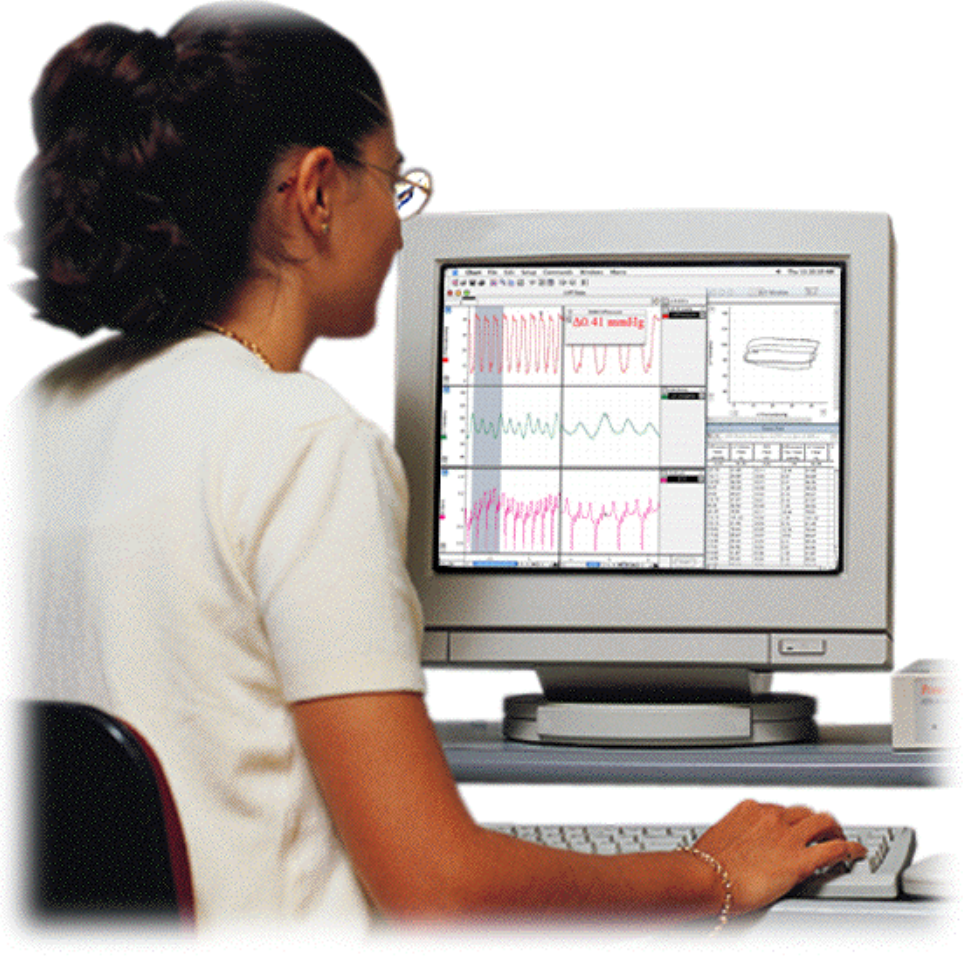
Chart Software Manual

Chart

version 5.0

for Macintosh



This document was, as far as possible, accurate at the time of printing. Changes may have been made to the software and hardware it describes since then, though: eDAQ reserves the right to alter specifications as required. Late-breaking information may be supplied separately.

Trademarks of eDAQ

e-corder and PowerChrom are registered trademarks of eDAQ Pty Ltd. The names of specific recording units, such as e-corder 201, are trademarks of eDAQ Pty Ltd. EChem is a trademark of eDAQ Pty Ltd. Chart and Scope are trademarks of ADInstruments Pty Ltd used by eDAQ under license.

Other Trademarks

Apple, Mac, and Macintosh are registered trademarks of Apple Computer, Inc.

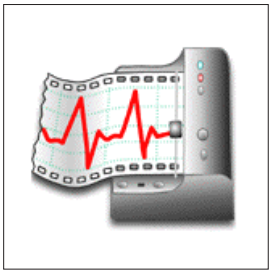
Windows 2000 and Windows XP are either registered trademarks or trademarks of Microsoft Corporation.

All other trademarks are the properties of their respective owners.

Document Number: UM-ES200M-1103

eDAQ Pty Ltd
6 Doig Avenue
Denistone East, NSW 2112
Australia

Web:www.eDAQ.com
E-mail:support@eDAQ.com



Contents

1

CHAPTER ONE

Getting Started

Welcome to Chart software for Macintosh computers. Chart operates as part of the e-corder system providing multichannel signal recording, display and analysis capability.

This chapter contains information on hardware requirements, and the use of this guide in learning to use the application. There is also a basic introduction to data acquisition.

Learning to Use Chart

Where to Start

Before recording data read the booklet that came with your e-corder system and the *e-corder Manual* on the Installer CD. Be sure to connect your e-corder to your computer properly.

How to Use this Guide

It is best to gradually work through this manual in front of your computer. The information in the following chapters is set out in the order you will probably require it.

Conventions

Menu commands and shortcuts are usually described using the conventions in Table 1–1. Note that shortcuts can appear in two forms: hyphenated in text, and with a + sign in tables, to make each clearer in context.

The screen shots used in this guide are from Mac OS 10.1. They were made using the Mac OS X default appearance settings. There may be changes in appearance when using Chart with later systems and settings.

Table 1–1
Shorthand usages referring to menu commands and shortcuts.

Example phrase	*Meaning*
File > New	The New command of the File menu
Chart > Preferences > Extensions…	The Extensions… command of the Preferences submenu of the Chart menu
Channel Function pop-up > Input Amplifier…	The Input Amplifier… command of the Channel Function pop-up menu
Command-S, or Command + S	Hold down the Command (apple, clover leaf) key and type ‘s’
Option-Shift-click, or Option + Shift + click	Hold down the Option and Shift keys and click the mouse button

Where to from Here?

This book is a reference guide for the main features of the Chart software. Some specialist features are provided using Chart Extensions (software plug-ins) available from our web site, www.eDAQ.com. Documentation for the Chart Extensions is also provided on the web site.

Our documentation is continually being improved and updated, and latest editions are available from www.eDAQ.com.

Computer Requirements

- PowerPC or better
- 128 MB RAM
- 40 MB free hard disk space
- 800 x 600, 256 color display or better
- Mac OS X 10.1
- A CD-ROM drive
- USB 2.0 or 1.1

The e-corder® System

The e-corder system is an integrated system of hardware and software designed to record, display, and analyze experimental data. The system consists of an e-corder recording unit and software programs (such as Chart and Scope) that run on the computer connected to the e-corder. Your e-corder unit has considerable computing power of its own and performs many tasks that are necessary during data recording. Once the e-corder transfers the data to the computer, the data are available for display, manipulation, printing, storage and retrieval.

First Use

Ensure that the e-corder is connected properly to your computer (this is covered in the manual that came with your e-corder) and turned on.

Click the Chart icon in the Dock or double-click the Chart icon in the Finder.

The first time you run Chart, you will be presented with the dialog box shown in Figure 1–1. Enter your name (minimum three characters), organization (minimum three characters) and the license code that you received with your copy of Chart. Click OK to enter the license, or Quit to leave Chart.

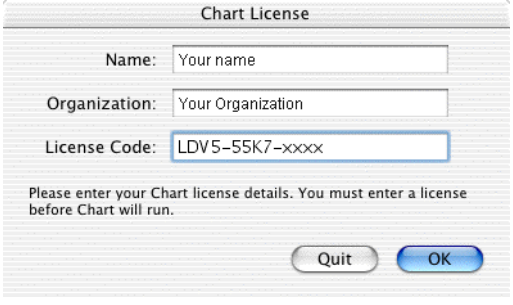


Figure 1–1
The Chart License setup dialog box.

Note that if the computer has an owner's name in the system already (for file sharing), the name will be put into the Name box and selected automatically. Just start typing if you want to overwrite it.

There may be a short delay while the program sets up the e-corder. If the e-corder is not connected, then after naming your copy of the application, the dialog box in Figure 1–2 will appear. If this dialog box appears when the e-corder is connected and turned on, see the manual that came with your e-corder for help. Some of the information from that guide on hardware startup problems is also repeated in Appendix B.

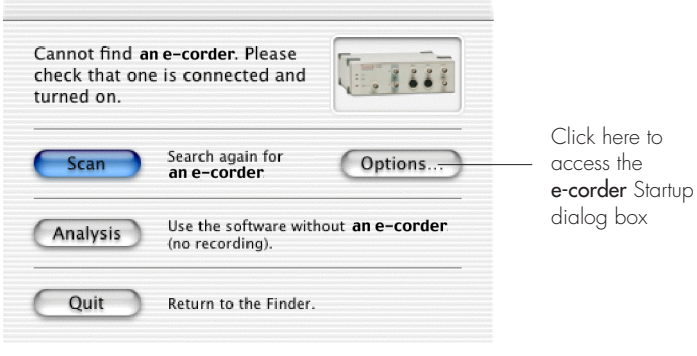


Figure 1–2
The dialog box that appears if the e-corder is not connected correctly.

Quitting Chart

If you want to quit Chart after naming your copy of the application, choose Chart > Quit. If you want to proceed with working through this guide, just carry on.

Basics of Data Acquisition

The purpose of the e-corder system is to acquire, store, and analyze data. Figure 1–3 summarizes the acquisition. Usually, the raw input signal is in the form of an analog voltage whose amplitude varies continuously over time. This voltage is monitored by the hardware, which can modify it by amplification and filtering, processes called 'signal conditioning'. Signal conditioning may also include zeroing, for example the removal of an unwanted steady offset voltage from a transducer's output. After signal conditioning, the analog voltage is sampled at regular intervals. The signal is then converted from analog to digital form before transmission to the attached computer (computers need digital data). The computer software usually displays the data directly; it plots the sampled and digitized data points and reconstructs the original waveform by drawing lines between the points. Digital data can be stored on disk for later retrieval. Software can also easily manipulate and analyze the data in a wide variety of ways.

Most of the parameters that affect acquisition can be set by the user through the software. To make a good recording, the parameters must be appropriate for the signals being recorded. In some disciplines you

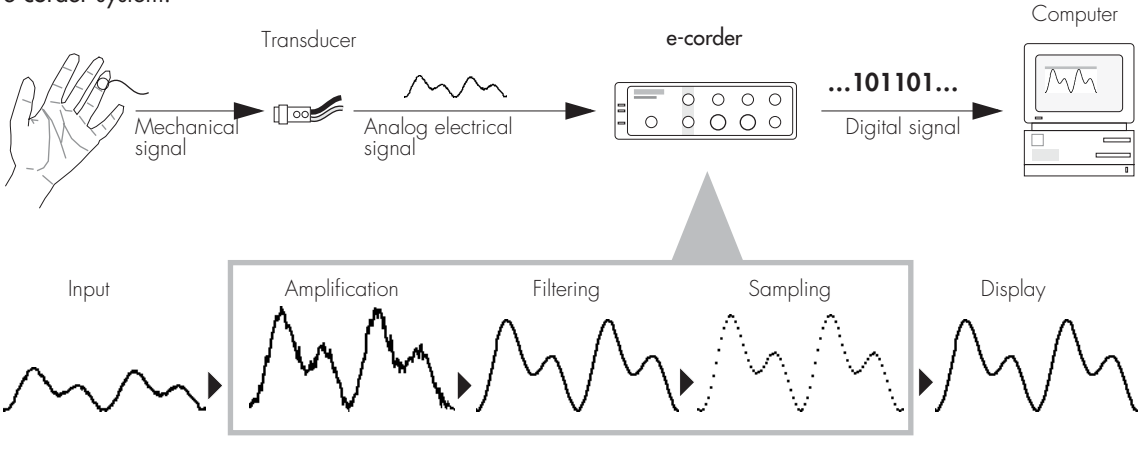


Figure 1–3
A graphical summary of data acquisition using an e-corder system.

may be able to find tables of suggested sampling rates, ranges, and filter settings, but these should not be applied blindly. You still need to know the science (what you are recording, why you are recording it, and what relation it bears to real phenomena) and the technique (how best to record, and what limitations or compromises are inherent in the process).

Sampling Rate

Sampling replaces the original continuous analog signal by a series of discrete values (samples) taken at regular time intervals. The appropriate sampling rate depends on the signal to be measured. If the sampling rate is too low, information is irreversibly lost and the original signal will not be represented correctly. If it is too high, there is no loss of information, but the excess data increases processing time and results in unnecessarily large disk files.

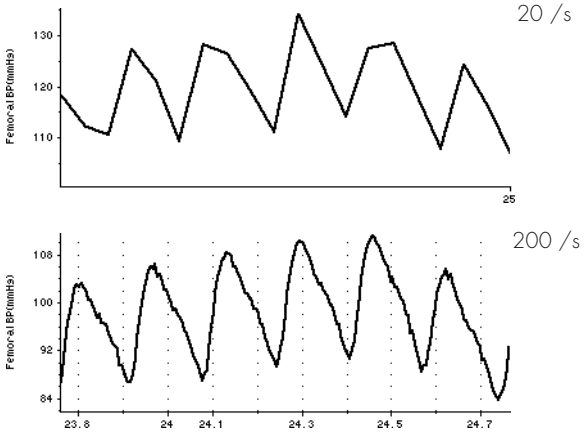


Figure 1–4
Undersampling: oscillating pressure signal recorded at 20 /s (too slow) and 200 /s (correct sampling speed)

Recordings of periodic waveforms that have been sampled too slowly may be misleading as well as inaccurate because of aliasing. An analogy to aliasing can be seen in old films: spoked wagon wheels may appear to stop or even go backwards when their rate of rotation matches the film frame speed — obviously not an accurate record.

To prevent aliasing, the sampling rate must be at least twice the rate of the highest expected frequency of the incoming waveform. This sampling rate is known as the Nyquist frequency, the minimum rate at which digital sampling can accurately record an analog signal. For example, if a signal has maximum frequency components of 100 Hz,

the sampling rate needs to be at least 200 Hz to record it accurately. To provide a safety factor to guard against information loss, it is usual to sample at five to ten times the highest expected frequency rather than the minimum two times.

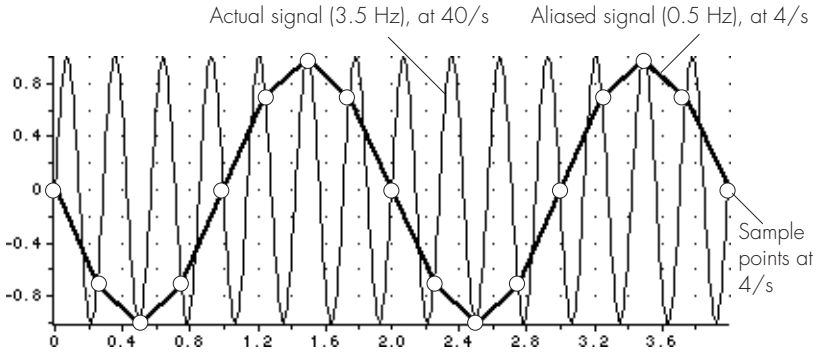


Figure 1–5
Aliasing: sampling a 3.5 Hz signal at 4 /s gives a misleading waveform, an apparent signal of 0.5 Hz.

In most cases, the highest expected frequency will be known. It may well be limited by the transducer used: a bridge transducer to measure mechanical force will not produce high frequencies, for instance. If you are unsure of the frequency range (bandwidth) of your signal, a useful rule of thumb is to choose a sampling rate high enough to allow at least 5 to 20 samples for any transient peaks or recurring waves in the signal.

The highest frequencies in a signal can be formally determined by sampling the signal at the maximum rate, and looking at the spectrum of the signal (using the Spectrum window). High-frequency components in the spectrum with less than 2% or so of maximum amplitude usually contribute little to recording accuracy.

Filtering

Any analog waveform can be described mathematically as the sum of a number of pure sine waves at various frequencies and amplitudes. Low frequencies characterize the slowly changing parts of a waveform; high frequencies, the quickly changing parts. A filter removes selected frequencies from a signal: for instance, a low-pass filter lets low frequencies pass and stops high frequencies. Low-pass filters are commonly used to help reduce noise and give a smoother signal. A high-pass filter removes any steady component of a signal; it also removes slow fluctuations.

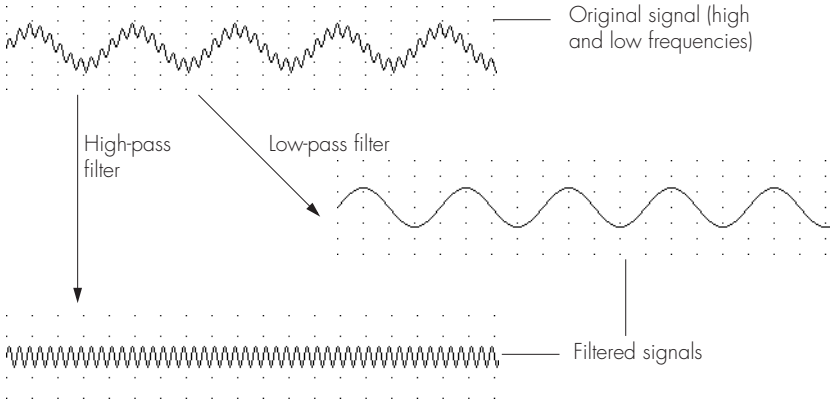


Figure 1–6
The effects of filtering on a mixed-frequency signal: a high-pass filter removes low frequencies; a low-pass filter removes high frequencies.

Filters are imperfect. A 200 Hz low-pass analog filter, say, might leave frequencies up to 150 Hz untouched, reduce a 200 Hz signal to 0.7 of its original amplitude (this is its cut-off frequency), and reduce higher frequencies more and more. If you were expecting useful frequencies of up to 100 Hz, you could sample at 400 samples per second and filter out any higher frequencies using a 200 Hz filter. If higher frequencies are left unfiltered, then they could possibly be aliased, resulting in the appearance of spurious lower frequencies.

Filtering can change the signal to some extent: its use must be balanced against the distortions it can remove, such as noise, baseline drift, and aliasing. If the filter settings overlap the bandwidth of a signal, then the signal will have components removed. If you were interested in a waveform with components down to 5 Hz and used a 20 Hz high-pass filter (filtering out 0 to 20 Hz signals), then vital information would be lost from the signal.

Figure 1–7
A signal with various low-pass filter settings: some filtering cleans up noise, but too much distorts the high-frequency spikes.

Filtering can also be applied to the recorded digital data after acquisition. Chart has a smoothing channel calculation available to help remove noise, clutter, and unwanted high frequencies from signals. This acts as a simple low-pass filter by averaging adjacent data points, but shouldn't be used as a substitute for the correct low-pass filter during recording. It is most useful in helping clean up signals recorded at high sampling rates.

Digitization

When analog data such as voltage amplitude is converted to digital form for use by a computer, it must conform to a fixed number of values (for instance, a digital thermometer might only measure temperature to the nearest degree). Any analog values between these values are rounded up or down. The approximation is usually very good, since the number of values is very large. The analog-to-digital converters (ADCs) that perform the digitization usually generate a number of values equal to a power of two: an ADC with 12-bit resolution can resolve a signal into 2^{12} or 4096 possible amplitude values, which is adequate for most biological signals; an ADC with 16-bit resolution can resolve a signal into 2^{16} or 65 536 possible amplitude values.

e-corder units use 16-bit ADCs. Chart fits 64 000 of the 65 536 possible values to the range, allowing some leeway above and below for a small amount of overrange. Thus the 10 V range would be divided into 64 000 fixed values from –10 V to +10 V; the minimum change in voltage that could be discerned at that range would be 0.3125 mV. At 10 mV range, the minimum discernible voltage change would be 0.3125 µV. ADC resolution is part of the hardware, and cannot be set by the user.

Range

Range is inversely proportional to gain, the amount of amplification, and is a more useful concept than gain since it relates directly to the signal being measured. The range can be set independently for each input on an e-corder recording unit.

If the signal amplitude exceeds the range, there will be severe loss of information. (This is the same as 'clipping' in a stereo system where music is severely distorted when the amplitude exceeds the capabilities

of the amplifier.) Any signal exceeding the range is 'out of range', a condition indicated where no amplitude can be given. If there is any possibility of this condition occurring, you should set the range to a larger value.

For the best resolution, the maximum amplitude of the signal you are interested in should be reasonably close to the chosen range without exceeding it. That way, the minimum change in voltage discernible in digitization remains small in relation to the signal being measured (the signal is digitized after it is amplified). If a signal is very small in relation to the range, then its resolution will be degraded. In extreme cases, the recorded waveform may appear stepped rather than smooth. Even though you could see a ±380 mV signal easily enough at the default 10 V range, you would use the 500 mV range to measure it at maximum resolution. It would be safer in practice to use a 1 V or 2 V range, though, since unexpectedly large peaks could exceed the 500 mV range if the signal was not well-behaved.

Changing the display of the waveform on screen (by enlarging it in the Zoom window or by stretching or shrinking its Amplitude axis, for instance) does not affect its resolution, just its appearance.

Noise

Noise is defined as 'unwanted signal'. It is likely to be a problem at lower range settings, when you are trying to measure very small signals. Random noise, such as thermal noise, is inherent in all electronic circuits, including those of the e-corder recording unit, and generally must be filtered to minimize it. The trick is to choose a low-pass filter setting that removes most of the background noise without unduly changing the signal of interest.

For biological signals, differential inputs are preferred, and can reduce common-mode noise due to ground loops. (Ground loops occur where multiple connected pieces of recording equipment are connected to

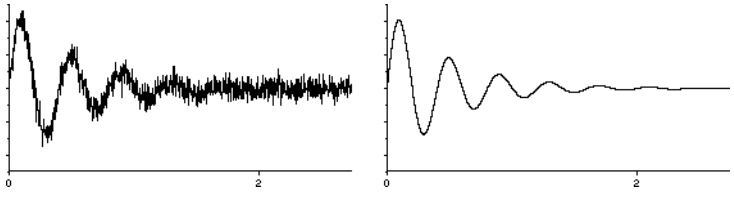


Figure 1–8
Noise in a signal (left) can mar the original signal (right), unless filtered out.

mains power grounds.) e-corder single-sided inputs are 'quasi-differential', and automatically neutralize up to a fraction of a volt of ground loop noise, the most that normally appears.

Other important causes of noise are stray electromagnetic and electrostatic fields, and include interference (often at the mains frequency of 50 Hz or 60 Hz) from unshielded power lines, switching equipment, fluorescent tubes, transformers, computers, network cables, VDUs, and so on. The interference can interact significantly with a recorded signal. Reasonable care in the arrangement and shielding of equipment and cables will reduce such interference. Particularly delicate measurements, however, may require special apparatus and a controlled environment.

Display and Expectations

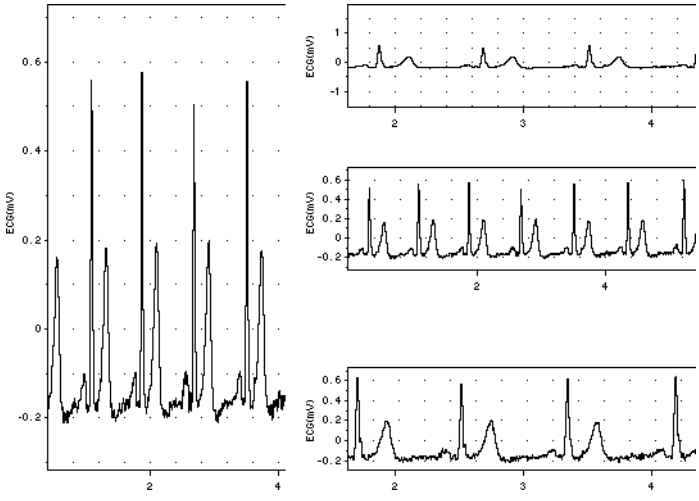
The two most important settings for data recording are the input range and recording speed. Provided these are set correctly, then your signals will be recorded which high precision. However, the actual appearance of the data on the computer monitor can be affected by the vertical magnification and time base compression used in the Chart display settings, and screen resolution of your monitor.

The screen display on a monitor is generally about 72 dots per inch (dpi), so the apparent resolution may be poor if the display is kept small. However, the resolution of the underlying recorded data is independent of the resolution of the display: even if the channel is very thin or not visible on screen, sampled data are recorded at full fidelity, as can be seen by expanding the channel display or examining the signal in the Zoom window.

High-resolution printing will also show data more accurately.

It is important to check display settings and axis labels carefully when examining a signal.

Figure 1–9
An signal shows with various display settings.



2

CHAPTER TWO

Introduction to Chart

Chart is one of the application programs that together with your e-corder make up the e-corder system, a powerful data acquisition system driven from an intuitive and robust interface.

This chapter provides a general overview of Chart, looks at the Chart window in detail, and deals with the basics of recording data in Chart.

An Overview of Chart

Chart, together with the e-corder hardware and a Macintosh computer, gives you the capabilities of a multi-channel chart recorder and more. Depending on your hardware, you can record on as many as sixteen channels at various rates. Chart also provides a range of powerful and easy-to-use features that transcend the limitations of a mechanical pen-and-ink recorder.

Controls and Display

Controls are easy and intuitive. The Chart window can be resized like other Macintosh windows. The data display area can be compressed or expanded horizontally, or split into two panes, and the vertical size of each channel can be changed to suit, simply by dragging the dividing bars. Channels can be turned off or hidden if they are not required, or overlaid to compare waveforms directly, and their Amplitude axes can be dragged, stretched, scaled, or set through a dialog box for optimum data display.

Range and filtering options, and even sampling rate, can be set independently for each channel. You can type in appropriate channel titles and define units of measurement for each channel. Display colors, patterns, and grids can be altered. A Tool bar allows common operations and user-defined macros to be performed with a single click of the mouse.

Recording

You can not only view data as they are sampled, but also review past data while sampling, in a split or single window. Sampling rate and range can be changed while recording at lower sampling rates. You can start and stop sampling at any time and build up a Chart file with many individual sections of data. Recording is usually to disk, and data recorded this way can survive a power failure or system crash — which is especially useful if you are making lengthy recordings. (You have the option of recording to RAM if your disk drive is slow.) Comments to mark points or areas of interest can be made during or after recording, on all or on specific channels. A Notebook accessory is available for making general notes about a recorded data file.

Saving, Printing, and Editing

Chart recordings can be printed, edited, and saved to disk for later review. You can save the settings of any Chart file to enable an experiment to be repeated quickly and easily, without having to go through the process of setting it up again. You can print a selection or save it as a file — this allows for easy editing by extracting only that part of the recording you need. You can append files to the end of an open file, to produce recording summaries conveniently in a single file. Data can be transferred as text to other Macintosh applications, such as spreadsheets or statistics programs.

Analysis

When you have finished recording, you can scroll through your data and make measurements directly from the recording — since everything is digital, you are given a direct read-out, with no chance of measurement errors. You can measure relative to a reference point set using the Marker, or set a baseline to remove an unwanted offset. You can search any channels for comments, peaks and troughs in the waveform, block boundaries, and so on, and select data according to criteria you specify. The Data Pad calculates and stores statistics about recorded data, and can be printed out or have its data transferred to other applications. The X–Y window gives you a plot of data from one channel against another. Chart has an Overview miniwindow for finding areas of interest in large recordings, and a Zoom window for examining a section of the recording in more detail in which you can overlay channels (independently of any overlaying in the Chart window). Exclusions let you mark points and areas to be excluded from data searches and so on. Comments and exclusions in a file are listed in the Comments & Exclusions window, from which you can go directly to the part of the record where they were added.

Advanced Features

Triggering functions let you control when Chart starts and stops recording, using internal or external measurements. The Stimulator allows you to set up an external stimulus for an experiment, and the Stimulator Panel control allows this to be turned on or off or adjusted as required during recording. A range of computed input functions can be applied in real time to measured data: event counting, signal

frequency, and so on, cyclic and envelope parameters, and differential and various integral functions are all available. Computed data can be displayed in place of the raw data or in addition, on another channel. Data can be smoothed by channel calculations to remove unwanted high frequencies in the waveform.

Customizing and Automating

Chart can be extensively customized for your purposes. Controls, and menus and their commands (and keyboard shortcuts) can be locked, hidden, or altered, and Chart as a whole simplified, say, for student use. Chart files and related files such as documentation and multimedia files can be added to the 'Experiments Gallery' for easy access. Macros can be created to speed up and to automate complex tasks, stored in any menu in a file, and added to the Tool Bar as buttons. Chart extensions are available to add specialist analysis capability to Chart, and to provide data export options to other applications. For example, physiological signal peaks can be analyzed using Peak Parameters, and Export QuickTime allows you to play your recorded data in a movie on a web site or in a presentation.

The Timed Events dialog box allows you to create a list of actions you want performed at particular times: Chart will do the rest. By setting up the digital output lines appropriately (only available on specially configured e-corder units), you can control their states while recording, to turn external devices on and off, control pumps, relays, indicator lights, and so on. By setting up a list of comments that correspond to states of the e-corder digital inputs, the external trigger or stimulator, or various Function keys, you can have Chart automatically insert appropriate comments while recording when the digital inputs change, a Function key is pressed, and so on.

Opening a Chart File

It is a good idea to have a Chart file open if you are working through this guide, so that you can try the commands, controls, and settings as they are discussed in the text. First, make sure that the e-corder is properly connected to your computer, and is turned on. You may wish to learn Chart without the e-corder — if you have taken home a copy on your laptop, for instance. In this case, on opening a file, a dialog box will offer the Analysis option, which lets you use Chart except

where it requires the e-corder hardware, such as for recording. Unusable controls appear dimmed.

To open a Chart file, click one of the Chart icons in the Finder to select it, and choose File > Open…, or simply double-click the icon. There may be a short delay while Chart sets up the e-corder. The top icon in Figure 2–1 shows the Chart application, which if double-clicked will open a new untitled file with the current start-up settings. The middle icon shows a file of recorded data, which opens up a saved Chart data file. The bottom icon shows a a settings file, which will open an untitled file set up in a predefined way.

Figure 2–1
Chart desktop icons: double-click one to open Chart.

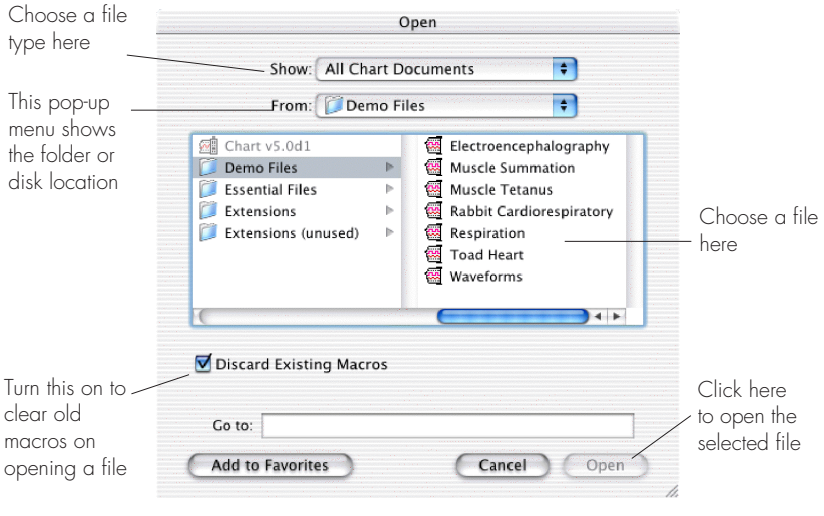
▼ ***Refer***
The Experiments Gallery, p. 96

In each case, Chart opens and the Chart window will appear. By default, the window of a new untitled file opened when Chart starts up will fill the screen, but its size can be adjusted. If you start Chart without a file and the Experiments Gallery has been set up, the Experiments Gallery dialog box will appear at this point: close the dialog box and ignore it for now; its use is described in Chapter 5.

Once the Chart application is open, you can open an existing file or create a new one. Choose File > New to create a new, untitled Chart data file. If you choose File > Open…, the Open dialog box appears (Figure 2–2).

At the top of the dialog box, the Show pop-up menu lets you choose which type of files are displayed. All Chart Documents displays data

Figure 2–2
The Open dialog box (see the Macintosh system help for the many shortcuts available).



Note
Hold down the Command key as you start up Chart to bypass the current start-up settings and use the default settings. Release the key when the alert box appears, and click the Yes button.

and settings files, or you can choose to display one or other of these types individually. Choosing Chart (Win) Data displays Chart for Windows data files. Other choices may be added through Chart extensions.

If the Discard Existing Macros checkbox is on, it prevents macros accumulating as you open files (this is discussed in a later chapter).

The information in a Chart data file is made up of data and settings. Data are the recorded waveforms. Settings are of two sorts: those that affect recording, such as the sampling rate, channel ranges, triggering, and stimulation functions; and those that affect the way the data looks, such as the window size, channel areas, and display settings (along with menu arrangements and macros). A data file opens with the settings it had when it was saved. Chart lets you have only one data file open at a time, so if you open another, your old file must be closed. If it has any unsaved changes, an alert box informs you and lets you save or discard them, or cancel. If you create a new file, the new file continues to use the settings from the file just closed.

Opening a settings file, if no Chart file is open, creates a new untitled data file with the defined settings. If an existing Chart data file is open, then an alert box gives you the choice of creating a new untitled data file with those settings, or applying the settings to the current Chart file. Applying settings to a file affects the display of existing data and the recording settings for subsequent sampling. It does not affect the recording settings of, or alter, existing data: sampling rates, ranges, applied units, and so on are all left unchanged.

Opening a Chart for Windows File

Chart for Macintosh can import files written by Chart for Windows. To show Windows formatted Chart data files, choose Chart (Win) Data in the Show pop-up menu. If one is chosen and the Open button clicked, a new untitled file will be opened containing the Windows data. The data and channel titles are imported. The settings for range, computed input, and units conversion are not imported and will need to be redefined if they are required for new data. Channel calculations are ignored (only recorded data is imported). Most display settings, such as data trace colors, channel heights, and so on, are ignored. The Data Pad and Macros are also ignored.

Closing a File or Quitting Chart

To close a Chart file, choose File > Close. To quit Chart, choose Chart > Quit. In either case, if you have made any changes, an alert box will appear, asking you if you wish to save your work. Click the Save button if you want to keep the changes you have made; click the Don't Save button to discard them. Note that when you close a Chart file, the Experiments Gallery dialog box (see Chapter 5) will appear (provided that it has been set up).

▼ ***Refer***
The Experiments Gallery, p. 96

The Chart Window

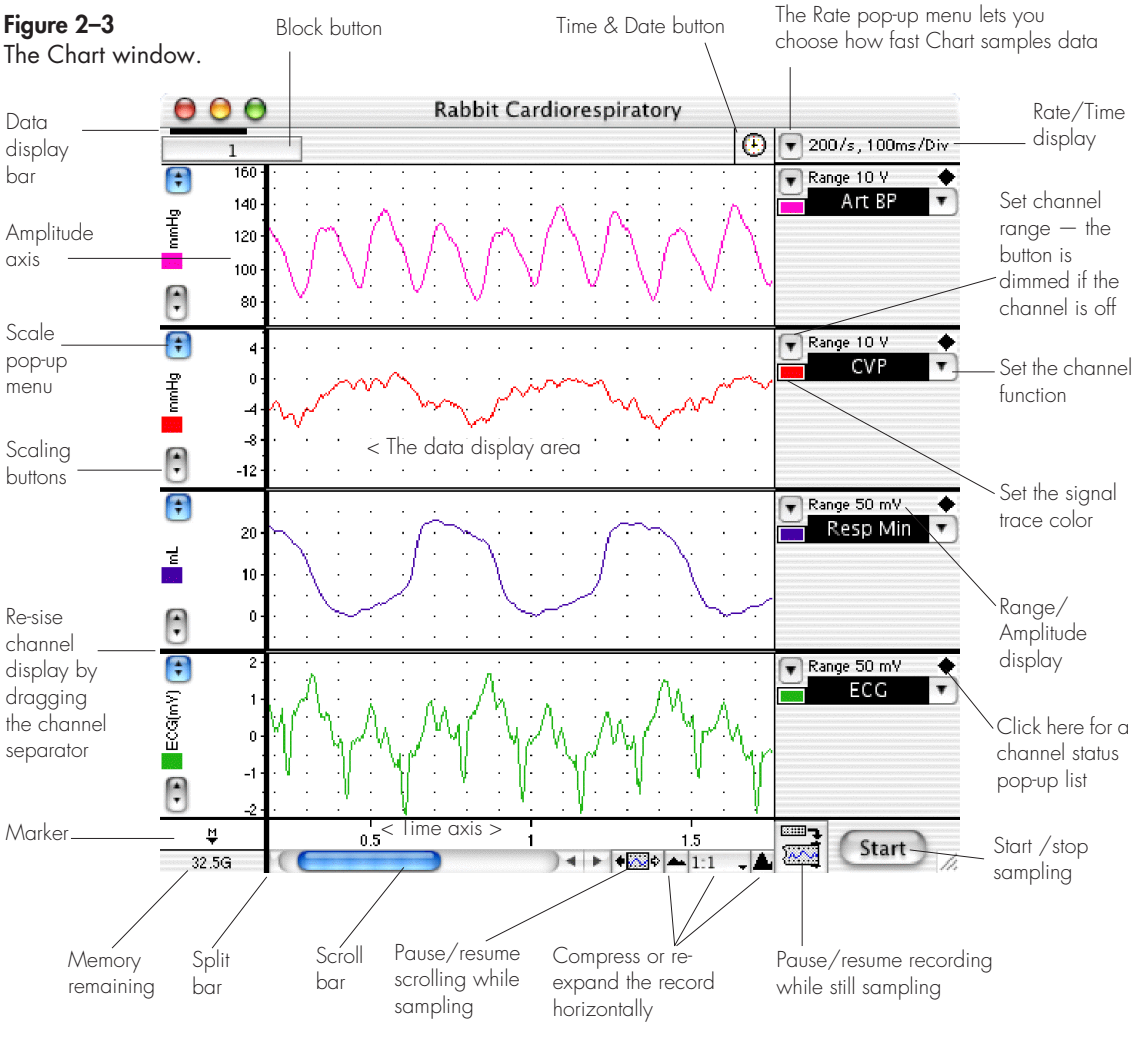
All essential controls for recording data are provided within the Chart window, illustrated in Figure 2–3. These controls are discussed briefly below, and, in most cases, in more detail elsewhere. There are three main areas in the window, from left to right: the Amplitude axis area, which contains the scale for each channel; the data display area, which contains recorded data; and the channel control area.

The Menu bar at the top of the screen contains the Chart menus (see Appendix A), allowing you to set up and modify the way Chart looks and behaves. Window > Chart Window returns to the Chart window from another, or creates a new, untitled Chart data file. The Tool bar appears by default between the Menu and Title bar of the Chart window, and provides shortcuts for common tasks, including returning to the Chart window or opening a new file.

Navigating

The Scroll bar lets you move through the file's data in the Chart window. The box in the Scroll bar shows where the display area is in relation to the file as a whole. Click the left or right arrows, or drag the box, to move smoothly left or right. Click in the gray region to either side of the box in the scroll bar to jump a screen left or right. You can also move left or right by pressing, respectively, the left and right arrow keys on the keyboard. Hold down the Option key while pressing the left or right arrow key to jump a block left or right (the block boundary will be moved to the left edge of the Chart window). Hold down the Command key while pressing the left or right arrow key to go to the beginning or the end of the file.

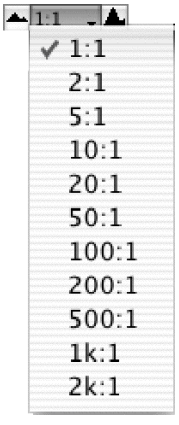
Figure 2–3
The Chart window.



You can manually scroll data by holding down the Option key while the pointer is over the data display area: this turns the pointer into a hand that can drag the data back and forth. If you 'push' the data, by moving the hand and releasing the mouse button while it is moving, the file keeps scrolling through automatically at the speed at which you moved it. It will stop at the beginning or end of the file, or when you click anywhere in the Chart window.

You can go directly to a block of data by clicking its numbered Block button. Clicking and holding the mouse down over the button pops up a menu letting you choose to go to the block or to select it.

View Buttons



The View buttons allow you to compress or re-expand the horizontal scaling of a file in the Chart window (the steps are 1, 2, 5, 10… up to 2000 to 1). To see more of the file on screen at once, click the left (far mountains) button to compress it. To expand the file out again, click the right (near mountains) button. The pop-up menu between the two shows the current compression and lets you choose the extent of horizontal compression directly. If you print a horizontally compressed file or selection, then it will print at the compression at which you see it on screen.

The Chart Axes

The horizontal Time axis, above the Scroll bar along the bottom of the Chart window, records the time from the start of sampling or the absolute time in various formats, depending on the time display mode (which can be set using the Display Settings dialog box).

For each channel, the vertical Amplitude axis on the left of the window indicates the amplitude of the recorded waveform. Note that the axis area remains blank until some data are actually recorded. The scale for each channel is initially set by the range control on the right side of the window, but can be stretched or dragged using the pointer. Display options can be chosen from the Scale pop-up menu, including which channel of an overlaid set is active. The data trace color, title, and units of the active channel are shown in the axis. Units are volts by default, but may be changed to any other units (for example mmHg, Ω, or kPa), by using units conversion.

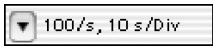
▼ ***Refer***
Units Conversion, p. 46

Scaling Buttons

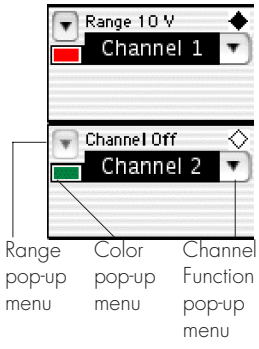
The Scaling buttons are at the bottom left of each channel's Amplitude axis. Click the up button to enlarge or down button to reduce the vertical scale, halving or doubling what is shown each time.

Channel Controls

The channel controls are located rightmost in the Chart window, at the right of the data display area.



The Rate pop-up menu at the top right of the Chart window controls the sampling rate, which is usually the same for all channels (but can be set independently for each channel).



There are three individual channel controls for each channel. Click the button to the left to choose the range from the Range pop-up menu. Click the channel title or the button at its right to choose options from the Channel Function pop-up menu. Click the colored box to choose the channel's data trace color from the Color pop-up menu. The channel's Range pop-up menu button is dimmed and unusable when the channel is off.

Sampling Parameter Display

The Rate/Time display shows the current set rate of sampling (the sampling rate in samples per second and the scrolling speed in seconds per division) if the pointer is over the channel control or Amplitude axis areas, or the time at the pointer position over the data display or Time axis areas. If channels are set up to record at different rates, then the Rate/Time display shows the maximum. The Range/Amplitude display shows the current range of each channel if the pointer is over the channel control or Amplitude axis areas, or the amplitude of the waveform at the pointer position over the data display or Time axis areas.

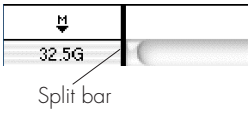
The Channel Status indicator is a diamond at the right of the channel control area for each channel. It is solid if the channel is on, open if the channel is off, and contains an = sign if a channel calculation is applied. Clicking the indicator pops up a list showing the sampling rate, range, what is to be recorded (raw data or a computed function, and from which input), the eDAQ Amp or Pod settings and filter settings, and any active channel calculation.

Data Display Area

Recorded data are shown in the area of the Chart window bounded by the channel control area on the right and the channel Amplitude axes on the left. The data for each channel are to the left of the channel title and bounded above and below by horizontal bars. These bars, or channel separators, can be dragged up or down to vary the size of the channel display areas (double-click them to restore their original

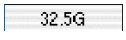
positions). The separators can also be removed, to overlay adjacent channels.

Split Bar



The vertical Split bar, at the left of the data display area, can be dragged to the right to split the data display area into two parts, each with its own scroll bar and View buttons (if there is room), so that you can compare different sections of recorded data, or compare data already recorded with new data as they are sampled.

Memory Indicator



A box at the bottom left of the Chart window gives a numeric indication of current memory available for recording (disk or RAM), in gigabytes, megabytes, or kilobytes. If the remaining memory becomes very low, the box is highlighted.

The Marker

The Marker can be found in a box at the bottom left of the Chart window, above the memory indicator box. It can be dragged from its lair onto the data display area to set a particular data point on a waveform as a zero reference point, so that measurements can be made relative to that point. Double-click it or click its box to send it home. During sampling, the Marker temporarily disappears, and its box shows roughly how much of the computer's processing power is used during the operation.

Start Button

To start sampling, click the Start button at the bottom right of the Chart window. The Start button is also available to the right of the Tool bar. The button then changes to Stop: click it to stop sampling. The button may show a dimmed Wait… while starting or stopping if the e-corder or computer is particularly busy.

Record/Monitor Button

The Record/Monitor button at the bottom right of the Chart window, to the left of the Start button, controls whether data are recorded as they

are sampled (the default) or merely displayed, and discarded when sampling stops. When monitoring (to get an idea of incoming signal characteristics, perhaps), a cross is shown. Click the button to switch between recording and monitoring.

Scroll/Review Button


The Scroll/Review button at the bottom right of the Chart window, to the left of the View buttons, controls whether data are scrolled while recording (the normal behaviour), or whether you can instead use the scroll bar to review the recorded data even during recording. Depress the button for the review option.

Time & Date

Click the Time & Date button, the clock at the top right of the Chart window, to open a dialog box letting you set the time scale format, and whether to display the date and time data at the cursor position were recorded.

Pointer

The pointer will change form as you move it about the Chart window, giving you an indication of its function in certain areas — it becomes an I-beam over a text entry area, for instance. It becomes dimmed when it cannot do something under particular conditions.

The Tool Bar

The Tool bar provides shortcuts for common tasks in Chart in the form of buttons. The default buttons are shown in Figure 2–4: you can change it to suit your preferences, and add new buttons for any available macros. You can assign Function keys to the buttons for use with an extended keyboard. The Tool bar can be hidden if you don't want to use it, or moved by Shift-dragging it.

Figure 2–4
The Tool bar.

The text box at the right of the Tool bar tells you the function of the button that the pointer is over. It will also indicate the state of Chart in some cases: loading data or settings, saving, sampling, recording a macro, and so on.

Recording

To start recording, click the Start button at the bottom right of the Chart window or to the right of the Tool bar. The button then changes to Stop: click it when you want to stop recording. The button may show a dimmed Wait… while starting or stopping if the e-corder or computer is very busy. Chart uses the visual metaphor of a mechanical chart recorder: recorded data scroll across the data display area from the right of the window as if the display area were a roll of paper in such a device, with new data being drawn at the right and old data moving left.

When recording, the controls at the bottom of the Chart window change, as shown in Figure 2–5. The Time axis area goes gray, and the Recording Status indicator appears; and the scroll bar is replaced by the comments bar. The Marker is replaced by an indicator showing roughly how much of the computer's processing power is used during sampling. The controls are discussed in detail later on.

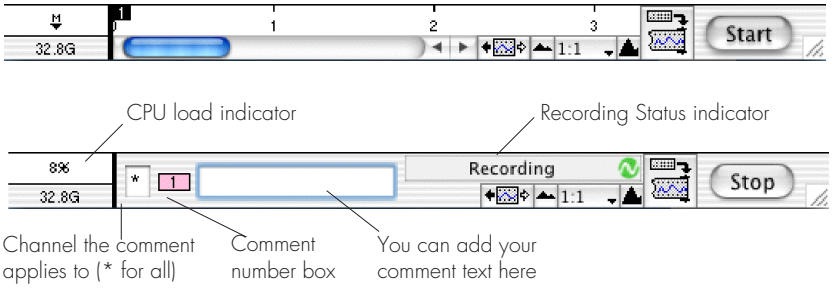


Figure 2–5
Control changes during recording.

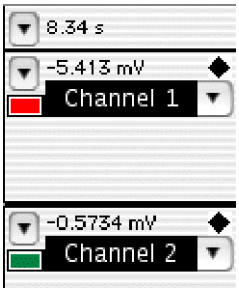
Display While Recording

While recording, the amplitude of the signal being recorded is shown in the Range/Amplitude display at the right of each channel, unless sampling at higher rates. If units conversion is being used, the value is displayed in the set units rather than as a voltage. The time is also

shown in the Rate/Time display at the top of the channel control area, in a form depending on the time display mode (usually from the start of the block). These displays are updated every second or so.

Chart records to disk by default, or memory (RAM) if data buffering is turned off, and sampling stops automatically when disk space or memory runs out. The space left in which to record is monitored. A small box at the bottom left of the Chart window gives a numeric indication of current remaining space, in gigabytes, megabytes, or kilobytes. If the remaining memory becomes very low, the box is highlighted.

Figure 2–6
Displays of the time and amplitude while recording.



Blocks and Settings

A solid vertical line is drawn between two sections (user-defined 'blocks') of recorded data to indicate discontinuity, for instance if you stop recording and then start again. If you change the range of one or more channels, a new scale is drawn between the two blocks for each changed channel to show the new range. Blocks always apply across all channels, even if only one has been changed. Block numbers are shown at the start of blocks as white-on-black tags in the Time axis. Block numbers, lines, and scales can be hidden if this is desired.

▼ ***Refer***
Display, p. 78

At slower rates, you can change the sampling rate and channel range settings without having to stop and restart recording. Chart will simply start a new block at the point where the settings were changed, drawing a solid vertical line or a new scale as appropriate. The display will momentarily stop scrolling while you are making settings changes, then update once the operation is complete.

A numbered Block button appears for each block as it is recorded. The width of the button is proportional to the number of samples in the block. You can go directly to a block by clicking its Block button; pressing the button pops up a menu letting you choose to go to the block or to select it. In any case, the start of the block is shown (the block boundary is moved to the left edge of the Chart window) if it is not already visible, and a brief animation shows the block's position. Under the title bar there is a thin black strip, the Data display bar, used to indicate where the data display area is in relation to the blocks. The bar is positioned over the buttons for the block or blocks visible in the data display area, and its length is in proportion to the extent of the block or blocks shown.

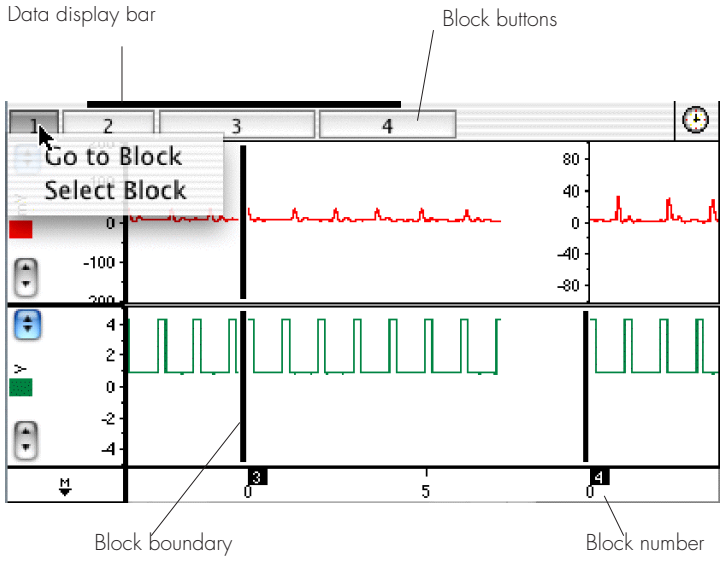
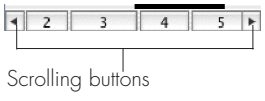


Figure 2–7
User-defined blocks of data: left break, after stopping and starting; right, after changing a channel's range.



If there are too many Block buttons to show along the top of the window, then left and right arrow buttons appear at either side: click them to scroll one Block button left or right — this doesn't change anything except the range of Block buttons that you can see.

Quick Block Information

Often, you want to get information about a recorded block. This can be obtained from the Data Pad easily enough, but for a quick check, just click and hold down the mouse in the data display area for a channel. This highlights the visible area of the block with a heavy border, and pops up a list (Figure 2–8) showing the sampling rate, range, any active units conversion or channel calculation, the block number, and the date and time at which the block recording started. (This is similar to the information available from the Channel Status pop-up list, but applies to existing data rather than the data to be recorded.)

Recording or Monitoring

The Record/Monitor button at the bottom right of the Chart window, to the left of the Start button, controls whether sampled data are recorded (the default) or merely displayed on the screen, perhaps to get an idea of incoming signal characteristics. When monitoring, sampled data can be seen coming in, but the data are not actually recorded, and

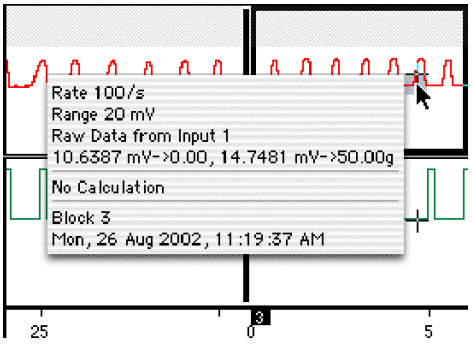


Figure 2–8
Block Information pop-up list.

disappear once sampling stops. Clicking the button switches between recording and monitoring. The data display area is grayed while monitoring, so it is easy to distinguish monitoring from recording. The grayed area disappears (along with any sampled data in that area) once monitoring stops. The button is inactive (and dimmed) when triggering is in operation. You cannot add comments while monitoring, since there is no real record, so the box in the comments bar is dimmed, and typing has no effect.

Figure 2–9
Record/Monitor button: left, data displayed and recorded; right, data displayed but *not* recorded.

You can stop or start recording data while sampling normally by clicking the Record/Monitor button. This is useful to see if incoming signals are behaving themselves before you actually record them. If fixed-duration recording is set up and Chart is monitoring rather than recording, then when you click the Record/Monitor button, Chart records for the set time and then goes back to monitoring.

Recording Status Indicator

Figure 2–10
Recording Status indicator display.

While sampling, a shadow box appears just to the left of the Start button, giving information on the recording status of Chart (see Figure 2–10): whether data are actually being recorded, or whether Chart is waiting for a trigger or for the post-trigger delay time to elapse. This gives you a quick visual indication of recording status.

'Recording' means that data are being recorded to memory (either to disk, the default, or to memory). The waveform icon at the right end of the box ripples when Chart is recording. If data are not being recorded and are only being displayed on the screen, 'Not Recording' shows. The waveform icon flashes to give a visual cue. If triggering is set up, 'Waiting for trigger' shows while the e-corder is waiting for a trigger event to occur before it starts sampling. If there is a trigger delay, 'Post-

trigger delay' shows after triggering, while the e-corder is waiting for the delay to elapse. If the internal timer is set up, 'Int. Timer' shows while the timer is counting down prior to recording a block of data. A few other messages appear in some circumstances, for instance, if an operation takes a while to suspend.

Adding Comments While Recording

During recording, comments can be entered as required, and are automatically numbered as they appear. Type what you want to say: it appears in the text entry area at the bottom of the Chart window (see Figure 2–5). Pressing the Enter or Return key adds the comment to the file at the time the key is pressed. By default, the comment applies for all channels, and the numbered comment box is preceded by an asterisk. To comment on a specific channel, select the asterisk by clicking it or pressing the Tab key, and type the number of the channel, or click the channel in the data display area: the channel number appears (for Channels 1 to 8; you can't make a specific comment for 9 to 16 while recording). To apply a comment to all channels, select the comment channel number and type a character other than 1 to 8, or click the gray area at the bottom of the Chart window (the Time axis when not sampling).

Comments are stored and saved along with recorded data. Comments are marked by numbered boxes in the appropriate channel on the record, or along the Time axis, and a dotted vertical line. Comment text may be visible in the window, or you can read the text in full by placing the pointer over the comment box and pressing the mouse button. Comments can also be added after recording, by choosing Commands > Add Comment…, and can be read, edited, deleted, found, and printed from the Comments & Exclusions window. Comment boxes, lines, and text can be hidden if this is desired.

▼ ***Refer***
Comments and Exclusions, p. 117
Display, p. 78

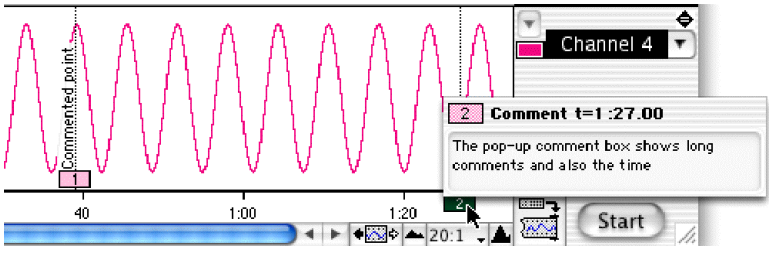


Figure 2–11
General and channel-specific comments, and the pop-up comment box.

Background Recording

You can do other things while recording in Chart. You can review recorded data, compare old data with new by using the split-screen feature, or even leave Chart recording in the background while you run other applications. This is useful for longer recordings, since the computer is not tied up doing one thing. You do need to be using Chart at slower or moderate sampling rates, though, in most cases.

Recording While Reviewing Data

Normally, when recording in Chart, the recorded data scroll across the data display area from the right of the window, with new data being drawn at the right and the old data moving left. In these circumstances, the scroll bar is dimmed and inactive, and the Scroll/Review button is set to Scroll. When the button is clicked, it highlights and depresses, and reviewing becomes active. The controls at the bottom of the Chart window also change: the Time axis and scroll bar appear, but the Recording Status indicator is still evident, showing that you are still recording.

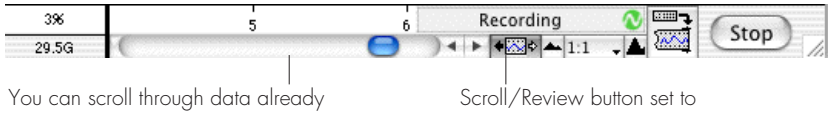
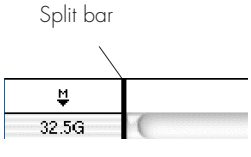


Figure 2–12
Time axis control changes when reviewing while recording.

Recording With a Split Data Display



You can split the data display area before or during recording, by dragging the vertical Split bar to the right. Splitting the data display area allows the incoming data to be viewed alongside previously recorded data, so that you can compare the two. Chart records normally in the right-hand pane, so you can use the Comments bar to

comment on newly acquired data there, and so on, and can scroll through the left-hand pane to check waveforms of interest. You can also use the split-display feature while reviewing is active, to give two independent scrolling views of the data while Chart is still recording.

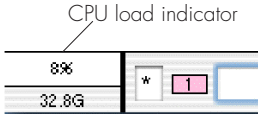
Running Other Applications While Recording

You can run other applications while Chart is recording in the background. You will need enough memory (RAM) in your computer to be able to run multiple applications, of course. How slowly your other applications run while background recording is going on depends on the sampling rate (in general, a slower rate would be needed), as well as the type of computer you have. It helps if you have a fast computer: the faster your computer, the faster it can handle data from the e-corder, and therefore, the more time it can give to another application.

Performance

To get the maximum performance from your e-corder, you should have a fast computer. At the root of most problems are low processing power, memory, and hard disk speed. Slower computers not only limit sampling rates, but also limit the rates at which you can make changes while recording. If too much data are coming in for the computer to cope with comfortably, then changing ranges, bringing up dialog boxes, and so on may stop recording.

▼ ***Refer***
Setting Sampling Rates, p. 36



To estimate how much of your computer's processing power is used, look at the CPU load indicator that appears in the Marker box during sampling. Although this indicator is at best approximate, anything greater than 50% indicates the system is under strain.

Chart estimates computer performance when it starts up and when it first starts sampling data. If the estimate is too high and the computer can no longer cope with the amount of data being collected, Chart stops recording and notifies you of the problem. This may occur if the amount of incoming data increases markedly, or after a while when recording very large files to disk, since the speed of writing to disk decreases as the disk becomes fragmented. Fragmentation means that data are written in small blocks all over the disk rather than as one contiguous file. This happens when a disk is nearly full, for instance, so that data must be written to leftover spaces. (As a rule of thumb, hard

disks should always have at least 10% free space, and should be checked regularly for file fragmentation with disk-checking software.)

