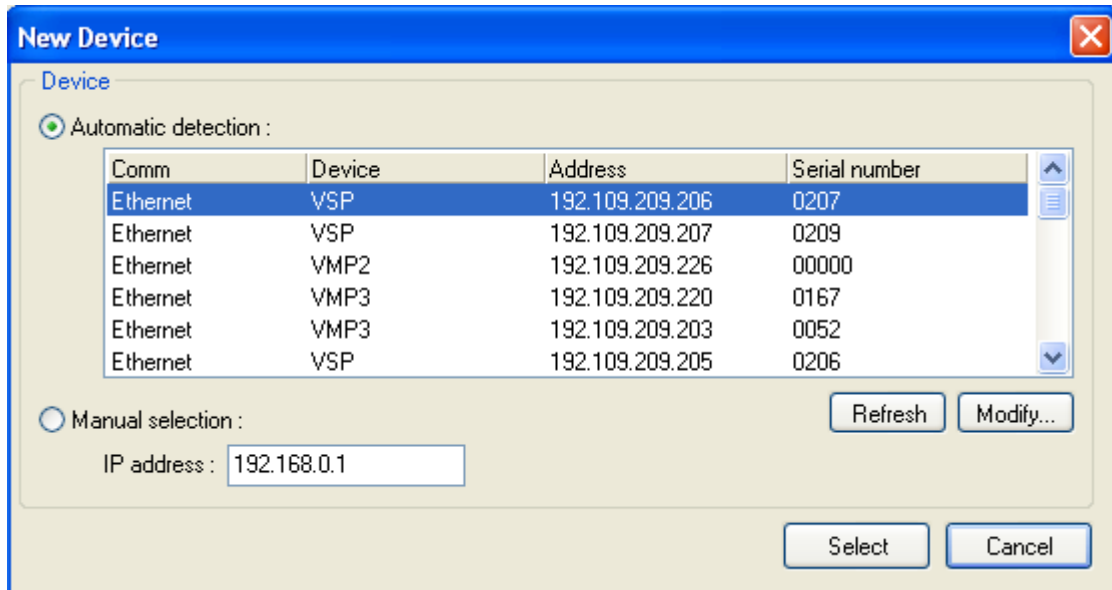
Fig. 41: "New Device" window to select and add an instrument to the current devices.

Automatic detection will give a list of instruments detected, but only for the instruments provided with an ARM communication board (VMP3, VSP, HCP, EPP, and the last generation of VMP2). If no device is found, the communication board is either a VM62 or a board VM42 (without a Mac address), or the communication has failed. In this case, you must select the Manual selection checkbox and type the instrument's IP address in the frame.

4) At this time you have three different ways to proceed.
   a. If the connection is a USB connection, select the device, click on **"Select"** and then **"Connect"**.
   b. If using a direct connection with a crossed cable or an IP address already valid in the network, the connection is an Ethernet connection that does not require changing the instrument's IP address.
   c. If the IP address is incompatible, change the IP address to add the instrument to the network or have a compatible address.

5) Connection without to change the instrument's IP Address:

Click on the IP Address to choose the instrument. Click on "**Select**" and "**Close**". The new IP Address appears in the "Device Configuration" window (Figure below). Click on "**Connect**" to make the direct connection.
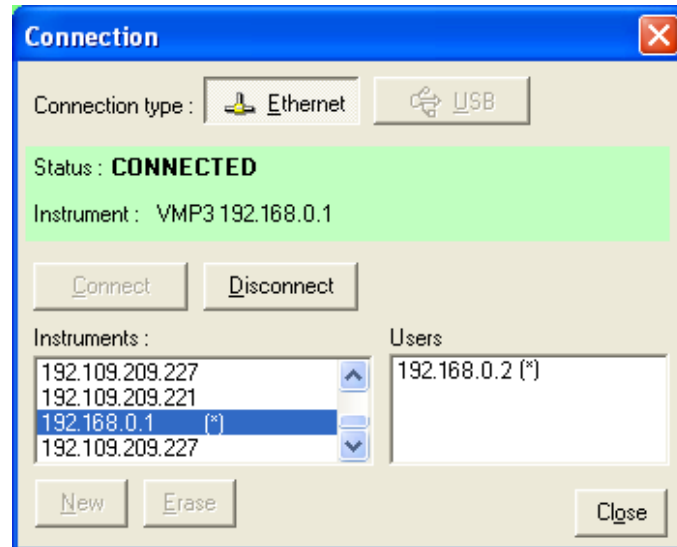
Fig. 42: "Connection" window with the instrument current IP Addresses added to the current devices.

When the connection is established, "Connected" is displayed in the connection status of the "Connection" window. One can see the "Connection status" with the device type and the instrument IP Address.

Note: this connection without modifying the IP Address is possible only if the computer has a valid IP Address in the same network as the instrument (in this example: 192.168.0.2)

5.1.2 BiStat IP address and gateways change: network connection

6) Connection changing the instrument's IP Address:

On the "**New device**" window (Fig. 41) select the desired instrument and click on "**Modify**". The following window then appears:

Fig. 43: "Advanced Ethernet settings" of the "New Device" window used to change the instrument IP Address.

Modify the IP Address to have a valid address in your network. Repeat this procedure with the Gateway and click on "Modify device". A "configuration changed" message is displayed in green when the instrument receives the new IP address. Several "Bip" sounds are emitted indicating that the communication board has reinitialized with the new IP Address. "Configuration changed" appears at the bottom of this window.

Fig. 44: BiStat New configuration.

Then click "**OK**" to display the "New Device" window where you have to click "**Refresh**" to refresh the window and select your instrument IP address.

7) On the "Device configuration" window (Fig. 42) choose your instrument's IP Address and click on "Connect". Then "**CONNECTED**" is displayed. The user can close the window.
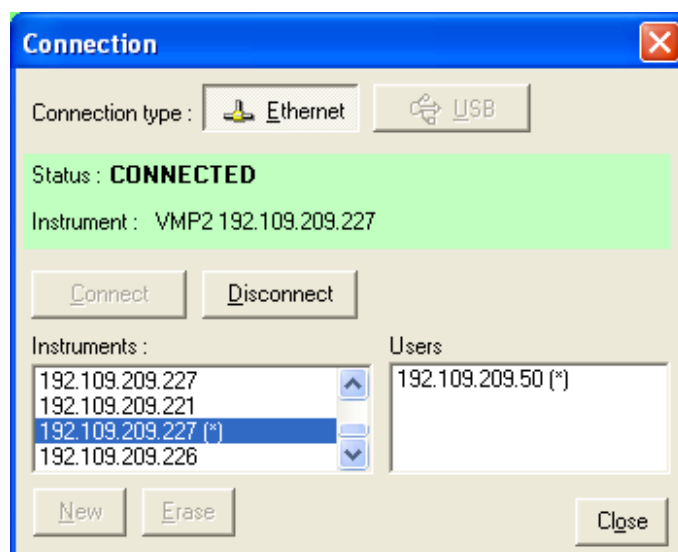
Fig. 45: BiStat connection window showing the connection status.

Now the instrument is ready to get used.

5.2 Network parameters configuration with the serial connection

This section is specially addressed to MPGs, VMPs, VMP2s, and BiStats delivered before September 2005. The concerned instruments have been delivered with a communication board including a serial connector .

5.2.1 BiStat Connection to the computer with EC-Lab® software

On the PC, run the EC-Lab® program and select the **Instrument...** item in the **Config** menu. This will display the following window:**.**
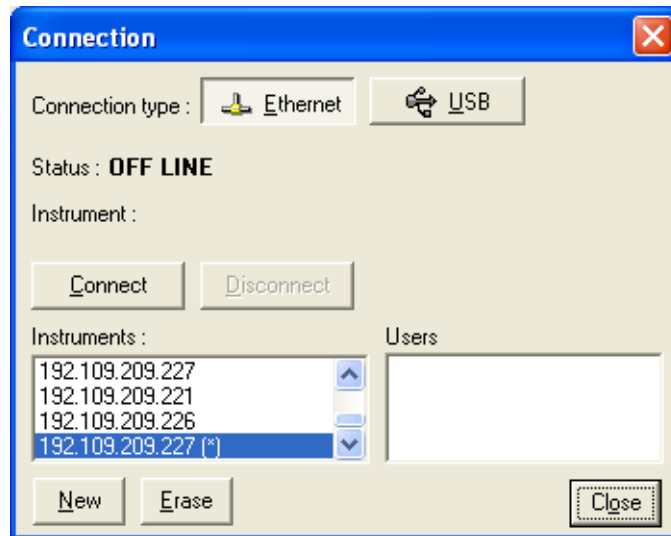
Fig. 46: Device configuration window.

If the instrument's IP Address is in the current devices you can choose it and click on "Connect". Else, click on "**New**". The following window will be displayed:
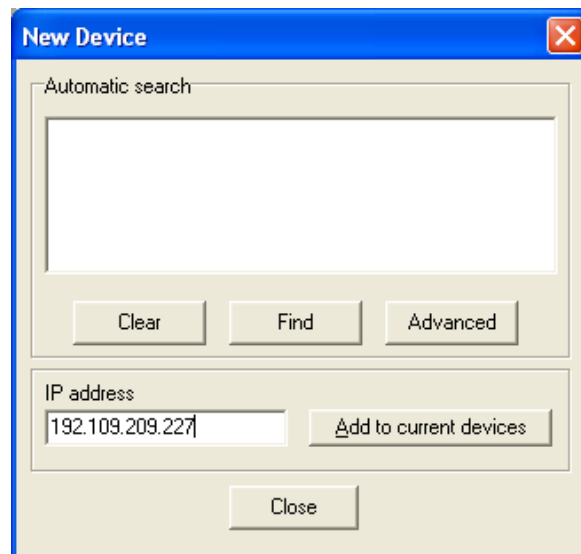
Fig. 47: New Device window to add the instrument IP Address.

Enter the BiStat's IP address into the text box, click on the "**Add to current device**" button to add the IP number into the list and close this window. Then click on the **Connect** button in the "Device Configuration" window to establish the connection with the BiStat.

5.2.2 BiStat IP Address change

To connect the BiStat to your local network, you need to enter an IP address for the BiStat. The instructions below explain how to enter the BiStat's IP address.

1- Connect the BiStat (TERM entry) and the PC (COM1 or COM2 port) with the supplied serial cable.

2- Click on the Tera Term Pro icon (**Start, programs, EC-Lab, Tera Term Pro**) on the PC. The Tera Term Pro window is displayed.
Note: by default Tera Term Pro is configured for the COM1 port. If you are using another port (COM2 for example), you will have to reconfigure Tera Term Pro:
- select **Setup, Serial port...** into the main menu
- enter **port:** COM2, validate with OK
- store the new default into TERATERM.INI with **Setup, Save setup...**

3- Type:
```
k
```
It will exit from the BiStat control programs and will display the following lines:
```
    Irq removed !!!
rcvt: ABORT, pid=28
$
```

4- Type :
```
$ vme ipa ↵
```
The current IP address is displayed.
Note 1 : ↵ is the "return" key.
Note 2 : the $ character is the command "prompt" of the OS-9 system.

