Biopac Student Lab *PRO* Manual

Professional Version 3.7.1 for Windows®/PC or Mac® OS X

Reference Manual Version 3.7.2 for

Biopac Student Lab PRO® Software and MP35/30 Hardware

Compatible Operating Systems

Windows® 98 SE /Me/2000/XP

Mac® OS X 10.3-10.4

Visit the BIOPAC web site for more information, including *PRO* Lessons and Application Notes

www.biopac.com

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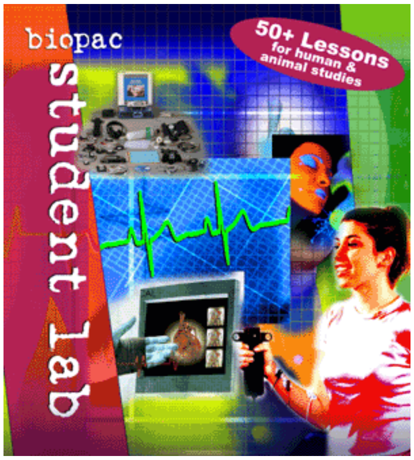
Table of Contents

Biopac Student Lab *PRO*



Welcome!

Welcome to the Biopac Student Lab *PRO*. The Biopac Student Lab *PRO* System includes both hardware and software for the acquisition and analysis of life-science data. You can use the Biopac Student Lab *PRO* for data acquisition, analysis, storage, and reporting and retrieval.

The Biopac Student Lab *PRO* not only makes data collection easier, but also allows you to quickly and easily perform analyses that are impossible on a chart recorder. You can edit data, cut and paste sections of data, perform mathematical and statistical transformations, and copy data to other applications (such as a drawing program or spreadsheet).

The *PRO* software uses the familiar point-and-click interface common to most applications. Complex tasks such as digital filtering or fast Fourier transformations are now as easy as choosing a menu item or clicking your mouse.

This manual covers use of the Biopac Student Lab *PRO* and details a variety of common applications. If the application you desire is not addressed, visit the BIOPAC web site at **http://www.biopac.com/** to download one of over 50 Application Notes, or call to request a hard copy.

Using this Manual

The Biopac Student Lab *PRO* Guide is divided into five parts:

Part A **Introduction**	You should look through the *Introduction* whether you're new to computer-based data acquisition systems or an old hand at physiological monitoring. This section covers the basic features of the BSL *PRO* System.
Part B **Recording Data**	Tells you how to be up and running with the Biopac Student Lab *PRO* in just a few minutes. Use this section to acquaint yourself with how the system works and the most frequently used features.
Part C **Acquisition Functions**	Explains data acquisition features and gives a detailed summary of different acquisition parameters. Provides an in-depth description of the commands used to determine acquisition rate, acquisition duration, and specialized functions such as triggering, averaging, and online calculations.
Part D **Analysis Functions**	Details information on analysis features; covers the range of post-acquisition analysis functions and transformations available with the Biopac Student Lab *PRO* software. Describes how to edit data, take measurements and perform basic file management options (save, print, etc).
Part E **Appendices**	Answers frequently asked questions, offers hints for working with files, includes information on upgrading from previous versions, discusses electrode use and digital filtering.

Additional Guides

In addition to The Biopac Student Lab *PRO* Guide, you should have the following Guides:

Installation Guide	The **Installation Guide** was packaged with your BIOPAC software CD. It contains complete, step-by-step instructions for connecting the MP unit to your computer and details the installation process screen shots.
BSL Hardware Guide	The **BSL Hardware Guide** is part of the Biopac Student Lab documentation – see the User Support folder. It provides instructions for connecting external devices to the MP35/30 acquisition unit (electrodes, transducers, stimulators, and so forth) and also includes practical examples of how the BSL *PRO* is used with different components for common types of data acquisition and sample results and applications for widely used test procedures.

IMPORTANT SAFETY NOTE

BIOPAC Systems, Inc. components are designed for life science education and research applications with humans and animals. BIOPAC Systems, Inc. does not condone the use of its instruments for clinical medical applications. Instruments, components, and accessories provided by BIOPAC Systems, Inc. are not intended for the diagnosis, cure, mitigation, treatment, or prevention of disease.

BIOPAC Systems, Inc. accepts no liability, or consequential liabilities, for the loss, effects of loss, or corruption of data caused when using any BIOPAC instruments.

Where do I find help?

The Introductory sections are intended to provide you with enough information to get up and running with the Biopac Student Lab *PRO*, and familiarize you with some basic functions. There are far more features than described in the first few pages, so here is a guide for how to continue using this manual.

The **Help** menu includes options to launch your web browser and go the BIOPAC site for *PRO* Lessons or launch Adobe Acrobat and open the complete Software or Hardware Guide as a searchable PDF document (see page 242 for details).

Biopac Student Lab PRO software

Information about how to edit, display and transform data can be found in Part D — *Analysis Functions*. It explains how to import and export data, how to save files, and other file management commands. This section also explains how to use all of the post-acquisition features of the BSL *PRO* software.

Connecting input devices

To find out how specific modules connect to the MP35/30 acquisition unit, refer to the *BSL Hardware Guide* that was included with your Biopac Student Laboratory Manual. This section describes how to connect electrodes, transducers and input/output devices to the MP35/30.

Acquiring data

For more specific information on different types of acquisitions, see Part C — *Acquisition Functions*. It covers basic acquisition parameters in detail, and describes some acquisition features (such as peak detection techniques and online calculation channels) not covered in the *Getting Started* section.

Working with large files

Acquisitions with fast sampling rates or long duration can generate large data files (several megabytes) that can be difficult to load, store, and view. The Biopac Student Lab *PRO* can handle such acquisitions — see Appendix B for information on how to optimize setup for these types of acquisitions.

Troubleshooting

Includes a list of the most frequently asked questions regarding the Biopac Student Lab *PRO*. Check this section (in Appendix A) for commonly encountered problems and solutions. For software problems or hardware conflicts, also check the troubleshooting section of the Biopac Installation Guide.

Contact BIOPAC Systems, Inc.

To speak directly with a representative, check the **How to Contact BIOPAC Systems, Inc.** directory of worldwide representatives (included at the back of this manual, in a separate section after the Index). You can visit the BIOPAC web site at **www.biopac.com** for product information and application guidelines, or send an email to **info@biopac.com**.

Biopac Student Lab *PRO* Features

Biopac Student Lab *PRO* 3.7 includes many of the features you have been asking for! Click any of the links below for more detailed information...

New Features in 3.7

- Output Control Panels—Stimulator, Pulses, Digital, Voltage, Analog CH
- Segment Overlap for Append
- More Powerful Markers—Distinguish Appended Segments from Events, Pre-Label markers, etc.
- Rewind—Delete last recorded segment
- Help menu—quick access to PDF support files and the BIOPAC web site
- USB1.0 and USB2.0 Options
- Horizontal Scale: Hold Relative Position
- Horizontal Axis Format
- Standard Curve for Colorimetery
- Manual Documentation Updates
- MP35 Software Adjustments
- *MP35 required* Digital Channels: 8 Input and 8 Output
- *Windows OS Only* Japanese Language Support
- *Windows OS Only* Works on XP Home/Pro/Media Operating Systems

Additional Features in 3.7.1

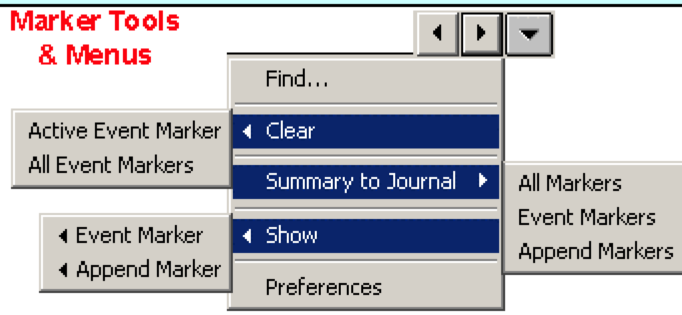
- Security Options utilize “Limited”or “Restricted” user account setup
- Preset Enhancements: Organization tools, new Newtons force, new EEG & Gamma
- Marker Manager allows access to all markers in the record (vs. previous limited view of 127)
- Data Selection Enhancement simplifies switching cursor styles and retaining selection
- Display Enhancements—right-click option to "Paste measurements to Journal” from graph
- Plot options—display a “thicker” line for any channel’s data plot.
- *MP35 only* Triggering via I/O: Synch acquisition to SuperLab interface or Stroboscope—
- *Mac only* Capture to QuickTime and Playback
- *New for Mac* Install both BSL Lessons and BSL *PRO* with a single, simpe installer

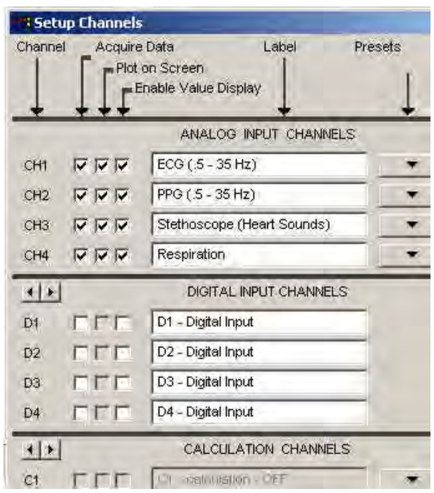
See the Features Overview on page 15 or see the corresponding section of the manual for each item.

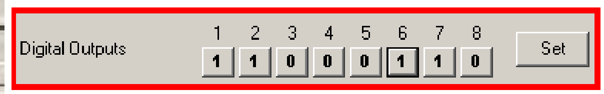
Features Overview

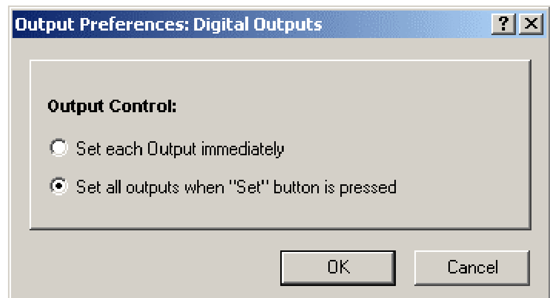
In conjunction with your computer, the Biopac Student Lab *PRO* is a complete system for acquiring almost any form of continuous data, whether digital or analog. The Biopac Student Lab *PRO* can perform a range of recording tasks, from high-speed acquisitions (up to 100,000 samples/sec) to long duration acquisitions. Generally speaking, for physiological applications, the Biopac Student Lab *PRO* is limited only by the speed of your computer and its available memory or disk space. Features of the Biopac Student Lab *PRO* include:

BSL PRO 3.7 Feature	Description
NEW **Output Control Panels**	Different control panels are used for different output devices: 1. CH3 or Selected CH# 2. Digital Outputs (if MP35 is connected) 3. Pulses 4. Voltage 5. Stimulator – BSLSTM 6. Stimulator – SS58L cable from MP35 The new **Output Control** panels attach to the graph window for consistency and their compact design leaves more display space for graphs. Access the Preference dialog for each output by right-clicking on the dialog. Save settings, much like a preset but within the graph or template; access is via a pull-down menu in the control panel.
NEW **Segment Overlap**	A new "Overlapping Segment" toolbar button is available in the Append acquisition mode to overlap appended sections of data in viewed in Scope or Chart mode. It acts like the scope mode applied to horizontal sections of data and can be very handy for data comparisons. Choose the active segment to take measurements and display markers; the active segment will be highlighted in the graph display and you can use a pull-down menu showing segment labels to change it.
NEW **Marker Controls**	The application includes three types of markers instead of just one: 1. **Append Markers** appear as triangles located above the marker label region and will be automatically inserted at the start of each recording segment in the Append acquisition mode. Append markers are blue when active. 2. **Automatic Event Markers** appear as green inverted triangles located below the marker label region (just as in BSL 3.6.7) and use labels that are generated automatically when the assigned function key is pressed. Event markers are yellow when active. ▪ You can pre-establish Automatic Event marker labels as sequential or fixed. 3. **Manual Event Markers** appear as inverted triangles with a line above them and are located below the marker label region (in the same region as the Automatic Event Markers). Event markers are yellow when active. Marker tools have been improved, too. Check out these new Marker features... 1. Marker menu additions 2. Pre-establish Labels 3. Automatic Time Stamp 4. New Journal Summary Preference

<table>
<tr><th>BSL PRO 3.7 Feature</th><th>Description</th></tr>
<tr><td></td><td>


</td></tr>
<tr><td>NEW
Digital Channels
MP35 required</td><td>
Use the new digital channels to work with visual presentation programs like SuperLab and E-Prime.
8 Digital Input Channels — Use the Setup Channels dialog from the MP35 menu to establish up to eight digital input channels (use the arrows to scroll channel # up or down).
8 Digital Output Channels — Use the "I/O Port" on the back of the MP35 to establish up to eight Digital Output channels, and use the Output Control and Preferences to establish parameters.


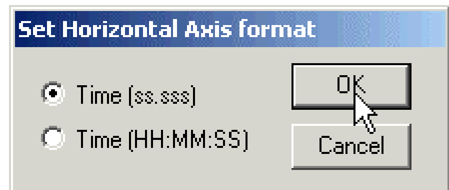
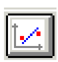
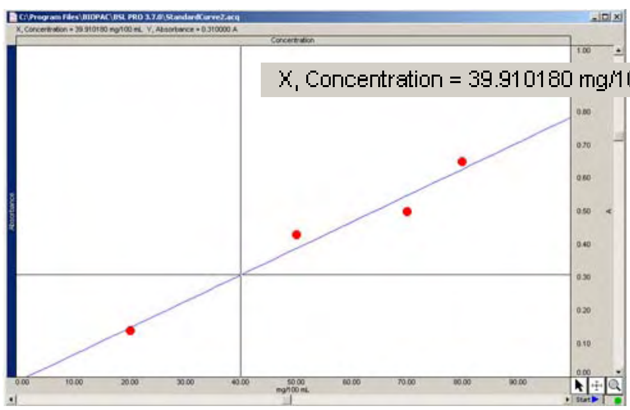




</td></tr>
<tr><td>NEW
Rewind</td><td>
A  “Rewind” toolbar button allows you to erase the last recorded segment of appended data (just like in the BSL Lessons software). When this button is pressed, a warning dialog will appear and if you proceed, the last segment will be deleted along with the Append Marker for that segment.
</td></tr>
<tr><td>NEW
Help menu</td><td>
Now you get our exclusive real-time System Manual, Hardware Guide, Sample Files, etc., with easy-to-use navigational tools. Search the manual (pdf files) while you are running BSL PRO for on-the-spot, targeted help. New Help menu contains the following digital support items:

PRO Lessons from Web... Opens the default browser, goes to our website and shows all available PRO lessons.
Open MP30 Hardware Guide... Looks for the “PDF” file; “MP30 Hardware Guide” located in Application Folder\Documents and if present, opens it in Acrobat Reader.
Open BSL PRO Manual... Looks for the “PDF” file; “BSL PRO Manual” located in Application Folder\Documents and if present, opens it in Acrobat Reader.
About Biopac Student Lab provides version details for Tech Support.

</td></tr>
<tr><td>NEW
LANGUAGES
Windows/PC only</td><td>
BSL PRO menu items and dialogs have been translated into Japanese. Also available in English, French and Spanish, with more translations on the way!
</td></tr>
</table>

BSL PRO 3.7 Feature	**Description**
NEW **USB**	The USB1W connector works with USB1.0 and USB2.0 driver files.
NEW **Horizontal Scale — Hold Relative**	Zoom in on a section of data and have the next acquisition (in any acquisition mode; Save Once, Append etc.) hold the relative position of the horizontal scale. This is extremely convenient for many experiments such as Compound Action Potential when one is performing multiple acquisitions where the signal remains in the same location for each acquisition. This is very convenient when trying to do short duration, high speed acquisitions, where the signal of interest is in the same position when one performs acquisition (like when the stimulator, where you would like to be able to zoom in on the signal of interest and have the relative position (from the start of acquisition) stay the same.
NEW **Horizontal Axis**	This option in the Display menu generates a "Set Horizontal Axis format" dialog with two time format options. 
NEW **Standard Curve**	The BSL *PRO* can be used with common Colorimeters used in most Physiology labs to generate a Standard Curve ("best fit" line) plot of Absorbance vs. Concentration. The Standard Curve can then be used to find the concentrations of unknown solutions.  A new tool bar button is available when the graph is in the X/Y mode that generates a "Plot Standard Curve" dialog. Step through a simple calibration procedure to produce accurate Absorbance vs. Concentration plots for a specific solution type. 
NEW **Documentation**	1. Updated algorithm information and formulas. 2. New BSLSTM and BSLSTMA Specifications in the Hardware Guide. 3. New USB Troubleshooting Guide. 4. New information about A/D resolution. 5. Updated GSR information in the Hardware Guide. 6. Updated descriptions for Cut, Copy and Paste. 7. Description of advanced analysis using the ECG arrhythmia data (from PhysioNet).
NEW **MP35 Adjustments**	The BSL *PRO* will detect whether an MP30 or MP35 is connected. If an MP35 is detected, the application will automatically make the following changes to optimize performance 1. The Setup Channels dialog will include a region for "DIGITAL INPUT CHANNELS". 2. The High Speed mode will be eliminated. Communications at sample rates above 2,000 s/s will be the same as at 2K and below. 3. The "Setup Triggering" dialog will have an additional item in the "Source" menu called "External" allowing it to work with the "External trigger" BNC on the back of

BSL PRO 3.7 Feature	Description
	the MP35. 4. The system will be optimized for MP35 performance (i.e., USB communication, "Gain" and "Input Ranges" settings may be changed).
NEW **Security**	In BSL 3.7.1, the system (or network) administrator can set user accounts to "Limited" (Windows XP) or "Restricted" (Windows 2000) access to achieve a good level of security when running under the Windows 2000 or XP Operating Systems. A Limited or Restricted user account can handle individuals or groups of students and allows the option of password protection (recommended). • See the "**Biopac Student Lab User Account & File Location Guide**" provided on the installation CD for more information.
NEW **Preset Enhancements**	• The Preset pull-down listing is now organized into two groups, Human and Animal, with a separator (horizontal line) between them. This applies to both the Analog Input Channels and the Calculation Channels presets list. • Preset separators (horizontal lines) can be added by the user when customizing the preset listing. The separator could be manually placed in the: MP35 > Organize Channel Presets dialog. • There is a new Analog Channel Preset available for the SS25LA Hand Dynamometer that is scaled to units of Newtons: "Clench Force (N)." This is a proper unit of force which is "more scientific" than the units of Mass (Kilogram and Pounds) that are commonly used. • There is a new, higher bandwidth, EEG Analog Channel Preset available: "Electroencephalogram (EEG), .5 - 100 Hz w/notch". When used in conjunction with the new "EEG gamma (30 - 90 Hz)" Calculation Channel Preset, it allows for the gamma frequency band to be recorded. The gamma frequency band seems to be correlated to information processing and cognitive functions of the brain.
NEW **I/O Triggering**	*MP35 only* The user may now specify triggering (start the acquisition) when a change of logic level occurs on any of the 8 digital Input lines ("I/O Port", DB25 on rear of unit). This can be useful for synchronizing the start of acquisition to un-isolated external devices, such as SuperLab interface, or a Stroboscope.
NEW **Marker Manager**	BSL 3.7.1 adds a "Marker Manager" option that allows access to all markers in the file. Previous versions limited the number of markers (to 127) that could be accessed in the Marker menu > Show Event Marker or Append Marker listings.
NEW **Data Selection Enhancement**	Following a single data point selection using the Arrow cursor, if the "I-Beam" cursor is selected, manually or using the "Ctrl + I" buttons; the cursor will be placed at the last data point selected. It is useful for users who have found data using the arrow cursor to preserve this position when they switch to the other cursor style.
NEW **Display Enhancements**	When in the Chart or Scope display modes, there is a new option in the right mouse pull-down menu (when cursor is in the wave plotting region) to "Paste measurements to Journal ". This is a common option for some users and accessing it from the right click menu is much faster then accessing it through the Edit menu.
NEW **Plot Option**	The user now has the option to display a "thicker" line for any channel's data plot. The Display > Show > Dot Size is available when the mode is "Line Plot". A thicker line can work better for display on projectors or when printing data. The line thickness for each channel will saved with the data file.
NEW *Mac only* **Playback mode**	Open saved files and replay as if acquiring data.
NEW *Mac only* **Capture to QuickTim**	Create a QuickTime movie for demonstrations, training, or presentations.
NEW *Mac only* **Expressions**	New Expression Functions for enhanced analysis options.

Biopac Student Lab *PRO* Benefits

Easy to use

The Biopac Student Lab *PRO* offers the same convenient and easy-to-use features that Windows® users are accustomed to. Since the Biopac Student Lab *PRO* software runs under these environments, you can run other applications while you are collecting data. In terms of hardware setup the Biopac Student Lab *PRO* uses simple plug-in connectors and standard interface cables. You don't need a degree in electronics to set up your system.

Flexible setup

The Biopac Student Lab *PRO* can be configured for a wide variety of applications, from single channel applications to multiple-device (up to 4 analog) measurements. You control the length of acquisition, the rate at which data is collected, how data is stored, and more...all with a few clicks of the mouse button. Whether you're measuring alpha waves or collecting zoological data, the Biopac Student Lab *PRO* can meet your needs.

Flexible acquisition rates

The BSL *PRO* can acquire data from 1 to 100,000 samples/sec. This allows recording of almost all physiological parameters from slow moving temperature data to fast response action potential data. This means you can use the BSL *PRO* System to replace both your chart recorder and oscilloscope.

Flexible menu display

You can easily customize menu displays to show only the functions you are using, thereby reducing the risk of error or confusion in the lab. This is particularly powerful for laboratories working to GLP guidelines and is also useful for teaching applications.

Online calculations

Although the Biopac Student Lab *PRO* software provides an extensive array of measurements and transformations you can apply to collected data, sometimes you need to perform computations *while* data is being collected. The Online Calculation functions allow you to calculate new channels based on incoming signals. This feature allows you to compute BPM, for instance, based on raw ECG data.

Online filtering

Many times, it is preferable to filter data as it is being collected, rather than having to wait until after the fact, so now you can apply filters to incoming data and view the results in real time. That means online monitoring of data filtered to suit your needs.

Online measurements

The Biopac Student Lab *PRO* software can instantly compute over a twenty measurements and computations for any given data point(s). These options are available from pull-down menus and include: mean; peak-to-peak value; standard deviation; frequency; and BPM.

Grid options

You can apply several different grid styles to your data to help with analysis. UNLOCKED grids help you view the data display on the monitor whereas LOCKED grids help more with printing. You can set the Grid Options to create printouts that look similar to chart recorder output.

Presets

There are over 50 factory-established "Presets" that allow you to easily configure hardware parameters. These presets can be modified, and/or new presets can be created and saved for later use.

Graph templates

This powerful feature allows instructors to predefine experiments. Students simply open the template file and click "Start" to run the experiment. A sample graph template file (HeartTemplate.gtl) is included with the *PRO* installation.

Replace (or augment) a chart recorder

Whether you want to replace a chart recorder or simply supplement an existing setup, the BSL *PRO* is fully compatible with most major recording devices. What's more, the BSL *PRO* is compatible with most popular input devices, so you can continue using the same transducers, electrodes and sensors.

Biopac Student Lab *PRO* Benefits

Preview your data Similar to chart recorders, the Biopac Student Lab *PRO* allows you to change both the vertical scale and the horizontal scale. You can change the amplitude scale or the time scale to any value you wish, or you can have the Biopac Student Lab *PRO* software automatically scale them for you.

Simplified editing It used to be that once your data was collected, the only way to edit it was with scissors and adhesive tape. Now you can delete unimportant sections of your data with a keystroke. You can "paste" together sections from different waves, or edit out noise spikes from individual waves.

Append mode For some applications, data only needs to be recorded during some portions of a long experiment. The Biopac Student Lab *PRO* software has added an Append mode that lets you pause the acquisition for as long as you wish, and resume the acquisition as many times as needed. When data are acquired in this mode, you can start and stop a recording as you would with a chart recorder. This saves on storage space and processing time for transformations.

Digital filtering All data contains measurement error and noise. Now you can reduce or eliminate that error by using the digital filters and smoothing transformations included in the Biopac Student Lab *PRO* software. You can smooth data or filter out noise from any frequency or bandwidth you wish.

X/Y plotting You can view and acquire data in the form of an X/Y plot, with one channel on the horizontal axis and another on the vertical axis. This allows you to explore relationships between different channels and opens up a whole range of applications, from chaos plots to respiration analysis to vectorcardiograms.

Histogram function You can easily examine the variability and the measures of central tendency of any waveform data with the histogram function. Set the plotting options to suit or let the software determine the "best fit" for graphing data.

Math functions In many cases, simply collecting raw data is not enough. The BSL *PRO* software has an array of built-in mathematical functions ranging from simple absolute value functions to computation of integrals, derivatives, and operations involving multiple waveforms (such as subtracting one wave from another). You can even chain multiple functions together to form complex equations.

Annotation The Biopac Student Lab *PRO* software has a journal you can use to append comments concerning the input data, either online or after the fact. This is especially useful for noting the characteristics of an acquisition (what was involved, what manipulations took place, and the like) for future reference.

Triggering If you need to measure response times or start data collection only after some event has occurred, the Biopac Student Lab *PRO* software allows you to trigger an acquisition in a number of different ways. You can trigger on the level of a signal, or with an external synchronizing trigger.

Event markers Many times, especially during a long acquisition or in a laboratory setting, it is useful to make a note of when specific events (such as manipulation) occur, so that any changes in the data can be noted. The marker function allows you to insert symbols in the record and add up to 80 characters of text for each marker. Markers can be added either while data is being collected or after the fact.