It is advisable to test the system before critical recordings using the sampling rates at which you intend to record, especially for extended fast sampling. Recording to disk (page 34) is recommended as it will give good performance on most computers, and in the event of a power failure or system crash, you will not lose your data. Recording to RAM (page 33) *may* give better performance on slower computers, but only if the amount of data being collected is less than the amount of RAM: otherwise virtual memory will be used, requiring a fast hard disk and processor.

▼ ***Refer***
Data Buffering, p. 198
Sampling Rates, p. 154

Background activities decrease the ability of the computer to cope with the data it gets from the e-corder. To avoid data loss at high sampling rates, it is best if Chart is the only application running. You may also want to turn off sharing services (in the Mac OS X System Preferences) such as file sharing, and unmount file servers.

Chart usually performs better with more memory. You can reduce the memory required for the Chart window buffer and speed up display by shrinking the Chart window and reducing the color depth of the display. Chart extensions (software plug-ins that add features to Chart) use up allocated memory and may slow down Chart: you should only use those that you need. Using computed inputs, or digital filters on many channels also limits sampling rates.

▼ ***Refer***
Data Buffering, p. 198
Chart Extensions, p. 196

Interruptions

Some activities may interfere with the transfer of information from the e-corder to the computer, possibly resulting in a loss of data. When recording critical data, avoid copying to and from floppy disks, or using applications that access the hard disk frequently (using virtual memory with many programs open has the same effect). Unusual network activity and screen savers may also cause performance problems, especially at higher sampling rates.

Recording Length

How long you can record for depends primarily on the free space you have in which to record. Chart can record to disk (the default, usually

▼ ***Refer***
Data Buffering, p. 198

allowing for longer recording) or RAM (may be useful if your disk drive is slow) as set up in the preferences for data buffering.

Recording limits also depend on the sampling rate, the number of channels sampled, and the extent to which Chart compresses the data. Each sample takes at most four bytes of storage (with no compression), so recording on one channel at 100 000 samples per second for example would use 1 × 100 000 × 4 = 400 000 bytes (400 K) of memory per second, or 24 megabytes per minute.

Compression takes place during recording. The compression efficiency depends on how the signal varies: signals that change very slowly, such as a straight line or gradual curve, can be compressed a great deal, while complex and rapidly changing signals may not compress much at all. The extent of compression, as well as the amount of free space and number of data points, can be seen by recording some data of the type in which you are interested, then selecting Chart > About Chart… to view the results.

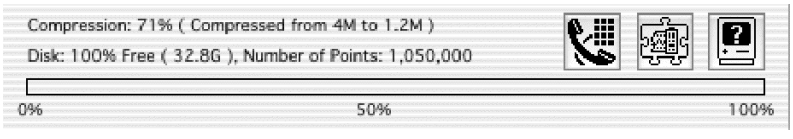


Figure 2–13
The lower portion of the About Chart dialog box.

Recording to RAM

Recording to RAM (physical memory) may be faster than recording to disk when using a slower computer. However, the benefits will be limited by the amount of RAM you have; if you need more space for the file you are recording than there is RAM, Chart will start using virtual memory, which accesses the hard disk anyway. You should also note that when you are recording to RAM, your data will be lost in the event of a power failure or system crash.

Chart uses some memory for an off-screen buffer to speed up data display. If the Chart window is large, more memory is used, especially at increased color depths. If the system is short on memory, you can use a little less by shrinking the Chart window to a smaller size and reducing the color depth of the display.

Recording to Disk

If you record to disk, you are only limited by the amount of free space on your disk. Computers almost always have more disk space than RAM, and data buffered to disk by Chart can survive a system crash or power outage, so recording to disk is a better choice unless the slowness of your computer forces you to record to RAM.

Chart has application limits of 16 000 or so blocks of data per channel and 256 000 000 samples per channel. The blocks are either defined by the user (starting and stopping recording and so on), or internally by Chart, which records continuous data in blocks of 16 000 samples at all sampling rates. Note that only the user-defined blocks are marked visually or used for selection purposes. At four bytes per sample, this gives limits of 976 MB per channel. The maximum file size for a Chart file would therefore be 15.2 GB with no compression (for 16 channels); but Chart limits maximum file size to 2 GB after compression. Chart will give an alert and stop sampling when it reaches this limit.

Files recorded by most users will typically be a lot smaller than the above limits. If you do record very large files (of the order of 1 GB), note that performance and manageability can be affected; for instance, saving could take a few minutes, during which recording would not take place. It is probably more convenient to save a large, long-term data recording as a series of smaller files, using macros. If your computer is taking a lot of time to perform actions on large files, it may help to change the size of the memory cache (Chart > Preferences > Memory Cache…).

▼ ***Refer***
Memory Cache, p. 198

3

CHAPTER THREE

Setting Up Chart

Chart gives easy access to basic settings and also offers a flexible array of setups suitable for different types of data.

This chapter describes basic settings controls such as the sampling rate and the channel range, together with features such as input amplification, units conversion, triggering and stimulation.

Setting Sampling Rates

You can choose the sampling rate using the Rate pop-up menu at the top right of the Chart window. If the pointer is not over the data display area or Time axis, the sampling rate (the number of samples taken per unit time) and the scrolling speed (the time taken for each graticule division to scroll past) are shown in the Rate/Time display beside the pop-up menu. The sampling rate is usually the same for all channels, but can be set independently for each.

▼ ***Refer***
Channel Settings, p. 51

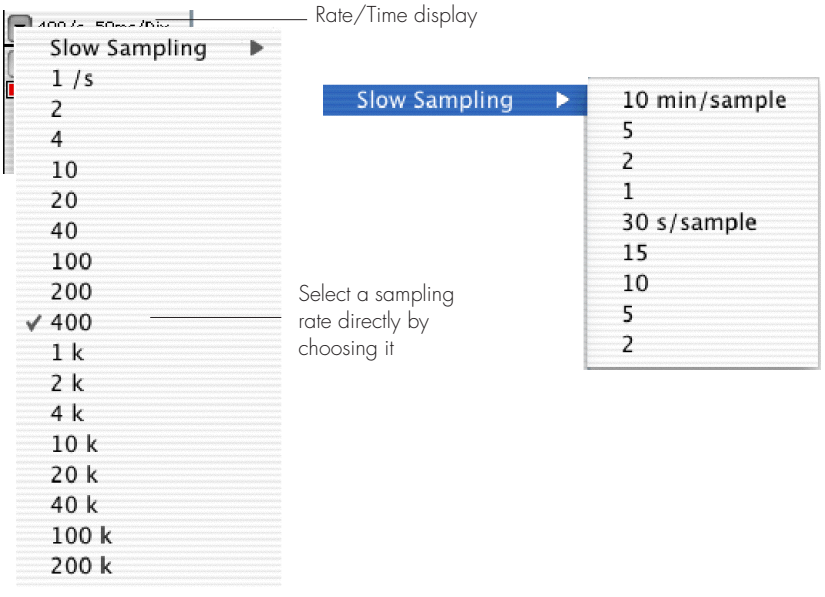


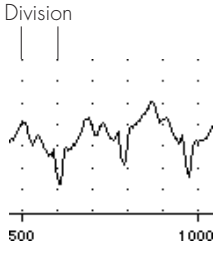
Figure 3–1
The Rate pop-up menu and the slow submenu.

Display While Sampling

Normally signals are shown as scrolling across the data display area from the right to left. The data display area is marked into divisions by a graticule, or grid.

Divisions are always 20 pixels wide at any horizontal scale, and are marked by the dot graticule in the data display area (they line up with unit divisions on the Time axis). The time taken for each graticule division to scroll past depends on both the sampling rate and the horizontal scale set using the View buttons. The compression indicated in the View buttons indicates the samples per pixel: at 1:1, each pixel

Figure 3–2
The graticule: with the display at 1:1, it is one division wide.



represents one sample, and there are 20 samples per division; at 20:1, each pixel represents 20 samples, and there are 400 samples per division.

Maximum Sampling Rates

The Rate pop-up menu lets you directly choose continuous sampling rates of from one sample per second up to 200 000 samples per second on one channel, 80 000 on two, 40 000 on three or four.

Maximum sampling rates may also be limited by the speed of the computer. When Chart starts up, it gauges the performance of the computer system at a range of tasks, and works out its probable limits when sampling data. Chart gives an alert if these limits are exceeded.

▼ ***Refer***
Performance, p. 31

Slow and Fast Sampling Rates

Chart offers a Slow Sampling submenu, which has the following rates (Figure 3–1): one sample every 2 s, 5 s, 10 s, 15 s, 30 s, 1 min, 2 min, 5 min, 10 min. Note that at these slower sampling rates, the e-corder actually samples more quickly and returns an average value.

Fast Sampling

At faster rates Chart doesn't scroll from right to left when drawing data on the screen, instead, the signal is drawn on screen from left to right, and when the right edge is reached, drawing starts again at the left (a vertical line precedes the newly drawn data crossing the screen). The effect looks like a series of sweeps are being made even though the recording is actually continuous. In addition, the graticule is not drawn while sampling, and the data are automatically scaled (compressed) horizontally, the amount depending on sampling rate. The exact speed at which this happens is dependent on the speed of the computer, and is necessary as very fast scrolling signals could not be adequately displayed as a continuous movement.

Channel Controls

▼ ***Refer***
Waveform Color, p. 72

Each channel in the channel control area has three pop-up menus, Range, Channel Function, and Color. Clicking the Range pop-up menu lets you select the channel's input range. The default setting is 10 volts (this means from –10 V to +10 V). For the best resolution, the amplitude of the signal you are interested in should be reasonably close to the chosen range without the risk of exceeding it. If the signal is too large or small at a range, select a more appropriate value. Clicking the channel title or the button at its right opens the Channel Function pop-up menu, which gives access to the other channel controls, described below.

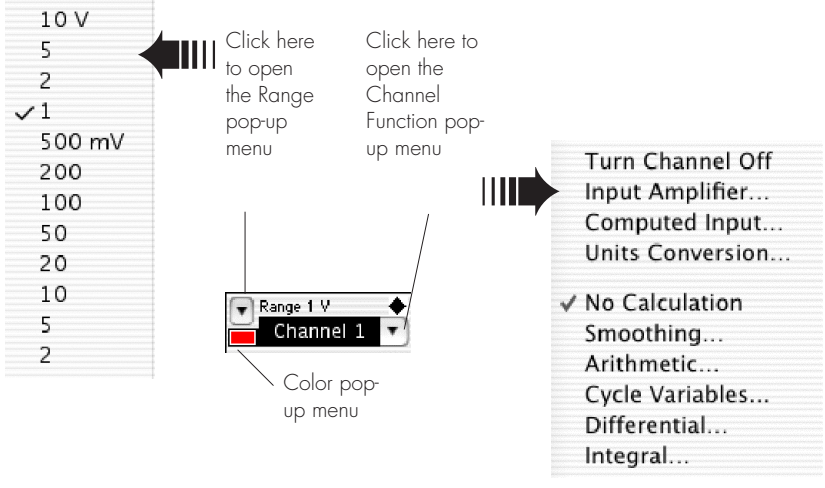


Figure 3–3
Channel pop-up menus: Range, Channel Function, and Color.

Turning Channels Off and On

The number of channels on when Chart starts up will be the same as the number of inputs on the connected e-corder. These channels will be set to record the raw data from the corresponding inputs. The rest of the channels, if any, will be off. Chart can display 16 channels. The number of channels that can be turned on, though, depends on the attached e-corder. When first turned on, any spare channels will be set to record from e-corder Input 1. They can be used for any computed function as required, though, using raw data from any input. Channels can display calculations even when turned off.

▼ ***Refer***
Channel Settings, p. 51

Choosing Channel Function pop-up > Turn Channel Off turns the channel whose pop-up menu was used off. The menu command then becomes 'Turn Channel On', and if chosen, turns the channel on again. Choosing the Input Amplifier… or Computed Input… menu commands will also turn the channel on before they open a dialog box, since the channel must be on for these dialog boxes to be used. Channels can be turned off or on while you are recording — this creates a new block in the record. You can also turn channels on and off using the On column in the Channel Settings dialog box.

There is a shortcut for dealing with multiple channels. If you hold down the Command key while opening the pop-up menu for a particular channel, the menu command will be plural: choosing it will turn that channel and all those below it off, or those with visible data on. When a channel is turned off, its Channel Status indicator is an open diamond rather than a solid one, its Range pop-up menu button becomes dimmed and inactive, and its Range/Amplitude display is replaced by 'Channel Off' instead of a range when not recording.

While recording normally, the amplitude of the signal being recorded is usually shown in the Range/Amplitude display at the right of each channel, but if a channel is off, this display stays blank. The data display areas of channels that are turned off appear gray while recording, and afterwards, the areas in the record where a channel was turned off appear blank (there is neither graticule nor data).

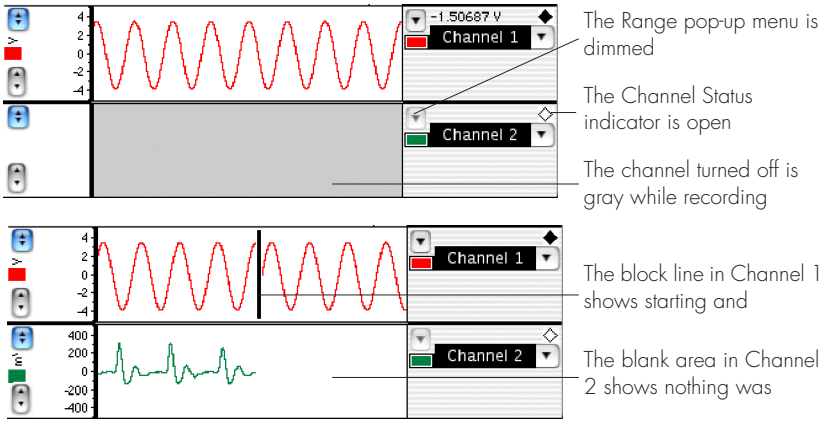


Figure 3–4
Data display during recording (top) and after recording (bottom) with a channel off.

Other Functions

The other functions in the Channel Function pop-up menu are described briefly below, and more fully elsewhere. Channels unable to be turned on have no Input Amplifier or Computed Input access.

▼ ***Refer***
The Input Amplifier, p. 41

Input Amplifier... opens the Input Amplifier dialog box, which lets you change input settings, apply signal filtering, and so on, and see the effects before recording.

▼ ***Refer***
Computed Input, p. 153

Computed Input... opens the Computed Input dialog box, which lets you process signals as they are recorded, converting the sampled raw data from any input into computed data. The menu command is ticked if the channel has computed input applied.

▼ ***Refer***
Units Conversion, p. 46

Units Conversion... opens the Units Conversion dialog box, which lets you scale or convert the standard voltage reading for a channel into useful units, such as mmHg, kPa, and so on, and lets you use waveform measurement to calibrate the channel.

▼ ***Refer***
Channel Calculations, p. 167

No Calculation is ticked if it is chosen, and means the displayed data in the channel is the recorded data (either raw data or computed data) with no extra calculation (such as Smoothing, Arithmetic, Cycle Variables, Differential or Integral) applied. It is the default setting.

Smoothing... opens the Smoothing dialog box, which lets you apply a calculation to smooth the recorded waveform in a channel.

Arithmetic... opens the Arithmetic dialog box, which allows you to arithmetically combine data in different channels.

Cycle Variables... opens the Cycle Variables dialog box, which allows you to analyze periodic waveforms.

Differential... opens the Differential dialog box, which allows you to calculate the first time derivative of data in a channel.

Integral... opens the Integral dialog box, which allows you to calculate time integrals with various resetting methods.

Chart extensions can add further channel calculations to the lower half of the Channel Function pop-up menu. In all cases, the menu command for the calculation that applies will be ticked.

The Channel Status Indicator

The Channel Status indicator is a diamond at the right of the channel control area for each channel. It is solid if the channel is on, open if the channel is off, and contains an = sign if a channel calculation is applied. Clicking the indicator pops up a list showing the sampling rate, range, what is to be recorded (raw data or a computed function, and from which input), Input Amplifier settings, such as eDAQ Amp or Pod settings, filter settings, and any active units conversion or channel calculation. This will apply to newly recorded data.

The Input Amplifier

The Input Amplifier dialog box allows software control of the input amplifiers and filters in the e-corder itself. Each input is set up independently. The signal present at an input is displayed so that you can see the effects of changes straight away. The Pod Scan button only appears if the e-corder has pod connections. The Input Amplifier dialog box appears when you choose Channel Function pop-up > Input Amplifier… (or click the Input Settings column in the Channel Settings dialog box). By default, Chart channels record data from the corresponding e-corder inputs. To set up the inputs quickly, click the arrows at the top left, or click the right or left arrow keys on the keyboard, to move to the dialog boxes for adjacent channels. This skips channels that are turned off.

Signal Display

The input signal is displayed so you can see the effect of changing the settings — no data are in fact recorded when setting up the input amplifier. To avoid aliasing, the input signal is sampled at 10 kHz. Each pixel width in the display thus represents a number of samples, and so is drawn as a vertical line from the minimum to maximum recorded values. Slowly changing waveforms are shown reasonably accurately, but quickly changing signals display as a solid area showing only the envelope (overall shape) of the signal. The average

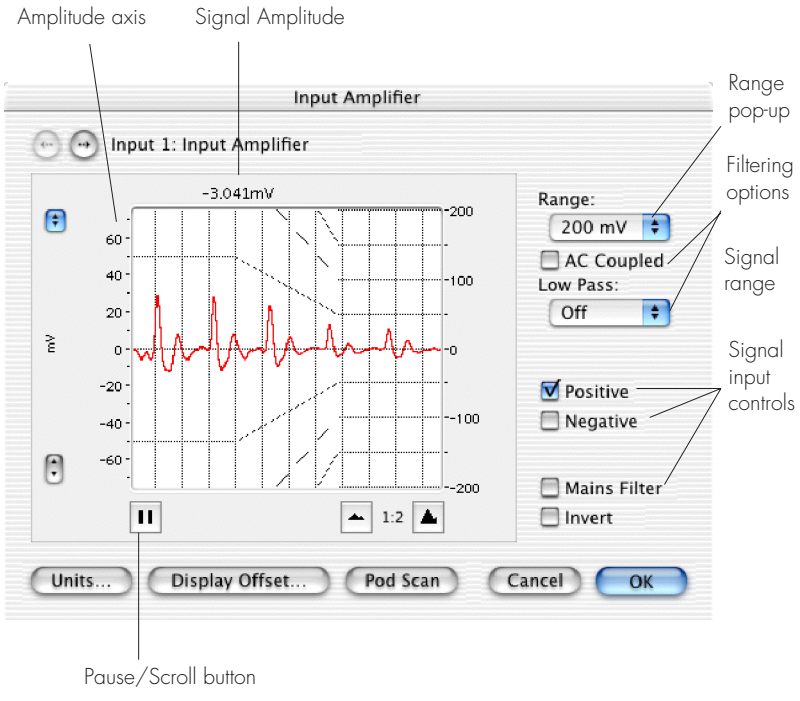


Figure 3–5
The Input Amplifier dialog box.

signal amplitude is indicated by a horizontal dotted line, and its numeric value is shown above the display area.

You can stop the signal scrolling by clicking the Pause button at the top right of the data display area (it looks like the pause button on a tape or CD player). It then changes to the Scroll button (like the play button on a tape or CD player): click it to start scrolling again.

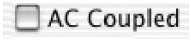
You can shift and stretch the vertical Amplitude axis to make the best use of the available display area. It is much the same as the Amplitude axis in the main window, and the controls, such as the Scale pop-up menu, function identically. There are also scaling buttons (up and down arrows) which double or halve the scale respectively. When the Amplitude axis is set to a scale that differs from the range, the signal shifts, expands or compresses (depending on how the amplitude axis is scaled) as it moves from right to left across the signal display area. This is to indicate the difference between scale and range. Changes made to the Amplitude axis here are reflected in the Chart window.

▼ ***Refer***
The Amplitude Axis, p. 73

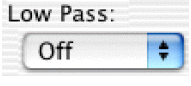
You can change the horizontal compression of the displayed signal by using the View buttons, which are similar to those in the Chart window. Click the left (far mountains) button to see more data in the display at once, and click the right (near mountains) button to see less.

Filtering

The AC Coupled checkbox provides each input with a high-pass filtering option. Low-pass signal filtering options are provided by a Filter pop-up menu. There is also a mains filter option available. (Your *e-corder Manual* gives technical details on filters.)

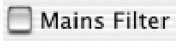


AC Coupled. Unless the AC Coupled checkbox is selected, the input amplifier will be DC coupled, and pass both DC and AC signals. When AC coupling is used, a high-pass filter before the first amplification stage removes any DC and low-frequency components from the input. The cut-off frequency is 0.1–0.5 Hz, depending on the e-corder. The AC coupled option is useful to remove a slowly changing signal component (when recording a fast signal superimposed on a slowly drifting baseline, for instance).



Low-Pass Filtering. The Low Pass pop-up menu gives a choice of low-pass filters from 2 kHz down to 1 Hz to remove high-frequency components from an input signal. These filters are commonly used to rid a signal of excessive noise. To turn the filters off, and use the maximum bandwidth of your e-corder (approximately 20 kHz), select Off from the pop-up menu.

These filters are implemented as digital filters within the e-corder and use some of its processor power. If you are using the digital filters on several channels along with computed functions, you may not be able to use the fastest sampling rates, or you might have to turn off one or more channels in order to sample.

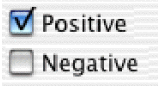


Mains Filter. By selecting the Mains Filter checkbox, you can filter out mains hum (typically seen as noise, with a frequency of 50 or 60 Hz, superimposed on your signal). Note the mains filter uses some of the e-corder's processing power and therefore reduces the maximum rate at which you can sample. If your signal is noise-free, leave the mains filter off, and if your signal is affected by mains noise, try removing possible sources before resorting to using the filter.

Signal Input Controls

▼ ***Refer***
Channel Controls, p. 38

The Range pop-up menu lets you select the input range or sensitivity of the input. Changing the range in the Input Amplifier dialog box is equivalent to changing it in the Chart window.



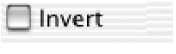
The Positive and Negative checkboxes control the signal input on an e-corder with positive and negative (that is, differential) inputs. These checkboxes do not appear where the input is only single-sided: in this case, the input functions as if the Positive box were checked permanently. The two checkboxes allow you to set up three possible input modes.

Positive. When only the Positive checkbox is checked, only the positive inputs on the front of the e-corder are used, and a positive signal fed into one will be shown as a positive signal on the display (non-inverting).

Negative. When only the Negative checkbox is checked, only the negative inputs on the front of the e-corder are used, and a positive signal fed into one will be shown as a negative signal on the display (inverting).

Note
The term 'differential' here should not be confused with the computed input differential, which is the time derivative, not a difference.

Differential. When both the Positive and Negative checkboxes are checked, both positive and negative inputs are used, and the signal shown in the channel display is the difference between the signals at the corresponding positive and negative inputs. If both input signals were the same, they would cancel each other out.



The Invert checkbox lets you invert the signal on the screen. It provides a simple way to change the polarity of the recorded signal without having to rewire a circuit or reconnect to the signal source. For example, you might be recording from a force transducer where an increase in force downwards gives a negative signal, but you want to have a downwards force shown as a positive signal on the screen. Selecting the Invert checkbox would change the display to do this.

Other Features

Display Offset. Clicking the Display Offset… button causes the Voltage at Input dialog box to appear. In the dialog box, a voltmeter displays

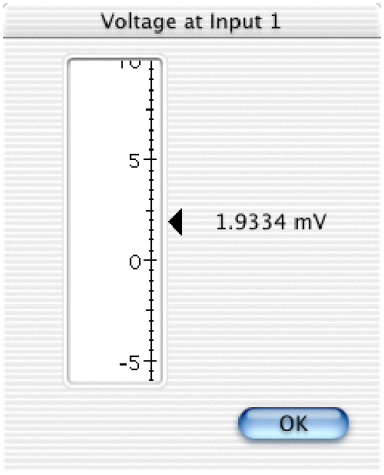


Figure 3–6
The Voltage at Input dialog box.

the signal currently being measured at an e-corder input (the input is indicated at the top of the dialog box). If a transducer or some other external equipment has offset adjustment capabilities, you can use this to help see when the device is zeroed.

This dialog box is not a control, simply an indicator that acts like a voltmeter. It is unavailable when the AC Coupled checkbox is selected, since AC coupling removes all DC current, and there would be no offset to measure.

▼ ***Refer***
Units Conversion, p. 46

Units. Clicking the Units… button opens the Units Conversion dialog box, letting you specify the units for a channel, and, using waveform measurements, calibrate the channel. The waveform currently in the data display area of the dialog box is transferred to the data display area of the Units Conversion dialog box. (Use the Pause button to capture any specific signal that you want to use.) Units conversion will only apply to subsequently recorded signals. This is the usual way to set up sampling parameters.

Pod Scan. Clicking the Pod Scan button updates the dialog box if it has been left open and a pod (a type of signal conditioner) has been connected or disconnected.

Zeroing Inputs

eDAQ Amps and pods (signal conditioners) connected to e-corder inputs may replace the Input Amplifier dialog box with a dialog box

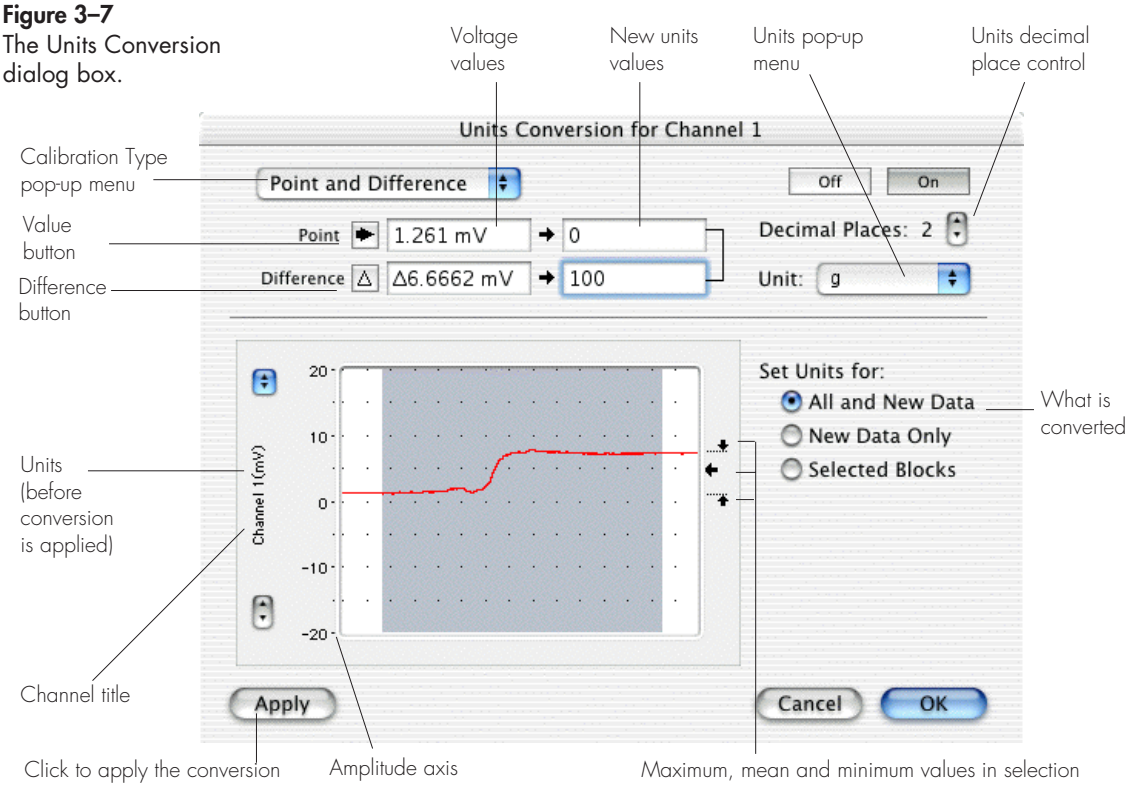
specific to the device, with controls for extra filtering, offsetting, and so on (but most functions will be similar). Some eDAQ Bridge Amps and GP Amps, have automatic zeroing to remove transducer offsets — see their manuals for details. Choose Setup > Zero All Inputs to have each eDAQ Amp automatically zeroed in turn.

Units Conversion

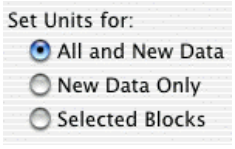
Units conversion lets you convert the standard voltage reading for a channel into suitable units for display. You can calibrate the channel using waveform measurements or known relationships. The conversion can be applied before recording, so that all subsequent recordings are scaled to the required units, or after recording, either to the entire channel (and all subsequent recordings) or to particular blocks of data. Each channel is set up independently.

To open the Units Conversion dialog box (Figure 3–7) directly, choose Channel Function pop-up > Units Conversion… for a channel. You can

Figure 3–7
The Units Conversion dialog box.



also click the Units… button in the Input Amplifier dialog box or click the Units column in the Channel Settings dialog box.



After you choose the Units Conversion… menu command directly, the selection in the Chart window is shown in the data display area of the dialog box. That area appears blank, or may contain a message, if there is no selection or a discontinuous one (over two or more blocks). If there is a selection point or area, you can choose to convert the units of the selected block or blocks of data; else the Selected Blocks radio button is dimmed and can't be chosen. If the dialog box is opened from the Input Amplifier or Channel Settings dialog boxes, you can convert only the units of subsequently recorded signals: you can't convert blocks of data or the whole channel, and the dialog box appears with no radio buttons.

Using the Units… button in the Input Amplifier dialog box transfers the data shown there to the units conversion data display area (Figure 3–8). This has a slightly different aspect ratio to the original display area, but the signal is also drawn differently. Lines are drawn connecting the minimum values and connecting the maximum values, and the area between them is shaded. This gives a truer representation of the signal envelope than is possible in the Input Amplifier dialog box.

▼ ***Refer***
Signal Display, p. 41

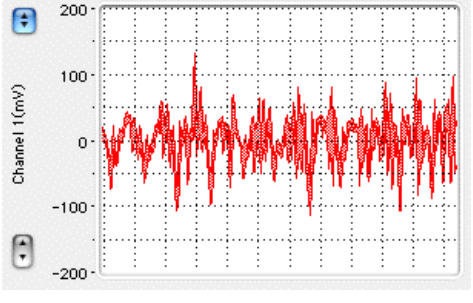
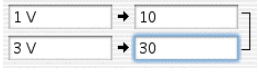


Figure 3–8
A signal transferred from the Input Amplifier dialog box to the units conversion data display area.

Converting Quantities

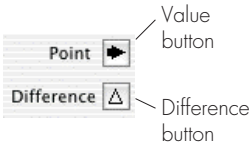


The dialog box has four text entry boxes: actual voltages go in the left boxes, and what those readings are equivalent to goes in the right boxes. Each box requires an entry, so that there are two sets of values to calculate the scaling between volts and the new unit. (It must be a linear relationship to work. Note that if the slope is negative, the Amplitude axis will be inverted.) You can type in some or all values in

the boxes directly, or use some readings from the data display area in the left boxes and type in known conversion values in the right boxes. Click the Apply button to see what the converted data look like. Click the OK button to convert the data into the chosen units, or Cancel to close the dialog box without making changes.

Entering Values

If you know the relationship between what is measured and the displayed voltage, then you can directly type in values in the four boxes (you can press Tab to move between the fields, left to right, top to bottom). If you are using a temperature transducer and calibration shows that a temperature of 10 °C gives a reading of 1 volt, and 30 °C gives 3 V, say, then you can key in the values (left to right, top to bottom: 1 V, 10; 3 V, 30), and choose °C from the Units pop-up menu.



You can set up units conversion using values from data points, averages, and changes in the waveform shown in the data display area. The Data Use pop-up menu changes which buttons are available for data transfer: either Point 1 and Point 2 or Point 1 and Difference. This in turn fixes how displayed data are used: you can either use two data points (or averages) or a point and a difference to fix the scaling for the conversion. (At least one base value must be absolute.)

You can shift and stretch the vertical Amplitude axis to make the best use of the data display area. It is the same as the Amplitude axis in the main window, and the controls function identically. If you click in the data display area, a vertical line indicates the active point, and an indicator arrow at the right of the data display shows the point of intersection with the waveform (Figure 3–9, ❶). If you make a selection in the data display area, the indicator arrow at the right of the data display shows the average amplitude of the waveform, and two markers above and below it indicate the maximum and minimum data points in the selection (Figure 3–9, ❹).

If there is an active point or a selection in the data display area, then clicking the Value button enters the voltage value (at the active point, or the average of the selected data) in the left box in its row. Clicking the Difference button enters the difference between the maximum and minimum of the selection in the left box in its row. Differences are indicated by a delta prefix (Δ). In each case, the right box of the row is selected so that you can type in the known value in the new units. As a

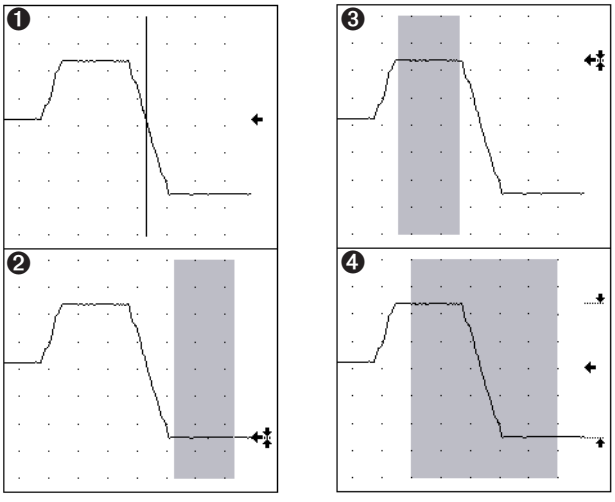


Figure 3–9
Selections in the data display area of the Units Conversion dialog box.

shortcut, you can double-click in the data display area to transfer the data at a point in one step (doing this a second time enters data in the unused row).

To calibrate a force transducer in a channel, say, start recording and apply two known forces to the transducer, to get two voltages. Stop recording, select the area with the two readings, and choose Channel Function pop-up > Units Conversion… for the channel. Choose Data Use pop-up > 2 Point Calibration in the dialog box. Select a point or area in the waveform corresponding to one force (Figure 3–9, ❷), click a Value button to enter its value in a left box, and type the known force in the right box beside it. Repeat the process for the other force (Figure 3–9, ❸), entering data in the unused row.

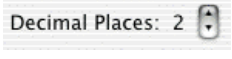
If you know the relationship between what is measured and the displayed voltage, but don't have two sets of values, you might use the Point and Difference option. For example, some temperature transducers produce a certain change in voltage for a given change in temperature (such as Δ20 mV giving Δ4 °C). Use an absolute reading in the top row (a calibration value, perhaps). Select an area in the data display where a known change in temperature has been recorded (Figure 3–9, ❹). Use the Difference button to enter the difference in values in the selected data in the left box of the bottom row, and type the known change in the right box.

Choosing Unit Names

The Unit pop-up menu lets you choose, define, or delete units. Units are just names, and the conversions are set independently, so you could have °C in two channels, say, with different conversions. Unit names are stored in the e-corder Settings file in the Preferences folder of the System folder, in common with those created in Scope, and are available to all Chart and Scope files once created (or unavailable once deleted). Some frequently used ones are provided.

Choose Unit pop-up > Define Unit… to define new units. The Define Unit Name dialog box appears, letting you type in up to nine characters for a unit, and add a prefix (there is a pop-up menu of standard prefixes in the dialog box; the default is none). Superscripts and subscripts can be used, as with channel titles. Choose Unit pop-up > Delete Unit… to delete units: the Delete Unit Name dialog box appears. Select the unit to be deleted from the scrolling field (Shift-click or Command-click to select several) and click OK to close the dialog box: the unit is then deleted. If you accidentally delete a unit, you must redefine it. Double-click a unit to delete it and close the dialog box in one step.

▼ ***Refer***
Superscripts and Subscripts, p. 82



You can set the number of decimal places of the new units (from 0 to a maximum of 6), by clicking the arrows at the top right of the Units Conversion dialog box. You can turn units conversion off or on without losing the values you have entered by clicking the Off or On buttons by the title of the dialog box. Clicking the Apply button to see how the units conversion will look, or the OK button to convert units and return to the Chart window, will turn units conversion on.

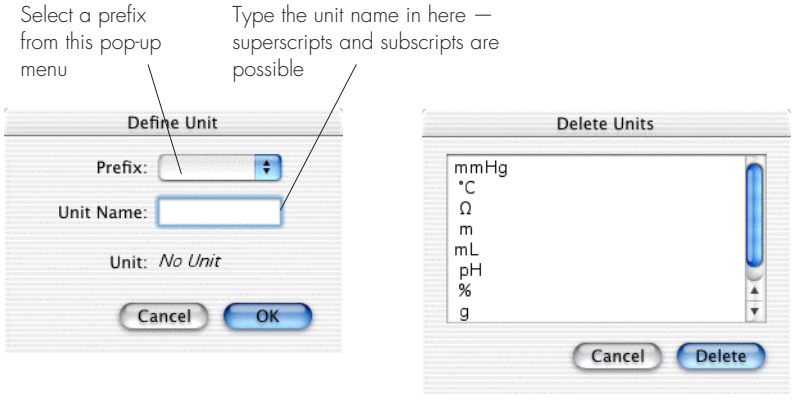


Figure 3–10
Dialog boxes for defining and deleting units.

Channel Settings

The Channel Settings dialog box lets you set up multiple channels conveniently: you can both see and specify recording and display settings for each channel in the one place. To open the dialog box, choose Setup > Channel Settings… or type Command-Y. Note that when there is no e-corder connected, a smaller version with only display settings visible will appear.

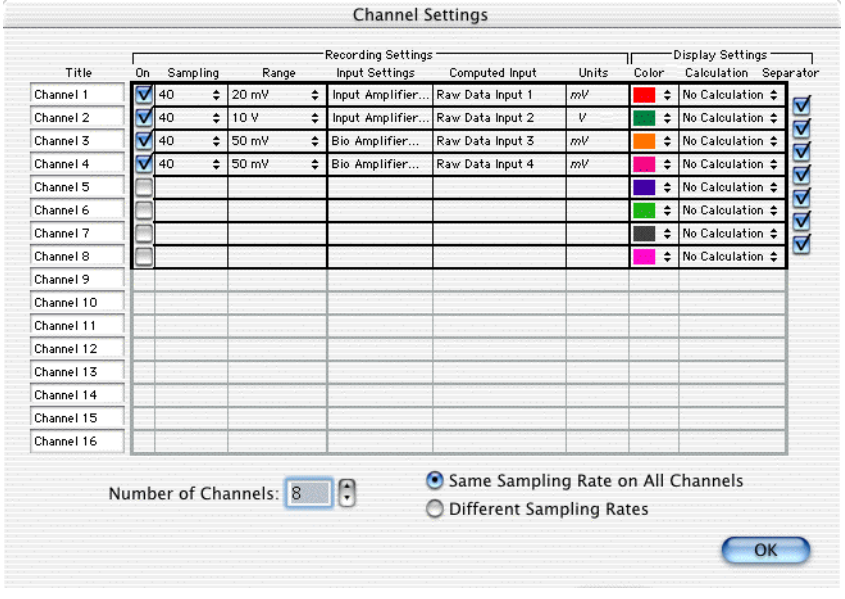
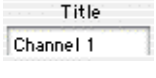


Figure 3–11
The Channel Settings dialog box.

The functions of the dialog box and the dialog boxes it gives access to are described briefly below, and more fully elsewhere. (Most of the recording settings are discussed in detail in this chapter, and the display settings in the next.) Click the OK button to apply the changes and return to the Chart window.

Title

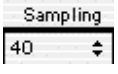


You can enter a title for each channel in its text entry box, replacing the default titles such as ‘Channel 1’.

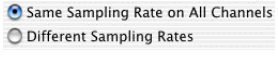
On

The checkbox lets you turn a channel off (unchecked) or on (checked). It is equivalent to selecting the 'Turn Channel Off' or 'Turn Channel On' menu commands from the Channel Function pop-up menu for a channel. There is a shortcut for dealing with multiple channels: hold down the Command key while clicking the checkbox for a particular channel to turn that channel and all those below it off or on. If a channel is off, its recording settings are blank and unusable.

Sampling



Sampling rates can be set using the pop-up menus in the Sampling column. They let you choose any of the continuous sampling rates available directly from the Rate pop-up menu. By default, the rate is the same for all channels, and the Same Sampling Rate radio button at the bottom of the dialog box is turned on. Changing the rate in any pop-up menu in the column changes it for all channels.



If the Different Sampling Rates radio button is turned on, then rates can be set independently for each channel. You might want to do this when some channels require high time-resolution (say, a vibration signal), but others being recorded concurrently do not (say, temperature). Chart samples on all channels at the maximum rate chosen for any of the channels, but interpolates rather than records some data points in channels with lower rates, enabling better data compression. Reducing the sampling rate for some channels therefore will not solve problems with the rate being too fast (you need to turn channels off for this); it just creates smaller data files.

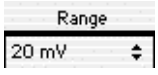
When some channels have different sampling rates, the Rate/Time display in the Chart window shows the maximum rate. Clicking the Rate button will not open the Rate pop-up menu in this case: rather, the button highlights, and when the mouse is released, the Channel Settings dialog box appears. Clicking the Same Sampling Rate radio button will set all channels to the maximum rate.

The pop-up menus in the Sampling column do not include the Slow Sampling submenu from the Rate pop-up menu. If a slower or faster sampling rate is set from the Chart window using these submenus, then the radio buttons at the bottom of the dialog box will be dimmed and unusable, and the pop-up menus in the Sampling column will be blank

▼ ***Refer***
Channel Titles, p. 81
Turning Channels Off and On, p. 38
Setting Sampling Rates, p. 36

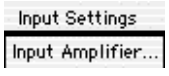
and also unusable: slow sampling rates must be the same for all channels.

Range



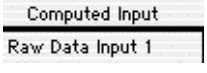
The pop-up menus in the Range column let you select the input range or sensitivity of each input. Changing the range is equivalent to changing it in the Chart window. For those channels with computed inputs, the ranges will be the computed input ranges.

Input Settings



Click the Input Settings column to open the Input Amplifier dialog box for an input, letting you change input settings, apply signal filtering, and so on, and see the effects without recording. This is the same as choosing the Input Amplifier… command from a Channel Function pop-up menu. By default, Chart channels record data from the corresponding e-corder inputs. The channel entry will change to show if an eDAQ Amp such as the pH/mV Amp is connected; so this column is useful to check to see if multiple eDAQ Amps are connected properly to the e-corder and are on.

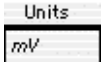
Computed Input



▼ ***Refer***
Channel Controls, p. 38
The Input Amplifier, p. 41
Computed Input, p. 153
Units Conversion, p. 46

Click the Computed Input column to open the Computed Input dialog box. This is the same as choosing the Computed Input… command from a Channel Function pop-up menu. The dialog box lets you choose to process signals as they are recorded, converting the raw data from any input into computed data. Raw Data means the sampled data with no computed function applied, and is the default setting. The channel entry displays the computed function being applied, if any, and the input from which the raw data came. The column is a useful way to check what is going on in each channel.

Units



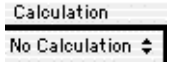
Click the Units column to open the Units Conversion dialog box for a channel, letting you change the standard voltage reading for a channel into useful units, such as °C, µA, kPa, and so on. This is similar to choosing units conversion through the Input Amplifier dialog box, and

applies only to subsequent recording. If units conversion has not been applied, the default units are shown in the column in italics.

Color

The pop-up dialog boxes in the Color column let you choose the color of the data trace in a channel, and whether the data points are displayed joined by lines or as unjoined dots. You can also set here the thickness of the data trace that appears in the Zoom window (data traces are always drawn one pixel thick in the Chart window).

Calculation



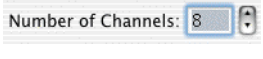
The pop-up menus in the Calculation column let you apply calculations to channels of recorded data. The options are the same as those in the lower half of a Channel Function pop-up menu. No Calculation is the default setting, and means the displayed data in the channel are recorded data (either raw data or computed data) with no extra calculation applied. Chart has the Smoothing, Arithmetic, Cycle Variables, Differential and Integral calculations available, and Chart extensions such as Spirometry can add others. The calculations do not replace the recorded data in a channel, and can be used in channels that are turned off. They may be online (you see the results as you sample) or offline (you see the results of the calculation only after sampling finishes).

▼ ***Refer***
Display Settings, p. 77
Channel Calculations, p. 167
Changing Channel Size, p. 75

Separator

The checkbox lets you turn a channel separator off (unchecked) or on (checked). Turning off the channel separator between two channels overlays them in the Chart window, allowing you to compare their waveforms directly: the line between channels in this dialog box also disappears so that the setting is easy to see at a glance.

Number of Channels



This control, at the bottom of the dialog box, lets you choose the number of channels displayed in the Chart window. It both turns them off, so that no data are recorded, and hides them, so that the data display area is not cluttered with channel separators. Click the up or down arrows to increment or decrement the number, or type a value in

the text box directly. The lower channels are turned off and hidden first: their rows are blank and borders grayed out, so that they can be distinguished from channels that are off.

Triggering

Triggering determines the way Chart starts and stops recording. A trigger is an event such as clicking the Start button or a voltage above some preset threshold in an incoming waveform. To set up triggering, choose Setup > Trigger: the Trigger window appears. You can use the controls to set up the type of trigger event you want, the delay until recording, the duration of recording, and so on.

The Trigger window is a normal window, and can be moved around the screen or left in the background while the Chart window is active. By default, the Source and Stop pop-up menus are set to User, and the other controls are dimmed. In this case there are no special trigger conditions, and recording starts or stops when the Start or Stop button in the Chart window is clicked.

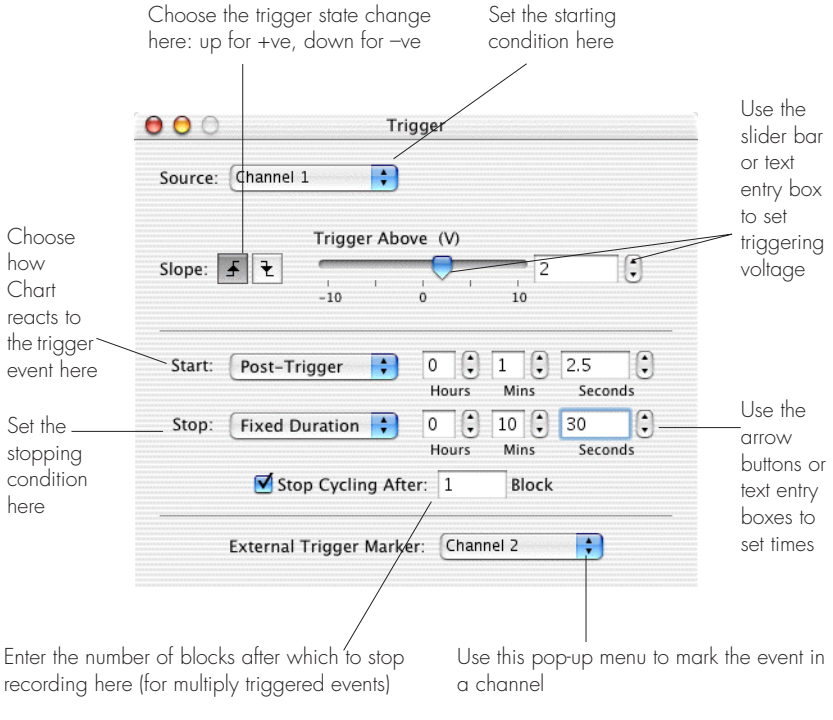


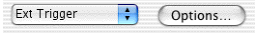
Figure 3–12
The Trigger window.

Setting the Controls

Source

You can choose the event that triggers recording from the Source pop-up menu, which gives you the choice of User, Ext Trigger, Internal Timer, or one of the Chart channels. If you select User or Internal Timer, Chart starts recording when you click the Start button.

If you choose one of the other options, clicking the Start button gets Chart ready to record: the Recording Status indicator shows the message 'Waiting for trigger', and the Record/Monitor button will be dimmed. The chosen trigger event then starts Chart recording.



If you select Ext Trigger, the event comes from an external source connected via the Trigger connector on the front of the e-corder. When External Trigger is selected in the Trigger dialog box, an Options... button appears. Clicking this button allows you to choose between TTL Voltage Level (a voltage pulse), and Contact Closure mode (when a contact is made between the two terminals of the input cable). An external voltage pulse must be over about 3 V for 5 µs or longer to register (see your e-corder Manual for details. Many instruments provide either TTL or contact closure trigger signals and these settings can be used to synchronize the Chart recording with such devices. Note that the external trigger does not function at a sampling rate of 200 000 samples per second.

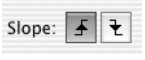
▼ ***Refer***
External Trigger, p. 190

If you choose a channel, a voltage above some threshold in the signal of that channel starts Chart recording. The channel must be turned on for its signal to be chosen as a triggering event.

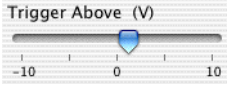
The Source time controls are only active when Internal Timer is selected in the Source pop-up menu, and are used to set the intervals at which recording starts. Click the up or down arrows to increment or decrement the numbers, or type values in the text boxes directly. The internal timer requires fixed-duration sampling. Chart records a block of the set duration, then counts down until the time set with the Source time controls has passed. After recording, the Recording Status indicator shows the message 'Int. Timer' and the time remaining. Chart then records another block, and so on until the number of blocks set in the Stop Cycling control is reached or the Stop button is clicked, at which stage recording stops.

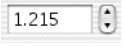
The internal timer is not intended for uses requiring very high accuracy. It should be accurate to a quarter second, as a rule, but since it is controlled from the computer, its accuracy depends on how fast the computer is, and how busy. Holding down a menu may delay the internal timer until the menu is released, for instance.

Slope and Level



When Ext Trigger or a channel is selected in the Source pop-up menu, the slope of the triggering voltage can be set. The trigger level is an absolute voltage: the slope determines whether triggering occurs when the voltage goes up (positive) or down (negative) through the trigger level. The active Slope button is highlighted: click the inactive button to change the slope.





The Level controls are used to set the trigger level voltage for a channel when one is selected in the Source pop-up menu (else it is dimmed). The range of voltages available depends on the range set for the trigger channel. You can either use the slider bar, enter a value directly in the text box or use the arrows beside it to change the trigger level.

Start

When Ext Trigger or a channel is selected in the Source pop-up menu, the Start pop-up menu becomes active. It offers the choice of At Event, Post-Trigger, or Pre-Trigger, to determine how Chart reacts to the trigger event, that is, whether there is a period of time between the triggering event and the start of recording.

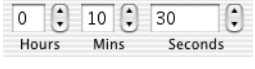
When At Event is selected, sampling starts as soon as the trigger event occurs, and no Start time controls appear. When Post-Trigger is selected, sampling starts at the time set with the Start time controls after the trigger event occurs. This is useful in cases of delayed response, if the signals you want to record will occur some time after the trigger event. When Pre-Trigger is selected, sampling starts before the trigger event occurs. Anticipation is limited to 16 000 samples (at present), since it relies on data buffered in memory, so the available time range for Pre-Trigger recording depends on the sampling rate. Pre-triggering is useful to record the onset of an event before the trigger level voltage is reached. It may result in negative values in the Time axis for the time preceding the trigger event (which takes place at zero time in some time modes). Pre-triggering ignores trigger events that occur before the

pre-trigger time is up, rather than starting if a trigger event occurs within that time. If you set the pre-trigger time to 5 seconds, say, Chart will sample for 5 seconds before even looking for a trigger.

The Start time controls are used to set the time before or after the trigger event when recording starts, and are only visible when either Post-Trigger or Pre-Trigger is selected in the Start pop-up menu. Click the up or down arrows to increment or decrement the numbers, or type values in the text boxes directly. If the time set exceeds the limit for pre-triggering, then when sampling starts it will be reduced to a shorter time (and Chart will alert you to the fact).

Stop

You can determine how Chart stops recording using the Stop pop-up menu: User, Fixed Duration, or End of Trigger. When User is chosen, recording continues until you click the Stop button (or memory runs out), and the Stop time controls are unavailable. When Fixed Duration is set, recording continues for a set period after the trigger event occurs. When Internal Timer is set in the Source pop-up menu, the Fixed Duration option is set automatically: if you change the option, you get an alert when you try to sample. When End of Trigger is selected, recording starts at the trigger event, and continues for a set period after the end of the trigger event (when the voltage passes through the trigger level again). If multiple trigger events occur during recording, recording continues until the set period after the end of the last one. You might use this to record while a nerve was firing, for example, and for some time afterwards: recording would start when the nerve potential starts, and stop a set time after the nerve potential falls below a certain value.

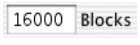


The Stop time controls are used to set the time for which recording continues, and are only visible when either Fixed Duration or End of Trigger is selected in the Stop pop-up menu. Click the up or down arrows to increment or decrement the numbers, or type a value in the text boxes directly. You should check to see if there is enough memory to record for the time entered (since Chart does not). The internal timer requires the value set in the Stop time controls (the time for which to record) to be less than the value in the Source time controls (the time between each cycle). If you set the stop time to more than the timer cycle, you get an alert when you try to sample. If you set it to zero, Chart still records two samples per cycle.

Stop Cycling

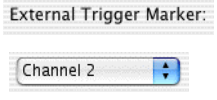
The Stop Cycling control lets you set up triggering for repeated events. The checkbox can be turned on or off when Fixed Duration is set in the Stop pop-up menu, and User is not active in the Source pop-up menu. Otherwise it is dimmed and unable to be used.

If the checkbox is off, then Chart just records a new block (of the duration fixed with the Stop controls) for each specified trigger event until it reaches its recording limits. If used with the internal timer, Chart starts recording a new block at each interval set in the Source time controls. If the trigger event is the external trigger or a channel voltage, then Chart starts recording a new block at each such event (ignoring those events that occur while already recording). This is obviously useful to record a series of sporadic events, for example.



If the checkbox is on, then you can enter a number in the text entry box to specify the number of blocks to record, from 1 to 16 000 (about the maximum number of blocks in a Chart file). Chart will record that number of blocks before it turns off.

External Trigger Marker



If you choose a channel from the External Trigger Marker pop-up menu, then the point when an external trigger pulse occurs is marked by a small data spike (this adds to any data in the channel). If you choose Off, no mark is recorded. The external trigger marker does not work at fast sampling rates (over 1000 samples per second).

You do not need to start sampling with the external trigger to use the mark; you could note the beginning of some phase of an experiment, or mark a particular event automatically at the instant it occurs by using a signal source connected to the external trigger. Unless you needed extreme accuracy, though, you would usually use comments or automatic comments for this purpose.

Making Changes in the Chart Window

If you have selected channel event triggering, you can change the trigger level voltage and slope, and the event channel, from the Chart window. If channel triggering is active, the Trigger Marker (an arrow, a T, and a triangle) is shown in the (vertical) Amplitude axis of the event

channel with the triangle pointing at the triggering voltage level. The trigger slope is represented by the arrow: up for positive and down for negative.

Double-clicking the Trigger Marker changes the slope. You can drag the Trigger Marker up or down to change its settings — a gray box and line appear, to indicate where it will go. When the box and line are at the desired voltage in the desired event channel, release the mouse button to apply the new settings to the trigger.

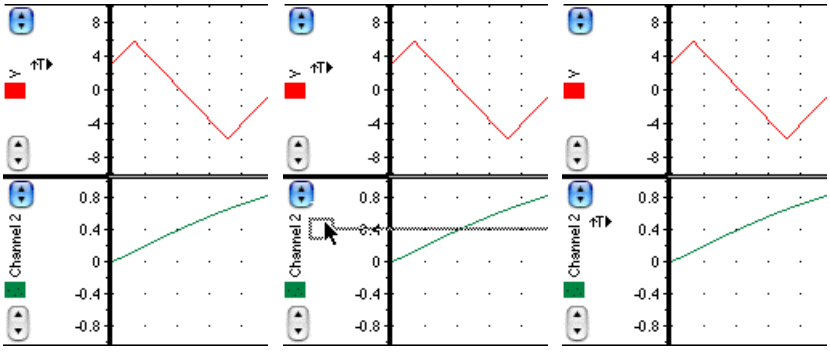


Figure 3–13
The Trigger Marker.

The Stimulator

The Stimulator lets you generate a stimulus (pulse or stepped waveforms), through the e-corder analog outputs. Select Setup > Stimulator: the Stimulator window appears which controls set the stimulus type and properties. The stimulus (output waveform) is generated via the sockets marked 'Output' on the front of the e-corder. The stimulator settings are independent of the sampling rate, but variable stimuli can only be generated while the e-corder is sampling, or while the Computed Input dialog box is open.

The Stimulator window is a normal window, and can be moved around the screen or left in the background while the Chart window is active. Parameters can be changed while sampling occurs. By default, the stimulator is off: Off is selected in the Mode pop-up menu, and the controls are inactive. The active controls in the window change with the chosen mode. You can turn stimulation off or on without losing the

▼ ***Refer***
The Stimulator Panel, p. 65

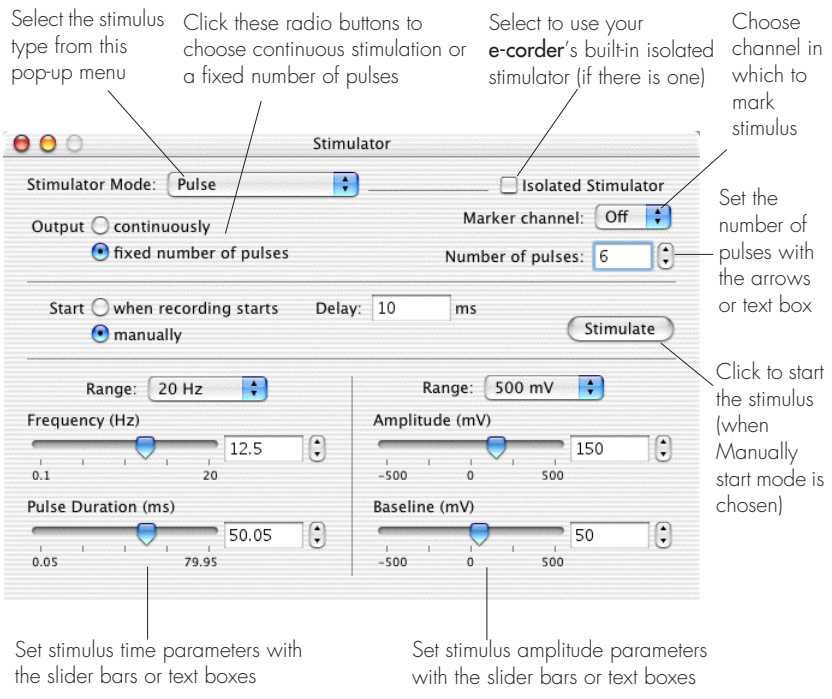


Figure 3–14
The Stimulator window.

values you enter. Stimulation parameters can also be controlled using the Stimulator Panel.

Mode

The Stimulator Mode pop-up menu lets you choose the stimulus type — pulse, step, ramp, triangle, or sine, Figure 3–14. Once the stimulus type is chosen, you can use the window controls to define its characteristics precisely.

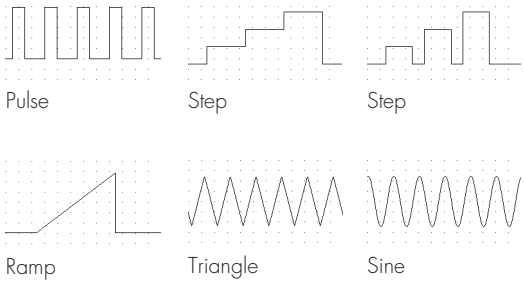


Figure 3–15
Types of stimulus waveform.