5- Type :
```
$ vme ipa [new IP address]↵
```
Example:
```
$ vme ipa 192.109.209.220↵
```

6- Restart the BiStat

5.2.3 Multi BiStats connection with one computer

To connect one PC to several BiStats, one must proceed a different way.
For example, to connect a PC to the BiStat n°1 with the TCP/IP address 192.109.209.203 and the BiStat n°2 with the address 192.109.209.204, one must create two shortcuts on the EC-Lab® program and specify the BiStats TCP/IP for each shortcut on the target line:
    shortcut "BiStat n°1", target: C:\EC-Lab\EC-Lab.exe 192.109.209.203
    shortcut "BiStat n°2", target: C:\EC-Lab\EC-Lab.exe 192.109.209.204
Then each shortcut will connect to the corresponding BiStat.
Note: in this case, this is not necessary to specify the BiStats TCP/IP address in the **Config, Device...** menu again.
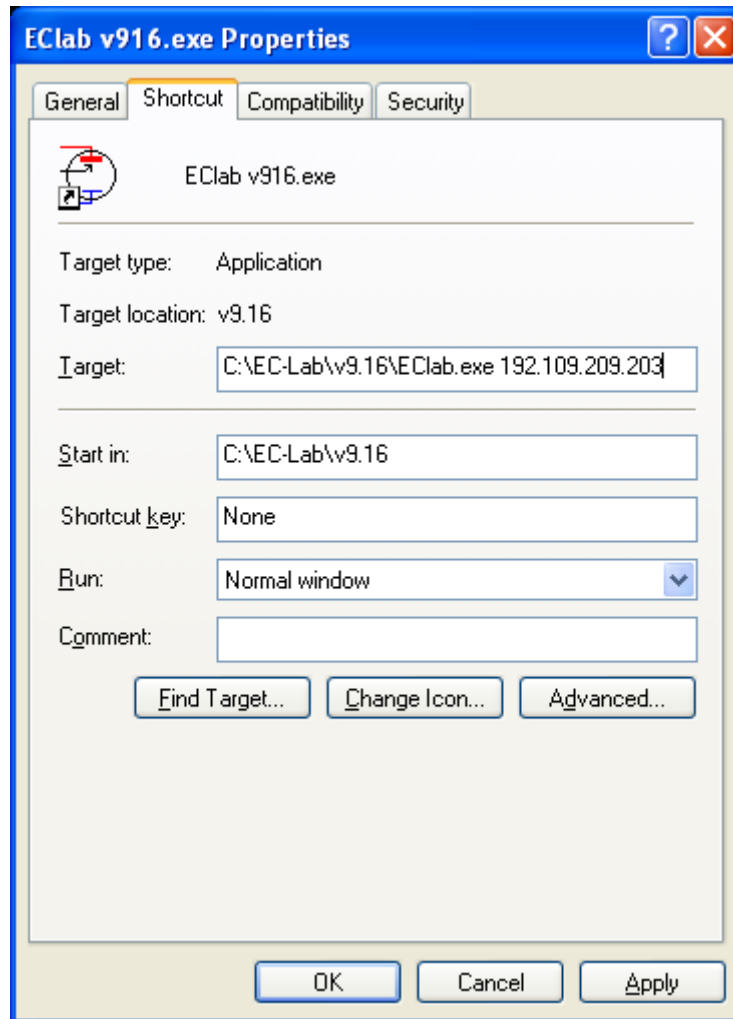
Fig. 48: EC-Lab® shortcut to connect 1 PC to several BiStats.

5.2.4 Accessing the BiStat from other networks through gateways

If the BiStat and the PC are on the same network, no gateway is required and one can skip this chapter. Else if the BiStat and the remote PC are located on different networks it is necessary to specify the gateway address for both.

The gateway address may be declared on the fly (while some experiments are running). Up to three gateways may be declared.

The procedure is as follows:

1- Install the serial cable between the available PC COM# port and the BiStat TERM port

2- On the PC, click the "Tera Term Pro" icon: **Start, Program, EC-Lab®, Tera Term Pro**

3- Type:
```
k
```
It will exit from the BiStat control programs and display the following lines:
```
Irq removed !!!
rcvt: ABORT, pid=28
$
```

4- In the "Tera Term Pro" window, press the [enter] key, the "$" prompt character appears

5-   The following commands are available:

```
$ vme                              display the current IP address
$ vme ipa 192.109.209.203          changes the IP address to 192.109.209.203 (default
                                   value)
$ vme subnet_mask                  displays the current subnet mask
$ vme subnet_mask 255.255.255.0    changes the subnet mask to 255.255.255.0 (default
                                   value)
$ vme gateway                      displays the gateway list
$ vme gateway 192.109.209.225      adds the gateway address 192.109.209.225 to the
                                   gateway list
$ vme gateway remove               remove all the gateway(s) from the gateway list
```

6- Close the "Tera Term Pro" window
Note: ipa and subnet_mask commands require a reboot of the instrument. Gateway command is immediately active.

7- Restart the BiStat

The next time the BiStat will be turned on, all the gateway(s) from the gateway list will be automatically declared.

5.3 **USB connection**

This section is specially addressed to new instruments delivered after September 2005 such as HCP-803, VMP3, EPP series and VSP. From September 2005 the new instrument generation is provided with a USB connection. The procedure to connect your computer directly to the instrument with the USB cable is as follows.

8) Launch EC-lab V9.00 software. In the main bar, click on "Config\Connection". Click on the USB button to see the following window showing the connection status "Off line":
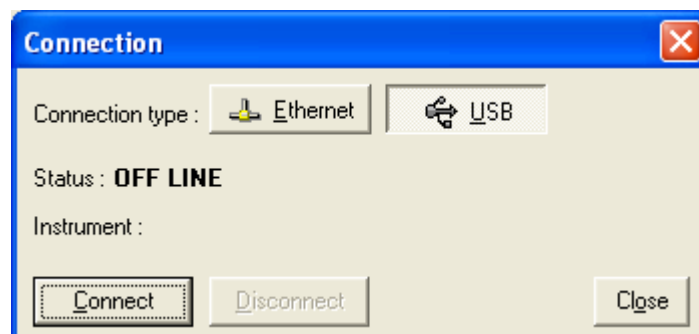
Fig. 49: USB "Connection" window for the connection between the computer and the instrument.

Note: The user can work with EC-Lab® software off-line (without to be connected). The software will work as if it was connected to a virtual potentiostat. The user just has to define the device he wants to simulate.

9) Click on "Connect". The following window is displayed when the connection is established showing the device type and the serial number:
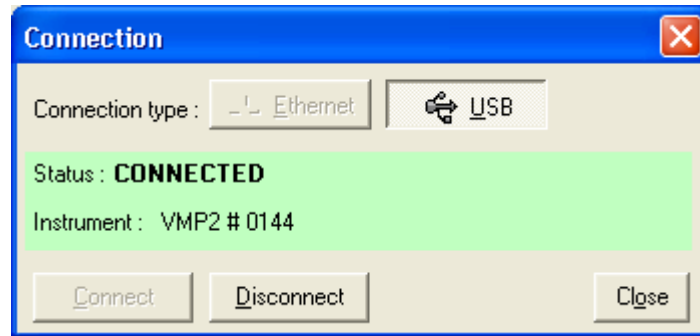
Fig. 50: "Connection" window when the instrument is connected.

5.4 BiStat Firmware Upgrading

When the user receives a new unit from the factory, the software (in the computer) and firmware (in the instrument) are installed and upgraded. The instrument is ready for use. It does not need to be upgraded. Nevertheless new EC-Lab® versions (with new protocols or improvement) are created and can be downloaded and installed by the user.

Since V8.00 the firmware is automatically upgraded (if necessary) when EC-Lab® starts. For older firmware versions, one must use "upgrade the firmware with v8.00 with the serial connection" first.

5.4.1 Automatic upgrade

If your BiStat instrument has a firmware V8.00 (or newer), the following message will be displayed the first time you will run a new EC-Lab® version that requires a new firmware (below V8.1x for example):
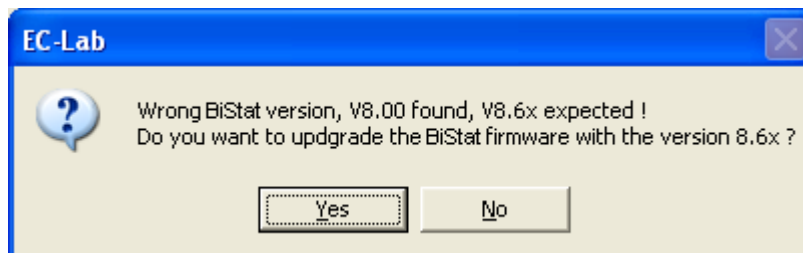
Fig. 51: Automatic upgrading message.

Click on the Yes button to perform the upgrade.

Then the new firmware transfers to the instrument through the Ethernet connection, and the following window displays the transfer progression:
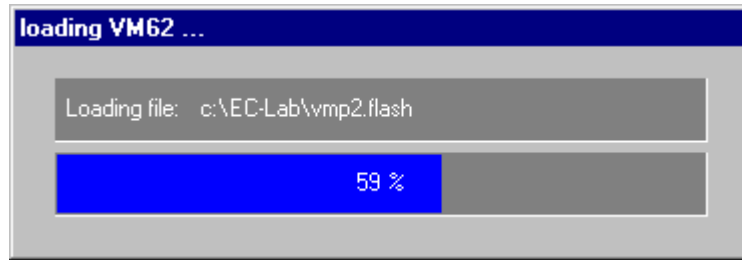
Fig. 52: Firmware upgrade proceeding.

Once the transfer is finished, the window is closed and the new one replaces the old firmware. At that step, the firmware upgrade is completed and you can start your session with EC-Lab®.

5.4.2 Upgrade to V8.00 with the serial connection

If your firmware is older than the V8.00, you must load the V8.00 firmware through the serial connection first. In this case, you will be asked for that at EC-Lab® connection:
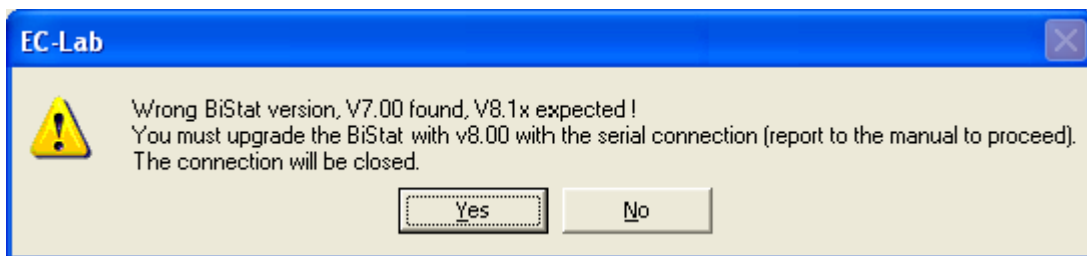
Fig. 53: Serial upgrading message.

The final firmware (that corresponds to your EC-Lab® version) upgrade will be automatically made with the procedure described before.

To load the firmware V8.00 into the BiStat with the serial connection, power on the BiStat and the PC and follow the next instructions:
Note: EC-Lab® is not required here and can be closed.

