Quad pH/mV Amp

Quad Amp
pH/mV
168

isolated

Channel 1	Channel 2	Channel 3	Channel 4

E   *E*   *E*   *E*

Ref   *Ref*   *Ref*   *Ref*

E/2   *E/2*   *E/2*   *E/2*

● *On-line*   ● *On-line*   ● *On-line*   ● *On-line*

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Contents

1

Overview

The eDAQ Quad pH/mV Amp is designed to work with an e-corder system, recording signals from:

- pH electrodes (either combination, or half cell electrodes)
- potentiometric ion selective electrodes (ISEs)
- redox (or ORP, oxidation–reduction potentiometric) electrodes
- other high impedance sources up to ±2 V requiring electrometer input.

Signals from up to four electrodes can be recorded simultaneously.

How to Use this Manual

This manual describes how to set up and begin using your pH/mV Amp. The use of the pH/mV Amp with the Chart software pH Calibration extension is discussed. The appendices provide technical and troubleshooting information.

Checking the Quad pH/mV Amp

Before you begin working with the Quad pH/mV Amp, please check that:

> • all items described in the packing list are included; and that

> • there are no signs of damage that may have occurred during transit.

Contact your eDAQ distributor if you encounter a problem.

You should also become familiar with the basic features of your e-corder system, which are discussed in the *e-corder Manual* on the Installer CD.

.eDAQ Amps

The Quad pH/mV Amp is part of a family of preamplifiers known as eDAQ Amps.

The Quad pH/mV Amp is designed for recording signals from up to four pH and other potentiometric electrodes. As with other eDAQ Amps, it is designed to be operated under full software control and is automatically recognized by Chart or Scope software which controls its gain range, signal filtering, and other settings.

The range of eDAQ Amps includes the:

• **Quad pH/mV Amp**, suitable for connection of pH, ion selective, and potentiometric (ORP) electrodes

• **Potentiostat**, a three–electrode potentiostat that can be used for voltammetric and amperometric experiments. Gain ranges of 20 nA to 100 mA in 1:2:5 steps.

• **Picostat**, a high sensitivity three–electrode potentiostat suitable for use with carbon fibre and other microelectrodes. Current gain ranges of 10 pA to 100 nA in 1:2:5 steps.

• **QuadStat**, a four channel, three electrode potentiostat suitable for use with amperometric biosensors. Current gain ranges of 2 nA to1 mA/channel in 1:2:5 steps.

• **Bridge Amp**, suitable for sensors requiring a low drift, high gain differential amplifier. Also provides DC excitation

• **GP Amp**, suitable for high output sensors requiring a high impedance single ended or differential amplifier. Also provides DC excitation.

See our web site at www.eDAQ.com for more information.

2

The pH/mV Amp

This chapter describes how to connect and use your eDAQ Quad pH/mV Amp.

IMPORTANT: Always make sure that the e-corder is turned off before you connect or disconnect the Quad pH/mV Amp. Failure to do this may result in damage to the e-corder and/or the pH/mV Amp.

The Front Panel

The front panel of the Quad pH/mV Amp is shown in Figure 2–1.

The Electrode and Reference Inputs

The BNC input connectors marked 'E' of the pH/mV Amp provide connection for combination pH, ISE or ORP electrodes. Combination electrodes have an internal reference and no separate reference electrode is required.

Some electrodes do not have an internal reference (most ISEs and ORP electrodes and occasionally some pH electrodes). These electrodes, which are referred to as half cell electrodes, will need to be used with a separate reference electrode. Half cell electrodes should be connected to the BNC input connector marked 'E/2'. The separate reference electrode is connected to the 4 mm socket marked 'Ref'.

The On-line Indicators

When lit, these indicate that the software (such as Chart or Scope) has located and initialized the pH/mV Amp. If the light does not go on when the software is run, check that the pH/mV Amp is properly connected.

Figure 2–1
The Quad pH/mV Amp front panel

Electrode inputs, BNC connectors. For combination electrodes

Reference electrode input, 4 mm socket

Half cell electrode input, BNC connector

On-line indicator
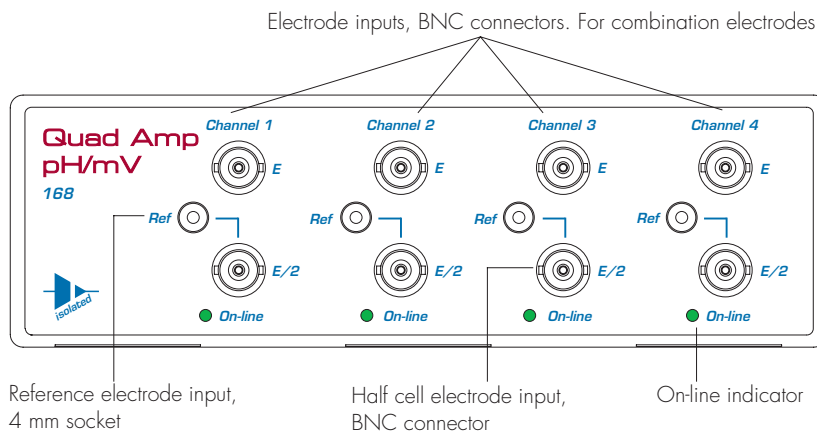
The Back Panel

The back panel of the Quad pH/mV Amp is shown in Figure 2–2.

The Signal Outputs

The Quad pH/mV Amp back panel has four BNC connectors labelled Channel 1 — Channel 4.

The Quad pH/mV Amp provides four signals, one for each sensing electrode.

pH/mV signals, BNC connectors

Chassis ground, 4 mm post

Channel 4   Channel 3   Channel 2   Channel 1

CE

Input I^2C Bus   Output

No user serviceable parts inside.
Refer servicing to qualified service personnel.

Made in Australia by eDAQ Pty Ltd.

DB–9 pin, I^2C connectors

I^2C control signals

Power lines

I^2C control signals

INT
DSD
SDA
DSC
SCL
Regulated +17 V DC
Regulated +8 V DC
Regulated –17 V DC
Digital Ground

Digital Ground
Regulated –17 V DC
Regulated +8 V DC
Regulated +17 V DC
SCL
DSC
SDA
DSD
INT