File compatibility With the Biopac Student Lab *PRO* software, you can save data in a number of different formats. You can output data in either text or graphical form, and export or use the clipboard to place data in other programs. Use BSL *PRO* data in word processing programs like Microsoft Word®, spreadsheet programs like Microsoft Excel®, drawing programs like Aldus IntelliDraw®, or desktop

Biopac Student Lab *PRO* Benefits

publishing programs like Aldus PageMaker®. Biopac Student Lab *PRO* software will even read-in raw data from a text file.

Pattern recognition Using an advanced pattern search/recognition algorithm, the Biopac Student Lab *PRO* software can automatically find a specific pattern within waveforms. This is useful for finding abnormal waveforms (such as irregular ECG waves) within a data file.

Peak detection The Biopac Student Lab *PRO* software has a built in algorithm to find either positive or negative peaks from any size data file. You can even search for all the peaks with one command and automatically log statistics like peak time and area to the journal.

Printing options The Biopac Student Lab *PRO* software provides a range of printing options, and allows you to fit data on one page or many. You can also print several graphs per page, even if you only have one-channel recordings. No special printer drivers are required.

Sample data files The Biopac Student Lab *PRO* installation disk includes sample data files from: a 4-channel recording, Blood Pressure, EEG, EMG with Force, Finger Twitch.

User support Whether you have a question about compatibility with existing equipment or need to develop a specialized measurement device, BIOPAC's Applications Department can address the problem. Plus, you can visit the BIOPAC website at **www.biopac.com** for answers to frequently asked questions, product information, and a wide array of Application Notes.

Application Notes

If you need information about an application not covered in this manual, visit the Support section of the BIOPAC web site at **http://www.biopac.com** to review more than 50 available Application Notes. The notes are static pages that provide detailed technical information about either a product or application. View or print the Application Note you need, or call to request a hard copy. The following table provides a partial list of application notes.

APP NOTE	Application www.biopac.com > Support
Sofware	
PS115	Hemodynamic Measurements
PS116	Additional Hemodynamic Measurements
PS117	Pulse Transit Time and Velocity Calculation
PS118	EMG Signal Analysis
PS119	EMG Power Spectrum Analysis
PS148	Automated ECG Analysis
AS156	ACQ File Format and API (includes *.acq files from BSL & BSL *PRO*)
PS158	Analysis of Inspired and Expired Lung Volume
PS161	Automated Tissue Bath Analysis
PS163	Biopac Student Lab v3.0 Upgrade
PS165	Integrated EMG
PS166	Upgrading from BSL *PRO* 2.xx to BSL *PRO* 3.0
PS167	Upgrading from Biopac Student Lab 2.XX to 3.0
PS168	Analysis of Intraventricular Pressure Wave Data (LVP Analysis)
PS180	BSL *PRO* v3.6 Software Changes
PS181	Producing an Integrated Airflow Signal
PS216	Scoring Methods for Electrodermal Activity (GSR) Changes
PS217	Importing BSL *PRO* Data Into Excel (or other spreadsheet programs)
Hardware	
PH130	Blood Pressure Measurement for the *BSL PRO*
PH132	SS12LA Variable Force Transducer
PH135	SS11LA Airflow Transducer Calibration
PH140	Angular Measurements with Goniometers
PH141	Tri-Axial Accelerometer Calibration
PH144	Hand Dynamometer Calibration
PH153	Physiological Sounds Microphone
PH172	The SS29L Multilead ECG Cable
PH173	The SS30L Electronic Stethoscope Transducer
PH179	Interfacing Narco Myographs to Biopac Student Lab
Updates	
PF182	Driver for USB1W with USB 2.0

PRO **Lessons**

Photo credit: Audris Zidermanis

PRO Lessons illustrate the scope of the Biopac Student Lab System. Each lesson describes the required hardware and software setup (channel setup, acquisition setup, gain, scaling, etc.) and outlines the basic procedure necessary to record and analyze a variety of applications on human and animal subjects.

When applicable, a downloadable template file (***.gtl**) is included with the lesson to further simplify setup. The template file includes all the appropriate settings for the lesson — just open the file, connect the hardware and begin recording!

- If you have developed lessons for your course, we invite you to make your lessons available to other users. *You will receive full credit for the lesson*. Just provide us with a copy of your lesson plan and a sample data file. We will add your lessons to the list and other users can benefit from your efforts. Please don't worry about formatting issues — the important part is the lesson plan and instructions. We'll take care of the formatting for you.A partial list of available lessons follows.

Visit our website or quick-click to the Lessons menu using “Help menu>*PRO* Lessons from web” for the most up-to-date listing and downloadable files. An overview of available BSL *PRO* Lessons follows.

CARDIOVASCULAR

BSL LESSON 5: ECG I

Record Lead II ECG and examine components of the ECG complex as an introduction to the electrocardiograph and the recording of the heart's electrical signal.

BSL LESSON 6: ECG II

Record ECG using bipolar Leads I and III; the software calculates Lead II to demonstrate Einthoven's law.

BSL LESSON 7: ECG & PULSE

Use a pulse plethysmogram transducer and Lead II ECG to examine the mechanical action of the heart and peripheral pulse pressure to learn how the heart pumps blood throughout the body.

BSL LESSON 16: SYSTEMIC BLOOD PRESSURE

Record arterial blood pressure using the auscultatory (cuff) technique, Korotkoff sounds using an amplified stethoscope, and ECG using Lead II.

BSL LESSON 17: HEART SOUNDS

Record ECG Lead II and place an amplified stethoscope at four different locations to listen to the sounds of the heart's valves and correlate the sounds with the cardiac cycle.

H01 12-LEAD ECG

Record a 12-lead ECG and observe changes in the frontal plane vectors throughout a cardiac cycle.

H08 ECG DIVE REFLEX—ACTIVE LEARNING

Subjects immerse their face in cold water and record the change in heart rate that occurs to investigate the physiological reason for the observed response.

H21 IMPEDANCE CARDIOGRAPHY

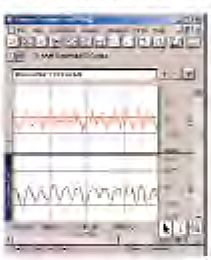
Noninvasively record and measure stroke volume and heart rate data and correlate with cardiac output.

H23 SIGNAL AVERAGED ECG

Record ECG data under different experimental conditions and perform a Signal Averaged ECG recording for each segment of data.

MUSCULAR

BSL LESSON 1: EMG I



Record maximum grip clench for the dominant and non-dominant hand to investigate the properties of skeletal muscle.

BSL LESSON 2: EMG II

Use a hand dynamometer to record maximum grip strength for both hands and explore the role of skeletal muscle in performing mechanical tasks.

H06 FINGER TWITCH—HUMAN

Record the force generated from a finger twitch and measure the stimulus frequency required to induce fatigue. (Alternative to Frog Gastroc.)

H07 EMG—ACTIVE LEARNING

Investigate the electrical activity of different muscles as they contract with varying degrees of force and design experiments by selecting muscles to record from and creating activities those muscles will perform.

H27 FACIAL EMG

Record EMG response on the corrugator supercilii & zygomaticus major muscles.

H34 ELECTROGASTROGRAM

Record electrical activity from stomach muscles (EGG) and note the power and frequency of contractions at rest and after eating.

RESPIRATORY & PULMONARY FUNCTION

BSL LESSON 8: RESPIRATORY CYCLE I

Record chest contraction & expansion and ventilation, then correlate respiration changes with ventilation to examine the effects of cerebral influence and chemoreceptor influence on the medullary control centers.

BSL LESSON 12: PULMONARY FUNCTION I

Perform a variety of pulmonary measurements: Tidal volume, Inspiratory capacity, Expiratory capacity, Functional residual capacity, Vital capacity and Total lung capacity.

BSL LESSON 13: PULMONARY FUNCTION II

Record and analyze Forced Vital Capacity, Forced Expiratory Volume ($FEV_{1,2,3}$) and Maximal Voluntary Ventilation (MVV) to build on the principles established in Lesson 12.

H19 VO_2 & RER

Record and measure oxygen consumption (absolute VO_2) and respiratory exchange ratio (RER) under a variety of conditions and observe the relationship between VO_2 and RER.

H29 BASAL METABOLIC RATE (Indirect Calorimetery)

Record indirect basal metabolic rate (BMR) and post-exercise metabolic rate.

NEUROPHYSIOLOGY

BSL LESSON 3: EEG I

Record EEG from the occipital lobe while performing a variety of tasks to demonstrate how the brain's electrical activity varies dependent upon the task being performed.

BSL LESSON 4: EEG II

Discover how the brain constantly receives sensory input and integrates the information before processing it. The system records and displays raw EEG, alpha wave and alpha-RMS activity.

Lesson Update

See www.biopac.com for lesson additions and product updates.

BSL LESSON 9: GSR & POLYGRAPH (EDA)

Record changes in respiratory rate, heart rate and electrodermal activity (skin conductance) to become familiar with the standard physiological measures recorded by a polygraph and study the effects of cognitive behavior and emotion.

BSL LESSON 10: ELECTROOCULOGRAM (EOG) I

Record horizontal and vertical eye movement to demonstrate eye fixation and tracking. Students perform a number of tasks that allow them to record the duration of saccades and fixation.

BSL LESSON 11: REACTION TIME I

Subject hears two schedules of clicks through headphones and reacts by pressing a pushbutton hand switch as quickly as possible to demonstrate the effect of learning and physiological processes on reaction times.

BSL LESSON 14: BIOFEEDBACK

Record ECG, heart rate and electrodermal activity, and try to influence heart rate and EDA (GSR) to control the position of a bar graph to demonstrate the principles of biofeedback training for relaxation purposes.

H03 NERVE CONDUCTION VELOCITY

Record responses along the ulnar nerve of a human subject to observe the Threshold, Maximal and Supra-Maximal response levels and determine nerve conduction velocity along the ulnar nerve.

H09 AUDITORY EVOKED POTENTIAL (AEP)

Present an auditory stimulus to a human subject and record Auditory Evoked Potential.

H10 HEMISPHERIC EEG

Record EEG and study effects of sensory stimulation or change in attitude/attention on alpha rhythm, beta rhythm, and hemispheric asymmetry.

H11 MIRROR TEST: SENSORY MOTOR LEARNING & EDA

Correlate efficiency in a task requiring movement and attention focus with reticular tone (which indirectly indicates emotional fluctuations) and analyze performance over repeated trials.

H12 SACCADES: EOG

Explore applications of electrooculography and observe the constant saccade durations for a variety of given angular displacements.

H13 TRACKING: EOG

Observe tracking movements used while watching a moving object and demonstrate the difference between eye movement based on actual visual stimulation and imagined recreations.

H14 FIXATION I: EOG

Record horizontal EOG and observe Ocular Fixation while reading.

H15 FIXATION II: EOG

Record a horizontal and vertical EOG and observe spontaneous gaze changes produced when viewing an image, and then correlate results from the plot with the subject's attitude or level of interest.

H16 REFLEXES & REACTION TIME

Measure basic reflex and reaction time (visual stimulus) exercises and record reaction time to auditory stimulus. Compare reaction times from fixed interval and pseudorandom presentation to study the effects of learning and physiological processes on reaction times.

H22 VISUAL EVOKED RESPONSE

Present a visual stimulus to a human subject and record Visual Evoked Potentials (P100 test).

H24 HABITUATION

Record EDA (GSR) and Heart Rate response to repeated stimulus to demonstrate habituation and its probabilistic trend toward decreased response.

H28 REFLEX RESPONSE

Record knee and ankle reflex response with the SS36L Reflex Hammer transducer. Option: Use the SS20L Goniometer to measure angular movement in response to varying strike force.

H30 STROOP EFFECT

Record strength of interference between two associative tasks: naming and reading.

H31 PREPULSE INHIBITION

Record the startle response with and without a prepulse inhibition stimulus.

H32 HEART RATE VARIABILITY

Explore statistical measures, geometric measures, and spectral analysis in heart rate variability.

EXERCISE PHYSIOLOGY

BSL LESSON 15: AEROBIC EXERCISE PHYSIOLOGY

Record ECG, heart rate, airflow and skin temperature under a variety of conditions to see how the body responds to changing metabolic demands.

H04 BLOOD PRESSURE

Record (noninvasive) blood pressure response to isometric or straining exercise.

H05 WINGATE TEST

Record the Wingate Anaerobic Test (on a modified, plate loaded, Monark 818E work ergometer) and complete WAnT calculations.

H17 BIOMECHANICS (GONIOMETRY & EMG)

Record muscle activity from the triceps and biceps while recording angle of limb movements.

H18 EXERCISE PHYSIOLOGY (BP)

Record Automatic Noninvasive Blood Pressure in pre- and post-exercise conditions and observe the change between the conditions.

H35 RANGE OF MOTION: SIT & REACH

Students use a goniometer to record angle of joint movement (i.e., hip, ankle etc.) during a Sit & Reach test.

H36 MUSCULAR BIOFEEDBACK

Students record EMG and use auditory and visual (bar graph) biofeedback and touch to increase muscle performance.

BME - BIOMEDICAL ENGINEERING

H02 COMPARTMENTAL MODELING

Explore Westheimer's saccadic eye movement model, which represents the eye as a 2nd order system. Record eye motion via EOG setup and compare to modeled results.

H20 FILTERING

Design and develop software-based digital filters to perform a variety of physiological signal filtering tasks. Cascade 2nd order biquads to create high order filters.

H25 SIGNAL PROCESSING BREADBOARD I (8 circuits)

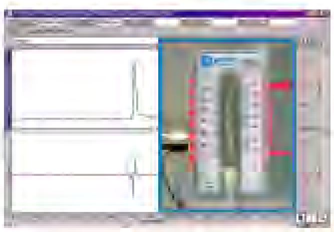
Schematics and design notes to build Instrumentation Amplifier, Active Filters, Sine Wave Generator, Logarithmic Amplifier, and Absolute Value Converter with SS39L.

H26 SIGNAL PROCESSING BREADBOARD II (System)

Block diagram to build ECG Amplifier and QRS Detector (ECG R-wave Detector) with SS39L.

H33 FFT FAST FOURIER TRANSFORM

Build up a square wave from cosine components and use the FFT function to analyze the composite response.



ANIMAL

A01 FROG PREPARATION

Explanation of how to pith and prepare a frog for experiments A02, A03 and A04.

A02 FROG GASTROCNEMIUS

Directly stimulate the frog gastrocnemius muscle (or stimulate the muscle via the sciatic nerve) and record threshold voltage and contractile responses.

A03 FROG SCIATIC NERVE

Record compound action potentials of the dissected sciatic (somatic motor and sensory) nerve.

A04 FROG HEART

Record cardiac rate and contractile responses of the surgically exposed frog heart. Option: Study the effects of chrono- tropic/inotropic agents on the heart.

A05 VISCERAL SMOOTH MUSCLE

Study the effects of media ionic composition, temperature, and various pharmacological agents on the contraction of the visceral smooth muscle of the rabbit ileum.

A06 COCKROACH VENTRAL NERVE

Record nerve activity from the ventral nerve cord while stimulating the cerci with puffs of air.

A07 Q_{10} PRINCIPLE (Dissolved O_2—Goldfish)

Demonstrate the Q_{10} principle by measuring the metabolic rate of goldfish at two temperatures: 22° C (acclimation temperature) and 32° C (acute exposure temperature).

A08 ACTION POTENTIALS IN EARTHWORM

Use extracellular recording techniques to stimulate and record action potentials from an earthworm's nerve cord. Measure conduction velocity and refractory period, and plot a strength versus duration curve.

A09 PROPERTIES OF CARDIAC MUSCLE IN THE TURTLE HEART

Measure the duration of systole and diastole and observe the effects of diastolic loading. Monitor the effect of vagal stimulation, temperature changes and spontaneous rhythmicity of the heart.

A10 REGULATION OF CIRCULATION & RESPIRATION

Record aortic and femoral blood pressure, ECG and cardiac output from an anesthetized pig (or dog) to study homeostasis via cardiovascular physiology and short term regulation of blood pressure.

A11 RESTING POTENTIAL (CRAYFISH MUSCLE)

Follow BSL setup and use "Lab 4: Crayfish Muscle Resting Potential" from the Crawdad CD-ROM Lab Manual for Neurophysiology (ISBN 0-87893-947-4) to record and alter resting potential by changing external ion concentration.

A12 MEMBRANE POTENTIAL (MUSCLE)

Use a glass microelectrode to record the membrane potential from the frog sartorius muscle. Record the potential change when the electrode penetrates a muscle cell.

A13 ACTIVE TRANSPORT

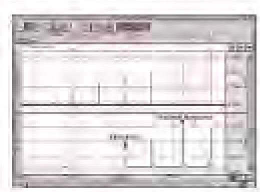
Use skin from a frog in an Ussing chamber to record active transport. Measure the skin potential and use Ohm's law to calculate the NaCl transport across the skin.

A14 CENTRAL PATTERN GENERATORS

Perform extracellular recording on tobacco hornworm pupae to study central pattern generators (CPGs) and neural mechanisms.

A15 EARTHWORM SMOOTH MUSCLE

Setup earthworm gut with a force transducer and tissue bath to measure contractions and the effect of drugs.



Human Anatomy & Physiology Society Position Statement on Animal Use

Adopted July 28, 1995

It is the position of the Human Anatomy and Physiology Society that dissection and the manipulation of animal tissues and organs are essential elements in scientific investigation and introduce students to the excitement and challenge of their future careers.

The Human Anatomy and Physiology Society (HAPS) is a national organization of science educators dedicated to the task of providing instruction of the highest quality in human anatomy and physiology. A fundamental tenet of science is the ordered process of inquiry requiring careful and thoughtful observation by the investigator. As subdivisions of biology, both anatomy and physiology share a long history of careful and detailed examination, exploration and critical inquiry into the structure and function of the animal body. Consistent with the origins and nature of scientific inquiry, HAPS endorses the use of animals as essential to the laboratory experiences in both human anatomy and human physiology.

Historically, the principal tool of investigation in anatomy has been dissection. A properly directed dissection experience goes beyond naming structures and leads the student to conclusions and insights about the nature and relatedness of living organisms that are not otherwise possible. To succeed in their future careers, students must become thoroughly familiar with anatomical structures, their design features and their relationships to one another. Dissection is based on observational and kinesthetic learning that instills a recognition and appreciation for the three-dimensional structure of the animal body, the interconnections between organs and organ systems, and the uniqueness of biological material. While anatomical models, interactive computer programs, and multimedia materials may enhance the dissection experience, they should not be considered as equivalent alternatives or substitutes for whole animal dissection.

HAPS supports the use of biological specimens for anatomical study provided their use is in strict compliance with federal legislation and the guidelines of the National Institutes of Health and the United States Department of Agriculture and that such use fulfills clearly defined educational objectives.

Physiology experiments involving live animals provide an excellent opportunity to learn the basic elements specific to scientific investigation and experimentation. It is here that students pose questions, propose hypotheses, develop technical skills, collect data, and analyze results. It is here that they learn to remain focused on the details of procedure and technique that may influence the outcome of the experiment and the responses of the animal. When faced with unexpected and even erroneous results, students develop and improve their critical thinking and problem solving skills.

Computer simulations and video programs are useful tools that help students acquire a basic understanding of physiologic principles. However, due to the inherent variability and unpredictable nature of biological responses, such programs fail to fully depict the uniqueness of living organisms and should not be viewed as equivalent alternatives or substitutes for live animal experiments. HAPS supports the use of biological specimens in physiology experiments provided their use is in strict compliance with federal legislation and the guidelines of the National Institutes of Health and the United States Department of Agriculture and that such use fulfills clearly defined educational objectives.

Science educators have in common a respect and reverence for the natural world and therefore have a responsibility to share this with their students. They must communicate the importance of a serious approach to the study of anatomy and physiology. HAPS contends that science educators should retain responsibility for making decisions regarding the educational uses of animals. Furthermore, it opposes any legislation that would erode the educator's role in decision making or restrict dissection and animal experimentation in biology.

Part A — Introduction

Part A - *Introduction* covers the basics of data acquisition and analysis with the BSL *PRO* System. All of the material in this section is covered in more detail in subsequent sections (see *Using this Manual* on page 12 for a guide to sections).

Chapter 1 Overview of the BSL *PRO* System

The Biopac Student Lab *PRO* System performs two basic functions: acquisition and analysis. The acquisition settings determine the basic nature of the data to be collected, such as the amount of time data will be collected for and at what rate data will be collected. All of the acquisition parameters can be found under the **MP35/30** menu. The other menu commands pertain to analysis functions such as viewing, editing, and transforming data.

The BSL *PRO* System is a computer-based data acquisition system that performs many of the same functions as a chart recorder or other data viewing device, but is superior to such devices in that it transcends the physical limits commonly encountered (such as paper width or speed). Data collection generally involves taking incoming analog signals and sending them to the computer, where they are

(a) displayed on the screen, and
(b) stored in the computer's memory (or on the hard disk).

These signals can then be stored for future examination, much as a word processor stores a document or a statistics program saves a data file. Graphical and numerical representations of the data can also be produced for use with other programs.

The Biopac Student Lab *PRO* consists of several major components, including hardware and software. The BSL *PRO* software allows you to edit data and control the way it appears on screen, and performs four general functions:

1. Controls the data acquisition process
2. Performs real-time calculations (such as digital filtering and rate detection)
3. Performs post-acquisition transformations (such as FFT's and math functions)
4. Handles file management commands (saving, printing, etc.)

The heart of the BSL System is the MP35/30 data acquisition unit. This unit takes incoming signals and converts them into digital signals that can be processed with your computer. The MP35/30 connects to your computer via the USB adapter (USB1W).

Launching the Biopac Student Lab *PRO* software

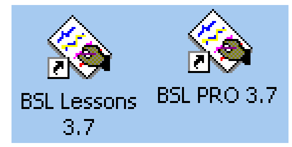
The first step is to launch the software.

Double-click the application icon 

on the desktop (Windows) or the Applications (Mac) folder.

Windows® OS users can also choose **Start menu** > Programs and then select:

Launch errors



BSL *PRO* and Biopac Student Lab (lessons) are both installed using default installation.

You cannot run more than one copy of BSL *PRO* at a time and you cannot run BSL *PRO* if BSL Lessons are running. Each application must be run individually—it is not possible to run BSL *PRO* and BSL Lessons at the same time. An error prompt will be generated to describe any application launch conflict:

> Another copy of BSL is still running. You must quit BSL before you can use BSL *PRO*.

or

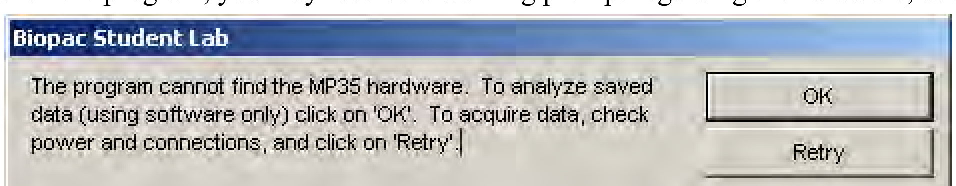
> Another copy of BSL *PRO* is still running. You must quit BSL *PRO* before you can use BSL.

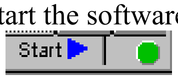
Quit the running application to enable launching the other. To quit an application, make it the active window and use **File** > **Quit** to exit the program.

TIP You can activate some BSL *PRO* analysis options within the BSL Lessons “Review Saved Data” mode to increase analysis functionality. To activate the BSL *PRO* analysis options, see “Menu Customization Options” in the BSL Orientation Guide.

Hardware prompts

After you launch the program, you may receive a warning prompt regarding the hardware, as shown here:



To use the Biopac Student Lab *PRO* software without the MP35/30 hardware, click “**OK**.” When you’re ready to acquire data at any subsequent time, connect and/or switch on the MP35/30 hardware and then restart the software. If the MP35/30 is properly connected, you will not get a warning and the light next to the 

button in the display window will change from grayed-out to green.

If the MP35/30 unit is connected and you receive the Hardware warning when you launch the software, there are two possibilities:

a) You have not properly connected everything and/or you have not powered up the MP35/30.

b) You may have a device or software (init) conflict, which may prevent you from using the BSL *PRO* software. If you have any problems communicating with your computer, there is probably a setting in your computer conflicting with the setting used by the BIOPAC program. See your System Administrator and then, if necessary, contact BIOPAC for Technical Support.

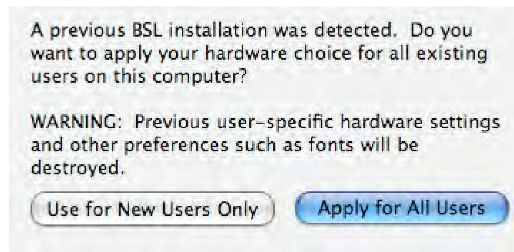
Windows USB Driver installation applies to the specific USB port the MP3X is connected to during installation.

Win XP+MP35 If the signed MP35 driver is installed to one particular USB port and the MP35 unit is later plugged into a different USB port on the same computer, the following prompts will occur automatically in rapid succession. It is not necessary to install the driver separately to each port.

Win 2000+MP3X If you switch the MP3X to another USB port, you must repeat driver installation for that port. BIOPAC recommends that you install drivers to all potential USB ports at the same time (repeat the procedure for each port).