1- Install the serial cable between the PC COM2 port and the TERM port of the BiStat VM42/VM62 module (see drawing).
If your PC does not have a COM2 port, you can use the COM1 port instead.
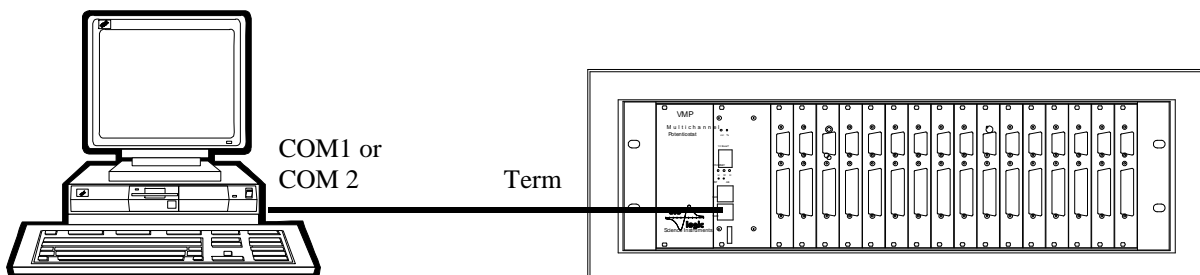
Fig. 54: PC to BiStat (Term), serial connection used for BiStat firmware upgrading only.

Note: according to the PC type, the DB25F / DB9M serial port adapter may be necessary.

2- On the PC, click on the "Tera Term Pro" icon. (**Start, Programs, EC-Lab, Tera Term Pro**).

Note: by default, Tera Term Pro is configured for the COM1 port. If you are using another port (COM2 for example), you will have to reconfigure Tera Term Pro:
- select **Setup, Serial port...** into the main menu
- enter **port:** COM2, validate with OK
- store the new default into TERATERM.INI with **Setup, Save setup...**

3- Press, then release the "RST" button of the BiStat VM42/VM62 module. As the "U"green light emitting diode (LED) begins to blink, press, then release the "AB" button of the BiStat VM42/VM62 module. In the "Tera Term Prol" window on the PC, the following message appears for the VM42 modules:
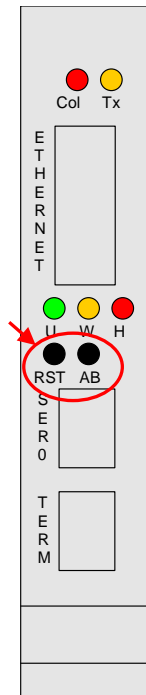
Fig. 55

```
+----------------------------------------------------------------------+
| BootLoader: VM(6)62/(6)42/30 VSBC/IUC-32 (V)IUC SMART-IO CM302 IUC332 |
|     V3.3                  (c) PEP Modular Computers                   |
+------------+----------------+---------------------+-------------------+
| CPU: 68040 | Speed: 33.2 Mhz | DRAM Size: 4096  kB | SRAM Size: 256 kB |
+------------+----------------+------+--------------+-------------------+
| FLASH Manufacturer: AMD            | FLASH Type: AM29F010            |
+------------------------------------+---------------------------------+
| Programmable FLASH area: 0x04000000 to 0x040F4CFF                     |
+----------------------------------------------------------------------+
| BootLoader used FLASH  : 0x040F4D00 to 0x040FFFF1                     |
+----------------------------------------------------------------------+
+======================================================================+
#                      W A R N I N G                                   #
#                                                                      #
# When programming FLASH Memory, *NEVER* press the RESET button nor cycle #
# power! This may damage the BootLoader and will consequently leave the  #
# board unusable due to damaged FLASH contents. The ABORT button may be  #
# used to cancel a running operation.                                  #
+======================================================================+
ABORT button pushed.

BtLd>
```

And the next message for the VM62 modules:

```
+------------------------------------------------------------------------+
| BootLoader: VM(6)62/(6)42/30 VSBC/IUC-32 (V)IUC SMART-IO CM302 IUC332   |
|     V3.5                 (c) PEP Modular Computers                      |
+------------+---------------+--------------------+--------------------+
| CPU: 68060 | Speed: 25.0 Mhz | DRAM Size: 16384 kB | SRAM Size: 256 kB |
+------------+---------------+------+-------------+--------------------+
| FLASH Manufacturer: AMD            | FLASH Type: AM29F040            |
+---------------------------------+----------------------------------+
| Programmable FLASH area: 0x04000000 to 0x041EFFFF                    |
+------------------------------------------------------------------------+
| BootLoader used FLASH  : 0x041F0000 to 0x041FB411                    |
+------------------------------------------------------------------------+
+========================================================================+
#                          W A R N I N G                                #
#                                                                        #
# When programming FLASH Memory, *NEVER* press the RESET button nor cycle #
# power! This may damage the BootLoader and will consequently leave the  #
# board unusable due to damaged FLASH contents. The ABORT button may be  #
# used to cancel a running operation.                                    #
+========================================================================+
ABORT button pushed.

BtLd>
```

It is important to note the module type for the next steps of the upgrade. The previous messages may differ a little (depending on module versions), but the VM42 is fully defined by CPU = 68040 (on the fifth line of the message) and the VM62 by CPU = 68060.

4-   On the PC, at the prompt (BtLd>) in the "Tera Term Pro" window, enter the following command:

```
BtLd>lf  -c↵
```

　　　(↵ is the "return" key)

5-   On the PC, in the "Tera Term Pro" window, choose **File**, then **Send file...** option. Select the file **vmpvm42.txt for the VM42 VMP module**, **vmpvm62.txt for the VM62 VMP and MPG modules** or **vmp2vm62.txt for the VM62 VMP2 module** and validate.

　　　The operation is about 40 minutes long, without any message and is over when the following prompt is displayed:

```
BtLd>
```

Warning: loading the wrong file (vmpvm42.txt on a VM62 module or reverse) may produce an unexpected behaviour of the BiStat and then you will have to restart the whole upgrade procedure at the first step!

6-   Press the RST button to restart the BiStat, close the " Tera Term Pro" program, and disconnect the serial cable.

6. Advanced features

6.1 External device control and recording

6.1.1 General description

EC-Lab® software offers the ability for the user to control external devices such as rotating electrodes, thermostatic baths and to record external analog signals through the auxiliary DB9 connector. The user has to configure the output to control an external device as well as Analog In1 and Analog In2 inputs to record external signals. Our instruments can control and record analog signals from – 10 to + 10 V. Most of the external devices work into a 0 to + 5 V range. The figure below shows the external device window where the user sets parameters. Many instruments are already configured in the software to be controlled by our potentiostat. The list will be completed in the future versions of EC-Lab® software. To configure external devices select "**External Device**" in the "**Config**" menu. The following window is displayed:
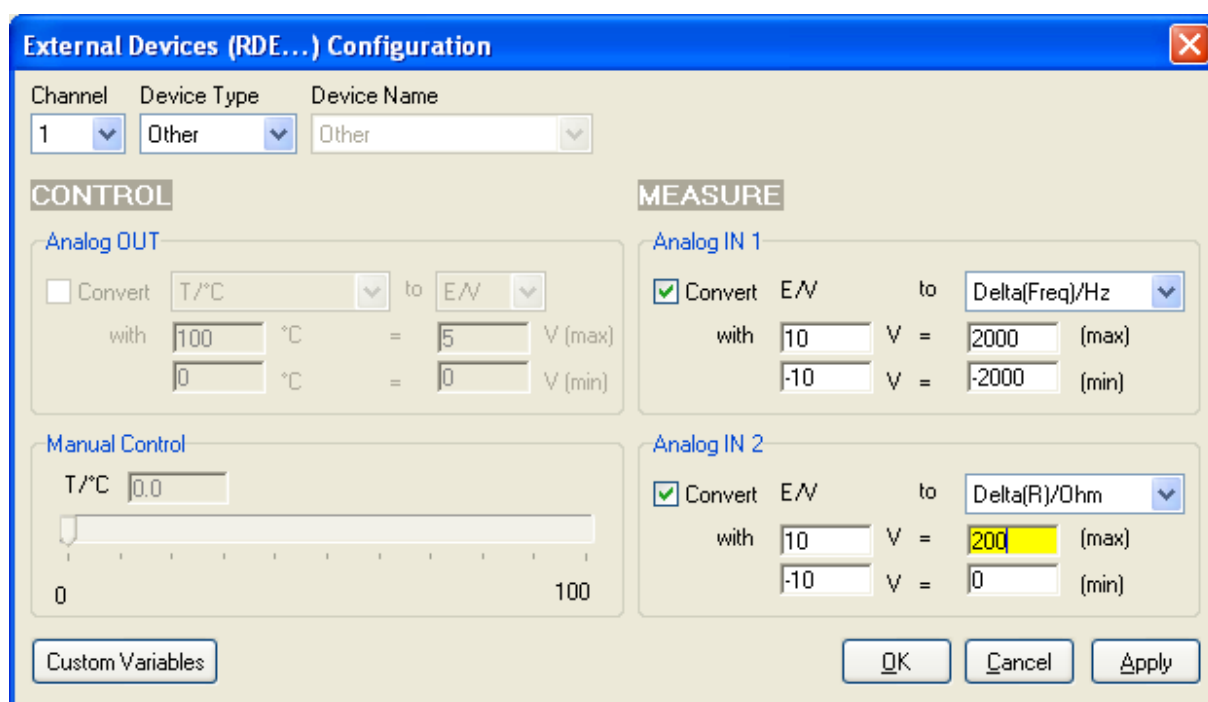
Fig. 56: External device configuration window.

The user must define several parameters to configure the external device either to be controlled via the analog output (left column) or to record/measure data via analog input 1 and 2 (right column). The way to proceed for the configuration of the auxiliary inputs/outputs is described below:

1- Choose the channel to configure. Each channel can be configured for a specific device. One channel can control one device and the other one another device.
2- Select the Device Type in the list between None, Thermostat, RDE, QCM, and other. According to the selected device type one or several device names are available.
3- Among the available devices, some can be controlled with the analog output and some can be used only to record values with analog inputs 1 and 2. The user must tick the box to activate the input/output.

4- In the activated frame, the user must define the conversion between the input voltage and the variable to plot. This is a direct linear conversion in the range defined by the user between the min and the max value.

5- The user can also define the name and the unit of the variable he wants to display. Click on "**Custom Variables**". The figure below is displayed:
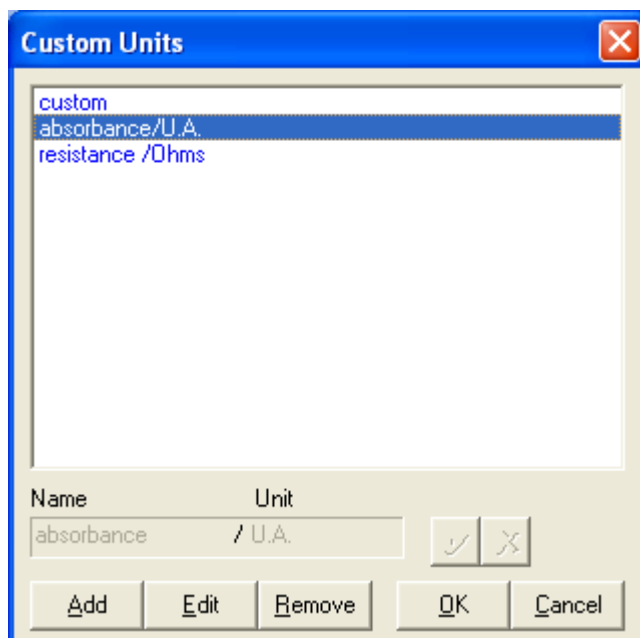
Fig. 57: Custom Units window to define new variables.