1   5
6   9

5   1
9   6

Input

Output

I²C Connector

The back panel, Figure 2–2, has two DB-9 pin 'I²C bus' connectors labelled Input and Output. The Input connector enables connection to the e-corder (or to the output of other eDAQ Amps). This connection provides power to the Quad pH/mV Amp and carries the various control signals (for gain range and filter selection) to and from the e-corder. The pin assignments are shown in Figure 2–3.
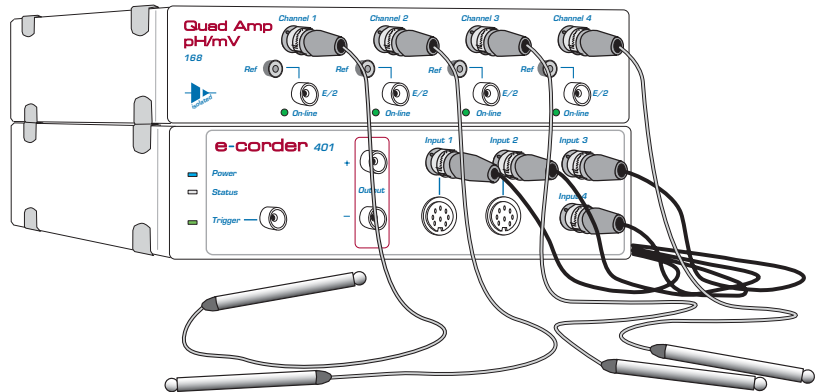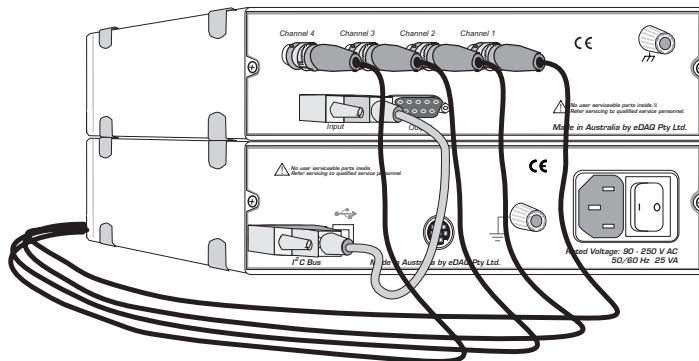
Connecting to the e-corder

Your Quad pH/mV Amp will have been supplied with an I²C cable (DB-9 pin connectors at either end), and four cables with BNC connectors at either end.

Figure 2–4
Four combination electrodes shown connected to a Quad pH/mV Amp and e-corder 401

Figure 2–5
Back view of Quad pH/mV Amp connected to e-corder

First make sure that the e-corder is turned off. Then connect the I^2C cable to the I^2C connector on the back panel of the e-corder, and the other end to the I^2C Input connector on the back panel of the pH/mV Amp. Use BNC cables to connect the signal outputs on the back panel of the Quad pH/mV Amp to the front panel of the e-corder as shown in Figure 2–4 and Figure 2–5.

Check that all connections are firm. Loose connections may cause failure to recognize the eDAQ Amp by the software, erratic behavior, or loss of signal.

Multiple eDAQ Amps can be connected to an e-corder. The number that can be connected depends on the number of input channels on the e-corder. The initial eDAQ Amp should be connected as shown in Figure 2–4. The remainder are linked via I^2C cables, connecting the I^2C output of one eDAQ Amp to the I^2C input of the next, as in Figure 2–5. The signal outputs of each eDAQ Amp are connected to an input channel of the e-corder.

The pH/mV Amp Self Test

After you have installed the software, connected the e-corder to a computer as described in your *e-corder Manual*, and connected the pH/mV Amp as described above, a quick check can be performed on the pH/mV Amp:

> • Turn on the e-corder and check that it performs its normal diagnostic tests, as described in the *e-corder Manual*

> • Once the e-corder is ready, open Chart or Scope.

> • During initialization, you should see these indicators flash briefly and then remain lit — the Quad pH/mV Amp is ready for use.

If the indicators do not light, check your cable connections and repeat the procedure. If this does not solve the problem, contact your eDAQ distributor.

Using Chart and Scope

Setting up the Quad pH/mV Amp

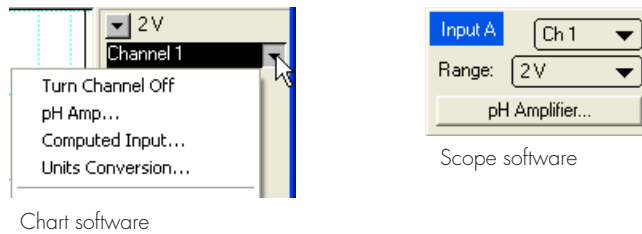When the Quad pH/mV Amp is connected to an e-corder input and successfully installed, the pH Amp… menu command appears in the Chart software Channel Function pop-up menu, Figure 2–6. In Scope software, the [pH Amplifier…] button appears in the Input A (or Input B) panel, see Figure 2–6.

Chart software

Scope software

If the software fails to find the Quad pH/mV Amp, the normal Input Amplifier… command or button remains. If you were expecting a connected pH/mV Amp, you should check the connections at this point, quit the application, then open it again.

Choosing the pH Amp… menu command or clicking the button will access the pH Amp dialog box (which replaces the Input Amplifier dialog box for that e-corder channel — your *Chart* and *Scope Software Manuals* have details on the Input Amplifier dialog box).

Previewing the Signal

The pH Amplifier dialog box allows you to preview a signal so that you can select the amplification and filter settings. The dialog boxes for Chart software are shown in Figure 2–7 and Figure 2–8. The Scope software controls are similar.

The incoming signal is displayed in real time, but is not recorded to hard disk (once the signal moves across the display area it is lost). Click the OK button to apply the selected settings.

Figure 2–7
The pH/mV Amp pH dialog box, for previewing a signal (Chart software on a Windows Computer)

Select input channel

e-corder input channel number

Pause/Resume buttons

pH Amp

Input 1

0.003 V

Range:
2 V

Gain range (sensitivity)
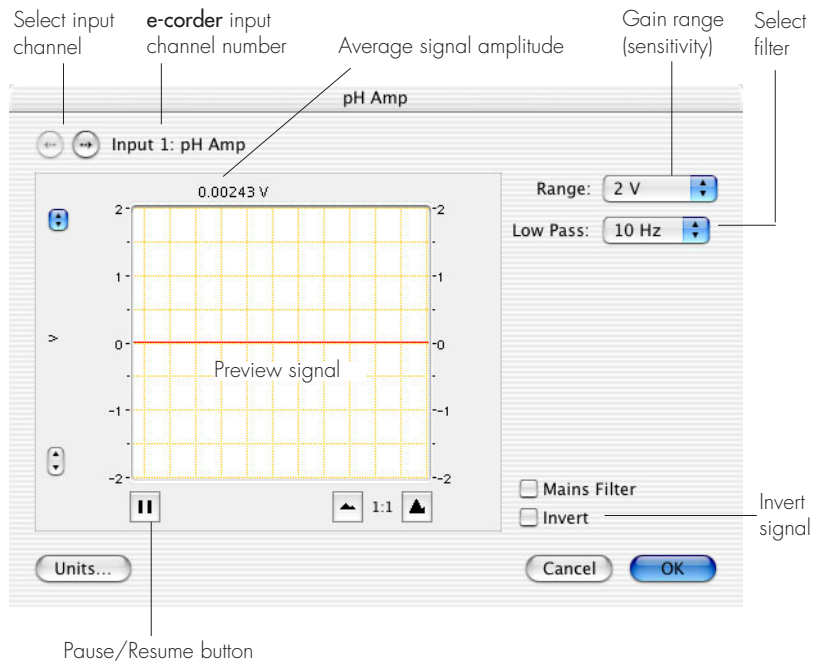
Low Pass:
10 Hz

Select filter

Average signal amplitude

Preview signal

Invert

Invert signal

Units...