Mac OS X 10.3 – 10.4 User Account Settings

Under Mac OS X, different user accounts can have different choices of MP hardware. If the installer detects a previous Mac 3.7.1 installation, the following prompt will be generated:

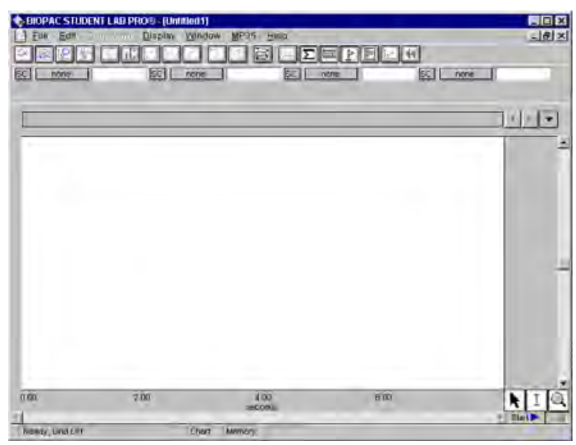


 "Use for New Users Only" will apply the MP hardware choice and line frequency setting to new user accounts added to the operating system; existing preferences will be unaffected.

"Apply for All Users"" will apply the MP hardware choice and line frequency setting to all existing user accounts and new user accounts added to the operating system

Graph Window and Start

After personalizing your copy — and assuming you have already connected the MP35/30 to your computer — you will see the following:



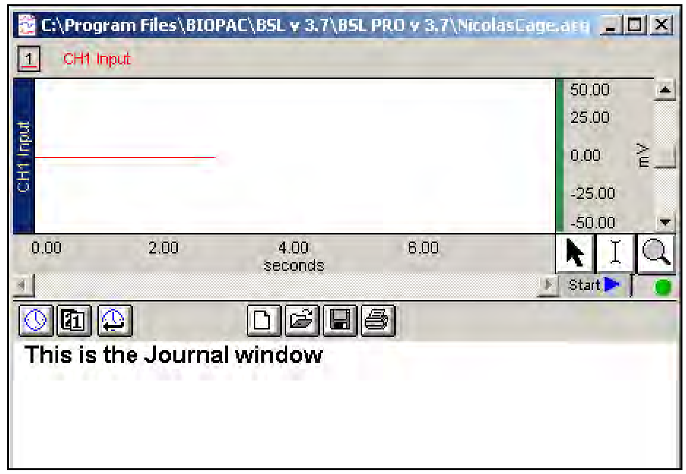
This will flash briefly each time Biopac Student Lab is launched. This screen lists the Biopac Student Lab *PRO* release number, which is useful if you ever need to call BIOPAC for technical support. The same information is accessible via the "**About Biopac Student Lab**" option of the Help menu.

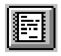
Assuming everything is properly connected and there are no conflicts, an empty Biopac Student Lab *PRO* graph window will be generated (like the one above).

A "**window**" is the term used for the area on your computer's screen where data is displayed and/or manipulated. Data can be displayed during acquisition. The graph window on the screen is designed to provide you with a powerful yet easy-to-use interface for working with data.

At this point, you can use the new window, open a template, or open an existing data file.

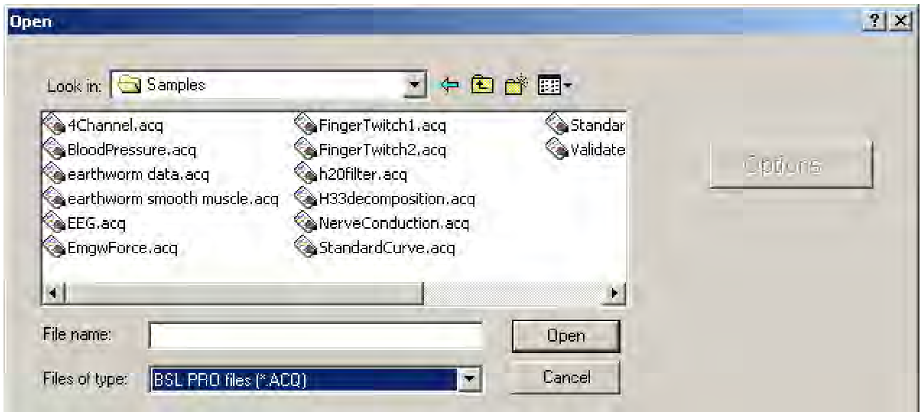
- To create a new graph window, choose **File**>**New**. It's a good idea to create a new graph window for each acquisition.
- To open an existing data file or a template, choose **File**>**Open** and then choose a file from the list in the dialog box. If you choose to open an existing file, you may want to close the new, blank window.



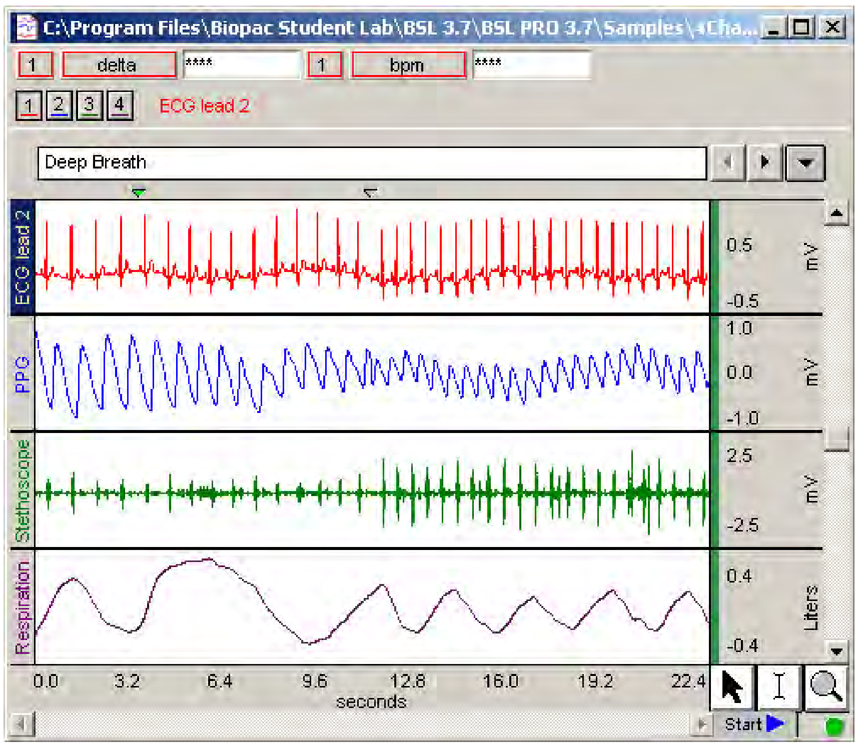
To open a Journal window, click the journal  icon on the toolbar (or choose **Display**>**Show**>**Journal**).

Sample Files

For purposes of illustration, you are encouraged to open a sample data file and follow along with the manual text. Default installation provides five sample data files at **C:\Program Files\BIOPAC\BSL 3.7\BSL PRO 3.7\Samples** (see page 243 for a static graph of each sample file).



Open the **4Channel.ACQ** sample file from the Samples folder.



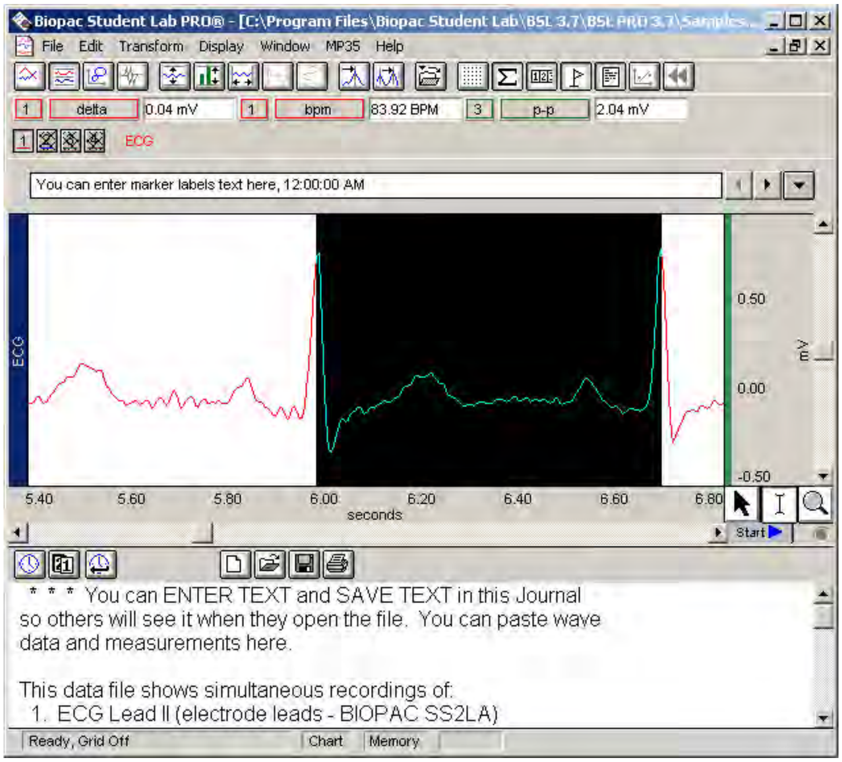
"4Channel.acq" Sample File Display

The **4Channel.acq** sample file contains four different types of data, with a border between each waveform display. To the left of each waveform is a vertical strip containing a channel label text string that can be used to identify each waveform: ECG, PPG, Respiration, etc.

The horizontal scale along the bottom denotes when the data was recorded relative to the beginning of the acquisition. Only eight seconds of the total data record are visible in the display window, although the file contains the complete record. The data displayed on the left edge of the window represent events that occurred about 12 seconds into the record, and the data displayed at the right edge of the screen represent events that occurred about 20 seconds after the acquisition was started. The display scale can be adjusted to virtually any value range.

The vertical scale along the right edge contains the amplitude unit range for each channel.

The Data Viewing Screen



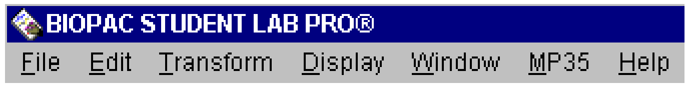
Parts of the* Biopac Student Lab *PRO screen

Software Controls

Use the left mouse button when a mouse function is referenced, except as noted for special shortcuts. See page 37 for information about right-click shortcuts.

Menu Structure

The pull-down menu structure runs across the top of the display window.



Menu	Type of Commands
File	General file management commands, including opening, saving, and closing files. "Save as" to export data files. Set program preferences.
Edit	Select, cut, copy, and paste between and within files.
Transform	Mathematical transformations and functions, from simple arithmetic to digital filtering and spectral analysis.
Display	Control how data appears on the screen either during or after an acquisition.
Window	Standard Windows functions. Refer to the Windows System Guide for detailed information.
MP35/MP30	Acquisition parameters, including channel, acquistion, and trigger setup. Output Control, including stimulator.
Playback	*Mac only*—when Capture to QuickTime is active, the MP menu changes to a Playback Playback menu and the Start button changes to Replay Replay.
Help	Access to BSL *PRO* lesson (requires browser), hardware and software documentation as real-time, searchable documents (requires Acrobat Reader), and information about the MP35, BSL software, and firmware.

Toolbar

The toolbar contains button shortcuts for many of the most frequently used features. Click an icon to activate it. The toolbar is displayed beneath the menu bar. To show or hide the toolbar, click **Display** menu > **Show** >**Tool Bar** or right-click at the top of the display screen in the menu bar region.

Icon Function

Change display to Scope mode.

Change display to Chart mode (default).

Change display to X/Y mode.

Change display to Overlap Segments mode—overlaps appended segments of data.

Autoscale, Vertical (active waveform only along the vertical axis).

Optimize Range—adjusts vertical scale of active channel to display full range of data; see pages 42 and 235.

Autoscale, Horizontal (all waveforms along the horizontal axis).

Center waveforms vertically in the active window (X/Y mode only).

Center waveforms horizontally in the active window (X/Y mode only).

Find the peak of a selected area.

Find the next peak (after peak has been defined).

Open a recently-used file. Select from a list of BSL PRO files in the current folder, or browse to open.

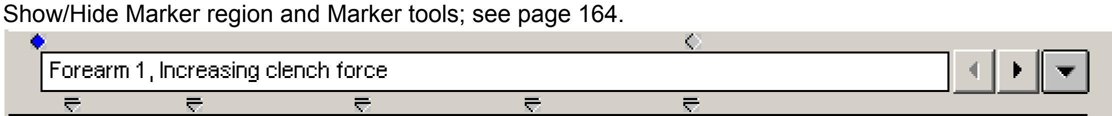
Show/Hide gridlines in the graph window.

Show/Hide measurement pop-up windows.

Show/Hide channel selection boxes.

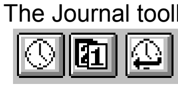
- Channel selection boxes are displayed above the graph window; see page 55.
- To select a channel, click the corresponding channel number box.
- To hide a channel, Ctrl-click the channel box. A slash mark indicates the channel is hidden.

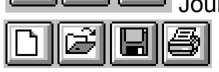
Show/Hide Marker region and Marker tools; see page 164.



Show/Hide Journal window

- Macintosh: Journal must be opened via the File menu. Once open, this icon toggles the display.
- The Journal toolbar is displayed in the Journal window. Journal tools are:

 Journal time, date, and auto-time paste functions.

 Journal file functions: new, open, save, and print.

Plot Standard Curve (X/Y mode only); see page 80.

Rewind (only active in Append acquisition mode). Delete the last recorded segment; see page 54.

Keyboard shortcuts

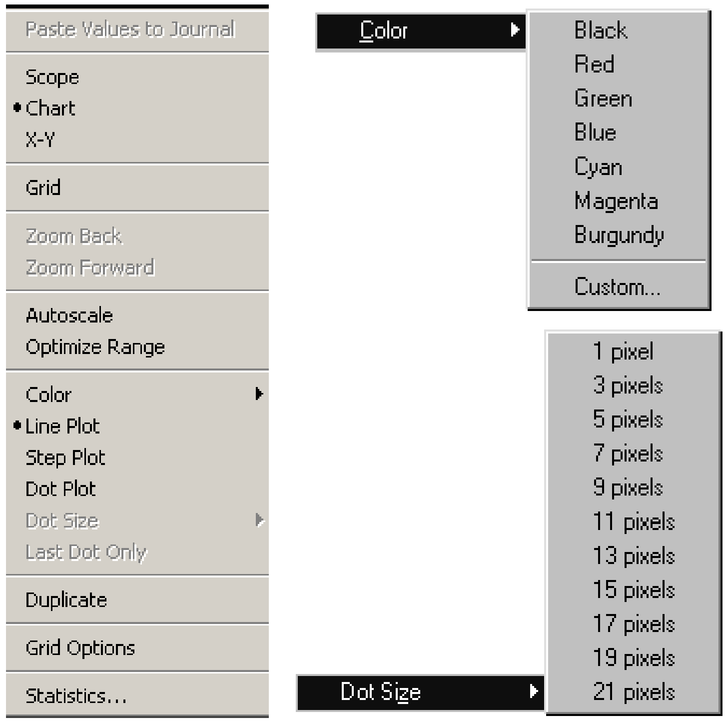
BSL *PRO* 3.7 is Section 508 Compliant; contact BIOPAC for a detailed Compliance Statement.

MENU ITEM	WINDOWS SHORTCUT	MAC SHORTCUT
File menu		
New	Ctrl-N	⌘N
Open	Ctrl-O	⌘O
Close	Ctrl-W	⌘W
Save	Ctrl-S	⌘S
Print	Ctrl-P	⌘P
Quit	Ctrl-Q	⌘Q
Edit menu		
Undo	Ctrl-Z (only shows when applicable)	⌘Z
Cut	Ctrl-X	⌘X
Copy	Ctrl-C	⌘C
Paste	Ctrl-V	⌘V
Clear	Delete	n/a
Duplicate waveform	no shortcut	⌘D
Select all	no shortcut	⌘A
Journal>Paste Measurement	Ctrl-M	⌘M
Journal>Paste Wave Data	Ctrl-D	n/a
Transform menu		
Find Peak	Ctrl-F	⌘F
Find Next Peak	Ctrl-E	⌘E
Find All Peaks	Ctrl-R	⌘R
Find Rate	Ctrl-A	n/a
Display menu		
Zoom Back	Ctrl-minus (works up to 5 times)	⌘-
Zoom Forward	Ctrl-plus (works up to 5 times)	⌘+
Cursor Style: Arrow	Ctrl-B	⌘B
Cursor Style: I-beam	Ctrl-I	⌘I
Cursor Style: Zoom	Ctrl-G	⌘G
MP35/30 menu		
AutoPlotting	Ctrl-T (toggles)	⌘T
Miscellaneous Functions		
Insert Marker	F9	Esc
Start/Stop acquisition	Alt-spacebar (toggles)	Control-Spacebar
Stop plot	Esc	n/a
Zoom out	Alt-click (when Zoom selected)	n/a

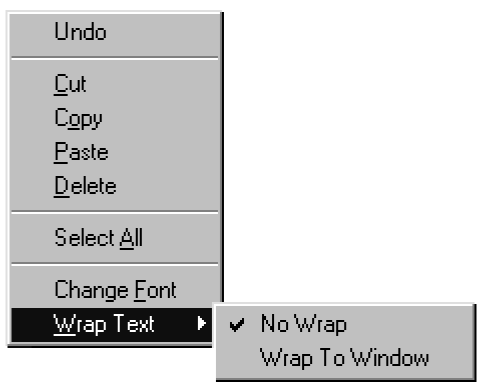
Right-click Shortcuts

Click the right mouse button in the designated window to generate the following shortcuts:

If the **Graph** window is active:

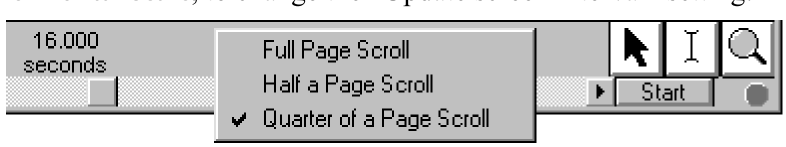


If the **Journal** window is active:



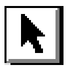
In the menu bar region, to show/hide the **Toolbars**:

By clicking on the **horizontal scale**, to change the “Update screen interval” setting:



Cursor Styles

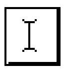
When working with data, you will often want to select only a portion of a waveform to edit or analyze. Once you have selected an area, you can perform a variety of operations—such as editing, measuring, transforming or saving data. The tool icons control the cursor style, which varies based on the editing or analysis function selected. The data selection tools are in the lower right corner of the display window. Click the desired icon to activate the corresponding cursor style. You can also set the cursor style under the Display menu.



Arrow

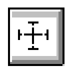
The *Arrow* icon activates a general-purpose cursor tool. It can be used to select a waveform or channel, pull-down menus to select options for editing, measurement, etc., scroll through data, and resize chart boundaries between waveforms.

All other cursors default to this style when moved outside of the graph window.



Selection (I-beam)

This is a standard **I-beam** area selection tool. The cursor changes to an I-beam when placed in the graph window. It is used to select an area of a waveform (or multiple waveforms) to be edited or transformed. This cursor is always selecting at least one sample point. See page 56 for details on using the I-beam to select an area.

The I-beam cursor becomes a crosshair  cursor in X/Y mode.

Zoom

This is a standard **Zoom** tool. It changes to a magnifying glass when placed in the graph window. It can be used to magnify any portion of any wave. See page 56 for details on using the Zoom tool to select an area.

If the I-Beam cursor is selected (manually or using “Ctrl + I”) after a single data point selection is made with the Arrow cursor, the I-beam cursor will be placed at the last data point selected. This is useful for preserving the data selection when switching the cursor style.

Scroll bars

You can use the **horizontal scroll bar** to move to different points in the record. As indicated by the horizontal scale, only a portion of the sample data file is displayed on each screen. The horizontal scroll bar allows you to move around in a data file, just as the scroll bar in a word processor allows you to move to different points in a document. Points left occured earlier in the record, points right occurred toward the end of the record. The horizontal scroll bar runs along the bottom of the display window.

You can use the **vertical scroll bar** to change the amplitude offset of a selected channel. This will reposition the waveform up or down within its display “track.” The vertical scroll bar runs along the right edge of the display window.

To use a scroll bar, click the bar and drag the box. Click the arrows at either end of the scroll bar to move in smaller increments.

✓ TIP To display the entire waveform (in terms of duration), choose Autoscale horizontal from the Display menu. The Autoscale horizontal command fits the entire data file into the window, regardless of the total length of the acquisition. You can identify the duration of the record by choosing Display > Statistics. This will generate an information dialog that includes the Length of the record.

✓ TIP You can “jump” to a different point in time by entering a “Start” value in the Horizontal Scale dialog. See the following section for more information.

Scale

Any changes you make in terms of rescaling (either horizontal or vertical) will only affect the way data is displayed, and will not change the basic characteristics of your data file. Horizontal scale options affect all channels; vertical scale options can be set independently for each channel.

Horizontal scale runs along the bottom of the display window and is where the numerical units are listed. You may show/hide the scale via the **Show>X-scale** command. The default setting uses four divisions (vertical lines) per screen. You can change the horizontal scale setting to control the amount of data that appears on the screen at any given time. See page 39 for details.

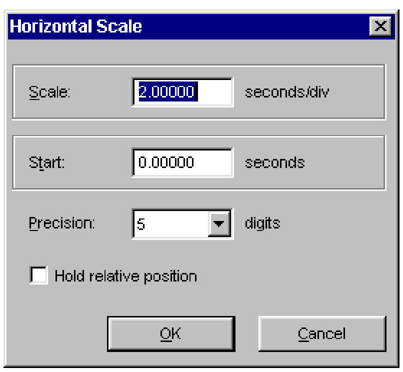
Vertical scale runs along the right edge of the display and controls the range of amplitude values displayed for each waveform. You may show/hide the scale via the **Show>Y-scale** command. You can set the scale midpoint (the value that appears in the center of the vertical scale) for each channel. When multiple channels are displayed, thick horizontal lines separate each waveform into its own vertical "track."

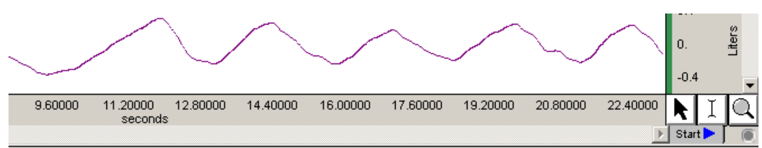
As with the horizontal scale, there are four divisions on the vertical axis, and the display range will equal the Scale value x 4. If Scale is set to 3 mVolts per division, 12 mVolts of data will be displayed. You can use the **Range Guide** as a visual aid to establish the proper Gain..

Note: The Scale Precision setting only applies to the Scale. You must set measurement result precision separately.

Horizontal scale

Click the cursor in the horizontal scale area to generate the **Horizontal Scale** dialog. The Horizontal Scale dialog — when display grids are not locked — is shown below. Note that the Horizontal Scale dialog will vary if grids are "locked." See page 166 for a discussion of Grid Options and how locking grids (Display>Show>Grid Options Display>Grid Options: Lock Grid Lines) affects the Horizontal Scale dialog.





Horizontal Scale dialog (Grid Unlocked)

Scale The **Scale** setting controls how much of the record will be displayed on the screen at any given time. When grids are unlocked, the screen displays the horizontal scale value multiplied by four. Larger values will display more data and smaller values will display less data.

Start Enter a number in the **Start** box to "jump" to a certain point in the data display. This does not affect the data file, just the display. To view data from the beginning of the sample record, enter a **Start** value of 0 seconds.

In the time scale shown above, the first data displayed (at the left edge of the graph window) was collected at the beginning of the acquisition (Time 0.0000 seconds). Also, the scroll box is fully to the left, indicating that the data on the screen represents data collected earliest in the record.

If you click in the horizontal scale area again, the same dialog will appear, and this time the value in the **Start** box should have changed from 12.0 to 0.00 to reflect the new section of data being displayed on the screen.

Precision

The **Precision** setting determines the number of digits to follow the decimal (default is 2). Significant digits will be rounded rather than truncated. This setting is for scale precision only; you must set the measurement precision separately under Display > Preferences > General.

✓ TIP To display the entire waveform (in terms of duration) in the data window, choose **Display > Autoscale Horizontal**. Use **Autoscale Waveforms** to adjust the vertical display and bring all data into view.

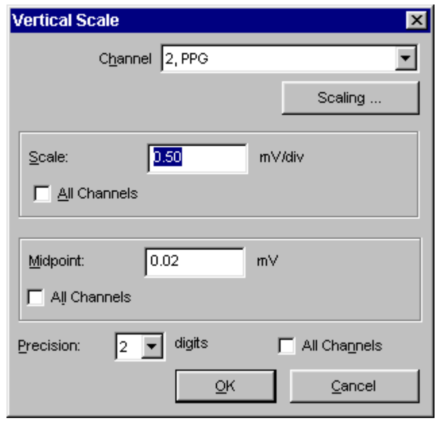
Hold Relative Position

Hold relative position is an option available only in the **Append** acquisition mode. When checked, the display for appended acquisitions will show the same relative position with respect to the start of acquisition. This is convenient when doing short-duration, high-speed acquisitions where you want to be able to zoom in on the signal of interest and have the relative position (from the start of acquisition) stay the same. If the acquisition is started with the horizontal scale such that it falls between acquisition segments, this feature is not implemented.

When **Hold relative position** is checked, if you zoom in on a section of data that has been selected (highlighted) and is completely within one appended segment, the scale of the selected area changes with each appended segment such that it remains relative to the start of acquisition for that segment and updates the measurements. If the selected data area falls within two or more appended segments, this feature is not implemented.

Vertical scale

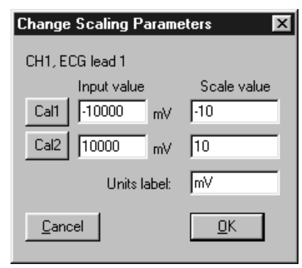
Click the cursor in the vertical scale area (on the right edge of the window, where units are displayed) to generate the **Vertical Scale** dialog. The Vertical Scale dialog — when display grids are not locked — is shown below. Note that the Vertical Scale dialog will vary if grids are "locked." See page 166 for a discussion of Grid Options and how locking grids (Display>Show>Grid Options Display>Grid Options: Lock Grid Lines) affects the Vertical Scale dialog.