To create a new variable with its unit, click on "**Add**" and put the name and the unit of the new variable in the frame. Then click on [✔] to validate. The new variable is displayed in the list in blue color (as a custom variable) and can now be selected as the recorded variable for the analog inputs.

6- Finally click on "**Configure**" to configure the selected channel to record the auxiliary input signal

The new selected variables for Analog In1 and Analog In2 are automatically displayed on the "Cell characteristics" window and activated for recording. In the "**Selector**" the created variables are displayed and can be plotted. These auxiliary variables can be used in several protocols as conditional limits of an experiment.

Note: - The parameters set in Analog In1 and Analog In2 to define the linear slope can be inverted to have an opposite variation of the recorded value with the plotted value.
 - The configuration of external devices that can be controlled by the potentiostat (analog output) is described in detail in the corresponding sections of the manual.
 - Manual control of external devices is also available on the right of the panel.
 - When a channel has been configured to control an external device, this device can be seen in the global view.

6.1.2 Rotating electrodes control

The standard BiStat instrument can control a rotating electrode such as ALS-RRDE-3A Rotating Disk electrode model with the auxiliary input/output. A specific control panel has

been designed to control the rotating speed. Note that no measurement of the rotating speed is available. This model of rotating electrode (ALS-RRDE-3A Rotating Disk electrode model) is designed to work either with one working electrode or with two working electrodes (ring-disk electrodes). A bipotentiostat is necessary for the measurement of the working electrode potential of both electrodes. The BiStat (using two channels) is the appropriated instrument for this kind of experiments.

Fig. 58: ALS-RRDE-3A Rotating Disk electrode

6.1.2.1 Connections

The instrument used to control a rotating electrode is provided with two cables. The connection of the electrochemical instrument with the electrode rotator depends on the working electrode. With only the disc electrode, one channel board is used and the connection is the standard one. With both ring and disc electrodes, two channels are used with only one counter and one reference electrode. The connection must be done according to the CE to Ground (N'Stat) mode. Please refer to the appropriate part of the manual for more information. In that case, the connection is described on the following picture:
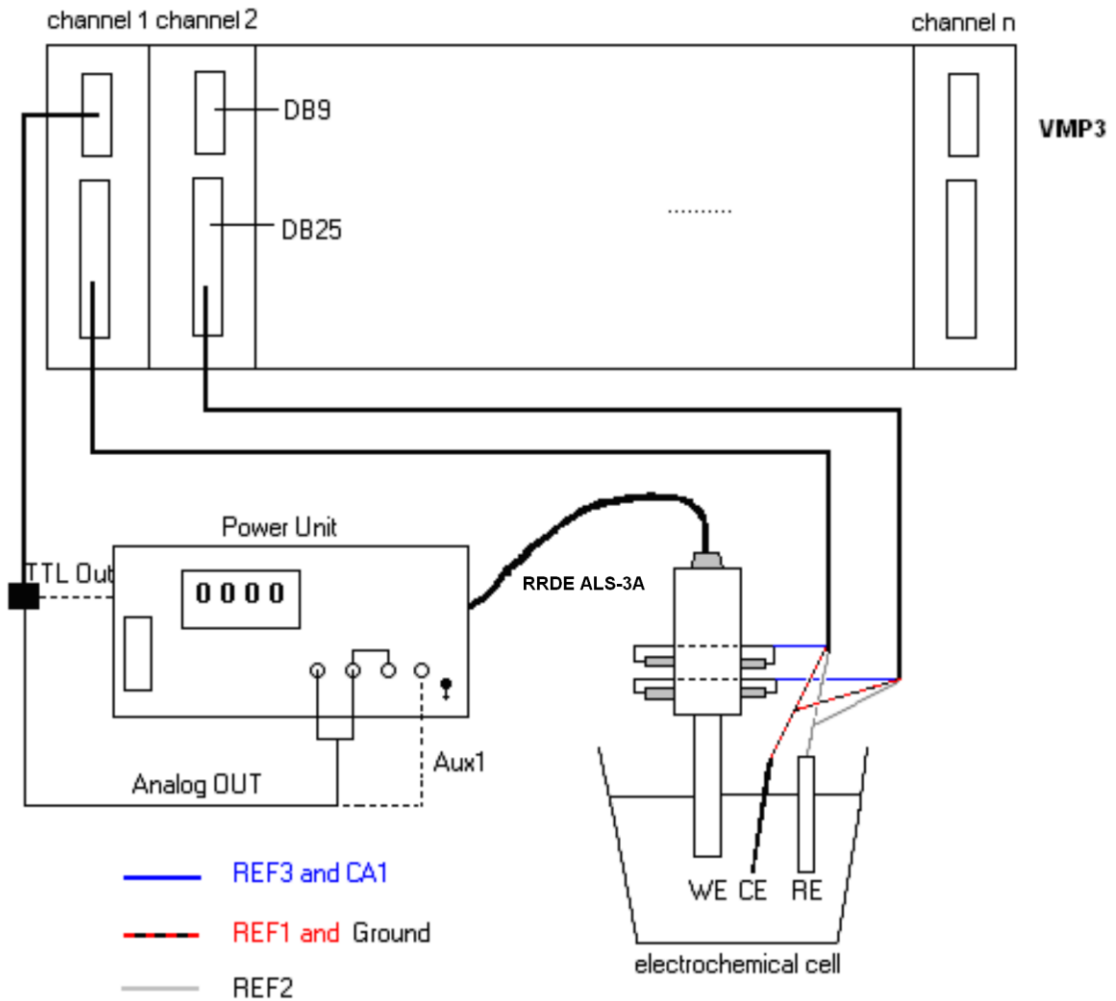
Fig. 59: ALS-RRDE-3A Rotating Disk electrode connection to the BiStat cell cable.

The connection of the two channel boards with the rotating system is as follow:
-   With the DB9 cable connect the auxiliary input/output of the channel board
-   Connect the "Analog out" and the "Ground" connectors at the rear panel of the RRDE
-   Connect the Ref3 and CA1 wires of the first channel to the disk brush, the Ref1 and Ground wires to the counter electrode and the Ref2 wire to the reference electrode.
-   Connect the Ref3 and CA1 wires of the second channel to the ring brush and the other wires as you did with the first cable.

Note: The user must not forget to choose the "CE to Ground" mode for the N'Stat connection in the "Advanced settings" window.

6.1.2.2 Control panel

Before running any experiment with a rotating electrode, one must first choose the rotating unit. Select **Config\External Device (RDE…)…** into the EC-Lab® main menu:
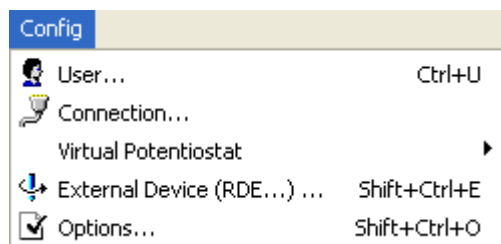
Fig. 60: Menu to choose for rotating electrode control.

Note: this menu is available only if channels designed to drive RRDE are connected with the RDE electrode rotator. Then the following window is displayed:
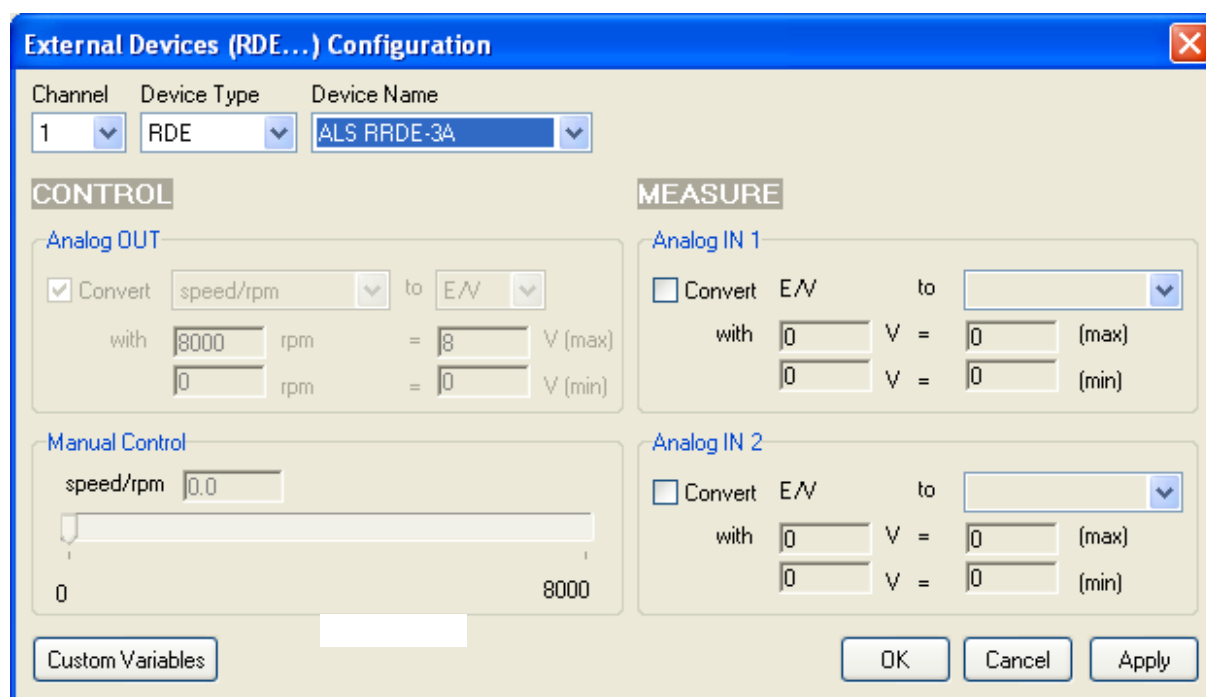
Fig. 61: Rotating electrode control configuration.

Under **Speed control unit**, one can select the standard supplied ALS-RRDE-3A, PINE RRDE or RADIOMETER CTV101 electrodes rotator. For these devices, the calibration parameters are factory set. Other external systems can be used but are not available. They will be added into the list upon request. Note that calibration parameters for already selected device are not available. Nevertheless if you select another device, it is possible in the "**Analog OUT**" window to define the control parameters. Click on the **Apply** button to validate the settings. Note that this menu can be activated without any rotating electrode unit, but will only have effects for the electrochemical instruments equipped with a rotating system.

When using two potentiostat/galvanostat channels and the some rotating ring-disk electrode (with two working electrodes), it would be useful for the user to synchronize both channels together in order to start the experiment on both channels at the same time. Report to the corresponding part in the manual for more information about the synchronize option.