Pulse. This setting generates a rectangular pulse stimulus that starts at a baseline voltage, is raised or lowered to the set amplitude for the pulse duration, and then falls or rises to the baseline voltage again.

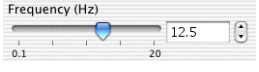
Step. This setting generates a stepped stimulus that starts at a baseline voltage, is raised or lowered to the set amplitude in a series of steps, and then falls or rises to the baseline voltage again. Each step can fall or rise to the baseline voltage if required.

Ramp. This setting generates a sloping (ramp-shaped) stimulus that starts at the start voltage, is smoothly raised or lowered to the end voltage, and then falls or rises to the start voltage again.

Triangle. This setting generates a triangular wave stimulus that is symmetrical about a baseline voltage, and rises and falls for the set amplitude from the baseline.

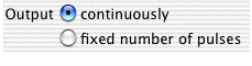
Sine. This setting generates a sine wave stimulus that is symmetrical about a baseline voltage, and rises and falls for the set amplitude from the baseline.

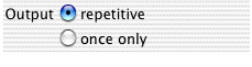
Setting the Controls

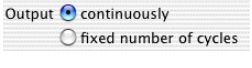


The slider bars for various stimulation parameters can be used to set the value in the normal way, by dragging the sliding handle. The value is displayed in the text entry box beside the slider bar. You can also change the value by clicking the up and down arrows at the right of the text entry box, or by entering a value directly.

Continuous Waveforms



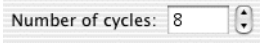


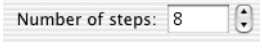


By default, the stimulator gives a continuous stimulus waveform, and the top Output radio button (at the top left of the window) will be on (Continuously for Pulse, Triangle, or Sine modes; Repetitive otherwise). If you choose Step mode, you can specify how many steps, from 1 to 2000, you want in your stepped waveform. In Ramp mode, the control is disabled.

Discrete Waveforms

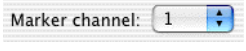
If the lower of the two Output radio buttons (at the top left of the window) is selected (Fixed Number of Pulses for Pulse, Once Only for Step and Ramp, or Fixed Number of Cycles for Triangle and Sine modes), then the stimulator will produce a set number of pulses or cycles of a waveform; or for Step and Ramp modes, a single stimulus of varying intensity.





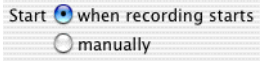
If you choose Pulse, Triangle, or Sine from the Mode pop-up menu, you can specify the number of pulses or cycles to be produced by the stimulator, from 1 to 2000, using the Number of Pulses (or Cycles) control at the right of the window. If you choose Step mode, you can specify how many steps, from 1 to 2000, you want in your stepped waveform (but note that only one stimulus is produced). In Ramp mode, the control is disabled.

Marker Channel



If you choose a channel from the Marker Channel pop-up menu, then the point when a stimulus starts is marked by a small data spike (this adds to any data in the channel). If you choose Off, no mark is added. The stimulus marker marks the start of each pulse, step, or ramp, or the start of each cycle for triangle or sine modes. It works at any sampling rate, up to a stimulus frequency of about 10 Hz.

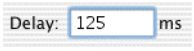
Start Mode



Click When recording starts to start the stimulator when the Start button is clicked. If the stimulus waveform is continuous, the Stimulator Panel controls will then include Off and On buttons to allow you to turn the continuous stimulation off and back on again.

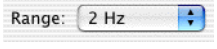
Click Manually to start the stimulator either when the Stimulate button is clicked, either in the Stimulator window or in the Stimulator Panel. (If the waveform is continuous, there will be Off and On buttons in the Stimulator Panel.)

Delay



If you wish the delivery of the stimulus waveform to be delayed after you click Start in the Chart View, or Stimulate in the Stimulator window or the Stimulator Panel, enter a delay time (from 0 to 1 000 000 milliseconds) into the text box.

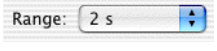
Range, Frequency, and Pulse Duration



For Pulse, Triangle, and Sine modes, the (frequency) Range pop-up menu lets you select the range for the Frequency control, from 2 Hz, 20 Hz, or 200 Hz. You can also choose PPM (pulses per minute), since it can sometimes be more convenient to have frequency stated in terms of minutes. The Frequency control is used to set the pulse or cycle frequency within these ranges, from 0.1 Hz to the maximum in each hertz range, and from 2 to 200 pulses (or cycles) per minute in the PPM range (about 0.033 Hz to 3.3 Hz).

For Pulse mode, the Pulse Duration control sets the time for which the pulse lasts. The time is dependent on the frequency set, since the pulse must be less than the period of the stimulus waveform. The smallest increment is 0.05 ms.

Range, Step Width, Ramp Duration, and Pulse Duration



For Step and Ramp modes, the (time) Range pop-up menu lets you select the range for the Step Width or Ramp Duration controls, from 20 ms, 200 ms, 2 s, or 20 s. The Step Width or Ramp Duration controls set the exact duration for these parameters within these ranges.

The Pulse Duration control (for Step mode) sets the time for which the pulse lasts within the step width — the pulse cannot exceed the step width. If the pulse duration is less than the step width, then the voltage step returns to the baseline voltage before increasing (or decreasing) to the next step. If the pulse duration is equal to the step width, then the voltage steps increase (or decrease), and do not return to the baseline voltage until the whole stimulus waveform is finished.

Range, Amplitude, and Baseline

For Pulse, Triangle, and Sine modes, the (amplitude) Range pop-up menu lets you select the range for the Amplitude and Baseline controls. Ranges of 200 mV, to 10 V are available. The Amplitude control sets the exact voltage, either positive or negative, within these ranges: a negative amplitude starts triangle and sine waveforms at the negative parts of their cycle. The Baseline control sets the exact baseline voltage within the range: triangle and sine waveforms are symmetrical about the baseline, and the pulse waveform just adds the (positive or negative) pulse to it. The baseline voltage is the same output as in the Stimulator Constant Output dialog box, and changing it in either place changes it in both.

▼ ***Refer***
Constant Output Voltage, p. 66

Range, End Level, and Start Level

For Step and Ramp modes, the (amplitude) Range pop-up menu lets you select the range for the End Level and Start Level controls. Ranges of 200 mV, to 10 V are available. The End Level and Start Level controls set the exact voltage level, for the starting and ending voltages of the step or ramp, within these ranges. The start level voltage is the same output as in the Stimulator Constant Output dialog box, and changing it in either place changes it in both.

The Stimulator Panel

Once you have set up stimulation using the Stimulator window, you can easily start or stop stimulation or change settings while sampling, by using the Stimulator Panel miniwindow (see Figure 3–16). Choose Setup > Stimulator Panel to open it.

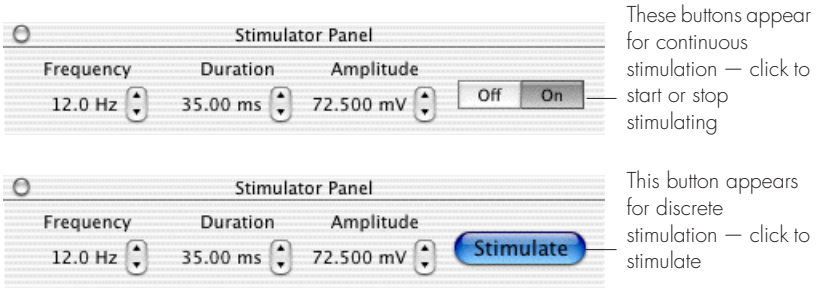


Figure 3–16
The Stimulator Panel miniwindow.

The Stimulator Panel miniwindow 'floats' in front of the active window, can be moved around with its title bar, and can only be dismissed by clicking its close button. If continuous stimulation was chosen, then the Panel will have Off and On buttons, so you can turn stimulation off or on at will. If you have chosen discrete stimulation, then the Panel will have a Stimulate button: click it to deliver a set number of pulses or cycles of a waveform; or for Step and Ramp modes, a single stimulus of varying intensity. As a shortcut, you can type Option-space bar to activate the panel button or buttons, to start a stimulus or turn one on or off.

Click the up or down arrows to increment or decrement the stimulus parameters during sampling — the set value is shown beside the control (the controls appearing depend on the stimulus mode). Changing parameters here changes them in the Stimulator window, and vice versa.

Constant Output Voltage

Stimulation voltages are generated by the e-corder via the outputs on its front panel. Choose Setup > Output Voltage… to set up a constant output. The Stimulator Constant Output dialog box will appear. You can use the controls to set continuous voltages.

The (amplitude) Range pop-up menu lets you select the range for the Amplitude control, from 200 mV to 10 V. The Amplitude control is used to set the exact voltage, either positive or negative, within these ranges. The slider bars can be used to set the value in the normal way, by dragging the sliding handle, or clicking the arrows or the slider bar area. The value is displayed in a text box to the right of the slider bar — you can enter a value directly here. The dialog box can be brought up during recording, so that the voltage can be adjusted, without stopping.

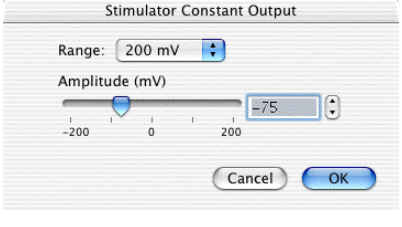


Figure 3–17
The Stimulator Constant Output dialog box.

The voltage is generated as soon as a value is set (the e-corder does not need to be sampling to produce constant voltages, as opposed to variable stimuli). The constant DC output voltage continues until Chart is quit or another application, such as Scope, uses the e-corder. (If you switch out of Chart to Scope and then switch in to Chart again, Chart will restore its set constant output voltage.)

The Stimulator Output

Output voltage signals are generated by the e-corder via the front panel output sockets. The outputs are bipolar, thus a 1 V setting produces +1 V at the Output + connector, and –1 V at the Output – connector, (Figure 3–18). Thus you could generate up to a 20 V output by connecting to both the Output + and Output – sockets and using a a 10 V setting.

The stimulator and constant output voltage work together: the stimulation voltage adds directly to the constant voltage, but the total of the two cannot exceed ±10 V. The output from the Stimulator Constant Output dialog box is the same as the Baseline voltage for Pulse, Triangle, and Sine modes or the Start Level voltage for Step and Ramp modes set in the Stimulator, and changing it in either place changes it in both.)

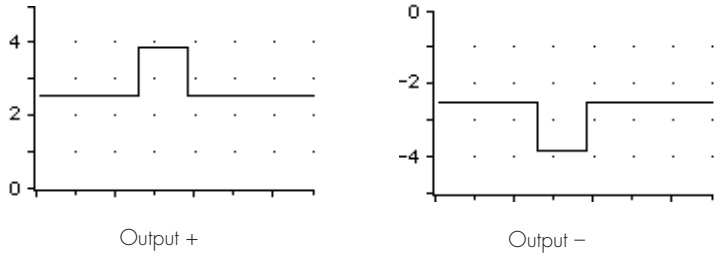


Figure 3–18
A pulse with constant output voltage setting on the stimulator.

4

CHAPTER FOUR

Data Display

Chart allows you great flexibility in displaying data. You can change the lines, patterns, and colors of the data display. You can resize the Chart window, expand or reduce the horizontal scaling, split the screen, and change the size of each channel's display, overlay adjacent channels, or even hide them. You can look at the overall trends in the recording, or look at a small section of data in great detail.

This chapter describes the display options available in Chart, from the basic settings through to Amplitude axis manipulation, channel titles, the Zoom window and displaying digital read-outs.

The Chart Window

As well as the essential controls for recording data, many controls to set the display format directly are provided within the Chart window.

Time Format

Click the Time & Date button, the clock at the top right of the Chart window, to open a dialog box letting you set the time scale mode, and whether to display the date and time when data were recorded.

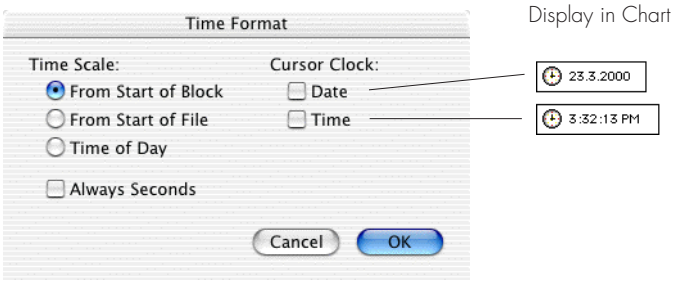


Figure 4–1
The Time Format dialog box.

Time Scale

The Time Scale controls let you choose the form and units of the Time axis. This applies to the whole axis, and can be changed at will just by bringing up the dialog box, since all time information about a recording is stored. The time at the pointer position along the Time axis shown in the Rate/Time display will be in the form chosen here. These controls are duplicated in the Display Settings dialog box, and changing them in either place changes them in both.

From Start of Block. Time is measured relative to the start of each new block of data (this is the default setting). Time is reset to zero at the start of each block of newly recorded data, that is, whenever Start is clicked or recording is started by triggering or the internal timer.

From Start of File. Time is measured relative to the start of the file. This is useful if you want to know the amount of time lost between sampling being stopped and started again.

Note
If you record new data in old files, and choose 'From Start of File', you might end up with very large numbers towards the right of the Time axis. If you append data from different files, you could even get negative times. Check the Time display for the dates and times of recordings.

Time of Day. Time is displayed as the time of day the sample was taken — it uses either 12-hour or 24-hour display depending on the settings in the system's Date & Time control panel. This is useful if you want to know at what time of day an event occurred.

Always Seconds. When the time gets large enough, it is displayed in hours, minutes, and seconds unless the Always Seconds checkbox is checked, in which case the time will be shown in decimal seconds (at high sampling rates, measurements will be shown in milliseconds). This checkbox is dimmed and cannot be chosen when the Time of Day radio button is selected.

Cursor Clock

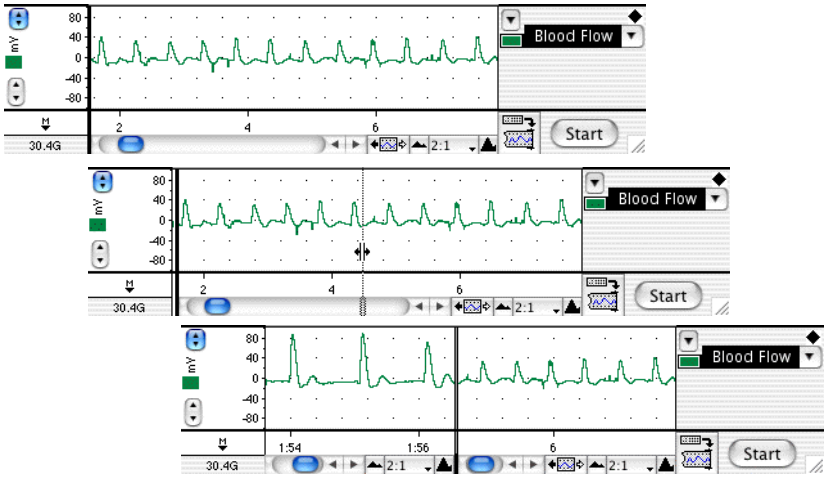
The Cursor Clock checkboxes (see Figure 4–1) control the display of the time and date in the Chart window. If neither is selected, only the Time & Date button (the clock icon) is shown, with no text display. If one or both is selected, the Time & Date button displays beside it the date or time or both at which the samples at the Waveform Cursor positions were recorded, if the pointer is over the data display or Time axis areas (otherwise the text area is left blank). This is handy for checking when data were recorded. The formats used are those set in the Mac OS X Date & Time System Preferences.

Split Bar

You can split the data display area of the Chart window vertically, into two sections or panes, to compare different sections of recorded data, or to compare recorded data with newly sampled data. When recording, the new data are shown in the right section of the window. You can perform most normal operations in the left-hand pane of the window: make selections, use the Zoom and X–Y windows, add comments and exclusions, add data to the Data Pad, copy data to other files, change data compression, and so on.

To split the window, position the pointer on the split bar (anywhere along its height), so that it changes into the split pointer. The vertical split bar is at the left side of the data display area. Drag the split bar to the desired position, so that the two panes of the window are the sizes you want them — a gray line appears, to indicate where it will go — then release the mouse button. You can do this while recording. You

Figure 4–2
Splitting the data display area: drag the split bar to the desired position and release the mouse button.

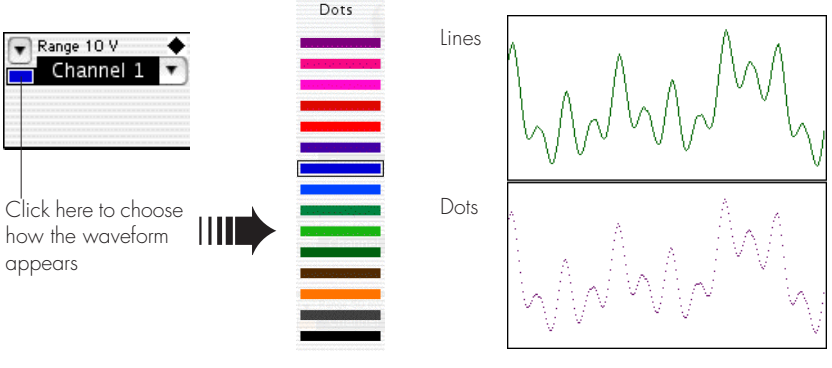


can use the scroll bars of the two panes to scroll through the two views of recorded data independently; keyboard scrolling commands control the right-hand pane. Double-clicking the split bar or dragging it as far left as it will go returns it to the 'off' position at the left of the data display area, and leaves you with a single pane once more.

Waveform Color

To set the channel's data trace color directly from the Chart window, click the Color pop-up menu, the colored box beneath the Range pop-up menu, and choose one of the fifteen display colors. The pop-up menu also lets you choose whether the data points are displayed joined by lines (the default for Chart) or as unjoined dots. Choose Color pop-up > Dots to show a dot for each sampled data point in the waveform. The menu command then changes to Line: choosing this gives you a continuous waveform.

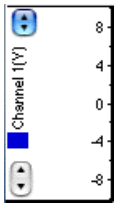
Figure 4–3
The Color pop-up menu.

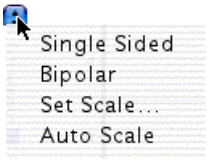


▼ ***Refer***
Color, p. 82

This Color pop-up menu is a simple version of the one that appears in the Color column of the Channel Settings dialog box; changing the settings in either place changes them in both.

The Amplitude Axis





The scale of the (vertical) Amplitude axis of each channel can be independently dragged, stretched, or set through a dialog box for optimum data display. Scale appearance options can be selected from the Scale pop-up menu, the button for which is located at the top left of each channel's Amplitude axis. The Bipolar and Single Sided options are disabled if units conversion is applied, or if the channel has no data. (The Scale pop-up menu for overlaid channels shows the overlaid channels as well, so you can see or set the active one.)

Single Sided. This option can be used to view only positive voltage signals. It shifts the vertical axis so that zero volts is located at the bottom of the display area. Any readings below zero volts will be off the screen (to see them, select the Bipolar option or drag the scale).

Bipolar. This is the default mode for each channel in Chart. It shows both positive and negative signals, with zero volts at the center of the vertical scale if no shifting or stretching has been applied.

Set Scale. This option allows you to adjust the Amplitude axis directly to show the range of values you want. It works whether units conversion is on or off. When you choose Set Scale…, the Set Scale dialog box for that channel appears, Figure 4–4, allowing you to type in directly the upper and lower limits of the scale to be displayed.

Auto Scale. This option scales the waveform currently visible in the channel to fit it vertically to the display area: the upper limit of the scale

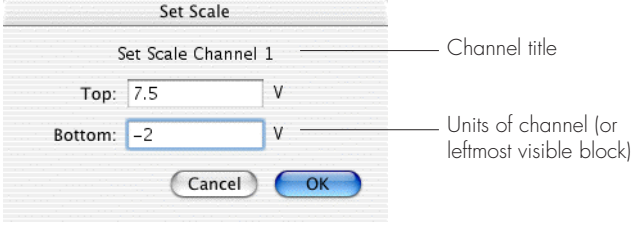


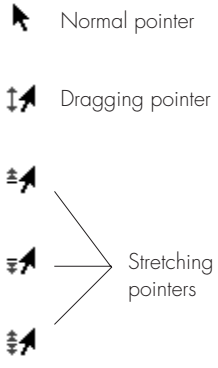
Figure 4–4
The Set Scale dialog box.

is set to the value of the highest peak and the lower limit to the value of the lowest trough. (This applies even if the signal is very small, such as background electrical noise.)

The Scaling buttons are at the bottom left of each channel's Amplitude axis. Click the up button to enlarge or down button to reduce the vertical scale, halving or doubling what is shown each time.

The scale of the Amplitude axis can be shifted or stretched or both. This would allow you to enlarge the signal viewed on the screen, for instance, or move it to fit better in the display area. The pointer changes, Figure 4–5, as it is moved over the Amplitude axis area. At the left of the area, it is a normal, leftward-pointing arrow. To the right of the area, though, the pointer points to the right, and a small marker appears beside it, indicating its function. Between numbers on the scale, a double-headed arrow indicates that dragging will move the scale. If the pointer is opposite a number on the scale, two triangles point away from the mid-point on the axis, indicating that dragging will stretch the scale in the direction they point — and dragging in the opposite direction will compress it (when you press the mouse button down, the number beside the pointer is outlined by a gray box to indicate that it is the dragging point).

Figure 4–5
Pointer changes in the Amplitude axis.



The Amplitude axis can be indefinitely expanded and contracted by stretching or compressing the scale, or using the Scaling buttons or the Set Scale dialog box. Whenever the scale of a channel is altered, the numbers for the scale in the Amplitude axis are changed to suit.

Double-clicking in the Amplitude axis area returns a shifted or stretched scale to its normal, unstretched position, with zero at the mid-point of the axis (the Bipolar display). Double-clicking in the Amplitude axis area repeatedly cycles an unshifted, unstretched waveform through Single Sided display, Bipolar display, and Auto Scale display, in order, from its current state.

Auto Scale All Channels

You can auto-scale the Amplitude axis in all channels simultaneously by choosing Commands > Auto Scale Data or clicking the Auto Scale button in the Tool bar. This scales the data currently visible in each channel so that the upper limit of the scale is set to the value of the highest peak and the lower limit to the value of the lowest trough. If the

Zoom window is open, the Auto Scale Data command scales the data in each channel shown there too.

Changing Channel Size

To change the size of a channel's display, position the pointer over one of the channel separators (anywhere along its length), so that it changes into the separator pointer. Drag the channel separator to the desired position — a gray line appears, to indicate where it will go — then release the mouse button. (See Figure 4–6.) You can do this while recording, if you need to change the data display.

When a channel is thin, the title that appears in the Amplitude axis disappears, so that only the data trace color and units are displayed. When a channel is very thin (a quarter inch, 5 mm, or less at 72 dpi), then there is little point displaying the data, so its data display area appears gray (as does a channel that is turned off while recording). Turning on or off multiple channels (by holding down the Command key and selecting the top command from a Channel Function pop-up menu) will turn off channels in this state, but won't turn them on.

If you drag a channel separator past others, it will pick them up — for instance, if you drag the separator of a channel up, you will drag up all those of the channels above it as well (a gray line appears for each channel). Double-clicking a channel separator also divides the data display area evenly into the number of visible channels.

▼ ***Refer***
Number of Channels, p. 83

Note that the resolution of the recorded data is independent of the resolution of the display. Unless a channel is turned off, data will be logged in it at full fidelity during recording, even if the channel separators have been adjusted so that the channel is very thin (with a gray data display area), or not visible on the screen.

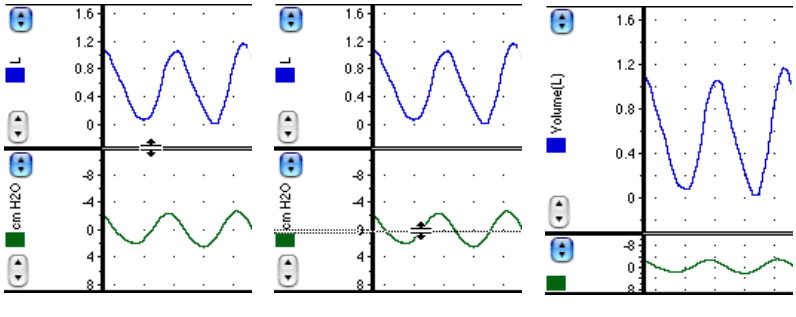


Figure 4–6
Changing a channel's size: drag the channel separator until the gray line is where you want it to be, and release the mouse button.

Overlaying Channels

You can overlay adjacent channels in the Chart window to compare their waveforms directly. From two to all of the channels can be overlaid, in one or more sets. For instance, you could overlay Channels 2 and 3, and Channels 6, 7 and 8, in two separate sets.

To overlay channels from the Chart window, Option-click the channel separators between them. The channel separators vanish, and the once-separate channels are overlaid. You can also use the Channel Settings dialog box, which lets you both turn off channel separators to overlay channels, and turn them on to separate the overlaid channels again (you can't separate overlaid channels from the Chart window).

▼ ***Refer***
Channel Separation, p. 83

The area used by the overlay is the sum of the areas used by channels individually. Waveforms in the data display area are kept at the same ratio of amplitude to full scale as they were individually. The channel controls of overlaid channels are fitted into the minimum space at the top of the channel control area at the right, and there is only one Scale pop-up menu in common in the Amplitude axis at the left.

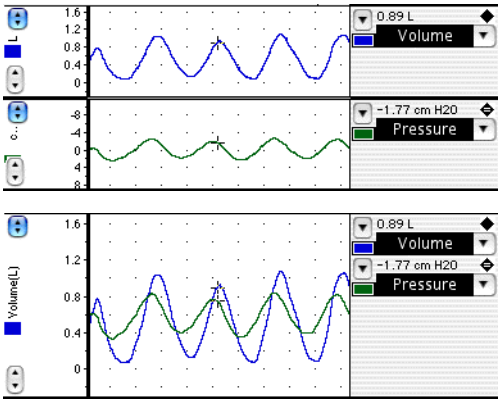


Figure 4–7
Overlaying channels: top, separate; bottom, overlaid.

The active channel, by default the top channel in a set, has its title, scale, and so on shown in the Amplitude axis. Shifting, stretching, and scaling operations affect only the active channel. The colored square beside the title, the same color as its data trace, helps to identify it. To adjust a waveform's position and scale, choose its channel from the bottom half of the Scale pop-up menu, which lists the titles of the

channels in the overlaid set: the chosen channel becomes the active one. The active channel has a tick beside it.

Waveforms are drawn from the top channel first, so the lowest channel in a set will be in front of the rest. Each waveform is tracked by a Waveform Cursor when the pointer is over the data display area, and the read-out shown in the Range/Amplitude display at the right. Overlaying in the Chart and Zoom windows is independent.

▼ ***Refer***
Measuring from the Waveform, p. 130

Display Settings

The Display Settings dialog box lets you choose the form and units of the Time axis, the way that Chart displays data as it records and how and whether blocks, comments and exclusions are shown. You can also use it to change the color and form of the graticule (the display grid) in all windows, and choose the line pattern or color of the X–Y plot. Choose Setup > Display Settings… to open the Display Settings dialog box.

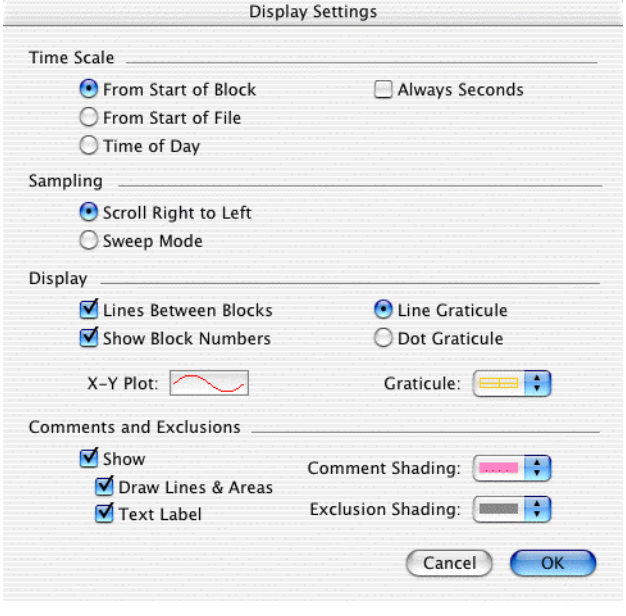


Figure 4–8
The Display Settings dialog box.

Time Scale

The Time Scale controls let you choose the form and units of the Time axis. This applies to the whole axis, and can be changed at will in the dialog box, since all time information about a recording is stored. The time at the pointer position along the Time axis shown in the Rate/Time display will be in the form chosen here. These controls are duplicated in the Time Format dialog box, and changing them in either place changes them in both.

▼ ***Refer***
Time Format, p. 70

Sampling

When the Scroll Right to Left option is chosen (the default), recorded data scroll across the data display area from the right of the Chart window as if the display area were a roll of paper in a mechanical chart recorder. New data are drawn at the right and old data are moved towards the left. You don't have to live with an old chart recorder's way of doing things, though. When the Sweep Mode option is selected, data are drawn on the screen from left to right, and when the right edge is reached, drawing starts again at the left (a vertical line precedes the newly drawn data as they cross the screen). Data are easier to view while being recorded if they are not moving quickly at the same time.

▼ ***Refer***
Slow and Fast Sampling Rates, p. 37

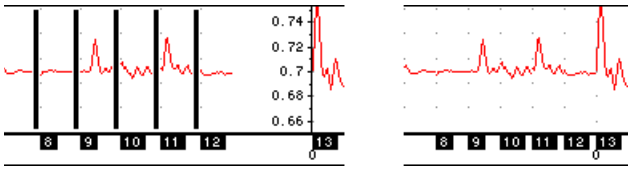
At the fastest sampling rates, recorded data is drawn as if in Sweep Mode, even if Scroll Right to Left is chosen.

Display

Lines Between Blocks. If this control is on, Chart draws a solid black vertical line between user-defined blocks of data to indicate some form of discontinuity, such as sampling being stopped and then restarted, a channel being turned off, or sampling rate being altered. A new scale is drawn in the channel if its range is changed. If you turn off this control, no separation line or new scale is shown between blocks. This is useful when you are recording for limited durations at very fast sampling rates, and so getting very short blocks.

Show Block Numbers. If this control is on, block numbers are shown at the start of blocks as white-on-black tags in the Time axis. They mark

Figure 4–9
A recording of short segments: left, with block lines; right, without.



blocks even if lines and scales are not being drawn between blocks. Turn off this control to hide them.

X–Y Plot. The Color pop-up dialog box for the X–Y plot is identical to those for the various channels in the Color column of the Channel Settings dialog box, but applies only to the plot of data from one channel against data from another in the X–Y window. There are fifteen colors and three thicknesses; click on colors and thicknesses to select them. Select Join Points with Line to show a continuous data trace, or select Show Points as Dots to show the waveform with a dot at each sampled data point. The waveform on the right of the dialog box gives you an idea of how the data will look.

▼ ***Refer***
The X–Y Window, p. 145

Figure 4–10
The Color pop-up dialog box.

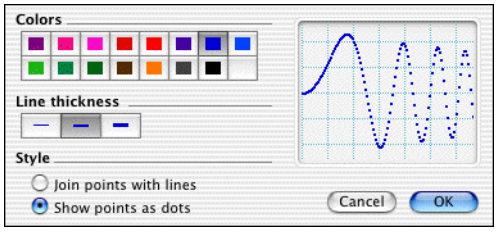


Figure 4–11
The Graticule Color pop-up menu.

Line Graticule and Dot Graticule. Choose the Line Graticule radio button to show a grid of dotted lines, or Dot Graticule to show a dot graticule of the chosen color.

Graticule Color. The graticule (or display grid) chosen from the Graticule pop-up menu (see Figure 4–13) affects the Chart, Zoom, and X–Y windows. The pop-up menu lets you choose the color of the graticule from the fifteen colors available; choosing Off hides the graticule. The graticule lines up with the unit divisions in the Time and Amplitude axes (divisions in the Time axis are always 20 pixels wide).

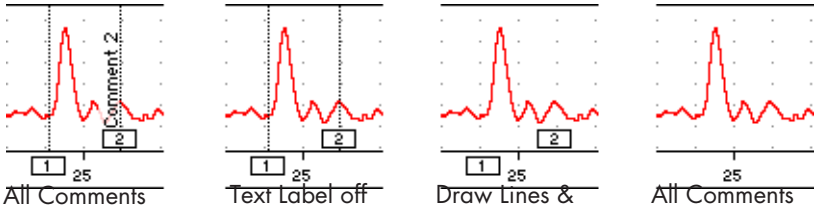
Comments

The Comments controls cover both normal comments and exclusions, a special category of comment. The checkboxes affect both.

Show. If this control is on, comments are marked in the recording by numbered comment boxes. They can be hidden by turning this control off (this also inactivates the checkboxes below it). This may be useful for printing, if you don't want data obscured by comment boxes, lines, areas, and text. (Comments can be printed independently from the Comments & Exclusions window, if you don't want to see them on the Chart data printout.)

▼ ***Refer***
Printing Comments, p. 123

Draw Lines & Areas. Comments can be associated with points or areas. If this control is on, a dotted vertical line is drawn through the point, or a light shading is applied to the area, to make location easier. Turning this control off may again be useful for printing, if you don't want data obscured.



All Comments checkboxes on | Text Label off | Draw Lines & Areas off | All Comments checkboxes off

Figure 4–12
Effect of comment checkbox settings.

Text Label. If this control is on, as much of the text of a comment as will fit is shown vertically beside a comment line, or horizontally across an area to the right of the comment box. The comment text appears in the channel of a channel-specific comment, or in the top channel of one applying to multiple channels. Vertical text dims the waveform beneath it.

Comment & Exclusion Shading. When an area rather than a point is commented or excluded, it is marked by a shaded region. The pop-up menus let you choose the color of the region from the fifteen light and pastel hues available (see Figure 4–13); obviously different shades should be chosen for comments and exclusions. Choosing Off hides the color, but leaves areas marked with a dotted line around their boundaries (if the Draw Lines & Areas checkbox is on).

Figure 4–13
The Comment and Exclusion Shading pop-up menu.

Channel Settings

The Channel Settings dialog box lets you set up multiple channels conveniently: you can both see and specify recording and display settings for each channel in the one place. To open the dialog box, choose Setup > Channel Settings… or type Command-Y. Note that when there is no e-corder connected, a smaller version with only display settings visible will appear. The columns in the dialog box are summarized in the Chapter 3, and most of the recording settings are discussed in detail. Most of the display settings are discussed in detail in this chapter.

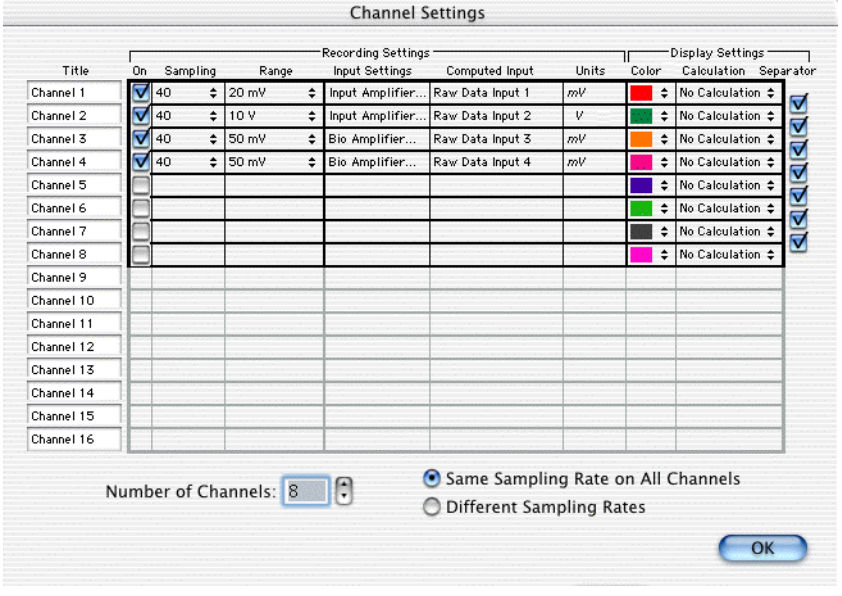


Figure 4–14
The Channel Settings dialog box.

Channel Titles

Normally the titles for each channel displayed at the right of the Chart window are 'Channel 1', 'Channel 2', and so on, down from the top. You can change the titles, if you wish, to indicate what you are recording. To do this, select the text entry box for a channel in the Title column of the Channel Settings dialog box, and type in a new title to overwrite the default one. Tab down the column to select each title in turn, to change many titles at once. Text in the text entry boxes can be

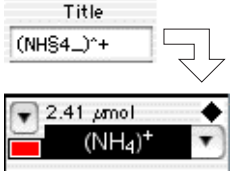
edited normally. If entries are left blank, the default titles ('Channel 1' and so on) will reappear when the dialog box is closed.

Most of the characters found in the system fonts should be available: use Key Caps to remind you how to get unusual characters, such as Ω (Option-Z), the degree sign, ° (Option-Shift-8), or Δ (Option-J).

Superscripts and Subscripts

Superscripted and subscripted characters, such as those occurring in Na^+ or C_2H_5OH, can be used in a channel title (and unit definitions).

- To superscript a character or characters, type Shift-6 (^), the caret character, before it or them.
- To subscript a character or characters, type Option-6 (§), the section character, before it or them.
- To return to normal characters after superscripting or subscripting, type Shift-hyphen (_), the underscore character.



The caret, section, and underscore characters appear in the text entry boxes, but not in the channel title. Ten characters at most, including those used to superscript and so on, can be entered for a title.

Once you have changed the titles of the channels you wish to affect, click OK to close the dialog box and apply these (and other) changes to the Chart window. If the title is too wide to fit in the title area of the Channel Function pop-up menu, it is truncated and an ellipsis (…) replaces the extra characters in the display.

Color

The Color pop-up menus for the channels, in the Color column of the Channel Settings dialog box, let you set the color and thickness of the data trace in a channel, and whether the data points are displayed joined by lines or as unjoined dots. Click the Color buttons to open the Color pop-up dialog (see Figure 4–10). There are fifteen colors and three thicknesses; click on colors and thicknesses to select them. Select Join Points with Line to show a continuous data trace, or select Show Points as Dots to show the waveform with a dot at each sampled data point. The waveform on the right of the dialog box gives you an idea of how the data will look (see also the waveforms in Figure 4–3).

▼ ***Refer***
Waveform Color, p. 72

While the color applies to the waveform anywhere, the thickness applies only in the Zoom window, and not in the Chart window (or Overview miniwindow for that matter), where waveforms are always drawn as one-pixel-thick lines or single-pixel dots. For this reason, the Color pop-up menu for a channel in the Chart window is a simple version of the one here, and does not affect the thickness of the waveform.

Channel Separation

The Separator checkbox lets you turn a channel separator off (when it is unchecked) or on (checked). Channels that are not separated are overlaid in the Chart window, letting you compare their waveforms directly: the line between channels in this dialog box also disappears when the channel separator is turned off so that the setting is easy to see at a glance. You can overlay adjacent channels from the Chart window (by Option-clicking the channel separators), but you can only turn overlaying off using these checkboxes.

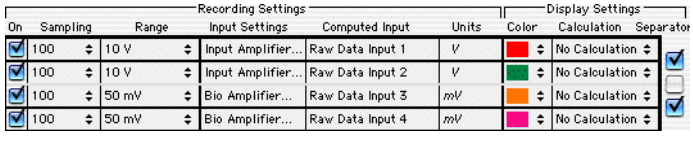
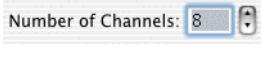


Figure 4–15
The Separator control in the Channel Settings dialog box.

Number of Channels



The Number of Channels control, at the bottom of the dialog box, lets you choose the number of channels displayed in the Chart window. Use the up or down arrows to increment or decrement the number, or type a value in the text entry box directly. The control's text entry box is highlighted when the dialog box is first opened, so that you can quickly change the number of channels used by Chart just by typing a number and pressing Return or Enter.

This control both turns channels off, so that no data are recorded (just as the checkbox in the On column does), and hides them, so that the data display area is not cluttered with channel separators. The data display area in the Chart window is divided evenly into the number of channels set. The lower channels are turned off and hidden first: their rows in the dialog box are blank and their borders grayed out. This feature is very useful: not everyone needs all possible channels all the

time, and it is handy to get them out of the way, and not have bunched-up channel separators using space in the data display area.

The Overview Miniwindow

The Overview miniwindow allows you to see all of a channel's data at once, to make locating particular events easier. It is useful for large recordings where you don't want to keep using the View buttons: you can look at the data in the main Chart window at a view of 1:1, while still having an overview of a channel to see longer-term trends. To open the Overview miniwindow, choose Window > Overview or type Command-M.

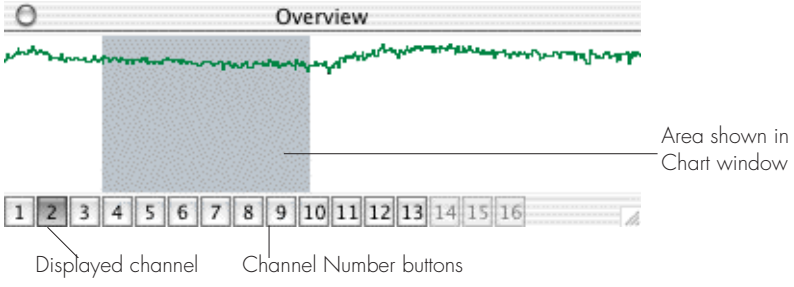


Figure 4–16
The Overview miniwindow.

The Overview miniwindow 'floats' in front of the active window, can be moved around with its title bar, and can only be dismissed by clicking its close button. It can be resized using the size box at its bottom right corner. The displayed channel can be changed by clicking the Channel Number buttons at the bottom left of the miniwindow — they correspond to the numbers in the default channel titles. The number of the displayed channel is highlighted. Buttons for channels containing no data are dimmed and unavailable.

The data currently displayed in the Chart window are highlighted (black on white) in the Overview miniwindow. You can scroll the contents of the Chart window by dragging this highlighted rectangle. If you click outside the highlighted area on a particular segment of the recording, the highlighted area is centered where you click, and the event is also centered in the Chart window. This enables you to locate events of interest quickly in large recordings. You can keep track of where you are by shrinking the miniwindow to a small size and leaving

it in an unused area of your screen. If you are using it on a huge file, the inverted area may be quite narrow: if so, drag the size box to enlarge the miniwindow and the area along with it (or use the View buttons to increase the data shown in the Chart window).

If the data display area of the Chart window is split into two panes, the highlighted area in the Overview miniwindow only shows the display area of the right-hand pane. The Overview miniwindow might initially take a long time to draw on large files with many data points (although it is optimized for most very large files). To interrupt its drawing, type Command-period: if you do this, the miniwindow will appear gray. Click a Channel Number button or the display area to make the miniwindow draw an overview once more.

The Zoom Window

In the Zoom window, you can look at a small section of data in great detail, either in one channel or in several channels over the same period of the recording. To zoom in on a data selection, drag to select an area of interest in the Chart window (in the Time axis for multiple channels), and choose Window > Zoom Window or click the Zoom Window button in the Tool bar: the Zoom window appears.

▼ ***Refer***
Selecting Data, p. 98

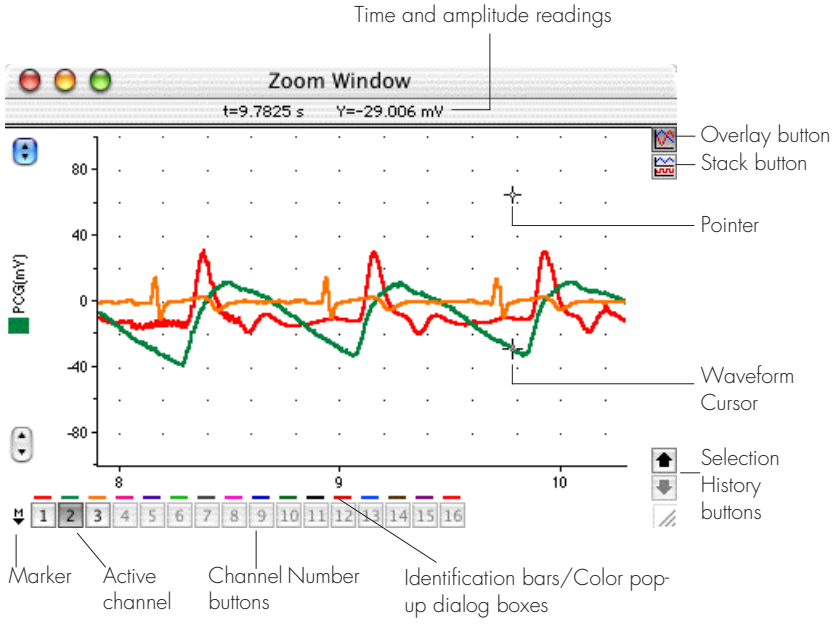


Figure 4–17
The Zoom window.

The Zoom window is a normal window, and can be moved around the screen or left in the background while the Chart window is active. It can be resized using the size box at its bottom right corner. By default, the Overlay button is on, and if multiple channels are selected, their waveforms are superimposed. Waveforms are drawn from the top channel first, so the lowest channel in a set will be in front of the rest. Overlaying or lack of it in the Zoom window is independent of any overlaying in the Chart window. The numbers of the Channel Number buttons at the bottom left corner of the window correspond to channel numbers, and buttons for channels with no selected data in the Chart window appear dimmed.

The Stacked View

If the Stack button is clicked, then the Overlay button is turned off, and selected channels are displayed stacked one below the other in much the same way that they are displayed in the Chart window. The height devoted to each channel is in the same proportion as in the Chart window, with channel titles and units shown at the left, or just units if the channel is thin. Any overlaying in the Chart window is ignored. Clicking the Overlay button turns off the Stack button and superimposes channel waveforms again.

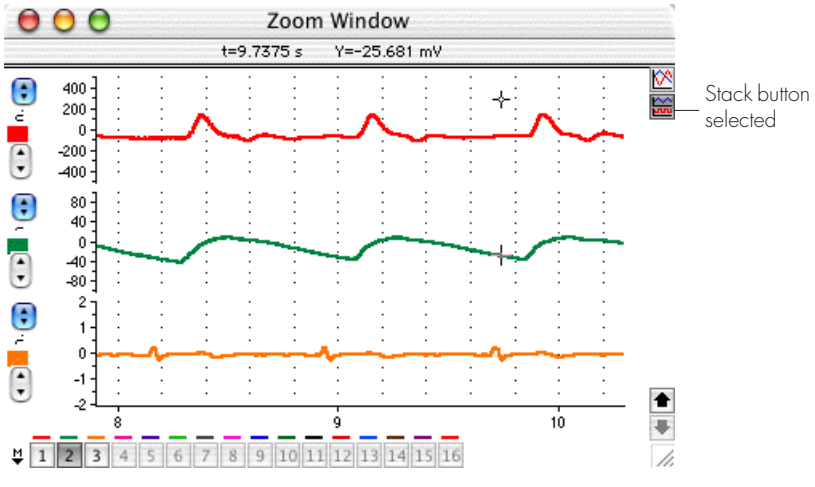


Figure 4–18
The Zoom window with the Stack button on — this is the same selection as shown in Figure 4–17.

Data Display

The highlighted Channel Number button indicates the waveform that the Waveform Cursor tracks (the active channel), whether the channels are overlaid or stacked. The time (t) and amplitude (Y) readings at the tracking point are indicated at the top of the window, in the forms of time and units set using display settings and units conversion. The active channel can be changed by clicking one of the (undimmed) numbered buttons at the bottom left corner of the window, or clicking on a different waveform. In either case, the button of the selected channel will be highlighted to indicate the channel now tracked.

▼ ***Refer***
Measuring from the Waveform, p. 130

The Marker from the Chart window is duplicated in the Zoom window — moving it onto a waveform in one will do the same in the other, double-clicking it will send it home, and so on. Its behaviour is also similar in the Zoom window, although there is a slight difference because the Waveform Cursor only tracks the active waveform, if there are several. When the Marker rests on the active waveform, relative measurements (preceded by Δ) are given in the readings for both time and amplitude; when the Marker rests on one of the other waveforms, the display is of relative times but absolute values.

▼ ***Refer***
Using the Marker, p. 131

A short bar of the color and thickness chosen for the channel waveform is shown above the Channel Number button to aid identification. It also doubles as a Color pop-up dialog box to let you choose settings for a channel's data trace. It is the same as the Color pop-up menus in the Channel Settings dialog box and for the X–Y plot in the Display Settings dialog box (see Figure 4–10). There are fifteen colors and three thicknesses; click on colors and thicknesses to select them. Select Join Points with Line to show a continuous data trace, or select Show Points as Dots to show the waveform with a dot at each sampled data point. The waveform on the right of the dialog box gives you an idea of how the data will look. The color applies to the channel waveform anywhere; the thickness applies only in the Zoom window.

▼ ***Refer***
Color, p. 82

If the selection in the Chart window is discontinuous (straddling two or more blocks), then the Zoom window displays a thin line to indicate a block boundary, and a thicker line to indicate a scale change, unless you have chosen to turn off the display of lines between blocks.

▼ ***Refer***
Display, p. 78

Changing the Selection

You don't have to return to the main window to change the selection in the Zoom window. Instead you can move, scale, and zoom in on data from the Zoom window. All changes made to the selection are reflected in the Chart window.

To zoom in further on data simply drag in the data display area to highlight an area of interest (you cannot drag in the Zoom window's Time axis). When you let go the mouse button, the selection expands to fill the data display area. If channels are stacked, you can change the vertical extent of the selection in the channel in which you drag, but the full height of the other channels is always selected. The horizontal extent will be the same over all channels.

The Amplitude axis in the Zoom window is the same as the one in the Chart window, and the controls function identically. If the channels are overlaid, then shifting, stretching, and scaling operations affect only the active channel (except for the Auto Scale Data command, which scales all channels), which has its title, scale, data trace color, and so on shown in the Amplitude axis.

▼ ***Refer***
The Amplitude Axis, p. 73

You can manually scroll data, as you can in the Chart window, by holding down the Option key while the pointer is over the data display area: this turns the pointer into a hand that can drag the data back and forth or up and down, to move the selection where you want it. (You cannot 'push' the data in the Zoom window, though.)

Changes made to selections are noted, and can be recalled by the Selection History buttons at the bottom right of the window. The up button takes you back through the selection states, and the down button takes you forward again. The selection history covers all states since the Zoom window was last closed, including selections made in the Chart window before the Zoom window was opened again. (It does not keep track of whether the selection was overlaid or stacked.)

Miscellaneous

The Zoom window might take a long time if the selection has many data points (millions). To interrupt its drawing, type Command- period: if you do this, the data display area will appear gray. Click the display area to make it draw the selection once more.

Double-clicking in the Zoom window adds relevant data at the active point to the Data Pad, just as it does in the Chart window: the expansion of the waveform in the Zoom window display obviously allows greater accuracy in selecting data points.

If you hold down the Command key when clicking a data point in the Zoom window, that data point is located and centered (if possible) in the Chart window. This is useful if you have selected a large area in the Chart window to zoom in upon, so that the data in the Zoom window ends up compressed. If you have zoomed in on a particular segment of data, and then scrolled through the Chart window to somewhere else, then if the selection has not changed, you can Command-click in the Zoom window to return to where you were.

Copying and Printing the Zoom Window

When the Zoom window is active, then the Print option in the File menu changes to Print Zoom…, and if the command is selected, the contents of the window are printed with the title 'Zoom of' and the file name. The Zoom window can also be copied as a picture for pasting into other applications, by choosing Copy Zoom… from the Edit menu.

Displaying Digital Read-outs

The DVM submenu of the Window menu provides a digital voltmeter for each channel (hence the name), and read-outs of the sampling time, in the form of resizable miniwindows. The miniwindows can let you keep an eye on recorded values from the other side of the room, for instance. To open one, choose a menu command from the DVM submenu, or drag the Range/Amplitude display for a channel, or the Rate/Time display, to tear it off.

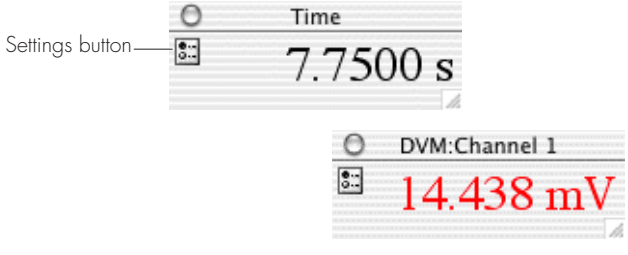


Figure 4–19
DVM miniwindows — for Rate/Time and Channel 1.

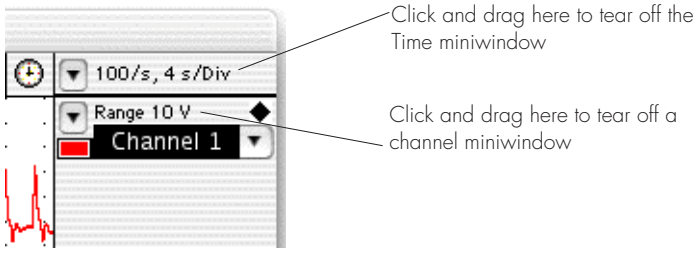


Figure 4–20
Tearing off DVM miniwindows.

A DVM miniwindow 'floats' in front of the active window, and can be moved around by dragging its border. It may be resized using the size box at its bottom right corner and can only be dismissed by clicking its close button. The title bar displays 'Time' or the name of the channel to which it applies. You can have one miniwindow for each channel, and another for Time.

When sampling, the DVM miniwindow shows the current input value in the units used for the channel. If the channel is off, the word 'Off' appears. When not sampling and with the pointer over the data display area (or Time axis), the Waveform Cursor tracks the waveform, and the DVM miniwindow displays the sample data or time values at the Waveform Cursor position. When the miniwindow is resized, the text also changes size for optimum fit. Thus, enlarging the window will make the text easier to read. The text color for the Time miniwindow is black. For channel data it is the same as the trace in the corresponding channel.

DVM Settings

The DVM Settings dialog box (Figure 4–21) is displayed either by clicking the Settings button in a miniwindow, or by selecting Settings… from the DVM submenu of the Window menu. The Settings dialog box provides a means to enable or disable certain advanced features of DVM used during sampling.

Simple Mode

With Simple selected, DVM updates its display whenever Chart has the time to do so. This means that the updates are asynchronous, and represent whatever sample value happens to be present at the time DVM requests it for display. This mode of operation has the advantage

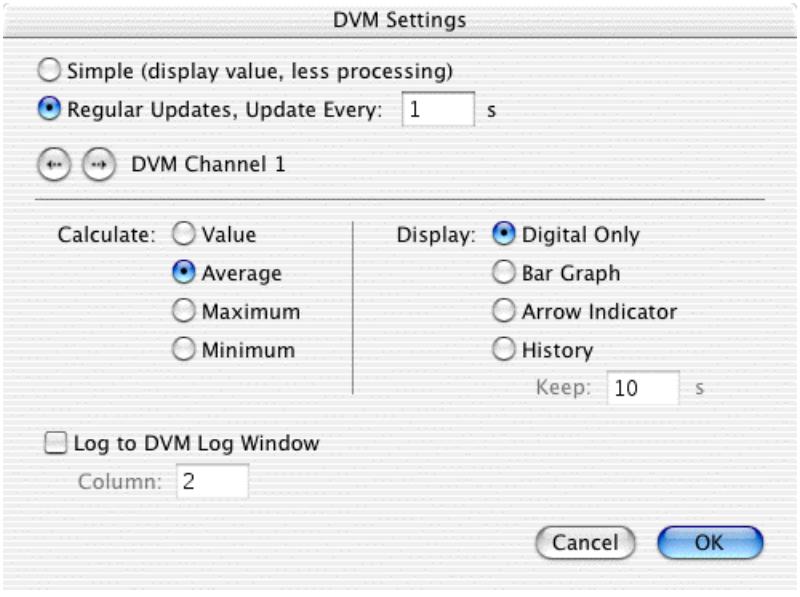


Figure 4–21
The DVM Settings dialog box.

of requiring minimum computational overhead, and thus does not interfere with Chart sampling at high speeds.

Regular Updates Mode

With Regular Updates selected, DVM synchronizes itself with the data stream and processes every sample. This makes possible simple computations, such as data-point averaging, as well as periodic data-logging. It also adds a significant computational overhead, which may interfere with high-speed sampling or other tasks. If this overhead turns out to be too high, Chart will stop sampling and issue a warning.

When the Regular Updates mode of operation is chosen, data are computed periodically, the interval being the value entered in the Update Every text box. If the computer is busy, the updates may appear at irregular intervals. If the update rate is higher than the sampling rate in a channel, Chart will update at the lower rate. Where different channels have different sampling rates, the channel with the highest rate will be the one used to determine the update rate.

The horizontal arrows allow paging through the settings panels for Time and all available channels. The settings panels are only enabled when

the Regular Updates mode is selected. Since they don't apply, some of the settings panel items for Time are always grayed out.

In the Regular Updates mode of operation, new display options also become available. In addition to the default display, Digital Only, the user may select to display either a Bar Graph or an Arrow Indicator. It is also possible to keep a History of recent data points, which is a self-scaling graph of those points. The number of points displayed in the graph depends on the time value entered in the Keep text box.

The values displayed and/or logged may be the Value of the last sample in the interval, or the Average, Maximum, or Minimum values of all the samples in the last interval.

If the Log to DVM Window check box is selected, the data will be logged to the DVM Log window, in the column entered in the text box. Upon starting each sampling run, and to aid with the identification of the columns, the title 'Time' or the name of the corresponding channel will also be displayed in the same column. The DVM Log window can be displayed by selecting it from the Window menu.

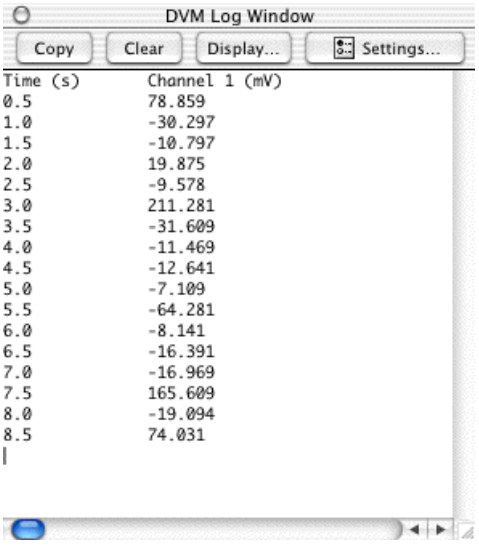
The data in the window may be copied to the clipboard and pasted into other applications, such as word processors and spreadsheets. They can also be saved to disk as a text file. If more than one channel is set to display in a given column, the numbers from the higher-numbered channel are displayed.

The DVM Log Window

The DVM Log window can be used for the periodic logging of data, which can then be exported to other applications for further processing, or saved to disk as a text file. It is opened by selecting DVM Log Window from Chart' s Window menu, and only works when Regular Updates mode has been selected in the DVM Settings dialog box.

Logged data are displayed in the window as columns. The appearance of these columns is controlled by the DVM Log Window Settings dialog box, which is displayed by clicking the Settings… button at the top of the DVM Log window. Font types and sizes, as well as the column width, can be adjusted by clicking on the Display… button.

Figure 4–22
The DVM Log window.