Default Vertical Scale (Grid Unlocked)

Channel Use this option, available only when grids are not locked, to jump to another channel and set its vertical scale options without having to close out of the dialog.

Scaling… The Scaling… button appears in the "Vertical Scale" dialog regardless of the scale or grid mode if there is hardware associated with the channel. This gives fast access to the **Change Scaling Parameters** dialog for calibration control. Scaling changes will be applied following the next start of acquisition, and must remain the same for all appended segments.



Scale This determines how many units (usually Volts) are displayed in each track. Smaller Scale values increase the apparent amplitude, larger values decrease the apparent variability. Entering a number about half the current value will cause the amplitude of the wave to appear to double.

Midpoint This sets the median value display for the track. You can vary the midpoint and apparent magnitude of each waveform by changing the Midpoint entry. If Midpoint is set to 2 mVolts, the selected channel will display a range from - 4 mVolts to + 8 mVolts.

Precision This setting determines the number of digits to follow the decimal (default is 2). Significant digits will be rounded rather than truncated. The vertical scale precision setting applies only to the specified channel. This setting is for scale precision only; you must set measurement precision separately under Display > Preferences > General.

All Channels Click in this box to apply the setting to all channels rather than to the selected channel only.

✓ TIP Use **Display > Autoscale Waveforms** to have the software automatically adjust the vertical scale parameters so all ampoitude data in the current time slice (horizontal scale) will be displayed.

Range Guide

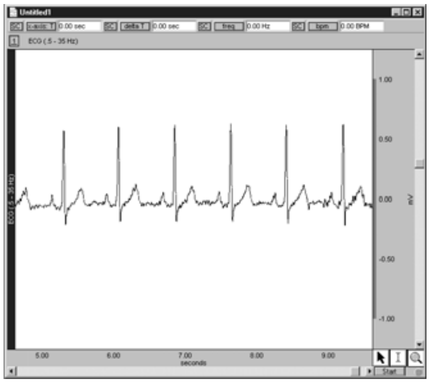


Figure 1

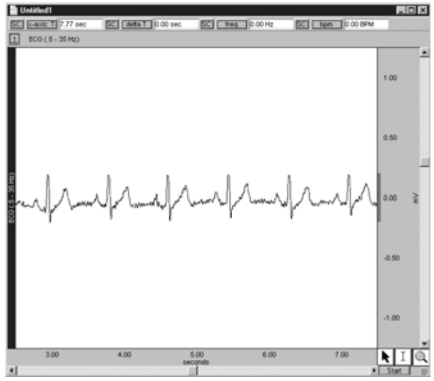


Figure 2

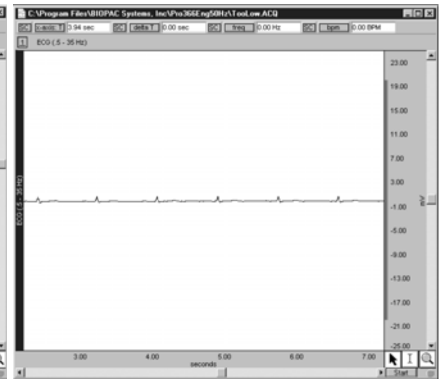


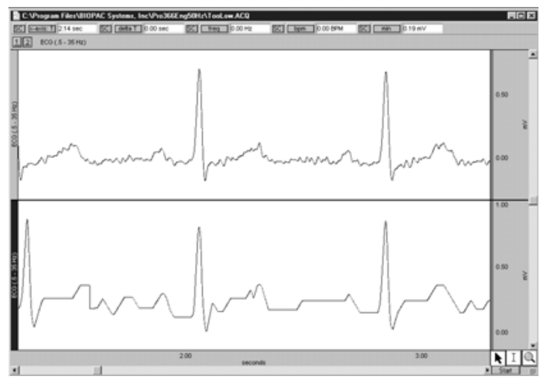
Figure 3

The **Range Guide** is a green bar that runs along the vertical scale in the graph window for analog channels (fig. 1). It displays the maximum signal range for the Gain established for that channel. You can use the Range Guide as a visual aid to establish the proper Gain.

The MP35/30 measures the *actual* input voltage and compensates for the Gain. As Gain increases, the peak-to-peak of a waveform stays constant but the resolution increases. Proper Gain will have a smoothing effect on the signal.

For the best resolution, establish Gain such that, allowing for baseline drift (if applicable) and the maximum peal-to-peak of the signal, the maximum signal display is close to the maximum range. If the signal is clipped (fig 2.), lower the Gain. If the signal is small compared to the range (fig. 3), increase the Gain to improve signal resolution.

Gain settings create a trade-off between range and resolution. Different gain settings applied to the same signal source show that



Higher Gain → better resolution + lower range (fig. 4, top)

Lower Gain → worse resolution + higher range (fig. 4, bottom)

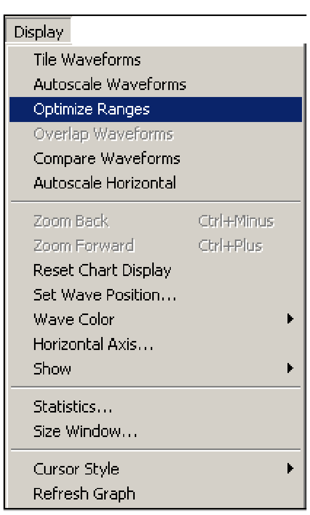
Figure 4

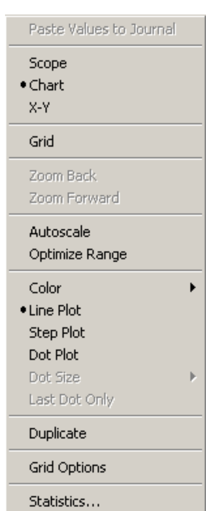
To display the full range (Fig. 2 vs. Fig. 4, for example), adjust the Vertical Scale.

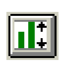
Gain guidelines are included in the **MP35/30 Input and Offset Range** table on page 97.

The **Range Guide** will always reflect changes made to the channel Scaling.

To quickly see the total range of each input channel, select **Optimize Ranges** from the Display menu. This will automatically adjust the upper and lower viewable limits of the Vertical Scales for all channels.







When Optimize Range is selected using the toolbar icon or the right-click mouse shortcut, only the active channel range guide is optimized. See page for 235 details.

Display modes

BSL *PRO* offers several display modes to change the way data appears on the screen at any time, even during an acquisition: Chart mode, Scope mode, Overlap Appended segments, and X/Y mode. To change the display mode, click the corresponding icon in the toolbar or make a selection from the **Display > Show** menu options. When in Chart or Scope mode, you have the additional option to display appended data in the Overlap Segments mode, activated from the Toolbar.

Chart mode

 **Chart** is the default display mode and plots with Time on the horizontal axis.

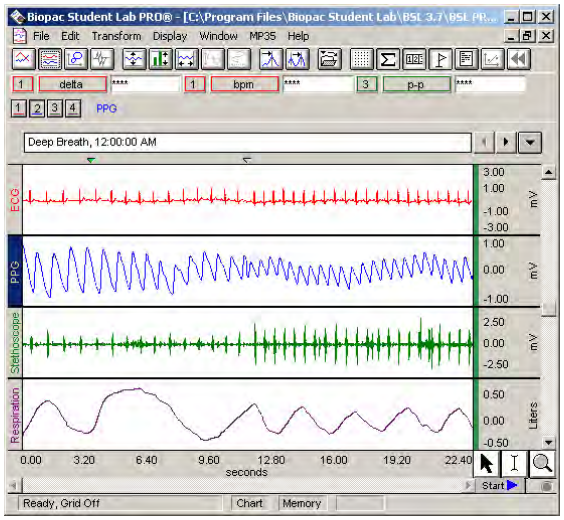
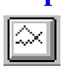


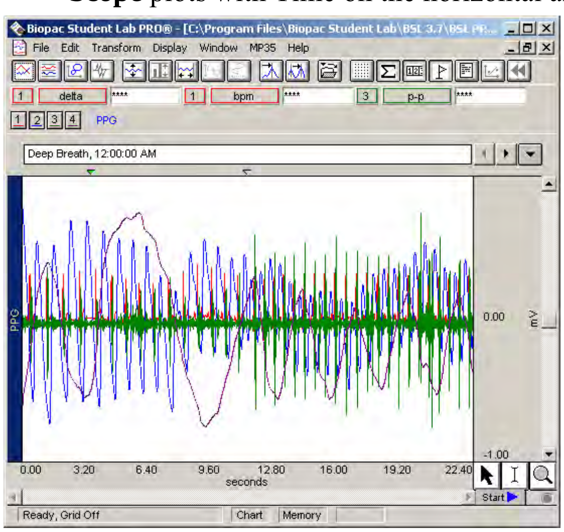
Chart mode emulates a chart recorder. Each channel of data is in its own "track" across the screen, with borders between channels. The waveforms will not cross boundaries into the tracks of adjacent channels.

Waveforms cannot overlap in Chart mode, but it is possible for the waveform to be plotted off the scale of the channel track. To remedy this, choose **Autoscale Waveforms** and the software will select the "best fit" for waveforms to their tracks.

When the active channel is disabled in Chart Mode, the first channel (of the remaining enabled channels) becomes the new (default) active channel and its Horizontal and Vertical Scales are displayed.

Scope mode

 **Scope** plots with Time on the horizontal axis.



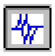
Scope mode emulates an oscilloscope. All waveforms are in a single window with no borders between channels. Waveforms can overlap.

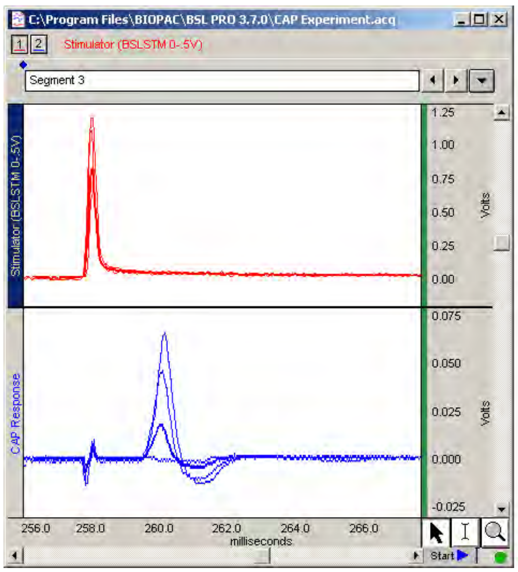
The **autoscale waveforms** command will automatically separate the waveforms in the graph window and autoscale each as if it were the only waveform in the display region. This can be useful when overlapping waveforms that are of different units and scales.

When the active channel is disabled in Scope Mode, the first channel (of the remaining enabled channels) becomes the new (default) active channel and its Horizontal and Vertical Scales are displayed.

> **Note**: When only one waveform is present, the **Scope** and **Chart** modes are identical.

Overlap Segment mode

 **Overlap Segments** plots with Time on the horizontal axis.



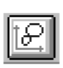
Overlap Segments mode overlaps appended segments of data and is useful for comparing waveforms.

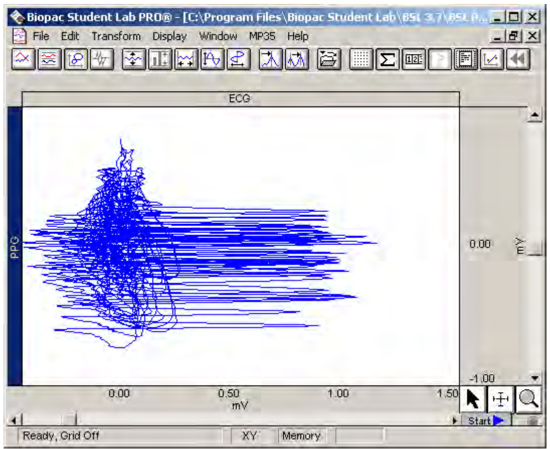
Overlap Segments may be toggled on and off; its Toolbar icon is enabled only when the acquisition mode has been set to Append, at least one segment of data has been acquired, and the display mode has first been set to Chart or Scope.

In Chart mode, when Overlap Segments is toggled on, all data segments of each channel are overlapped in their respective channel “tracks.” In Scope mode, all segments of all channels are displayed in a single window.

The active segment is highlighted and its Horizontal scale, automatic Append marker, and marker label are displayed; Event markers are not displayed in this mode—see page 164 for Marker details.) To choose a new active segment, right-click when the cursor is over the graph and select **Show Segment** from the pop-up menu.

X/Y mode

 **X/Y** mode plots one channel on the horizontal axis against another channel on the vertical axis. When a channel is plotted against itself, a straight line will be displayed.

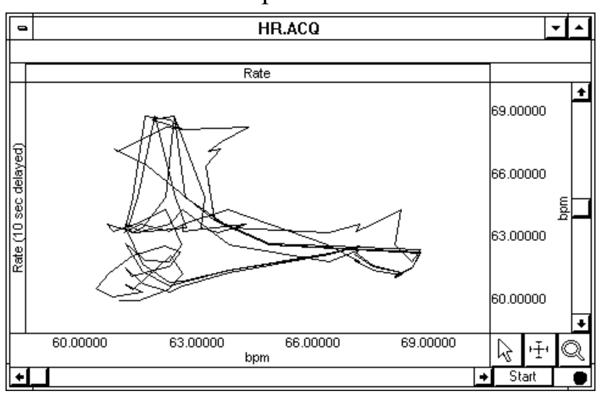


X/Y mode can be useful for chaos investigations and respiration studies.

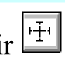
- When X/Y mode is selected, you can Plot Standard Curve, which is useful for colorimetry studies. See page 80for Standard Curve setup.

In X/Y Mode, the label for the channel being plotted for the X-axis is displayed *above* the waveform window. The label for the channel being plotted for the Y-axis is displayed to the *left* of the waveform window.

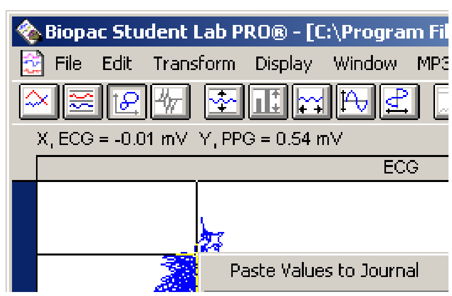
Clicking once in either the X-axis or Y-axis label areas generates a pull-down menu of all currently plotted channels. Select a channel from the list to plot it on the selected axis.



X/Y plot of BPM (X) and lagged BPM (Y)

BSL *PRO* functionality changes when in X/Y mode	
I-beam tool	The I-beam tool changes into a crosshair  cursor and when it is moved into the graph window, the coordinates of the crosshair are displayed in the upper left corner of the graph window. The X value is the horizontal coordinate and the Y value is the vertical coordinate of the crosshair.
Plot Standard Curve	The **Plot Standard Curve** function is enabled in X/Y mode. This function plots a curve used in colorimetric measurements. See page 80.
Autoscale Waveform	The **Autoscale Waveform** function changes to read **Autoscale Vertical**, which plots the vertical channel so that it takes up two-thirds of the vertical channel space. This function controls the "height" of the data being plotted in the graph window.
Autoscale Horizontal	The **Autoscale Horizontal** function plots the waveform so that the waveform is plotted in the center two-thirds of the window. This function controls the "width" of the data being plotted in the graph window.
Tile Waveforms /	Since only two channels can be displayed at a time in X/Y mode, the **Tile**

BSL *PRO* functionality changes when in X/Y mode	
Compare Waveforms	**Waveforms** and **Compare Waveform** commands are replaced by the more relevant **Center Horizontal** and **Center Vertical**. These two center commands change the midpoint of the horizontal and vertical scales (respectively) so that the midpoint of the scale is equal to the mean value (average) for that channel. These features are useful for centering the display so that it is easier to interpret. Whereas **Autoscale** commands adjust the center point and the range of data displayed, **Center** functions adjust only the midpoint.
Channel boxes	The channel numbering boxes are disabled in X/Y mode since they are not meaningful in X/Y mode.
Measurement region	The measurement windows are disabled in X/Y mode since they are not meaningful in X/Y mode. Instead, when the cursor is the X/Y plotting region of the graph, the measurement region displays the **X-axis and Y-axis coordinates** of the data point closest to the cursor. If the left mouse button is pressed, horizontal and vertical lines track the cursor movement. If the right mouse button is pressed (even while the left mouse button is down) and a journal is open, a "Paste Values to Journal" option is available from the pop-up menu.



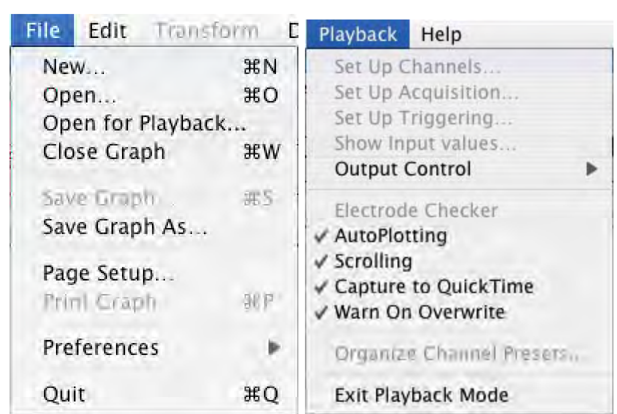
Playback Mode – Mac only

Use Playback mode to replay (or simulate) acquisition using a previously acquired graph file. The data in a graph file can be used to simulate an MP unit that returns the data stored in the graph file.

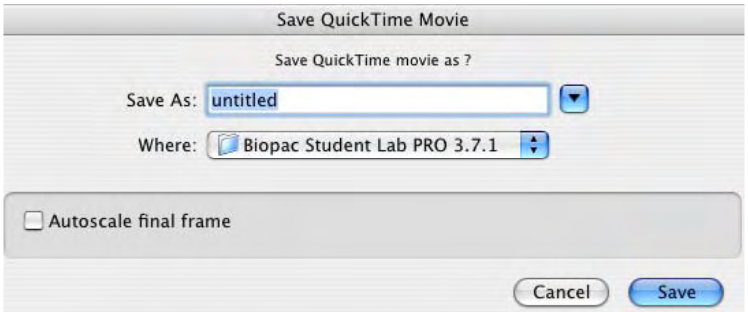
1. Select File > Open for Playback.
2. Locate a graph file and then click Open.
3. A new graph window will be generated.
4. Press Replay to begin playback.

(The "Start" button becomes "Replay")

5. Select Playback > Exit Playback mode to return to MP menu and acquisition options.



QuickTime Movies of Acquisitions



You can create a QuickTime movie of Biopac Student Lab *PRO* window content during or after acquisition (from a graph file saved on disk). Capture waveform plotting, results of autoscaling, autoscrolling, and any other visual changes to the graph window that occur during acquisition.

- By postponing QuickTime creation, you can make sure data is clean and optimize settings to reduce file size — QuickTime movies can be gigabytes in size and it's a hassle to accidentally run out of disk space in the middle of an acquisition.

Flattening—QuickTime movies are generated in the "Animation" format with no compression codec used and flattened at the end of the acquisition. Flattened movies are cross-platform compatible with Windows™ PCs. Due to limitations of QuickTime 6, flattening may take 10 minutes.

<u>Save Quick Time Movie Options</u>

- **Location—**The disk where the movie is saved should have several gigabytes free space available for movies longer than 3 minutes.
- **Autoscale final frame**—Creates the last frame of the movie after an Autoscale Horizontal operation so the last frame of the movie shows all of the data from the start of the acquisition to the end.

<u>Optimize graph size and display settings</u>

The actual dimensions of the movie will be taken from the size of the graph window, so optimizing the display will help reduce file size and emphasize signal representation(s).

- Optimize graphs size
    - Select Display > Size Window and enter the smallest reasonable size for the visual dimensions of the movie (e.g. 400x300).
    - The smaller the size of the graph window, the smaller the resulting movie will be (in both size on disk and visual dimensions).
    - Do not resize the graph window while a QuickTime capture is in process.
- Optimize display settings for the reduced graph size
    - Hide toolbars, events, hardware menu, measurements, etc.
    - Set the scales such that details of the waveform(s) will be discernable in the small graph window plotting area.
    - Perform autoscaling as necessary to get appropriate vertical scales for the entire data file.
    - Optimize the horizontal scale for the reduced display region.
    - Set precision of the axes (usually 2-3).
    - Set the "Initial time offset" of the horizontal axis to zero, either through clicking on the axis or scrolling all the way to the left.

Create a QuickTime file from a Saved Graph File

Preferred Method —This procedure requires two acquisitions

Stage 1

1. Select File > Open File for Playback (the MP menu will change to “Playback”).
2. Select the file containing the source data for the video.
3. Disable (uncheck) Playback > Capture to QuickTime.
4. Set the acquisition storage mode to “Save once to Memory” (Playback > Set Up Acquisition).
5. Press “Replay” in the graph window and wait for acquisition to terminate.
   - This acquires all of the original data into the graph window so all of the data is present for determination of vertical scaling appropriate for the entire acquisition.

Stage 2

6. Optimize graph window size and display settings to reduce movie file size.
7. Select Edit > Select All.
8. Select Edit > Clear All.
9. Enable (check) Playback > Capture to QuickTime.
10. Press “Replay” in the graph window.
11. Set options in the “Save QuickTime Movie” dialog and then click Save.
    - Watch for error dialogs and wait for playback acquisition to finish.
    - Wait for the QuickTime file to flatten (may take 10 minutes).
12. Open the movie in QuickTime Player and check for any problems.
13. If necessary, go back to the playback graph window and repeat from Step 6.

Create QuickTime file during Acquisition

Riskiest method — You are more likely to run out disk space

1. Enable MP1#0 > Capture to QuickTime.
2. Optimize graph window size and display settings to reduce movie file size.
3. Press Start in the graph window.
4. Set options in the “Save QuickTime Movie” dialog and then click Save.
5. Stop acquisition (automatically or via the Stop button).
   a. The QuickTime file will automatically be saved (separately from the acquisition).
   b. Save the graph file.

Part B — Recording Data

Part B – *Recording Data* covers the basics of data acquisition and analysis with the Biopac Student Lab *PRO*. All of the material in this section is covered in more detail in subsequent sections (see *Using this Manual* on page 12 for a guide to sections).

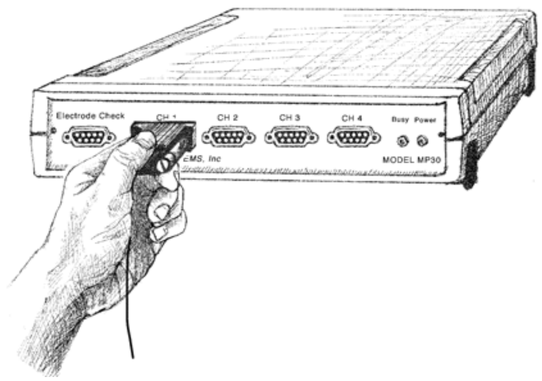
Chapter 2 Acquisition Overview

Collecting data / acquisition

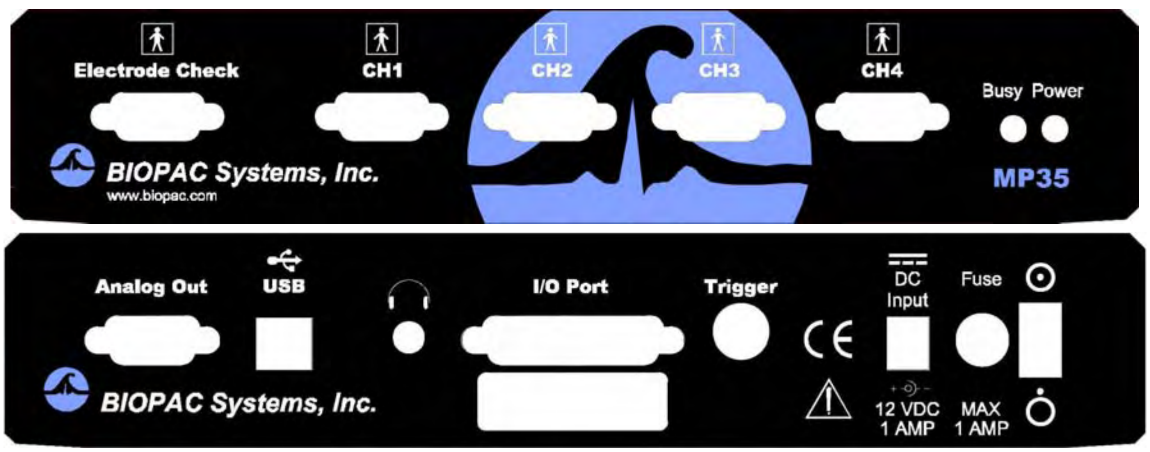
Acquisition is defined as data collection from an external source (such as electrodes connected to an amplifier). BSL *PRO* acquisitions require hardware connections and software setup.

Hardware Connections

The MP35/30 is designed to accept amplified small analog signals and large analog signals (up to ± 10 Volts). Specific connections to the MP35/30 acquisition unit will vary greatly, depending on the amount and type of data collected. The most common applications of the BSL *PRO* involve amplified signals collected from electrodes and/or transducers.



Input connection to the MP35/30



MP35 Front and back Panels — see page 265 for MP35/30 specifications and symbology

The two common types of input devices that connect to the front of the MP35/30 to interface between the subject and the hardware are electrodes and transducers. Electrodes directly reflect the electrical signal generated by the body, and transducers convert a physiological signal into a proportional electrical signal. You can also connect I/O devices to the MP35/30.