6.1.3 Temperature control

A temperature control is possible with the auxiliary output voltage of a BiStat. Several thermostats have already been configured on the BiStat such as the Julabo series and Haake Phoenix series.
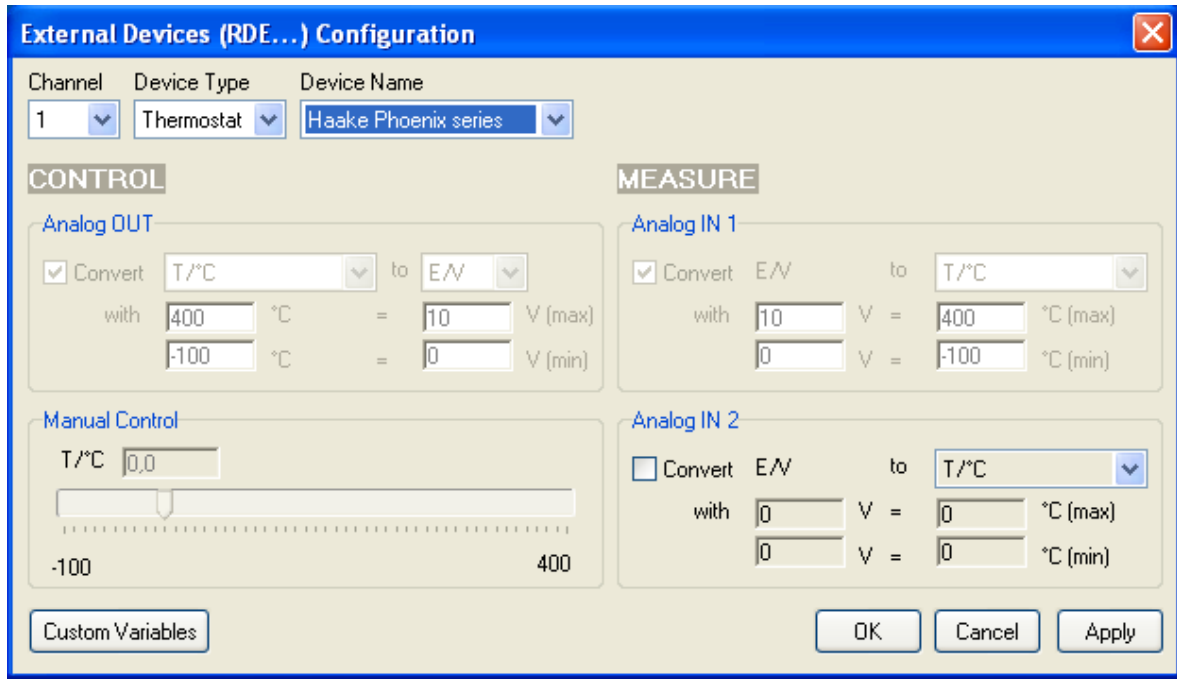
Fig. 62: Haake Phoenix series thermostat control configuration with a BiStat.

The user can configure other thermostats only to record temperatures (Analog in) or to both control (Analog Out) and record (Analog In) temperature.

6.1.4 Electrochemical Quartz Crystal Microbalance coupling

The SEIKO EG&G QCM 922 quartz crystal microbalance has been coupled with our potentiostat / galvanostat to record both the frequency variation and the resistance variation. The configuration for the EQCM coupling is described in the figure:
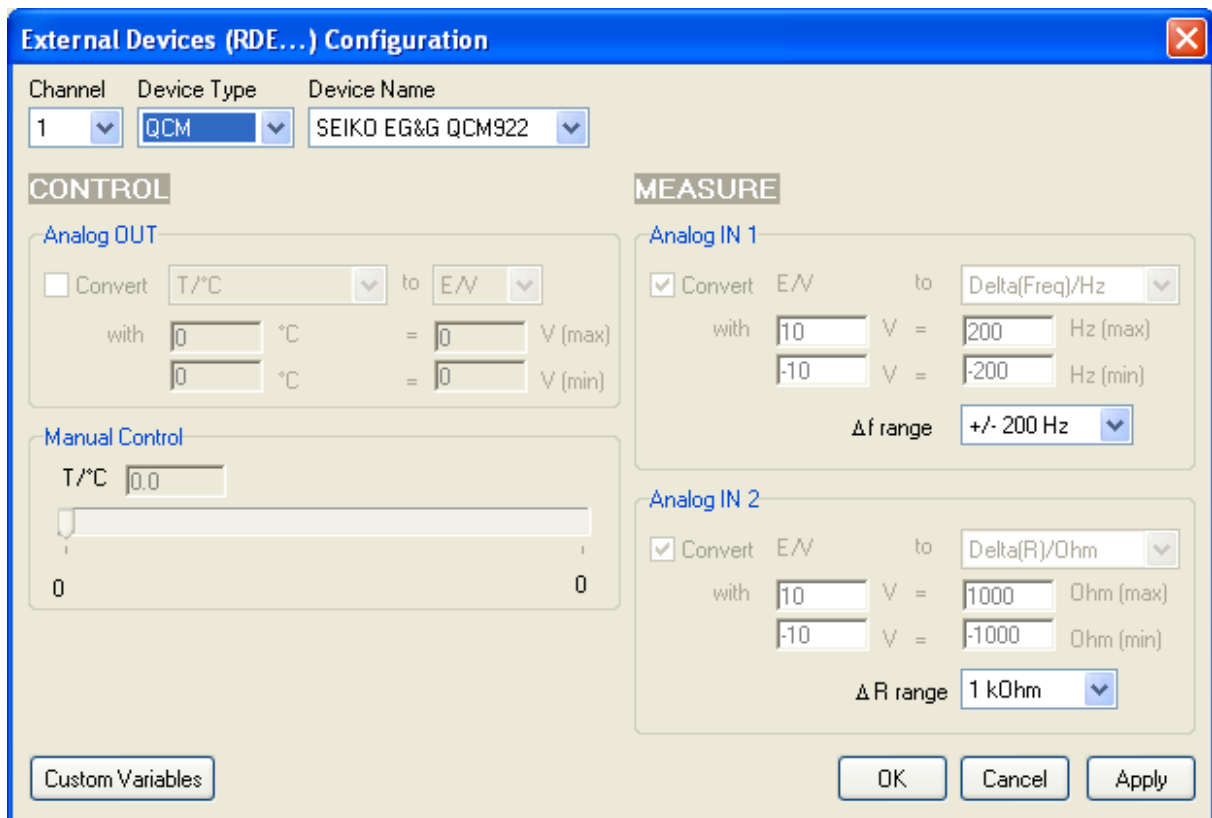
Fig. 63: SEIKO EG&G QCM-922 configuration window.

The potentiostat analog inputs record both frequency and resistance variations. The user has to define both the frequency range and the resistance range. The results of this experiment are displayed below:
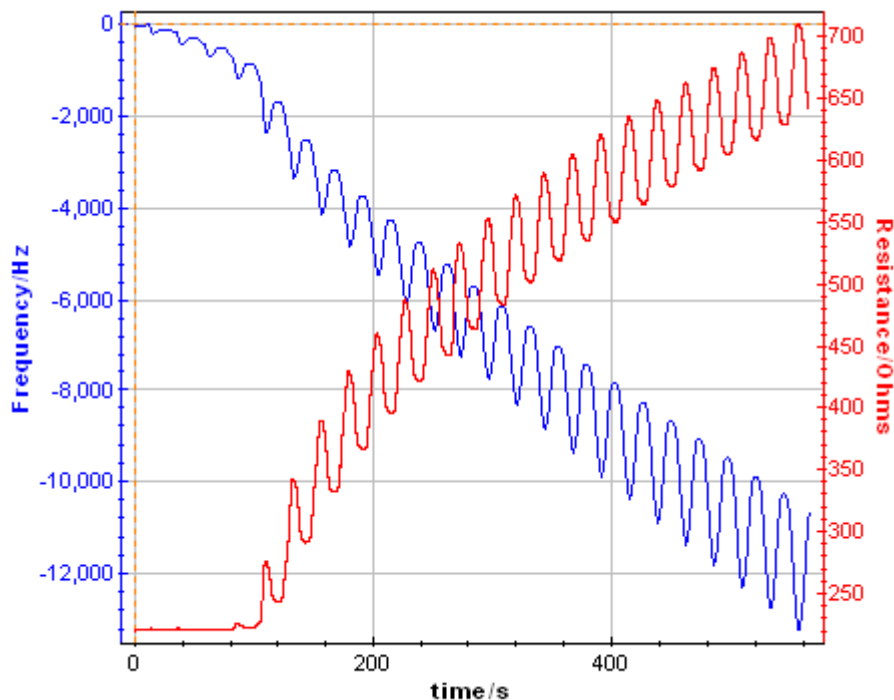
Fig. 64: Frequency and resistance variations recorded from the analog inputs for a BiStat coupled with a SEIKO EG&G QCM 922.

A process is also available to calculate the amount of a species electro-disposed on the quartz. To use this process, select the process data option in the Analysis menu.

6.2 **Virtual potentiostat**

The user can work with the EC-Lab® software without to be connected to an instrument. In that case, the software sees a virtual potentiostat that is not available for experiments but that can be used as a user's interface. The user can select his virtual instrument in the "Config menu" and the corresponding software interface will appear. The available techniques and time bases are different according to the instrument selected.

6.3 **Switching the BiStat and the boosters between 110 V and 240 V**

The Bistat instruments and the Bistat boosters can be connected directly to the 110-120 V or 220-240 V without any action required.

The table below summarizes the fuses values for the next instruments:

BiStat	BiStat booster
4 A	10 A

7. Maintenance and calibration

7.1 Maintenance

Our instruments do not require specific maintenance. Each channel board is calibrated at the factory (at 25°C) before being delivered to the customer. We recommend adjusting gains and offsets of the channel boards twice a year due to temperature differences between winter and summer, especially if the instrument is not in an air-conditioned room. This adjustment is performed using the EC-Lab® software's channel calibration in the "**Tool**" menu. We also recommend a full check-up of the instrument (at the factory) every two years.

The user must be careful that the ventilation grids are not obstructed on the right and left sides and under the chassis. An external cleaning can be made with a vacuum cleaner if necessary.

7.2 New boards installation in an existing instrument

When the user orders new boards (channel board or low current board) the installation can be made by the user himself. The procedure for this operation is described in the corresponding service note. With the provided boards the last software version is always installed. The procedure consists in 4 steps:

1- Install the new software version on the computer and on the instrument firmware in order to have the same software version for the old unit and the new boards.
2- Power off the unit.
3- Install the new boards in the chassis and power on the unit.
4- Calibrate the new boards (with EC-Lab®) in the unit.

The low current board is coupled with a channel board. The low current board must **ALWAYS** be calibrated with the corresponding channel board.

7.3 Software channel calibration

CAUTION !!!: Before operating remove all cell's cables from the channel boards.