Clicking the Copy button places a copy of the entire content of the DVM Log window on the clipboard. Clicking the Clear button permanently deletes all logged data.

5

CHAPTER FIVE

Working With Files

Chart files can be easily accessed with the Experiments Gallery, and can be edited, printed, and saved to disk in various formats. This chapter describes these operations, and such features as creating a single file summarizing results from many files, and saving settings to allow easy repetition of an experiment. Other topics covered include the transfer of data to other applications, the use of comments and exclusions, and the Notebook, and finding particular Chart files quickly.

The Experiments Gallery

The Experiments Gallery is a framework that provides easy access to Chart data and settings files, as well as any related material such as documentation, text files or multimedia files.

It is particularly useful in a teaching environment as it allows teachers to organize files for different experiments and make them easily accessible to students. If you are a researcher you will also find it useful for organizing and getting easy access to your recordings.

Using the Experiments Gallery

Before you can use the Experiments Gallery, it must have been created and files or folders must have been added. This may have already been done in your version of Chart, but if not, see Managing the Experiments Gallery, p. 97.

Once the Experiments Gallery is in place, the Experiments Gallery dialog box will be displayed when you choose Experiments Gallery… from the File menu. If you select the Show at startup checkbox at the bottom of the dialog box, it will also be displayed when:

- You start Chart without a document (for example, when you double-click the Chart desktop shortcut
- You close the last open Chart document.

The left-hand pane of the dialog box contains a folder hierarchy of the Experiments Gallery contents. It is similar to the Macintosh Finder and is navigated in the same way, clicking on the disclosure triangles to expand branches of the folder structure, for example. In the right-hand pane are shown the files in the folder selected in the left-hand pane. The selected file is indicated by shading, and can be opened by clicking the Open button. Alternatively you can double-click files to open them.

Depending on how the Experiments Gallery has been set up, there may be an information area above the file list (as shown in Figure 5–1), containing comments about the contents of the selected folders.

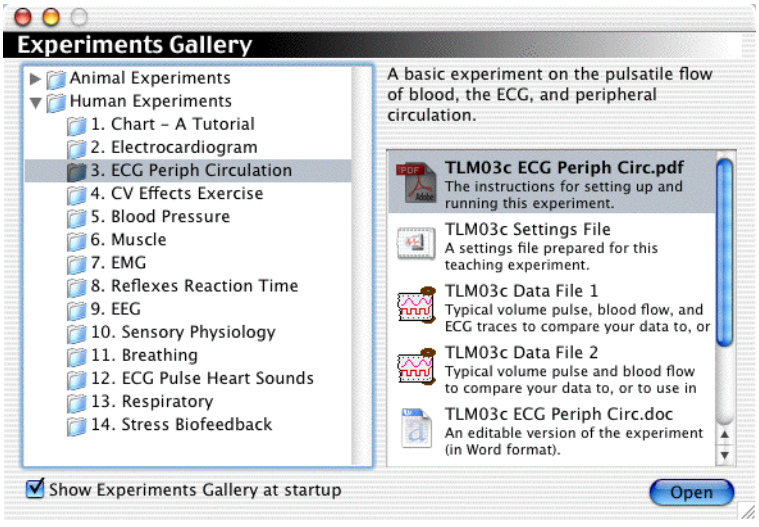


Figure 5–1
The Experiments Gallery dialog box.

Individual files may also have labels describing them, in addition to their file name.

Managing the Experiments Gallery

If you are a teacher or a researcher, you will probably want to create an Experiments Gallery tailored to your own needs.

First, create a folder called 'Experiments Gallery' in the same folder as the Chart Application (Figure 5–2). Note that this folder may already exist, depending on your version of Chart.

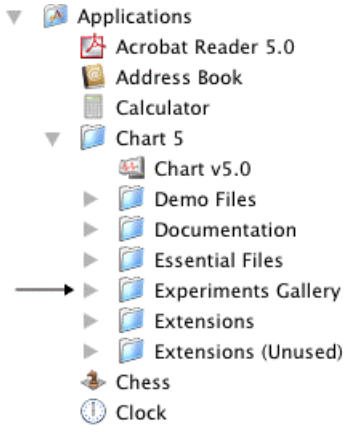


Figure 5–2
Creating the Experiments Gallery folder.

Add folders and files to the Experiments Gallery folder you have created (if there are no folders or files in the Experiments Gallery folder, the Experiments Gallery dialog box won't appear in Chart). You can organize the folders and files in a manner which suits the structure of your experiments. You can add shortcuts as well as files, to give access to files stored on a network, for example. Remember that it can be useful to add documentation, text files, multimedia files and so on to the Gallery. The folders and files will be displayed with the same hierarchy in the Experiments Gallery dialog box.

To delete the Experiments Gallery, and stop the dialog box from appearing in Chart, either remove all the folders and files from the Experiments Gallery folder, or delete the Experiments Gallery folder entirely.

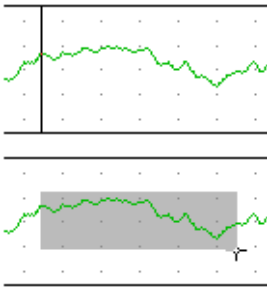
▼ ***Refer***
Experiments Gallery Configuration Files, p. 263

You can control the way the files in a folder contained in the Experiments Gallery appear by creating a 'configuration file' and including it in the folder. Details on creating configuration files, with an example, can be found in Appendix D.

Selecting Data

If you click in the Time axis, a blinking vertical line indicates the active point over all channels; if you click in a channel, the blinking line and active point are confined to one channel (Figure 5–3, top). An active point is distinct from a selected area, and is used for adding comments, transferring information to the Data Pad, and so on. Although you can copy a single data point to the Data Pad, you cannot copy it to the Clipboard, save it as a file, or zoom in on it.

Figure 5–3
An active point (top) and a selection rectangle in a channel of the Chart window.



To select an area of data in one channel, position the pointer and drag to highlight a rectangular area (Figure 5–3, bottom). Shift-click to extend the selection in the channel. The extent of vertical selection affects display in the Zoom and X–Y windows, but will not affect transfer of information to the Data Pad, printing the selection, or saving the selection as a file: these operations will use the full array of data points over the recording period of the selection. Command-drag to select the full height of a channel.

To add channels to a selection, hold down the Shift key and drag in the display area of the channels you want: the vertical extent of the

selected rectangle in other channels can be varied, but the horizontal extent will be the same as that in the first selected channel. (The recording period over which selections are made in multiple channels must always be the same.) Command-Shift-click in the display area of a channel you want to add to select its full height. Option-Shift-click to select the same relative area of an added channel as in the first channel. This area takes into account any stretching or scaling of a channel's Amplitude axis, making direct comparison of waveforms overlaid in the Zoom window easy. It only deals with the recorded data, though, and ignores any scaling due to units conversion.

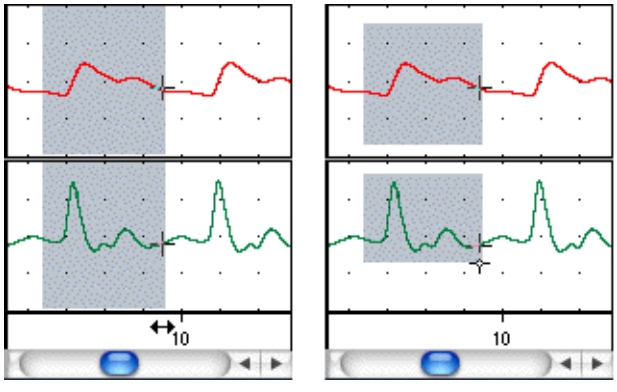


Figure 5–4
Selecting data in multiple channels: left, from the Time axis; right, Shift-dragging in the channel you want to add.

↔

To select an area of data in all channels, position the pointer in the Time axis area: the pointer will change to a double-headed arrow. Drag in the Time axis area to highlight a rectangular area over all channels: Shift-click along the Time axis to extend the selection from the point at which you started to drag. Shift-click in the display area of a channel to deselect it. Double-clicking in the Time axis selects an entire block of recorded data (the whole file, if it is continuous).

If two or more channels are overlaid, simply drag to create a common selection rectangle over both channels. If you overlay separate channels with existing selections in one or more of them, you should reselect the area to ensure a common selection rectangle.

Finally, you can select all data in the Chart window by choosing Select All from the Edit menu, or typing Command-A.

When there is a selection in the data display area, some of the menu commands available change to reflect this. In the File menu, the basic

Print command changes to Print Selection…, and Save Selection… becomes undimmed. In the Edit menu, Copy Selection… and Delete Selection become active as well.

Deleting Data

There are two sorts of data deletion available when the Chart window is active: you can clear a selected area of data for all channels, or you can clear all of the data recorded in a particular channel. (You cannot just delete an area of data in one channel.) These operations cannot be undone, so alert boxes ask you to confirm your decisions. If you do accidentally delete vital data, and you have saved the file previously, you should immediately close the file without saving the changes — the file will revert to the last version saved. You may lose some changes, but the data just deleted will be there on reopening the file. (Frequent saves and backups are, of course, always good practice.)

To delete an area of data common to all channels, drag along the Time axis to select the area corresponding to the period between two points on the axis. This would be useful to delete stretches of a recording where nothing particularly interesting occurred. Choose Edit > Clear Selection, or press the Delete key. In fact, if there is any selection in the Chart window in one or more channels, then these actions will clear the data block from all channels, subject to confirmation through the alert box. Since you create a discontinuity in the record by deleting data over a specified period, a new block is defined. It is marked by a solid vertical line, unless display settings are otherwise set up. (If there is only an active point rather than a selection in the Chart window, then pressing the Delete key does nothing and the Clear Selection command is dimmed.)

▼ ***Refer***
Display, p. 78

To delete all data from a particular channel, make a selection in that channel (an active point will do), and choose Edit > Clear Channel… to clear all data from a particular channel. An alert box will ask you to confirm the deletion.

Transferring Data

▼ ***Refer***
Saving Options, p. 104

It may be useful at times to transfer data from Chart to other applications, such as a spreadsheet or drawing program. A file, a selection, or the contents of the Data Pad can be saved as a standard text file able to be opened by any application that can import text, such as a word processor, spreadsheet, or statistics package. (Choose File > Save As… to do this.)

You can copy selected data from Chart and paste the data directly into another application. The Copy command in the Edit menu changes to show available options when different windows are active, or under different conditions. If the Data Pad is the active window, then you can copy all of it, or selected rows, to the Clipboard as text. (The menu command will be Copy, Copy All, or Copy Selection, depending on what is selected.) If either the Zoom or X–Y window is active, then the Copy command changes to Copy Zoom… or Copy X–Y… respectively. These two commands copy the contents of the window to the Clipboard as a QuickDraw picture. When chosen, the Copy as Picture dialog box appears (with the name of the window in its title).

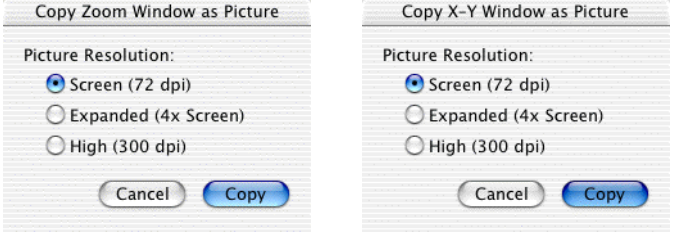


Figure 5–5
The Copy as Picture dialog box.

There are three options for picture resolution when copying a picture: in each case, a QuickDraw PICT is created at the specified resolution. **Screen** copies the contents of the window at 72 dots per inch, the ostensible screen resolution, so the picture you see on the monitor is exactly what is pasted into another program. **Expanded** copies the picture at four times the visible size: when pasted into a program that can scale it, it can have an effective resolution of 288 dpi. **High** creates a 300 dpi picture, the same resolution as an older laser printer.

Click a radio button to choose the option appropriate to the program where you intend to paste the picture. A drawing application would

handle a high-resolution picture, and you could use the extra features available to modify it for a report or for display. Some programs might convert PICTs into bitmaps. The Expanded resolution option lets you create a picture that if converted to a bitmap and scaled to a quarter of its size, prints nearly as well as a high-resolution picture.

Copying a Selection

If the Chart window is active and you select an area of data, choose Edit > Copy Selection… to copy the data as text: the Copy to Clipboard dialog box appears.

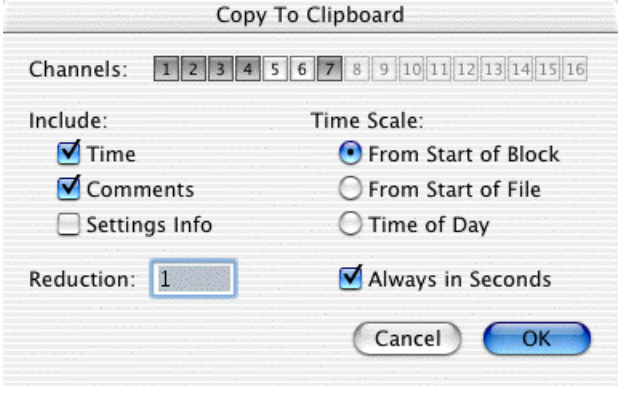


Figure 5–6
The Copy to Clipboard dialog box.

Channels. The Channel Number buttons let you choose the channels to be saved (and correspond to the numbers in the default channel titles). Those buttons whose channels have no data or are not selected will be dimmed. Highlighted buttons indicate the channels to be included in the text (by default, all selected ones with data). Click the buttons to select or deselect channels. Channel data will appear as columns in the text, in numerical order, left to right, separated by tabs.

Time. When the Time checkbox is selected, then the time at which each sample was taken is listed in addition to the data points themselves, preceding the channel data (as the first column of text). The time format can be chosen using the controls at the right of the dialog box. The options are the same as those for display settings.

▼ ***Refer***
Time Scale, p. 70

Comments. When the Comments checkbox is selected, comments at any data point are included as the last column in the text. If there are no comments in the file or selection, this option will be dimmed. If the Comments checkbox is the only thing selected, a numbered list of comments is copied. (Exclusion comments are ignored.)

Settings Info. If the Settings Info checkbox is selected, then sampling rates, ranges, units conversion information, and recording dates and times are noted as data header lines for every block of data in the text. Channel titles are also included, but other Chart display settings are ignored. This information allows Chart (using a Chart extension, Read Text) to reconstruct a Chart file from a text file, and match the original Chart file exactly. It is useful for transferring files between versions of Chart, retrieving files archived as text, and so on.

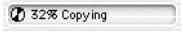
Reduction. By default, the text includes a data point for every sample in the file. You might not want all this detail, say, if you have recorded something at a high sampling rate, and there are too many data points for your graphing application to cope with. By entering a number other than 1 (the default) in the Reduction box, you can use fewer samples. If you enter 2, the text would include the data points for every second sample, if you enter 3, the text would include those for every third sample, and so on. Comments are not lost, even if the particular data points they were attached to are not included.

▼ ***Refer***
Using Exclusions, p. 123

Exclusions (points or areas marked as excluded from analysis) are treated as separate blocks containing no valid data, and are not copied to the text. Exclusion comment text is also ignored.

The Clipboard

Whenever you cut or copy data from Chart, the information is stored on the Clipboard. Choose Edit > Show Clipboard to see what has been copied: the Clipboard window appears. It is a normal window and can be moved around the screen or left in the background while the Chart window is active. The Clipboard window can show a representation of a picture (sized to fit the window), or in text format, data from the Chart window or Data Pad.



If a large selection is made, then during copying a progress indicator and the percentage of the file currently copied as text are shown in the

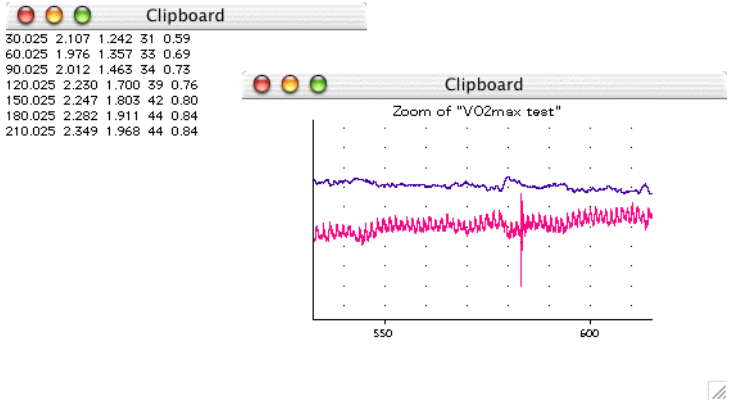


Figure 5–7
The Clipboard window after copying: left, Chart window/Data Pad; right, Zoom window.

text box of the Tool bar (if it is visible), just as occurs with a file being saved as text. To stop the process, type Command-period.

Saving Options

To save a file of recorded data, choose File > Save, type Command-S, or click the Save button in the Tool bar. When this is done, an existing file will have any changes made to it saved to disk. The first time that you save a file, or whenever you choose File > Save As…, the Save As dialog box appears.

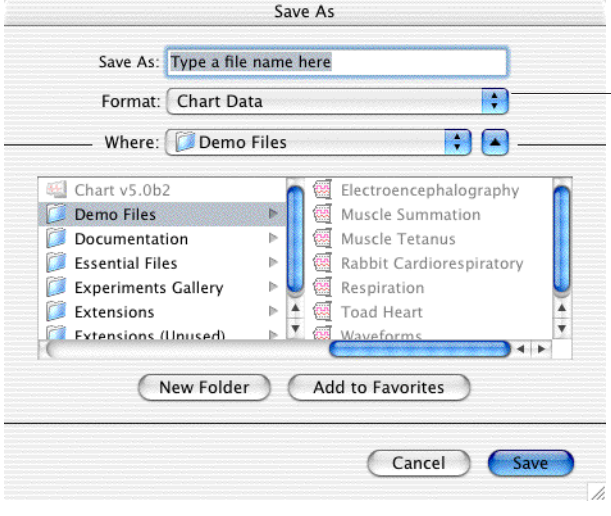


Figure 5–8
The Save As dialog box (see the Macintosh system help for the many shortcuts available).

The dialog box lets you navigate through the filing system of the computer to choose where your file will be saved. Once you choose a file format from the Format pop-up menu, and enter a name for the file, you can then save the file by clicking the Save button. The main formats are data file, settings file, text file and Chart for Windows data file. You can also save the contents of the Data Pad, Spectrum window or DVM Log window as a text file. Other formats can be added by Chart extensions. You can save multiple copies of a file in any format or formats, if the copies have different names or are in different places.

Data File


Data File

The data file format, the default, saves both data and settings (including macros). The file includes the entire recording, and is the usual way to save data. Since Chart lets you have open only one data file at a time, opening or creating another means you must close any currently open file. If such a file has any unsaved changes, an alert box informs you and lets you save or discard them, or cancel.

Settings File


Settings File

The settings file format does not save any recorded data, but stores the current settings. These include those that affect recording, such as the sampling rate, channel ranges, triggering, and stimulation settings, and those that affect the way the data looks, such as the window size, channel areas, display settings, and menus. Macros are also stored as settings. Using settings files, you can build up a library of settings for many different experiments, to enable quick and easy preparation for recording.

Opening a settings file, if no Chart file is open, creates a new untitled data file with the defined settings. If an existing Chart data file is open, then an alert box gives you the choice of creating a new untitled data file with those settings, or applying the settings to the current Chart file. Applying settings to a file affects the display of existing data and the recording settings for subsequent sampling. It does not affect the recording settings of, or alter, existing data: sampling rates, ranges, applied units, and so on are all left unchanged.

Text File

This format saves data as a standard text file able to be opened by any application that can import text, such as a spreadsheet, word processor, or statistics package. Each sample recorded is stored as a row of data readings for each channel, separated by tabs and ending in a return character (that is, taking up a single line). If you opt to save a Chart file as a text file, the Save As Text File dialog box appears when you click Save. It is much the same as the Copy to Clipboard dialog box (see Copying a Selection, p. 102, for details).

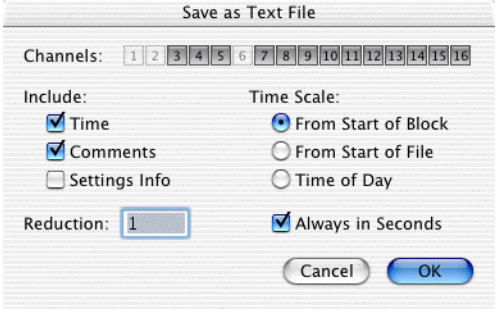
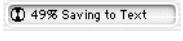


Figure 5–9
The Save As Text File dialog box.



The size of a text file is much greater than the size of the Chart data file from which it is created. While a file is being saved as text, the text box of the Tool bar (if it is visible) shows a progress indicator and the percentage of the file currently saved. Type Command-period to stop the process: you get a text file with as much data as had been dealt with at the time you stop.

Chart allows you to record files with different sampling rates on different channels. If you save such a file as a text file, Chart will determine the smallest sampling interval (highest sampling rate) used and will include data points separated by that interval for all channels. For the channels that have longer sampling intervals, the extra data values are generated by linear interpolation. For example, if you had recorded on Channel 1 at 1000 /s, on Channel 2 at 200 /s and on Channel 3 at 100 /s, the text file would include data values separated by 0.001 s, for all three channels. In the case of Channel 2, every fifth data value included in the file would be 'real', with four interpolated 'pseudo' values in between. With Channel 3, every tenth data value would be 'real' and there would be nine interpolated values between.

Chart for Windows Data File

This format saves a file as a data file that can be read by Chart v4.2 for Windows or later. Choose Chart (Win) Data in the Format pop-up menu: the '.edcht' suffix will be appended to the name. Windows needs this to identify the file type. The data and channel titles are exported. The settings for range, computed input, units conversion and macros are not exported and need to be redefined if they are required for new data. Most display settings, such as data trace colors, channel heights, and so on are ignored.

If you save a Chart file containing calculated data, a dialog box appears that lets you choose to save the calculated data, or just the underlying recorded data.

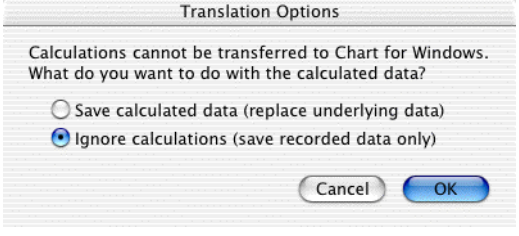


Figure 5–10
The Translation Options dialog box.

Note that the Chart for Windows program reads all the data in an exported file as recorded data — only the result of a calculation is saved, not the settings that generated the calculated data. For this reason, if the calculation can be applied in Chart for Windows, exporting the data and then applying the calculation in Chart for Windows is preferable to applying the calculation in Chart for Macintosh and then exporting.

Exclusions are treated as normal comments. Excluded data are treated as valid, so they are included in the export. Commented and excluded areas become commented points in Chart for Windows, positioned at the start time of the area. If the extent of an area in a Chart for Macintosh data file is important for the translation, it should be noted in the comment text.

Data Pad, Spectrum and DVM Log Window Text Files

▼ ***Refer***
The Data Pad, p. 136
The Spectrum Window, p. 147
The DVM Log Window, p. 92

The contents of the Data Pad, Spectrum window and DVM Log Window can be saved as standard text files able to be opened by any application that can import text, such as a word processor, spreadsheet, or statistics package.

Data Pad text file. To save the Data Pad contents as a text file, choose Text – Data Pad from the Format pop-up menu in the Save As dialog box. Each row in the Data Pad becomes a line in the text file, with the contents of the column cells in the row separated by tabs. Empty columns are not included in the file. Titles can be added to the top of each column by using the Data Pad's Add Titles command prior to adding the data.

Spectrum text file. To save the Spectrum window contents as a text file, choose Spectrum Text from the Format pop-up menu in the Save As dialog box. The text file contains two columns separated by tabs, one column for frequency and one column for the height of the spectrum at that frequency.

DVM Log window text file. To save the DVM Log window contents as a text file, choose DVM Log Window from the Format pop-up menu in the Save As dialog box. The text file contains columns for each channel that has been set up to log to the DVM Log window, and one for time too, if it is being logged.

Auto Save

Choose File > Auto Save… to set up Chart to automatically save while sampling (you need to do this before you start sampling). The Auto Save dialog box appears (Figure 5–11).

Select the Auto Save while sampling checkbox to turn on automatic saving. You can choose the period between saves, from one to 1000 in units of minutes or hours. Choosing the Append to current file option simply means that your data will be saved to the same file each time an autosave runs. Choosing the Use new file each time option means that your data is saved to a new file each time an autosave runs, with files named *file(001)*, *file(002)*, and so on, where *file* is the name of your Chart file. This is useful for breaking up a very large file into smaller

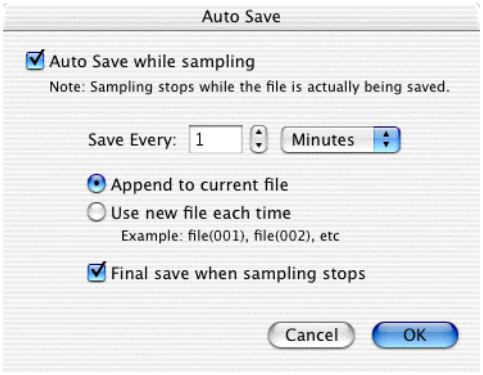


Figure 5–11
The Auto Save dialog box.

pieces, to reduce the risk of losing everything in case of file corruption. You can also specify whether you want a save to occur when sampling stops. Note that Chart stops sampling while the save occurs, so bear this in mind when setting the autosave period and mode.

Saving a Selection

You can choose to save a selected area of data instead of the whole file, letting you extract and place into a new file only the part of the recording that you need. You can save the data between any two points on the Time axis for any combination of channels. If there is a selection in the Chart window, then File> Save Selection… is available; otherwise it is dimmed and cannot be chosen. Choose the command to open the Save Selection dialog box.

This dialog box is similar to the Save As dialog box, except that you have a choice of only two file formats from the Format pop-up menu, data file and text file: the other options are dimmed and unavailable. Once you choose a file format from the Format pop-up menu, and enter a name for the file, you can save the file by clicking the Save button. Saving a selection does not save the contents of the Data Pad. If you save the selection as a text file, the Save As Text File dialog box appears when you click Save (Figure 5–9). If there are any comments in the file, the Comments checkbox there will not be enabled. If, however, none are in the selection, a created text file will have tabs at the end of each line (since these would have preceded any recorded comments), unless the checkbox is turned off. In conjunction with the Append feature, you could use the ability to save a selection for quick

▼ ***Refer***
Saving Options, p. 104

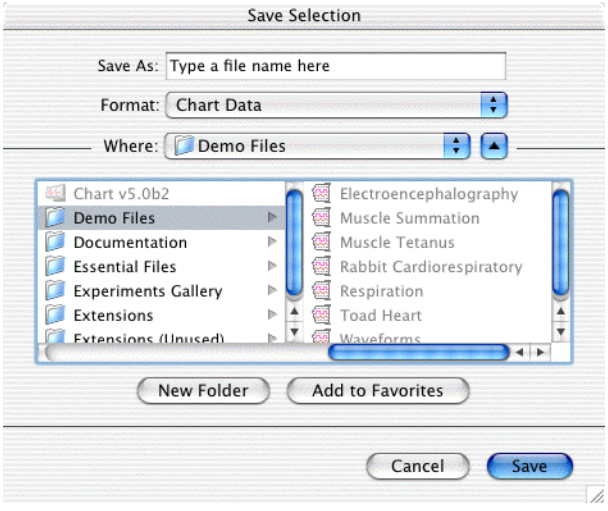


Figure 5–12
The Save Selection dialog box.

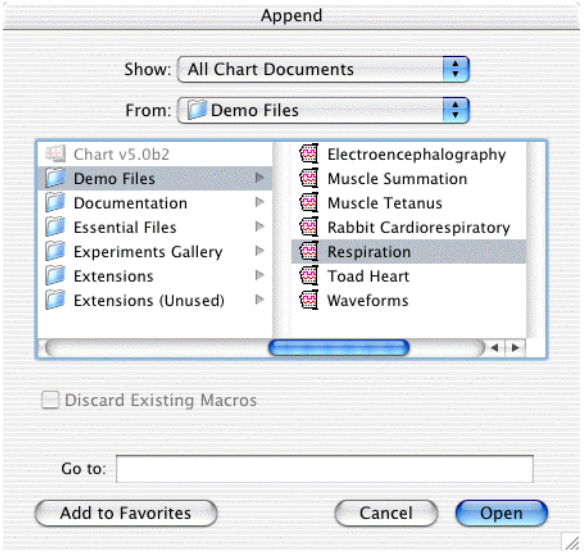
creation of new files containing summarized results from much larger recordings.

Appending Files

This feature allows any Chart file to be appended to the end of an open Chart data file in order to produce a single file with the desired contents. By combining this feature with Chart's ability to save selections of data as files, summary files can be created using only those recording segments that have significance. Choose File > Append… to append a file to an open data file. The Append dialog box will appear.

The Format pop-up menu lets you choose the sort of file to open: only the chosen types will be visible in the scrolling list. Chart files are usually the only choice available, but others may be added through Chart extensions. Select the file to append to the currently open file and click the Open button to append it. All comments will be copied across and renumbered, following on after the last comment in the original file. Settings from the appended file are not copied across, so the Discard Existing Macros checkbox is dimmed and unavailable. Recording settings such as channel ranges and sampling rate will be the same for subsequent recording as they were prior to appending the file. Each appended file is treated as a new user-defined block or set of blocks. The appended file's Data Pad is appended to the current file's Data Pad (so it helps if you have titles to separate the data sets). You can

Figure 5–13
The Append dialog box.



append files to the currently open file as long as there is enough memory to perform the operation.

Appending a settings file is the same as opening one with an existing Chart data file open. An alert box gives you the choice of creating a new untitled data file with those settings, or applying the settings to the current Chart file. Applying settings to a file affects the display of existing data and the recording settings for subsequent sampling. It does not affect the recording settings of, or alter, existing data: sampling rates, ranges, applied units, and so on are all left unchanged.

Printing

Printing a Chart file or part of it gives you a hard copy of data for use in write-ups of experiments, reports, presentations, and so on. There are two menu commands in the File menu to do with printing: Page Setup… and the basic Print command (with a keyboard shortcut of Command-P), which changes depending on what can be printed.

Page Setup

To print, you need to set up the document correctly for the printer being used. Choose File > Page Setup… to open the Page Setup dialog box:

its appearance depends on your printer and software (the printer driver). The documentation that came with your printer and computer should explain most of what is involved. Select the paper size that you will print on (A4, Letter, and the like), page orientation (portrait or landscape), and so on. Chart has its own specific options in the dialog box: choose Chart from the pop-up menu to set them (Figure 5–14).

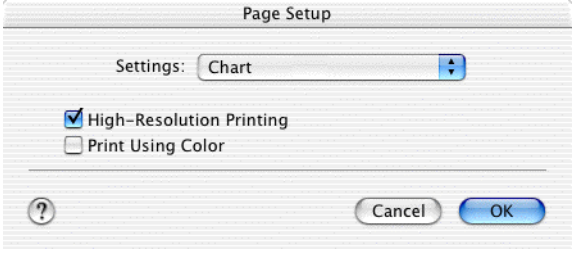


Figure 5–14
Chart's Page Setup options.

High-Resolution Printing

Selecting this option allows you to print the Chart, Zoom or X–Y windows at the maximum resolution of the selected printer. If you are using a 600-dpi laser printer, Chart will print with a resolution of 600 dots per inch. This will result in print of the best quality, but, since every data point and connecting line is drawn at full resolution, printing may be quite slow, especially for the Chart window.

Without high-resolution printing, the drawing resolution is limited to the nominal resolution of the computer screen (around 72 dots per inch). This is, however, adequate for drafts and overviews, and will result in quicker printing — especially for overviews where the file is horizontally compressed, since a lot of data must otherwise be drawn unnecessarily. If your computer and printer are slow, we recommend that in most cases you use high resolution only for the final copy.

Print Using Color

▼ ***Refer***
Display Settings, p. 77

Selecting this option enables color printing of your data. You can set up data display colors using the Display Settings dialog box. Some colors may not be supported by certain color printers, or the colors actually printed may differ from those that appear on a color monitor. Try a few

samples with your setup to establish color compatibility. Colors will print as grays on a grayscale printer.

The Print Command

If the Trigger, Stimulator, or Clipboard windows are active, the Print command is dimmed and cannot be chosen. In other circumstances, though, the command will be available and will appear in various forms depending on which window is active and whether any selection has been made (Table 5–1). Clicking the Print button in the Tool bar is in all ways equivalent to choosing the basic Print command.

Table 5–1
Printing commands.

Print Command	*Active Window*	*What Prints*
Print All…	Chart	The whole file
Print Selection…	Chart	The selected area
Print Zoom…	Zoom	Zoom window contents
Print X–Y…	X–Y	X–Y window contents
Print Comments…	Comments & Exclusions	List of comments in file
Print Data Pad…	Data Pad	Data Pad contents
Print Notebook…	Notebook	Notebook contents
Print Spectrum…	Spectrum	Spectrum window contents

Print All… can print the whole Chart file. When using a compatible continuous-feed printer, this provides a continuous record just like that obtained from a mechanical chart recorder. You can specify a more limited printing range in the Print dialog box provided by the operating system, but it is better to select the data you want printed. Print Selection… prints the selected area or areas in the Chart window. If there is no selected area in the Chart window (only an active point, say), then Print All… is the available command. If you have used the View buttons to compress a file horizontally (up to 2000:1), then the file or selection will print at the chosen compression.

When printing the contents of the Zoom, X–Y or Spectrum windows, the Page Layout dialog box lets you adjust the size and location of the image. The shaded rectangle shows the dimensions and orientation of the printed page, as chosen in the Page *Setup* dialog box. Drag the

image to reposition it on the page (the gray border shows where it will go), and drag the gray box at the bottom right of the image to adjust its size. You can double-click the image to scale it to the maximum size that will fit on the page. With the Zoom and X–Y windows, the Keep Shape checkbox is present in the Page Layout dialog box. If this is deselected, then the image can be reshaped at will. Otherwise the image is scaled in proportion to its original dimensions (which are those of the Zoom or X–Y window) or the dimensions set when the checkbox was off.

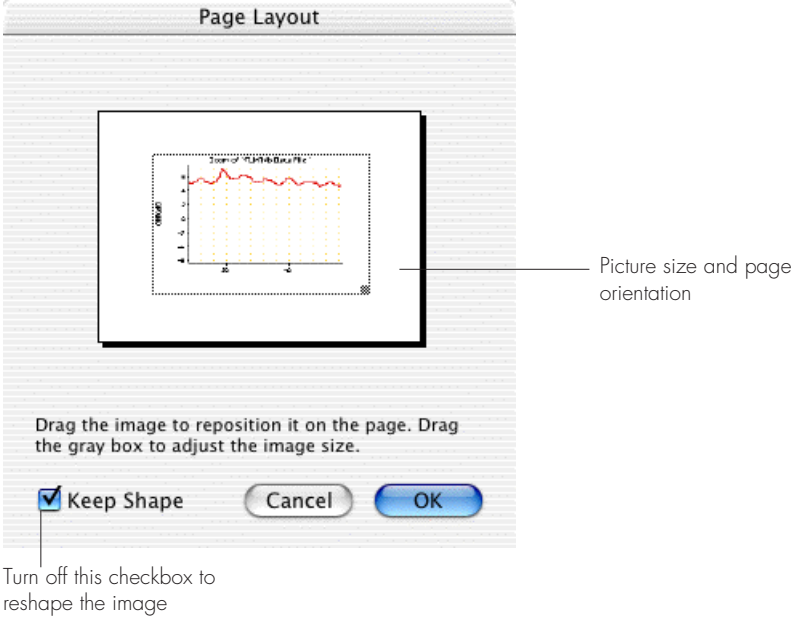


Figure 5–15
The Page Layout dialog box.

The Data Pad and Spectrum windows are printed out looking much like they do on screen, except that empty columns are not included in the Data Pad printout. The Notebook pages are also printed out much as they appear on screen (Chart will not print empty Notebook pages). The Print dialog box that appears when you select the Print command will depend on your printer and software (the printer driver). The Print dialog box lets you select a page range when you choose the Print All… command, but Chart works out the page breaks as it prints, so you may not get what you want. It is better to select the data to print and print that selection.

When printing the contents of the Chart, Zoom or X–Y windows, Chart includes a footer on each page consisting of a separating line, beneath which are the date and time of printing, the computer owner's name if it is in the system already (for file sharing), and the page number of the printed page. If the file has been saved, its title appears at the top of the first page. The Marker is drawn if visible, but the pointer and Waveform Cursors are not. When printing a selection or the first page of a file, channel titles and units are included at the left of the print-out, and the ranges of the channels are also drawn, much as things appear in the Chart window. The date and time at the start of each block is shown along the top of the print-out, where the block is wide enough.

When printing the Spectrum window, Chart includes a title containing the file name and channel from which the selection was taken. Information on the data selection (start time and duration) and calculation shown in the Spectrum window are also noted.

The Notebook

The Notebook is like a laboratory notebook attached to (and saved along with) a Chart file. It can be used to explain experiment protocols, macros, and expectations. It lets you make general notes about the recording as a whole, in contrast to comments, which are meant for brief information specific to a particular time, channel, or data selection. To use the Notebook, choose Window > Notebook. The Notebook window appears. It is a normal window, and can be used and moved while sampling, or left in the background while the Chart window is active.

The Notebook has a total of eight numbered pages that can be used for jotting down general notes about a file. Each page can contain up to 32 000 characters, and you can autoscroll vertically through the contents using the up and down arrow keys on your keyboard. (Only about the first 1200 characters will print if the Notebook is printed, though: transfer the text to a word processor if this is a problem.) Clicking the 'dog-ears' at the lower left of the window turns the pages back and forth. Click the Date or Time buttons at the bottom of the window to add the date or time to your notes at the insertion point (in the format set for your computer in the Date & Time control panel). The commands Cut, Copy, Paste, and Clear can be used to edit text normally, although you cannot paste graphics into the Notebook.

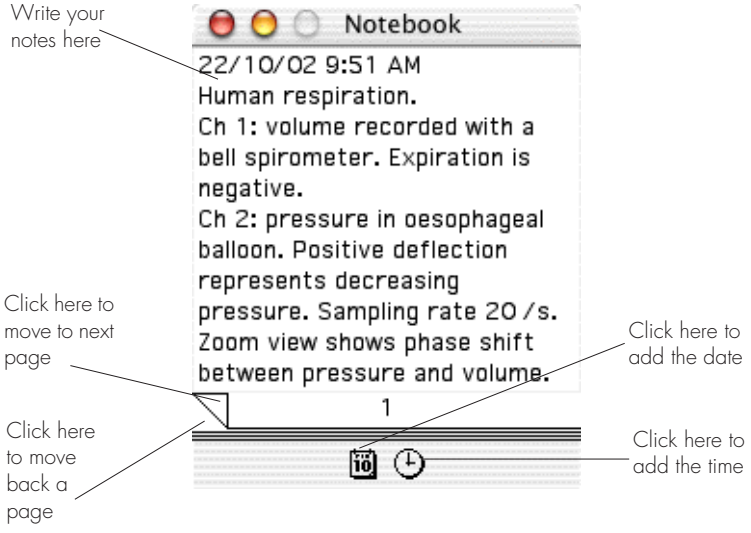


Figure 5–16
The Notebook window.

The contents of the Notebook window are saved with both Chart data and Chart settings files. However, if you append a settings file containing Notebook information to a data file that also contains Notebook information, the data file's Notebook contents will not be replaced.

▼ ***Refer***
Appending Files, p. 110

Printing the Notebook

When the Notebook window is active, then the Print option in the File menu changes to Print Notebook…, and if the command is selected, the contents of this window are printed rather than those of the Chart window. The Print dialog box allows you to print the contents of the Notebook, or any selected page range (Chart will not print empty Notebook pages). The pages are printed out as they appear on screen, stretched to fit the text to some extent, but text in excess of 1200 characters or so will be truncated. You can copy the contents of the Notebook, page by page, to the Clipboard for pasting into a word processor if you want to use the text elsewhere.

Comments and Exclusions

Comments are normally used to note brief information specific to a particular time, channel, or data selection. (You can make more general and extensive comments about the recording as a whole in the Notebook.)

Comments let you annotate your recording, marking times, points, and areas of interest. They provide a quick and accurate method of locating specific data and times in a file. Exclusions are a special category of comment marking points and areas to be excluded from data searches, Data Pad calculations, saving as text, and so on. The mechanics of adding, viewing, and editing comments and exclusions are much the same, but the effects are different: comments merely mark a point or area, but exclusions can change the way a point or area is treated. The discussion here applies to both categories unless otherwise indicated.

Using the Comments Bar

The Comments bar is used to add comments to single data points while recording (it does not appear when Chart is not sampling). It cannot add exclusions or comment upon areas, but is useful for quickly noting events as they occur. Type in the text entry area at the bottom of the Chart window, and press the Enter or Return key to add the comment to the file at the time the key is pressed.

By default, the comment applies for all channels, and the numbered comment box is preceded by an asterisk. To comment on a specific channel, select the asterisk by clicking it or pressing the Tab key, and type the number of the channel, or click the channel in the data display area: the channel number appears (for Channels 1 to 8; you can't make a specific comment for 9 to 16 here while recording). To apply a comment to all channels, select the comment channel number and type a character other than 1 to 8, or click the gray area at the bottom of the Chart window (the Time axis area when not sampling).

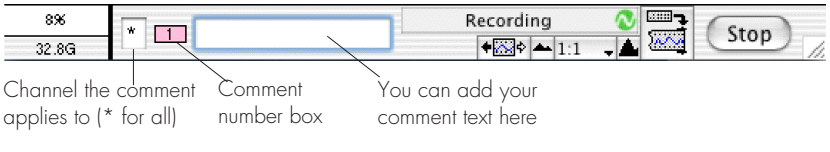


Figure 5–17
Comment entry during recording.

The Automatic Comments feature lets you add predefined comments while recording, at the press of a Function key. These are also single commented points, not areas or exclusions. These comments are entered in the Automatic Comments dialog box. (You could also just hit the Return key and edit the comment later, if you are unprepared.)

▼ ***Refer***
Automatic Comments, p. 226

Adding Comments to Recorded Data

Comments and exclusions can be added to existing data once it has been recorded. (This can be done while sampling if the Chart window is split and recorded data are selected in the left-hand pane.) First ensure there is a suitable active point or area selected. To add a comment, choose Commands > Add Comment…, type Command-K, or click the New Comment button in the Tool bar. The Add Comment dialog box appears. To add an exclusion, choose Commands > Add Exclusion… or type Command-E. The Add Exclusion dialog box appears.

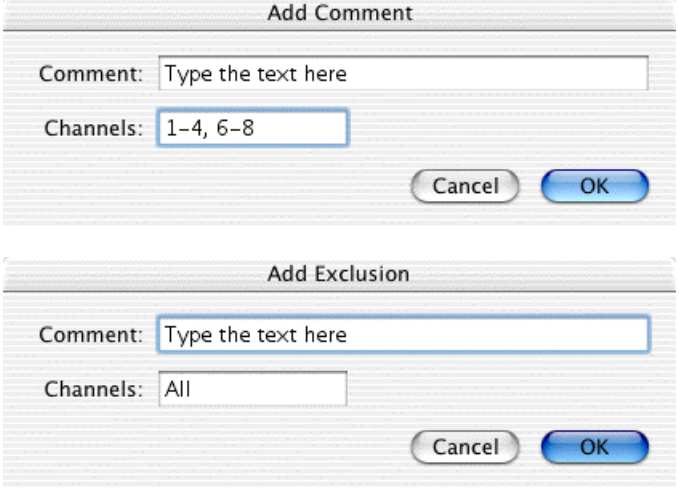


Figure 5–18
The Add Comment and Add Exclusion dialog boxes.

A comment can be typed or pasted into the Comment text entry box. For practical purposes, the text should not exceed 60 to 70 characters, since more than that will neither be clearly visible in the pop-up comment box nor print in full when a list of comments is printed.

You may choose at the outset to apply the comment to all channels, a specific channel, or a set of channels, by clicking or making a suitable selection in the Time axis area or the channel of interest. When the

dialog box appears, the Channels text entry box shows your initial selection, but you can change it. Enter 'All' for all channels (1–16), or the numbers of channels to be affected, in one or more sets. Spaces are ignored, commas separate, and hyphens indicate a range, so entering '2, 4, 6–8' would apply the comment to Channels 2, 4, 6, 7 and 8. You can apply a comment to a channel currently hidden or off.

Click OK, or press the Enter or Return key, to add the comment to the file at the active point or over the selected area, in the chosen channels. If Chart cannot make sense of an entry (if a channel number was over 16, say), it will instead apply the comment to your initial selection.

Appearance

The appearance of comments in the Chart and Zoom windows is set in the Display Settings dialog box. They can be hidden altogether, shown as numbered boxes, marked by dotted lines or areas of a chosen shade, and may have the comment text visible as well.

▼ ***Refer***
Display Settings, p. 77

Comments are automatically numbered in the order in which they are added to a file, regardless of category (comment or exclusion), and not necessarily left to right across a file. Numbered comment boxes are shown in the Time axis for comments applying to all channels, in the channel of a channel-specific comment, or in the top channel of a comment applying to several channels. The boxes are filled with the shade assigned to the comment category.

Commented points are marked by a dotted vertical line, and areas are marked by a chosen shade (comments use a solid shade; exclusions are striped). Comments apply to a time or time range, so they always mark the full height of the channel or channels to which they apply. As much of the comment text as will fit is shown vertically beside a comment line, or horizontally across an area to the right of the comment box. The text appears in the channel of a channel-specific comment, or in the top channel of one applying to multiple channels. Vertical text dims the waveform or block boundary beneath it.

Text labels are obviously very useful, since one can immediately read what the comment or exclusion marks, if the text is brief. If the comment is too long to be seen in the space available, you can read it by positioning the pointer over the comment box and pressing the mouse button (Figure 5–19). As well as the text of the comment, the pop-up

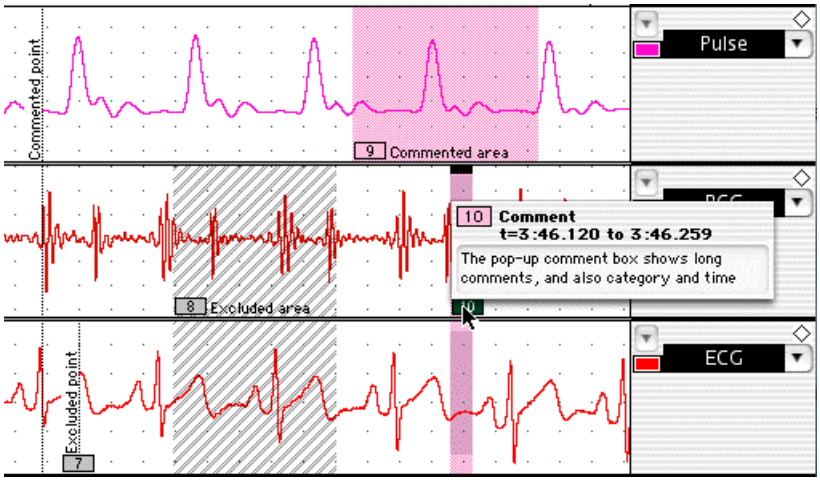


Figure 5–19
General and channel-specific commented and excluded points and areas, and the pop-up comment box.

comment box shows its number, category, and time or time range. A comment read like this in the Chart window is highlighted in the Comments & Exclusions window, and scrolled to if it is not visible, if that window is open.

Changing Times

Comments can be edited in various ways. Changing the time or time range is done in the Chart window. To do this, click the comment box for the comment to be changed. A commented point will show a single control handle (a black box) at the top of its dotted line and an area will show three control handles at the top of its area. The control handles still appear even if lines and areas are not displayed. Drag the (middle) control handle to move the comment. Drag the outer control handles of an area to increase or decrease the area's extent, and hence the comment's time range. A highlighted line or area shows where things will end up when you release the mouse button. You can't move or extend comments beyond a block boundary. If you need finer control of comment position, use the Zoom window to look at a selection in more detail: comments are duplicated there, and can more easily be assigned to particular data points or areas.

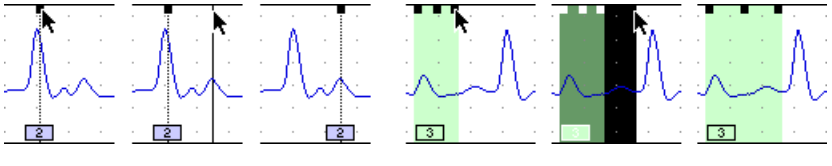


Figure 5–20
Changing a comment's time (left), and time range (right) in the Chart window.

The Comments & Exclusions Window

The Comments & Exclusions window lets you look at comments in the file together, locate or delete them, or edit their text. To use the window, choose Window > Comments & Exclusions or type Command-L. The Comments & Exclusions window can be moved around the screen or left in the background while the Chart window is active.

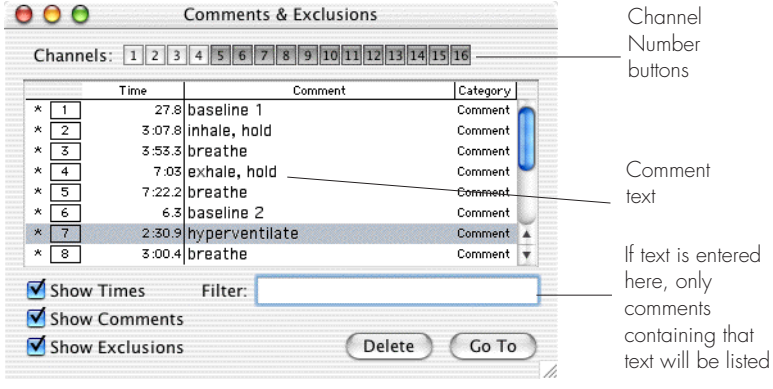


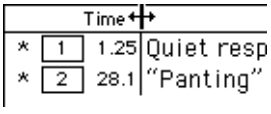
Figure 5–21
The Comments & Exclusions window.

The comments are listed down a scrolling field in the order that they appear left to right across a file (and so not necessarily in numerical order). The comment numbers appear in boxes, as they do in the Chart window, with the box preceded by the number of a specific channel it applies to, or an asterisk if it applies to more than one channel. The category of the comment (comment or exclusion) is listed at the right. Use the scroll bar to the right of the window to go through long lists of comments.

A number of features in this window help in searching large files for comments by restricting which comments appear in the scrolling list. The Channel Number buttons at the top of the window let you hide channel-specific comments. Comments for channels with highlighted buttons appear (by default, all of them): click to deselect or reselect a channel. Comments applying to all channels are not affected by these buttons. The Show Comments and Show Exclusions checkboxes let you choose which categories of comment appear: by default, both are on, but you can turn a checkbox off to hide all comments in that category (at least one must be on). Type text in the Filter text entry box to show

only comments containing that text (ignoring case and context, so 'new' also covers 'New' or 'newer').

The Show Times checkbox (on by default) precedes comments with the times at which, or time ranges over which, they appear. If you turn it off, then times do not appear, either in this window or in the list of comments printed from it.



The Time column shows the times or time ranges in the form set by display settings. Column widths can be changed, for instance to give more room if comments in the list are truncated, or if the times are short rather than time ranges or times of day. Position the pointer on the dividing line so that it changes into the resizing pointer, drag until the column is the desired width — a gray line appears, to indicate position — then release the mouse button.

Once a comment in the list is selected (by clicking it), then it may be edited, deleted, or located (comments selected in the list will show control handles in the Chart window). The pointer changes to an I-beam over text in a single selected row, and the text can be edited normally. The channel identifier, comment number, time, and category cannot be altered here. If the Delete button is clicked, a selected comment is deleted. To choose multiple comments for deletion, drag or Shift-click to select contiguous comments, or Command-click to select or deselect multiple comments individually.

If a comment is selected and the Go To button is pressed, the Chart window becomes active, the comment is located and centered in the data display area, and a brief animation shows its position. Currently hidden comment boxes are made visible again. Lines and areas, or text labels, may also be made visible if their checkboxes are on in the Display Settings dialog box. This is very useful for locating commented features or excluded areas in the file. If you have multiple comments selected, the comment at the top of the list is the one centered in the data display area. If the data display area is split into two panes, comments are located in the right pane.

Comment Numbering

When comments are deleted, the numbers for the remaining comments in a file do not change (this helps to prevent confusion when editing files). When a file is appended to another file, the comments in the

appended file remain in the same order, but are renumbered following on from the highest comment number in the file to which it was appended.

Identifying a Data Point

If the Marker is dragged to a comment box in the Chart window, the box will highlight. When released, the Marker locates itself on a data point recorded at the time the comment was made (the start of a commented area). If the comment is channel-specific, the Marker is located on the waveform of that channel, if it has data; else (if the comment applies to all channels, say), the Marker is located on the waveform of the top channel.

Printing Comments

If the 'Text Label' checkbox is on in the Display Settings dialog box, comments are printed where they in the data print-out when you are printing a whole file or a selection. When the Comments & Exclusions window is active, then the Print option in the File menu changes to Print Comments…, and if the command is selected, the contents of this window are printed rather than those of the Chart window. Comments are printed out as a numbered list, with the numbers boxed. Only those comments chosen for display using the Channel Number buttons in the Comments & Exclusions window will print. If the Show Times checkbox is on, then times (start times, not time ranges) will be printed; if it is off, times are not printed. Categories are not printed. This helps if you have long comments, since comment text longer than one line will not be printed — an ellipsis (…) in the print-out indicates truncated text.

Using Exclusions

Artifacts in a recorded signal can interfere with analysis. Large data spikes can result from bumping laboratory equipment, adjusting measuring electrodes, and so on, especially with sensitive recordings. Temporary loss of a signal can result from a loose connection. When recordings are analyzed, such glitches, unrepresentative of the signals being measured, can show up as serious anomalies in derived readings such as frequency, peak height, cyclic variables, and so on.

Exclusions are a way to mark invalid data without removing them from the file. If you just delete the data, the action creates a time discontinuity (and hence a new block boundary). A selection must also be deleted over all channels. An exclusion can apply to a single channel, so otherwise unaffected data on other channels are not lost, and it doesn't create a new block: excluded data are simply ignored for most calculations and analysis, saving as text, and so on. The text of the exclusion can be used to indicate why the point or area was excluded. Since exclusions are easily added and deleted, you can also use them to exclude data temporarily to see what effect this has on particular readings.

Finding Files

It is simple enough to organize a small number of data files with a very basic filing system using a few folders. Once a large number of files have been recorded, especially if there are many similar ones, the task becomes harder. Chart's file information feature helps you to keep track of data files. Suitable information can be stored in a file, and then (along with any comments in the file) can be searched for, so that you can quickly find a specific file when it is wanted.

File Information

Choose File > File Information… to prepare a file for later searches: the File Information dialog box appears. Enter text in the various fields according to some suitable system. The title can be a longer version of the file title. The Other field lets you enter extra keywords, for instance, or descriptive text (perhaps transferred from the Notebook). The Ask for Information pop-up menu determines when all this is asked for. By default it is set to Manual, which means you must remember to choose the menu command to add the information. You can make Chart request file information by choosing one of the other options. If Before Saving is chosen, then the File Information dialog box appears for you to enter information when you save a file. If Before Sampling is chosen, then the dialog box appears when you click the Start button. Click the Cancel button to dismiss the dialog box without entering information, or the OK button to accept any entered text. The text is not saved with settings, but the state of the pop-up menu is.

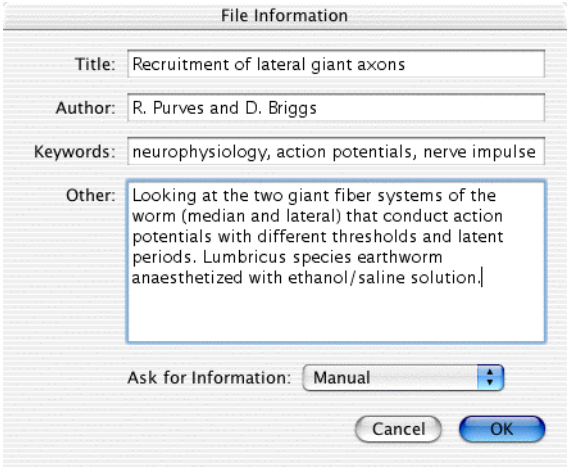


Figure 5–22
The File Information dialog box.

Searching for Files

Choose File > Find File… to find a Chart file using its internal file information: the Find File dialog box appears.

The Search in pop-up menu lets you choose where to search: local disks, all currently available disks including mounted servers, or any specific disk. The Search field pop-up menu lets you choose which of the five fields Title, Author, Keyword, Other and Comments to search in. The first four of these fields correspond to those in the File Information dialog box, and the last lets you search the comment text of files, which is useful for files that lack specific file information. Enter the text to search for in the Contains text box (ignoring case and context, so 'new' also finds 'New' or 'newer'), and click the Find button to look for files.

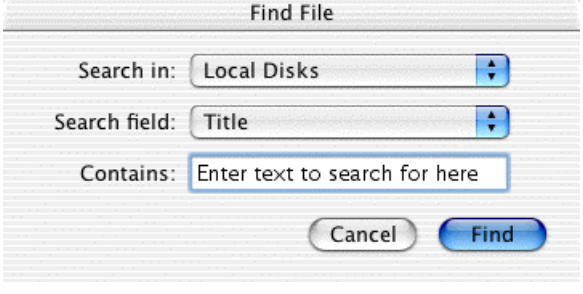


Figure 5–23
The Find File dialog box.

While the search is under way, the Found Files dialog box appears. The search criterion is shown under the dialog box title: as files matching it are found, they are added to the File List in the top half of the dialog box. To halt the search at any time, click the Stop button.

Once the search is finished, the File List shows which files have been found, with the context of the found text shown at the right. Click to select one of the found files: its location is shown in the File Location List in the lower half of the dialog box. If the search proved unsatisfactory, you can click the Find Again… button to open the Find File dialog box once more, and try a different approach. Click the Open button to open a selected Chart data file.

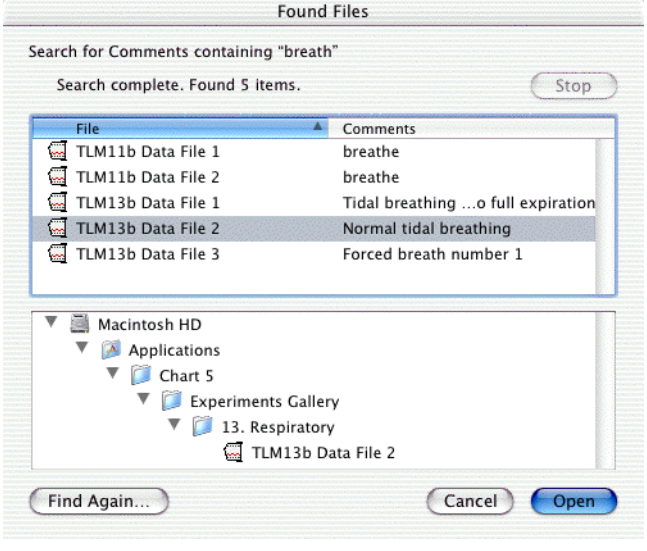


Figure 5–24
The Found Files dialog box.

Backing Up Files

It is always good practice to back up computer files. Computers are reasonably reliable, but file corruption, disk failures, and accidental deletion of data can still occur. If your Chart files are important, you should back them up. You can get data backup software to do this automatically, or you can set up a backup schedule yourself. Off-site and Internet-based backup services are available as well. It helps if things are well organized, and your files and folders sensibly named and arranged. (If it takes you as long to find the backup as it would to record the data again, you haven't saved yourself much work.)