Electrodes are relatively simple instruments that attach directly to a subject's skin surface and pick up electrical signals in the body. Electrode lead cables connect to the electrodes and send the signal to the MP35/30 unit. The MP35/30 amplifies the signal and sends it to the computer and the Biopac Student Lab *PRO* software. Depending on where electrodes are placed, different types of signals will be picked up.

Transducers convert a physiological parameter (such as clench force, blood pressure, or Galvanic Skin Response) to a proportional electrical signal. One example of this is the respiration transducer, which is like a rubber band that stretches with your chest. It measures how much larger your chest becomes when you breathe in, and how much smaller it becomes when you exhale. A device inside the transducer converts this physical change into an electrical signal, which can then be sent to the Biopac Student Lab *PRO* System and relayed to your computer, where it is plotted on the screen.

I/O devices are specialized Input/Output devices, such as push-button switches and headphones.

Regardless of the type of device connected, every sensor or I/O device connects to the MP35/30 acquisition unit using a "Simple Sensor" connector. The Simple Sensor connector is designed so that there is only one way to plug it into the MP35/30, so you don't have to worry about plugging things in upside down or into the wrong socket. You don't have to screw the end of the Simple Sensor into the computer port unless you want to — this makes it easy for you to experiment with different transducers.

➢ See the *BSL Hardware Guide* for more information on the Simple Sensors available for use with the Biopac Student Lab *PRO*.

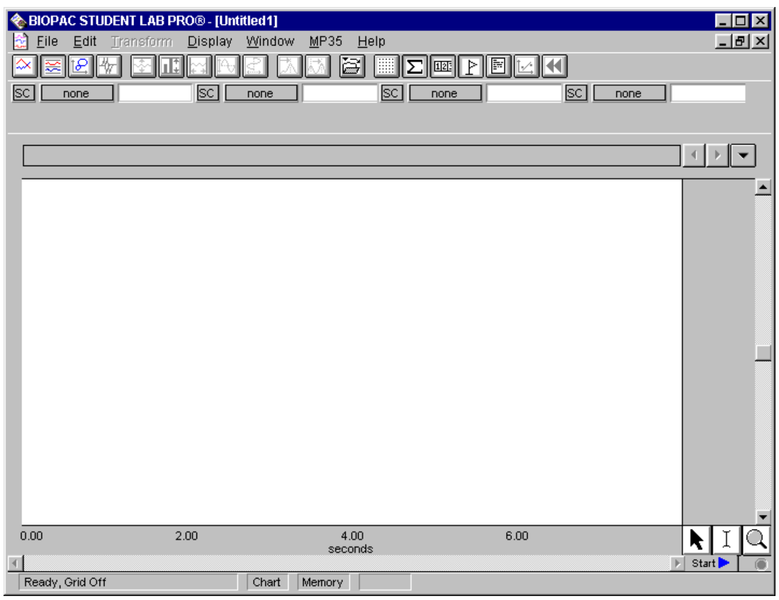
Software Setup

You must set up the input channels to acquire data and the acquisition parameters to use for each channel, such as sample rate, data storage, and acquisition length.

➢ Before you begin software setup, make sure the MP35/30 is turned on and connected to your computer. If the MP35/30 is not connected to your computer and/or not turned on, a warning will be generated when you launch the BSL *PRO* Software. If you need more information on installation and connections, refer to the Installation Guide.

1. Launch the Biopac Student Lab *PRO* application via the **Start** menu (Windows) or double-click the Biopac Student Lab *PRO* icon from the program/application folder or desktop.

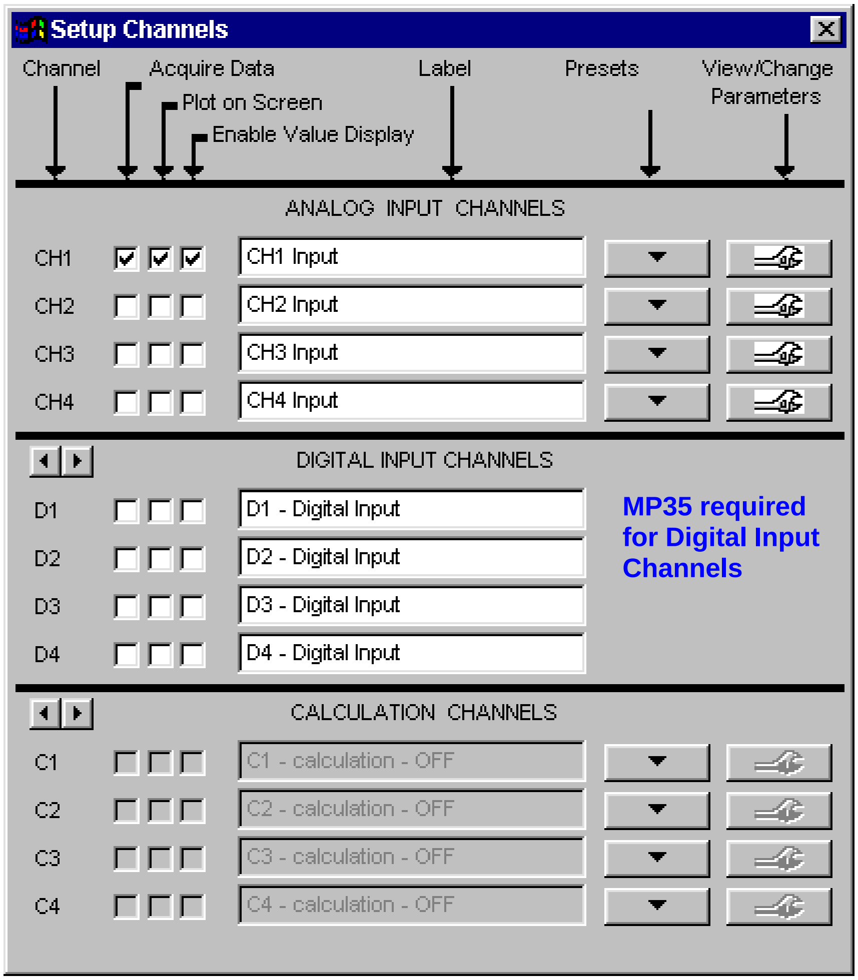
   BSL *PRO* opens to a new graph window. You should see a window similar to the following:



2. You must setup the specific channels to acquire data on. See **Setup Channels** for details.
3. You must setup the acquisition parameters (such as sampling rate, acquisition length, and data storage options). See **Setting up Acquisition** for details.

Set up channels

Select **Set up Channels** from the **MP35/30** menu. This will generate a **Set up Channels** dialog where you will designate the channels to be acquired, and the parameters for data acquisition.



Setup Channel Options

Channel	The **Channel** column contains the alpha-numeric channel numbers. “**Analog**” (or continuous) input channels begin with “**CH**” and run from CH1-CH4. “**Digital**” input channels begin with “**D**” and run from D1-D8. “**Calculation**” channels begin with “**C”** and run from C1-C12. ▪ Display is limited to four channels of each type. Use the scroll button to set up additional Digital or Calculation channels.
Acquire	When the **Acquire Data** box is checked for a given channel, data will be collected on that channel.
Plot	If **Plot on Screen** is also checked, data will be plotted on screen in real-time during the acquisition. If the plot box is unchecked, data will still be recorded for that channel, but the waveform display will be disabled. To display the waveform plot after the acquisition is over, show the channel.
Enable Value Display	Checking the **Enable Value Display** box means that you can choose to display (numerically and/or graphically) the values for each channel in real time. To display the values, you must also select **Show Input Values** (via the MP35/30 menu). Input values are displayed in a separate window from the main graph window.
Default	The default is to collect one channel of data on analog channel 1 (CH1), and to plot and

enable value display for this channel

✓ **TIP** Usually, you will want to check all three boxes for each channel you acquire data on

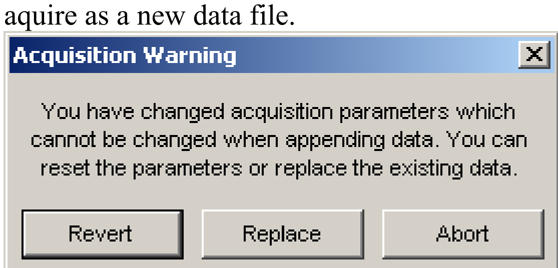
Label The **Label** entry for each channel allows you to type in up to 38 characters to identify the channel.

Presets Clicking on the **Presets** button will generate a menu of available presets for the channel. Presets for common applications configure the hardware gain, filters, etc.

➢ For a detailed summary of **Analog Input channel, Digital Input channel,** and **Calculation channel** options see the **Presets** section beginning on page 73.

View/Change To **View/Change Parameters** for a Preset, click the wrench icon. If you change the parameters, you have the option of creating a **New Channel Preset** to make the established parameters available to other channels.

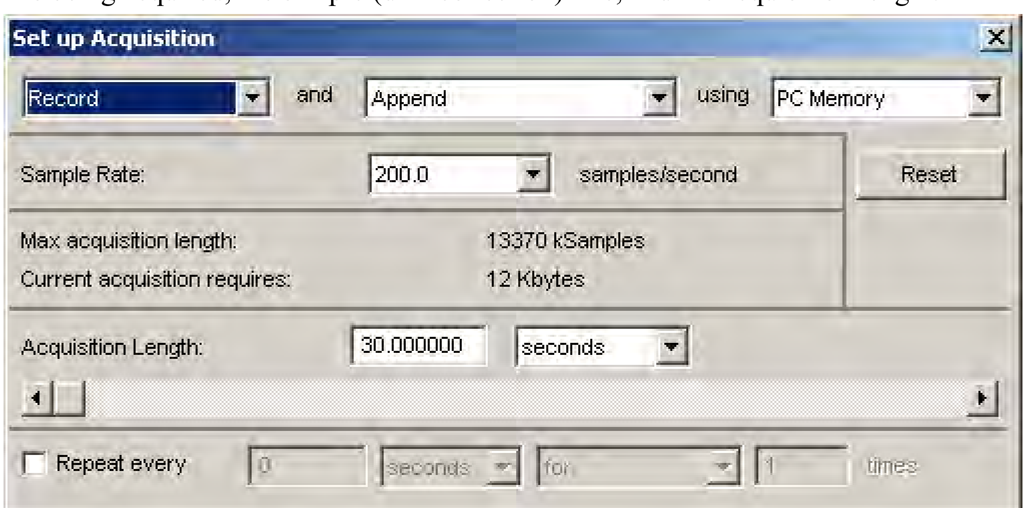
If you make a change to a preset and start recording in the Append mode, you will be prompted as follows. Choose Abort, save your data, and then change the presets to aquire as a new data file.



Setup Acquisitions

Once you have set up the channel parameters, the next step is to specify the acquisition settings. You can do this by choosing **Setup Acquisition** from the **MP35/30** menu. This generates a dialog box that will describe the type of acquisition about to be performed.

There are a number of options here, but the basic parameters involve specifying: where data should be stored as it is being acquired, the sample (data collection) rate, and the acquisition length.



Data storage — At the top of the Acquisition Setup dialog box, you should see a display that reads **Record** and **Append** using **PC Memory**. This is the default option for collecting data and tells the Biopac Student Lab *PRO* to automatically record data into single continuous file, and to store the data in computer memory (RAM) during the acquisition. The third pop-up menu (which defaults to **PC Memory**) allows you to specify where the data should be stored during the acquisition. You will need to choose **PC Memory** or **Hard Disk** storage. Computer memory (RAM) is usually faster (but less abundant) than disk space. If your system uses any virtual memory, the Biopac Student Lab *PRO* software will use as much as possible.

Sample rate — This is analogous to "mm/sec" on a chart recorder, and refers to how many samples the MP35/30 System should take each second. As the sample rate increases, the representation of the signal becomes more accurate — however, so does the demand for system resources memory, disk space, etc.). The Biopac Student Lab *PRO*'s sampling rate has a lower bound of 1 sample per second, and an upper bound of 100,000 samples per second (2 kHz). Choose the best sample rate from the pull-down menu generated when you click the Sample Rate entry.

✓ A good rule of thumb is to select a sampling rate at least four times the highest frequency of interest for the signal.

Acquisition Length — This entry controls how long an acquisition will last (duration). This can be scaled in seconds, minutes, hours, milliseconds or number of samples, as selected from the pull-down menu. Set this value by entering a number in the Acquisition Length box or by moving the scroll box left (to decrease) or right (to increase).

Repeat — The **Repeat** function is an advanced operation and is discussed on page 91.

Starting an acquisition

After you have setup the channels to contain data and defined the channel parameters, you are ready to start the acquisition. If a file window is not already open, choose **File** > **New** to generate a graph window.

In the lower right corner of the screen, next to the button, you should see a button with a circle next to it. The circle indicates the status of the communication link between your computer and the MP35/30. If the MP35/30 is properly connected to the computer and is turned on, the circle should be solid and green. If the MP35/30 is not properly connected, a solid gray circle will appear (on monochrome displays, the circle will appear solid when the MP35/30 is connected properly, and unfilled when the MP35/30 is not communicating with the computer).

You can start the acquisition by positioning the cursor over the button and clicking the mouse button or by selecting "**Alt + Spacebar**." If there are no input devices (e.g., electrodes or transducers) connected to the MP35/30, it will collect a small value of random signal "noise" with a mean of about 0.0 Volts.

- For information on how to connect measurement devices to the Biopac Student Lab *PRO*, see the *BSL Hardware Guide*.
- You may also start an acquisition using a variety of "triggers," which are discussed on page 140.

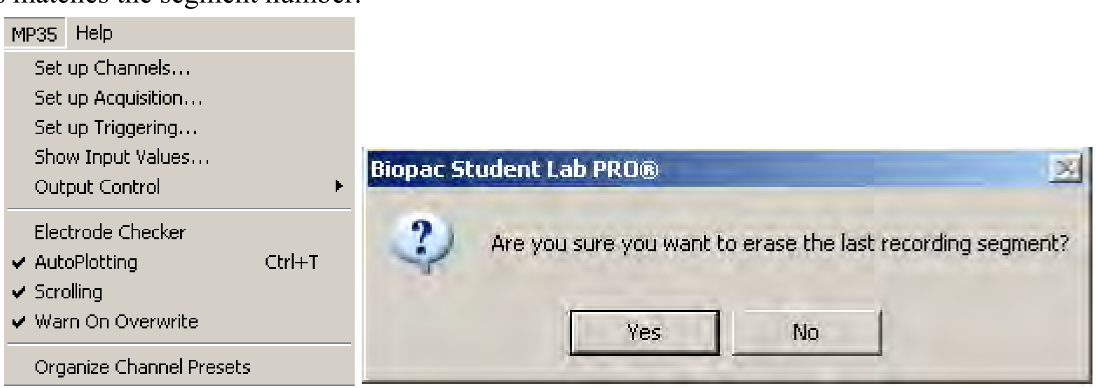
Once acquisition starts, the button in the acquisition window changes to . The two opposing arrows to the right of the button indicate that data is being collected. Also, the "Busy" status indicator light on the front of the MP35/30 will illuminate, showing that data is being collected.

Stopping an Acquisition

To stop an acquisition at any time, click the button in the lower right corner of the screen or select "**Alt + Spacebar**." An acquisition will stop automatically when it has recorded an amount of data equal to the **Acquisition Length** entry.

Rewind

The Rewind button on the Toolbar allows you to erase the last recorded data segment and continue to Append data to the existing data file. This function will erase the last segment along with the Append Marker for that segment; the application will keep track of Append Marker labels, so that the label always matches the segment number.



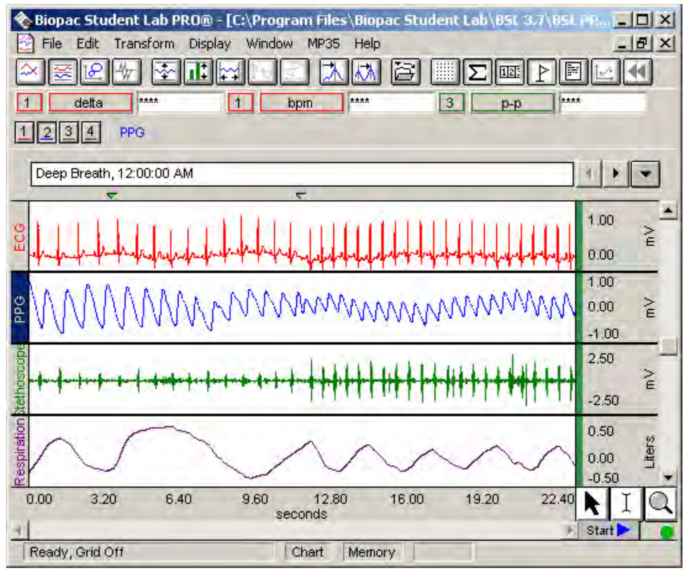
- If the "Warn on Overwrite" option is active, a warning dialog will be generated before the segment is deleted.

Saving acquisition data

To save a data file, pull-down the **File** menu and choose the **Save** command (see page 176 for details).

Chapter 3 Analysis Basics

Selecting a waveform / channel



Although multiple waveforms can be displayed, only one waveform at a time is considered "active." Most software functions only apply to the active waveform, which is also referred to as the selected channel. Selecting a channel allows you to highlight all or part of that waveform, and enables you to perform transformations on a given channel.

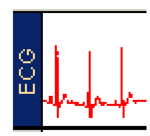
In the upper left corner of the graph window there is a series of numbered boxes that represent each channel of data. The numbers in the boxes correspond to the channel used to acquire the data (the specifics of setting up channels are discussed on page 51).

In the sample file, ECG is on channels 1 and 2, with respiration is on channel 3 and blood pressure is on channel 4.

To select a channel, position the cursor over the channel box that corresponds to the desired channel and click the mouse button or position the cursor on the waveform of interest and click the mouse button. Note that the selected channel box appears depressed and the channel label to the right of the channel boxes changes to correspond to the selected channel. Additionally, the channel label in the display (on the left edge of the track) will be highlighted for the active channel.

Channel Labels

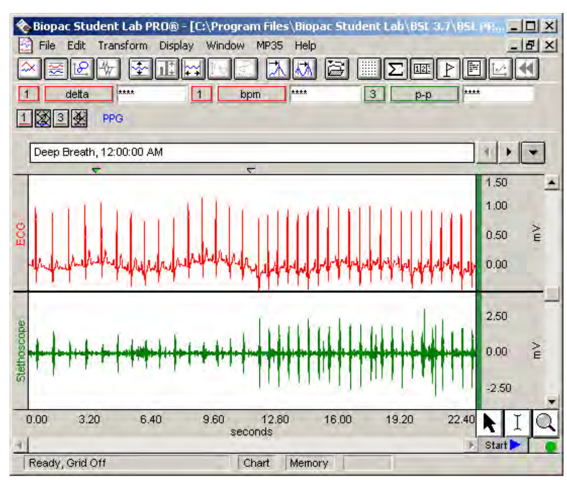
Each channel has a label on the left edge of the track to identify the contents of the channel. When a channel is active, its label is highlighted and also appears by the channel boxes.



To change the label for a given channel, double-click the track label. A dialog will be generated so you can change the text. You can also change the **Label** entry in the **MP35/30 > Setup Channel** dialog. When you change the Label this way, the change will not take effect until you start an acquisition.

Hide a channel

You can "hide" a waveform display without changing the data file. To hide a channel, hold down the **Ctrl** key and click in the channel box. When a channel is hidden, the channel box will have a slash through it. You may view a hidden channel by holding down the **Ctrl** key and clicking in the channel box again. Channels 2 and 4 are hidden in the following display.



- ✓ When the active channel is hidden in Chart or Scope Mode, the first channel (of the remaining enabled channels) becomes the new (default) active channel and its Horizontal and Vertical Scales are displayed.

- ✓ The hide/show function should only be used after acquisition, not during. The entire Graph window will be refreshed when channels are shown or hidden during an acquisition. For large acquisitions, the refresh may interfere with the acquisition and generate an "Acquisition buffer overflow" and stop acquisition.

Selecting an area

Once you have selected a channel, you can "edit" parts of that channel by selecting a section of the waveform. The options available to you include cutting, copying, and pasting sections of waveforms. You can also transform and analyze entire waveforms or specific sections of waveforms.

➢ **IMPORTANT**: When multiple waveforms are present, the highlighted area appears to include all of the waveforms, but most modifications and transformations apply only to the selected channel.

For any of these functions, you will need to use the **I-beam** tool to select (or highlight) an area.

To select the I-beam tool, position the cursor over the icon in the lower right hand corner of the screen and click the mouse button. Now move the cursor to the first point in the area that you wish to select. As you move the cursor into the graph area, you will see it change from an arrow cursor to a standard I-beam editing tool.

To highlight a section of a waveform:

1) Position the I-beam at the left edge of the desired area and hold down the mouse button.
2) Move the mouse to the right until the desired area is selected and then release the mouse button.

To select an area that spans multiples screens:

1) Click the I-beam at the start (left edge) of the section to be highlighted.
2) Use the horizontal scroll bar to move to the desired endpoint (right edge) in the record.
3) Hold down the **Shift** key while you position the cursor and click the left mouse button.

This method of selecting an area allows you to "fine tune" the selected area to include only a specific range of data. To fine tune: coarsely select an area, then zoom in (using the Zoom tool) on either edge and shift-click with the I-beam to precisely select and/or align the edge of the selected area.

To deselect an area:

Click a new point of data with the I-beam tool to deselect the last area.

Once a channel has been selected and a section of data highlighted, you can operate on and edit that section of the waveform. The editing commands behave much the same way as the editing functions in a word processor. You can cut, copy, delete or paste sections of data as defined by the selected area. In most cases (depending on available memory) you may undo an edit by choosing **Undo** from the **Edit** menu, or by using the **CTRL + Z** shortcut.

Selecting a portion of a waveform allows you to apply transformations to a particular area, rather than the entire area or all waveforms. Selecting an area also allows you to take snap measurements for parameters such as delta T, mean, standard deviation, frequency, and so forth. The measurement options are discussed on page 149.

Zoom

Another way to select an area is to use the "zoom" tool. The zoom tool allows you to select any portion of any wave and magnify it for closer analysis.

To use the Zoom tool:

1. Click the icon in the lower right portion of the screen.
2. Positioning the cursor at one corner of the data region of interest and hold down the left mouse button.
3. Drag the crosshair horizontally, vertically, or diagonally to form a "box" which encompasses the area you need to zoom in on.
4. Release the mouse button.

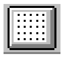
When you draw a Zoom box, the Biopac Student Lab *PRO* software will automatically adjust the horizontal and vertical scales for all waveforms, not just the selected one.

To "unzoom" or repeat the zoom one level at a time, choose **Zoom Back** or **Zoom Forward** from the **Display** menu. You can select either function up to five times per zoom. Keyboard shortcuts are **Ctrl-Minus** (Zoom Back) and **Ctrl-Plus** (Zoom Forward).

You can also use **Zoom/Ctrl-Zoom** to zoom in and out by a factor of 2 without drawing a zoom box.

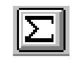
Grids

You can apply several different grid styles to data to help with analysis.

Click the Grid  icon in the toolbar or select **Display > Show > Grids** to toggle grid display on and off.

Select **Display > Show > Grid Options** to set grid options such as locked/unlocked, major/minor divisions, line color, and line width. UNLOCKED grids help you view the data display on the monitor whereas LOCKED grids help more with printing. Using the Grid Options, you can create printouts that look similar to chart recorder output or clinical ECG. See page 166 for Grid details.

Measurements

To display the measurement windows, select **Display > Show > Measurements** or use the  icon

Once you have selected a channel, you can quickly and easily take measurements on each waveform. The following measurements are available (see page 153 for a full explanation of measurements):

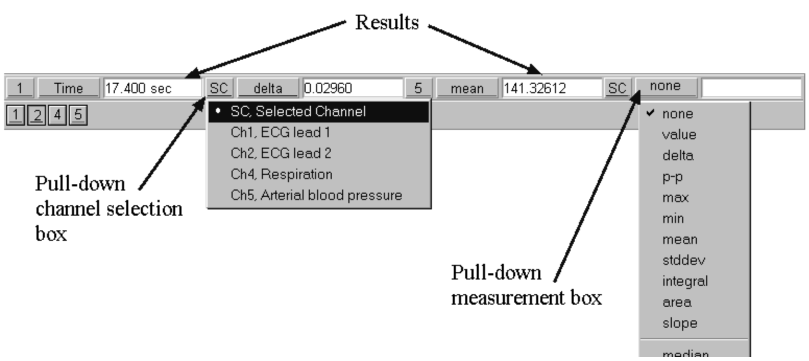
Single-point measurements	***Selected range measurements***
Delta S, Lin_reg, Max, Max T, Min, Min T, Samples, Time, Value, X-axis T/F/X	Area, BPM, Correlate, Delta, Delta S, Delta T/F/X (based on units), Frequency (time domain), Integral, Lin_reg, Max, Max T, Mean, Median, Median T, Min, Min T, p-p, Samples, Slope, Stddev

Measurement Area

It is important to remember that the software is always selecting either a single point or an area spanning multiple sample points. When a single point is selected, the cursor will "blink." Otherwise, the selected area will be highlighted. If an area is defined and a single point measurement is selected (such as Time), the measurement will reflect the last selected point. See page 150 for further explanation.