1) In the EC-Lab® software, Select "**Tools/channel calibration**" and follow the instructions. You will receive the following message:
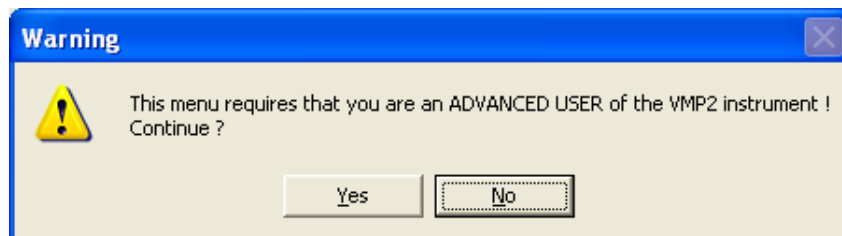
Answer "**Yes**" to the warning message. Then the board calibration window appears.
2) Select a channel (in our example channel 3) and click on the calibrate icon button.
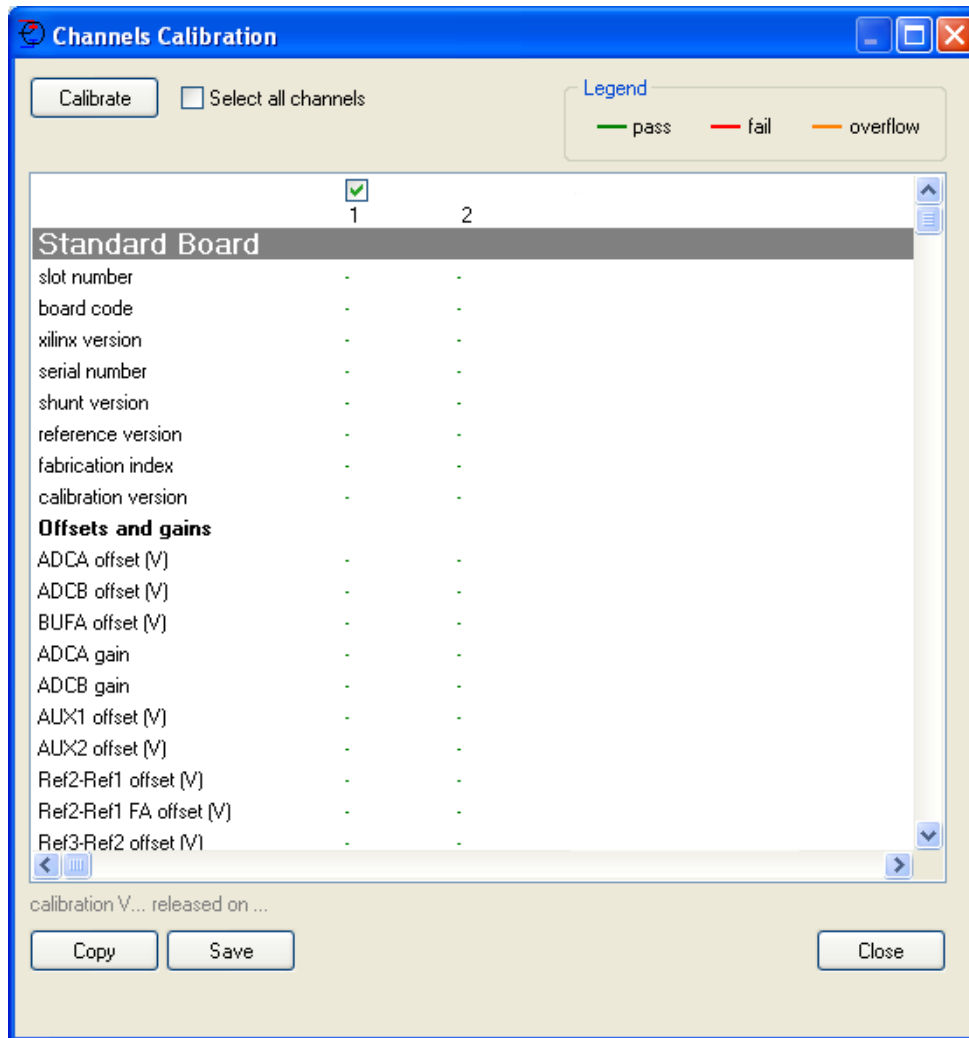
3) A warning message will follow:
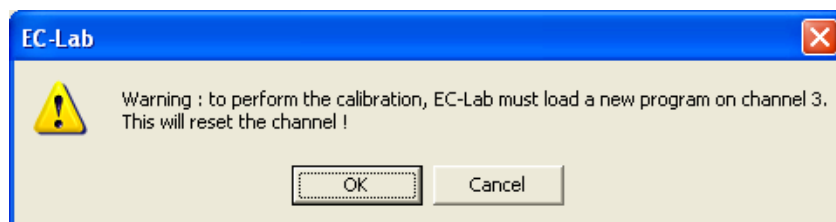
4) Click on Ok.
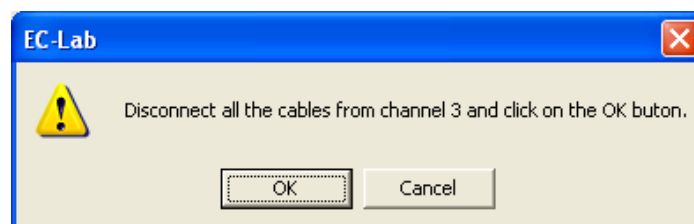
5) Disconnect all the cables from the channels to calibrate as called in the message. Then the calibration of the channel board will begin. For each variable, the numerical value corresponds to the compensated offset or gain and "pass" signify that the calibration is

made. If "failed" appears instead of "pass" then the calibration cannot be done. The channel board is probably damaged and must come back at Bio-Logic to be repaired.

When this calibration is finished, click on copy and paste the results in Word. Then save the file and print the report.
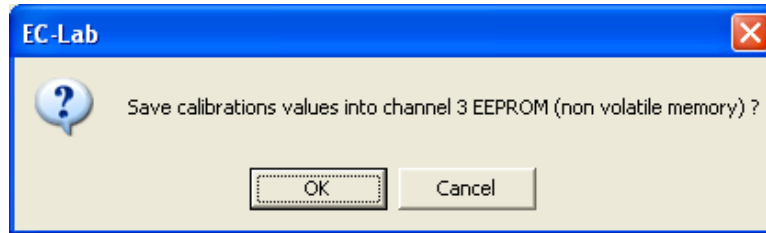
6) Click on "Ok" to save the calibration parameters on the channel board. On the board calibration window the message "calibration saved on channel X" is displayed. After the calibration of the channel board, a message will ask the user if a "p" low current board is associated to the standard channel. If a "p" low current board is connected to the channel, the user must calibrate the low current board as follow.
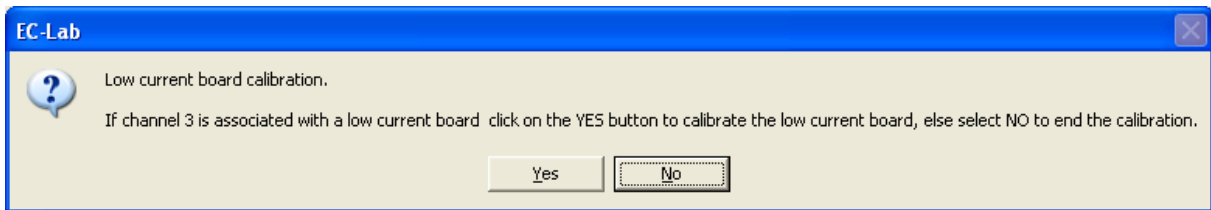
Click on "Yes" to calibrate the low current board. The connection message between the standard and the low current board appears:
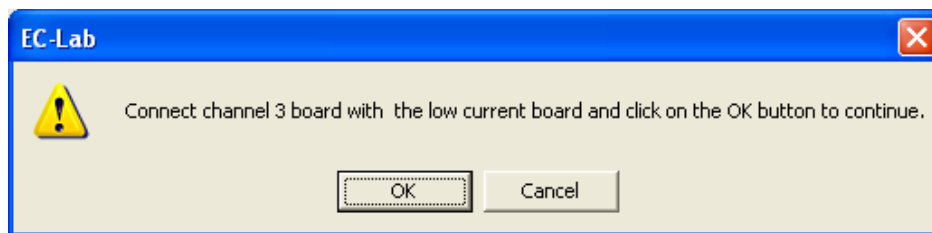
7) Click on "Ok" to start the low current board calibration.
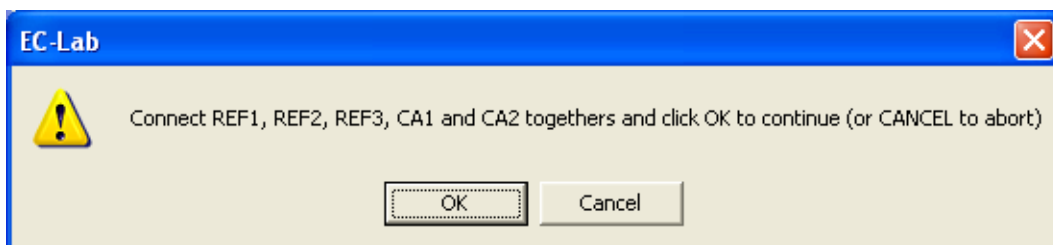
8) Connect all the banana terminal plugs of the low current board together to the same potential point and click on "Ok" to start the low current board calibration.
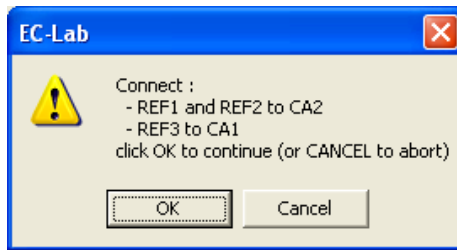
9) Disconnect Ref3 and CE/CA1 from the other cables and connect them together. Click "Ok"

10) A last message will ask you to save the calibration values in the low current board memory.

The standard channel board is now calibrated, and the calibration parameters have been saved in the channel board's memory. If a low current board is connected to this channel board, it has been calibrated too.

Now **close** the calibration window. The standard program will reload on the channel board.

8.   The BiStat's accessories

The Bistat potentiostat is designed for all fields of electrochemistry. The specification of the instrument must allow the user to work with very small currents (with the low current board option) and also to apply and measure very high currents (with current power booster option). Note that the BiStat cannot be equipped with options such as an EIS board or internal power booster.

8.1 The current power boosters (External power boosters)

The BiStat is designed to accept 400 mA maximum continuous current for each of the channel boards at a room temperature of 25°C. The user can apply currents up to 80 A using a current power booster. A booster is made of a chassis with current booster channels. Different booster channels are available (2 A, 5 A, 10 A, 20 A and 80 A). A chassis can contain mixed amplification boards up to 20 A (example: 2*2 A + 1*5 A + 1*10 A). From 2 to 20 A, the power booster can work in a voltage range of ± 10 V. For the 80 A booster, the voltage range is limited to ± 3 V.

8.2 Test boxes for calibration check and user's training

8.2.1 Test Box 4 for user's training

The Test Box 4 is a tool provided with all the instruments. It is made with dummy cells circuits (one for each channel). The electrical circuits of the dummy cells can be used to simulate the behaviour of linear electrochemical systems. With this box the user will have the ability to test the electrochemical impedance spectroscopy or electrochemical protocols like Cyclic Voltammetry or Linear Polarization. The resistance values are given with 1% accuracy.

8.2.2 Test Box 2
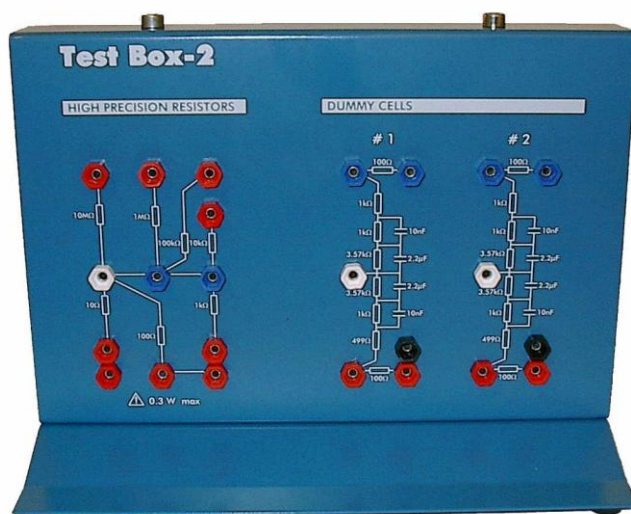
The Test Box 2 is a tool to check the calibration of our multichannel potentiostats/galvanostats. This testing box is made of one electrical circuit with high precision resistors for calibration check and two dummy cells circuits for user's training. It has been specially designed to check calibration of the standard channel boards of our instruments. The high precision resistor circuit is made with 7 resistors in order to check each current range of the board.