OK   Cancel

Drag labels and tick marks to adjust axis
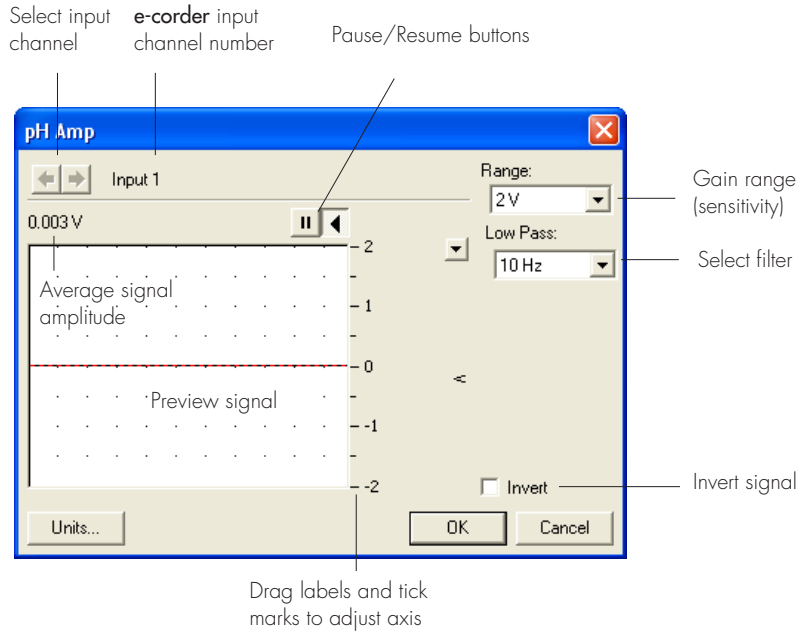
Figure 2–8
The pH/mV Amp pH dialog box, for previewing a signal (Chart software on a Macintosh Computer)

Select input channel

e-corder input channel number

Average signal amplitude

Gain range (sensitivity)

Select filter

pH Amp

Input 1: pH Amp

0.00243 V

Range: 2 V

Low Pass: 10 Hz

Preview signal

Mains Filter

Invert

Invert signal

Units...

Cancel   OK

1:1

Pause/Resume button

Signal Display

The input signal is displayed so that you can see the effect of changing the settings. The average signal value is displayed at the top left of the display area. Slowly drifting signals (as from pH electrodes) will be represented quite accurately, whereas quickly changing signals will be displayed as a solid dark area showing only the envelope (shape) of the signal formed by the minimum and maximum recorded signals.

You can stop the signal scrolling by clicking the Pause button at the top right of the display area ▮▮. Click the Scroll button ◀ to resume scrolling.

You can shift and stretch the vertical Amplitude axis to make the best use of the available display area (see the Input Amplifier dialog in the *Chart Software Manual* for further details). Changes made here update settings in the main window of the program.

Setting the Range

Use the Range pop-up menu to select the input range (sensitivity) of the channel.

At 25 °C, a change of one pH unit corresponds to a 59 mV change. This relationship is used in Table 2–1 which shows the pH ranges corresponding to various pH/mV Amp range settings, assuming that the pH electrode has a response of zero millivolts at pH 7. For pH measurements covering a wide range, a setting of 500 mV should be

Table 2–1
pH ranges corresponding to pH/mV Amp settings

Range setting (mV)	Resolution[†] (µV)	Range (pH)	Resolution (pH)
±500	15.6	−1.5 to 15.5*	< 0.001
±200	6.25	3.6 to 10.4	< 0.001
±100	3.13	5.3 to 8.7	< 0.001
±50	1.56	6.2 to 7.8	< 0.001
±20	0.625	6.7 to 7.3	< 0.001

[†] Resolution is 16 bits, or 0.0015%, of range setting.
* In practice this range will be limited by the pH electrode

used, while the 200 or 100 mV settings are suited to narrow range pH measurements (for example for biological pH monitoring).

Filtering

Low pass filter settings of 10, 5, 2 and 1 Hz are available. The low pass filter will remove high frequency noise. pH and ion selective electrodes have a slow response time, usually in the order of seconds, and the 1 Hz filter setting is often routinely used. If you are using fast response electrodes then a higher setting can be used.

The Mains Filter, ☐ Mains Filter , removes 50 or 60 Hz interference due to mains hum. See the *Chart Software Manual* for more information. For most applications it is recommended to have the Mains Filter on.

Inverting the Signal

Ticking the Invert checkbox, ☐ Invert , reverses signal polarity (that is positive and negative signal values are reversed).

Units Calibration

Clicking the ⬚ Units... ⬚ button access the Units Conversion dialog box. For more information about Units Conversion, see the *Chart Software Manual* or *Scope Software Manual.*

However, when using Chart software for recording data from pH and ion selective electrodes, and where single or double point calibration is employed, use the pH Calibration extension, see Chapter 3 — do NOT use Units Conversion.

Where multiple point calibration (more than two points) is required, use the Multiple Point Calibration extension.

Both the pH Calibration extension and Multiple Point Calibration extensions can be obtained from the eDAQ website (www.eDAQ.com).

3

Electrode Calibration

The pH Calibration extension is a Chart software plug-in that adds the 'pH Calibration…' command to the Chart channel pop-up menus.

The extension:

• performs single or double point calibration of the pH or ISE electrode;

• prepares a calibration graph from the measured electrode signal;

• enables manual temperature compensation (MTC) adjustment; or

• enables automatic temperature compensation (ATC) if temperature readings are collected on a second channel

The resulting calibration information is used to convert the raw voltage signal from the electrode into appropriate units (pH, pF, pNa, etc.), which will then be displayed in the Chart window.

Multiple point (i.e. more than two points) linear or non-linear calibration can be performed with the Multipoint Calibration extension.

Both the pH and Multipoint Calibration extensions can be downloaded free of charge from the eDAQ website (www.eDAQ.com).

Signal Calibration

Choosing the pH… command (available after installing the pH Calibration extension) from a channel pop-up menu accesses the Electrode Calibration dialog box, Figure 3–1 and Figure 3–2.

If a region of the electrode signal has first been selected in the Chart window then that region will also appear in the display area of the Electrode Calibration dialog box.

The raw signal values (with units of V or mV) and the corresponding pH values are entered in the boxes (at right) to calibrate the electrode. For single point calibration only the top set of boxes need to have values entered. The software will calculate the electrode response based on an assumed isopotential point of zero mV and an ideal 100% Nernstian response. For more accurate calibration two calibration points should be used and the actual electrode response will be calculated.
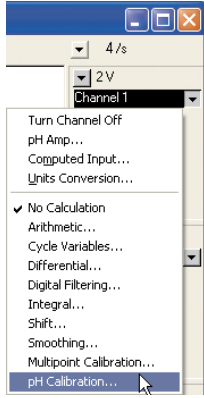
While the raw signal values can be entered directly by typing them in, it is more usual for the electrode to be immersed in a standard buffer solution of known pH (or ion concentration) and the signal recorded for a minute or so until it has stabilized. If two point calibration is required, then the electrode is immersed in a second standard buffer solution of a different pH (or ion concentration).