Measurement Window

Each measurement window consists of three boxes:

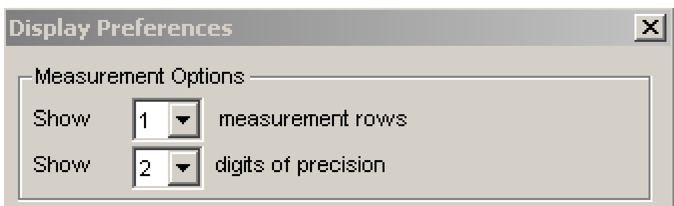


Channel selection	Allows you to calculate a measurement either for the selected channel (SC) or from a numbered channel in the record. To switch between the channel options, click in the channel window. The pop-up menu shows the channel numbers for all channels in the file. By default, each measurement will reflect the contents of the selected channel.

Measurement function Allows you to choose between different types of measurements. To choose a measurement, click the measurement pop-up menu and select a measurement from the list. Depending on the nature of the measurement being taken, the windows can display information regarding a single point or a range of values on the selected channel. Some of the measurements that depend on a selected area look at differences in the horizontal axis, such as the delta T measurement, which returns the difference in time between the first sample point in the selected area and the last sample point in the selected area. Other range measurements also select an area, but use the vertical scale information in calculating measurements, like the peak to peak (p-p) measurement, which computes the difference in amplitude between the maximum value in the selected area and the minimum value in the selected area.

Measurement result Lists the result for the selected measurement across the selected area. If no data is selected, or if not enough data is selected for a meaningful measurement, the measurement result box will display "****." In the following example, the BPM for the selected channel (SC) is 230.7, whereas the mean for the selected area of channel 1 is 0.18030, and the integral calculation for channel 40 is 0.04557.

The number of measurement windows depends on (a) the width of the screen and (b) the number of rows selected in the **File > Preferences > General** dialog box. By default, only one row of measurement windows is displayed. As the screen gets wider, more measurement windows can be displayed in the area above the graph windows.



Transforming data

The Biopac Student Lab *PRO* software includes a vast library of functions, which can transform data or perform mathematical calculations on waveform data. All of these options can be found under the **Transform** menu, and are discussed in detail in the *Transform Menu Commands* section beginning on page 192.

When performing transformations, keep in mind that when a section of a waveform is highlighted, the transformation will apply to that section. Also, if no area is defined, the BSL *PRO* software will always select a single data point. Some transformations can only be performed on a selected area (spectral analysis and digital filtering, for instance), so if a single point is selected the entire waveform will be transformed.

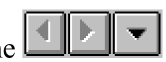
Markers

In many instances it is useful to have the BSL *PRO* software "remember" an occurrence or event during an acquisition so it can be referenced later. For instance, you may want to note when a treatment began or when an external event occurred so you can examine any possible reaction.

The Biopac Student Lab *PRO* software uses "markers" which are placed above the data to record events. "Append markers" are automatically inserted each time you record a new segment in "append" mode, and you can enter an "Event markers" either during an acquisition or after recording (off-line).

- You can automatically insert event markers **during** an acquisition by pressing the **F9** key on a PC. This will insert a marker at the exact time the key is pressed and will activate the text line entry so you can immediately enter a comment to be associated with the marker.
- To enter an event marker **after** the recording session, click the cursor in the area beneath the marker area. This will insert a marker. To add text describing the event, click the cursor in the marker box and key the desired text.

To view the text associated with a marker, position the selection tool over the marker and click the mouse button.

You can also move from marker to marker by using the  icons in the marker toolbar.

Refer to the Marker section on page 164 for a detailed description of markers and marker functions, including options to pre-establish marker labels and set function keys for different labels.

Journals

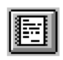
The journal is a general-purpose text editor built into the *PRO* software. The journal is essentially an "electronic notepad" that allows you to record notes and data at the same time you are acquiring data. Using the journal, you can store waveform data (in numeric format) or make notations and comments in a text file. One common function of a journal is to save comments and other similar information about an acquisition in a text file, so that this information can be referenced later. The journal works in connection with Find Peak and other measurement functions to paste in values from waveform data for further analysis.

Once a Journal is open, you can enter text, data or both. To enter text, just click the cursor in the journal area and begin typing. This is especially useful for noting the date and time of a recording, what was involved, and so forth.

You may also paste measurements and waveform data into the journal.

- To paste measurements into an open journal, select the desired area or point and choose **Paste measurements** from the **Edit > Journal** menu. This will paste all visible measurement window data into the journal.
- To paste waveform data into the journal, select the desired area and choose **Paste Wave Data** from the **Edit > Journal** menu. This will insert a text file of the waveform into the journal, where points and trends can be analyzed.

Open a Journal

Click the Journal  icon on the toolbar or choose **Display**>**Show**>**Journal**.
Each graph window has its own "embedded" journal. The journal is displayed below the graph window and will be saved with the graph file.

Resize a Journal

To resize the journal window, click the bar at the top of the Journal window and drag it up (to increase the size) or down (to decrease the size).

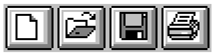
Enter Text

To enter text, just begin typing when the journal is open. To automatically "wrap" the text to fit the screen width, use the wrap option in the **File > Preferences > Journal** submenu. PC users can click the right-mouse button in the Journal window and select **Wrap Text > Wrap to Window** from the shortcut menu. To change the font or tabs of the Journal, use the **Display > Preferences > Journal** dialog.

Time Stamp, Date Stamp and Auto-time functions

 These options are available in the upper left corner of the journal window and refer to the computer's clock to record the time and/or date directly into the Journal. The **Time** option is a clock icon and the **Date** option is a calendar icon. Just click the icon to activate the option. The **Auto-time** function records the time at the instant the carriage return is pressed, which is useful for tagging commands as data is collected. To activate "Auto-time" click the clock icon with the left-pointing arrow.

Journal File Functions

 The Journal file icons perform the following functions (as displayed from left to right):

New The **page** icon will clear the Journal and provide a blank page.
Any Journal entry not saved to a separate file will be lost.

Open The **open folder** icon is used to "load text" from any simple text file, including previously saved journal files. When pressed, the **open folder** icon will generate a standard "Open" dialog. The default file type is "text." Only files of type "text" (.txt) can be opened and loaded into the Journal. Upon selecting a file, the text in the selected file will be "loaded" into the Journal. If there is already text in the Journal, the new text will be inserted at the current cursor location. After insertion, the cursor location moves to the end of the newly inserted text block.

Save The **disk** icon will generate a Save As function dialog. The data in the journal will be saved in simple text (.txt) format.

Print The **printer** icon will generate a Print function dialog.

Paste measurements and data into the journal

To paste measurements into an open Journal, select an area, then select **Edit** > **Journal** > **paste measurements** (Ctrl+M). The measurements in the measurement windows are copied into the Journal. By changing the **Journal Preferences**, you can simultaneously record measurement name, channel number, and units.

Paste waveform data into the journal

To paste waveform data into a journal, select an area, pull down the **Edit** menu, select the **Journal** option and choose **Paste Wave Data** (Ctrl+D). The result is a text file of wave data from the selected area for all channels pasted into the active journal.

Note: See pages 152 and 190 for more information about pasting data to the Journal.

Saving data

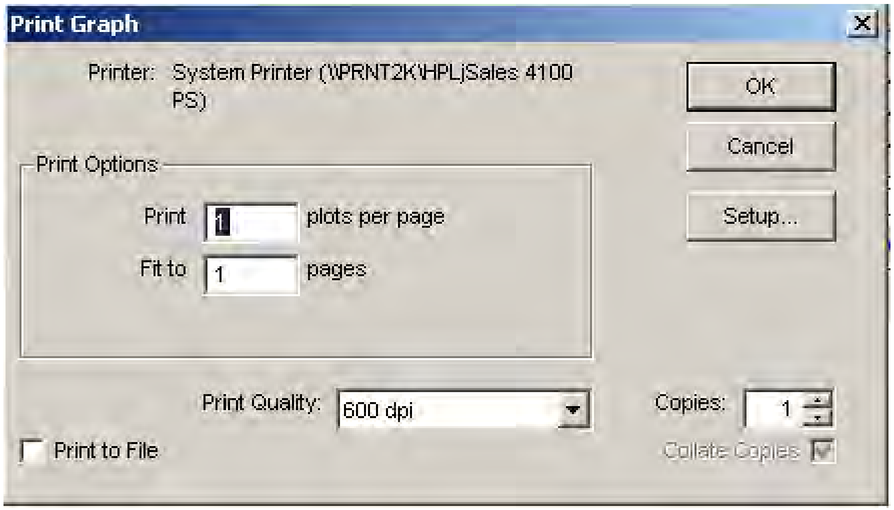
Once data has been collected, it can be saved as a file and opened later. The data file can be moved, copied, duplicated and deleted just like any other computer file. By default, files are saved .ACQ files, which use a proprietary format designed to store information as compactly as possible. Although these files can only be opened with the Biopac Student Lab *PRO* software, the data in these files can be exported either as a text file or as a graphic image.

Exporting data to a text file allows you to examine the data using other programs, such as a spreadsheet or statistical analysis package. Saving data as a graphic (.WMF format) enables you to work with the data in graphic format.

One of the most useful applications of the **Save As** options is the ability to edit and place Biopac Student Lab *PRO* data as it appears on the screen. You can use this feature to paste graphs into word processors, drawing programs, and page layout programs. To learn more about these options, turn to the **Save As** section beginning on page 176.

Printing

In some cases, it is important to have a hard copy of the data. The Biopac Student Lab *PRO* software allows you to produce high-resolution plots of graphs much as they appear on-screen. To print a file, choose **Print** from the **File** menu. An example of the print dialog box follows.



Print dialog box

If you click **OK**, the contents of the screen will be printed on the selected printer.

- To print the entire file, choose **Autoscale Horizontal** from the **Display** menu first, so that the screen contains the entire record.

Often, you may want to print the contents of a file across several pages. To do that, change the value in the **Fit to __ pages** box. Entering “4” in this box, for instance, will place the length of the page evenly across four pages when printing. To find out more about the **Print** command, see page 179.

Chapter 4 Creating Your Own Lessons

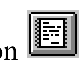
The multi-level learning features of the BSL software let you control the material and method of each experiment. Use our 17 guided- BSL Lessons for introductory concepts, modify them with your own lab procedures or analysis techniques, choose from 35+ *PRO* Lessons for advanced concepts, or easily create your own lessons. You can even use the BSL for graduate programs and advanced research. BSL lesson experiments are included in a number of the leading published lab manuals and have been successfully used to study:

ECG	Biofeedback	Nerve Conduction
EEG	Bioimpedance/Cardiac Output	Pulmonary Function
EMG	Blood Pressure	Respiration
EOG	Heart Sounds	Reaction Time
GSR (EDR)		Temperature

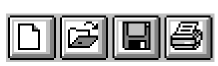
By combining two of the new features it is possible to create your own lessons. The graph template function (described on page 174) allows you to save custom settings. The menu customizing function (described on page 64) allows you to remove menu options that are not required in your lesson. This prevents students from being confused by unnecessary options.

To create your own lesson:

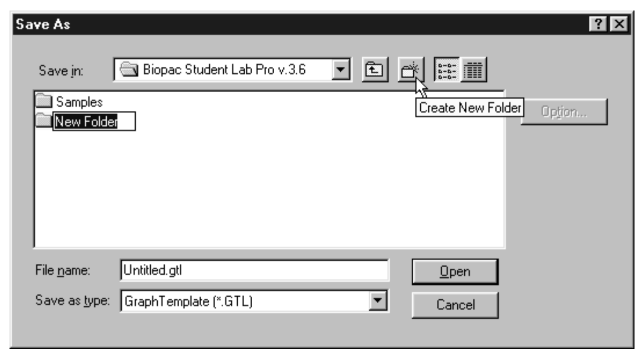
1) Set the channel, acquisition, and display options you require.
2) Type any comments and/or instructions for your students into the Journal window.

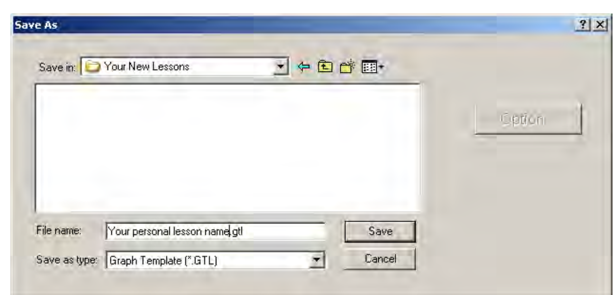
   ➢ To open a journal window: Select Display > Show > Journal or click the toolbar icon .

3) Select “File > Save as” and choose “**Graph Template**” from the file type options in the dialog.
4) **Create a new folder**, then name it appropriately for your lesson.
5) Save as a **graph template** (.gtl) file in the new folder for your lesson. To further protect your file settings, set the Read-only attribute in the file Properties dialog.
6) Clear the Journal window using the **clear journal icon** in the journal tools section.

   Journal tools = 
   clear journal / open file /save file /print journal

7) Copy and revise the Startup menu to turn “OFF” the menu items you do not require (page 64).
8) Save the Startup file as directed.



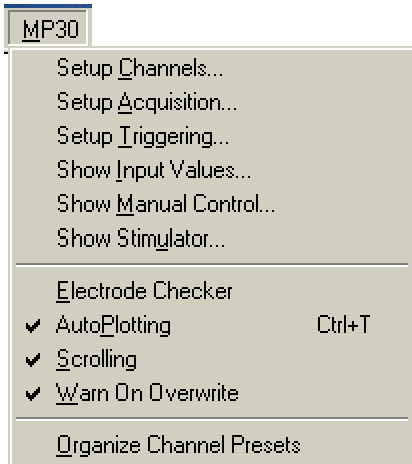


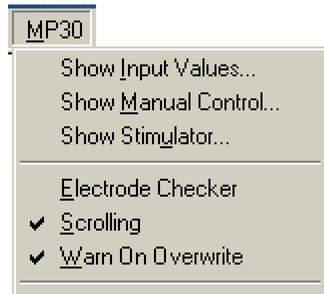
Menu customization will be applied when the BSL *PRO* software is next launched

See Application Note PS202 at **www.biopac.com** for more detailed instructions.

Customizing Menu Functionality

The BSL *PRO* software includes a powerful customization feature that lets you choose the program features to display as menu options. If you have a specific procedure, you can limit the menu options to list only those functions you need, thereby reducing the chance for confusion or error in your lab. For instance, you might want to display (or not display) the menu options for BSL *PRO*, as discussed in “Adding BSL *PRO* Analysis Features to BSL” on page 68.Or you might want to choose to remove Setup options from the MP35/30 menu, as shown below:



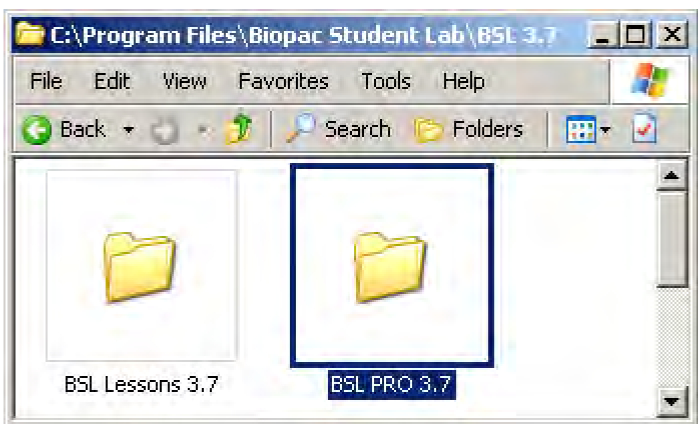


Default MP35/30 menu **Customized MP35/30 menu**

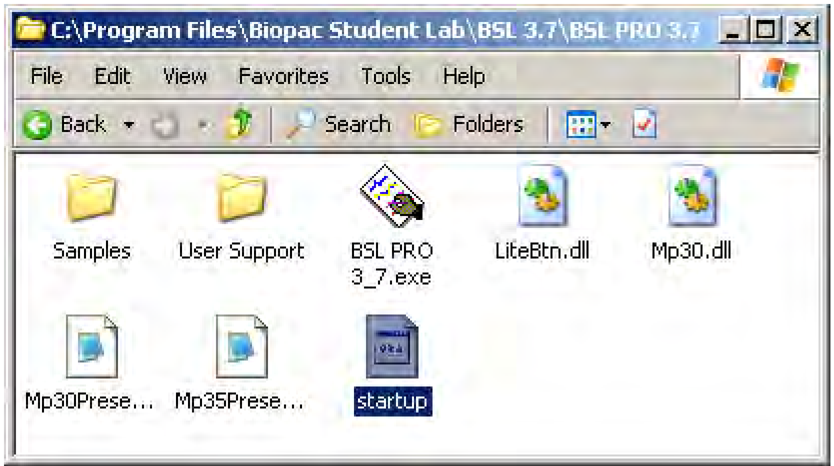
When BSL *PRO* is first launched, a “startup” routine runs to establish any global application variables; translate application prompt and dialog text (mainly if language other than English); remove any menus that are not used in the *PRO*; and check if the MP unit is connected (only if installed for Hardware). If disconnected, it generates the communications error prompt.

Follow the simple procedure below to customize the startup for your own needs.

1) Open the BIOPAC Program folder (default installation used C>Program Files>Biopac Student Lab>BSL 3.7).



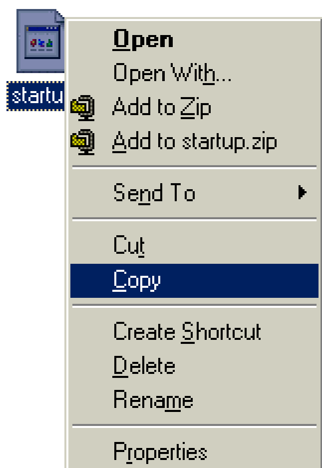
2) Open the BSL *PRO* 3.7 folder.

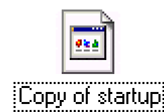


3) Copy the Startup file.

a. Right-click the Startup file and scroll to select "Copy."

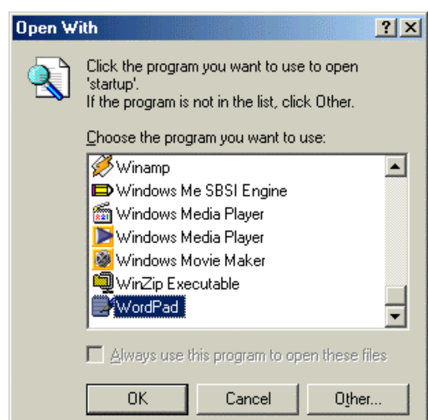
b. Right-click in the folder and scroll to select "Paste."



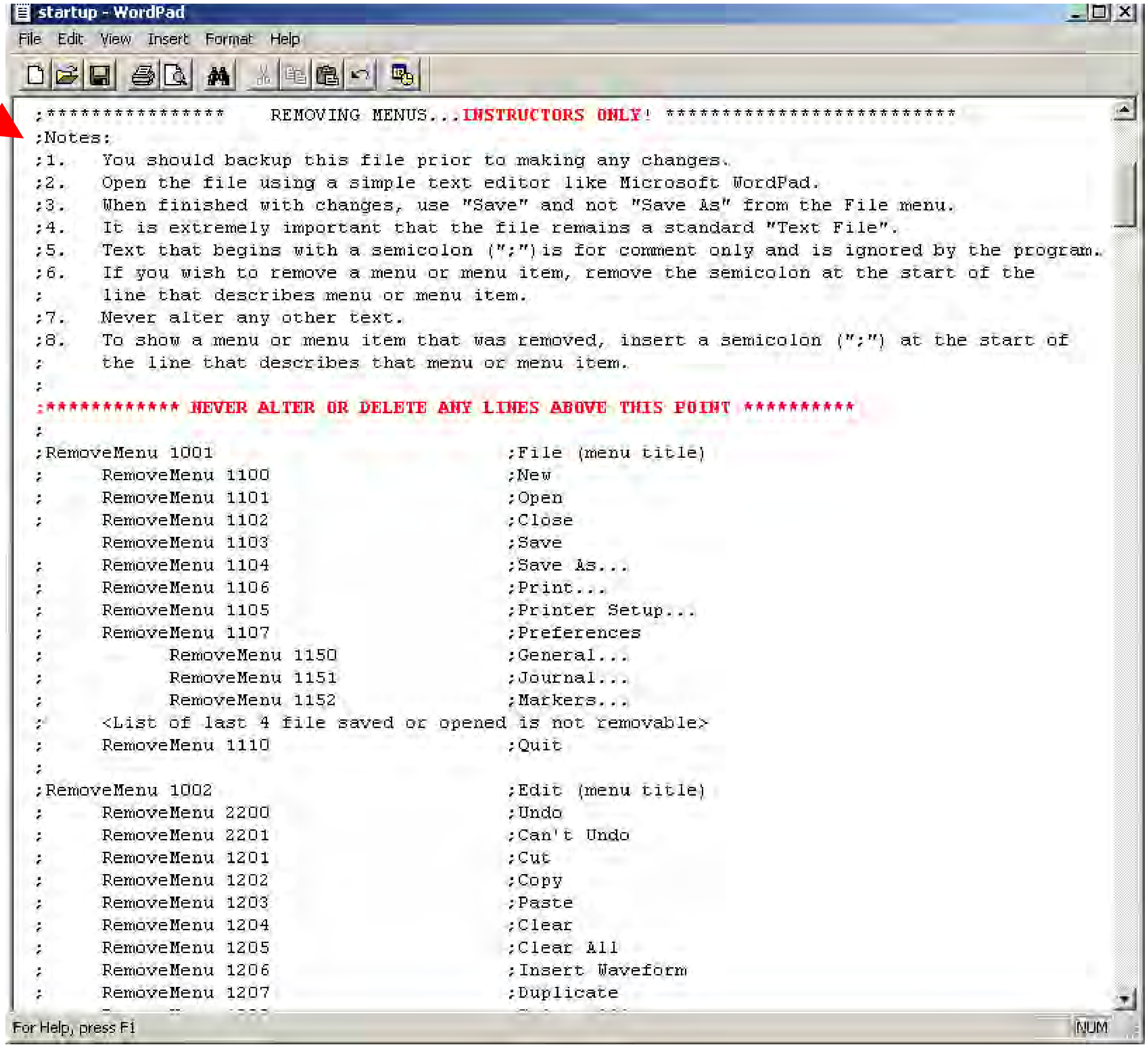


4) Open the original Startup file ("Copy of startup" is for backup).

a. Choose to select a program from a list and select Microsoft **WordPad** if prompted for a program to open Startup with.



5) Follow the instructions provided in the Startup file.




```
;****************    REMOVING MENUS...INSTRUCTORS ONLY! ***************************
;Notes:
;1.    You should backup this file prior to making any changes.
;2.    Open the file using a simple text editor like Microsoft WordPad.
;3.    When finished with changes, use "Save" and not "Save As" from the File menu.
;4.    It is extremely important that the file remains a standard "Text File".
;5.    Text that begins with a semicolon (";")is for comment only and is ignored by the program.
;6.    If you wish to remove a menu or menu item, remove the semicolon at the start of the
;      line that describes menu or menu item.
;7.    Never alter any other text.
;8.    To show a menu or menu item that was removed, insert a semicolon (";") at the start of
;      the line that describes that menu or menu item.
;
;************ NEVER ALTER OR DELETE ANY LINES ABOVE THIS POINT **********
;
;RemoveMenu 1001                          ;File (menu title)
;      RemoveMenu 1100                    ;New
;      RemoveMenu 1101                    ;Open
;      RemoveMenu 1102                    ;Close
       RemoveMenu 1103                    ;Save
;      RemoveMenu 1104                    ;Save As...
;      RemoveMenu 1106                    ;Print...
;      RemoveMenu 1105                    ;Printer Setup...
;      RemoveMenu 1107                    ;Preferences
;            RemoveMenu 1150              ;General...
;            RemoveMenu 1151              ;Journal...
;            RemoveMenu 1152              ;Markers...
;      <List of last 4 file saved or opened is not removable>
;      RemoveMenu 1110                    ;Quit
;
;RemoveMenu 1002                          ;Edit (menu title)
;      RemoveMenu 2200                    ;Undo
;      RemoveMenu 2201                    ;Can't Undo
;      RemoveMenu 1201                    ;Cut
;      RemoveMenu 1202                    ;Copy
;      RemoveMenu 1203                    ;Paste
;      RemoveMenu 1204                    ;Clear
;      RemoveMenu 1205                    ;Clear All
;      RemoveMenu 1206                    ;Insert Waveform
;      RemoveMenu 1207                    ;Duplicate
```

The Startup script is sensitive to syntax errors, font change, name change, etc., so **be extremely careful** not to change anything — just add or delete semicolons at the start of the line that contains the menu item you want to change.

a. Remember to use **File** > **Save** (*not* Save As!) to save your changes so the script file name is exactly the same — the program will not recognize an altered file name.

b. Do not alter lines above or below the specified area.

c. To **hide** a menu/menu item, delete the semicolon (“**;**”) at the start of the line that lists it.

```
;
;RemoveMenu 5000                          ;MP30 or MP35 (Menu title)
        RemoveMenu 5100                   ;Setup Channels...
        RemoveMenu 5101                   ;Setup Acquisition...
        RemoveMenu 5102                   ;Setup Triggering...
;       RemoveMenu 5104                   ;Show Input Values...
;       RemoveMenu 5103                   ;Output Control
;               RemoveMenu 5201           ;CH X (CH3 for MP30. CH1, CH2, CH3 or CH4 for
;               RemoveMenu 5202           ;Digital Outputs (MP35 only)
                RemoveMenu 5203           ;Pulses
;               RemoveMenu 5204           ;Voltage
                RemoveMenu 5205           ;Stimulator - BSLSTM
                RemoveMenu 5207           ;Stimulator - SS58L (MP35 only)
;       RemoveMenu 5110                   ;Electrode Checker
;       RemoveMenu 5106                   ;AutoPlotting
;       RemoveMenu 5107                   ;Scrolling
;       RemoveMenu 5112                   ;Warn On Overwrite
;       RemoveMenu 5111                   ;Organize Channel Presets
```

d. Tc **how** a menu/menu item, add a semicolon (“**;**”) at the start of the line that lists it.

```
;
;RemoveMenu 5000                          ;MP30 or MP35 (Menu title)
;       RemoveMenu 5100                   ;Setup Channels...
;       RemoveMenu 5101                   ;Setup Acquisition...
;       RemoveMenu 5102                   ;Setup Triggering...
;       RemoveMenu 5104                   ;Show Input Values...
;       RemoveMenu 5103                   ;Output Control
                RemoveMenu 5201           ;CH X (CH3 for MP30. CH1, CH2, CH3 or CH4 for
;               RemoveMenu 5202           ;Digital Outputs (MP35 only)
;               RemoveMenu 5203           ;Pulses
;               RemoveMenu 5204           ;Voltage
;               RemoveMenu 5205           ;Stimulator - BSLSTM
;               RemoveMenu 5207           ;Stimulator - SS58L (MP35 only)
;       RemoveMenu 5110                   ;Electrode Checker
;       RemoveMenu 5106                   ;AutoPlotting
;       RemoveMenu 5107                   ;Scrolling
;       RemoveMenu 5112                   ;Warn On Overwrite
;       RemoveMenu 5111                   ;Organize Channel Presets
```

6) Select File>Save to save the revised Startup file.
   a. DO NOT USE the “SAVE AS” option.