Chart data compression is very good, so you don't save too much space by archiving data files. Simply copying them to another disk is enough (having copies on the same disk doesn't help if the disk fails). The most reliable backup media are recordable CDs, magneto-optical disks, or hard disks (including servers, especially if they also have tape backup). Floppy disks are best treated as temporary media only.

If you back up files onto a computer using the Windows OS, be careful. Try to make sure the files are only handled from the Mac OS. Windows systems typically do not understand Macintosh files, and may discard information such as the file type or resource fork if the files are manipulated by the OS or an archiving program. Chart files should still be recoverable even if the file type and resource fork are lost. It may be necessary to add ".cfm" to the file name in the Finder to force Chart to recognize it as a Chart file.

Always test your backup procedures as fully as possible. Try backing up and retrieving sample files to make sure things work before working with critical files.

6

CHAPTER SIX

Data Analysis

The whole purpose of recording data, of course, is to find things out through analysis of the recording. Chart offers a wide range of online and offline calculations and makes it easy to extract parameters and statistics from your data.

This chapter discusses Chart's many analysis options.You can measure absolute or relative quantities with the Waveform Cursor, and calculate, store and export further parameters with the Data Pad. You can plot data from one channel against that from another using the X–Y window. You can arithmetically combine data in different channels, smooth data, and analyze the cyclic components or the derivatives and integrals of your signals. This can be done during sampling by applying Computed Input functions, or after recording by using channel calculations. You can also use the Spectrum window to analyze the frequency components of your data.

Measuring from the Waveform

When you have finished recording, you can scroll through your data and make measurements directly from the recording — since everything is digital, you are given a direct read-out, with no chance of the measurement errors that could occur in analyzing a paper-and-ink record. You can make direct or relative measurements.

When the pointer is over the data display area (or Time axis), the Waveform Cursor for each channel tracks the waveform at the time position of the pointer. In this case, the Rate/Time display shows the time at the pointer location, and the Range/Amplitude display for each channel shows the amplitude of the waveform at the Waveform Cursor location. The Waveform Cursor only gives discrete measurements, jumping from data point to data point (you can see this more clearly in the Zoom window). It cannot provide a reading on the line that is drawn between the points for display purposes.

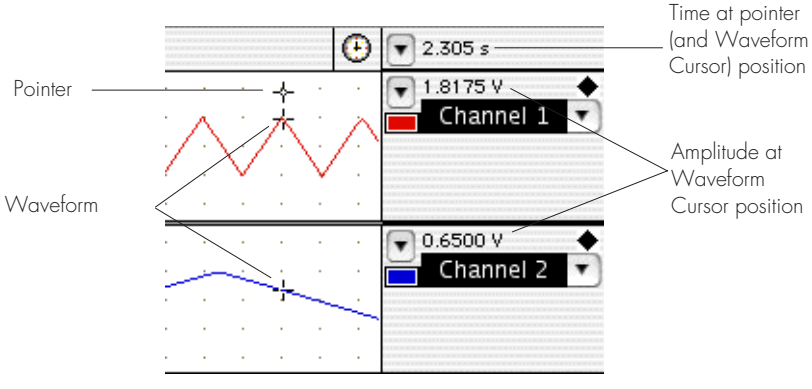


Figure 6–1
Measuring waveform data.

The pointer appears as a cross over the data display area (or a double-headed selection arrow along the Time axis). The Waveform Cursor's shape is a cross by default, but can be changed in the file preferences to suit the waveform.

▼ ***Refer***
Cursor, p. 192

Using the Marker

The Marker can be found at the bottom left of the Chart window. It is used to set a particular data point as a zero reference point, so that relative measurements can be made with respect to that point.

To set the reference point, drag the Marker into the channel of interest; it will lock onto the waveform there when you release the mouse button. Watch the changing numbers in the Rate/Time and Range/Amplitude displays to help to select a data point. If you need finer control of where the Marker ends up, use the Zoom window to look at a selection in more detail: the Marker is duplicated there, and can more easily be assigned to a particular data point.

If there is a selection in the Chart window, you can choose commands from the Set Marker submenu of the Commands menu to locate the Marker where you want it: Minimum Point, Maximum Point, First Point, or Last Point. The Marker is then moved to the lowest, highest, left-most, or right-most points in the selection respectively, either in a specific channel, or the top one of several. If there is an active point in the Chart window, any of the commands moves the Marker to the position of the active point.

Once the Marker is in position, measurements relative to it (preceded by Δ) are given in the readings for time in the Rate/Time display as the pointer moves. The reading in the Range/Amplitude display for the channel where the Marker is located is also relative to the Marker, but the values at the Waveform Cursor positions for the waveforms in other channels are absolute. The 'Δ' (delta) symbol before a value indicates it

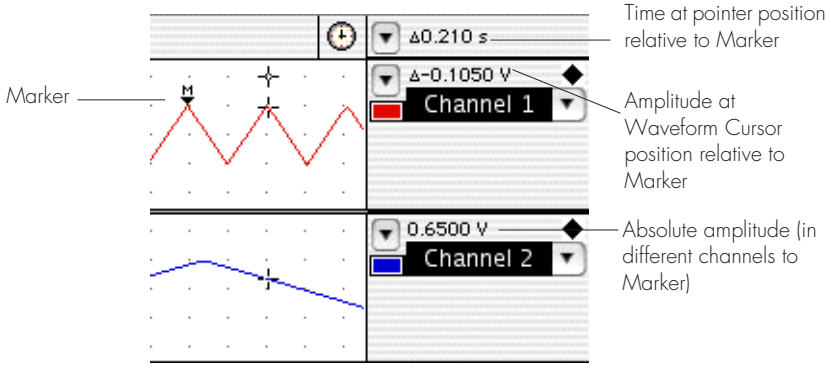


Figure 6–2
Measuring relative waveform data.

is a difference, not a direct reading. Derived values (in the Data Pad and so on) take the Marker into account when appropriate.

The Rate/Time display indicates if the pointer is not in the same block as the Marker, and if the block has a different scale or different units to the one the Marker is in, the Range/Amplitude display reads 'Δ Range Invalid' as well.

If the Marker is dragged to a comment box in the Chart window and released, the comment box highlights and the Marker locates itself on the data point recorded when the comment was made, either in the channel of a channel-specific comment, or the top channel otherwise.

Double-clicking the Marker or clicking its box at the bottom left of the Chart (or Zoom) window sends it back to its box.

Setting and Removing Baselines

The Set Baseline command is used for setting relative amplitude measurements where the voltage (amplitude) baseline of a channel is not zero. Once you have recorded a waveform, you may find that the baseline value is not zero volts (or set units) when it should be — that is, there is some slight offset. To remedy this, select an active point or area along the waveform where the measurement should be zero, and choose Commands > Set Baseline. The value at that point or the average of the selection is set at zero, and scale units of the Amplitude axis change to show this. The position and size of the waveform in the channel display does not change: if you want it altered, simply drag or stretch the scale.

The baseline is set for the particular block or blocks of data in a channel that the selection intersects. To set the baseline across the whole channel for all blocks of data, hold down the Command key while choosing Commands > Set Baseline. Remove Baseline removes a baseline previously set, and also affects the selected block or blocks of data in a channel. Holding down the Command key while choosing Commands > Set Baseline removes any set baselines across the whole channel.

Finding Data

The Overview miniwindow gives an overview of a channel, where you can see longer-term trends, and find particular events on a large scale. The events you want to find may be of smaller scale, and may not be obvious in overview. Chart therefore provides another method to find and select data of interest in a recording, according to criteria you specify. It also helps in automating searching by macros. To find data, choose Commands > Find… or type Command-F: the Find and Select dialog box appears (Figure 6–3).

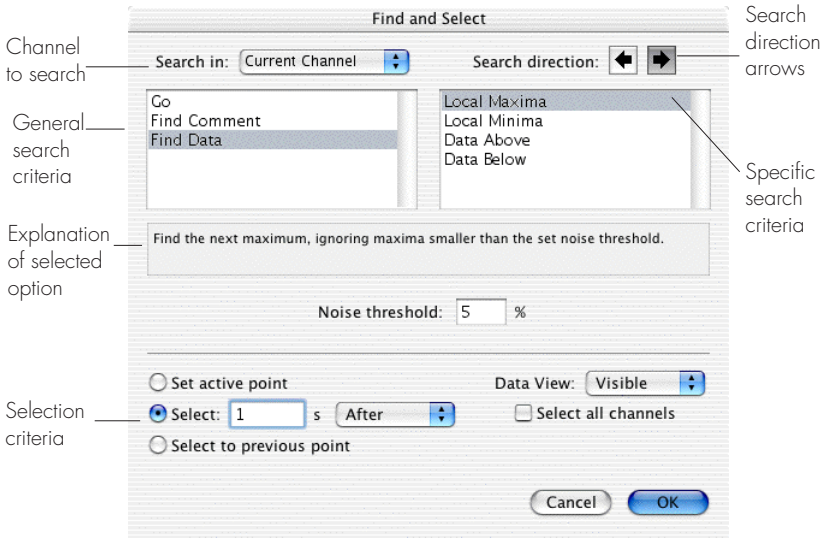


Figure 6–3
The Find and Select dialog box.

You can set up search and selection criteria as desired, to search any channel for comments, peaks and troughs in the waveform, block boundaries, and so on, and to set the active point at the position found, or select data for a period before, around, or after it, for the active channel or all channels.

Search Criteria

You can search for an event in a specific channel or in the current channel (the default), that is, the one with a current selection or active point. If the active point or selection in the Chart window extends across multiple channels, then the topmost one is searched. Use the

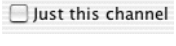
Channel pop-up menu at the top left of the dialog box to choose the search channel from the list of channel titles. Two scrolling lists let you select from the many forms of information that could be sought. The left-hand list gives the general type, and the right-hand one options available in that set. The selected option is briefly explained in a box beneath the two lists. The exact controls in the dialog box depend on what is chosen in the scrolling lists.

Go

Go can find the start or end of the file or the current block within the file, the start of the next block, or the end of the previous block. You can also move forward or backward through a file by a set time in seconds. If you select the Move Forward or Move Backward options, a text entry box appears, in which you can type in a number from 0.00001 to 10 000 seconds, in increments of 0.00001 seconds (the time between samples at 10 000 samples per second). This always moves at least one data point, whatever the sampling rate.

Find Comment

Find Comment searches for text in comments (including exclusions). There is only one option in the list; the search direction is set by the direction arrows to the right of the Channel pop-up menu. Click the right one to search forward, the left one to search backward.

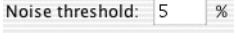


Two more controls appear beneath the scrolling lists: type text in the text entry box to find only comments containing that text (ignoring case and context, so 'new' also finds 'New' or 'newer'). Turn on the Just this Channel checkbox to find only comments that apply to the search channel (ignoring channel-specific comments in other channels).

Find Data

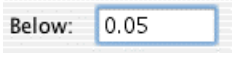
▼ ***Refer***
Using Exclusions, p. 123

Find Data can search for local maxima or minima, or data points above or below a set value. The search direction is set by the direction arrows to the right of the Channel pop-up menu. Click the right one to search forward, the left one to search backward. These searches ignore excluded data (points and areas marked by exclusions).



If you select the Local Maxima or Local Minima options, Find Data searches for peaks or troughs respectively. A text entry box appears, in

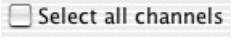
which you can type in a number from 1 to 90 to set a noise threshold for the event, as a percentage of the range of the channel (the default value is 5%, which is 1 V for a ±10 V range). For a data point to be recognized as a peak or trough, the data points that follow must decrease (for a local maximum) or increase (for a local minimum) by at least the noise threshold value. Local maxima and minima in the waveform with smaller amplitudes than this value will be ignored. Raise the value to get rid of unwanted small fluctuations (noise and so on); lower it to detect missed events.



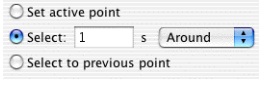
If you select the Data Above or Data Below options, a text entry box appears, in which you can type in a value from ±0.00001 to ±10 000 to set the value, in whatever units are assigned to the search channel. The first matching data point above or below the set value is found.

Selection Criteria

Once an event is found, an active point or selected area is set in the Chart window, using the controls at the bottom of the dialog box.



The Select All Channels checkbox is off by default, in which case the active point or selected area set by the command is confined to the search channel. If the search channel is in a set of overlaid channels, then all channels in that overlay will be selected. A selected area will extend to the full height of the channel or channels. Click the checkbox to turn it on and set an active point or selection area over all channels, as if you had clicked or dragged in the Time axis.



Choose the Set Active Point radio button to set an active point at the time of the event. Choose the Select to Previous Point radio button to set a selection area from the time of the event to the nearest boundary of the previous selected area, or the previous active point. If you choose the Select radio button, a text entry box and pop-up menu appear. Type in a time from 0.00001 to 32 000 seconds to set the horizontal extent (duration) of the selected area. Choose one of the options in the pop-up menu: After, Around, or Before. **After** selects an area from the time of the event forwards; **Before** selects an area from the time of the event backwards. **Around** selects an area of data symmetrically around the time of the event.

The active point or selection area set is shown in the Chart window if it is not visible already. You can choose from the Data View pop-up menu

whether the found data are merely visible, or shown at the left or right of, or centered in, the Chart data display area. Setting a fixed position is useful for repeatedly finding data, since you can keep looking at the same area of the screen as you go through the file.

Repeatedly Finding Data

Once the criteria for finding and selecting an event have been set up, you can choose Commands > Find Next or type Command-G to find and select the next such event. You can repeat this command as needed to find multiple events (it will repeat at your keyboard's auto-repeat rate if you hold the keys down). This is easier than scrolling through manually to look for events, and is very useful in conjunction with macros, for instance, to select events in a channel automatically and record information to the Data Pad.

▼ ***Refer***
Macros, p. 202

If the Find… or Find Next commands fail to find an event (because the selection would move outside the file boundaries, for instance), then Chart will beep.

The Data Pad

The Data Pad is used to analyze waveform data. It is easy to set up and use; you can record up to 32 columns of data in it, either direct waveform values or calculated values from any channel, from active points or over selected areas. The Data Pad can store large amounts of data — up to 32 000 rows, with each row having a maximum of 255

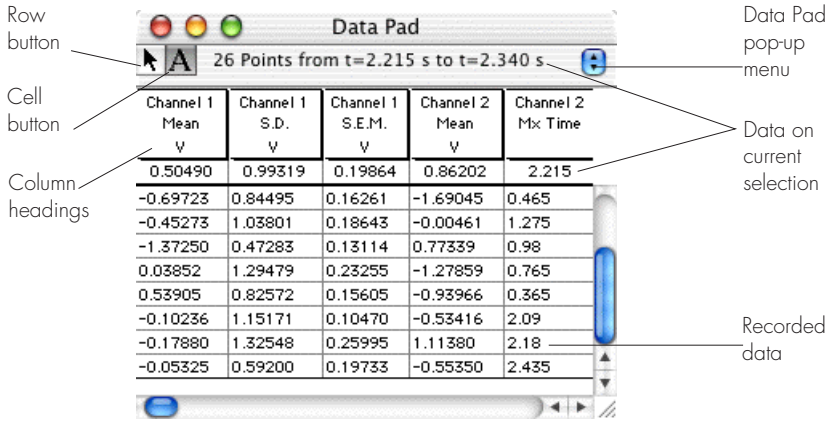
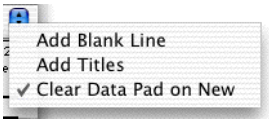


Figure 6–4
The Data Pad window.

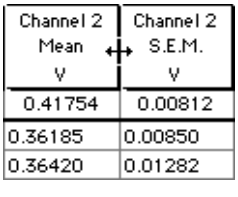
characters per cell, and a total of 2000 characters per row over the 32 columns. Its contents can be saved as a text file or copied in whole or part to the Clipboard for transfer elsewhere. To open the Data Pad, choose Window > Data Pad.

The Data Pad is a normal window and can be moved around the screen or left in the background while the Chart window is active. Information on the current selection or active point is displayed just above and beneath the column headings: the readings beneath the column headings are separated from recorded data by a heavy line, and are centered rather than left-justified to help to distinguish them. As data are added to the Data Pad, new rows of values are created below existing rows in the data area. Each cell contains only one entry, the value added to the Data Pad at the time the calculation for its column was made. The column heading shows the title of the channel from which the reading currently derives. Use the scroll bars to move down or across through rows and columns.

The two tools used to deal with data in the Data Pad are chosen using buttons at the top left of the window. By default the Row tool is selected (and the leftmost button, with the pointer-like arrow, highlighted): in this case, the pointer changes to a heavy cross when over the data area. Click to select a row, drag or Shift-click to select contiguous rows, or Command-click to select or deselect rows individually; the data can then be cleared, or cut or copied to the Clipboard as tab-separated text, using the commands in the Edit menu (Cut, Copy, Paste, Clear). If the Cell button (with the A) is clicked, the pointer changes to an I-beam when over the data area, and text in each cell can be edited in the normal way. Clicking the Cell button deselects all selected rows.



The pop-up menu to the right of the window lets you add to the Data Pad either blank lines (rows), or the full current column headings as three lines — useful to keep track of changed settings, or when transferring data to other applications. (Superscripts and subscripts in column headings are converted to plain text when added to the Data Pad.) You can also choose whether to keep or clear the Data Pad contents when a new file is created: a tick appears beside the lowest menu command when it is active (it applies only to the current file).



Channel 2 Mean V	Channel 2 S.E.M. V
0.41754	0.00812
0.36185	0.00850
0.36420	0.01282

The width of columns can be changed to suit the displayed data and headings. You might want to narrow columns to display more on screen, for example, or have a wide column to the right in which to

add comments. Position the pointer on the heavy dividing line between column headings, so that it changes into the resizing pointer, drag until the column is the desired width — a gray line appears, to indicate position — then release the mouse button.

Adding Data to the Data Pad

To add data on a selection or active point in the Chart window to the Data Pad, choose Commands > Add to Data Pad or type Command-D. As a shortcut, you can double-click in the data display area to transfer data at a point (double-clicking in the Time axis selects a block, though, and transfers no data). If you need finer control of what is transferred, use the Zoom window to look at a selection in more detail: a particular data point can be double-clicked more easily.

If a selection straddles two or more blocks and the blocks have different units, the selection will be noted as having multiple units rather than any Data Pad calculation being attempted. Exclusions (points or areas marked as excluded from analysis) are treated as separate blocks containing no valid data, so no calculations based on that data are attempted. Exclusion comment text is also ignored. Time and selection values for excluded data are returned, however.

▼ ***Refer***
Using Exclusions, p. 123

The data recorded depends on the choices made in the Data Pad Column Setup dialog box. By default, the first few columns are set to record the mean of the selection in a channel (or, when there is an active point, the waveform value at that point). Any column can record data from any channel, though (so you could have any number of variables deriving from Channel 1, for instance).

Setting Up the Columns

The data recorded in the Data Pad depends on the choices made in the Data Pad Column Setup dialog box: it appears on clicking a column heading, and will have the column number (1–32) in its title.

Note
Other functions may be added to the Data Pad through Chart extensions.

To move to the dialog boxes of adjacent columns (and set up many columns quickly), click the arrows by the dialog box title, or press the right or left arrow keys on the keyboard. Click OK to close the dialog box after you have set up all the columns you need. Two scrolling lists let you select from the many forms of information that could be

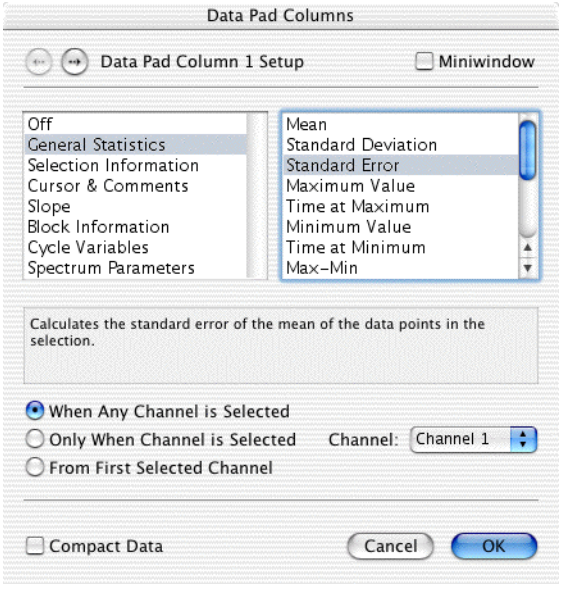


Figure 6–5
The Data Pad Column Setup dialog box.

recorded, whether derived or direct. The left-hand list gives the general information type, and the right-hand list options available in that set. The selected option is briefly explained in a box beneath the two lists. The channel from which data are taken is selected in the Channel pop-up menu at the right of the dialog box.

Off simply turns the column off: no data are recorded in it. This will disable and dim the radio buttons and Channel pop-up menu.

General Statistics

Mean calculates the mean of the data points in the selection, or returns the value at the active point. **Standard Deviation** calculates the standard deviation of the data points in the selection. **Standard Error** calculates the standard error of the mean of the data points in the selection. **Maximum Value** returns the value of the largest data point in the selection. **Time at Maximum** returns the time at which the largest data point in the selection was recorded. **Minimum Value** returns the value of the smallest data point in the selection. **Time at Minimum** returns the time at which the smallest data point in the selection was recorded. **Max–Min** calculates the difference between the largest and the smallest data points in the selection (zero for an active point).

Integral returns the integral of the selection, calculated as the sum of the data points multiplied by the sample interval; $\sum y\,\Delta t$. **Integral from Minimum** returns the integral of the selection, calculated as the sum of the data points minus the minimum value in the selection, multiplied by the sample interval; $\sum(y-y_{min})\,\Delta t$. **Integral from Start** returns the integral of the selection, calculated as the sum of the data points minus the first value in the selection, multiplied by the sample interval; $\sum(y-y_{first})\,\Delta t$. **Integral from Baseline** returns the integral of the selection, calculated as the sum of the data points minus the value on a baseline (drawn from first to last data points in the selection), multiplied by the sample interval; $\sum(y-y_{baseline(t)})\,\Delta t$.

Number of Points returns the number of data points in the selection (one for an active point). **RMS** calculates the RMS (root mean square) value of the data points in the selection, or returns the value at the active point. **1/3Max + 2/3Min** calculates 1/3 of the maximum value plus 2/3 of the minimum value of the data points in a selection, or returns the value at an active point.

Selection Information

Start returns the start time of a selection, or the time at the active point. **End** returns the end time of a selection, or the time at the active point. **Duration** returns the duration of a selection, or the sample interval for an active point. **Number of Points** returns the number of data points in the selection (one for an active point).

Cursor & Comments

Time returns the start time of a selection, or the time at the active point. **Value** returns the value at the start of a selection, or the value at the active point. **Comment Full** extracts the full comment text. **Comment Numbers Only** extracts the first number from comment text (e.g. 'Add 100 mL of 2 mM' would return '100'). **Comment Number** returns the number of a comment. **Comment Time** returns the start time of a commented area, or the time at a commented point. For comments, in each case the Data Pad looks for the first comment to the left of an active point or from the right edge of a selection. **Comment Duration** returns the duration of a comment.

Slope

Average Slope returns the average slope (time derivative) of the data points in a selection, or the slope at an active point. The average slope is calculated from the least-squares line of best fit. **Maximum Slope** returns the maximum slope of the data points in a selection, or the slope at an active point. **Minimum Slope** returns the minimum slope of the data points in a selection, or the slope at an active point. **Time at Max Slope** returns the time at which the maximum slope in a selection occurs, or the time at an active point. **Time at Min Slope** returns the time at which the minimum slope in a selection occurs, or the time at an active point.

Block Information

Range returns the range used when recording for the block containing the active point or selection. **Sample Interval** returns the time between samples for the block containing the active point or selection. **Block Number** returns the block number for the block containing the active point or selection. **Block Duration** returns the total time of the block containing the active point or selection. **Samples in Block** returns the total number of samples in the block containing the active point. **Start Time** returns the time of day at the start of the block containing the active point or selection. **Start Date** returns the date at the start of block containing the active point or selection. **Sampling Rate** returns the sampling rate used when recording the block containing the active point or selection. If a selection straddles two or more blocks, however, then it will be noted as discontinuous.

Cycle Variables

▼ ***Refer***
Cycle Variables, p. 176

Cycle Variables parameters are for analyzing periodic waveforms. The calculation of each parameter is based on waveform cycles. When a Cycle Variables parameter is selected in the Data Pad Column Setup dialog box, an Options… button appears. Clicking this button allows you to set up the way in which waveform cycles are detected, in the same way as you do when using the Cycle Variables channel calculation.

The way in which you set up cycle detection applies to the detection of *all* cycle variables in the channel chosen in the Data Pad Column Setup

dialog box's Channel pop-up menu. This is handy when you have multiple columns in the Data Pad showing various cyclic calculations for a single channel, since the detection parameters only need be set up or changed once for the whole lot. Any changes made to the cycle detection settings for a particular channel here will affect the Cycle Variables calculations for that channel as well, and vice versa.

Cycle Variables parameters can only be calculated if there is a valid selection. The Data Pad and Data Pad miniwindow displays show certain messages when Cycle Variables cannot produce a useful result. 'No Selection' shows if there is no selection, but only an active point, for example. 'Invalid' shows if the selection crosses a block boundary or is in a channel with no data, or if no Cycle Variables or cycles are detected (for instance, there is less than a full cycle from which to calculate a peak-to-peak value).

Event Count counts the number of events in a selection. **Cycle Count** counts the number of cycles in a selection. This will be zero if there is only one event. **Frequency** calculates the average frequency of the cycles in the selection in cycles per second (Hz). **Rate** calculates the average frequency of the cycles in the selection in reciprocal minutes (BPM, beats per minute). **Average Period** calculates the average period between the cycles in the selection. **Minimum Period** calculates the minimum period between the cycles in the selection. **Maximum Period** calculates the maximum period between the cycles in the selection. **Average Minimum** calculates the average of the cyclic minima in the selection. **Average Maximum** calculates the average of the cyclic maxima in the selection. **Average Peak-to-Peak** calculates the average of the cyclic peak-to-peak (maximum minus minimum) differences in the selection. **Average 1/3Max+2/3Min** calculates the average of the cyclic 1/3Max+2/3Min values in the selection. (1/3Max+2/3Min calculates 1/3 of the maximum value plus 2/3 of the minimum value of the data points in a cycle.)

▼ ***Refer***
The Spectrum Window, p. 147

Spectrum Parameters

Spectrum parameters are based on spectra which are calculated according to the settings in the Spectrum Settings window, and displayed in the Spectrum window. When a Spectrum parameter is selected in the Data Pad Column Setup dialog box, an Options… button appears.

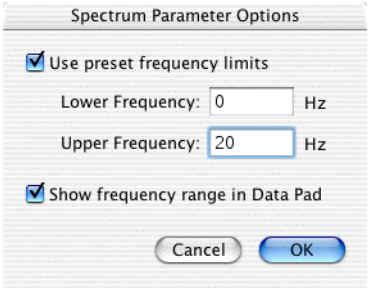


Figure 6–6
The Spectrum Parameter options dialog box.

If there is a selection of valid data in the Chart window, Spectrum can perform a range of calculations in the Data Pad to determine the spectral parameters. The Spectrum window does not need to be visible in order for these parameters to be calculated. The Data Pad and miniwindow displays show 'Invalid' if there are no selected data. To preset frequency limits, or choose whether or not to display (in the Data Pad headers) the frequency limits within which the parameters are calculated, click the Options… button at the bottom of the Data Pad Column Setup dialog box. The Spectrum Parameter Options dialog box appears.

If you know the range of frequencies in which you are interested, you can turn on the Preset Frequency Limits checkbox and enter them in the text entry boxes. Parameters are then calculated from between those frequency limits (or as close as possible, given the frequency resolution). If the checkbox is off, then parameters are calculated over the frequency limits of any selection in the Spectrum window, or else the frequency range visible in the window if there is no selection.

Turn on the Show Frequency Range in Data Pad checkbox to display the frequency range used by Spectrum in calculating parameters, in the Data Pad column headers, and in the Data Pad miniwindows (it appears in brackets after the units).

Maximum Power displays the maximum power. **Minimum Power** displays the minimum power. **Maximum Amplitude** displays the maximum amplitude. **Minimum Amplitude** displays the minimum amplitude. **Frequency at Max** displays the frequency at maximum power/amplitude. **Frequency at Min** displays the frequency at minimum power/amplitude. **Power** displays the power. **% of total Power** displays the percentage of the total power. **Mean Amplitude Freq** displays the mean amplitude frequency; $\sum A_i F_i / \sum A_i$ where A is amplitude, F is

frequency, and *i* is the 'bin' number. **Mean Power Freq** displays the mean power frequency; $\Sigma P_i F_i / \Sigma P_i$ where *P* is power, *F* is frequency, and *i* is the 'bin' number. These options are calculated over all the frequency bins in the frequency range. The range used is set by either the preset frequency limits, or failing that, the frequency limits of any selection in the Spectrum window, or failing that, the frequency range visible in the window.

Start of Selection displays the time at the beginning of the data selection used to generate the spectrum. **End of Selection** displays the time at the end of the data selection used to generate the spectrum. These options refer to the selection in the Chart window.

The three radio buttons indicate when information is to be recorded. If the top one is selected, then if there are any data selected in the Chart window, information will be recorded about the channel selected in the Channel pop-up menu (if you have selected an area in Channel 2, information on Channel 3 would still be recorded, for instance). If the middle radio button is selected, information is recorded about the column channel only if that channel is included in the selection. If the bottom radio button is selected, information is recorded only about the lowest-numbered channel if more than one is selected (Channel 2 if Channels 2 to 4 are selected, for example). Data transfer from the Zoom window is always as if the top radio button were selected, regardless of the settings.

The Compact Data checkbox works together with the middle radio button: if you select data from different channels at different intervals after the same stimulus, say, it will place all the data on the same line in the Data Pad (if the checkbox is off, then each entry will be recorded on a new line). It doesn't work if you record times as well, so it is only useful for simple data capture.

Its various functions make the Data Pad useful for quickly finding out information about a file or blocks in it: you can leave the Data Pad itself, set up to display the required information, as a slim visible background window that will be constantly updated. In addition, miniwindows can be created to display the current values of statistics or

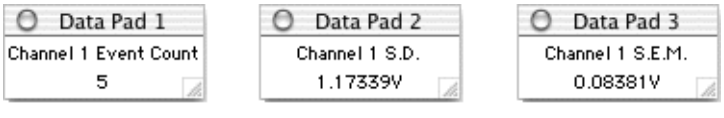


Figure 6–7
Data Pad Value miniwindows.

measurements set up in particular columns from the Data Pad. To show or hide the miniwindow for a column, turn on or turn off the Miniwindow checkbox in the Data Pad Column Setup dialog box, or drag the column heading to tear it off. Drag the miniwindow by its title bar to where you want it, click the close box to dismiss it, or click its body to open the dialog box again. Its title bar contains its column label and its body the heading, to indicate what it displays. Data Pad miniwindows can be resized by dragging their bottom right corners.

Printing

When the Data Pad window is active, then the Print option in the File menu changes to Print Data Pad…, and if the command is selected, the contents of the window are printed with the title 'Data Pad from' and the file name. The Data Pad will print across two or more pages if it is wide enough, but empty columns are not printed.

The X–Y Window

By using the X–Y window, you can plot data in one channel against data in another over the same period of the recording. To open the X–Y window, drag in the Time axis to select an area of interest (over two or more channels) in the Chart window, and then choose Window > X–Y Window.

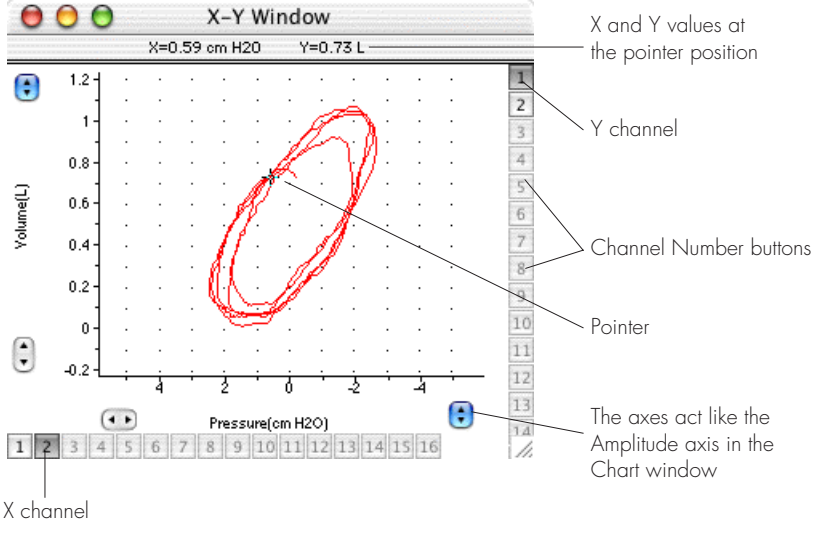


Figure 6–8
The X–Y window.

The X–Y window is useful to establish how two time-related variables relate themselves, by eliminating time: you could measure pressure and temperature versus time, say, then use the X–Y window to show pressure versus temperature. It would also show phase relationships, such as the hysteresis loop of a changing external field versus its induced ferromagnetism. The values along the x-axis (X) and y-axis (Y) at the pointer position are indicated at the top of the window, in the units assigned to the channels. The waveform is not tracked: there is no Waveform Cursor.

The Channel Number buttons at the bottom left (horizontal x-axis) and right side (vertical y-axis) of the window correspond to the numbers in the default channel titles. Buttons for channels not included in the selection, or without data, appear dimmed. The highlighted Channel Number buttons indicate which two channels are used in the plot: the bottom one provides the x-values, and the one on the right the y-values. The channels plotted against each other can be changed by clicking the (undimmed) numbered buttons: the buttons of the newly selected channels will be highlighted.

Both X and Y axes in the X–Y window have the same controls as the Amplitude axis in the Chart window, and function identically. Changing the display in the X–Y window does not affect the selection in the Chart window. The display will appear gray if no channels are selected in the Chart window or if no Channel Number buttons are selected. The X–Y window does not indicate if the selection in the Chart window is discontinuous (crossing block boundaries), but the X–Y plot will probably look strange if it is. The color for the waveform is chosen in the Display Settings dialog box. Comments and exclusions are ignored by the X–Y window, since they are time-based, and the X–Y plot eliminates time.

▼ ***Refer***
Display Settings, p. 77

Copying and Printing the X–Y Window

When the X–Y window is active, then the Print option in the File menu changes to Print X–Y…, and if the command is selected, the contents of the window are printed with the title 'XY Plot of' and the file name. The X–Y window can also be copied as a picture for pasting into other applications, by choosing Copy X–Y… from the Edit menu.

The Spectrum Window

The Spectrum window can calculate and display various power and amplitude spectra of selected data. Spectra indicate the strength of the various frequencies in a time-varying waveform. This may make apparent significant frequencies in a waveform that would not otherwise be easily observed. Spectra (various forms of power or amplitude spectra) are calculated using the discrete Fast Fourier Transform (FFT) to convert data from the time domain to the frequency domain. Technical details of the FFT used by Spectrum are included in Appendix C.

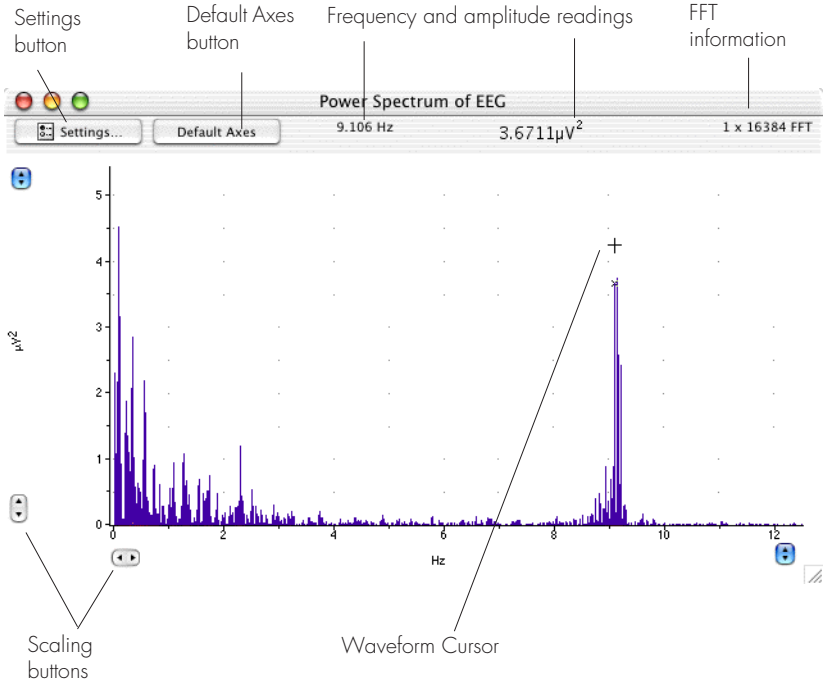


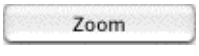
Figure 6–9
The Spectrum window: the type of spectrum (power or amplitude) and channel name are shown in the title bar.

To display spectra, select the area of interest in the Chart window and choose the Spectrum command from the Window menu. The Spectrum window appears. Only the horizontal extent of the selection affects the computation. If more than one channel has data selected, the top one is chosen. If a selection is made over two or more blocks, Spectrum uses only the data in the left-most block. The data display area will appear

gray if there is no selection (in which case the title of the window will just be Spectrum), or if 32 or fewer data points are selected: the reason will be noted in the selection information at the right of the window.

The Spectrum window displays information on the data selection. As the pointer is moved over the Spectrum data display area, the Waveform Cursor tracks the data, and the frequency and amplitude readings at its position are displayed at the top of the window. The spectrum is drawn in the data trace color used for the channel, and can be drawn as lines, bars, or connected points. The graticule is the same as that used in the Chart window.

The two axes of the Spectrum window can be shifted, stretched, and dragged for optimum data display, just like the Amplitude axis of a channel in the Chart window. In addition, you can use the Scaling buttons in the bottom left corner of the window: click the up arrow to double or the down arrow to halve the current scale of the axis to which they apply. If no units are present in the source channel the Amplitude axis will show units as 'unknown'.



You can drag within the data display area of the window to select an area to examine in more detail: the area becomes highlighted, and the Zoom button appears at the top left of the Spectrum window (replacing the Default Axes button). Click the Zoom button or double-click the selected area: the selection expands to fill the data display area, and the axes show the new scale.

A gray area may appear at the edge of the Spectrum window. This is a data limit area (as appears in the Chart window) that indicates the

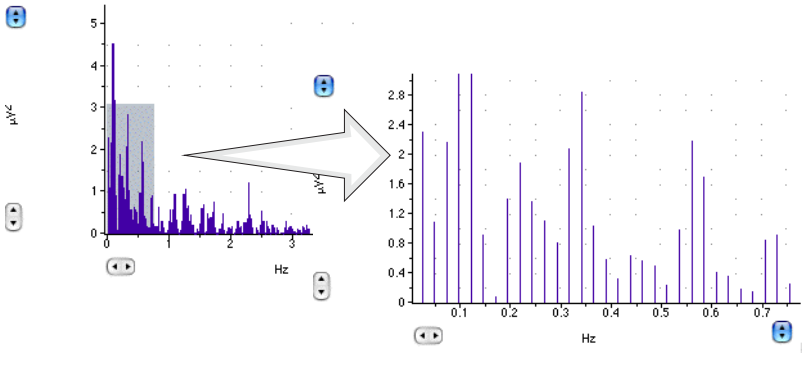
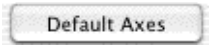


Figure 6–10
Enlarging a selection in the Spectrum window: click the Zoom button or double-click the selected area.

recorded or calculated limit of data in the window. To hide the data limit area, drag the axes or use the Scaling buttons.



Altering the data displayed in the Spectrum window does not change the selection in the Chart window. Once you have altered the axes, zoomed in, and so on, the Default Axes button appears (replacing the Zoom button if it was showing). Click it to revert to the default axes, and show the full spectrum of the selection in the Chart window again. The Default Axes button is dimmed and inactive when the default axes are showing (since there's nothing to revert) or when the data display area is gray.

Spectrum Settings

Clicking the Settings button at the top left of the Spectrum window opens the Spectrum Settings window, where parameters for calculation and display of the spectrum can be set. The Spectrum Settings window can be moved around the screen or left in the background while the Chart or Spectrum window is active. You can keep it active and change the settings, and observe the changes in the Spectrum window in the background, if that window is visible: the spectrum will be recalculated or redrawn as you change settings.

FFT Size. The Discrete Fourier Transform is computed using a Fast Fourier Transform (FFT) method. The FFT works on a certain number of data points at a time over the selection to be analyzed. The larger that number, the greater the frequency resolution (the number of frequency 'bins' into which the signal is resolved). Smaller FFT sizes give a higher

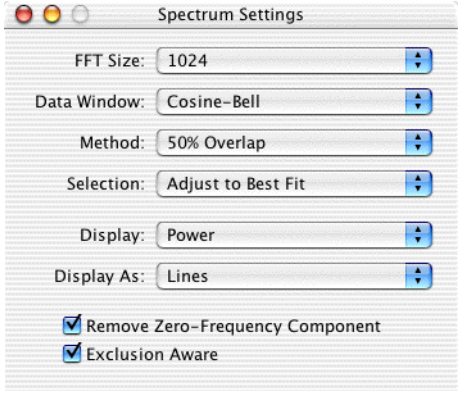


Figure 6–11
The Spectrum Settings window.

amplitude accuracy, but a lower frequency resolution. The FFT sizes available in the pop-up menu are various powers of two: 128, 256, 512, 1024, 2K (= 2048), 4K (= 4096), and so on, up to 128K (= 131 072 = 2^{17}) data points. This is indicated in the window above the graph.

Data Window. Windowing functions reduce the importance of data at the edges of the data segments used by the FFT, thus preventing spurious peaks arising from edge-related effects. There are many such functions, but they are all basically similar. By default, Cosine Bell is chosen in the Data Window pop-up menu, but you can choose Cosine Bell, Hamming, Blackman, or Welch windowing functions. More details on the windowing functions can be found in Appendix C. To turn off the windowing functions, if none of them are suitable, choose None from the pop-up menu.

Method. If the number of selected data points is greater than the FFT size, Spectrum determines the spectra of selected data for successive segments of a particular FFT size and then calculates an average spectrum from these FFTs. You can choose from the Method pop-up menu whether successive segments follow one after another with no overlap, or overlap by 50% of the FFT size (the default). If a windowing function other than None is chosen, the Method of computing the spectrum changes to 50% Overlap.

If No Overlap were chosen from the Method pop-up menu, a data selection of 1024 points with an FFT size of 512 points, for example, would be divided into two segments: points 1–512 and points 513–1024. If 50% Overlap were chosen for the same data, the segments would change to points 1–512, points 256–768, and points 513–1024. The 50% Overlap option (Welch's method) better approximates the moving average of the selected data, by doubling the number of computations and overlapping the segments from which spectra are computed. On the other hand, the extra calculations take more time, and may slow things down if your computer is an older model.

Selection. There are two choices in this pop-up menu. The Use Current option brings the total data points in a selection to a multiple of the FFT size by padding the data with zeroes (adding points with a value of zero) on the right-hand side.

The Adjust to Best Fit option adjusts Spectrum's 'internal' data selection so that it is a multiple of the FFT size, by extending (symmetrically, if possible) the data points selected for use within the same block. Note that the visible selection in the Chart window is not altered, only Spectrum's internal data selection, so care must be taken when using this feature.

Display. Spectrum can calculate various forms of power or amplitude spectra: you can choose which is shown from the Display pop-up menu. Details on how these are computed are given later. In each case, the height of the spectrum at a particular frequency is representative of the power or amplitude contained in the waveform at that frequency. Appropriate units are shown in the axis labels.

Spectrum displays the results of the discrete Fourier transform in various ways. The Power spectrum is basic; other forms are derived from it. The power in a 'bin' of the spectrum is the modulus squared of the discrete Fourier transform at that frequency. The amplitude in a bin is the amplitude of a sine wave whose average power is the same as the bin's power. Power and amplitude values are always positive or zero; they cannot be negative.

Power Density and Amplitude Density show the power or amplitude per unit frequency. Density is calculated by dividing the computed values by the width of each horizontal frequency bin (this width narrows as the frequency resolution increases and a greater number of discrete frequencies are recognized). The units of power density are (y-axis units)^2/Hz, and the amplitude density units are (y-axis units)/$\sqrt{}$Hz.

The Log of Power and Log of Amplitude options show the power and amplitude spectra as $\log_{10}$ values. The logarithmic display makes discernible smaller components that might otherwise be difficult to see in the graph because of the wide range of values.

The Power Attenuation and Amplitude Attenuation options give a logarithmic display showing the relative attenuation of spectral lines with respect to a reference value (P_{max} for a power spectrum, A_{max} for an amplitude spectrum). The reference value is always taken as the largest value in the spectrum and shows as 0 dB. Power attenuation is calculated as $dB = 10 \log_{10}(P_i / P_{max})$, and amplitude attenuation as $dB = 20 \log_{10}(A_i / A_{max})$, where P_i is the *i*th power component and A_i is the *i*th amplitude component.

Display As. FFTs are often drawn as bar graphs, with a vertical line or bar for each data point. You can use this pop-up menu to display the FFT as lines, bars, or connected points, to suit the waveform or personal taste. The Waveform Cursor will track the left edges of bars, when these are displayed.

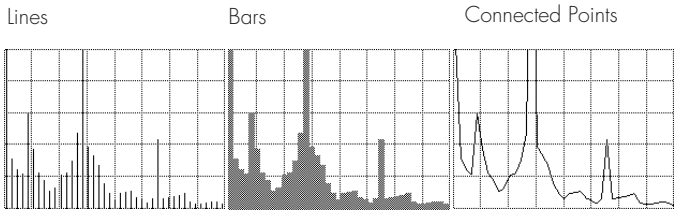


Figure 6–12
A spectrum displayed as lines, bars and connected points.

Remove Zero-Frequency Component. This option removes any zero-frequency value (that is, the DC offset, or the average value of the original data) from the data before the spectrum is calculated. The checkbox is on by default since the zero-frequency component often has the largest amplitude of all components in a spectrum, and is usually unimportant. Click the checkbox to turn it off or on.

Exclusion Aware. Chart data can be marked with exclusions — points or areas to be excluded from analysis for various reasons. By default the Exclusion Aware checkbox is on and Spectrum takes exclusions into account, ignoring excluded data. In this case, exclusions are treated as separate blocks containing no valid data. Thus a spectrum will not be calculated for a selection lying wholly within an exclusion, and if a selection intersects with an exclusion, only the left-most unexcluded data will be used. If the checkbox is turned off, Spectrum ignores exclusions and treats all data as valid.

▼ ***Refer***
Using Exclusions, p. 123

Data Pad Functions

As well as calculating and displaying spectra in the Spectrum window, you can also log parameters based on calculated spectra to the Data Pad. Spectrum Data Pad functions are discussed in the Data Pad section of this chapter.

▼ ***Refer***
The Data Pad, p. 136

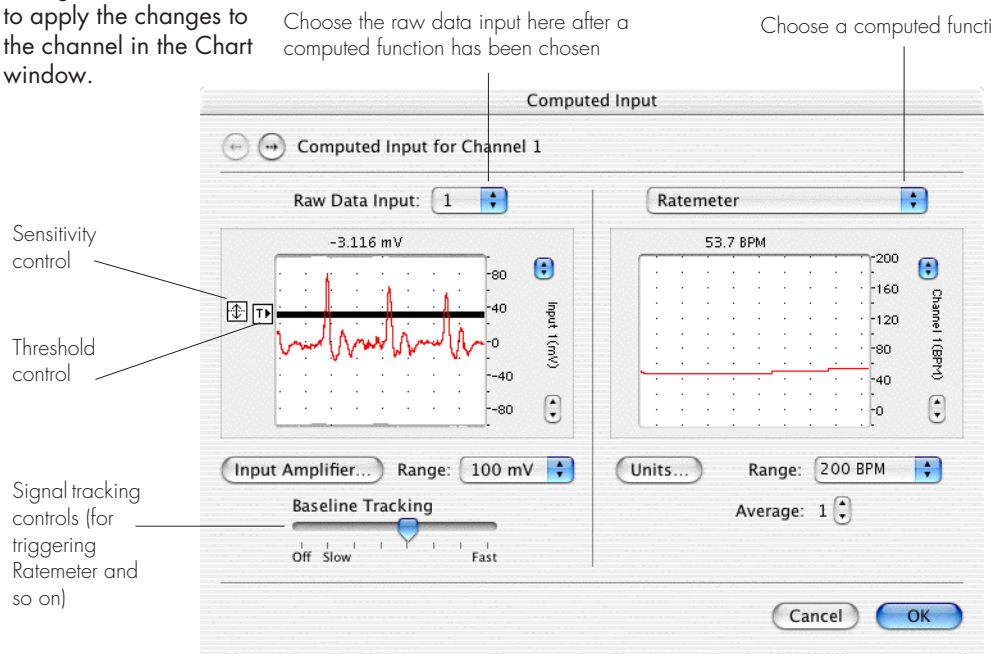
Any changes made in the Spectrum Settings window will affect the Spectrum Data Pad functions.

Computed Input

Often some computation based on raw signal data may be of more use, or may be required in addition to the original signal. For example, if you have an oscillating signal it may be of use to show a trace of the period or frequency of the oscillations, or you may want an RMS calculation of a vibration signal, or to plot the differential (rate of change of the signal. Chart has a number of powerful computed input functions that allow the online processing of raw signals.

The Computed Input dialog box (Figure 6–13) lets you process signals as they are recorded, converting the raw data from any e-corder input into computed data. Both raw and computed data are displayed there, for optimal settings adjustment. The dialog box appears if you choose Channel Function pop-up > Computed Input… for a channel, or click the Computed Input column in the Channel Settings dialog box. The channel is indicated in the dialog box title. To set up many channels quickly, click the arrows by the dialog box title, or press the right or left arrow keys on the keyboard, to move to the dialog boxes for adjacent channels. This skips channels that are turned off. Click OK to close the dialog box afterwards.

Figure 6–13
The Computed Input dialog box — click OK to apply the changes to the channel in the Chart window.



▼ ***Refer***
Channel Settings, p. 81

The Computed Input… command from a Channel Function pop-up menu is ticked if the channel has computed input applied. You can easily check all the channels at once to see the computed function applied, if any, by looking in the Computed Input column of the Channel Settings dialog box.

The Computed Input dialog box has two main areas: the left side shows the signal display for the raw data (similar to that in the Input Amplifier dialog box), and the right shows the signal display for the computed data. Initially the right display is gray, and few controls appear; if something other than Raw Data is chosen from the Computed Function pop-up menu, then computed input is active, the computed signal is shown in the right signal display area, and more controls are available. Different functions may have different controls.

Sampling Rates

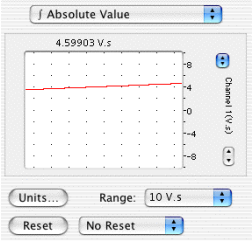
You might have to reduce the sampling rate or turn off channels to sample when using computed inputs, since they can use a lot of the e-corder's processing power. Chart will give an alert if the sampling rate is too high for your setup. All computations are done on raw data taken at 2000 samples per second or higher in the e-corder and then processed to give derived values at the sampling rate set in Chart (this means that if you choose a sampling rate of 2000 /s or slower, computations use raw data sampled at 2000 /s, and if you choose a sampling rate above 2000 /s, computations use raw data sampled at the set rate). The sampling rate you can set is limited by the number and type of computed inputs chosen (since different functions use different amounts of processing power), as well as the computer and the connection.

Signal Displays

The raw and computed data are displayed so that you can see the effect of changing the settings. No data are actually recorded when setting up computed input, although stimuli can be generated while the dialog box is open (so that Stimulator output waveforms can be observed). The current signal value is displayed at the top left of each display area. Slowly changing waveforms will be represented quite accurately, whereas quickly changing signals will be displayed as a solid dark area showing only the envelope (shape) of the signal formed

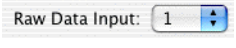
by the minimum and maximum recorded values. You can shift and stretch the vertical Amplitude axis of each signal display to make the best use of the available display areas. Apart from being at the right, each is the same as the Amplitude axis in the Chart window, and the controls function identically.

Figure 6–14
The computed data display area with an integral function selected.



Raw Data Controls

By default, Chart channels record the raw data for the corresponding e-corder inputs. When first turned on, higher-numbered channels with no matching physical inputs record the Ratemeter computed function based on the raw data of e-corder Input 1.

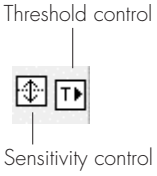


The Raw Data Input pop-up menu lets you choose any e-corder input as the source signal upon which computations are performed. This means that raw data from any e-corder input can be processed and the computed results displayed on any channel. You can show raw data on one channel and computed data on another, to compare them, or use several channels to show various computations based on raw data from the same input. It is even possible to show the raw data from one input on the channel corresponding to another input, although this could be unnecessarily confusing in practice. Note that whenever you record computed data in a channel, you replace any raw data that would otherwise have been recorded there, so any original signal in that channel would be unavailable for further analysis.

Clicking the Input Amplifier… button opens the Input Amplifier dialog box, allowing convenient access to filtering options, the display offset, and so on for the raw data signal. The Range pop-up menu lets you select the range of the input to get the best signal response. Changing the range in this dialog box is equivalent in all respects to changing it in the Chart window: the pop-up menu is duplicated here for convenience.

The Threshold and Sensitivity and the Baseline Tracking controls are available when one of the cyclic rate functions (Ratemeter, Period, Frequency, and Counter) or cyclic amplitude functions (Cyclic Mean, 1/3Max+2/3Min, Cyclic Minimum, Cyclic Maximum and Cyclic Height) is selected.

Threshold and Sensitivity



The Threshold control sets the minimum level at which the signal will trigger the computed input for a cyclic rate or cyclic amplitude function. The incoming signal must cross through the threshold level in order to register an event. The Sensitivity (or hysteresis) control allows you to adjust how sensitive the trigger is to small signal fluctuations.

The Threshold control is initially set to zero: if the signal has a lot of noise in this region, it is best to move the trigger away from zero. You can drag the Threshold control up or down to change its settings — a gray box and line appear, to indicate where it will go. When the box and line are in the desired position, release the mouse button to apply the new settings. The Sensitivity control is automatically moved with the Threshold control. It can itself be dragged up to adjust the sensitivity bandwidth symmetrically above and below the threshold level — again, a gray box and line appear. When the box and line are in the desired position, release the mouse button to apply the new settings. A highlighted area indicates the hysteresis region. For a signal to trigger the computed input function, it must go above the highlighted area and cross back through it: a signal remaining within the region will not trigger the computed function.

Once the incoming signal is stabilized for cyclic rate and cyclic amplitude functions, a threshold and hysteresis should be defined. Because the signal is periodic for functions where this applies, it doesn't matter in many cases where the threshold is, because it will occur in the same place in each cycle. It is best to move the threshold if there is a lot of noise around zero, though, or if the repeating waveform has multiple peaks.

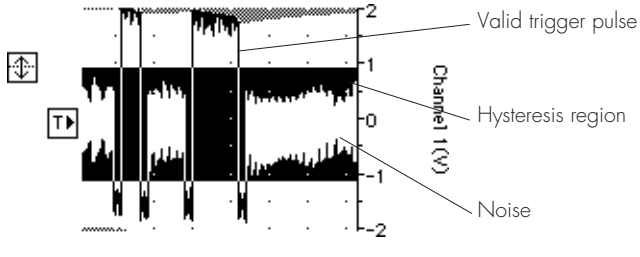


Figure 6–15
Using the Sensitivity control to stop noise triggering the computed input.

Baseline Tracking

Baseline tracking is used to remove any constant or slowly changing signal from the raw data before computed function triggering occurs. In effect, it acts as a variable-frequency high-pass filter, ensuring that the threshold and sensitivity settings follow the waveform. It works by applying a suitable averaging technique to the raw data and subtracting the result to modify the signal. The amount of averaging depends on the position of the Baseline Tracking slider (Slow gives a little, Fast gives a lot). Modified data are shown in the data display.

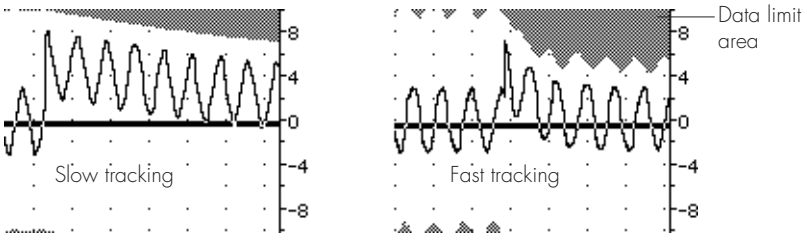


Figure 6–16
Applying a sudden change to the input signal at slow and fast tracking speeds.

Figure 6–16 shows the differences at slow and fast tracking speeds when applying a sudden change to the input signal. The signal is outside the trigger band for much longer with a slow tracking setting. When using faster baseline tracking settings, the shape of the signal may become distorted, but because data are only being used for triggering when baseline tracking is available, the distortion does not affect calculation accuracy. Figure 6–17 shows the distortion of a square wave with a fast tracking setting.

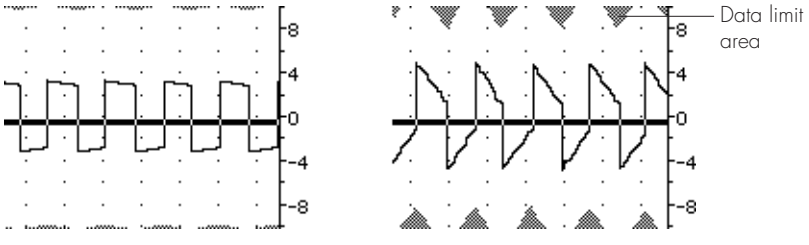


Figure 6–17
A square wave (left) distorted at fast tracking speeds (right).

The gray data limit area that can appear at the top and bottom of the data display area indicates the full scale of the e-corder input at the current range setting. If the gray area moves down and meets the signal, the input amplifier is overloaded (this is the same as having the signal go off scale in the Input Amplifier dialog box). If this occurs, select a higher input range value. In general, the baseline tracking rate

should be set as fast as is possible without decreasing the reliability of triggering. Baseline tracking also has an Off setting, so it can be turned off. This is useful where tracking the waveform could be counterproductive: say, when recording a digital pulse.

Computed Input Controls

Figure 6–18
The Computed Function pop-up menu.

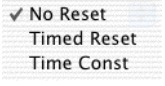
The Computed Function pop-up menu gives the range of available functions. Raw Data means the sampled data with no computed function applied, and is the default setting. The other functions are in related groups: **cyclic rate** (Ratemeter, Period, Frequency and Counter); **cyclic amplitude** (Cyclic Mean, 1/3Max+2/3Min, Cyclic Min, Cyclic Max and Cyclic Height); **absolute value** (Abs Smoothed and RMS smoothed); **envelope** (Envelope Min and Envelope Max); and **calculus** (Differential and the five forms of Integral: normal Integral (∫), ∫ Absolute Value, ∫ Positive Only, ∫ Negative Only, and ∫ Reset Each Cycle). The functions are discussed in detail below.

The Units and Range controls are available when one of the cyclic rate or calculus functions is selected, and the Average control is available when Ratemeter, Period, or Differential is selected. The Time controls are available when one of the integral functions is selected, with the exception of ∫ Reset Each Cycle, and the Reset control is available for all of the integral functions.

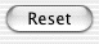
Clicking the Units… button opens the Units Conversion dialog box, letting you change the given units for the computed channel to the units of your choice. The waveform in the right data display area is transferred to the data display area of the Units Conversion dialog box, if you do this. The conversion will only apply to subsequently recorded signals, so it is more limited than choosing units conversion directly, since you cannot convert individual blocks of data. Units conversion is performed on the computed data, not the raw data.