After recording the raw signal from the two buffer solutions, a signal similar to that shown in Figure 3–3 should be obtained. Select a region that includes the signal response from both buffer solutions, and choose pH… from the Channel Function pop-up menu. This opens the electrode calibration dialog box with the selected waveform displayed, Figure 3–1 and Figure 3–2.

Select a suitable part of the signal in the data display by using the mouse to drag the pointer across it. You can also shift and stretch the vertical Amplitude axis to make the best use of the available display area.

If you click in the data display area, a vertical line indicates the active point, and an indicator arrow, ⬌, shows the point of

Calibration report — Raw signal values — Standard buffer values — Ionic charge pop-up menu — Units pop-up menu — Decimal places selection

Choose the pH Calibration… command from the channel menu

Temperature compensation

View electrode response, Figure 3–11

Selected signal from main Chart windows

Select region of signal for raw value

Figure 3–2
The Electrode Calibration
dialog box of the pH
Calibration Extension
(Macintosh)

Raw signal values — Standard buffer values — Units pop-up menu — Decimal places selection

Calibration report

Temperature compensation
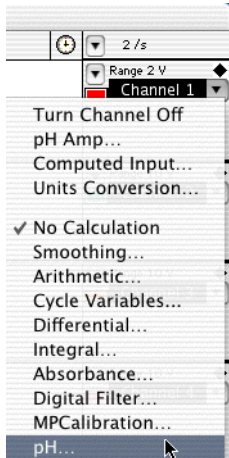
Choose the pH… command from the channel menu

Select region of signal for raw value

Calibration temperature

Electrode response dialog button

Figure 3–3
Selection of raw mV data
from two buffer solutions,
for use in electrode
calibration
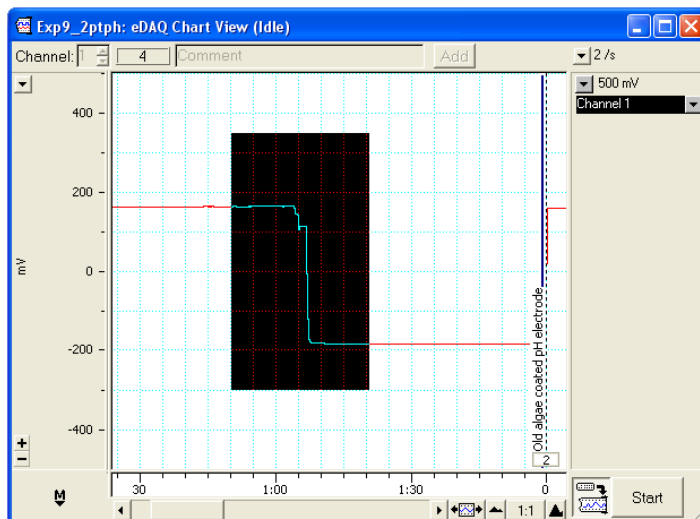
Figure 3–4
Selecting different
regions of the electrode
signal
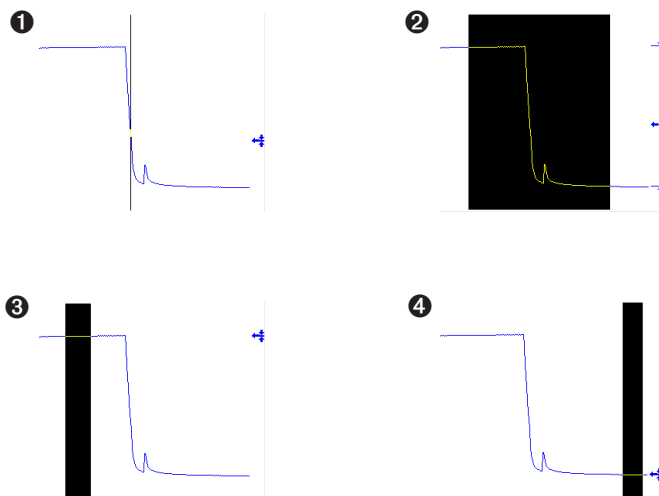
intersection with the signal (Figure 3–4, ❶). If you select an area, drag the pointer (mouse) across the signal, the ← arrow shows the average amplitude of the signal, and two markers, ⁺ and ._⁺ indicate the maximum and minimum data points in the selection (Figure 3–4, ❷).

Usually a region of steady signal is selected (Figure 3–4, ❸ and ❹), then clicking the Value button ➡, enters the raw signal value (the

Click on arrow to enter
average signal value   Enter buffer pH

Select region of
signal for first buffer

Results of
single point
calibration

Click on arrow to enter
average signal value   Enter second buffer pH

Select region of
signal for second
buffer

Results of
double point
calibration
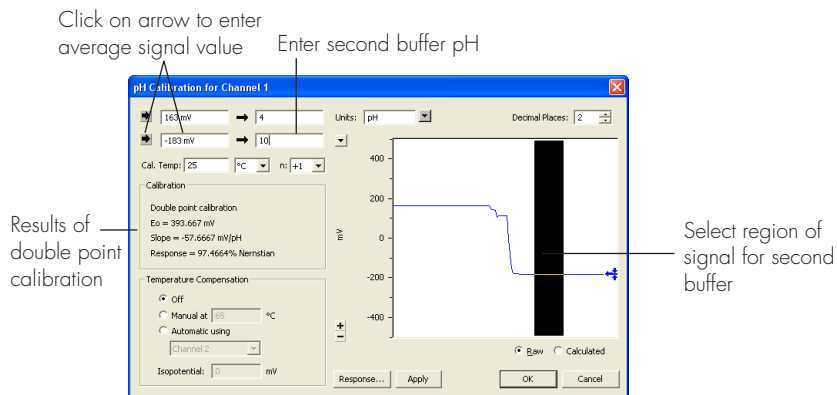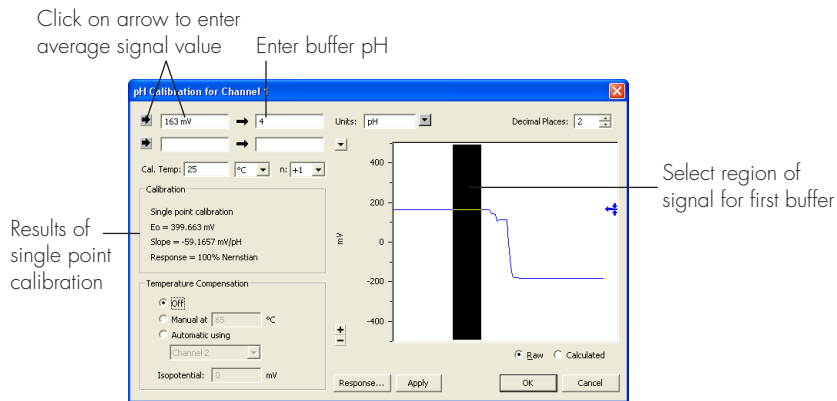
average of the selection) in the adjacent box, for example
➡ -183 mV . The standard buffer value is then manually entered in
the adjacent box, ➡ -183 mV ➡ 10 , and the desired units
selected (see next section).