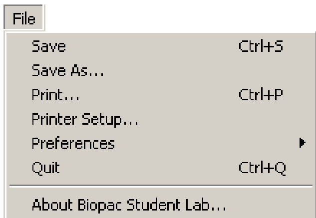
7) Restart the BSL *PRO* 3.7 program.

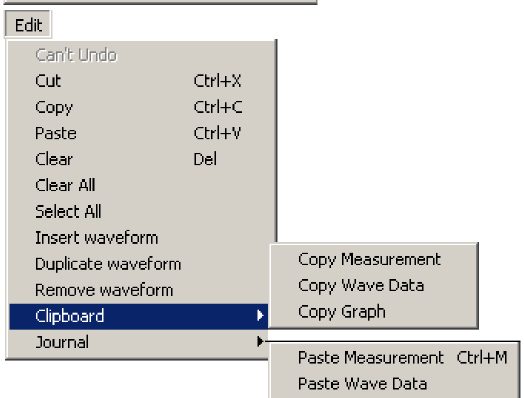
8) Check your menu listing.
   a. The MP menus on page 64 show the result of changing the MP35/30 Menu items per step 5e above. Note that the Setup options, AutoPlotting, and Organize Channel Presets are no longer included in the menu listing (rather than simply being disabled and grayed-out).
   b. If you have the desired menu result, you may delete “Copy of Startup” from the program folder.

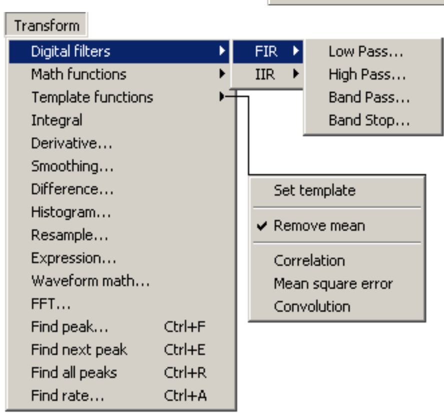
Adding BSL *PRO* Analysis Features to BSL Review Saved Data Mode

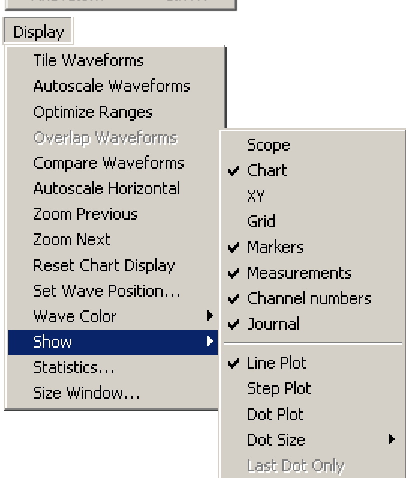
The primary difference between each level of the Biopac Student Lab is the number of software options employed. The standard version uses pre-configured lessons to manage the setup, collection, and analysis of data. The *PRO* version affords a greater degree of control over the setup and data collection parameters, although with a slightly different "look and feel." The following *PRO* features can be activated within Review Saved Data mode of the BSL Lessons:

BSL *PRO* Analysis Tools in RSD Mode

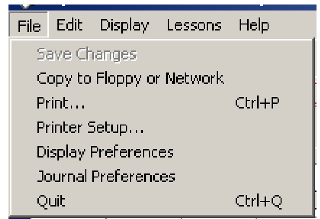


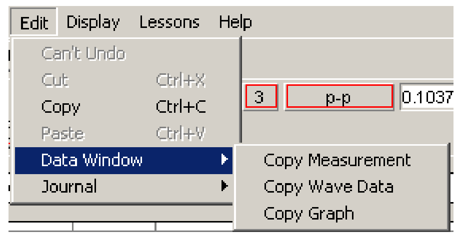


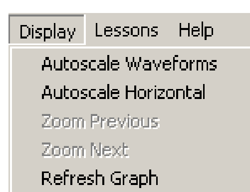




Default BSL Analysis Tools

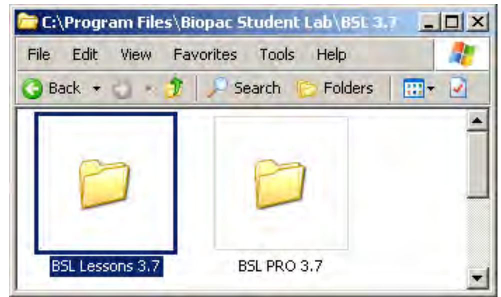






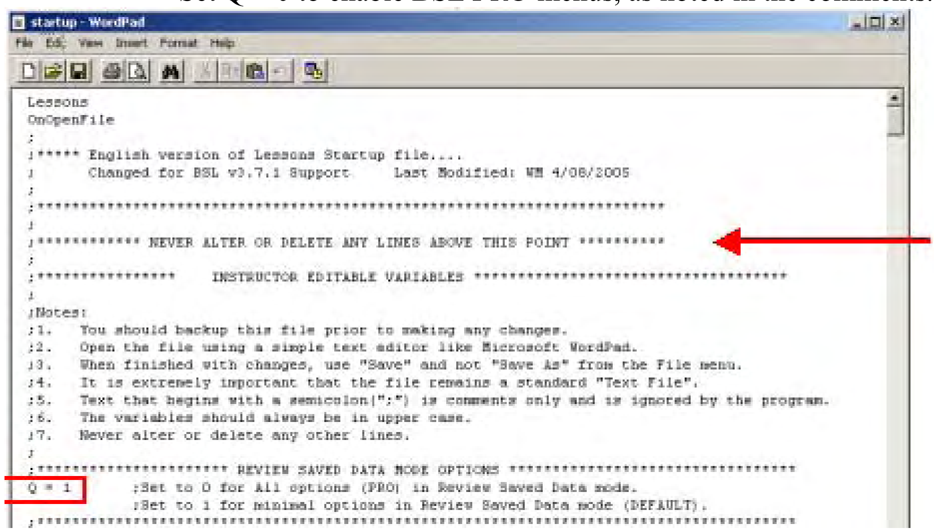
To activate the *PRO* software features for the *Review Saved Data* mode of the BSL Lessons, you must set the *PRO* menu option in the BSL Lesson startup file. The procedure is outlined below, and more fully detailed in “Customizing Menu Functionality” on page 64.

1) Locate the BIOPAC Program folder (default installation used C>Program Files>BIOPAC).
2) Open the BSL v 3.7 folder.
3) Open the BSL Lessons Folder.
4) Copy the Startup file to create a backup.
5) Open the original Startup file (not the copy) with a text editor such as Word Pad.



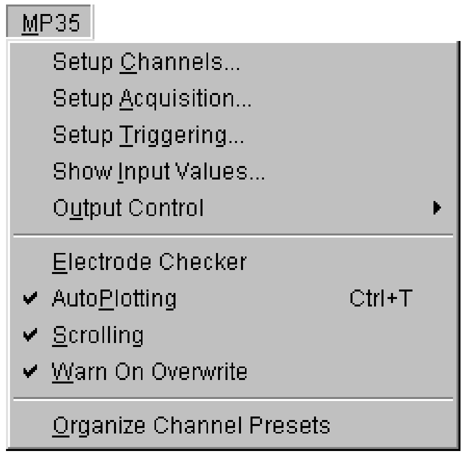
6) Locate the “REVIEW SAVED DATA MODE OPTIONS” section.

Set Q = 0 to enable BSL *PRO* menus, as noted in the comments.



7) Select File>Save to save the revised Startup file.
   - DO NOT USE the “SAVE AS” option. The file must retain the exact same name as the original startup file.
8) Close the Startup file.
9) Restart the BSL program.
10) Check the menu listings.
   - If you have successfully configured the startup script, the menus will now have the BSL *PRO* options specified on page 68 and you may delete the copy of the startup file that you created as a backup from the program folder.

Part C — Acquisition Functions: The MP35 Menu



This section describes the various acquisition parameters for the Biopac Student Lab *PRO* that can be set under the MP35 Menu. Acquisition is defined as data collection from an external source (such as electrodes connected to an MP35 input channel). Biopac Student Lab *PRO* software adds acquisition and control capability to the BSL System. The **MP35 Menu** commands and procedures can be used to:

a) Setup channels for data acquisitions

b) Control acquisition parameters such as sampling rate and duration

c) Perform online calculations and apply digital filters

d) Set acquisitions to begin on command from a mouse click or external trigger

e) Display values numerically and graphically during an acquisition

f) Output waveforms and digital signals during an acquisition

g) Control the on-screen waveform display characteristics

Note: The Setup Channels and Setup Acquisition menu items are inactive (grayed) during acquisition.

Recording Data (Part B) covered some of the basic functions involved in setting up an acquisition. This section will cover the same functions in more detail, as well as describe some features not discussed in Part A or Part B. All the commands covered here can be found under the **MP35** menu.

Chapter 5 Recording Basics — Acquisition Overview

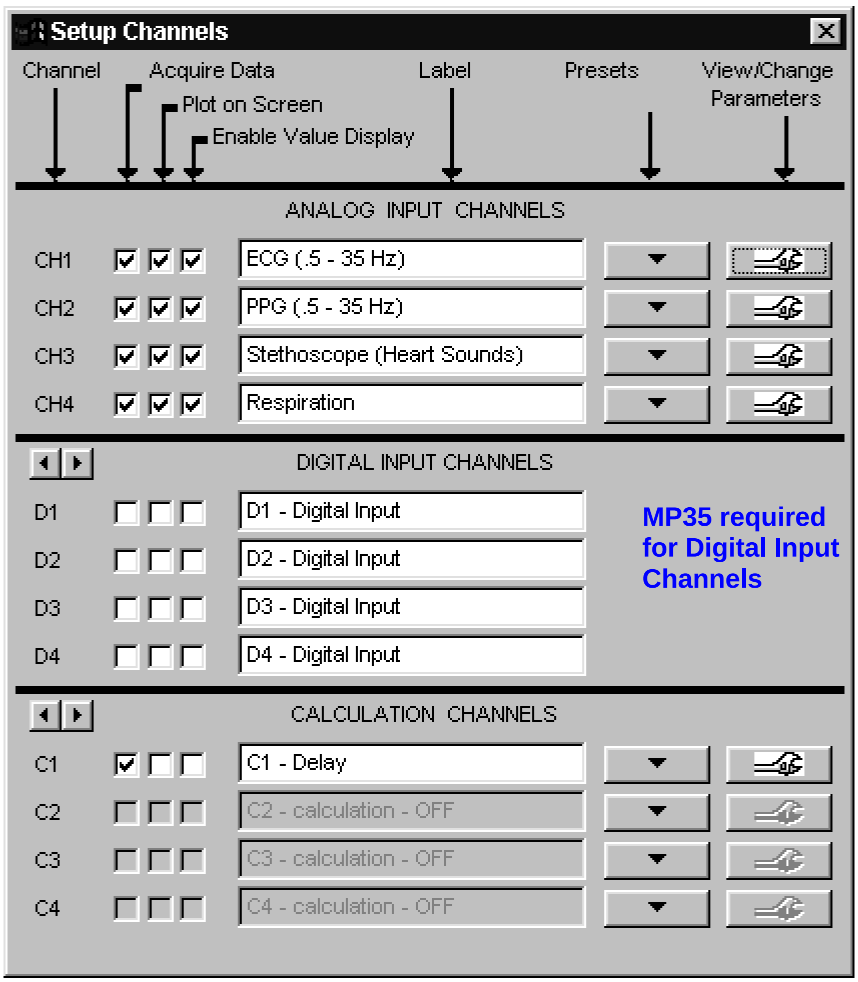
Setup Channels

Basic *PRO* Channel Setup

Before you acquire data, you must specify which channels you will collect data from and establish their respective input parameters. The first step is channel setup. To access the channel setup options, select **Setup Channels** from the MP35 menu.

The minimum setup is to acquire analog data from one channel, which is the default (on CH1). You must set **Setup Channels** options prior to starting the acquisition. You cannot change the channel setup during acquisition. The **MP35/30** > **Setup Channels** menu item is inactive (grayed) during acquisition.

BSL *PRO* can record and display up to **four analog input signals** from devices connected to the analog inputs on the front of the MP35 Acquisition Unit. It can record and display signals from up to eight **digital inputs signals** connected to the I/O port on the back of the MP35. In addition, BSL *PRO* can perform **calculations** based on the inputs and display and save them as separate signals. All three types of signals are referred to as “channels.”



The **Setup Channels** dialog is divided into sections for **Analog Input Channels**, **Digital Input Channels**, and **Calculation Channels**. Each channel type has options for:

a) Acquire Data
b) Plot on screen
c) Enable Value Display
d) Label

Analog Input and Calculation channels have options to select **Presets** and **View/Change Parameters**.

Note: Setup options function similarly for each channel type, although there are considerable differences between the types of data each channel is designed to handle. Setup options will be discussed briefly here. See the **Advanced Channel Setup** beginning on page 73 for more details.

Setup Channels Dialog

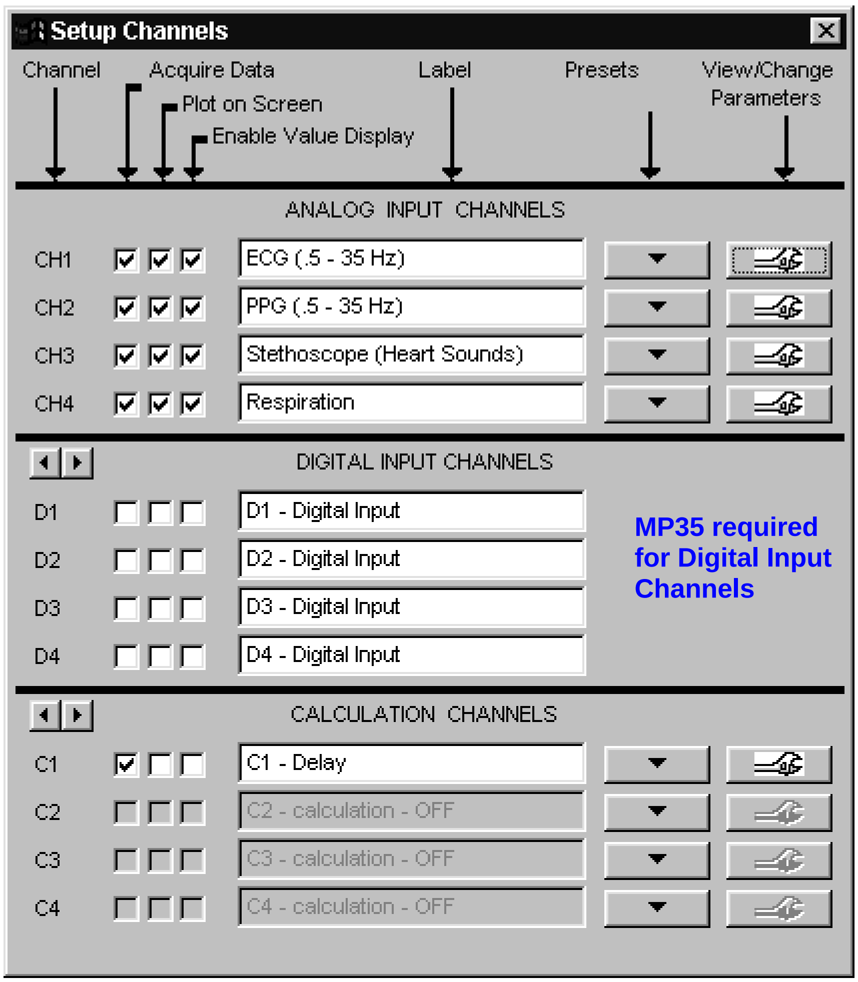
Channel	Channels are designated alpha-numerically. **Analog** (or continuous) Input channels begin with “**CH**” and run from CH1-CH4. **Digital** Input channels begin with “**D**” and run from D1-D8. **Calculation** channels begin with “**C”** and run from C1-C12. Display is limited to four channels of each type. Use the scroll button to set up additional Digital and Calculation channels.
Acquire Data	The **Acquire data** box must be checked for the software to collect data from a channel.
Plot on Screen	The **Plot on Screen** box indicates whether or not data for each channel will be plotted on the screen. When unchecked, data will still be collected (if the Acquire box is checked), but it will not be displayed during the acquisition.
Enable Value Display	This option enables incoming data values to be displayed during an acquisition, either numerically and/or in “bar chart” format. Values are displayed in a separate **Show Input Values** window activated under the **MP35** menu.
Label	You may attach an editable “label” to each channel. Channel labels allow you to provide a brief description for each channel. To change the label for any channel, position the cursor in the **Label** box and revise the text.
Presets	Preset parameters are provided for specific kinds of physiological data (e.g., ECG, EEG. EMG, etc.). Set the preset the parameters for each channel to match the type of data you are collecting. The preset values are designed to be good starting points for most acquisitions, though you may wish to modify them for your particular laboratory situation. Click the **Presets** button to generate a list of available presets. Scroll to select the Preset you want to apply to the selected channel. You can also establish custom parameters and save your own Presets. Presets are available for Analog Input and Calculation channels but not for Digital Input channels.
View/Change Parameters	Click the Settings button to generate an Input Parameters dialog for the selected Preset. To access the scaling parameters, click the **Scaling** button at the bottom of the Parameters dialog. View/Change Parameters options are available for Analog Input and Calculation channels but not for Digital Input channels.

Advanced Channel Setup

The previous section covered the basic options used in almost all acquisitions. In addition to the features described above, a number of other options are available in terms of setting up channels. These advanced features are also found under the **MP35>Setup Channels** menu item.

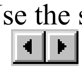
Most acquisitions involve collecting analog signals and then displaying them on screen. It is frequently useful, however, to collect other types of data (digital data, for instance) or to perform transformations (calculations) on data as it is being acquired or after it has been acquired.

The **Setup Channels** dialog is divided into three sections, **Analog Input Channels**, **Digital Input Channels**, and **Calculation Channels**. For each channel you wish to collect data on, there are three options: **Acquire Data**, **Plot on Screen**, and **Enable Value Display**. The general features (acquiring, plotting, enabling value display, labeling) are the same for each type of channel, although there are considerable differences between the types of data each channel is designed to handle. Additional options for Analog Input channels and Calculation channels allow you to set **Presets** and **View/Change Parameters**.



Channel

This is the alpha-numeric channel designation. **Analog Input** channels are designated CH1-CH4, **Digital Input** channels are designated D1-D8 and **Calculation** channels are designated C1-C12. The dialog displays only 4 channels at a time. Use the scroll button to display and set up additional Digital Input and Calculation channels.

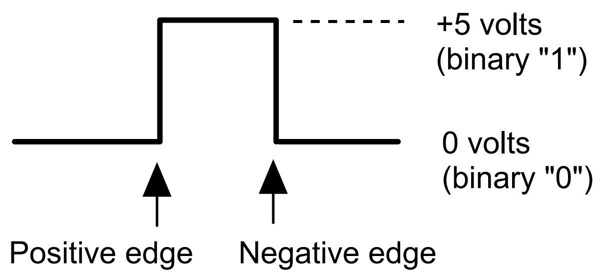


Channel Types

Acquisitions involve collecting analog or digital signals and then displaying them on screen. It is frequently useful, however, to perform transformations on data as it is being acquired, or after it has been acquired. Channels containing transformed data signals are referred to as Calculation channels. The MP35 can collect up to four Analog Input channels, 8 Digital Input channels, and 12 Calculation channels. Analog and digital channels may be acquired in any combination, and the only requirement for Calculation channels is that they be based on at least one input channel (either analog or digital).

Analog Input channels are the most common type of channel and are used to acquire any data with "continuous" values. Examples of this include nearly all physiological applications where input devices (transducers and electrodes) produce a continuous stream of varying data. The range of values for analog channels is typically in the range of ±50 mV, although voltages as high as ±50 V can be measured with BSL *PRO*. BSL *PRO* records and displays up to four analog signals from devices connected to the analog input ports on the front of the MP35 Acquisition Unit.

Digital Input channels, in contrast to analog input channels, are designed to collect data from a signal source with only two values (0 and 1). This type of data can be useful in recording whether a switch is open or closed, and ascertaining if a device is on or off, as in reaction time studies or control applications. Input values for digital channels have two values, +5 Volts and 0 Volts. The MP35 interprets +5 Volts as a digital 1 and interprets 0 Volts as a digital 0. Since digital channels have a fixed value, the parameters and scaling options are disabled for these channels. The main function of digital channels is to track on/off devices such as push-button switches and/or to receive digital signals output by timing devices. Similarly, these channels are also used to log signals from devices that output auditory/visual stimulus for examination of stimulus response patterns. BSL *PRO* records and displays up to eight digital signals from devices connected the I/O port on the back of the MP35 acquisition unit.



Digital Input Channels Have a Fixed Value

Calculation channels transform incoming data in some way (rather than collect external data as input channels do). The original data is not altered — it is just stored in a modified form on a new channel. You can use Calculation channels to compute a host of new variables by using transformations (such as BPM, integration calculations, and math functions).

Up to 12 Calculation channels can be acquired. You may use the output of one Calculation channel as the input for another channel, as long as the output channel has a higher channel number than the input channel. In other words, it is possible for Calculation channel 3 to include the result of Calculation channel 1, but not the other way around. This allows for complex Calculations to be performed that involve two or more Calculation channels, such as filtering ECG data then computing BPM.

Each Calculation channel acquired will reduce the maximum possible sampling rate and increase the amount of memory required to store data both during and after an acquisition. Thus, you may want to consider performing some of these functions after the fact if high sampling rates are needed for your particular application.

Notes: Calculation channels are OFF by default. To turn a Calculation channel on, click the ▼ Presets button for that channel and make a selection from the menu.

✓ TIP All of the calculations that can be performed online can also be performed after an acquisition has been completed. These options are available under the Transform menu.

Acquire Data

Check the option **Acquire Data** if you wish to collect data on a channel. Unless you specify otherwise, BSL *PRO* by default will only collect data on Channel 1. To collect data on other channels, position the cursor over the **Acquire** box (on the far left) and click the left mouse button. Toggle the Acquire box to uncheck.

- With BSL *PRO*, it is possible to leave hardware connected to the MP Acquisition Unit, but have the software essentially "ignore" the channel by leaving the **Acquire** box unchecked. Thus, if an input device (such as a force transducer) is connected to the CH3 input on the MP, data from that channel will not be collected unless the CH3 **Acquire** box is checked.

Plot on Screen

The second option determines whether or not data for each channel will be plotted on the screen. In most cases, you will want to check this option. When this box is left unchecked, data will still be collected when the Acquire box is checked, but it will not be displayed during the acquisition.

Disabling **Plot on Screen** can be useful for

a) Large scale acquisitions (i.e., multiple channels and/or high sampling rates). This will allow for faster display rates (see Appendix B - *Hints for working with Large Files* for other options).

b) Calculation channel setup. For example, you may need the ECG Rate data for a calculation, but not need to see the ECG display.

Enable Value Display

The third option enables incoming data values to be displayed either numerically and/or in a "bar chart" format in a separate window during an acquisition. Checking **Enable Value Display** allows you to open an **Input Values** window (by choosing **Show Input Values...** under the **MP35** menu) that displays the value for each input that has the **Enable Value Display** option checked.

- This option is especially useful for tracking slowly changing values such as heart rate, respiration rate, or concentrations of chemicals in a substance. For more information on how input values are displayed, please turn to page 142.

✓TIP Hold down the Ctrl (PC) or Option (Mac) key while you check an Acquire, Plot, or Enable Value Display box to toggle the entire column of boxes for that option. In other words, if none of the Acquire boxes are checked and you check the Acquire box for CH1 with the Ctrl key depressed, the Acquire boxes will be checked for all channels. If the Acquire box for CH1 is then unchecked while the Ctrl key is depressed, the Acquire boxes for all channels will be unchecked.