The Range pop-up menu lets you select the range for the computed signal to get the best display. This range applies only to the computed signal, and is independent of the range for the raw data signal from the e-corder input. The Range pop-up menu for a channel in the Chart window duplicates this one when the computed function is applied to the channel, and the range can be changed in either place.

The Average control allows smoothing of the data when you want to see a trend in a Ratemeter or Period waveform rather than sample-by-sample changes. Click the up or down arrows to increase or decrease the averaging: the sequence is 1, 2, 4, 8, with 1 being no averaging. The Average control is also available for the Differential computed function, with the sequence reaching 64. The control works by averaging the values of the specified number of preceding samples, and so may give rise to a slight phase shift in the waveform, especially with the Differential function. If you need to know exact times, you should record the raw data separately as well.



The Time controls let you choose how an integral function resets to zero. For periodic waves, resetting corrects for cumulative errors, such as those due to DC offset. If No Reset is chosen in the pop-up menu, the text box is dimmed and inactive; otherwise you can enter a value of up to 3600 seconds for Timed Reset or 65 seconds for Time Const, in increments of the sampling interval (0.1 seconds if you sample at 10 samples per second, say). Timed Reset resets the signal to zero after each multiple of the entered time. Time Const introduces an exponential decay, so that (given a zero input signal) the integral drops to 37% of its initial value over the set time.



The Reset button resets the signal in the computed input data display area to zero when clicked. It is only used for convenient zeroing of the display signal while in the dialog box.

Computed Input Functions

Ratemeter

Frequency, or rate, is how often a given event occurs within a certain time. The Ratemeter function measures lower-frequency periodic signals and gives the output in reciprocal minutes (BPM, beats per minute) up to 2000 BPM. The Ratemeter function first calculates the waveform period (see below) and then takes its reciprocal and scales it appropriately.

Since the period is the difference between valid triggering signals, if triggering is lost, then the period will get larger. In this case, the period is constantly updated to show that it is currently at least a certain length. The computed signal thereupon falls exponentially (since it is

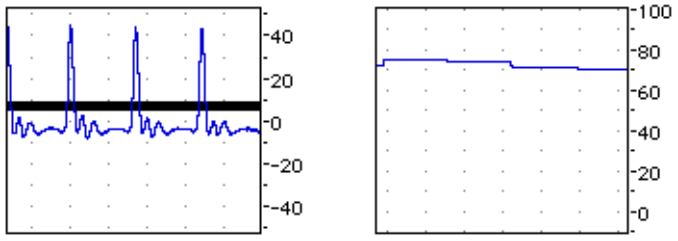


Figure 6–19
Ratemeter: left, the raw data showing periodic pulses; right, the computed ratemeter signal in BPM.

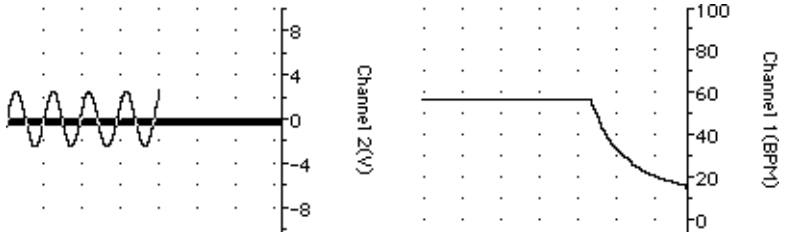


Figure 6–20
Loss of Ratemeter triggering signal: left, raw data; right, computed input.

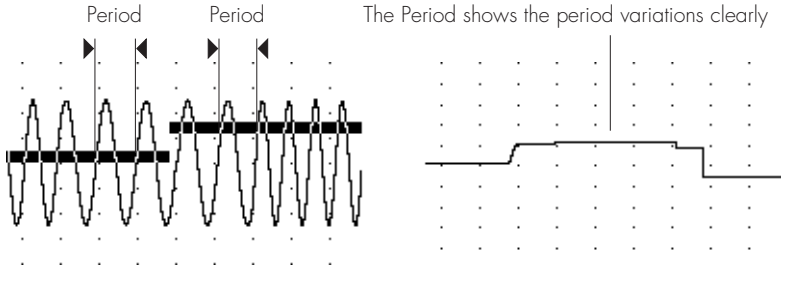


Figure 6–21
Period: left, raw data (showing two threshold settings, either setting would work well); right, computed period signal.

based on the reciprocal of the period), which gives an indication that triggering has been lost: if just a straight line were presented, continuing to show the last valid rate, it might be assumed incorrectly that things were still all right.

Period

A period is the time taken to complete one cycle of a regularly recurring waveform. The Period computed function is basically the Ratemeter without the reciprocal, and gives information about the

periodic behavior of a waveform. Note that the measurement is independent of where the trigger point is in the cycle.

The period is the difference between valid triggering signals, so if triggering is lost, then the period will get larger. In this case, the period is constantly updated to show that it is currently at least a certain length, and will increase until the maximum period for the set range is reached. Period can be more a useful measure than frequency for waveforms with very slow cycles, such as waves in water or tremors in earth.

Frequency

Frequency is how often a given event occurs within a certain time. The Frequency function measures the frequency of the waveform in hertz (cycles per second) up to 2000 Hz, and is suitable for measuring periodic signals of higher frequency than those for which the Ratemeter is used. The calculation is done differently to that for the Ratemeter, to ensure accuracy. The Frequency function works by breaking each second into 20 'bins'. Each time the threshold is crossed from lower to higher, the count in the current bin is increased by one. (That is, it counts the number of times the signal crosses the threshold in one direction every 0.05 s.)

Chart shows the sum from the last 20 bins. This gives a faster and smoother result than if summing were just done for one second. For example, if recording a 100 Hz signal that changed to 200 Hz over one second, you would see the frequency gradually changing from 100 to 200 Hz. If results were summed over one second, you would just see a jump from 100 to 200 Hz, with an intermediate value (the average of the two signals).

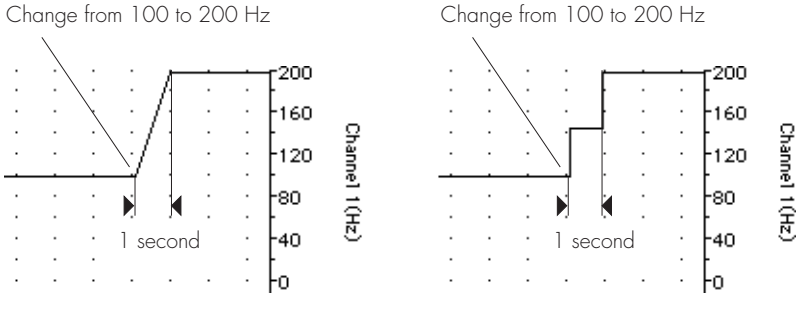


Figure 6–22
Frequency: left, the gradual change used by Chart, right, if summation were coarser.

Counter

The Counter function just counts transitions from below to above the threshold, displaying up to 20 000 registered events versus time. It wraps back to zero when it gets to the maximum number of counts in the current range. If you set the range to 200, for example, then after the count reaches 199, the waveform will reset, so that the next, 200th, count will be 0 again. This lets you quickly get a total count over a time by looking at the number of resets, plus the last number shown for the count. This function has a number of useful purposes, for instance tallying the radiation blips registered by a Geiger counter.

Cyclic Mean

A cyclic mean is the average amplitude of a waveform over a cycle. Variations indicate some form of asymmetry. The Cyclic Mean function sums the values of the data points between two successive threshold transitions and divides by the number of points summed. Note that this calculation is only useful for truly cyclic (oscillating) signals, it should not be used to try to determine the mean of a noisy signal. The threshold controls where the summation starts and ends, but because the input is a cyclic wave, the result should not depend on threshold position. Only when the waveform has some other periodic signal superimposed on it does the actual threshold affect accuracy of calculation. The results you get from the cyclic mean are the same as if you selected an exact period of the raw data, integrated that selection, and divided the integral by the period.

Note that in Figure 6–23, summing starts and ends at different times when the threshold is in different places, but the results are the same. It would be much better in this case to leave the threshold in the center of the waveform, because it will still work even if the amplitude of the signal changes slightly. In the right-hand example, if the amplitude were much smaller, the triggering would be lost.

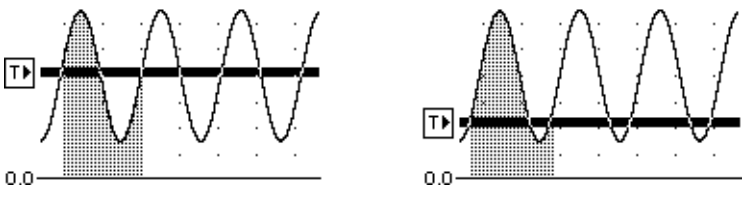


Figure 6–23
Cyclic Mean: summed area for different thresholds (shown shaded).

1/3Max+2/3Min

The 1/3Max+2/3Min function adds, for each cycle, one third of the maximum amplitude of the waveform to two thirds of the minimum, to give an approximate mean and is included for historical purposes. A more accurate mean is obtained using the Cyclic Mean computed function.

Cyclic Max, Min, and Height

In the Cyclic Max function, the trigger threshold identifies cycles. At the end of a cycle, the maximum data point found within that cycle is shown until another cycle has been measured. The Cyclic Min function works similarly, save that the minimum value of a cycle is found, and displayed during the next cycle. The Cyclic Height function determines the maximum minus the minimum value. These functions are useful for showing the cycle-by-cycle minima or maxima or the difference between the two.

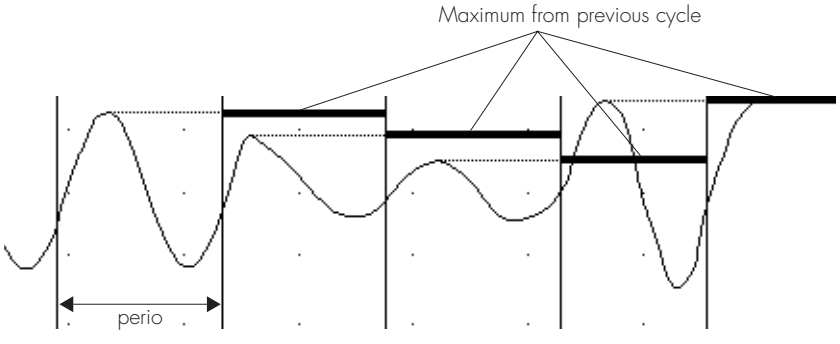


Figure 6–24
Cyclic Max: the largest value obtained by the waveform in the previous cycle is retained.

Abs and RMS Smoothed

Abs Smoothed smooths using the absolute values of the preceding data points over the time set in the Smooth pop-up menu. RMS Smoothed (root-mean-square) smooths using the square root of the average of the squared values of the preceding data points over the time set in the Smooth pop-up menu. (In each case, the data points are sampled at 2000 samples per second or faster.) These two functions provide similar ways of getting the same thing, a modified moving average, set by time, not by number of samples, and ignoring whether peaks are positive or negative (that is, regardless of whether the waveforms are

biphasic). They are useful in electromyography and studies of spontaneous neural activity, to provide an indication of the average amount of activity.

Envelope Max and Min

Envelope Max finds the maximum value of the data points over the time between samples at the sampling rate set by the user, and displays it during the next time period. Remember that the e-corder always samples data for computed input at least 2000 samples per second, even if the apparent rate is much less. If you set a sampling rate of one sample per second in Chart, then the maximum value of the samples in the previous second would be shown each second in the display. Information is not required about cycles or periods in the incoming data, so the triggering controls don't appear.

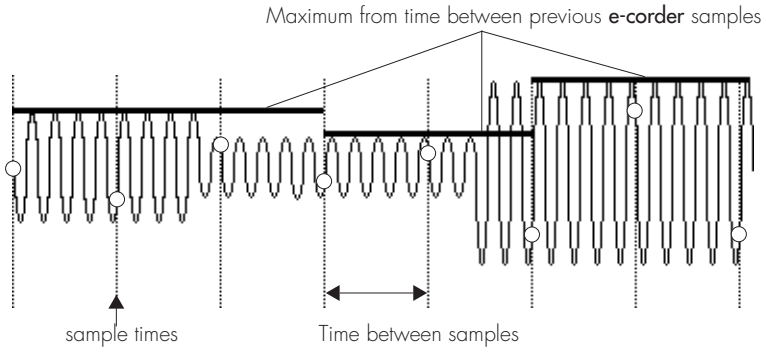


Figure 6–25
Envelope Max: sample times are independent of the waveform period — note that the raw sampled data, shown as open circles, could be quite misleading in this case.

The Envelope Min function works similarly except that the minimum value over a time is found, and displayed during the next time period. These functions are useful if the specifics of the signal are of no interest, but the maxima or minima are important, since they let you record at a much lower sampling rate than would otherwise be the case. As you can see from Figure 6–25, you would need to record at a far higher rate to get an accurate depiction of the waveform. These functions could be used, for instance, to record the maximum and minimum amplitudes of a oscillating signal: no additional information is gained by sampling these more than once per oscillation.

Differential

The Differential function gives the first derivative with respect to time of a selected channel's waveform. It is useful when the slope, or rate of change, of a signal is more informative than the raw signal itself. For example, the volume of fluid in a container could be weighed as it is collected, using a force transducer. The differential of this plot would give the rate of change of volume, that is, the flow rate.

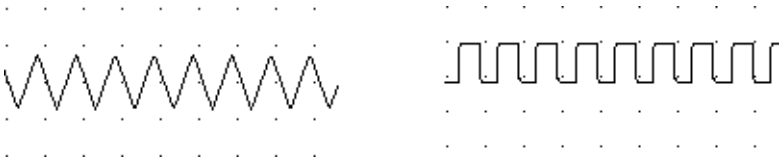


Figure 6–26
Differential: the derivative of a triangular wave (left) is simply a square wave (right).

This function is particularly sensitive to noise, so the data smoothing provided by the Average control has been extended beyond that offered for Ratemeter or Period functions, with your choice of 1, 2, 4, 8, 16, 32 or 64 preceding samples being averaged. (Note that this may give rise to a slight phase shift in the waveform.)

Integral

The Integral measures the area under a waveform, calculated as the sum of the data points multiplied by the sample interval. You could integrate the signal from an instrument that measures flow rate to calculate volume, for instance.

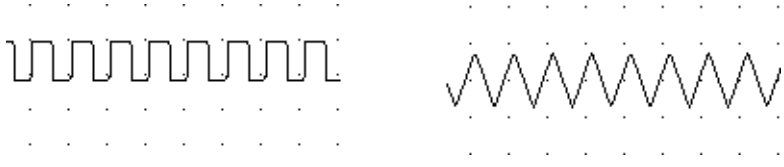


Figure 6–27
Integral: the integral of a square wave (left) is simply a triangular wave (right).

Five types of integral function are available, each useful for a different purpose.

∫ (**Integral**). This, the normal integral, is simply calculated as the sum of the data points multiplied by the sample interval. The integral over time of a signal with equal positive and negative summed values would be zero.

∫ **Absolute Value** is calculated as the sum of the absolute values of the data points multiplied by the sample interval. The integral over time of a signal with equal positive and negative summed values would be double the summed values of either.

∫ **Positive Only** is calculated as the sum of the positive values of the data points multiplied by the sample interval. The integral over time of a signal with positive and negative data points would only include the summed values of the positive data points.

∫ **Negative Only** is calculated as the sum of the negative values of the data points multiplied by the sample interval. The integral over time of a signal with positive and negative data points would only include the summed values of the negative data points.

∫ **Reset Each Cycle**, like the normal integral, is calculated as the sum of the data points multiplied by the sample interval. The integral over time of a signal with equal positive and negative summed values would be zero. This function also, however, resets the integral to zero every time the original waveform passes from below to above zero, so it is particularly useful for periodic waveforms subject to drift (with an uncontrolled offset voltage).

Resetting helps to compensate for drift that might otherwise take an integrated signal off the scale. All integrals reset to zero when they reach the positive or negative limits set by the Range control. The ∫ Reset Each Cycle resets the integral each time the original waveform passes through zero from below; other forms of integral reset the integral as specified in the Time controls. The reset effectively subtracts the range whenever the range is exceeded, so you can count the number of resets to get the total value.

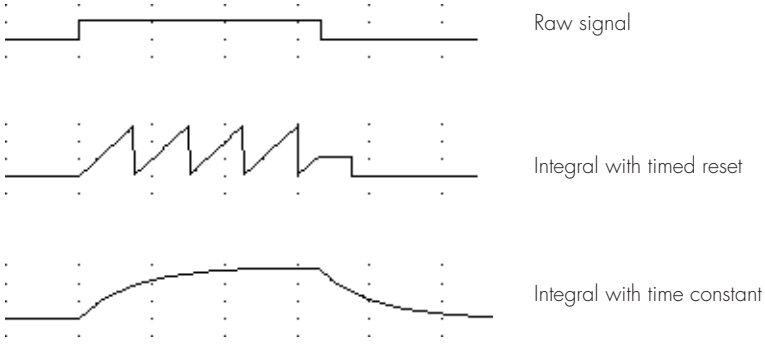
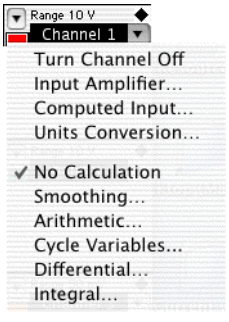


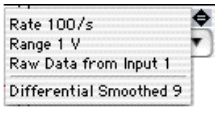
Figure 6–28
A steady offset, and its integral, using two forms of resetting.

Times entered in the text entry box smaller than the sampling interval may round down to zero, in which case no resets occur. Values should be longer than the interval over which integration is desired, in any case. ∫ **Timed Reset** resets the signal to zero after each multiple of the entered time. This method copes with drift, and computes an accurate integral before the reset. ∫ **Time Const** introduces an exponential decay, so that (given a zero input signal) the integral drops to 37% of its initial value over the set time (up to 65 seconds). This avoids drift and sudden resets, but the resultant integral will be inaccurate: this inaccuracy increases as the time constant gets smaller.

Channel Calculations



The options in the lower half of a Channel Function pop-up menu allow you to apply calculations to channels of recorded data. No Calculation is the default setting, and means the displayed data in the channel are recorded data (either raw data or computed data) with no extra calculation applied. The Smoothing, Arithmetic, Cycle Variables, Differential and Integral calculations are built into Chart, and are described here. Other channel calculations may be added with Chart extensions. Channel calculations may be online (you see the results as you sample) or offline (you see the results of the calculation only after sampling finishes).



To turn on a channel calculation, choose its menu command from a Channel Function pop-up menu. To revert to the data recorded in a channel (if any) choose No Calculation. A tick beside the option shows which is active: only one can be at any time. Calculations apply to the entire length of the channel, and operate on the displayed data of the source channel (Arithmetic can also operate on underlying recorded data). You can turn off a channel calculation without losing the values you enter in its dialog box. You can easily set up many calculations at once, or check all channels at once to see if any calculations are applied, by using the Calculation column of the Channel Settings dialog box.

▼ ***Refer***
Channel Settings, p. 81

If a channel calculation is applied to a channel, an = sign appears in the Channel Status indicator (the diamond at the right of the channel's Range/Amplitude display). Clicking the indicator pops up a list

showing the sampling rate, range, what is to be recorded (raw data or a computed function, and from which input), and any active channel calculation.

Common to most channel calculation dialog boxes is a source pop-up menu, which lets you choose the waveform in any Chart channel as the source to be processed. You may want to use one channel to display the source signal, and another to display the calculation, for comparison between the two. To display only the calculated signal, you would choose the same channel for the source as for the display.

The calculation for a channel calculation is generally done when its dialog box is closed. Quite often, you might want to adjust some settings (such as the degree of smoothing) repeatedly and observe the effect on a waveform. This requires bringing up the dialog box each time you do it, so a keyboard shortcut has been provided to ease the process and avoid the stress of a long trip to the pop-up menu. The latest calculation to be applied in the Chart window (Smoothing in Channel 4, say) gains a keyboard shortcut, Command-=, which appears beside it in its Channel Function pop-up menu: just type Command-= to recall the dialog box. If No Calculation is chosen, no keyboard equivalent appears, and any existing one is dispelled.

Channel Calculations and Exclusions

Exclusions are a special type of comment that mark data to be excluded from searches and analysis. All the channel calculations built into Chart (Smoothing, Arithmetic, Cycle Variables, Differential and Integral) do not recognize exclusions, and make the same calculation whether or not they are present. Channel calculations added by Chart extensions vary in their handling of exclusions: check their accompanying documentation for details.

▼ ***Refer***
Comments and Exclusions, p. 117

Channel Calculations and Computed Functions

There is some overlap between computed functions and channel calculations: which is best in a situation depends on the data and what you want to do with them. Computed functions must be chosen before sampling is started, and can apply to individual blocks of data. Channel calculations can be turned on or off as required, and always apply to the entire length of the channel in which they are active. They can be applied before, during, or after sampling, and can be used to

analyze data recorded at faster rates than possible using computed inputs, which use some of the e-corder's processing power. Channel calculations do not replace the recorded data in a channel, and can be used in channels that are turned off. They are useful when you need to retain the raw data as well as manipulate it in some way, and don't have enough channels to do everything at once. Some calculations work online and offline, but the more complex ones tend to be offline only, so you can't see results as you sample. Computed functions are always online, so that you can see results as you record.

Table 6–1
Comparing computed input with channel calculations.

Feature	*Computed Input*	*Channel Calculation*
Results visible during sampling	Yes	Simpler ones, yes; others, no
Raw data retained	Only if recorded on another channel	Yes
Can be applied after sampling	No	Yes
Channel can be off	No	Yes
Can record at the highest sampling rates	No	Yes

In addition to differences in the way computed inputs and channel calculations are used, there may also be differences in the accuracy and precision of the results of corresponding computed functions and channel calculations, such as integral and rate computations. Details are given in Appendix C, but the following general rules apply:

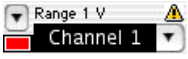
- When computations rely on a window of points, channel calculations have a greater *accuracy* than the corresponding computed input functions; otherwise accuracy will be the same.

- If the sampling rate is < 2000 Hz, computed input functions have a greater *precision* than the corresponding channel calculations; otherwise precision will be the same.

Hidden Data

If a channel contains recorded data and channel calculations for that channel are turned on, its displayed data will be the calculated data.

The recorded data (either raw data or computed data) still remain underneath, and can be seen simply by turning the calculation off.

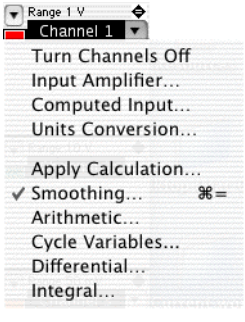


If the display in a channel uses calculated data from other channels, a warning icon flashes in the channel control area to the right of the Range/Amplitude display, on top of the Channel Status indicator. This is a reminder that what you see in the channel is not necessarily what you are recording on that channel. If you click the icon, an alert box tells you the area of concern (in this case, that the channel has recorded data hidden by calculated data from other channels). If the calculation for a channel manipulates any data from the channel (even if data from other channels are included), then there is no warning icon or alert, since the data must bear some direct connection to the recorded data. The icon and an appropriate alert may appear at other times, such as when a calculation in a file was set with a Chart extension no longer present.

Channel calculations normally work on the displayed data in a channel, so you can use them in sequence. For instance, you could smooth a waveform in one channel using the Smoothing calculation and then show the log of that smoothed waveform in another using the Arithmetic calculation. Some calculations, such as Arithmetic, let you choose to work on the underlying recorded data of a channel as an alternative to the displayed data.

Applying Calculations Permanently

Channel calculations are usually temporary, and can be created and discarded at will. You can, however, apply a channel calculation permanently to a channel, so that the calculated data become the recorded data for the channel. Beware! This replaces any recorded data already in the channel. Once gone, such original data cannot be retrieved, so an alert box will ask you to confirm your decision. When applying calculations like this, it is a good idea to use channels with no recorded data in them or to work with a copy of the original file.



To apply a calculation to a channel, hold down the Command key while opening the channel's Channel Function pop-up menu, and choose the Apply Calculation… menu command that replaces the No Calculation menu command: the calculation is applied, subject to confirmation through the alert box. The calculated values effectively then become the recorded data. If no channel calculation is active in

the channel, the Apply Calculation… menu command will be dimmed and unavailable.

Smoothing

The Smoothing calculation lets you remove unwanted high frequencies, noise, or clutter from a waveform. Smoothing always operates on the displayed data of the source channel. This in turn may have been calculated by another channel calculation (such as Arithmetic). The Smoothing channel calculation is offline, so you can see the smoothed data only when Chart is not sampling (during sampling, you see any recorded data).

Choosing the Smoothing… command from a Channel Function pop-up menu opens the Smoothing dialog box for that channel.

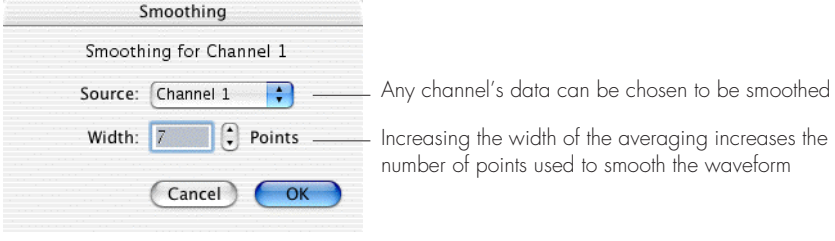


Figure 6–29
The Smoothing dialog box.

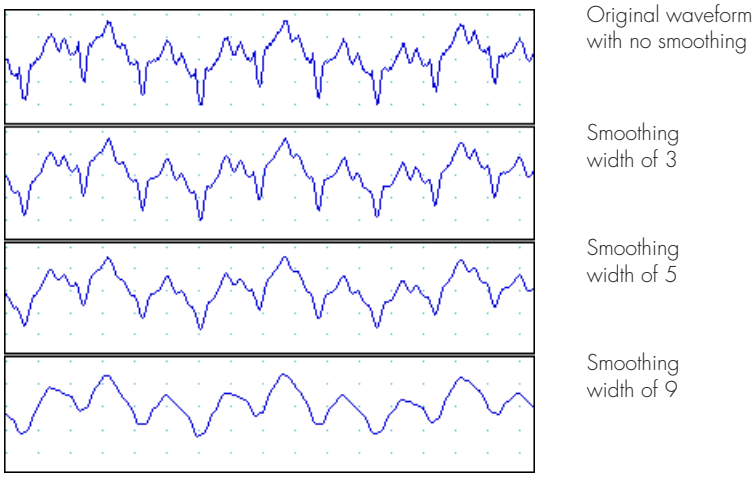


Figure 6–30
The effects of smoothing on a waveform.

By default, the channel in the dialog box title is chosen in the Source channel pop-up menu, but you can choose any channel as the source signal to be processed. If you want to display both the smoothed and the recorded data, to compare them, you could apply the function to an unused channel, leaving the source recorded data channel intact.

Smoothing works by taking a certain width of data, the sample point and an equal number of points on either side, weighting the points suitably, and averaging them to give the smoothed value for the sample point. The points are weighted using a triangular (Bartlett) window, so that the central point affects the result more strongly, with points further out affecting the result less and less. (For 3-point smoothing, the central point would be weighted by 1/2, and the two points beside it by 1/4; for 5-point smoothing, the central point would be weighted by 1/3, the two points beside it by 2/9, and the two outlying points by 1/9; and so on.) This is a modified moving average that avoids phase shift, and doesn't smooth or smear the waveform as much as simply averaging together a number of points.

The width is always an odd number. Click the up and down arrows to increment or decrement the number, or type in the number of points, from 3 to 201, in the text entry box. At the start and end of the waveform, fewer points can be taken on one side, so the number of points used in the average decreases at the extremes.

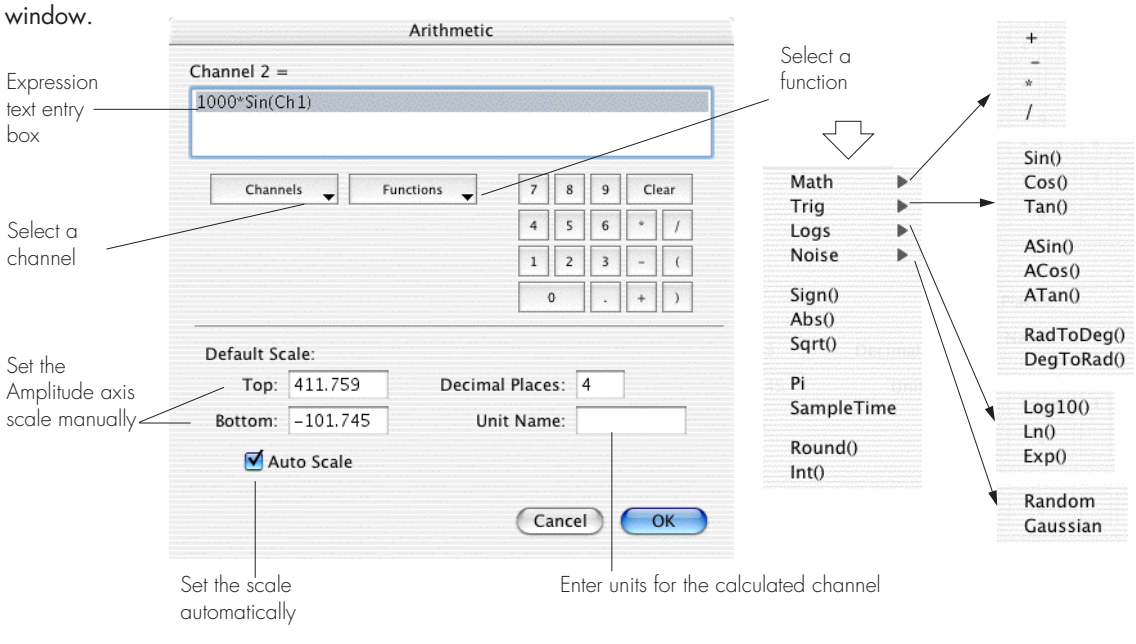


Figure 6–31
The Arithmetic dialog box — click OK to show the function in the display channel in the Chart window.

Smoothing affects different waveforms in different ways: quickly changing waveforms cannot be smoothed too much without distortion, but those that change slowly can be smoothed a lot more.

Arithmetic

The Arithmetic calculation allows you to arithmetically combine waveform data from different channels. It works online (during recording) as well as offline. Choosing the Arithmetic… command from a Channel Function pop-up menu opens the Arithmetic dialog box. The channel from which the command is chosen, and in which results will be displayed, is indicated in the dialog box title.

Entering an Expression

To enter an expression, click in the expression text entry box and type, or click the various buttons and choose channels and functions from the pop-up menus. For channel data, type 'Channel1' or 'Ch1' and so on (case is unimportant, but no spaces should be used), or choose a channel from the Channel pop-up menu. For functions, choose a function from the Function pop-up menu, or type the text of the function as it appears there (case is unimportant). Any combination of channels, functions, and operations can be entered. The normal order of operations applies, and brackets should be used as appropriate: 4*9+6 gives 42; 4*(9+6) gives 60. If you enter a simple arithmetic operation (say, 4*9+6) without references to channel data or time, you will get a straight line in the channel logging the result.

By default, Arithmetic operates on the displayed data of the channels you specify. The data in these channels may be calculated by other channel calculations (for instance, smoothing may have been applied). You can choose to work on the recorded data of an input channel, ignoring any other calculations that may be active, by typing 'R' before the channel expression ('RChannel1' or 'RCh1'), or choosing a channel from the Recorded Data submenu in the Channel pop-up menu. The recorded data is the signal that comes from the e-corder to Chart before any channel calculations are applied, and can be either raw data or computed data.

Checking the Expression Syntax

When you click OK, Arithmetic checks to see if it can understand the expression. If it cannot, an error message will be displayed. Possible causes of problems are missing brackets or having nothing at all entered. Also, note that most functions that includes brackets, such as Abs(), require an argument (that is, something to operate on) within the brackets.

Math Functions

Basic mathematics functions (**+** add, **–** subtract, ***** multiply, **/** divide) can be entered by typing, using the buttons, or choosing from the Math submenu of the Functions pop-up menu.

Trigonometric Functions

Trigonometric functions can be chosen from the Trig submenu of the Functions pop-up menu. **Sin()**, **Cos()**, and **Tan()** return the sine, cosine, and tangent. These functions expect an argument in radians.

ASin(), **ACos()**, and **ATan()** return the arc sine, arc cosine, and arc tangent, that is, the angle whose sine, cosine, or tangent is equal to the given value. These functions are the inverse functions of sine, cosine, and tangent. The result is expressed in radians. ASin() and ACos() need arguments from 1 to –1 inclusive (since sine and cosine produce no values outside those limits), so you may need to scale data to fit.

DegToRad() converts degrees to radians, and **RadToDeg()** converts radians to degrees (2π radians is equal to 360 degrees).

Logarithmic Functions

Logarithmic functions can be chosen from the Logs submenu of the Functions pop-up menu. **Log10()** returns the base 10 logarithm of a number. **Ln()** returns the natural, base-*e*, logarithm of a number. The constant *e* equals approximately 2.7182818. **Exp()** returns the exponential of a number, that is, e^x (*e* raised to the power of the argument). The exponential is the inverse function of the natural logarithm.

Noise Functions

Random() returns random numbers from a uniform distribution between –1.0 and 1.0 inclusive. **Gaussian()** returns random numbers from a normal distribution with a mean of 0.0 and a variance of 1.0.

Other Functions

The function **Sign()** returns the sign of a number, that is, Sign(x) = 1 if $x \geq 0$, –1 if $x < 0$. **Abs()** returns the absolute value of a number, that is, negative numbers are made positive. **Sqrt()** returns the square root of a number (the square root of a negative number returns zero).

Pi returns the constant π, approximately 3.1415927, when used in an expression. **SampleTime** returns the time in decimal seconds from the start of the data block.

Round() rounds a number to the nearest whole number (0.5 rounds up). **Int()** returns the integer part of a number, truncating any fractional part, regardless of sign. For instance, Int(2.999) will return 2.

Units and Scaling

If units conversion is applied in a channel used in an expression, Arithmetic ignores the units and just uses the displayed values in that channel for its calculations. Note, though, that the linear scaling performed by units conversion may affect numeric values. For this reason, you will be alerted if a channel used in an expression has different units in different blocks. Units conversion does not work in a channel where the Arithmetic calculation is active. So that units can be provided for a calculated channel where you want them, the Unit Name text entry box lets you type in up to 10 characters for a unit name. As with normal units, superscripts and subscripts can be used.

By default, the Auto Scale checkbox is selected, which causes Arithmetic to estimate the most appropriate scale for the channel (when there is data to base a scale on). If channel data and operations are unusual and the checkbox is deselected, a scale can be assigned manually.

You can type in directly the lower and upper limits of the scale to be displayed, in the Top and Bottom text entry boxes. (This deselects the Auto Scale checkbox.) This option allows you to adjust the Amplitude axis directly to display a desired range of values, just as you can with the Set Scale dialog box, available from the Chart window. The scale will affect the accuracy (in significant figures) of the displayed numbers.

Channel calculations in Chart use single-precision floating point arithmetic, so results are accurate to six decimal places. The number of decimal places set in the dialog box, from 0 to 6, affects only the display, not the internal accuracy of the calculation.

Using Unconverted Voltages

Data in volts, millivolts, or microvolts (with no units conversion applied), are all dealt with by the Arithmetic calculation as volts. This means care must be taken when using lower ranges, and when dealing with data recorded at ranges with different orders of magnitude. Depending on the data and the operations performed, the numbers calculated may be very large or very small. They can be adjusted to be easier to use by using a scaling factor in the expression.

If you recorded signals on the 10 mV range, for example, and used Arithmetic to add a two such channels together, the results would be expressed in volts, not in mV. To get a derived value in mV, you need both to type 'mV' into the Unit Name text entry box, and to bracket the sum of the channels and multiply it by 1000: (Ch1+Ch2)*1000. This scales the expression correctly.

In general, you have to work out what you want the results displayed in and apply an appropriate scaling factor to the expression: 1000 if the data are to be in mV or 1 000 000 if the data are to be in µV. As always, it is important to be sure about what you are looking at and calculating.

Cycle Variables

Cycle Variables is a calculation for analyzing periodic waveforms. Since it works offline, it can be used after recording, for analysis of data recorded at faster sampling rates than is possible using cyclic rate and cyclic amplitude computed input functions.

▼ ***Refer***
Computed Input Functions, p. 159

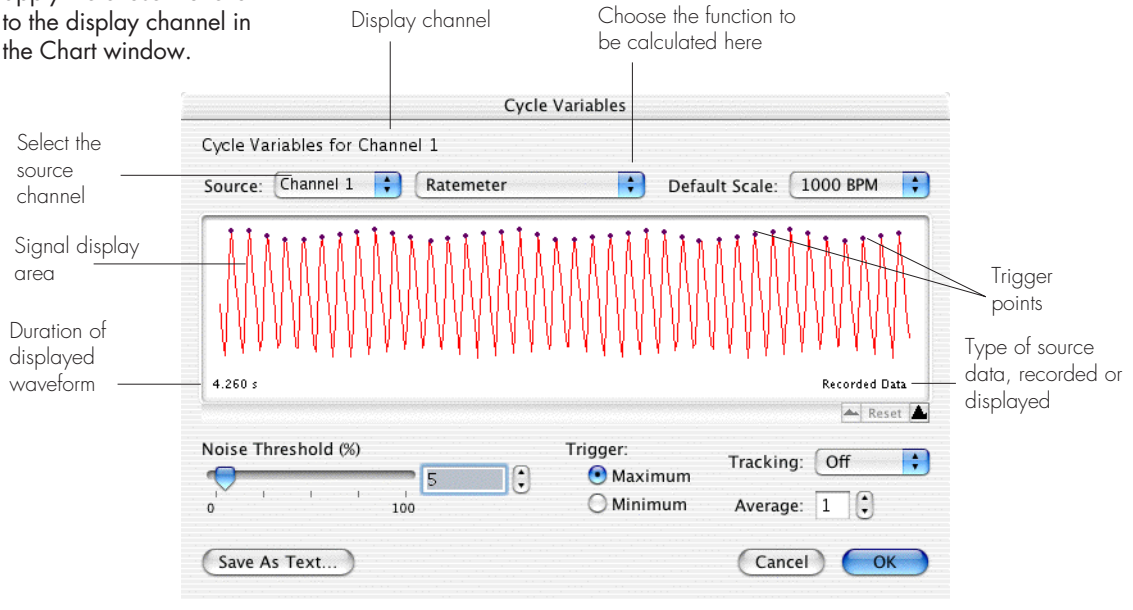
Choosing the Cycle Variables… command from a Channel Function pop-up menu opens the Cycle Variables dialog box. The results will be displayed in the channel indicated in the title bar.

Setting Up Cycle Variables

The signal display area in the dialog box shows the waveform for the source channel. If a selection has been made in the Chart window, data are shown over the approximate recording period of that selection (starting from the left edge of the selection, and using only the data in the left-most block of a selection containing two or more blocks). If there are too many trigger points in the selection, Cycle Variables limits the display to show a sensible number. The duration of the displayed waveform is shown in the bottom left of the signal display area. If there is no selection, the data visible in the Chart window (or the largest visible block if two or more blocks are visible) are shown. This displayed waveform is used to set detection parameters, such as noise threshold.

Whether the source signal is recorded or displayed data is shown in the bottom right of the signal display area. Displayed data are simply what is shown in the source channel, whether calculated, raw, or

Figure 6–32
The Cycle Variables dialog box — click OK to apply the chosen function to the display channel in the Chart window.



computed. If Cycle Variables has been chosen as a channel calculation in the source channel, though, the dialog box will show recorded data (raw or computed). This is because the detection parameter settings apply to this underlying data and make no sense in relation to the calculated waveform.

You can change the initial display by using the controls at the bottom of the signal display area. The scroll bar lets you move through data in the Chart window if the block used by Cycle Variables is not wholly displayed. The box in the scroll bar shows where the display area is in relation to the block. Drag the box to move left or right. Click the left or right arrows to move left or right by 10% of the visible waveform; click in the gray region to either side of the box to move left or right by 90% of the visible waveform. View buttons, like those in the Chart window, let you compress or expand the data shown. To see more of the source waveform, click the left (far mountains) button to compress it. To expand the source waveform for a closer view, click the right (near mountains) button. Click the Reset button between the two to revert to the initial display.

Cycle Detection

Cycle Variables detects cycles by finding local maxima and minima, in a similar way to the Find command. Detected trigger points are marked on the displayed waveform in the dialog box as small blobs. Whether maxima or minima are used depends on which radio button in the Trigger panel is chosen. This makes no difference to the method of cycle detection, but may make a difference to the results, depending on the waveform. (If, for instance, a waveform contains a well-defined upwards spike and two similar downwards spikes in each cycle, it would make more sense to trigger on the maximum.)

▼ ***Refer***
Find Data, p. 134

Detection parameters (noise threshold, triggering, tracking) apply to the detection of all cycle variables in the same source channel. In other words, Cycle Variables will use the same parameters whenever it bases calculations on that source channel. This is handy when you have multiple channels showing various cyclic calculations for a single source channel, since the detection parameters only need be set up or changed once for the whole lot.

Noise Threshold

The Noise Threshold control lets you adjust how sensitive the trigger is to small signal fluctuations. The noise threshold for the event is a percentage of the range of the channel (the default value is 5%, which is 1 V for a ±10 V range). For a data point to be recognized as a peak, say, the data points that follow must decrease by at least the noise threshold value. Peaks or troughs with smaller amplitudes than this value will be ignored. Raise the value to get rid of unwanted small peaks (noise and so on); lower it to detect missed peaks. The noise threshold percentage can be set by using the text box or the slider bar. When the noise threshold is changed, the trigger points, marked on the displayed waveform as small blobs, will shift after a short delay, so you can see the effect of the change.

Tracking

In the case of a waveform with an amplitude that drifts significantly over time, or a low signal-to-noise ratio, the usual triggering scheme may run into difficulties. Tracking helps to solve these problems. The Tracking pop-up menu in the Trigger panel is normally set to Off. You can choose a tracking interval from this pop-up menu to turn tracking on. The noise threshold is now taken to mean a percentage of the maximum amplitude within the tracking interval rather than a percentage of full scale. (The noise threshold usually needs to be increased relative to its normal settings when using tracking.) The tracking interval is centered on the current data point, and moves along as the detection algorithm is applied. This helps deal with changes in the overall signal amplitude.

Even if the tracking interval has been set to less than or equal to the sampling interval, it will always be set wide enough to include at least

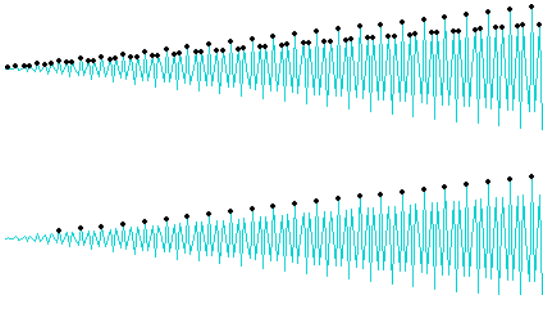


Figure 6–33
Adjusting tracking and noise threshold to detect significant peaks in a waveform of varying amplitude.

three data points. Changes in amplitude of less than 5% of the current data range are not tracked, so the range should be chosen so that data are making reasonably good use of it. Note that tracking slows down the Cycle Variables calculation a bit.

Functions

▼ ***Refer***
Computations with Computed Input Functions and Channel Calculations, p. 261

The Function pop-up menu gives the list of cyclic variables that can be calculated. There are rate functions (Ratemeter, Period, and Frequency) and amplitude functions (Cyclic Height, Cyclic Mean, Cyclic Maximum, Cyclic Minimum, and 1/3Max+2/3Min). The functions are similar to cyclic rate and cyclic amplitude computed input functions, but may give slightly different results, for reasons explained in Appendix C.

The Default Scale pop-up menu lets you select the range of the channel to get the best display of the calculated function. This menu is only available when one of the rate functions (Ratemeter, Frequency, or Period) is chosen in the Function pop-up menu. Changing the range in this dialog box is equivalent to changing it in the Chart window. It is useful if you know the approximate settings already; you cannot see the resultant waveform in the Cycle Variables dialog box as you can in the Computed Input dialog box.

Ratemeter. Frequency, or rate, is the number of times that a given event occurs within a certain period. The Ratemeter function gives output in reciprocal minutes (BPM, beats per minute) up to 2000 BPM (about 33 Hz).

Period. A period is the time taken to complete one cycle of a regularly recurring waveform. This function determines the period between adjacent cycles in a waveform. The period is taken as the time between two successive crossings of the threshold from higher to lower. Its accuracy will depend on the number of samples taken during that time. Period can be more a useful measure than rate or frequency for waveforms with very slow cycles.

Frequency. Frequency is the number of times that a given event occurs within a certain time. The Frequency function measures the frequency of the waveform in hertz (cycles per second) up to 2000 Hz.

Cyclic Mean. A cyclic mean is the average amplitude of a waveform over a cycle. Variations indicate some form of asymmetry. The Cyclic

Mean function sums the data points between two successive peaks and divides by the number of points. This is useful, say, for determining the mean displacement of a vibrating object. The results you get from the cyclic mean are the same as if you selected an exact period of the source, integrated that selection, and then divided by the period.

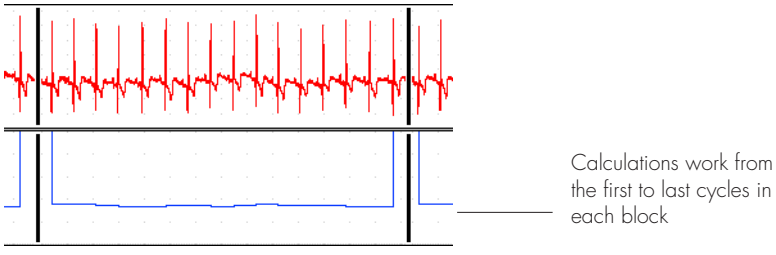


Figure 6–34
Source (top channel) and the cyclic mean (bottom) calculated from it, for a block of data.

1/3Max+2/3Min. The 1/3Max+2/3Min function adds, for each cycle, one third of the maximum amplitude of the waveform to two thirds of the minimum, to give an approximate weighted mean and is included for historical puposes. A more accurate mean can be obtained using the Cyclic Mean function.

Cyclic Maximum and Minimum. The Cyclic Maximum function displays the maximum value found within a cycle. The Cyclic Minimum function works similarly, except that the minimum value of a cycle is shown.

Cyclic Height. The Cyclic Height function calculates the difference between the maximum value and the minimum value in a cycle.

Average

The Average control lets you set the number of cycles, from one to 50, over which the chosen cycle variable is averaged. The average is calculated over cycles after and including the current one, so if an average of four were chosen, the current cycle and the next three cycles would be used. By default, the average is set to one. Click the up and down arrows to increment or decrement the number, or type a value in the text box directly. Averaging smooths fluctuations in the cyclic variable, and is especially useful with erratic data. The number set in the Average control must be substantially less than the number of cycles in the data (perhaps less than half), or the values will not make sense.

Display in the Chart Window

Once the controls in the Cycle Variables dialog box have been adjusted, click OK to apply the calculation to the display channel in the Chart window. The calculated variable applies to the whole channel, but is calculated and drawn only as blocks become visible (else the process would take a long time for very large files). It draws from the first detected cycle to the last in a block. Where there is no sensible value (such as at the very start and end of a block), the value of the plot is set to 'Out of Range'.

Saving a Text File

A text file containing any or all of the cyclic variables associated with a waveform can be saved to disk. To save the text file, click the Save As Text… button in the Cycle Variables dialog box. The Save Cycle Variables as Text dialog box appears.

Select the checkboxes in the Include panel to include variables in the text file to be produced. Just what part of the data is saved depends on the radio button selected in the Save panel. Note that the Selection option uses the selection as a guide only: Cycle Variables works from the left of the selected data, and may shift to the right to get a whole number of cycles.

The standard text file created can be opened by any application that can import text, such as a word processor, spreadsheet, or statistics

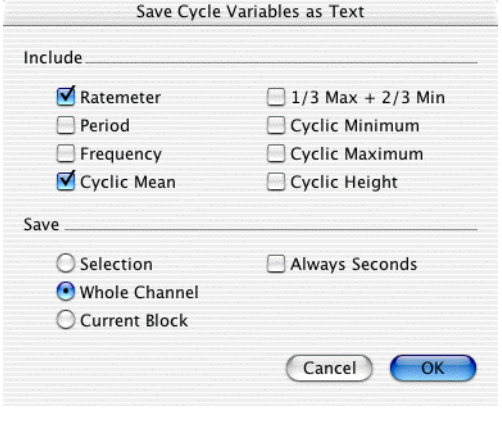


Figure 6–35
The Save Cycle Variables as Text dialog box.

package. The data for each cycle is stored as a row of numbers, separated by tabs and ending in a return character. The first number in each row is the time at which the cyclic transition was found. The time is from the start of the block, and if you select the Always Seconds checkbox, it will always be in seconds. The time is followed by one result corresponding to each checkbox selected in the Save Cycle Variables as Text checkbox. Because there is only one point per cycle for the time and derived values, a text file of cycle variables data will generally be a lot smaller than a text file of Chart data.

When you click OK, a standard Save As dialog box appears. Type in a file name as required and click the Save button to create the cycle variables text file.

Data Pad Functions

▼ ***Refer***
The Data Pad, p. 136

Cycle Variables adds functions to the Data Pad. These functions are similar to those available as channel calculations, and are based on the same cycle detection settings. Cycle Variables Data Pad functions are discussed in the Data Pad section of this chapter.

Any changes made to the cycle detection settings of the Cycle Variables calculation for a particular channel will affect the Cycle Variables Data Pad functions as well, and vice versa.

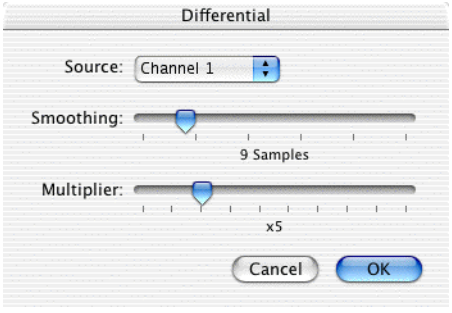
Differential

The Differential channel calculation calculates the first time derivative of the data in a channel. The calculation is offline, so you can see the derived data only when Chart is not sampling (during sampling, you see any recorded data). Choosing the Differential… command from a Channel Function pop-up menu displays the Differential dialog box for that channel.

As with most channel calculations, you specify a source channel in the Source channel pop-up menu.

The slider bars for the Smoothing and Multiplier controls can be used to set values in the normal way, by dragging the sliding handle, or clicking the slider bar area. The value is displayed below the slider bar.

Figure 6–36
The Differential dialog box.



By default, the Smoothing and Multiplier controls are set to No Smoothing and ×1 respectively.

The Smoothing control lets you set the amount of smoothing used in the differentiation, either none, or from 2 to 50 samples. The differential at any sample point is effectively the average of the slope of two lines. One is from the sample point to a point *n* samples before it, and one is from the sample point to a point *n* samples after it, where *n* is the number of samples set using the Smoothing control.

The Multiplier control lets you amplify the differential waveform up to 1000 times. This is used to enlarge the differential waveform to make it easier to deal with, since it can end up quite small if the signal changes slowly.

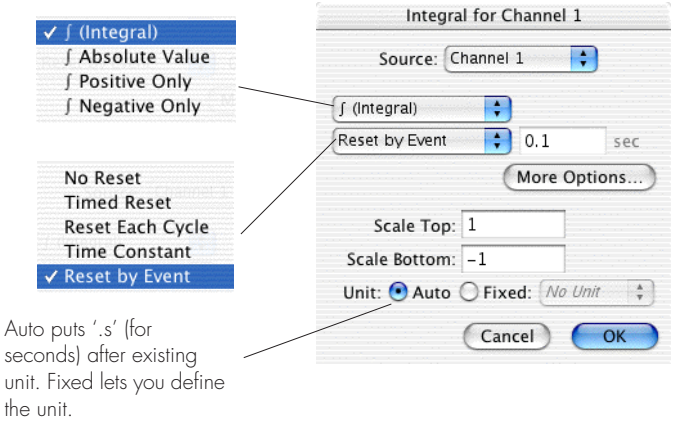
Integral

The Integral calculation provides the ability to calculate time-integrals both online and offline. It is more versatile than the Computed Input Integral functions, in that the integral can optionally be reset to zero by 'events' (threshold crossings of a signal in any Chart channel).

▼ ***Refer***
Computed Input, p. 153

Choosing the Integral… command from a Channel Function pop-up menu opens the Integral dialog box for that channel, in which you choose the source channel, the type of integral, the resetting mode and the scale with which the integral is displayed.

Figure 6–37
The Integral dialog box.



Integral Type

▼ ***Refer*** *Computations with Computed Input Functions and Channel Calculations, p. 261*

There are four types of integral that you can select from the Integral type pop-up menu. They are similar to the computed input integrals, but may give slightly different results, owing to the fact that computed input functions always have a precision based on a sampling rate of 2000 Hz or higher, regardless of the sampling rate set in Chart.

∫ (Integral) calculates $\sum y\,\Delta t$, where Δt is the interval between samples. **∫ Absolute Value** calculates $\sum |y|\,\Delta t$. **∫ Positive Only** calculates $\sum y^{+}\,\Delta t$, where $y^{+} = y$ if $y > 0$ and is zero otherwise. **∫ Negative Only** calculates $\sum y^{-}\,\Delta t$, where $y^{-} = y$ if $y < 0$ but is zero otherwise.

Resetting Mode

Every integral is set to zero at the start of a data block. The nature of most data integrals is to increase (or decrease) continuously. It is, therefore, usually necessary to introduce a resetting mechanism to keep the integrated signal within bounds. Resetting modes are:

- **No Reset.** The integral is not reset.
- **Timed Reset.** Reset to zero occurs regularly at an interval entered in a text box.

- **Reset Each Cycle.** The integral is reset each time the source signal passes through zero to a positive value.

- **Time Constant Decay.** The integral is not reset sharply, but tends to decline towards zero with a time constant as set in the text box. With no input to the integral, its value decays to about 37% (1/*e*) in each time constant. This is like a 'leaky' analog integrator.

- **Reset By Event** is a generalization of Reset Each Cycle. The resetting event can be on any channel or threshold level on a rising or falling signal. You can also set a Skip time that locks out the event detection for a specified time after an event occurs. The Skip time is useful for preventing premature resetting by certain multi-peaked repetitive waveforms. To set these options, click the More Options… button in the Integral dialog box, which displays the More Integral Options dialog box (Figure 6–38).

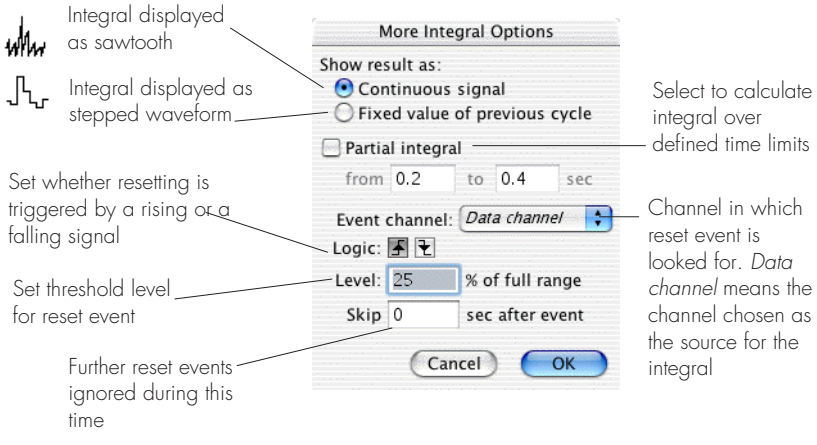


Figure 6–38
The More Integral Options dialog box.

Other Integral Options

The More Integral Options dialog box (Figure 6–38) provides controls for two further options, in addition to controls for resetting by event.

For integrals that have a timed reset, or are reset by cycle or event, you can display the calculated integral as continuously increasing during each cycle (giving a sawtooth-like appearance), or you can display it as showing the value reached during the previous cycle, until the integral is reset (giving a stepped appearance).

Selecting the Partial Integral checkbox means that integrals are calculated as definite integrals over the chosen limits. Before the first limit, the integral is zero. After the second limit, the integral holds its value constant. This mode is most likely to be useful in a recording with multiple data blocks.

7

CHAPTER SEVEN

Customizing & Automating Chart

Chart can be extensively customized and automated, to increase its convenience and ease of use. It can be simplified or modified by locking, hiding, or altering controls, menus, and menu commands. Macros can be created to speed up and automate tasks, and added to menus and the Tool bar; and new menus can be created. A time schedule can be defined to control recording, voltage output, and so on. External devices can be controlled, and comments inserted automatically in response to external events. Chart extensions (software plug-ins) are available to add extra features to Chart.

This chapter looks in detail at Chart preferences, customizing options, and recording automation and control functions.

Preferences

The various options in the display settings and recording controls allow basic customizing of Chart. You can also choose to lock, hide, or alter controls, menus, and menu commands (and their keyboard equivalents). This can be particularly useful in simplifying Chart for teaching purposes. The commands in the Preferences submenu of the Edit menu let you manage aspects of Chart behavior and display (Chart and e-corder startup, the external trigger, the Tool bar, cursors, menus, controls, Chart extensions, memory allocation and data buffering).

▼ ***Refer***
e-corder Startup, p. 229

External Trigger

On selecting Chart > Preferences > External Trigger…, the External Trigger Options dialog box appears which lets you choose, whether a TTL voltage level or a contact closure event will trigger recording.

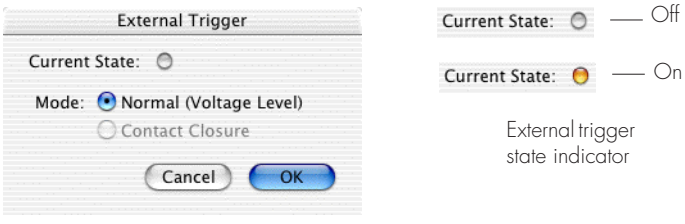


Figure 7–1
The External Trigger Options dialog box.

The Current State indicator shows if the external trigger (Ex) is off (gray) or on (yellow), so that you can apply voltage levels or a contact closure and observe the effects. The state indicator replicates the behavior of the Trigger light on the front of the e-corder, and is useful if the e-corder hardware can't be clearly seen.

Tool Bar

On selecting Chart > Preferences > Tool Bar…, the Tool Bar Settings dialog box appears. It lets you choose whether the Tool bar is shown, and which buttons appear in it and how they are arranged. Initially, the Visible scrolling list displays all the standard buttons that appear, and the Hidden scrolling list displays, for all available macros, the name of the menu that the macro is in, a colon, and the name of the macro.

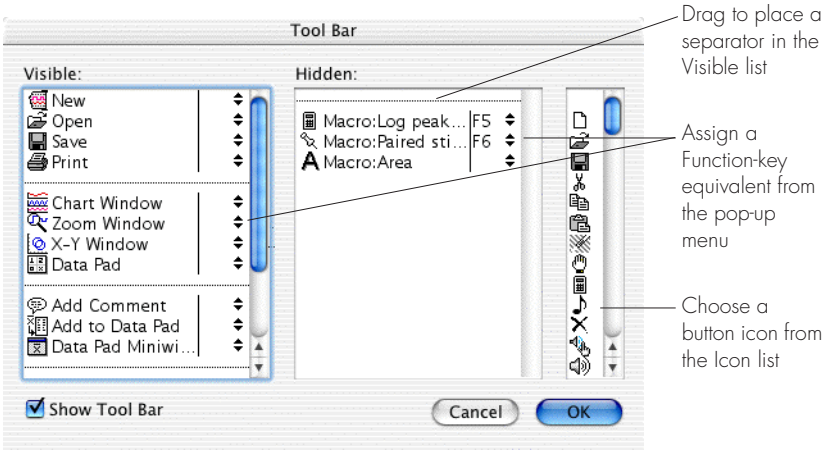
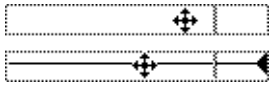


Figure 7–2
The Tool Bar Settings dialog box.