This is then repeated for the second buffer solution Figure 3–5.

Choosing Units

The Units pop-up menu, Units: pH ▼ , is used to select the unit
name. Common units are included in the menu but you cans also define
new units, or delete unwanted ones. Unit names are stored in a
preferences file and become available to other files.

Choose Define Unit… from the Units pop-up menu to access the Define
Unit dialog box, Figure 3–7, to enter a new unit name.

Figure 3–6
Defining new unit names

Units pop-up menu

Enter the unit name
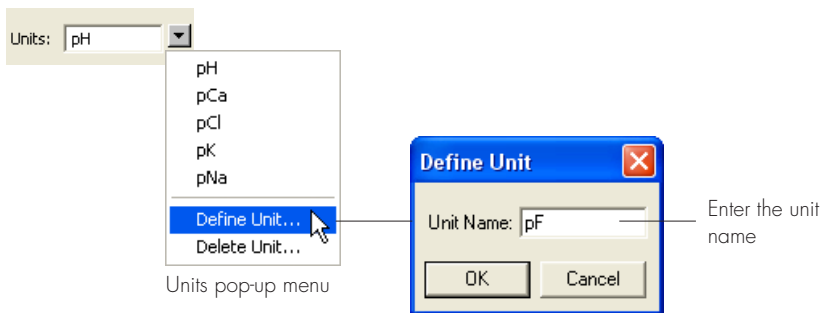
Delete unwanted units by choosing Delete Unit... from the pop-up menu.

Set the number of decimal places to be displayed for cursor readings of the calibrated signal, by clicking the arrows, Decimal Places: 3, (Figure 3–1 and Figure 3–2).

To preview the signal with the new units, click the Apply button. You can apply and cancel the units conversion without losing the values you have entered by clicking the Raw Calculated buttons. To apply the changes to the channel and return to the Chart window, click the OK button. To abandon the changes click the Cancel button.

Ionic Charge

Use the n: +1 pop-up menu, Figure 3–7, to select the value for the number of electrons transferred at the electrode. This usually corresponds to the charge of the ion and thus for pH, sodium, or potassium measurements $n = +1$; for magnesium or calcium $n = +2$; while for halides, or nitrate $n = –1$.

The value of n is used to calculate the response of the electrode using the Nernst equation, and *must* be set correctly to obtain a valid calibration.

Figure 3–7
The Ionic Charge pop-up menu
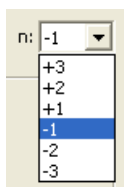
Calibration Temperature

You must also enter the temperature of the standard buffer solutions,
Cal. Temp: [25] [°C ▼]. Please remember that the pH value of a buffer
solution is temperature dependent and that the correct buffer value
should be used at that temperature.

Temperature Compensation

For the most exacting work, both calibration and experimental
measurements are performed in a thermostatted glass reaction vessel
maintained at a known temperature to within ±0.05 °C. Under these
conditions temperature compensation is NOT required.

When pH, or other ISE measurements, will be made at temperatures
(T_m) other than the temperature under which calibration was performed
(T_c), the Nernst equation can be used as a basis for compensation of
the readings.

The pH extension offers two types of temperature compensation:

• manual temperature compensation (MTC). Used where the
measurements are made at a constant temperature, but where
$T_m \neq T_c$.

• Automatic temperature compensation (ATC). Used where
temperature fluctuations are expected to occur during the
experiment, that is, when T_m is not constant. In these cases
temperature should be monitored on a second channel. Note that
the calibration must still be performed at a known constant
temperature.

Both MTC and ATC corrections can be removed if required, so that the
original, raw data can be re-displayed.

Manual Temperature Compensation

The manual temperature compensation (MTC) option is for use when
you need to measure ionic concentration at a temperature other than
that at which the electrode was calibrated. For example, the calibration
may have taken place at 25°C, but the subsequent samples might be at

Figure 3–8
Selecting temperature
compensation

Manual temperature compensation   Automatic temperature compensation,
with temperature measured on channel 2
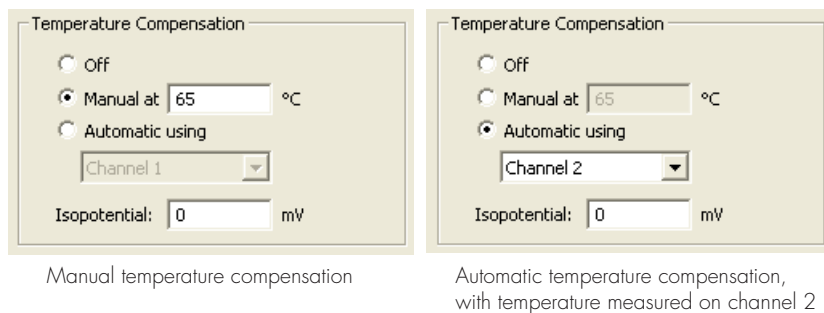
37°C, or 65°C etc. MTC will alter the electrode response slope to suit the new temperature on the basis of the Nernst equation.

Make sure that temperature compensation is enabled in the Temp. Compensation check box by selecting ⊙ Manual. The temperature at of the sample data should be also be entered ⊙ Manual at 65 °C .

Automatic Temperature Compensation

When the temperature of the solution being measured is changing it is necessary to perform automatic temperature compensation (ATC).

Using a suitable temperature probe and amplifier (for example the eDAQ Thermocouple Pod) the temperature signal can be recorded on a a spare e-corder channel. When the Automatic option is chosen, the pH extension will use temperature data from one of the Chart channels to correct the pH channel for variations in temperature. To choose the automatic temperature compensation option click in the radio button next to the Automatic option. The channel selection pop-up menu can select the channel on which temperature was recorded.

Recording Temperature

To use a temperature channel for ATC, the channel must first be appropriately calibrated, using the Units Conversion feature, with units of °C, °F, or K. If you have not calibrated the temperature channel an alert will appear, Figure 3–9, because the pH extension needs to know these units in order to apply the Nernst equation.

Figure 3–9
Uncalibrated
temperature channel
warning alert

Figure 3–10
Previewing the
temperature signal and
setting up units for the
temperature channel