Combined with EC-Lab® software channel calibration described in the technical note # 18, the test box 2 can allow the user to keep an always well-calibrated instrument.

Ref: Technical note #18 is available on the support section of our web site.

High precision resistor Characteristics:

High precision resistor	I range	VMP2/BiStat/VSP/VMP3/EPP	VMP	MPG
10 Ohms +/- 0.02%	1 A	×		
100 Ohms +/- 0.02%	100 mA	×		
1 kOhms +/- 0.02%	10 mA	×	×	×
10 kOhms +/- 0.02%	1 mA	×		×
100 kOhms +/- 0.02%	100 µA	×	×	×
1 MOhms +/- 0.02%	10µA	×		
10 MOhms +/- 0.02%	1 µA	for the "p" low current option	×	

8.2.3 Test Box 3
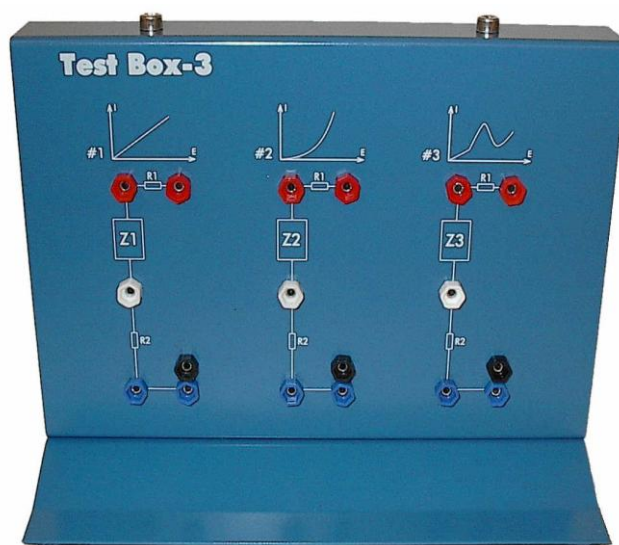
The Test Box 3 is a tool for learning and practice on linear and non-linear electrochemical systems. This testing box is made of three electrical circuits simulating real electrochemical systems. Along with the application notes #8 and #9 the Test Box 3 can be used to highlight some usual overlooked items about the electrochemical impedance spectroscopy. By the means of the Test Box 3 some general electrochemistry protocols like Cyclic Voltammetry, or corrosion protocols such as Linear Polarization or Generalized Corrosion can also be studied.

Stationary curves :
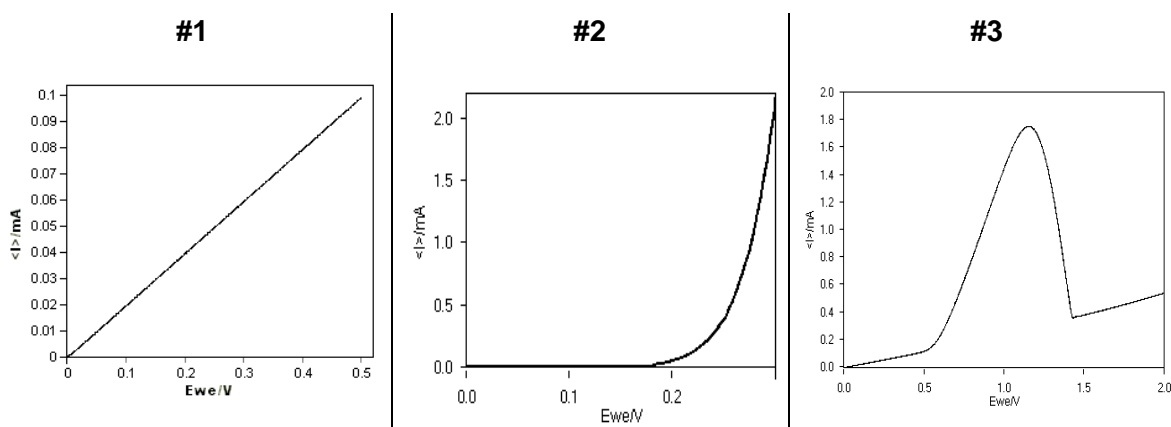
Ref: Application notes #8 and #9 are available on our web site.

8.3 Control of external devices

The auxiliary input/output of the BiStat can be used to record and control external signal such as a rotating disk electrode (for example ALS-RRDE-3A Rotating Disk Electrode), a temperature control unit. A BiStat DB9 cable is used for this connection. The available signals are E_{we} monitor, I monitor, TTL input, TTL output, External input 1, External input 2. See part 6.1 page 43 for more details.

8.4 Development package

The BiStat potentiostat can be controlled with the free EC-Lab[®] development package. This package is devoted to software developers who need to integrate the control of the Bio-Logic potentiostats/galvanostats/EIS in an OEM software.
The EC-Lab[®] development package also includes a LLB LabVIEW[®] library where the functions of the DLL are implemented (Requirements: LabVIEW[®] V6.1 or higher).

This development package includes a DLL with specific functions for:
- connection/disconnection to a selected instrument (Ethernet or USB),
- initialization of the channels by loading the firmware,
- loading protocols on the channels:
    - voltage scan (cyclic voltammetry),
    - current scan,
    - potentio impedance,
    - galvano impedance,
    - chronoamperometry,
    - chronopotentiometry,
    - open circuit voltage,
    - galvanostatic pulses,
    - potentiostatic pulses,
    - staircase potentio EIS,
    - staircase galvano EIS,
    - constant power,
    - constant load,
    - loop.
- start/stop the selected channel(s),
- retrieving data.

Note that the time base is 10 or 20 µs with these LabVIEW[®] Vis depending on the considered protocol.

9. Technical Specifications

9.1 BiStat specifications

SPECIFICATIONS	
Cell control	
Connection	2, 3, 4 or 5 terminal leads (+ ground)
Converters	16 bits dynamic DAC
	12 bits attenuation DAC
	12 bits DC shifts DACs
Compliance	20 V range adjustable from $\pm$ 10 V to 0 – 20 V
Maximum current	± 400 mA continuous
Maximum potential resolution:	300 µV on 20 V dynamic range
	programmable down to 5 µV on 200 mV dynamic range
Maximum current resolution	0.004 % of the dynamic range
	programmable down to 0.76 nA on the 10 µA range
Accuracy (DC):	< 0.1 % FSR*
Rise Time:	< 2 µS (no load)
Acquisition time	20 µs

Current measurement	
Ranges	± 10 µA, ± 100 µA, ± 1 mA, ± 10 mA, ± 100 mA, ± 1 A
Maximum resolution	0.004 % FSR*
Acquisition speed:	200,000 samples/s
Accuracy (DC)	< 0.1 % FSR*

Potential measurement	
Converters	16 bits ADC + 12 bits DC shift DAC's
Ranges	± 2.5 V, ± 5 V, ± 10 V
Maximum resolution	0.0015 % of the range, down to 75 µV
Acquisition speed	200,000 samples/s
Accuracy (DC)	< 0.1 % FSR*

Electrometer	
Inputs	3 potential measurements leads with 2 differential voltage measurements
Impedance	> 10^{12} ohms in parallel with 20 pF
Bias current	< 5 pA
Common mode rejection	> 60 dB at 50kHz

Auxiliary Inputs / Outputs	
2 general purpose analog inputs	16 bits resolution with automatic ± 2.5 V, ± 5 V, ± 10 V ranges
1 analog output	± 10 V
1 input trigger	TTL level
1 output trigger	TTL level
1 security input to Open Circuit	TTL level

General	
Dimensions, weight	95 x 430 x 335 (mm, H x W x D), 8 kg
Power	85-264 VAC, 47-440 Hz
Number of channels	2

LOW CURRENT OPTION (LC)	
Cell control	
Maximum current	± 100 mA continuous
Maximum current resolution	0.004 % of the dynamic range programmable 76 fA on the 1 nA range
Applied current resolution	< 1 % FSR* on the 1 nA range < 0.5 % FSR* on the 10 nA range < 0.1 % FSR* on the other ranges

Current measurement	
Ranges	± 1 nA, ± 10 nA, ± 100 nA, ± 1 µA, ± 10 µA, ± 100 µA, ± 1 mA, ± 10 mA, ± 100 mA, ± 1 A
Maximum resolution	0.004 % FSR*
Accuracy	< 1 % FSR* on the 1 nA range < 0.5 % FSR* on the 10 nA range < 0.1 % FSR* on the other ranges

Electrometer	
Impedance	10^{14} ohms in parallel with 1 pF
Bias current	60 fA typical, 150 fA max at 25°C
Bandwith	1 MHz

*FSR: Full Scale Range
Specifications subject to change.

Current measurement noise (rms/Bandwidth):

Noise is always present since all materials produce noise at a power level proportional to the material temperature. The shunt resistor is the first noise source in a current measurement path. A resistor noise is generally referred to as thermal noise or white noise. Just as the white light contains all the colors, the white noise includes uniformly distributed power at all frequencies. Thus, total power noise is proportional to the bandwidth. To minimize noise measurements, carefully select circuits with low noise specifications.

I range	Boost OFF
100 uA	16 nA/100 kHz
10 uA	1.6 nA/26 kHz
1 uA	0.16 nA/3.5 kHz
100 nA	17 pA/520 Hz
10 nA	1.7 pA/100 Hz
1 nA	0.18 pA/28 Hz

9.2 PC requirements

Minimum:
  - Pentium 500 MHz
  - 64 Mo RAM
  - Hard Drive necessary free space: 40 MB
  - 1 serial port (for MPG, VMP, VMP2, BiStat only)
  - 1 USB port
  - Screen resolution 800*600
  - Ethernet board with 10 base T (RJ45) connector
  - Windows 2000$^{©}$ or Windows XP$^{©}$ or Windows Vista$^{©}$.
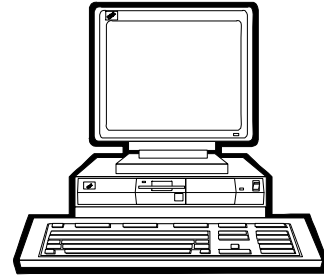
Recommended:
  - Pentium 2 GHz
  - 512 Mo RAM
  - 160 GB Hard Drive
  - Screen resolution 1280*1024
  - Ethernet board with 10/100 base T or USB port
  - Windows XP$^{©}$ (SP2).
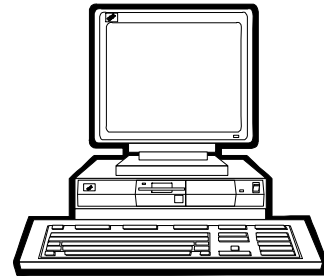
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9.3 Safety precautions

To avoid electrical shocks:
- The equipment must be connected to a protective ground.
- The equipment must be disconnected from the power source before it is opened.