Names that are too wide are truncated: an ellipsis (…) replaces extra characters. Once things are arranged, click the OK button to apply the settings or the Cancel button to close the dialog box without making changes.

Turning off the Show Tool Bar checkbox hides the Tool bar. This is useful if you don't have much room on your screen or don't much care for Tool bars. (The Tool bar can be moved by Shift-dragging it if you just want it elsewhere.)

The order of items from top to bottom in the Visible scrolling list indicates the order of buttons from left to right in the Tool bar. A separator (dotted line) in the list adds a space between buttons, so that buttons with similar functions can be logically grouped.



Items can be moved to alter the default arrangement. Just drag an item by its title (to the left of the vertical bar) to move it. The pointer changes to an arrow-headed cross, and as you drag, a gray outline indicates where the item will go. When items are moved to, or about in, the Visible scrolling list, a horizontal line and left-pointing triangle indicate the insertion point. Items moved to the Hidden scrolling list are just added to the bottom; separators are discarded, since new ones can always be added to the Visible list by dragging from the (left side of the) permanent one at the top of the Hidden list.

The icon for a standard item cannot be changed, but a macro item can be assigned an icon by dragging one from the Icon scrolling list. The pointer changes to an arrow-headed cross, and a gray outline shows

where the icon will go. The item highlights if the pointer is over it: the icon appears at its left when dropped, replacing any icon already there, and will appear on its button if it is in the Visible scrolling list.

Use an item's pop-up menu, to the right of the vertical bar, to assign one of the 15 Function keys (F1 to F15) to a button, for use with an extended keyboard (the default is none, a blank). Pressing the assigned key activates the macro, even if the button or Tool Bar is hidden. Note that Function keys assigned to a button on the Tool Bar override those same keys assigned for automatic comments.

Cursor

Choose Chart > Preferences > Cursor… to open the Waveform Cursor dialog box (Figure 7–3). Click one of the radio buttons to choose a Waveform Cursor shape that is easy to see when tracking the waveform. The line cursor is a vertical line that crosses all channels, with short bars where the waveforms are intersected. It is useful with a large screen or noisy waveforms, when the other Waveform Cursors might be harder to see. Click the OK button to apply your choice.

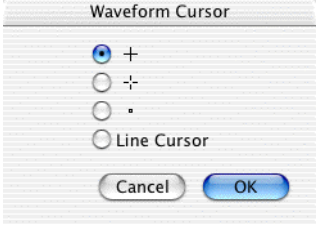
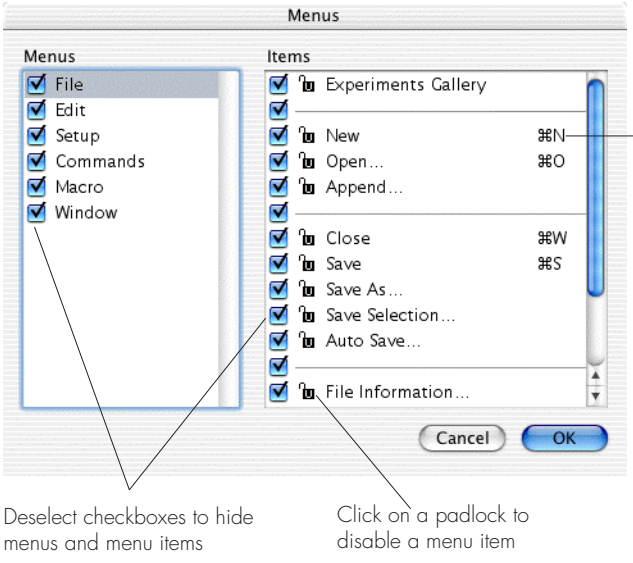


Figure 7–3
The Waveform Cursor dialog box.

Menus

The six Chart menus (File, Edit, Setup, Commands, Macro, Window) and their commands can be modified from the default settings by using the Menus dialog box. Choose Chart > Preferences > Menus… to open this dialog box. You can hide or lock any menu or menu command to create a very simple Chart setup, if you want to limit the actions that can be performed. This is particularly useful for teaching in a laboratory environment, where you might want students to be able to use some features of Chart, but not to edit, delete, or change the data in files.

Figure 7–4
The Menus dialog box.



The dialog box will initially display just the menu names in the left-hand pane: to see the items for a particular menu, select the menu name.

By default, menu titles and all items within the menus will have selected checkboxes to their left, and all menu commands will have open padlocks beside them as well, indicating that everything is visible and unlocked. Items in submenus cannot be edited, but the submenus themselves can be hidden. Locking or hiding a menu command will have no effect on the equivalent Tool bar button.

Deselecting the checkbox beside a menu title will hide the menu: it will not appear in the menu bar when you return to the Chart window, and any keyboard shortcuts in it will not work. Deselecting the checkbox beside a menu command or a dividing line hides it: it will not appear in the menu, and neither will any keyboard shortcut work. Selecting a checkbox again will show the previously hidden item beside it.

Clicking an open padlock (with a U for unlocked on it) changes it to a closed padlock (with an L for locked on it), and locks the menu command beside it. The command still appears in the menu, but if it is chosen or the keyboard shortcut typed, an alert notifies the user that it is locked and cannot be used. Clicking a closed padlock changes it to an open one, and unlocks the previously locked menu command beside it.

Keyboard Shortcuts

Keyboard shortcuts for menu commands can be added or changed. Click the shortcut text next to a menu item to select it: the text highlights and the letter key appears selected. You can either change it, or delete it so that no keyboard shortcut is available. To assign a keyboard shortcut, type a single lower-case letter or number in the text entry box (letters are automatically capitalized; invalid characters will be rejected).

If you choose a character already in use, an alert box will warn you of the fact and tell you where it is assigned. If you choose the character anyway, your choice overrides the previous assignment, and the keyboard shortcut (Command-S, or whatever) will only work for (and appear beside) the menu command that you have chosen.

▼ ***Refer***
Shortcuts and Tips, p. 237

Controls

On selecting Chart > Preferences > Controls…, the Controls dialog box appears. By default, all the checkboxes are highlighted, and their functions active. Click the checkbox or the function beside it to toggle the function off or on. The dialog box allows you to remove Chart functions that could be confusing or are unnecessary for a student or new user, who might easily feel lost and bewildered by choice. Click OK to apply your changes.

Allow Printing of Whole File. Turning this checkbox off disables the Print All… command in the File menu — other printing commands such as Print Selection… are still available, but the whole file cannot easily be

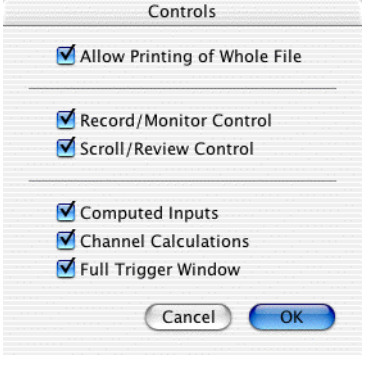


Figure 7–5
The Controls dialog box.

printed. This is useful in student labs, where usually only a small portion of a file would need printing.

Record/Monitor Control. When this checkbox is turned off, the Record/Monitor button is hidden. This can help prevent new users losing data by accidentally clicking the button and switching from recording to monitoring. Even if the button was set to monitor before the control was hidden, Chart will only record, not monitor.

Scroll/Review Control. When this checkbox is turned off, the Scroll/Review button is hidden. This can help prevent new users becoming confused, should they accidentally set the review option, and Chart's data stops scrolling, and so on.

Computed Inputs. When this checkbox is turned off, the Computed Inputs… menu command disappears from the Channel Function pop-up menu, so that the Computed Input dialog box is no longer accessible from there.

Channel Calculations. When this checkbox is turned off, the options in the lower half of a Channel Function pop-up menu that perform channel calculations on data are removed (including those added by Chart extensions). This helps to prevent new users confusing recorded data (raw or computed) with calculated data.

Full Trigger Window. When this checkbox is turned off, the Start and Stop Cycling controls do not appear in the Trigger window.

The Computed Inputs and Channel Calculations controls don't stop access to the functions through the columns in the Channel Settings dialog box, so to stop access you should hide the Channel Settings… menu command as well.

Note that the settings for Computed Inputs, Channel Calculations, and the Trigger Window (such as pre-triggering or the number of blocks after which to stop cycling) remain in effect, so make sure they are set to what you want before you hide them.

License Manager

The Chart License Manager allows you to view, add and delete license codes for Chart. Choose Chart > Preferences > License Manager… to open the License Manager dialog box (Figure 7–6).

Existing license codes and their descriptions are shown in the lower half of the dialog box. Note that the last four characters of the license code are shown as 'xxxx' — you will have been provided with the full license code including the last four characters when you purchased the software. To add a license code, enter it into the License Code text box and click Add. The new code will appear in the dialog box.

To delete a license code, select it and then click Delete. You will be asked to confirm the deletion. If you delete your Chart license code, the next time you try and run Chart, you will be prompted to enter a valid license code. Chart will not run until you have done this. If you delete all the license codes shown in the License Manager dialog box, you can edit the entries in the Name and Organization text boxes.

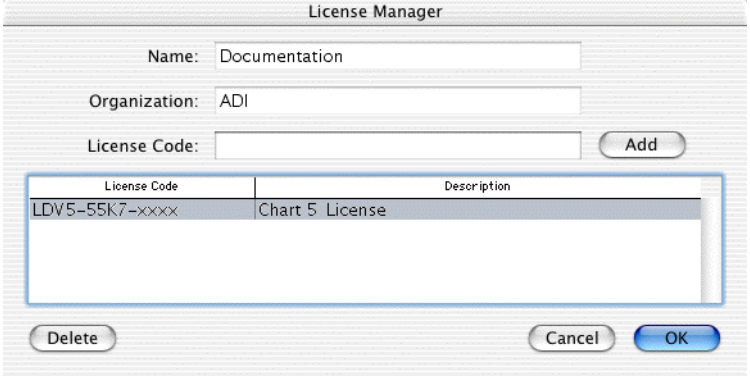
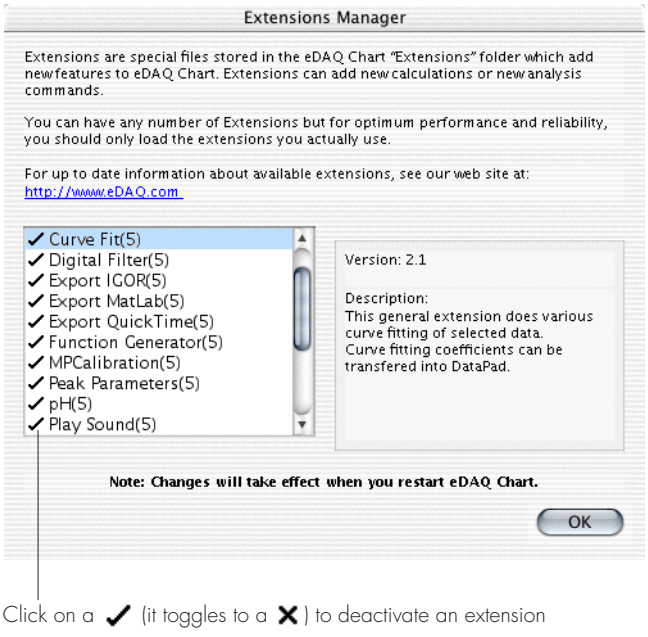


Figure 7–6
The License Manager dialog box.

Chart Extensions

Chart extensions are additions to the Chart program that add extra functionality, such as file translation capability, data analysis. For example, the Export MATLAB extension allows you to save Chart files in a format readable by the data analysis application MATLAB. Extensions are separate files that may be downloaded free from the eDAQ web

Figure 7–7
The Extensions Manager dialog box, showing some extensions.



site (www.eDAQ.com), along with documentation that describes how to use them.

When Chart is installed, the 'Chart 5' folder created in your Applications folder includes an Extensions folder. This folder should not be renamed or moved, or no Chart extensions will load. To install an extension, quit Chart and place the extension file in this folder, or run the installer if one was provided. Extensions in the Extensions folder will be loaded when Chart starts up.

The Extensions Manager dialog box lists the Chart extensions within the folder, explains what they do, and lets you choose which of them will be loaded when Chart starts up. Choose Chart > Preferences > Extensions… to open the dialog box. Chart extensions in the Extensions folder are shown in the scrolling list at the left. Click one to select it: its version number and a description appears to the right.

✓ ✗

It is unlikely that you will want to use all the Chart extensions. To change the ones used, click the ticks or crosses in the list. Clicking a tick will toggle it to a cross, and vice versa. Those Chart extensions marked with a tick will be loaded when Chart starts up; changes take effect when Chart restarts. You can decide which Chart extensions

should be loaded during startup, as well. Hold down the space bar as Chart starts up to open the dialog box, and click the tick or cross beside each Chart extension to change its status.

Memory Cache

If your computer is taking a lot of time to perform actions on large files (such as redrawing windows), it may help to change the size of the memory cache. Choose Chart > Preferences > Memory Cache… to open the Memory Cache dialog box (Figure 7–8). Then select the Manual option and adjust the size of the memory cache by adjusting the position of the slider bar (depending on the system and resources being used, performance may be improved by either decreasing or increasing the size of the cache, so you may need to experiment with both).

▼ ***Refer***
Recording Length, p. 32

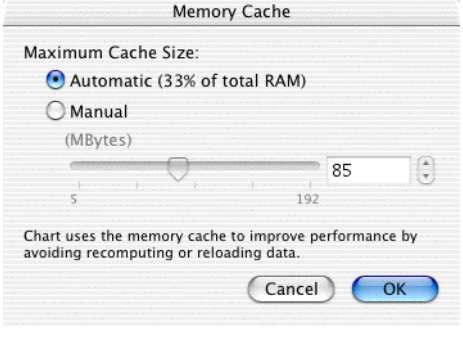


Figure 7–8
The Memory Cache dialog box.

Data Buffering

Data buffering lets you choose where the data you record will be stored, memory or disk. Files are stored on the system disk (the current startup disk) by default. Recording data to RAM (physical memory) may be faster than recording to disk when using a slower computer. However, the benefits will be limited by the amount of RAM you have; if you need more space for the file you are recording than there is RAM, Chart will start using virtual memory, which accesses the hard disk anyway. Most systems have more disk space than RAM, and data buffered to disk by Chart can survive a power failure or system crash, so recording to disk is a better choice unless the slowness of your computer forces you to record to RAM. Data buffering settings can be

▼ ***Refer***
Recording Length, p. 32

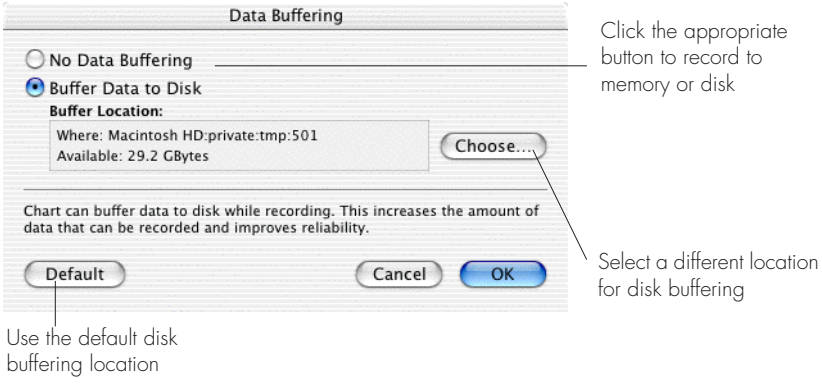


Figure 7–9
Data Buffering dialog box.

changed only when Chart has open either no file or a new file with no data. Close any open Chart file containing data and choose Chart > Preferences > Data Buffering… to choose where data will be buffered. The dialog box in Figure 7–9 appears.

If recording to disk, you can select a different disk buffering location (on a different disk, perhaps) by clicking the Choose button. The amount of free space on the disk containing the chosen folder is displayed. Note that this is a temporary location, different from the location you choose in the Save dialog box when you save a file. Data can be recorded to an internal or external hard disk, removable media such as magneto-optical disks or removable hard disks. Hard disks are generally faster than the other options. Care should be taken that removable media are not removed in the middle of recording! When Chart comes to write to a removed disk, it will open the standard system dialog box asking you to insert the missing disk, and will cease recording until the disk is inserted.

If Chart is set up to record to disk, it creates a buffer file as soon as it starts up. This temporary file is called '…Chart Buffer File…' in the Finder and has a different icon from normal files. Blocks of data are written to the file at set intervals when sampling. As a general rule, a new block is written to disk every 16 000 samples or every two minutes, whichever comes first. Once recording has finished, you still must save the file using the standard Save command. Quitting Chart or opening a new file will prompt you to save the file first: if you abandon it at this stage, the data will be lost. When a file is saved, all the buffered data are written to it, and the buffer file is emptied, ready for

the next bout of recording. When you quit Chart normally, the buffer file is erased.

In the case of a problem that terminates sampling, Chart only loses a maximum of the last block of data recorded, that is, 16 000 samples or the last two minutes of recording. The rest is stored in the buffer file. The next time Chart runs, it searches for a buffer file. If it finds one, an alert box indicates that the file being recorded prior to the problem needs recovery (since it will not have been saved properly). In most cases, most of the buffered data should be recoverable. If you choose to delete the file, the data will be lost.

Startup

Settings are of two sorts: those that affect recording, such as sampling rate, channel ranges, triggering, and stimulation functions; and those that affect the way the data looks, such as the menu configuration, window size, channel areas, and display settings. To save or clear customized settings, choose Chart > Preferences > Startup… to open the Startup Settings dialog box.

Click the Save button to save all current settings in a preferences file (Chart StartUp) in the user's Preferences folder, so that they are used each time Chart starts up. Click the Clear button to clear any settings currently stored in the Chart StartUp file: when Chart next starts up, it uses its default settings, taking the whole screen for its display, with visible channels having a 10 V range, and so on. (Settings in use remain until you quit and restart Chart.) To bypass the current startup settings and use the default settings for a single session, hold down the Command key as Chart starts up: release the key when the alert box appears, and click the Yes button.

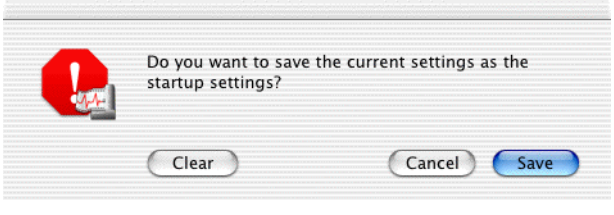


Figure 7–10
The Startup Settings dialog box.

Special Access

Because it is possible to change menu preferences so that vital menu commands are locked or menus themselves hidden, it is necessary to have a back door in. Access to dialog boxes often needed, but made unavailable in order to safeguard files, is possible through the Special Access dialog box, which appears on typing Command-\ (the backslash character). If your keyboard does not have a \ character, type Control-Command-1 instead.

Clicking the Menu Editor… button opens the Menus dialog box, letting you show hidden menus, unlock menu commands, and otherwise alter settings. This is obviously useful if by locking or hiding things you have removed access to that dialog box.

Clicking the Tool Bar… button opens the Tool Bar Settings dialog box, letting you choose whether the Tool bar appears, and which buttons appear in it and how they are arranged. This is useful, say, to change keyboard shortcuts, which still apply if the Tool bar is hidden.

Clicking the Save As… button opens the Save As dialog box, which allows you the complete range of options in saving a Chart file. It is useful where you have disabled the ability to save a file, and particularly to save the file as a Settings file with the hidden or locked menu items remaining as specified when the file was saved.

Clicking the Controls… button opens the Controls dialog box, which lets you remove Chart functions that could be confusing or are unnecessary for a student or new user. This is useful to reinstate functions when they are required.

Figure 7–11
The Special Access dialog box.

Clicking the Startup… button opens the Startup Settings dialog box, letting you save the current settings in the file (including menu layouts and so on) as those Chart will use when it starts up. This is useful when you use Chart for routine work requiring the same settings day after day. It also means that quitting and restarting Chart will not face the user with a Chart file that could have quite different settings, and none of the safeguards you may have set up.

Macros

Macros are used to group sets of commands together conveniently, letting you speed up repetitive and tedious tasks, such as changing the settings for various parts of an experiment. They can help to automate recording and analysis. They record the results of your actions step by step, then reproduce them when played back. If you find yourself regularly doing the same series of tasks in Chart, whether simple or complex, macros can ease things considerably. Macros can record almost any Chart operation: setting dialog box and window controls; changing the display format; sampling; copying waveform data to the Data Pad; saving data as a new file; printing the Zoom window display of selected data; and so on. There are some differences between recorded and real operations, but in general, dialog boxes will guide you through your options.

Note that macros record the results of your actions, not individual keystrokes and mouse clicks, and record the simplest possible interpretation of those actions. Even if you spend some time fiddling with control settings during the recording of a macro, only the final settings you obtain will be used. Macros cannot be edited, and may be incompatible between versions of Chart.

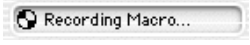
You should keep a written record of the steps involved in your macros, and their purpose: it is easy to forget which macro does what when you haven't used them for a few weeks. Noting the steps down before actually recording will help when constructing complex macros, since it can prove easy to miss out a step or end a repeated sequence in the wrong place, with detrimental effects.

When a file is saved, all currently available macros are saved with it, becoming part of the file. When you open a Chart data or settings file, any macros in that file are loaded into memory. In the Open dialog box there is a Discard Existing Macros checkbox. If this is on, macros

currently in memory are discarded when the file is opened, and any macros in the opened file replace the previous set. If the checkbox is off, macros accumulate in memory as you open files until you quit and restart Chart, or delete the macros.

Recording a Macro

To record a macro, choose Macro > Start Recording or type Command-R (the menu command then changes to Stop Recording…). When a macro is being recorded, for the most part Chart remembers rather than executes operations, but opening files, changing channel ranges, or turning channels off, for example, are done as you record.



During the process, a progress indicator is shown in the text box of the Tool bar, to remind you that your actions are being recorded, not necessarily effected. Perform all actions to be recorded, then choose Macro > Stop Recording… or type Command-R again to finish. The New Macro dialog box appears (Figure 7–12).

The Menu pop-up menu lets you choose the menu in which your macro will appear from a list of existing menus. By default, the macro will be added as a new menu command to the Macro menu. You can create a new menu by entering its title (up to 10 characters) in the Menu text entry box: it will be added to the right of the Macro menu in the menu bar. The name of the macro (up to 20 characters) should be entered in the Item text entry box. Each name must be unique in its menu. To create a menu divider, so that similar macros can be logically grouped, record a simple macro (playing a sound, say), and start the macro name with two hyphens (–). It will appear only as a divider in the menu, and cannot be chosen (it is accessible through the Tool bar, though).

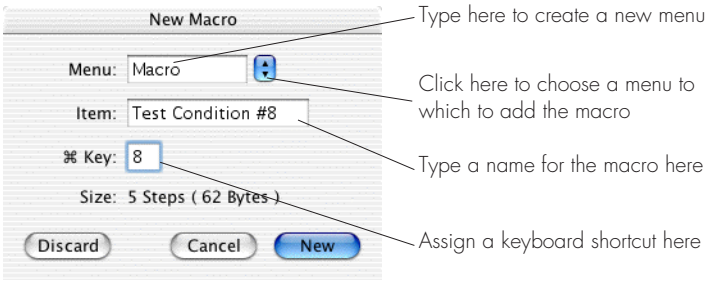


Figure 7–12
The New Macro dialog box.

▼ **Refer**
Shortcuts and Tips, p. 237

An optional keyboard shortcut can be assigned to the macro as well: type a single lower-case letter or number in the text entry box (letters are automatically capitalized; invalid characters will be rejected). An alert box will warn you if you choose a character already in use, and tell you where it is assigned. If you proceed anyway, your choice overrides the previous assignment, and the keyboard shortcut will only work for (and appear beside) the menu command just created.

The Size indicator tells you the number of steps recorded (useful if you can't remember which step you are up to in the middle of a complex macro), and the memory used by the macro (which depends on the procedure). Click the Discard button to discard the macro you have just recorded. Click the Cancel button to leave the dialog box and record more steps in the macro. Click the Add button to add the macro to the bottom of the selected menu; the button is only active and undimmed when the macro is named and a menu is chosen.

Until you save the file, new macros exist only in memory and are not permanently stored. If you open another file (without discarding currently available macros) and save that file, the macros will become part of the new file. When you quit Chart, you will not be asked to save changes if the changes are only concerned with macros, so it is a good idea to save the file each time you create a macro.

Playing a Macro

Once assigned a name and location, a macro acts much as if it were a menu command. To use one, select it from its menu or type its keyboard shortcut (or click its button in the Tool bar). While a macro plays, the title of the menu in which it resides is highlighted, the message 'Playing Macro…' is displayed in the text box of the Tool bar, and no other functions can be performed within Chart. If you switch to another application and leave Chart in the background, the macro stops playing at its current step. To stop a macro playing at any time, type Command-period (.): the macro stops at its current step.

Deleting a Macro

To delete existing macros, choose Macro > Delete Macro… to open the Delete Macro dialog box. A scrolling list displays the name of the menu that the macro is in, a colon, and the name of the macro, for all

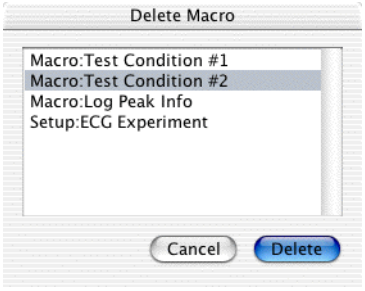


Figure 7–13
The Delete Macro dialog box.

available macros. To delete a macro, select it and click the Delete button. To choose multiple macros for deletion, Shift-click or Shift-drag to select contiguous macros, or Command-click to select or deselect macros individually. Once the Delete button is clicked, the dialog box closes and the macro or macros will be gone. As a shortcut, double-click a macro to delete it and close the dialog box in one step.

As was mentioned, macros are part of a particular file, and when a file is saved, all currently available macros are saved with it. When you delete a macro, you delete it from memory. If it has been assigned a button in the Tool bar, the button disappears. If the macro is part of the current file, it is permanently deleted from that file only when the file is saved (although it will not be available while the file remains open). Copies of the macro attached to other files are not deleted.

Options When Recording Macros

Operations involving files and dialog boxes can be made to behave differently when playing macros, depending on whether you want to do the same thing all the time, allow user modification, and so on.

Changing Dialog Box Settings

Macros can be used to change dialog box settings to values specified when you record, or to open a dialog box for the user to change settings when the macro is played.

If you want a macro that changes the settings in a dialog box, then select the dialog box as you would normally while recording the macro. Change the settings, and then click OK in the dialog box. (If you click Cancel, changes made in the dialog box are ignored.) When playing the macro, the settings are changed without displaying the dialog box.

When changing control values in dialog boxes, absolute values are recorded, not relative changes. For example, if you move a slider bar that increases voltage from 2 V to 3 V, the new voltage (3 V) is recorded, not the change in voltage (+1 V) or the percentage change in voltage (+50%).

If you want a macro that lets the user change dialog box settings when the macro is played, then while recording the macro, hold down the Option key when selecting the command that shows the dialog box, then click the OK button. Do not make any setting changes. When the macro is played back, the dialog box is displayed so that its settings can be changed by the user. At that stage, clicking the OK or Cancel buttons in the dialog box lets the macro continue, with the user-defined settings or the original settings respectively.

Starting Sampling

Macros can be used to control when sampling starts and stops. Should you click the Start button when recording a macro, the Macro Sampling dialog box will appear. In general, you would probably want to retain the default setting in the upper part of the dialog box (that is, stop the macro while sampling), but in some cases you might want to perform steps as sampling proceeds (adjusting some settings, for example). Another macro command, Wait While Sampling, lets you suspend sampling after a particular step, if you choose this option. The lower part of the dialog box allows you to specify when sampling stops. This could be useful to override, for a certain portion of an experiment, a fixed duration set in the Trigger window.

▼ ***Refer***
Wait While Sampling, p. 221

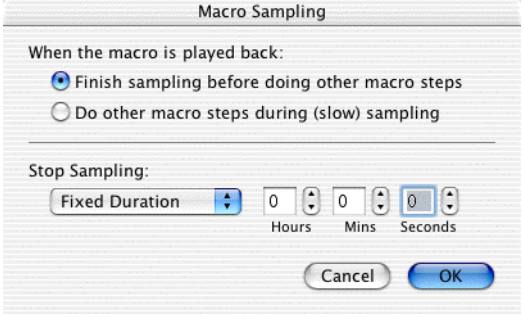


Figure 7–14
The Macro Sampling dialog box.

Opening and Appending Files

A macro can be used to open or append the same file each time it is played, or to allow the user to choose a file. To open or append a particular file with a macro, choose File > Open… or File > Append… while recording a macro: in each case the Open File for Macro dialog box is displayed. To append rather than open a file, turn on the Append checkbox.

To let the user choose which file is to be opened or appended when the macro is played, press the Option key when selecting the command while recording the macro. An alert box reminds you that you are giving the user a choice. The Open dialog box will be displayed when the macro is played.

When opening the same file each time, if the file has been moved (or deleted) since the macro was recorded, then Chart searches in the most recently used folder and in the same folder as Chart. If the file is in neither place, an alert box lets you know that Chart cannot find the file, and the Open dialog box is displayed to allow you to find it yourself. If you choose a different file at this stage, that one will be opened instead; if you click the Cancel button, the macro will stop.

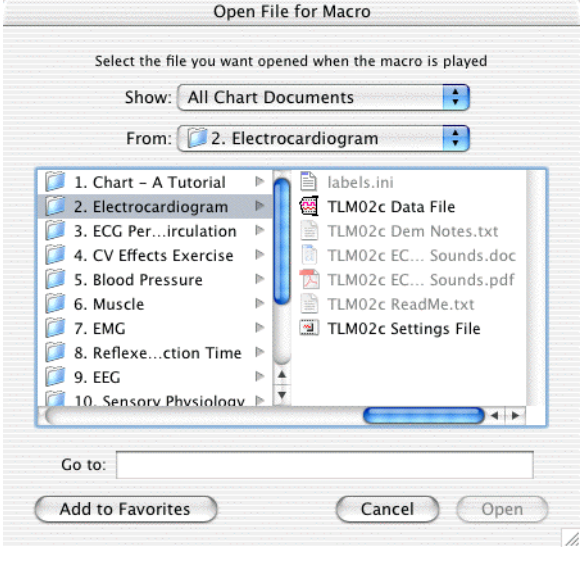


Figure 7–15
The Open File for Macro dialog box.

Saving Files

When playing a macro, you can save data in a file or in a series of files. Choosing the plain Save command will save a current named file. You might want to do this at specified intervals to minimize data loss in case of possible power loss. To let the user choose where and under what name the file is to be saved when the macro is played, press the Option key when selecting the command while recording the macro. An alert box reminds you that you are giving the user a choice, and the Save As dialog box will be displayed when the macro is played.

Data are not recorded during the time it takes to save a file to disk, so large files might take a while to save. To minimize data loss during automated recording, you can instead save a series of short files, and also specify where and in what form you want the data to be saved, by choosing File > Save As… or File > Save Selection… when recording the macro. The Save File for Macro dialog box appears. The formats are data file, settings file, and so on, as usual.

The three 'Append filename with' checkboxes let you specify unique file names. If none are turned on, then each time you play the macro, the

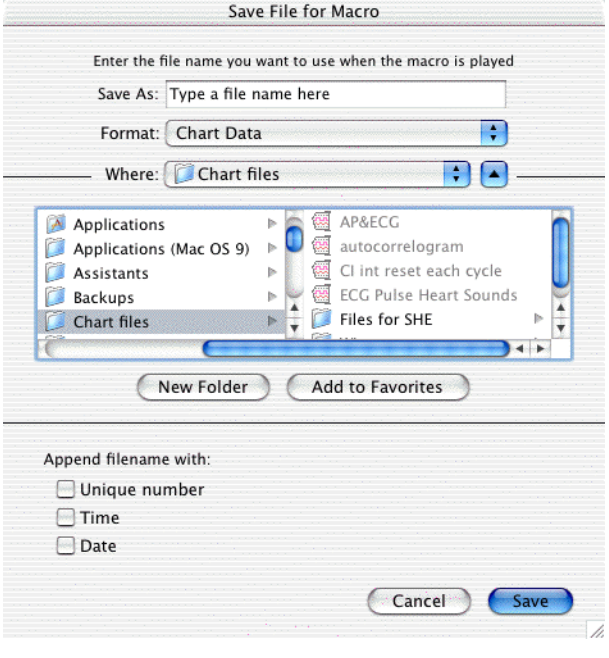


Figure 7–16
The Save File for Macro dialog box.

file will be overwritten, just as it is when saved normally. If the Unique number checkbox is selected, a different number is added to the end of the given file name each time the file is saved during the playing of the macro. Numbers are added in numerical sequence starting with '1'. For example, if the file name is CoolData, then the next files generated will be CoolData(001) and CoolData(002). If the macro is played again, numbering will follow on from the last such numbered file to give CoolData(003) and so on. Selecting the Time checkbox appends the current time to the file name. Selecting the Date checkbox appends the current date to the file name. The two may be combined. These checkboxes are dimmed and unavailable if the Unique number checkbox is selected.

Macros That Call Other Macros

Once a macro has been created, it can be used by other macros (when it is loaded in memory) as a step in the recording of the new macro. This enables modular construction of complex procedures. Macros can only be nested up to ten deep, however. An alert box will appear during the playing of your macros if the combination becomes too recursive, and the macro sequence will stop at that stage. If a macro is called by other macros, Chart warns you if you attempt to delete it. If a macro is deleted without being replaced, then if it is called, an alert box tells you that it cannot be found, and the calling macro stops.

Macro Commands

Control structures for macros are provided in the Macro Commands submenu; the menu commands are only available while recording a macro. They let you provide user feedback using dialog boxes and sounds, set up repeat sequences, wait for a certain time, and so on.

Update Screen

Normally, when a macro is played, the screen is updated after each macro step (a tick beside the Update Screen menu command indicates that it is active). Choosing the command from the menu as the first step in a macro causes the macro to play without redrawing the screen each time the data display is altered in some way (the tick disappears). Update Screen can be turned off or on at any stage of a macro. The

settings toggle. If Update Screen is off, the screen will be redrawn only when the macro is finished, or it is turned on again.

This may considerably speed up some macros, for example, those involving multiple changes to view and display settings, or repetitive selection and transfer of data to the Data Pad: in this case, the data on screen will still be seen to be selected, but data off screen will not be scrolled through before selection, as would occur if Update Screen were on (it was ticked in the menu). Since you cannot edit macros, you cannot change the Update Screen settings once the macro is finalized. You can, however, record another macro that consists of two steps: turning update screen off or on, then calling the original macro.

Wait...

Choosing the Wait... macro command opens the Wait dialog box. A pop-up menu lets you choose from Wait For, Wait Until, and Wait Until the Next, to wait for a set length of time (say, 55 seconds), wait until a certain time (say, 11:20 a.m.), or wait until the next time division (say, at the next hour) before the macro continues.

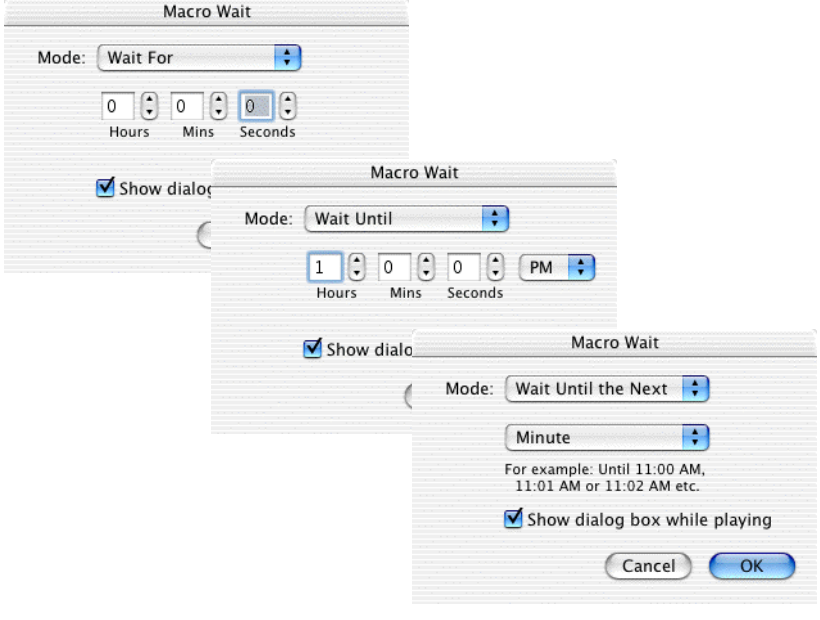


Figure 7–17
The Macro Wait dialog box, showing the three options selected.

The checkbox lets you choose whether a dialog box with a progress bar appears during the wait (generally a good idea). The dialog box gives a visual indication of wait progress, and provides the options of proceeding immediately to the next step of the macro by clicking the Skip the Wait button, or aborting the macro by clicking the Stop Macro button (equivalent to typing Command-period).

This feature is useful if you want to perform some steps of an experiment at certain intervals, or to record multiple sampling sequences with a specific interval between them.

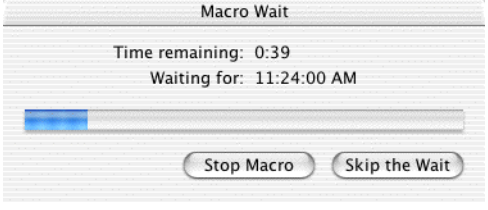


Figure 7–18
The Macro Wait dialog box during the playing of the Wait step of a macro.

Play Sound…

Choosing the Play Sound… macro command opens the Macro Play Sound dialog box, which allows you to choose from the range of sounds in your computer's system to set audible alerts in macros. Click the name of a sound in the scrolling list to select it. If you wish to hear the selected sound, click the Play button. To have it actually played in the macro, click the OK button (which closes this dialog box). To choose more than one sound option, Shift-click or Shift-drag to select contiguous sounds in the list, or Command-click to select or deselect multiple sounds individually. Sounds appear in the list in the order they were installed in the system, and are played back in that order. To save time in creating multiple sounds, you can create a library of sound combination macros, and simply incorporate one or more of them in the macro that needs them.

You might wish to have three beeps signal when the e-corder starts recording data, or a bell and a whistle when a trigger point has been reached. You can even record short verbal cues, if your computer has a microphone input, using the Sound System Preferences, and use these in your macros.

Figure 7–19
The Macro Play Sound dialog box.

If a macro attempts to play a sound not in the system (created on a computer with a different setup, or since removed from the system), then an ordinary system beep will be substituted for the sound originally specified.

Message…

If you select the Message… macro command, the Macro Message dialog box appears. This allows you to cause alert boxes requiring user response to appear at certain stages within the macro.

You can type in the message of your choice (up to 255 characters). The dialog box produced will have an OK button, and if the checkbox at the top is on, a 'Cancel' button as well (for exiting the macro). There are four choices of icon: the default shape is highlighted. Click one of the icon buttons to choose it. You can use the icons to indicate the urgency of an important message, and the Chart icon for general messages that indicate Chart's state. Click the OK button when you

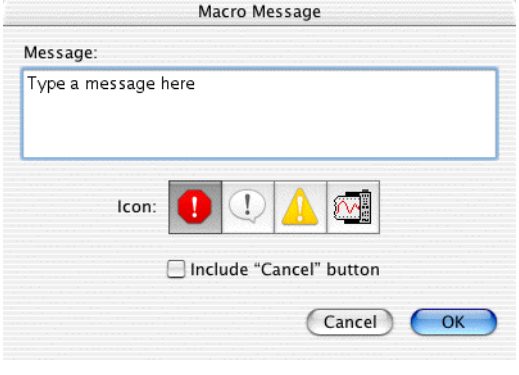


Figure 7–20
The Macro Message dialog box.

have chosen an icon and typed in the message. You could use messages to remind you what the macro does.

It may help to notify a user that something is up if you precede an alert box with an audible signal (using the Play Sound… macro command), since he or she may not be looking at the screen when an alert box appears.

Speak Message…

If you choose the Speak Message… macro command, the Speak Message dialog box appears. You can use it to give audible messages in macros, if the computer playing the macro has speech available. You can type in the message of your choice (up to 255 characters). If the Use System Volume checkbox is on (it is by default), the volume at which the message is spoken is the system volume set in the Sound System Preferences. If this checkbox is off, the volume can be set with the slider bar.

Three radio buttons give a choice of actions when the macro step is reached, depending on whether you want to display an alert box, just as if the Macro message dialog box were used, and whether the computer on which the macro plays has speech enabled. If an alert box appears, it will stop the macro until its OK button is clicked. If not, the macro carries on playing after this step.

Figure 7–21
The Speak Message dialog box.

If the Never radio button is on, then the message will be spoken if speech is enabled, otherwise a standard system beep is used instead. In either case no alert appears. If the Only if Speech is not Available radio button is on, then the message is spoken if speech is enabled, otherwise the alert appears. If the Always radio button is on, then an alert box appears whether or not speech is enabled.

AppleScript…

This macro command allows you to insert an AppleScript as a macro step. AppleScript is a scripting language for automating tasks, and controlling applications and their interactions through Apple events. It should be installed on your computer. On selecting the AppleScript… macro command, the AppleScript from Macro dialog box appears. You can enter a script of 32 000 characters in the scrolling field. The dialog box is a movable modal one, which means you can switch out of Chart, to get tested scripts from the Script Editor, say, and paste them in. You will lose text styles from a formatted script if you do this: scripts are just left as unformatted text in the dialog box, even when compiled there.

Click the Check Syntax button to check and compile the script — you are told if the script will not run. The AppleScript is checked and compiled once you click the OK button, if you have not checked it already. It will look for named applications at that stage. Click the Test button to actually run the script (so that you can see how it works, while you are recording the macro).

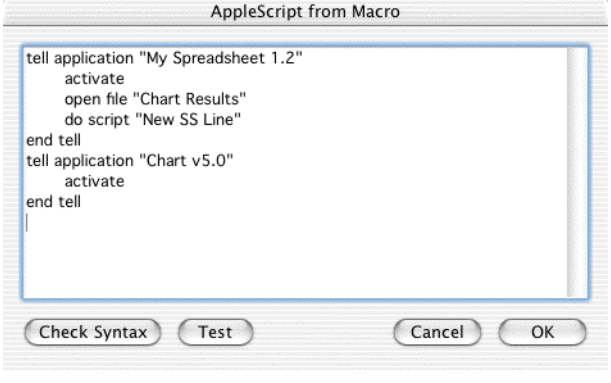


Figure 7–22
The AppleScript from Macro dialog box.

Once you click the OK button, the AppleScript is stored as one step of the macro. It thus can't be edited, but it is recommended that only simple scripts will be used from within Chart: complex scripts that might require adjustment are better left residing in the Finder, and then called using a simple AppleScript macro step within Chart.

For example, you could transfer data to an Apple event aware spreadsheet as you worked through a Chart file, by running a macro to cut a line from the Data Pad, and using an AppleScript step to switch to the spreadsheet, paste the data into the next row, and switch back to Chart.

Chart is Apple event aware, but not Apple event recordable, and has no dictionary. It supports the required suite, and one more command.

The macro to be played by the 'do script' Apple event is identified by the name of the menu that the macro is in, a colon, and the name of the macro (just as it is shown in the Delete Macro dialog box). You don't need to tell Chart to activate: it is automatically brought to the front when this event occurs. If an AppleScript macro step both switches out of Chart to some other program and then switches back in, the macro carries on and completes any remaining steps. If the AppleScript switches out of Chart, but does not switch in again, then the macro finishes at that step, and any remaining steps are ignored.

Learning AppleScript is left up to you — it is not trivial, but is worth it if you want to do a lot of automation. Check the Mac OS X help or the AppleScript web site (www.apple.com/applescript/) for documentation and example scripts.

Table 7–1
Apple events understood by Chart (it can also send other Apple events to programs that recognize them).

Command	*Function*	*Example*
open	Open the specified Chart document	open file "Test Results"
print	Print the specified Chart document	print file "Test Results"
quit	Quit Chart application	quit application "Chart v5.0"
run	Launch Chart application	run application "Chart v5.0"
do script	Play the specified Chart macro	do script "Macro:Beep"

Repeat While in Block

This macro command allows you to perform some operation while the selection or active point remains within a block of data. You should specify an End Repeat command after the instructions you want performed in the repeated sequence. For instance, you may want to find all the peaks from the start to the end of a block of data, and record their heights in the Data Pad. You would make use of the Find… command for this:

▼ ***Refer***
Finding Data, p. 133

1. Choose Macro > Start Recording.
2. Choose Commands > Find…, and set up the Find and Select dialog box: Go, Start of This Block, Set Active Point.
3. Choose Macro > Macro Commands > Repeat While in Block.
4. Choose Find… again, and set up the Find and Select dialog box for the search: Find Data, Next, Local Maxima, Set Active Point.
5. Choose Commands > Add to Data Pad.
6. Choose Macro > Macro Commands > End Repeat.
7. Choose Macro > Stop Recording.
8. Name the Macro and assign a keystroke if you wish.

Repeat While in Selection

This macro command works similarly to the Repeat While in Block command except that it allows you to perform some action from the start to the end of a selection rather than from start to end of a block.

Repeat Select Every…

This macro command allows you to select sequential periods of data in a Chart file and to perform some operation on them. When you choose the Repeat Select Every… macro command, a dialog box appears, allowing you to set a selection period (with a minimum selection of two data points) and choose whether the command applies to the whole file, the currently selected block or to a current selection. You could, for example, transfer data to the Data Pad for every ten-second period within a given block.

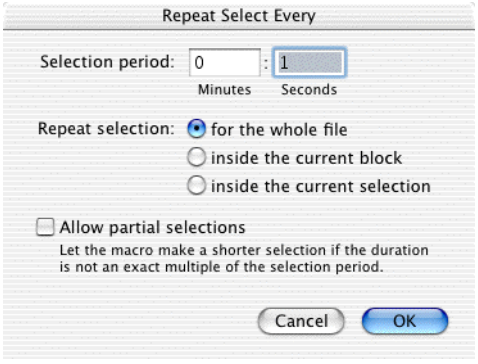


Figure 7–23
The Repeat Select Every dialog box.

If the Allow partial selections checkbox is selected, and the recording period is not an exact multiple of the selected time period, the last selection will be a shorter time making up the balance — for example, if the file were 45 seconds long and the selection period 10 seconds, the last selection would be the remaining five seconds. If the checkbox is off, the last selection in a block will not be included in the case where the length of the block is not an exact multiple of the selected time period.

Figure 7–24 shows a macro selecting a period of data (0.1 seconds) sequentially through a Chart file: each selection of data is dealt with before moving on to the next one. When this macro command plays, it will scroll through the Chart file and highlight each new selection, which may take a while unless the Update Screen command is turned off.

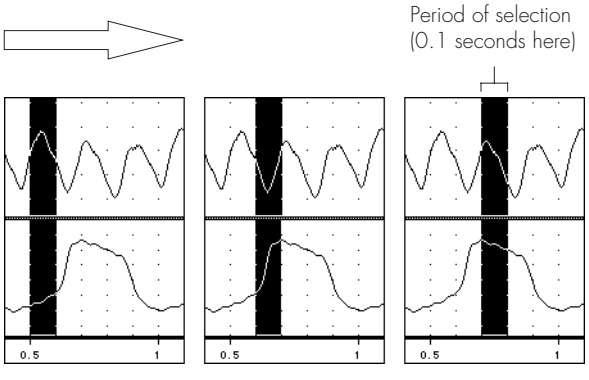


Figure 7–24
The Repeat Select Every… macro command in action.

You cannot nest this command within itself, but you could nest it within the Repeat Select Each Block command, say, if you wanted to copy the mean of a channel for each ten-second period in a block to the Data Pad, and write the data of each block to a new file. You should specify an End Repeat command after the instructions you want performed in the repeated sequence.

Repeat Select Each Block

This macro command allows you to perform some operation on each block of data in turn in the Chart file. For instance, you may want to get the mean of a channel for each block and copy the information to the Data Pad. When this macro command plays, it will scroll through the Chart file and highlight each new block, which may take a while: turn off the Update Screen command to avoid the visual feedback. As with all Repeat macro commands, you should specify an End Repeat after the instructions you want performed in the repeated sequence.

Begin Repeat

The Begin Repeat macro command is used to repeat steps in a macro. You can repeat any group of commands up to 100 000 times. This could be used, for example, to set up fast sampling at staggered intervals overnight. You should specify an End Repeat command after the instructions you want performed in the repeated sequence.

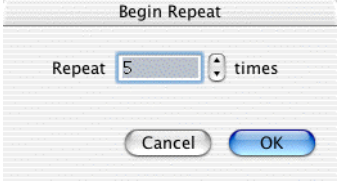


Figure 7–25
The Begin Repeat dialog box.

End Repeat

Each and every Repeat macro command step you specify should be paired with an End Repeat. If you do not specify enough End Repeat steps, Chart adds them when you choose Stop Recording…, but if you have a complex macro, the repeated sequences might not end up in the

right places. Writing down the macro before recording it will help to avoid such problems.

Set Units Conversion…

The Set Units Conversion… macro command lets you automate units conversion. It may be more convenient to use this command in a macro rather than the proper Units Conversion dialog box. On choosing the command, the Set Units Conversion dialog box (Figure 7–26) appears. Select the Point 1 or Point 2 radio button to select the first or second pair of values. You can choose the recorded data of a particular channel, or the mean, maximum, or minimum values from a selection of recorded data, using the Channel and Selection pop-up menus. The converted value should be typed into the Value text entry box. Choose or define units from the Units pop-up menu.

▼ ***Refer***
Units Conversion, p. 46

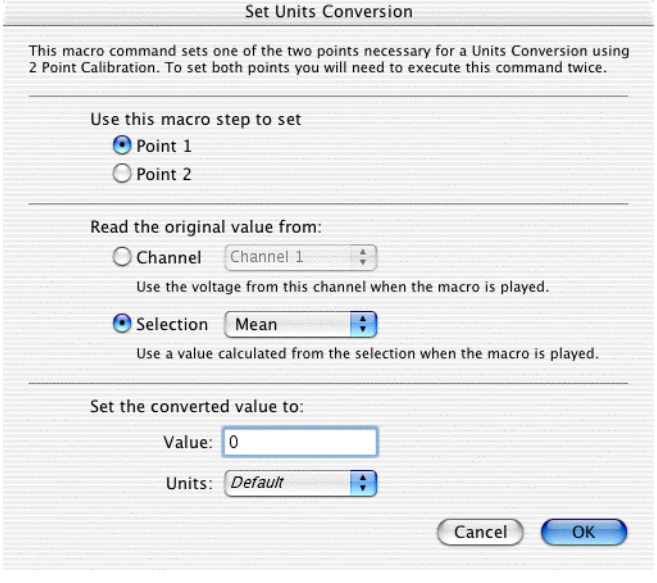


Figure 7–26
The Set Units Conversion dialog box.

To get a macro that converts the units of a channel into a percentage of the maximum reading, say, you should perform the following steps:

1. Select data containing the greatest and smallest data points in the channel you want to affect.
2. Choose Macro > Start Recording.

3. Choose Macro > Macro Commands > Set Units Conversion… to open the Set Units Conversion dialog box.

- Click the Point 1 radio button in the dialog box (if it is not already selected).
- Click the Selection radio button.
- Choose Minimum from the pop-up menu beside it.
- Enter '0' in the 'Value' box.

4. Click 'OK'.

5. Choose Macro > Macro Commands > Set Units Conversion… to open the Set Units Conversion dialog box again.

- Click the Point 2 radio button in the dialog box.
- Click the Selection radio button.
- Choose Max from the pop-up menu beside it.
- Enter '100' in the 'To Value' box.

6. Define units of '%' using the Units pop-up menu.

7. Click 'OK'.

8. Choose Macro > Stop Recording.

9. Name the Macro ('Percent', or whatever) and assign a keystroke if you wish.

On finishing recording, you can apply this macro to any channel as required. Remember that it only applies to the current selection, so you will have to select a range of data including the largest and smallest points recorded to have the scale set correctly. To select an entire channel, Command-drag to select a rectangle the full height of a channel at its start of the record, scroll to its end, and Shift-click to extend the selection — this ensures that all data points are included.

This feature can also be used for automatic calibration of transducers during setup. To do this, set up a macro with prompting messages. You must select the channel you are going to use, which means you must have started recording — simply start and stop, then click the channel to which the transducer will be connected. For example, in the case of a pressure transducer, the macro should be of the form:

1. Macro Message. (Remove weight from transducer and click OK.)

2. Macro Set Units Conversion. (Set to 0.)

3. Macro Message. (Put 100 g weight on transducer and click OK.)
4. Macro Set Units Conversion. (Set to 100, and set units to g.)
5. Macro Message. (The transducer is now calibrated.)

Once the macro has been recorded and named, it can be invoked when starting to record. The message box will appear, at which time the user should ensure the transducer has zero grams weight applied to it. When the second message box appears, the user should apply 100 grams weight to the transducer, after which it will be calibrated.

Wait While Sampling

The Wait While Sampling macro command is used to suspend some steps in a macro until sampling stops. It can be used at any stage in a macro after sampling starts, just by choosing it from the submenu: later macro steps are suspended until sampling stops, then continue.

The Macro Sampling dialog box lets you suspend all other macro steps while sampling, or just continue with them while sampling. Sometimes this all-or-none choice isn't enough. For example, you might want to start recording, apply some stimuli (which must be done while sampling), record the results for a time, and give the user the choice to start another cycle of stimulation or stop the macro, using a macro message. You would need the alert box to appear only after sampling had stopped, not straight after the stimulus, so macro steps would have to be suspended at that stage. Choosing a Wait While Sampling step before the Message step allows this refinement.

▼ ***Refer***
Starting Sampling, p. 206

Stop Sampling

The Stop Sampling macro command is used to stop Chart sampling. Choose it from the submenu, at any stage in a macro, to provide a user stop (the Start button doesn't actually start Chart sampling while you record a macro, so the Stop button does not appear). In some circumstances, if you switch back and forth between recording and monitoring, or change multiple settings such as input ranges, this can result in the recording of very short blocks between the steps of the macro. Stopping sampling using this macro command before such steps prevents that problem.

Timed Events

The Timed Events feature allows you to create a list of actions you want to be performed at particular times from the start of recording, including setting the analog output or (on specially configured e-corder units) digital output: once the list is set up, Chart will perform the actions at the times you have specified. Choose Setup > Timed Events… to set up a list of timed events. The Timed Events dialog box will appear (Figure 7–27).

Click the New button to create a new event row in the scrolling list. To set the time from the start of recording at which you want the event to occur, click in the cell of the row in the Time column, and enter the time, in either seconds (any numerical value) or hours, minutes, and seconds (the value in the format hh:mm:ss). The time will be rounded to the nearest second, and expressed as hours, minutes, and seconds. For example, typing 10 will result in the time being set to 0:10. If you type in 120, the value is converted into 2:00, that is, two minutes from the start of recording. To set an event to occur at two hours and forty five minutes from the start of recording, you would enter 2:45:00. Actions can be scheduled for the start or end of recording by clicking the Start or End buttons. Alternatively, you can type in the letter S, for start, or E, for end, in the time entry field. This is useful for tidying-up tasks, such as resetting the analog output.

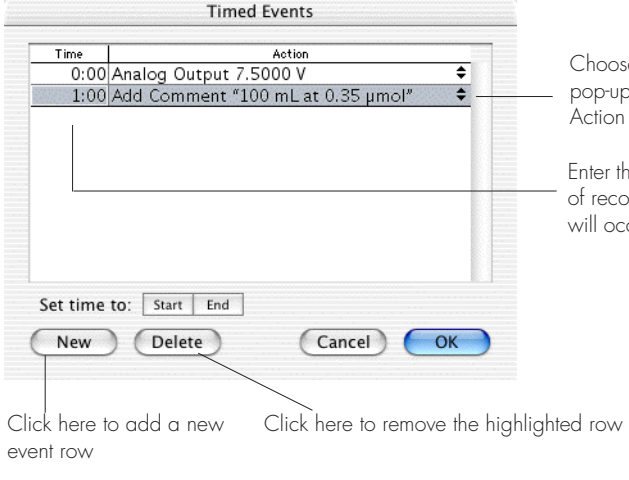


Figure 7–27
The Timed Events dialog box.

The timed events list will automatically re-sort rows in chronological order once you have finished a new row. This allows you to add new events to the list at any time, while being able to view the list in order of events. You can have two or more events scheduled at the same time: Chart will execute one after the other as quickly as it can.

Timed Event Actions

Clicking the mouse button when the pointer is in a row in the Action column opens the Action pop-up menu of events. Three types of event can be chosen: setting an e-corder output voltage; adding a comment; and (on specially configured e-corder units) applying a digital output configuration.

Choose Action pop-up > Add Comment… to add a comment to the recording at a specified time. The Add New Comment dialog box will appear. You can type in the comment you want to add, and choose to apply it to all channels or to a specific channel through the Channel pop-up menu.

▼ ***Refer***
Comments and Exclusions, p. 117

Choose Action pop-up > Set Analog Output… to set the analog output voltage level from the Output sockets at the front of the e-corder. The Timed Event Stimulator Output dialog box appears, letting you adjust the constant output voltage. The amplitude range within which the output voltage is set is taken from the Stimulator Constant Output dialog box.

▼ ***Refer***
Constant Output Voltage, p. 66

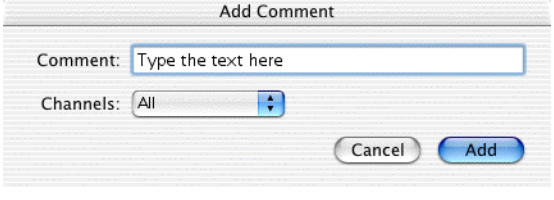


Figure 7–28
The Add Comment dialog box.

Note that 'Analog Output 2' events are not available with current e-corder models.

If you have previously defined a list of digital output configurations (only possible on specially configured e-corder units), they will be

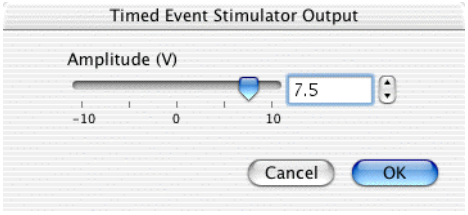


Figure 7–29
The Timed Event Stimulator Output dialog box.

included as menu commands at the bottom of the Action pop-up menu, and can be applied at scheduled times by selecting them as event actions.

The 'Repeat Sequence' command can be used to make the timed events sequence start from the beginning again. When Chart encounters the Repeat Sequence action, it goes back to the beginning of the event list and performs each event in order, starting the sequence from the time for which the Repeat Sequence was set. This allows you to pause between repeating events.

The example in Figure 7–30 shows how the Repeat Sequence can be used. It shows the sequence of list events on a time line. The event list in the dialog box consists of two actions at the beginning of recording, two actions at 1 minute 40 seconds, and two actions at 5 minutes, at which stage the event sequence finishes. By placing a Repeat Sequence action at 10 minutes, we get the whole sequence repeated again 5 minutes after the end of the last one. Note that the sequence is repeated immediately after the repeat sequence action.