Select Temperature from
the channel menu

Select suitable range:
5 V up to 100 °C
2 V up to 40 °C

Access Units Conversion for
temperature signal

0 V = 0 °C and
5 V = 100 °C
are the factory
default settings for
the RTD probe
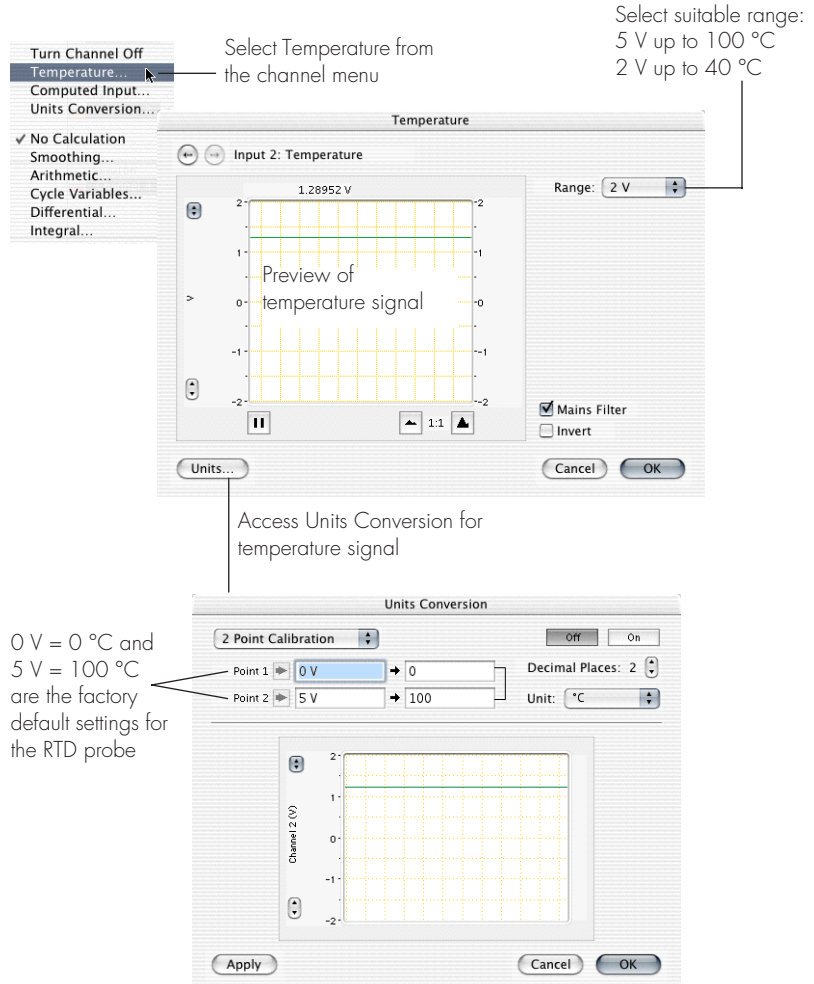
To set the units of the temperature channel, preview the temperature
signal by using the Temperature command (channel menu) to access the
dialog box shown in Figure 3–10.

Isopotential Point

The isopotential point of the electrode is the potential which remains constant as the temperature changes, see Figure 3–12. Most pH electrodes are constructed so that the isopotential point is about 0 mV (which for most pH electrodes also corresponds to pH 7). But it is not uncommon to find, even in new pH electrodes that the isopotential point is actually anywhere between ±50 mV and that this value changes as the electrode ages. Ion selective electrodes may have an isopotential completely outside the measuring range of the electrode.

Most pH meters assume an isopotential point of 0 mV (at pH 7) when they apply MTC or ATC. However, with the Chart pH extension, you can enter any isopotential value. To calculate this value you must do two calibration runs at different temperatures. Refer to Appendix D for more information on how to determine the isopotential point.

Viewing Electrode Response

The pH extension plots the voltage response of the electrode versus pH (or other ion) giving a calibration graph of the electrode.

Click the `Response...` button in the pH dialog box, Figure 3–1, and Figure 3–2. Typical electrode responses are shown in Figure 3–11. The isopotential point will be set to zero unless temperature compensation is turned on and a new value entered.

Adjusting the Scaling

The vertical axis will automatically scale to the full range at which the data was recorded. For example, if you were recording on the 1 mV range then the scale would have a range of ±1 mV. You can then drag the axis tick marks, and tick labels to stretch and offset the axis and obtain a better scaling.

The horizontal axis represents the ionic concentration. In the special case of pH, the horizontal scale will be automatically scaled between 0 and 14. The axis tick marks and labels can then be dragged to new positions to better scale the axis.

Figure 3–11
The Electrode Response
dialog box

Calibration point

Single point calibration uses
an ideal Nernstian slope

Print
calibration
report

Calibration points

Calibration
points

Double point calibration

Copy
calibration
report
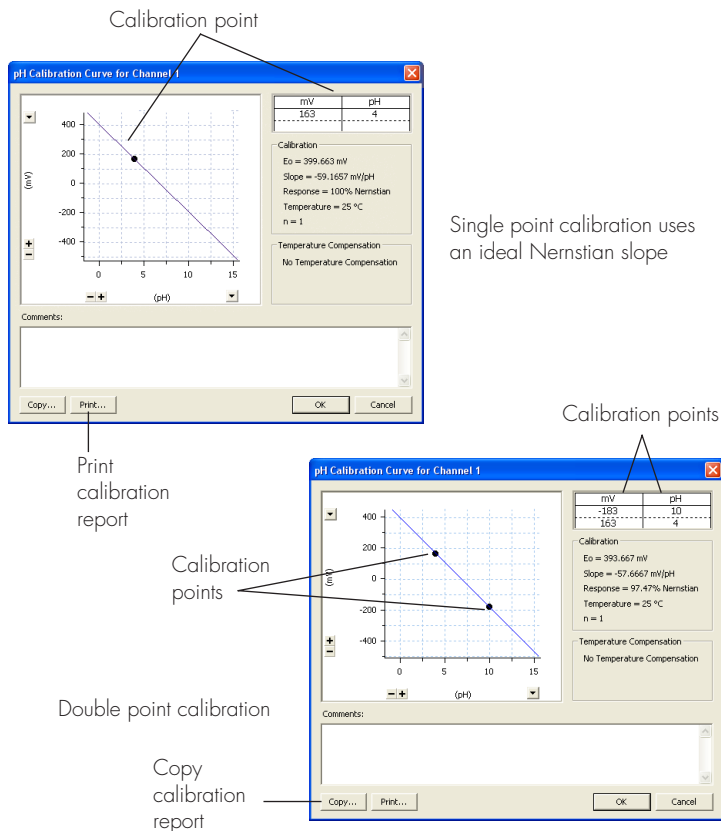
The ─+ buttons and ▾ pop-up menu next to the axes can also be
used for scaling.

Manual Compensation Response

When the manual temperature compensation mode is selected and a
temperature other than the calibration temperature is entered, the
electrode response dialog will display two electrode plots: one
representing the response at the calibration temperature; and a second
plot showing the response at the specified temperature.

The calibration response can be identified as the line with one or two
calibration points on it. These are represented as dots. The information
displayed on the right of the dialog shows the calibration points and
the values used for the Nernst equation.

Figure 3–12
Electrode Response
dialog box when using
manual temperature
compensation.