To avoid electrostatic shocks:
- Every lead from the BiStat to the cells (or amplifier to cells) must be connected either to an electrochemical cell or to the testing box.

10. Troubleshooting

10.1 Data saving

Problem: Data cannot be saved from a given channel (this channel appears in yellow into EC-Lab®, and the program displays an error message while attempting to save data):
Solution(s):
- ensure that the saved file has not be moved or destroyed, or opened by another application.
- if the saved file is on a network drive, ensure that you have the right to write data into the same directory (create and destroy a text file). Otherwise see your network authorizations…
- into EC-Lab®, select **File, Repair...** Then select the saved file and click on the **Repair** button.
- Ensure that the computer IP Address has not been modified since the beginning of the experiment.
- if the problem persists, contact us.

10.2 PC Disconnection

Problem: The PC is disconnected from the instrument ("Disconnected" is displayed in red into EC-Lab® status bar):
Solution(s):
- check the PC – instrument connection :
- direct connection : verify that the crossed Ethernet cable is plugged from both ends.
- network connection : verify that the yellow led is blinking on the instrument front panel and that you can access to your network directories from the PC.
- check that the green led is blinking (this assumes that the multichannel potentiostat is always running properly).
- in the Tera Term Pro window type "r" or "R" : this will restart the Ethernet connection program that is a part of the instrument firmware.
  WARNING: this operation is not a simple task, so proceed like this only in case of trouble.
- if the problem persists, contact us.

10.3 Firmware upgrading with the Hyper Terminal software

Concerned instruments: MPG, VMP, VMP2, BiStat.

Problem: In previous versions of EC-Lab®, the Hyper Terminal upgraded the firmware. And with recent computers and Windows versions, the operation exceeded the 40 minutes expected (up to several hours).
Solution: This problem has been solved by replacing the Hyper Terminal (delivered with Windows) with the Tera Term Pro freeware.
Nevertheless, one can use any other terminal software that supports the serial port connections. Just enter the next parameters to communicate with the instrument:

Port: COM1 or COM2
Baud rate: 9600
Data: 8 bit
Parity: none
Stop: 1 bit
Flow Control: Xon/Xoff

Note: once the firmware upgrading operation has been started, it is highly recommended not to stop it!

10.4 Effect of computer save options on data recording

Electrochemical experiments often have a long duration (more than 24 hours). During the experiment, the computer should always be able to record the data points. If the user has enabled the power save option for his hard disk, he risks being unable to record the data points. In order to avoid that, remove the power save option of the computer in the settings panel.

10.5 Preliminary checks

Cables failure

Cell cable

Booster cable

Connection cable

Low current cable

Error message such as:
- Current values blinking in red color
- Current amplifier overflow on channel X (error message in yellow)
- Values E_{ce} and E_{we} when cable connected to a cell without any control are not stable or absurd

Booster not detected by the software

No possibility to test the cable

If possible

- Compare "Control vs Time" with I vs Time or Ewe vs time for confirmation
- Remove the cable from channel X
Connect it to channel Y → Same message that for channel X

Shut down and restart both the potentiostat and the booster to reinitialize them.

Cable broken → Repair at the factory

Board failure

Channel board

Booster board

- Impossibility to apply the correct control value
- Values E_{ce} and E_{we} when cable connected to a cell without any control are not stable or absurd
- Not proper measurement
- Overflow error messages
- Noisy measurements / oscillations
- In current measurement autorange mode, gaps when current changes

- Compare "Control vs Time" with I vs Time or Ewe vs time for confirmation
- Do Channel Calibration of the board
If failed appears in the calibration, the analog part of the board is failed

- Do EIS measurements on test box or resistor with the amplified current range using the setting files C:\ECLab\samples\PEIStest.mps or C:\ECLab\samples\GEIStest.mps
If results are not satisfactory
- Check the LEDs on the front panel, if one of them is red

Board probably faulty → Repair at the factory

Communication failure

- Network problem in Ethernet mode (verify the IP address and the uniqueness in the network)
- PC Ethernet board trouble (difficult to diagnose from the instrument side)

LEDs on the front panel of the board are not blinking

If the potentiostat seems OK when switch on (blinking LEDs and/or BIP sound) but the connection is not possible

Contact your network administrator

Board stopped / Reinitialization of potentiostat is needed
When restarting the instrument,
 * on VM62 and VM42 communication boards, a green and a yellow LEDs blink,
 * on ARM communication board, several BIP are emitted and LEDs blink.
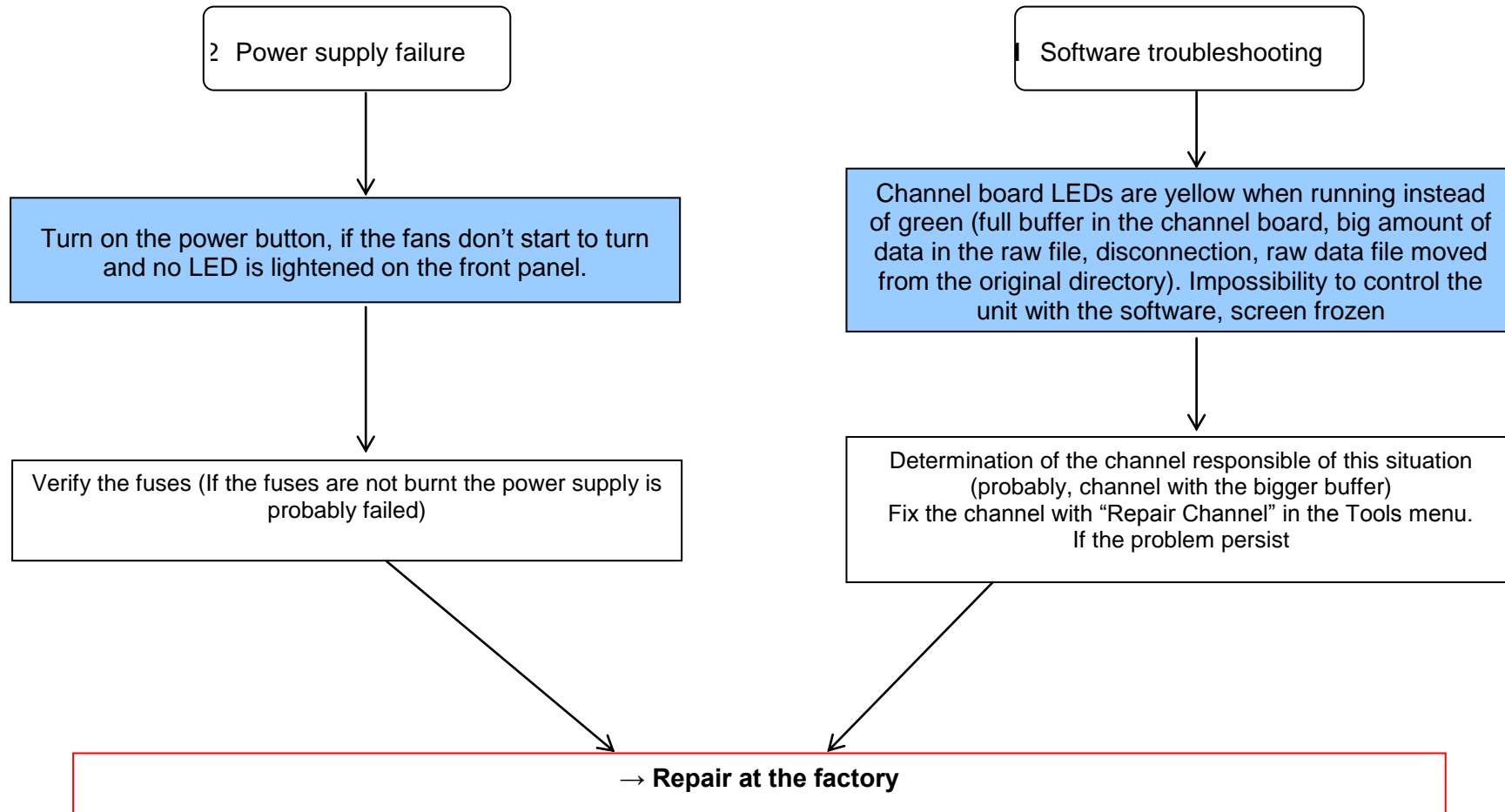
Check Antivirus and Firewall

Note: Two series of communication boards are available in our instrument range:
- VM42 and VM62 communication boards (without USB connection) for the VMP1, MPG, VMP2 and first generation of BiStat
- ARM communication board (Ethernet and USB connection) for the VMP3, VSP, HCP-803, EPP series, SP150, SP-50, VSP and last generation of BiStat.

2 Power supply failure

Software troubleshooting

Turn on the power button, if the fans don't start to turn and no LED is lightened on the front panel.

Channel board LEDs are yellow when running instead of green (full buffer in the channel board, big amount of data in the raw file, disconnection, raw data file moved from the original directory). Impossibility to control the unit with the software, screen frozen

Verify the fuses (If the fuses are not burnt the power supply is probably failed)

Determination of the channel responsible of this situation (probably, channel with the bigger buffer)
Fix the channel with "Repair Channel" in the Tools menu.
If the problem persist

→ **Repair at the factory**

11. Glossary

This glossary is made for the user to understand most of the terms used in this instrument installation and configuration manual. The terms are classified in the alphabetical order.

Amplifier: current power booster that can be added to each channel individually.

Bandwidth: represents the frequency of the regulation loop of the potentiostat. It depends on the electrochemical cell impedance. The bandwidths values are going from 1 to 7 with increasing frequency.

Calibration: operation that has to be done for each channel in order to reduce the difference between a controlled value (for example E_{ctrl}) and the corresponding measured value (for example E_{we}).

CE to ground connection: also called N'Stat connection, this mode allows the user to lead measurement onto eight working electrodes with one or eight reference electrodes and one counter electrode connected to the ground. It is a very interesting tool for biosensors study. This mode can be activated in the "Advanced settings" window.

Cell connection: connection of the instrument channel board to the electrochemical cell with five leads.

DB25: connector with 25 pins on the instrument front panel where the cable connecting the channel board and the electrochemical cell is set.

DB9: connector with 9 pins on the instrument front panel used as auxiliary input/output

Default settings: settings defined and saved as default by the user and automatically opened when the corresponding protocol is selected.

Firmware upgrading: the firmware is the operating system of the instrument. With new improvements on the instrument, it is necessary to upgrade the firmware and the software to benefit of the most recent version.

Gateway: IP address allowing the connection of computers from different networks onto an instrument.

Impedance: defined by the ratio E/I.

Low current: option providing a sub-pA resolution that can be added to each channel. This option extends the current range down to 1 nA.

Network: group of computers connected together in which the multichannel potentiostat can be added. Several users with different computers can lead experiments in one or more channels of the potentiostat.

Specifications: Characteristics of the instrument such as cell control or current and potential measurement.

Subnet mask: IP number used when the instrument is not in the same network as the computer.

TCP/IP: Transfer Control Protocol/Internet Protocol using IP addresses to identify hosts on a network.

Triggers: option that allows the instrument to set a trigger out (TTL signal) at experiment start/stop or to wait for an external trigger in to start or stop the run.

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