Editing and Saving Timed Events

To add a new event, click the New button again, and create the new event you need at the time you want. Once it is entered, Chart sorts the event list in chronological order again. To change an existing event, select the time or action to change and enter the changes. To remove an event, click a row to select it (it becomes highlighted) and click the Delete button. Shift-click or Shift-drag to select contiguous rows, or Command-click to select or deselect multiple rows singly, for mass deletion. If there are entries in the dialog box, timed events will occur when you start recording. You have to delete all entries to turn timed events off.

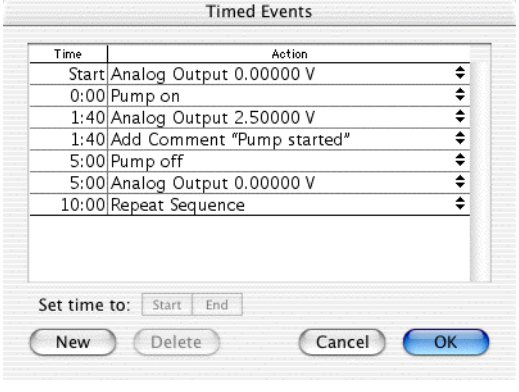
You can save timed events setups in settings files, or as macro steps. If you open the Timed Events dialog box while recording a macro, its

state is recorded as one macro step when you click the OK button, and its timed events are made available and used when the macro is played, during a sampling step. If various sets of timed events were recorded as steps before sampling steps, different lists of actions could be applied during each macro sampling step.

▼ ***Refer***
Automatic Comments, p. 226

The Accuracy of Timed Events

The timed events feature is not intended for uses requiring very high accuracy. Since it is controlled from the computer, its accuracy will depend on how busy the computer is: very fast sampling, a slow processor, or running intensive applications in the background may all delay it. Holding down a menu while timed events are about to occur forces a delay until the menu is released. In general, though, it should



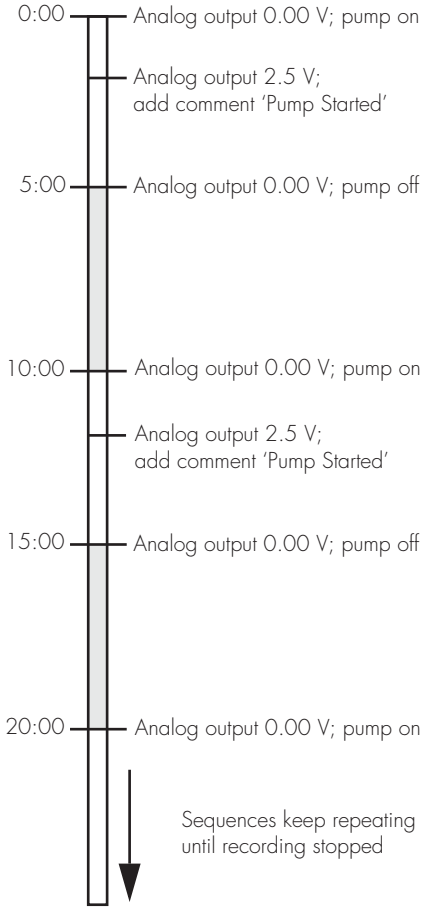


Figure 7–30
An example of a repeat sequence and the associated time line.

be accurate to the second entered. If greater accuracy is required, the automatic comments feature might be more suitable.

Automatic Comments

The automatic comments feature lets you generate predefined comments while sampling. By setting up a list of comments (in the Automatic Comments dialog box) that correspond to certain events, you can have Chart automatically insert the corresponding comment when the event occurs. The events include certain states or changes of state of the e-corder digital inputs, external trigger, or stimulator, so that you can keep notes of all such changes during automated recording. The timing of automatic comments is very accurate (unlike the timed events feature), so it is particularly suitable for this. The events also include using Function keys, so that a single keystroke can be used to enter a long comment. If you have external equipment to monitor or routine analyses to run, then automatic comments can save a lot of time.

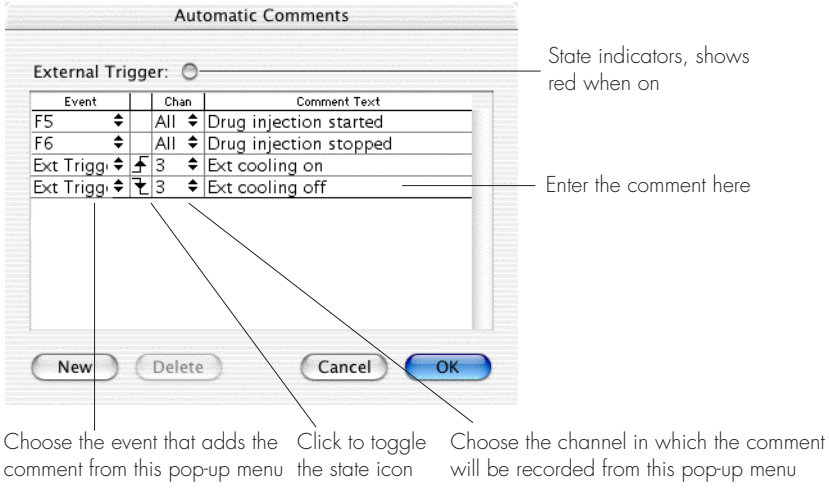
▼ ***Refer***
Comments and Exclusions, p. 117

Choose Setup > Auto Comments… to create a list of automatic comments. The Automatic Comments dialog box appears. The dialog box gives some feedback about the e-corder hardware. The state indicators at the top of the dialog box show if the external trigger (Ex) is on (highlighted) or off (plain), so that you can observe the effects while setting up automatic comments.

To create a new automatic comment, click the New button to add a new row to the scrolling list. Type the comment text in the Comment Text column of the row. The comment can be applied to any of the available channels or to all channels, by selecting the appropriate item from the pop-up menu in the Chan column.

The pop-up menu in the Event column lets you choose what causes the comment in a row to be added. As a shortcut, you can click one of the numbered state indicators to apply that bit to a selected row. The pop-up menu also has an Any Bit option. When this option is selected, Chart adds a comment when any digital bit changes.Those rows where the comments are activated by digital input bits or the external trigger will have a state change icon in the second column. Click the state change icon to toggle it up or down, showing the input signal change to cause the comment to be added to the recording: up for an off-to-on

Figure 7–31
The Automatic Comments dialog box.



transition (from a low to a high state), and down for an on-to-off transition (from a high to a low state).

Function Keys

You can choose one of the 15 Function keys (F1 to F15) in the Event column, for use with an extended keyboard. Then rather than typing in comments in the text entry area at the bottom of the Chart window while recording, you can simply press the key to add the assigned comment, saving both typing and time. This is useful if you are doing a routine experiment or have typical things you note about recorded data. Note that Function keys assigned to a button on the Tool bar override those same keys assigned for automatic comments.

▼ ***Refer***
Tool Bar, p. 190

External Trigger, Stimulator

If you choose the external trigger (Ext Trigger) in the Event column, the event comes from an external source connected via the Trigger connector on the front of the e-corder. Chart adds the matching comment when a TTL voltage pulse (or contact closure) activates the external trigger, at the start or end of the event, depending on the whether the state change icon is up or down (you could measure event width by using both).

▼ ***Refer***
Triggering, p. 55

If you choose the stimulator (Stim Mark) in the Event column, Chart will add the matching comment when it starts a stimulus. The comment is added at the start of each step or ramp. If continuous (repetitive) stimulation is chosen, the comment is added at the start of each pulse, or the start of each cycle for triangle or sine modes; otherwise it is added at the beginning of the set number of pulses or cycles. Stimulation starts when sampling starts, for repetitive stimulation, so a comment will be added at time zero. This feature helps to avoid having both to enter a comment and apply stimulation manually at the same time. It works at any sampling rate, up to a stimulus frequency of about 10 Hz. Unlike the stimulus marker, it won't add a data spike to a channel's waveform.

▼ ***Refer***
The Stimulator, p. 60

Repeating Automatic Comments

You can have more than one comment attached to the same event, in which case Chart simply cycles through them. You might want to indicate 'first heating phase', 'second heating phase' in monitoring a digital input, say. Chart takes account of the state change icon in the second column of the dialog box, so that, for instance, the start and end of an external trigger pulse are treated as separate events.

Repeated automatic comments can also be numbered to help keep track of them. If you set up an automatic comment that contains the # character, then when this comment is added, an incrementing number replaces the #. An automatic comment 'Pump on #' would give 'Pump on 1', 'Pump on 2', and so on in the recording. Up to ten independent lists of numbered repeat comments can be generated, by adding a number (0 to 9) immediately after the # (#0 is the same as just using # by itself). To set up a comment that gives the current digital input byte, use #D in the comment text column.

Editing and Saving Automatic Comments

To create a new automatic comment, click the New button. To change an existing comment, select the text and type over it; to change the event, choose another from the Event column. To delete an automatic comment, click a row to select it (it becomes highlighted) and click the Delete button. Shift-click or Shift-drag to select contiguous rows, or Command-click to select or deselect multiple rows individually, for mass deletion. If there are entries in the dialog box, automatic comments will

be applied as set up when you start recording. You have to delete all entries to turn automatic comments off.

You can save automatic comments setups in settings files, or as macro steps. If you open the Automatic Comments dialog box while recording a macro, its state is recorded as one macro step when you click the OK button, and its comments list is made available and used when the macro is played, during a sampling step. If various sets of automatic comments were recorded as steps before sampling steps, different lists of comments could be applied during each macro sampling step. To change the list, you must first stop recording.

Choosing a Connected e-corder

Usually a single e-corder is connected to a computer. It is possible, to use multiple copies of Chart, and connect multiple e-corders to one computer. Each copy of Chart can be assigned to work with an individual e-corder.

e-corder Startup

You control the way in which the software starts up by changing the default settings in the e-corder Startup dialog box. Choose Chart > Preferences > e-corder Startup… to open the dialog box.

If the top radio button in the dialog box is on, the software always starts in analysis mode without even looking for an e-corder; this avoids the 'e-corder Unavailable' dialog box, and is useful if you are using Chart on a computer without an e-corder attached (for example to review and analyse existing data files).

▼ ***Refer***
Figure 1–2, p. 4

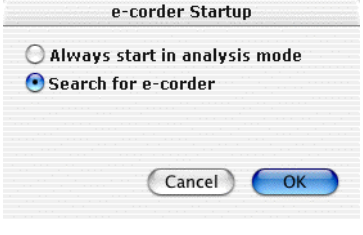


Figure 7–32
The e-corder Startup dialog box.

Choosing and Naming an e-corder

If you have multiple e-corders connected to your computer then you can hold down the Option key as Chart starts up to open a dialog box that lets you choose which one to use. This could be useful if you have the e-corders set up for particular tasks and don't want to disconnect or reconnect them.

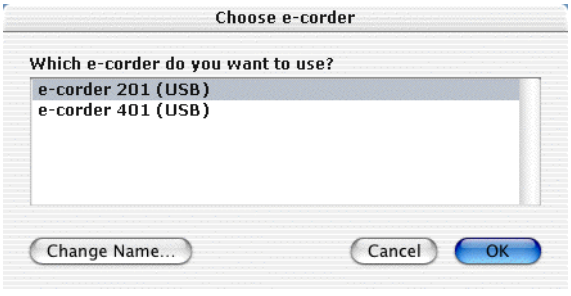


Figure 7–33
The Choose e-corder dialog box.

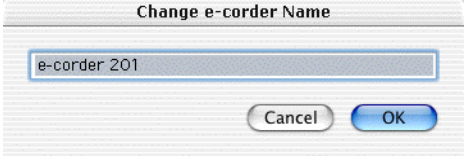


Figure 7–34
The Change e-corder Name dialog box.

To choose a connected e-corder, click it in the scrolling list. Click the OK button to start up Chart with the chosen e-corder. If you click Cancel, a dialog box appears letting you choose to work in Analysis mode.

You can also name an e-corder selected in the scrolling list by clicking the Change Name… button. A dialog box appears: enter a name in the text entry box to replace the default (model) name and click the OK button to apply it.

Naming an e-corder is useful if you have several e-corders of the same type. The e-corder stores the name and can be identified by it whenever it is connected.

If you do record on multiple copies of Chart simultaneously, you may need to synchronize the recording. To do this, use the same triggering setup in each Chart file, and use an external triggering device connected in common to the trigger input at the front of each e-corder to start recording.

A

APPENDIX A

Menus & Shortcuts

Menus

The menus shown here are the default settings, and your copy of Chart may be set up differently, since Chart menus can be extensively customized. Chart has seven menus: Chart, File, Edit, Setup, Commands, Macro and Window; macros, Chart extensions can add more. Some of the menu commands shown will change or be disabled depending on the active window and what, if anything, is selected. An ellipsis (…) after a menu command indicates that it opens a dialog box; a tick to its left indicates that it is currently active; and a keyboard equivalent, if there is one, is shown to its right.

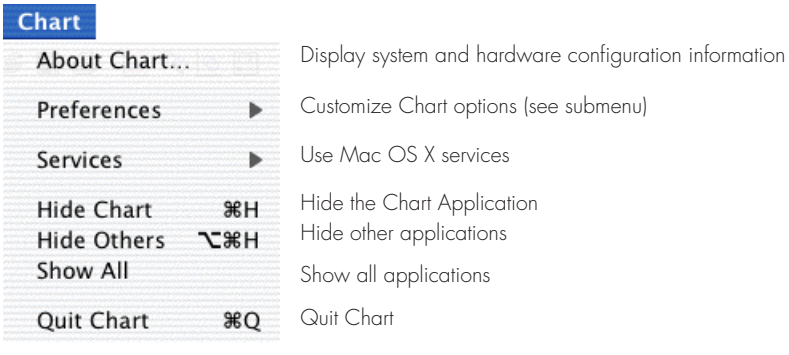
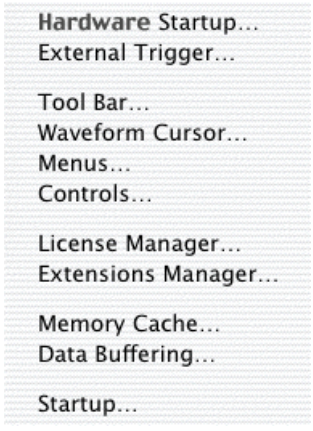


Figure A–1
The Chart menu.

Figure A–2
The Preferences submenu.



Choose how Chart looks for **e-corder**
Choose trigger event: voltage level or contact closure

Set up the Tool bar
Choose shape of the Waveform Cursor
Modify Chart menus
Modify various Chart features and settings

View, add and remove Chart licenses
Choose which Chart extensions to use

Change the size of the memory cache
Choose to store data on disk or in memory

Save current settings as default settings

Figure A–3
The File menu.

View a list of your experiment and supporting files

Create a new Chart file
Open an existing file
Append an existing file to the current file

Close the current file
Save the current file
Save file with a new name, or location, or format
Save the current selection as a separate file
Set up Chart to save automatically

Set up file information to search for
Search for Chart files by file information or comments

Set up page size and so on to suit the printer
Print all data (or active window)

Figure A–4
The Edit menu.

Undo previous action (if possible)

Cut selected data to the Clipboard
Copy selected data to the Clipboard
Paste selection
Clear selection
Select all data

Clear all data in a channel

Show Clipboard

Figure A–5
The Setup menu.

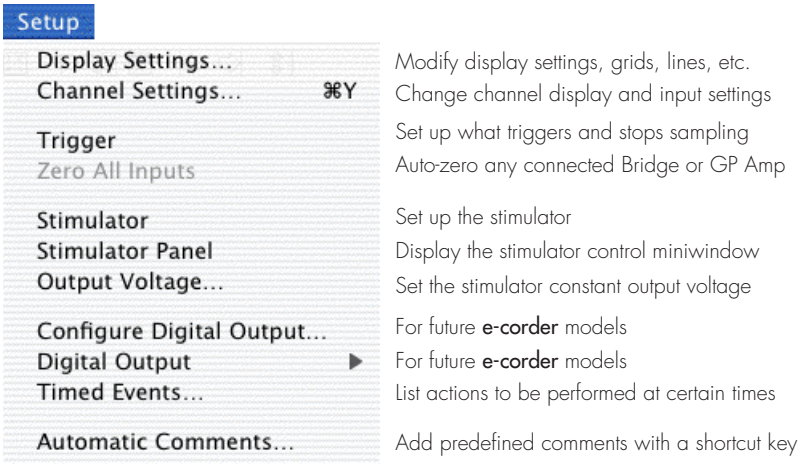


Figure A–6
The Commands menu.

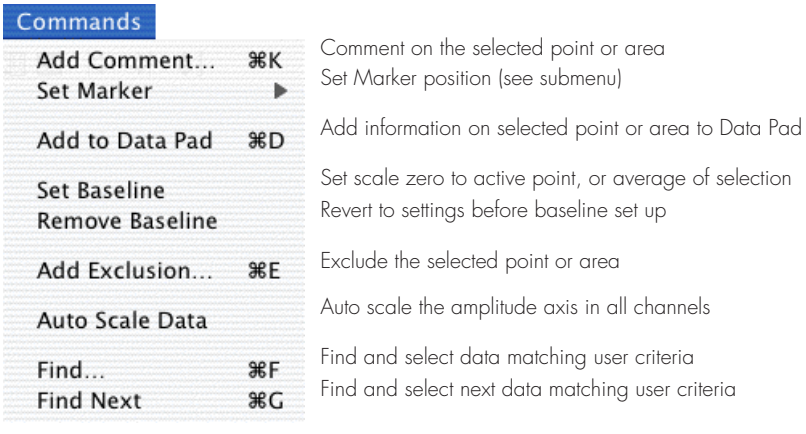


Figure A–7
The Set Marker submenu.

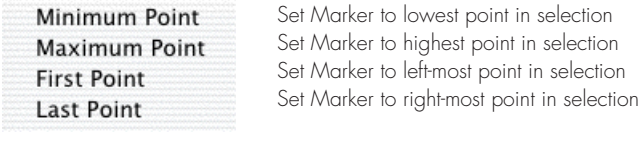


Figure A–8
The Window menu.

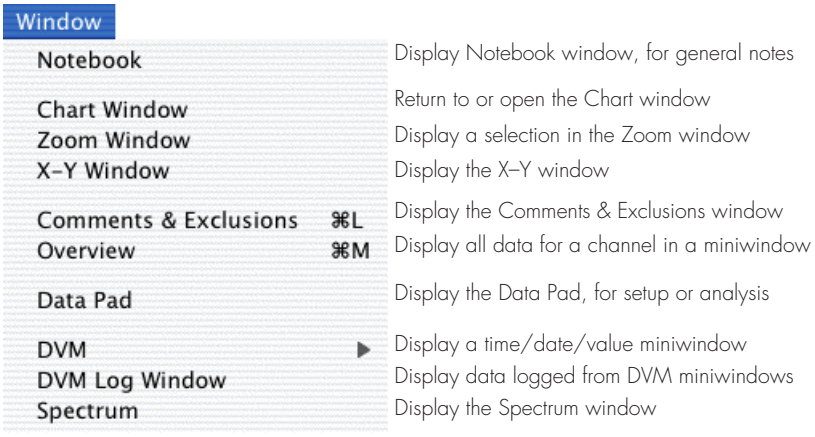


Figure A–9
The Macro menu.

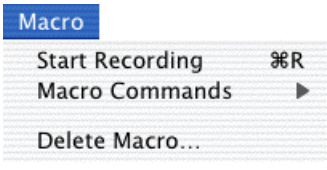
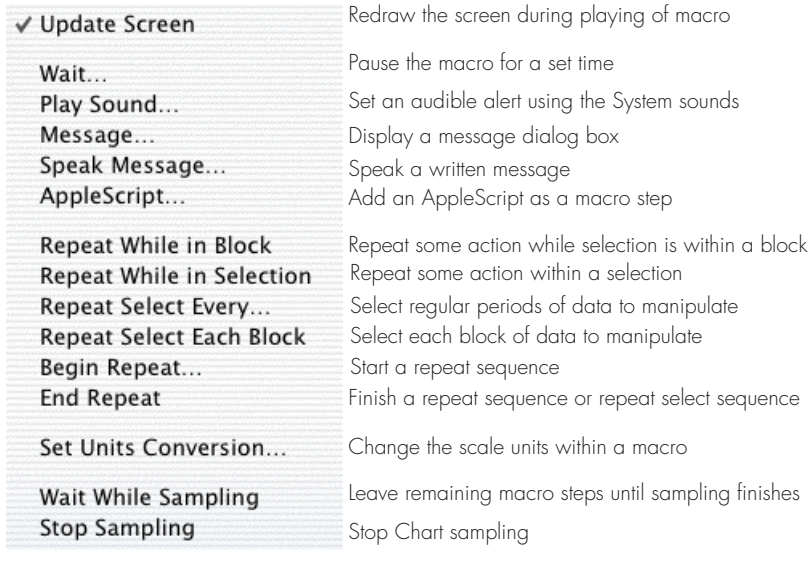


Figure A–10
The Macro Commands submenu.



Shortcuts and Tips

Actions in general apply to the Chart window. Keyboard shortcuts for menu commands can be added, changed, or assigned to user-defined actions (menu commands are listed alphabetically by shortcut so that you can see at a glance which keys have been used). Some of the shortcuts shown will change or be disabled depending on the active window and what, if anything, is selected.

Menu Commands

Table A-1: Chart keyboard and other shortcuts: the table is divided into named groups of related shortcuts for convenience.

Action	*Shortcut*
Select all	Command + A
Clear selection	Command + B
Copy to Clipboard	Command + C
Add information to Data Pad	Command + D
Mark data to be excluded from analyses and so on	Command + E
Find and select data matching user criteria	Command + F
Find and select next data matching user criteria	Command + G
Hide Chart	Command + H
Add comment	Command + K
Comments & Exclusions window	Command + L
Overview miniwindow	Command + M
New Chart data file	Command + N
Open file	Command + O
Print	Command + P
Quit Chart	Command + Q
Start/stop macro recording	Command + R
Save file	Command + S
Paste	Command + V
Close active window	Command + W
Cut selection	Command + X
Channel Settings dialog box	Command + Y
Undo/redo	Command + Z

Navigation

Action	*Shortcut*
Scroll left or right	Left or Right arrow
Go to previous or next block	Option + Left or Right arrow
Go to start or end of file	Command + Left or Right arrow
Manually scroll data display area	Option + drag the area (Chart or Zoom window)
Auto-scroll data display area	Option + drag the area, let go while dragging
Go to a block	Click the block button
Go to a comment	Double-click comment in Comments & Exclusions window
Go to any section of data display area	Drag highlighted region in Overview miniwindow
Center off-screen selection	Command + click in Zoom window

Selecting Data

Action	*Shortcut*
Set active point in a channel	Click in channel
Set active point over all channels	Click in Time axis
Select area in a channel	Drag in channel
Extend selection in a channel	Shift + click in channel
Select full height of a channel	Command + drag in channel
Select area of additional channel	Shift + drag in additional channel
Select full height of additional channel	Command + Shift + click in additional channel
Select same relative height of additional channel	Option + Shift + click in additional channel
Select area over all channels	Drag in Time axis
Extend selection over all channels	Shift + click in Time axis
Deselect selected channel	Shift + click in channel
Select a block	Press the block button and choose Select Block, or double-click in Time axis

Starting up Chart

Action	*Shortcut*
Choose the extensions to load	Hold down Space Bar while Chart starts up
Use the default settings for a session	Hold down Command key while Chart starts up

Display

Action	*Shortcut*
Revert shifted or stretched vertical scale	Double-click in Amplitude axis
Cycle through scale display modes	Double-click repeatedly in Amplitude axis
Hide split bar (show Chart window with one pane)	Double-click split bar
Give each channel the same area	Double-click any channel separator
Overlay adjacent channels	Option + click their channel separator
Separate overlaid channels	In Channel Settings dialog box, turn on their Separator checkbox
Move Tool bar	Shift + drag Tool bar

General

Action	*Shortcut*
Select/deselect adjacent items in list	Shift + click in list
Select/deselect separate items in list	Command + click in list
Move between text entry fields in dialog boxes	Tab
Accept (OK) dialog boxes	Return
Cancel dialog boxes	Esc key or Command + . (period)

Miscellaneous

Action	*Shortcut*
Start/stop sampling (on most systems)	Command + Space Bar
Stop process (sampling, macro playing, drawing, etc.)	Command + . (period)
Bring up last chosen channel calculation dialog box	Command + =
Special access to dialog boxes (Menu, Save As, etc.)	Command + \ or Control + Command + 1
Delete selection	Delete
Add information on a data point to Data Pad	Double-click in channel
Show recording settings information for a channel	Click Channel Status diamond
Show block information summary for a channel	Click in data display area of channel
Make channel-specific comment while sampling	Tab, type channel number, comment, then Return
Make non-specific comment while sampling	Tab, type any letter, comment, then Return
Send Marker home	Double-click Marker, or click Marker box
Transfer data from display to initial voltage values in Units Conversion dialog box	Double-click in its data display
Activate Stimulator Panel buttons to start or stop stimuli	Option + Space Bar
Maximize image in Page Layout dialog box	Double-click image
Set/Remove baseline over whole channel	Command + choose Commands > Set/Remove Baseline
Turn channel and all below it off or on	In Channel Settings dialog box, Command + click the On checkbox

Action	*Shortcut*
Turn channel and all below it off, or those with visible data on	Command + choose Channel Function pop-up > Turn Channels Off/On
Apply channel calculation permanently to a channel	Command + choose Channel Function pop-up > Apply Calculation…

There are many other general Macintosh shortcuts, of course, such as the set available in the Open and Save dialog boxes. See the Macintosh system help for details.

B

APPENDIX B

Troubleshooting

Technical Support

Chart has been extensively tested to make sure that it runs smoothly and without difficulties. Occasionally, however, problems may arise or something unexpected may occur. The second part of this appendix gives a list of possible problems and likely solutions: you should look there first to see if your needs are addressed specifically. (This can save you some money in telephone calls or faxes!)

If you are experiencing difficulties with Chart that are not covered in this manual, or you need technical assistance with your e-corder system in some form, then eDAQ and its authorized distributors are glad to help. The About Chart dialog box gives access to contact addresses and information on the system and hardware configuration. Choose Chart > About Chart… to open it.

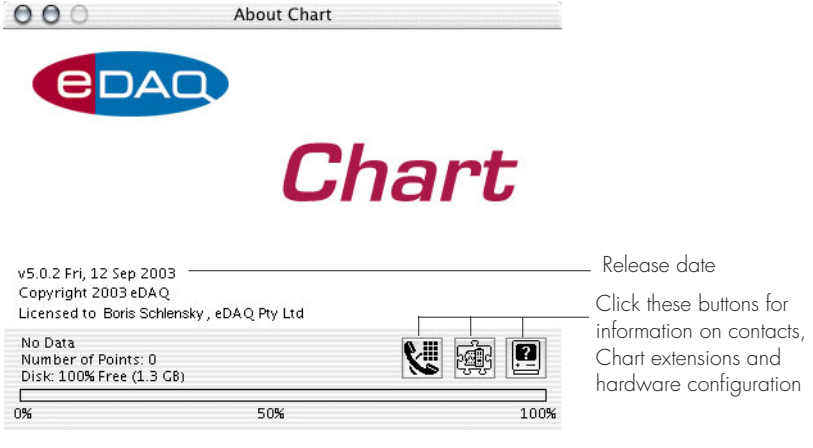


Figure B–1
The About Chart dialog box.

Dealer and Distributor Information

If you need help or information from an eDAQ distributor, click the Telephone button to open the eDAQ Contacts dialog box. Feel free to get in touch with your local eDAQ distributor to discuss hardware and software requirements generally, and find out more about the latest releases, upgrades, and software maintenance information. You can also visit the eDAQ web site for general information of this nature.

Figure B–2
The eDAQ Contacts dialog box.

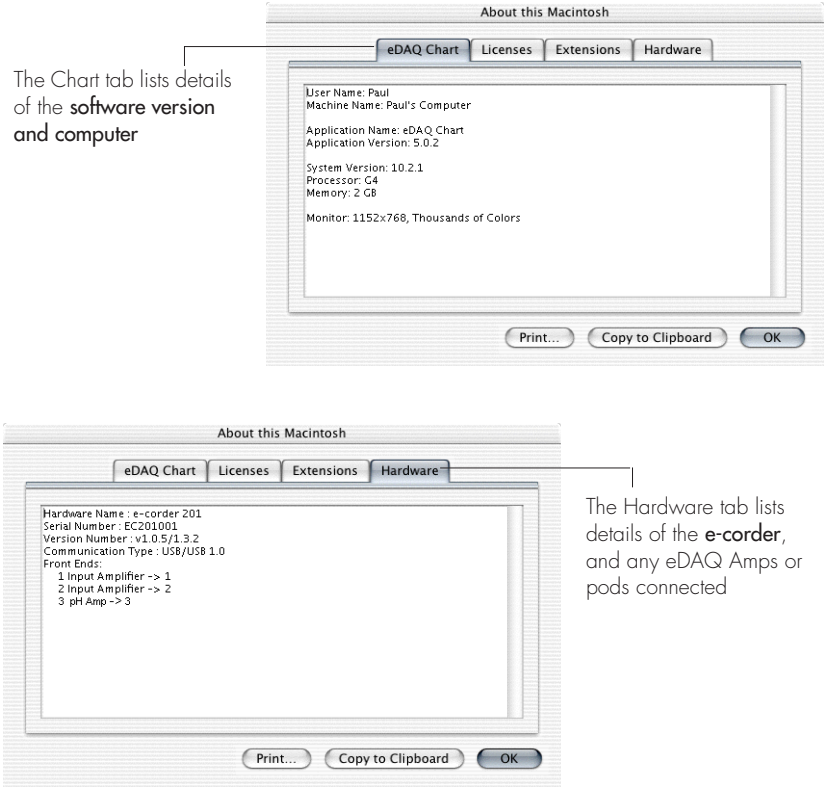
The dialog box should have up-to-date contact information. Click in the scrolling list on the left of the dialog box to select your country, or the nearest one to it, and contact information will appear to the right. Click the Copy button to copy the information to the Clipboard, to save typing it out.

The Web and email addresses in this dialog box, and the Web address are hyperlinks. Clicking a link will open your web browser and take you to the web site, or open your email program and fill in the mailing address for you.

System Configuration Information

In general, we will need quite specific information about your hardware and software to help to isolate and to solve problems effectively. Since this type of information can be tedious to collate, Chart does it all for you. Click the computer button to open the About this Macintosh dialog box.

Figure B–3
The About this Macintosh dialog box.



The dialog box has four tabs. The Chart tab gives information on which version of Chart is running, together with information about your computer and operating system. The Licenses tab lists your current license for Chart and you have installed (this information is also available in the License Manager dialog box). The Extensions tab lists installed Chart extensions, if any. The e-corder tab contains details of your e-corder and how it is connected, as well as any connected eDAQ Amps and pods. If the e-corder has any pod connections without pods connected, they are listed as 'Input Amplifier'. Click the Print… button to print a tab, or the Copy to Clipboard button to copy the text for pasting into an email, letter or fax to your eDAQ distributor.

General

We welcome customer comment. If you have comments or suggestions you would like to make about the Chart Application or this manual, please feel free to write to us directly at info@eDAQ.com. We value your responses, and they are taken into account when future releases are being worked on.

Solutions to Common Problems

Chart has an extensive array of dialog boxes which appear in most cases where problems arise. Very often they will suggest appropriate courses of action. Otherwise this section of the manual may prove useful.

Starting Up

Startup errors are mostly hardware problems, and are dealt with in detail in your *e-corder Manual* (supplied as a pdf format file) but are briefly covered here.

The computer can't find the e-corder

- The e-corder is off or the power is switched off at the wall, the power cable is not connected firmly, or a fuse has blown. Check switches, power connections, and fuses.
- A poor connection between e-corder and computer, or bad cable. Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.
- The software preferences are set to start up in analysis mode or only using a certain connection. (e-corder settings are common for Chart and Scope, so this could have been set in either program.) If the 'e-corder Unavailable' dialog box has appeared, click the Options… button in it to open the e-corder Startup dialog box so that you can change the settings. Otherwise choose Chart > Preferences > e-corder Startup… to open the dialog box.

Chart 'hangs' or gives an alert on start-up

- It may be that the copy of Chart on your computer has become damaged in some way. Try reinstalling Chart from the original CD.

Chart starts up with strange settings and macros

- If you started Chart by opening a settings file or a data file with custom settings start up again from the Chart program itself.
- If the startup settings have been customized start up Chart with its default settings, by hold down the Command key as you open the software. Release the key when an alert box appears.
- To revert to the default startup settings, choose Chart > Preferences > Startup… and click Clear in the dialog box that appears. The next time Chart starts up, it will open with the default settings.

Interface Problems

Some data display areas show gray

- Chart channels show gray if they are turned off while recording, or if they are monitoring rather than recording, or if they are very thin. Most dialog boxes and windows require a selection of data in the Chart window to display a waveform (not just an active point). The X–Y window needs to have the x and y channels selected to plot against each other. The Zoom window and Overview miniwindow show gray if they were stopped while drawing.
- Turn the channel on, switch from monitoring to recording, or drag the channel separator to widen it; select data in the Chart window if there is no selection; click x and y numbered buttons in the X–Y window to get an X–Y plot; click the display area in the Zoom window for it to redraw; click the display or a numbered button in the Overview miniwindow for that to redraw.

The Time axis shows very large or negative values

- The file with which you are working is an old one with new data recorded in it, or one created by appending files or selections, and the time is displayed from the start of the record. Chart remembers, but does not display, the date and time of all recordings. Hence a section recorded before the one at the start of the file and subsequently appended to it, say, will appear with a negative time relative to the start of the record. Very large values to the right of the Time axis reflect a large lag between the time the record was created and the latest recording.

• If the values are a problem, simply change the time mode display to show time from the start of each block (the default setting).

Defined units display strangely

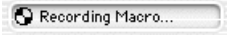
• Chart will deal with a unit prefix correctly only if it is chosen from the Prefix pop-up menu in the dialog box for defining units: if defined as part of a unit, it is ignored. Take a tesla (T), the standard unit of magnetic flux density. If you type in mT as one word with no prefix, then Chart will display a waveform of a thousandth of a mT with units of mmT. If the prefix m were chosen, Chart would scale the unit prefix properly, to give measurements in μT.

▼ ***Refer***
Choosing Unit Names, p. 50

• The indentation of defined units in the Unit pop-up menu in the Units Conversion dialog box shows if a prefix has been used properly.

Commands seem to have no effect, or a strange one

• If commands do not work in all circumstances, or if you have no selection or active point in the Chart window (for example, you cannot use commands to do with selections or active points, such as adding data to the Data Pad or printing a selection) then make sure you have a selection or active point in the Chart window, or otherwise have things appropriately set up.



• If Macro recording has been turned on, then you record what you are doing rather than actually doing it. Choose Macro > Stop Recording… and discard the macro.

Keyboard shortcuts don't work, or do strange things

• Menu commands may have been deleted, or keyboard shortcuts reassigned to other menu commands or macros. Look at the menus and compare them with the tables in Appendix A. See below for resetting procedures.

Menus, controls, or settings don't match those in this guide

• If you started Chart by opening a settings file or a data file with custom settings start up again from the Chart program itself.

• If the startup settings have been customized start up Chart with its default settings, by hold down the Command key as you open the software. Release the key when an alert box appears.

• To revert to the default startup settings, choose Chart > Preferences > Startup… and click Clear in the dialog box that appears. The next time Chart starts up, it will open with the default settings.

• Chart extensions may also add menus and alter some options. To start up Chart and choose which Chart extensions load, hold down the space bar while Chart opens. Release the key when the Extensions Manager dialog box appears. To stop particular Chart extensions being loaded at all, move them from the Extensions folder into the Extensions (Unused) folder (or make another such folder to suit your needs).

I've altered menus and locked myself out, can't save, and so on

• Type Command-\ or Command-Shift-1 to open a dialog box that allows special access to menu, Tool bar, control, startup settings and saving options.

Dialog boxes don't appear where I want them

Chart dialog boxes usually appear on the main monitor (the one with the menu bar). There are times, however, when you want one to appear on a secondary monitor, for instance, if that monitor is color and you are changing display colors.

• Chart usually opens dialog boxes on the monitor where the pointer is positioned. Move the pointer to a secondary monitor and use a keyboard shortcut to open the dialog box there (if there is no shortcut, add one or define a macro with one to do it).

I keep getting alerts saying the sampling rate is too fast

▼ ***Refer***
Setting Sampling Rates, p. 36
Performance, p. 31

• Chart has a maximum continuous sampling rate of 200 000 samples per second on one channel, 80 000 rates on two, and 40 000 on three or four. The external trigger can't be used at a sampling rate of 200 000 /s. Turn off the external trigger when sampling at 200 000 /s, reduce the number of channels used at fast rates, and so on.

• Faster computers allow better sampling rates on more channels, slower computers may limit recording speed. A USB 1.1 computer may not handle the very fastest sampling rates.

• Turn off unused Chart extensions, channels, computed inputs, and filters. This will decrease the workload for the computer.

• Channels do not need to be visible to record data, so check that any bunched up in the Chart window are actually off.

• Change the size of the memory cache (choose Chart > Preferences > Memory Cache… to open the Memory Cache dialog box.

• If the Chart window is large and the display is at a high color depth, more processing power is needed to draw it. Shrink the Chart window and reduce the color depth of the display.

• Miniwindows floating over the data display area will slow down sampling rates, especially if they overlap multiple channels.

• Keep miniwindows away from the data display area, turn them off, or make sure they keep to only one channel.

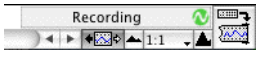
• Background activities (other programs and devices) can reduce the ability of the computer and connection to cope with recorded data. Turn off programs other than Chart that could slow down or (as in the case of electronic mail) interrupt data sampling, and don't use too many devices at once, especially on a USB chain.

• When recording to disk, ensure that your disk is not too full and is not fragmented: this slows down the speed of writing to disk.

• Recording to RAM (if you have enough) may be better for slower computers.

Nothing seems to be recording


• The Record/Monitor button (bottom right of the Chart window, by the Start button) may be set to monitor; there will be a cross through it if this is so, the Recording Status indicator (above the Time axis) will read 'Not Recording', and incoming channels will be grayed. Click the Record/Monitor button to make the cross disappear, and then data shown on screen will be recorded normally. If the button is not visible, then use the Controls dialog box (Edit > Preferences > Controls…) to show it.



• Chart may be recording, with nothing visible going on. This happens if Chart is reviewing rather than scrolling. If so, the Scroll/Review button will be highlighted (depressed), the Recording Status indicator will read 'Recording', and the scroll bar replaces

the Comments bar. Click the Scroll/Review button to change its state and record normally.

• You may be sampling at a very slow rate with a highly compressed horizontal scale, so that it takes a long time for data to appear. Check sampling rates and View buttons, and change as needed.

• Chart may be waiting for a trigger event or its internal timer: in this case the Recording Status indicator, above the Time axis, will read 'Waiting for trigger' or 'Int. Timer' or something similar. Values in the Range/Amplitude display may still change with the input signals. The e-corder also indicates it is waiting for a trigger. Supply the necessary trigger event, or choose Setup > Trigger and set the Event in the Trigger dialog box to User.

The computer 'hangs' while recording, or there is data loss

• There may be a poor cable connection between the e-corder and the computer, or a bad cable. Ensure that the cable is firmly attached at both ends and try again. If there is still a problem, try a new cable.

• Network connections or a strange system extension could also be at fault.Check your network connections and system extensions. It recommended to avoid using the intenet, email, or other network connections whilst collecting data.

Running out of memory

• You may be recording to RAM rather than to disk. Record to disk instead — choose Chart > Preferences > Data Buffering…

• Chart extensions use up allocated memory and may slow down Chart as well: only use those that you need. Turn off unnecessary Chart extensions (choose Chart > Preferences > Extensions… to get the dialog box), then quit and restart Chart.

• Chart uses a reasonable amount of memory for an off-screen buffer: if the Chart window is large, more memory is used, especially at increased color depths. Shrink the Chart window and reduce the color depth of your display.

Comments are truncated when printed

- Turning off the Show Times checkbox in the Comments window will allow a little extra space for printing comments either at the end of a Chart file or on their own.
- Comments are only designed for short notes, but if they are still too long to print after trying the above remedies, then transfer them as text to a word-processing program.

Printing is very slow

- Reduce the color depth of your display, and compress your file using the View buttons to minimize the number of pages that must be printed. Ensure that you are using the latest printer driver.
- The Page Setup options affect printing speed. Experiment with them to see which give best results. For a PostScript laser printer, Substitute Font should be on. In general, the Faster Printing option is most useful for older, slower computer systems; new systems should print Chart files more quickly with it off.
- When setting the Layout options in the Print dialog box leave the Layout option at printing one page per sheet, since the scaling can be quite slow.

The quality of the hard copy using faster printing should be sufficient for most purposes except publication. Printing speed depends on hardware as well: the faster the computer and printer, the faster that material can be printed.

Macros behave unexpectedly

- Make sure that you have the right macro, not a different one of the same name (in the case of name conflicts, the latest macro loaded into memory is used).
- Check that you have the steps and effects recorded somewhere, and that you haven't misremembered them — it is very easy to do.
- If the macro is a new one, it is possible that a step was not recorded correctly, and in particular, that a repeated sequence was ended in the wrong place. Try recording it again.

I have macros in files where I don't want them

- A macro, once created, floats around in memory until it is discarded or you save a file, whereupon a copy is saved with the file. If you have opened many files containing macros, you may end up with a lot in memory.
- Ensure that the Discard Existing Macros checkbox in the Open dialog box is on. This prevents accidental accumulation of unwanted macros as you open files.
- Delete unwanted macros using the Macro > Delete Macro… (this action merely removes macros from memory) and then save the file you want free of them (this removes them from the file).

I created a macro, but lost it on quitting Chart

- Macros are saved when a file is saved. The macro may have been attached to another file, or lost if you didn't save a file before quitting Chart.

Chart can't seem to recognize a Chart file

- You may be using an early version of Chart with a later version's file. File formats can change between versions, so software cannot always read later files. Newer software updates files when it opens them. Always use the latest version of Chart.
- The file may have become corrupted, possibly through disk damage.Use disk-checking software to find and fix the problem.
- If you back up files onto a computer using the Windows OS, be careful. Try to make sure the files are only handled from the Mac OS. Windows systems typically do not understand Macintosh files, and may discard information such as the file type or resource fork if the files are manipulated by the OS or an archiving program.
- Chart files should still be recoverable even if the file type and resource fork are lost. It may be necessary to add ".cfm" to the file name in the Finder to force Chart to recognize it as a Chart file.

Chart quits unexpectedly, crashes, or freezes

- If Chart quits unexpectedly or crashes, or the pointer freezes, then there may be a Mac OS system problem. See the guide to the Mac OS that came with your computer for details on this problem and how to deal with it.

• The file you are using may have become corrupted, possibly through disk damage. Use disk-checking software to find and fix the problem.

• Try reinstalling Chart from the original CD.

• Check your disk with anti-viral software. If you find a virus, you should check all potentially affected computers, disks, and backups, and eliminate the infection.

• Check to see if the problem occurs again. If so, note down what you were doing as fully as possible (use the About this Macintosh dialog box, and add any relevant details, such as sampling rates and the like) and notify eDAQ.

Note
Chart checks itself on startup for damage or virus infection, and will present an appropriate alert box if it detects a problem. (Files are not checked, though.)

C

APPENDIX C

Technical Notes

Calculation Details

Depending on your data it may be useful to know the mathematical details behind some of Chart's analysis functions, in order to get the best use out of them. This appendix gives details of the algorithms used by the Spectrum window. It also explains why the results of computed input functions and corresponding channel calculations may differ.

The Spectrum Window FFT

Physical phenomena can be described in terms of time or its inverse, frequency. The functions describing a phenomenon in the time domain or frequency domain are effectively equivalent, and one can switch between them using certain linear transforms. Spectrum uses a discrete Fast Fourier Transform (FFT) algorithm to convert data from time to frequency domains.

Spectrum divides the data into segments, with the number of data points in each segment equal to a power of two (a requirement of the algorithm): this is the FFT Size shown in the Spectrum Settings window. Once a selection made in the Chart window is divided up into segments of this size, the transform is applied to each segment to calculate its spectrum. The spectrum plotted is the average of these partial spectra. Averaging improves the amplitude accuracy over a large selection.

If the number of data points selected does not divide up exactly into a whole number of FFTs, and the selection is unadjusted ('Use Current' is chosen in the settings), or if not enough points exist within a data block, the remainder is padded with zeroes, which are added to the right side of the remaining data points of the selection before the transform is applied. The Spectrum window shows selection information above the graph area: the number of FFTs, the number of data points per FFT, and either the number of padded points (if any), or whether the selection was adjusted to give an integral number of unpadded FFTs. (This information changes with Spectrum's settings.)

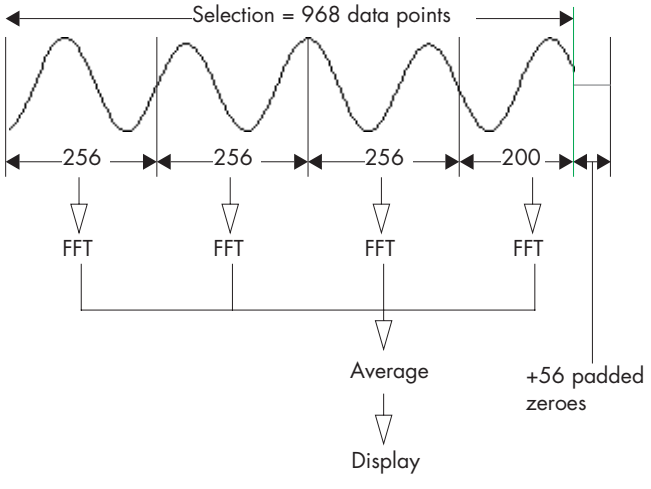


Figure C–1
A selection of 968 data points with FFTs of 256 (no overlap) divides into 3 FFTs with 200 left over, so Spectrum adds 56 zeroes at right to pad out data for the fourth FFT.

Spectrum's Implementation of the FFT

The treatment here is only a summary; see Press et al.[1] for a more complete discussion. Chart takes samples at discrete intervals set by the sampling rate. If we look at a sequence of N consecutive samples, where N is an even number (for simplicity), with a sampling interval Δ, we can define a function $h_k \equiv h(t_k)$ where the time when sample k is taken, $t_k \equiv k\Delta$, and k is the series 0, 1, 2, … N–1. It is assumed that the function that describes the sampled points is representative of the entire waveform, that is, that there is some form of periodicity. The FFT transforms these N discrete samples in time, with h voltage (or derived units), to N discrete samples in frequency, with H frequency amplitude. The frequencies can be assigned the discrete values $f_n = n/N\Delta$, where

n is the series $-N/2, \ldots, N/2-1$. The discrete Fourier transform of the N points h_k is defined by:

$$H_n \equiv \sum_{k=0}^{N-1} h_k e^{2\pi i k n / N}$$

This transform maps N complex numbers h_k into N complex numbers H_n (for data measured from physical phenomena, such as Chart deals with, numbers h_k are real with the imaginary part set to zero). H_n are in the frequency domain, since the horizontal axis is measured in units of $1/\Delta$, which represents frequency. Zero frequency corresponds to $n = 0$; positive frequencies correspond to values $1 \le n \le N/2-1$. The function can be seen to be periodic in n with period N, with $H_{-n} = H_{N-n}$ for values of n other than zero. One can let the n in H_n range from 0 to $N-1$ so the correspondence between k in the time domain and n in the frequency domain is more obvious, but we don't for this treatment.

If $\mathrm{Re}(H_n)$ and $\mathrm{Im}(H_n)$ are the real and imaginary parts of the nth frequency component of the FFT, then the power (modulus squared) of the nth frequency component of the spectrum may be expressed as:

$$P(n) = 2\,\frac{Re(H_n)^2 + Im(H_n)^2}{N}$$

The amplitude (modulus) of the nth frequency component of the spectrum is then:

$$A(n) = \sqrt{2P_{(n)}}$$

where the factor 2 converts from RMS value to amplitude.

Note that the accuracy with which FFT can resolve frequencies depends on the sampling rate $1/\Delta$, and the number N of points sampled. If a frequency reading is not an integral multiple of $1/\Delta N$ Hz, then it will be resolved into peaks above and below that value, distorting the result. Keeping N at a large value minimizes these problems.

Windowing Functions

The FFT assumes that samples represent an integral number of cycles of a periodic waveform. The assumption of perfect periodicity can lead to problems. If, say, the first and last values of a waveform seen in the sampling window do not join smoothly together, then a spurious

frequency reading will be detected at the edge of the sampling window by the FFT: this is known as an edge effect. Windowing functions reduce the importance of data at the edges of the window used by the FFT, thus preventing spurious peaks arising from edge effects. If a windowing function is used, the original data are multiplied by the windowing function *w(k)* to weight them:

$$H_n \equiv \frac{1}{w_{av}} \sum_{k=0}^{N-1} w(k) h_k e^{2\pi i k n / N}$$

Four of the more useful windowing functions have been provided in Spectrum, as shown in Figure C–2 (there are many others, as discussed in Reference 1). To compensate for the attenuation due to a windowing function when one is in effect, all power values *P(n)*, calculated as shown earlier, are multiplied by a factor

$$\frac{N}{\sum_k w(k)^2}$$

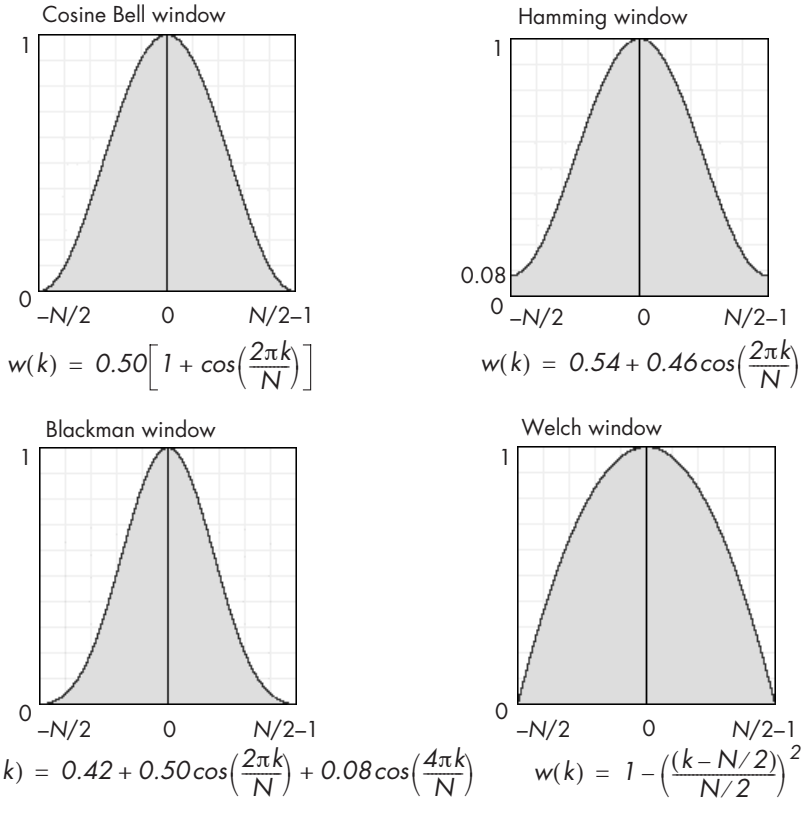


Figure C–2
Windowing functions used by Spectrum and their definitions: *k* is a value between *–N/2* and *N/2–1*, where *N* is the number of sampled points.

Zero-padding

If Spectrum's internal data selection is not a multiple of the chosen FFT size, the data size is extended to the right by padding it with zero values. Windowing functions are applied to the true data, before its length is extended by zero-padding.

Computations with Computed Input Functions and Channel Calculations

There is some overlap in functionality between computed inputs and channel calculations. The cyclic rate and cyclic amplitude computed input functions are duplicated as options in the Cycle Variables channel calculation (except for Counter, which is represented by the Cycle Variables Data Pad functions Event Count and Cycle Count); the Differential computed input function is duplicated as the Differential channel calculation; and the five integral computed input functions have corresponding options in the Integral channel calculation. (Note, however, that the two smoothing computed input functions provide a different computation to the Smoothing channel calculation.)

In addition to differences in the way computed inputs and channel calculations are used (computed inputs are used online while channel calculations are principally used offline, for instance), the results yielded by the two may differ. There are three factors, which may or may not contribute depending on the type of computed input/channel calculation used. Which factor affects which type of computed input/channel calculation is summarized in Table C–1.

1. The sampling rate used for computation may differ. Computed inputs will always have a precision based on a sampling rate of 2000 Hz or higher — the speed at which Chart samples internally for these computations, even if a lower sampling rate is chosen. Since channel calculations operate offline, they are based on the sampling rate set for the channel. If the sampling rate is ≥ 2000 Hz, the precision of results calculated using computed inputs and channel calculations will be the same, but if the sampling rate is < 2000 Hz, then the precision of results computed using channel calculations will be less than those using the

computed inputs. This difference affects all corresponding computed inputs and channel calculations.

2. Computed inputs must use data as they are acquired, whereas channel calculations are able to use data in a 'window' extending either side of any particular data point. This affects cyclic computations, because computed inputs must show results for the *previous* cycle, whereas the Cycle Variables calculation can show values for the *current* cycle. It also affects the Differential computed input function and channel calculation, because neighboring points are used in the numerical calculation of a derivative. This is not a factor for the integral computed functions and the Integral channel calculation, which do not rely on a window of points.

3. Computed inputs and channel calculations differ in their method of cycle detection. The former use a threshold and hysteresis function, while the latter use local maxima or minima. This affects cyclic rate and cyclic amplitude computed input functions and the corresponding Cycle Variables channel calculation options.

Table C–1
Factors contributing to different results from computed inputs and channel calculations, for different types of computation.

	Factors contributing to differences between computed inputs and channel calculations		
Computation type	Sampling rate	Use of 'window' data	Cycle detection method
Rate	x	x	x
Cyclic	x	x	x
Differential	x	x	
Integral	x		

Reference

1. Press, W.H. et al., *Numerical Recipes in C: The Art of Scientific Computing*, second edition (Cambridge University Press, Cambridge, Massachusetts, 1994).

D

APPENDIX D

Experiments Gallery Configuration Files

You can customize the appearance of files that are shown in the Experiments Gallery, by adding text labels, hiding files, choosing a default selected file, and so on. This is done on a folder-by-folder basis by adding a configuration file called 'labels.ini' to the appropriate folder.

The configuration file is a text file containing 'sections', 'key lines' and (optionally) 'comment lines' (see below for an example).

Note: Character case is unimportant for section and key names, but is preserved in key values.

Sections

A section starts with a line containing a section name in square brackets, and is followed by key lines. Most section names consist of filenames (for example, [Electroencephalography] would be the section name for a Chart data file named 'Electroencephalography') and are used to control the appearance of the entry for the file with that name in the Experiments Gallery dialog box. The order of the filename sections in the configuration file is the order the entries are shown in the file list. Files in a folder that do not have sections in the labels.ini file are shown in the file list after the files that do have entries.

The section name [folder] is optional and is followed with a key line whose value is text that will be shown in the information area in the Experiments Gallery dialog box. This text is usually used to give a

general description of a folder. If this section is omitted the info area is not shown.

Key Lines

A key line contains a key name followed by an equals sign and a key value. Spaces around the key value are ignored. The following keys may be used within a filename section:

Text. This key provides the text to be shown as additional description text for the file.

Flags. Various options used to control some of the behavior and appearance of the entry for a file. Available flags are:

- **Bold**. Show the label (filename and descriptive text) in bold face.
- **Default**. Make the file selected in the file list whenever the relevant folder is selected in the Experiments Gallery dialog box.
- **MacOnly**. Only show this entry on a Macintosh system.
- **WinOnly**. Only show this entry on a Windows system. (When creating labels.ini files that will be used on Windows, you need to create them in a text editor that can insert line feed characters.)
- **Hide**. The entry is not shown in the file list.

Comment Lines

A comment line starts with a semicolon (";"). Comment lines may be placed anywhere in the configuration file and are ignored when Chart reads the file. Blank lines are ignored and are useful for visually separating sections.

Example

Below is the text of a typical configuration file. The corresponding appearance of the Experiments Gallery dialog box, when the folder containing that configuration file is selected, is shown in Figure D–1:

[Folder]
text=A basic experiment on the pulsatile flow of blood, the ECG, and peripheral circulation.

[TLM03c ECG Periph Circ.pdf
text=The instructions for setting up and running this experiment.
flags=default, bold

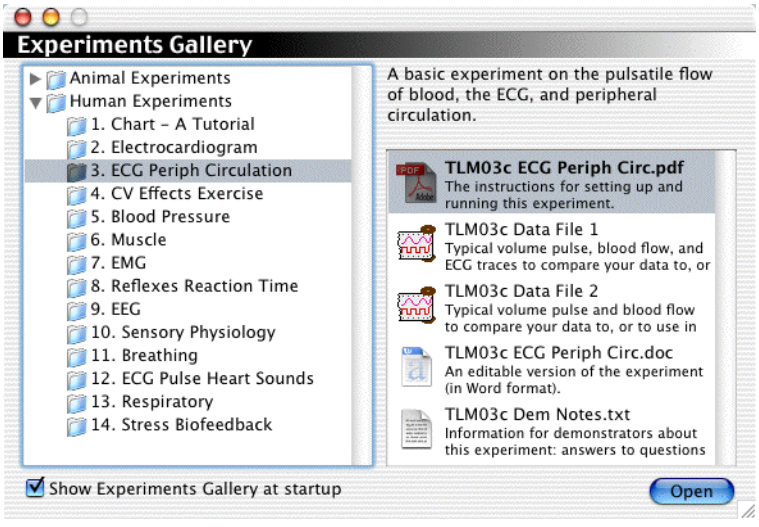
[TLM03c Data File 1]
text=Typical volume pulse, blood flow, and ECG traces to compare your data to, or to use in case of poor results.

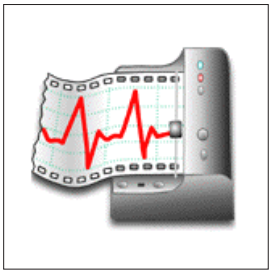
[TLM03c Data File 2]
text=Typical volume pulse and blood flow to compare your data to, or to use in case of poor results.

[TLM03c ECG Periph Circ.doc]
text=An editable version of the experiment (in Word format).

[TLM03c Dem Notes.txt]
text=Information for demonstrators about this experiment: answers to questions and troubleshooting help.

Figure D–1
Appearance of the files in a folder called ECG Periph Circulation, when the labels.ini file above has been added to the folder.





Index

C

D

E

F

G

H

I

K

L

M

N

S

T

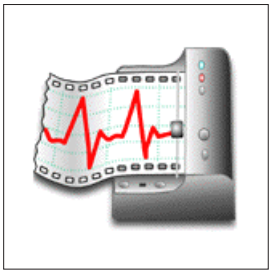
U

V

W

X

Z



Licensing & Warranty

Copyright and Trademarks

e-corder and PowerChrom are registered trademarks, and EChem a trademark of eDAQ Pty Ltd. Chart and Scope are trademarks of ADInstruments Pty Ltd and are used under license. All eDAQ software, hardware, and documentation is protected by copyright. eDAQ retains the exclusive ownership of the trademarks and registered trademarks represented by its company name, logo, and product names.

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 e-corder systems, 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 Scope software. (Your employees or students, for example, are entitled to use it, provided they adhere to this agreement.) Each separate purchase of the Scope software licenses it to be used on two computers at any given time (on one computer for data acquisition with an 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.
- 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 Scope v4.0.1)

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.