Response at 65 °C   Isopotential point   Response at 25 °C
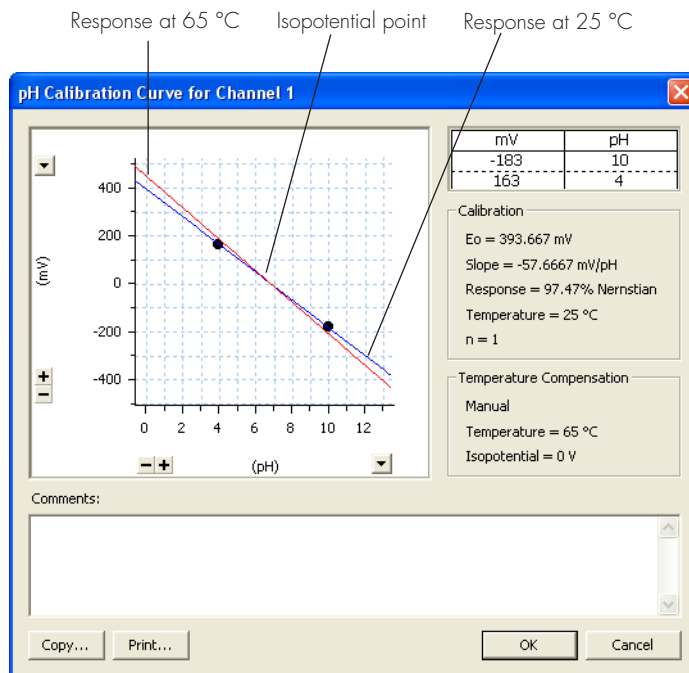
Printing or Copying

Use the Copy... or Print... buttons to copy the electrode
response graph for pasting to a word processor document, or to print a
quick report.

Removing the Calibration

The calibration can be turned off at any time by choosing the
✔ No Calculation command from the channel pop-up menu, Figure 3–1
and Figure 3–2. This displays the raw electrode signal (in millivolts or
volts) again.

Technical Aspects

This appendix describes the some of the important technical aspects of the Quad pH/mV Amp. You do not need to know the material here to use the pH/mV Amp. Please remember that user modification of the equipment voids your rights under warranty.

Quad pH/mV Amp Operation

The Quad pH/mV Amp and other eDAQ Amps have been designed to be used with an e-corder system. The pH/mV Amp is effectively an extension of the e-corder's analog input channels. It provides:

- very high impedance, electrically isolated inputs suitable for direct connection to pH or other ion selective electrodes.

- software controlled filtering of the signal.

- reference electrode input.

- software selectable gain ranges.

Technical Description

As with other eDAQ Amps, all internal functions of the Quad pH/mV Amp are controlled from the e-corder by sending information on a special communications connection called the I^2C (eye-squared-sea) bus. This connection supplies power to the eDAQ Amp as well. eDAQ Amps are connected to the analog input channels of the e-corder via

BNC-to-BNC cables, through which the amplified and filtered signal is sent to the e-corder. The overall operation of the pH/mV Amp can be better understood by referring to Figure A–1.

The *E* input is used for combination electrodes where the reference electrode is connect to the cable shield. The electrode signal is fed to a high input impedance amplifier of unity gain.

The *E/2* input is meant for use with 'half cell' electrodes (that is those that require the use of a separate reference electrode). In these cases, the reference electrode should be connected to the *Ref* socket. The output of the electrometer amplifier is fed to a 3 pole, 10 Hz low pass filter.

The *E/2* signal is protected with a actively driven shield. If you use a half cell electrode with a coaxial cable then the shield will be extended to the electrode. This will minimize signal leakage and allow the use of longer cable runs (typically several metres) than would otherwise be the case.

The pH/mV Amp output signal is fed to the e-corder for secondary amplification and filtering.

Figure A–1
Block Diagram of Channel 1 of the Quad pH/mV Amp
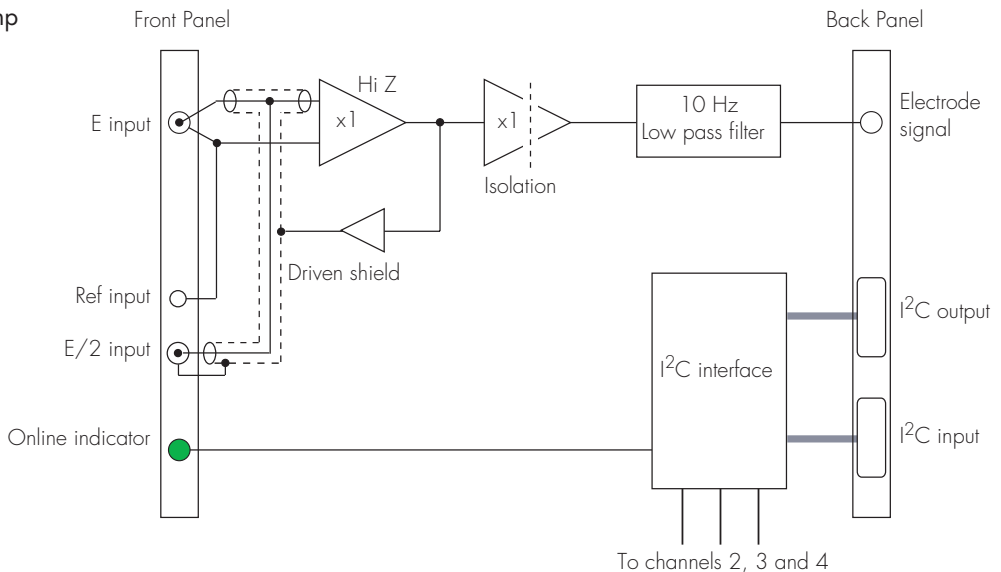
B

Troubleshooting

If you experience any difficulty with the Quad pH/mV Amp use this section to try to resolve the problem. In the majority of cases, the problem can usually be fixed by ensuring that the connecting cables are correctly connected and firmly attached and the re starting the Chart or Scope software.

The On-Line indicator fails to light when Chart or Scope is opened

> • If the e-corder is off check switches and power connections.

> • The BNC to BNC cable from the pH/mV Amp to the analog input channel of the e-corder may not be properly connected. Check that the cable is firmly connected to the BNC connector on the back panel of the pH/mV Amp and to a BNC input on the front panel of the e-corder.

All or some of on-line indicators fail to light when the Chart software is opened, and the pH/mV Amp controls are not accessible

> • If all the lights are off, then the I^2C cable from the pH/mV Amp to the e-corder may not be properly connected. Check to see that the I^2C cables are firmly seated and screwed in.

> • Try a new cable to check that the BNC and/or I^2C cables are working correctly.

> • If you have tried the above suggestions and still cannot get the Quad pH/mV Amp to work properly, then try using it on another e-corder if you have access to one. If the on-line indicators still fail to light on the second e-corder, the unit may be faulty and should be returned for repair.

C

Specifications

Quad pH/mV Amp

pH/mV Amplifier:	Four. High impedance, electrometer type. Galvanically isolated.
Input range:	±2 V
Secondary ranges:	±1000, 500, 200, 100, 50, 20, 10, 5, 2 mV, supplied by e-corder
Input resolution:	16 bits, 0.0015% of range
Input impedance:	10^{13} Ω typical
Amplifier noise:	< 1μV rms (4 μV p–p) @ DC – 10 Hz
Maximum Input:	±10 V
Input Connection type:	Insulated BNC (E and E/2) 4 mm socket (Ref)
Bandwidth/Low pass filter:	-3 dB @ 10 Hz 3 pole Bessel
Secondary filters:	5, 2, 1 Hz (digital filters of e-corder)

Control Port

I^{2}C input and output: Male and female DB–9 pin connectors.
Provides control and power.

Power requirements: ±17 V DC
+8 V DC
~3 W

Physical Configuration

Dimensions (h × w × d): 60 × 150 × 200 mm
2.4 × 5.9 × 7.9 inches

Weight: 1.5 kg (3.3 lb)

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

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

D

Electrode Behavior

The Nernst Equation

Most pH and ion selective electrodes exhibit behavior that closely follows the Nernst equation which describes the relationship between potential, ion activity ($\approx$ ionic concentration), and temperature.

$$E = E_0 - 2.303\left(\frac{RT}{nF}\right)pY$$

where

- E is the observed potential (in volts)

- E_0 is the potential when pY = 0 (in volts)

- R is the gas constant (8.314 J K^{-1} mol^{-1})

- T is the temperature in Kelvin

- F is the Faraday constant (96487 C mol^{-1})

- n is the number of electrons transferred at the electrode (usually the charge of the ion)

- $pY = -\log_{10}[Y]$ where [Y] is the activity of the ionic species

Note that if pY is plotted against $E,$ then the Nernst equation predicts that a straight line should be obtained of intercept E_0 and a slope of $-(RT/nF)$. For pH measurements (n=+1) at 25°C, the term 2.303RT/nF has a value of 0.05916 V. This is referred to as the Nernstian slope of the electrode.

Electrode Response

If two solutions of known pH are measured then these values can be used to construct a linear plot to determine E_0 and electrode slope. The percentage Nernstian response of the electrode is given by:

$$response = 100\% \times slope_{observed} / slope_{calculated}$$

where:

- $slope_{observed}$ is the observed slope and
- $slope_{calculated} = -2.303(RT/nF)$

High quality pH electrodes will have a response in the range 95 – 102%. Cheaper or old electrodes will most likely have a response outside this range. Ion selective electrodes often exhibit a wider variation.

The Isopotential Point

At isopotential point, the electrode potential remains constant as temperature changes. Most pH electrodes are constructed so that the isopotential is about 0 mV (which for most pH electrodes also corresponds to pH 7). However, it is not uncommon to find that even in new pH electrodes this value may be anywhere between ±50 mV and that the value also changes as the electrode ages. Ion selective electrodes may have an isopotential completely outside the measuring range of the electrode.

Most pH meters assume an isopotential point of 0 mV (at pH 7) when applying manual or automatic temperature compensation. However, the Chart pH Calibration extension allows you to adjust the isopotential point if required. In order to calculate the isopotential, two calibration runs must be made at two different temperatures, T_1 and T_2.

From the Nernst equation:

$$E = E_{01} + (slope_1) \text{ pH}$$
$$E = E_{02} + (slope_2) \text{ pH}$$

on rearranging terms:

$$pH = (E - E_{01})/slope_1$$

$$pH = (E - E_{02})/slope_2$$

where

$$slope_1 = -2.303RT_1/nF; \text{ and}$$

$$slope_2 = -2.303RT_2/nF$$

At the isopotential point both potential and pH are constant for both T_1 and T_2, that is $E = E_{ip}$, and $pH = pH_{ip}$. Combining equations gives:

$$\frac{E_{ip} - E_{01}}{slope_1} = \frac{E_{ip} - E_{02}}{slope_2}$$

which can be solved for E_{ip}:

$$E_{ip} = \frac{E_{02}slope_1 - E_{01}slope_2}{slope_1 - slope_2}$$

or, simplifying terms:

$$E_{ip} = \frac{E_{02}T_1 - E_{01}T_2}{T_1 - T_2}$$

For best results ensure that T_1 and T_2 are at least 20 degrees apart.

Non-Linear Calibration

Both single and two point calibration assume that the electrode has a linear response to ion activity. Experimentally there will always be some deviation from linearity in the response. This is most noticeable at very high or low concentrations. In these instances a non–linear calibration technique must be used for accurate work.

Also, if you need to calibrate an electrode directly in terms of ionic concentration (or log of concentration) rather than activity, a non-linear calibration is needed.

In either case, the Chart Multipoint calibration extension can be used for non-linear electrode calibration. See our web site, at www.eDAQ.com for more information.
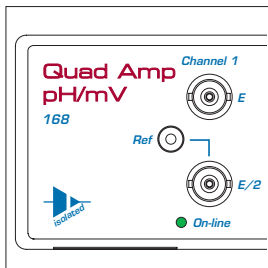
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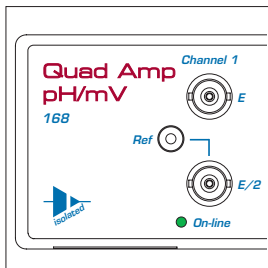troubleshooting 29

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License & Warranty

Trademarks

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Responsibilities

You and any others using any eDAQ product agree to use it in a sensible manner for purposes for which it is suited, and agree to take responsibility for their actions and the results of their actions.

If problems arise with an eDAQ product, eDAQ will make all reasonable efforts to fix them. This service may incur a charge, depending on the nature of the problems, and is subject to the other conditions in this Agreement.

Hardware Warranty

eDAQ Pty Ltd warrants the Quad pH/mV Amp, to be free of defects in material and workmanship for one year from the date of purchase. eDAQ Pty Ltd will repair or replace defective equipment as appropriate.

To obtain a warranty repair/replacement you must first notify us before return of the instrument and we will issue you with a RAN (return authorization number). You must ship the defective product at your expense. We will pay return shipping. The product should be packed safely (preferably in its original packaging) and have the RAN on the shipping label. Returns sent without a RAN may be refused delivery.

This warranty does not cover hardware that has:

- • been modified by the user in any way;

- • been subjected to unusual physical, electrical, or environmental stress. This includes damage due to faulty power sockets, inadequate earthing, or power spikes or surges;

- • been damaged because of incorrect wiring to ancillary equipment, or because of substandard, connectors or cables; or

- • had the original identification marks removed or altered.

Software License

You have the non-exclusive right to use the supplied eDAQ software (Chart, Scope etc). Your employees or students, for example, are entitled to use it, provided they adhere to this agreement. Each separate purchase of the eDAQ software licenses it to be used on two computers at any given time (on one computer for data acquisition with a e-corder hardware unit, and on a second computer for the analysis of existing data files). Although multiple copies of a program may exist on several computers, more than two copies must not be used simultaneously. Departmental/company licences are

available if you wish to run more than two copies simultaneously.

Technical Support

Please register your unit to receive technical support. Technical assistance is available via email. Please describe the problem with as much detail as possible. Include a small example data file, if appropriate. Please also state:

- the model and serial number of your e-corder unit and Quad pH/mV Amp.

- the type of computer and operating system being used (for example Windows XP, or Macintosh OS 10.2)

- the software version you are using (for example Chart v5.1.2)

We endeavor to answer all your questions, but in some cases, for example where the problem relates to the other equipment that you are using, a nominal fee may be charged.

Jurisdiction

eDAQ Pty Ltd is bound by the laws of New South Wales in Australia, and any proceedings shall be heard by the Supreme Court of New South Wales in Australia.

Disclaimer

eDAQ reserves the right to alter specifications of hardware and software without notice.

No liability can be accepted for consequential damages resulting from use of eDAQ products.