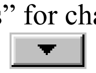
Label

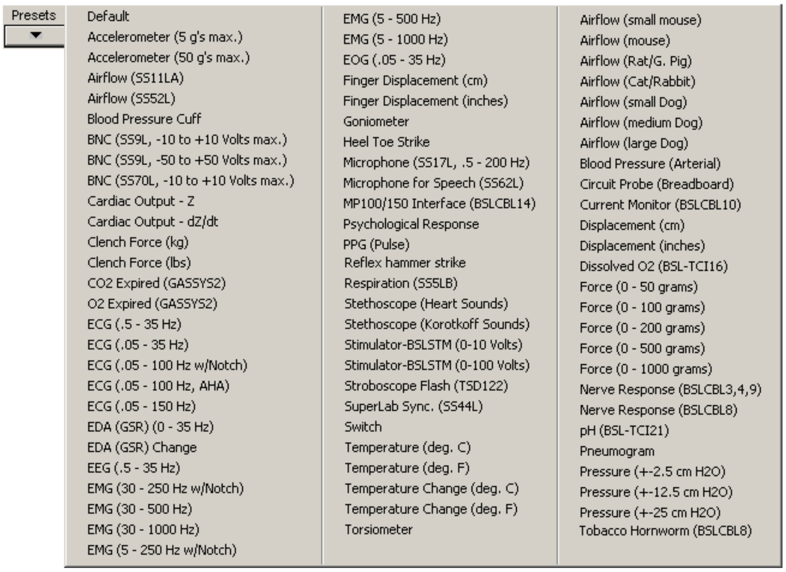
You may attach an editable "label" to each channel to provide a brief description for each channel. To change the label for any channel, position the cursor in the **Label** box and enter a text label. You may key up to 38 characters.

When a Preset is selected, a corresponding preset Label description will be automatically entered.

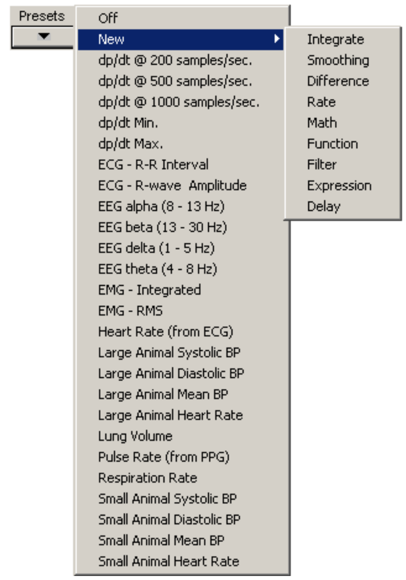
A channel's label is used in the display window and for a variety of software dialogs. If you revise a label entry, the change will display after you start an acquisition.

Presets

Presets are like "templates" for channel parameters. There are two ways to establish channel parameters. You make a selection from the **Presets**  menu and (1) use the corresponding default parameters or (2) modify the Preset using the View/Change Parameters  tool.



Analog Input Channel presets



Calculation Channel Presets

Click the **Presets** button  to generate a list of available presets. Scroll to select the Preset you want to apply to the selected channel. When you select a Preset, the channel **Label** will change to reflect the selected preset name.

Preset parameters are provided for specific kinds of physiological data (e.g., ECG, EEG, EMG, etc.). Set the preset the parameters for each channel to match the type of data you are collecting. The preset values are designed to be good starting points for most acquisitions, though you may wish to modify them for your particular laboratory situation. You can also establish custom parameters and save your own Presets.

Analog Input Presets and Calculation Presets are mutually exclusive and control different settings, as appropriate for the type of data each channel contains. Presets are not available for Digital Input channels.

See **Channel Presets** on page 92 for more information. The **Table of Analog Presets** beginning on page 250 and the **Table of Calculation Presets** beginning on page 260 provide details on the settings that each preset specifies.

An important concept to understand about Presets is that each channel uses its own set of parameters. When you select a Preset, the software performs a one-way dump into the channel to establish the parameters. Once the preset parameters are set in the channel, the settings are no longer tied to the Preset. That is to say, any modifications you make to the settings in the Input Parameters dialog after you select the Preset will affect only that channel, not the Preset file. If you choose the Preset from the menu again, the original, default settings of the Preset will be used.

If you want to create a new preset so your modified parameters are available for other channels, just change the **Channel Preset** name to a new, unique name. This enables the **New Channel Preset** button. Click the button to create a new Preset with the parameters you establish.

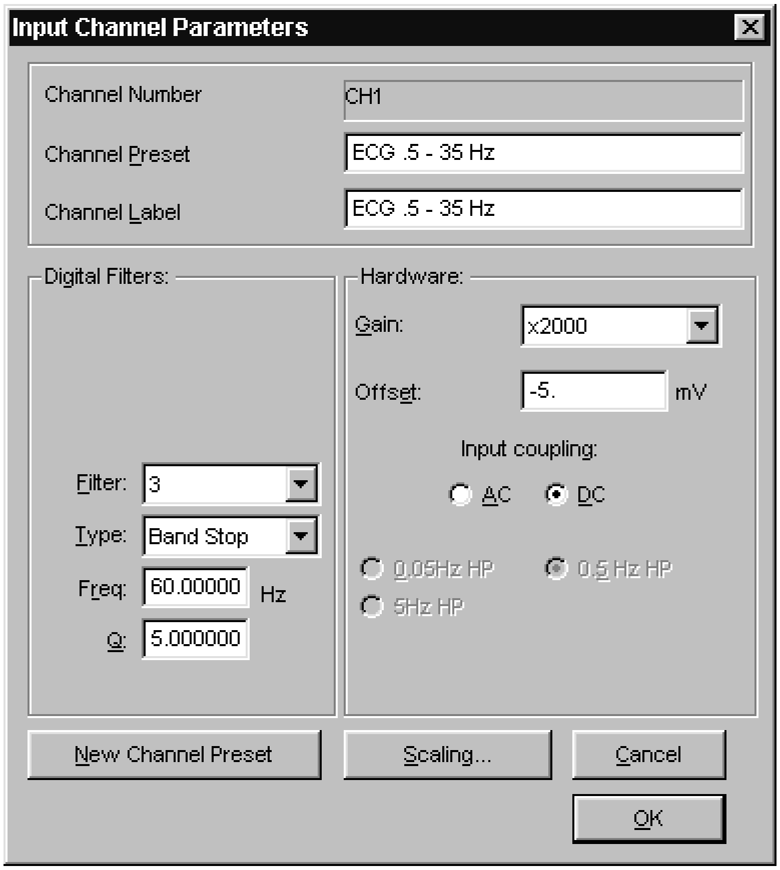
You will see the following dialog if you have been successful:

Note: You can use the Organize Channel presets option from the MP35 menu to rename, rearrange or delete Presets. For instance, you might move frequently used Presets to the top of the list. See page 145 for more information.

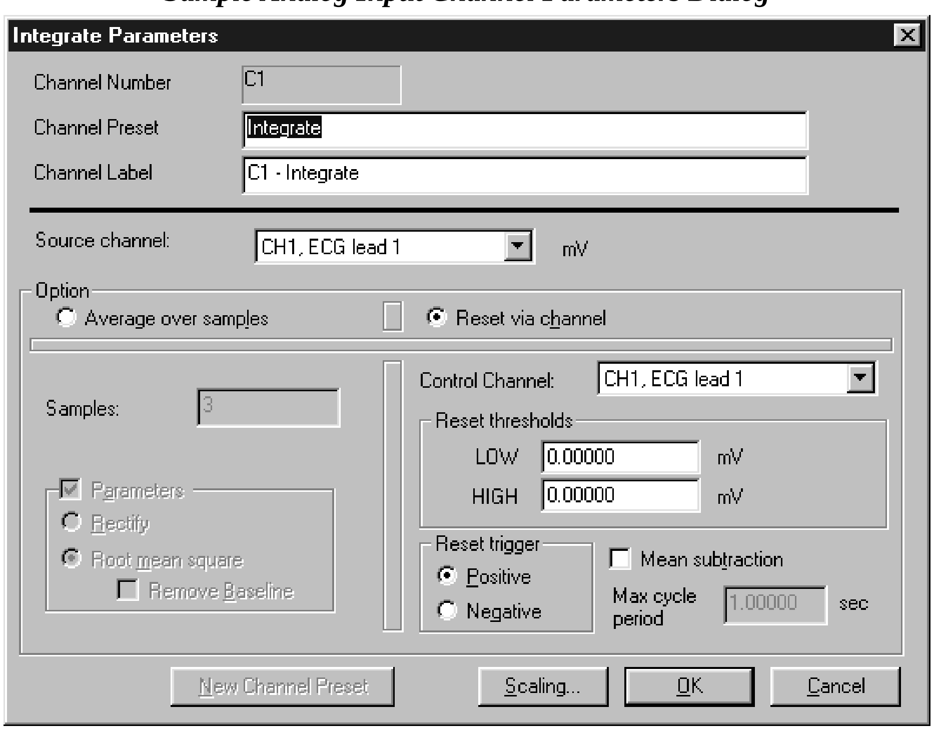
You can use the **Save As Template** option from the File menu to save setup parameters in a BIOPAC graph template file (.gtl). A Graph Template never contains data; it only contains the setup parameters. Templates only save MP35 Menu functions — this includes calculation channel functions, but not their Transform menu counterparts. Graph templates will open to the same window displays and positions you closed the file with. See page 174 for more information.

View/Change Parameters

The settings for a Preset can be accessed via the **View/Change Parameters** button in the **Setup Channels** dialog. This will generate an **Input Channel Parameters** dialog for the specified channel Preset.



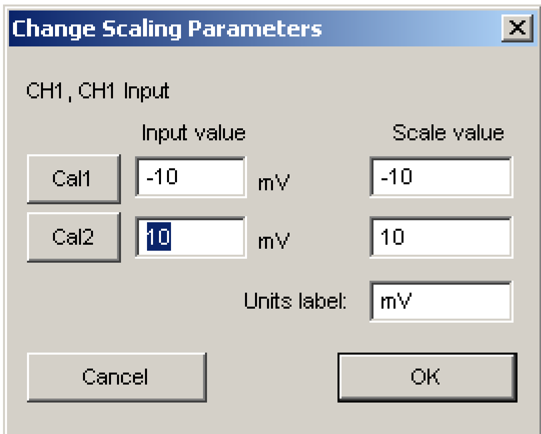
Sample Analog Input Channel Parameters Dialog



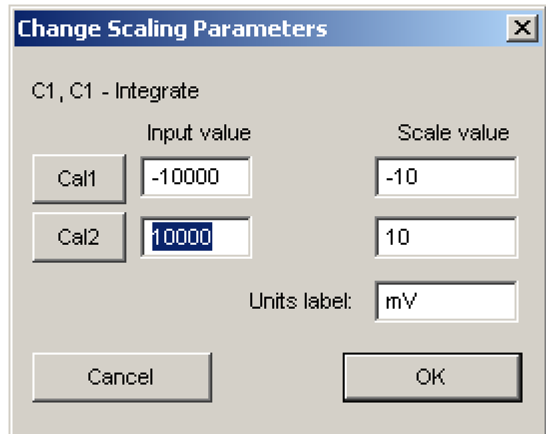
Sample Calculation Channel Parameters Dialog

Scaling

To access the scaling parameters, click the **Scaling** button at the bottom of the Parameters dialog. This generates the Change Scaling Parameters dialog.



Analog Scaling



Calculation Channel Scaling

Scaling options vary based on the channel type. For Calculation channels, the Input value must be 1,000x the Scale Value for a 1-to-1 scaling (mapping) result. See the following pages for further explanation of scaling.

Analog scaling

The *PRO* software allows you to rescale the signal on analog channels to more meaningful numbers. As an example, let's say a temperature transducer is connected to channel 1. Ordinarily, the values from the input channel would be read in as milliVolts. For this acquisition, the signal from the transducer should be expressed in terms of degrees Fahrenheit.

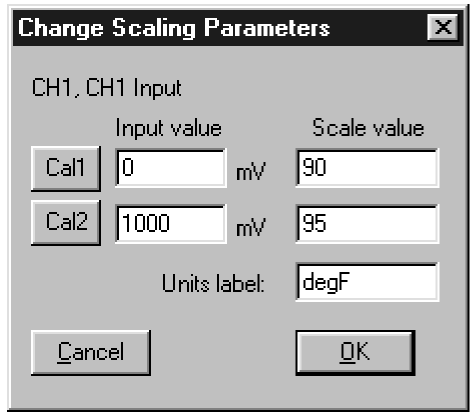
To calibrate the transducer, you would bring it to two known temperatures. At the first temperature you'd take a voltage reading by selecting **Show input values** from the **MP35** menu. At 90° F, you'd get a reading of 0 Volts. The transducer would then be brought to a temperature of 95° F, and you'd get a reading of +1 Volts.

To have the software map the incoming signal to degrees F, click the "**Scaling**" button at the bottom of the **Parameters** dialog to open the **Change Scaling Parameters** dialog.

The **Input value** and **Scale value** boxes reflect the value of the incoming signal and how it will be plotted on the screen, respectively. Enter these numbers into the Channel Scaling Parameters box, type in the new units as "degrees F," and click the **OK** button. Then click OK again to close out of the Input Channel parameters.

See **Calibration Guidelines** on page 273.

The software calculates the slope and offset from the two points entered. Each data sample from channel 1 will be scaled according to the slope and offset calculations previously made. When an acquisition is performed, the amplitude scale (vertical axis) will reflect the rescaled units.



Scaling set to rescale from Volts to degrees Fahrenheit

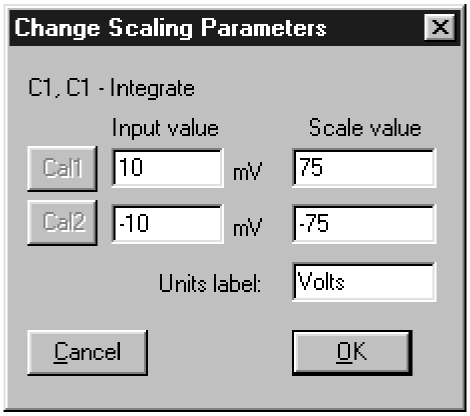
Note: An incoming signal of +1 Volts would be plotted as 95° F, whereas a signal of 0 Volts would be plotted as 90° F. The software will perform linear extrapolation for signal levels falling outside this range (i.e., -2 Volts will be mapped to 80 ° F), as well as perform similar interpolation for values between this range.

As a shortcut for scaling analog channels, you can use the **Cal 1** and **Cal 2** buttons. Click either one of these buttons to read the current voltage for the selected channel. Set the transducer to a known value (i.e., temperature) and click the **Cal 1** button, then enter the value in the **Scale value** box for **Cal 1**.

Then bring the transducer to another known value that is considerably higher or lower than the first, click **Cal 2** and enter the new known value in the **Scale value** box for **Cal 2**. The software calculates the slope and offset from the two points entered. Each data sample from the selected channel will now be scaled according to the slope and offset calculations previously made. When an acquisition is performed, the amplitude scale (vertical axis) will reflect the rescaled units.

It is important to note that **Cal 1** and **Cal 2** may be set when data is being acquired but will not take effect until the acquistion is stopped and then restarted. A channel must be calibrated before data acquisition. To set the calibration for a given channel, connect the input device to the MP35 and power up the BSL *PRO* System, then perform calibration before starting data acquisition.

Calculation channel scaling



Input value 10 V *constant*

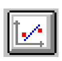
Scale value Input value **x** (sample rate/samples to be mean averaged)

It is important to note that this rescaling should be performed independent of any rescaling performed on analog channels themselves. Even if an analog channel is being rescaled to some other units, the **Input values** in the calculation channel scaling should be set to +10 Volts (next to **Cal 1**) and -10 Volts (next to **Cal 2**).

The "Scaling" option for Calculation Channels corresponds to the source Analog Channel input (and not the source channel's mapped value). Typically, the default scaling settings will be fine. However, if the calculation values will be on a different scale than the original units, you need to change the scale of the calculation channel to reflect the new units (i.e., liters/sec to liters). Click the **Scaling…** button to generate the **Change Scaling Parameters** dialog, which includes options that allow you to modify the units or linearly scale the output.

Rescaling involves multiplying the "Input value" by a factor determined by the sampling rate and number of samples mean averaged across. As an example, if data was acquired at 75 samples per second and you wanted to integrate across an interval of 10 samples, you would set the **Integrate** > **Scaling** parameters so that an Input value of +10 Volts corresponded to a Scale value of 75 and an Input value of -10 Volts corresponded to a Scale value of -75.

Plot Standard Curve

 The **Plot Standard Curve** command is only available in **X/Y mode**. A **Standard Curve** is a graph used in colorimetry to help determine the concentration of a solution, wherein the light absorbance value of the solution is compared to standard values.

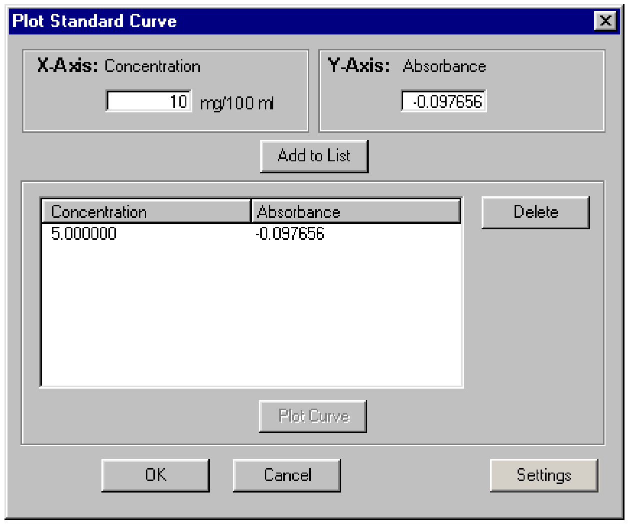
BSL *PRO* can generate a Standard Curve on a plot of Concentration vs. Absorbance of known solutions, which can then be used to determine the concentrations of unknown solutions.

> ***About Standard Curve***
> Colorimeters, or spectrophotometers, are useful for determining such things as the amount of glucose, cholesterol or protein in blood. Colorimeters use a monochromatic light source (composed of a single wavelength). They output an Absorbance value, which is a measure of the percent transmission of light through a liquid. Because the light is monochromatic, Beer's Law can be applied. Beer's Law states that the absorbance value is directly proportional to the concentration of the solution. One or more solutions of known concentrations, called Standards, are used to generate a "Standard Curve"plot. The concentrations of unknown solutions can then be determined from the Standard Curve data.

Before plotting a Standard Curve, you must first set up two Channels in a BSL *PRO* file to represent your X-axis (normally "Concentration") and Y-Axis (normally "Absorbance"). Refer to "Setting up a file to plot a Standard Curve" on page 82.

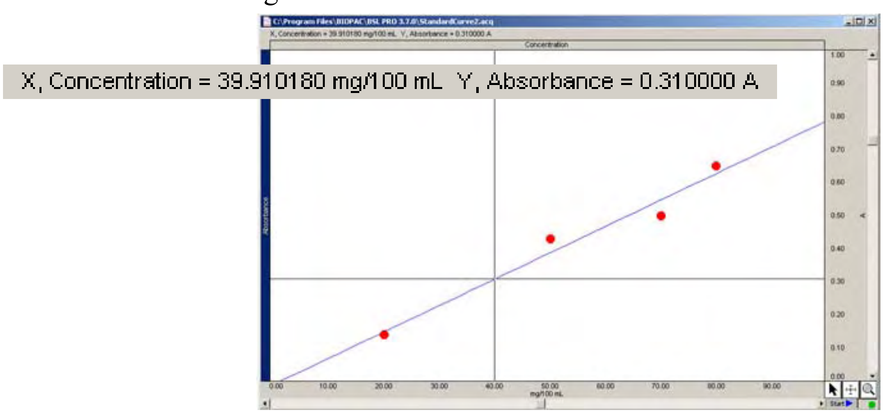
✓ Consider starting with the sample file "StandardCurve.acq" for preset X-Axis and Y-axis units and scale. Review the sample file "StandardCurveData.acq" for sample data.

Plot your curve by pressing the Plot Standard Curve button on the Toolbar.  This will generate the Plot Standard Curves dialog.



Plot Standard Curve Dialog

1. For <u>each</u> standard data point to be plotted, place a standard in the colorimeter and then
   a. Enter values for the X-axis [Concentration (mg/100mL)] and the Y-axis (Absorbance) from the colorimter
   b. Press **Add to List**.
      - To delete a data point, select it from the list and click **Delete**. If a curve has been previously plotted, adding and deleting points generates an alert that the previous curve will be deleted.
2. Once all data points have been entered and added to the list, click **Plot Curve**.
   - The standard data will be displayed in the graph as dots and the standard curve will be plotted as a "best fit" line drawn through the standard data..



A typical Standard Curve (blue line) plotted through Standard data (red dots)

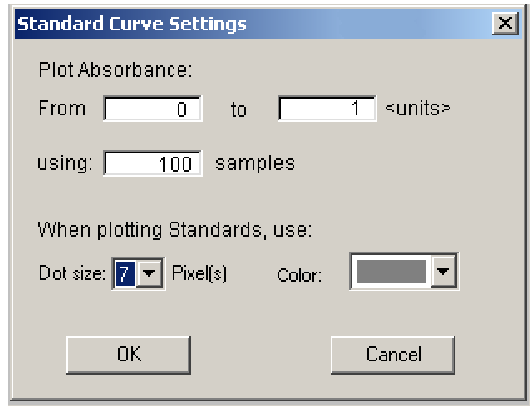
When you click a plotted data point in the graph window with the Cursor, its X-axis and Y-axis values are displayed in the measurement region. You may record these values to the journal, if the journal is open, by right-clicking and choosing "Paste Values to Journal."

To determine the concentration of an "Unknown" solution:

1. Place unknown solution in the Colorimeter and obtain the Absorbance value.
2. To find the Absorbance value in the graph, click and hold the left mouse button, which activates the "snap to" data function, and move the mouse to the left or right until the Absorbance value is displayed in the cursor reading (upper left portion of graph). When the Absorbance value is displayed, its corresponding Concentration will be shown. X, Concentration = 39.910180 mg/100 mL Y, Absorbance = 0.310000 A
3. To paste the Absorbance and Concentration values into the journal, right-click (while the left button remains pressed) and choose "Paste Values to journal" from the pop-up menu.

Standard Curve Settings

Standard Curve Settings sets parameters for the Standard Curve to be plotted. If a curve has been previously plotted, an alert is generated and the graph is immediately updated to reflect the new settings.



Plot From/To: Defines the range of Y-axis values for the data points to be plotted. The default range is from 0 to 1 units. Enter new range values to expand or limit the points on your list that are referenced when plotting the curve.

Plot using: Sets the resolution, or number of samples, of the plotted curve. The default is 100.

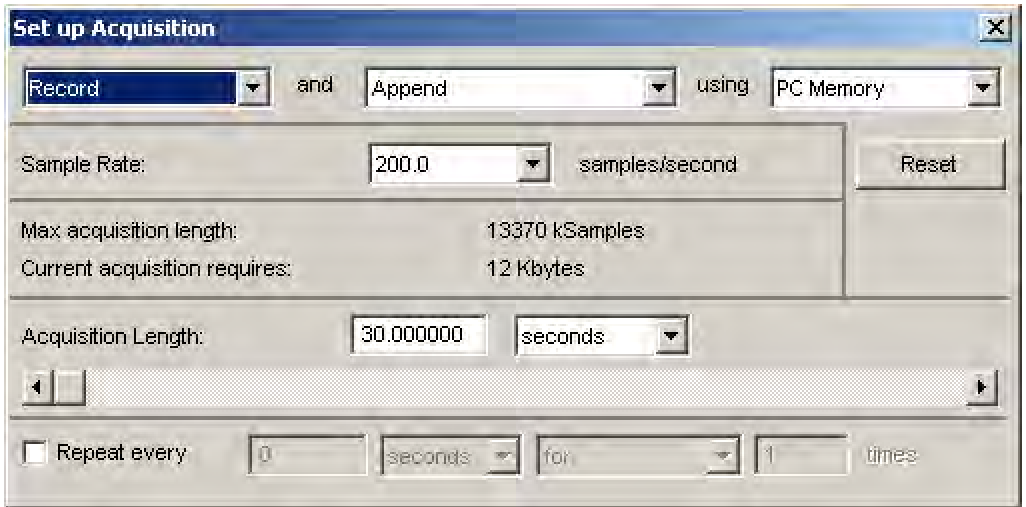
When plotting Standards, use: Allows control of dot color and size of the standard points on the list to be plotted. Choose from the pull-down menu to enter a new setting. (Note: The color of the standard curve is assigned on the X-axis channel, selected by right-clicking in the graph and choosing the Color option.)

Setting up a file to plot a Standard Curve

1. Launch BSL *PRO* to a new BSL *PRO* file with default parameters.
2. Choose **MP35>Setup Channels** and set CH1 and CH2 for **Acquire Data** and **Plot on Screen**.
3. Change the **Label** for Channel 1 to "Concentration" and change **Scaling** units to "mg/100 ml."
   - Click **View/Change Parameters** for Channel 1 and change the channel **Label** to "Concentration." Click **Scaling** and change the **Units** label to "mg/100 ml." Click **OK** to accept the new scaling parameters. Click **OK** again to close out of the Input Channel Parameters dialog.
4. Change the **Label** for Channel 2 to "Absorbance" and change **Scaling** units to "A."
   - Click **View/Change Parameters** for Channel 2 and change the channel **Label** to "Absorbance." Click **Scaling** and change the **Units** label to "A." Click **OK** to accept the new scaling parameters. Click **OK** again to close out of the Input Channel Parameters dialog.
5. Close the **Setup Channels** dialog.
6. Press the **Start** and then the **Stop** button of the graph window to acquire a small amount of data.
7. Go to the **X/Y display** mode by clicking its icon on the Toolbar. 
8. Establish "Concentration" for the X-axis and "Absorbance" for the Y-axis.
   a. Click in the **X-axis** label displayed above the waveform window and choose **Ch1, Concentration** for the X-axis.
   b. Click in the **Y-axis** label displayed to the left of the waveform window and choose **Ch2, Absorbance** for the Y-axis.
9. Scale the X-axis (**Horizontal Scale**) and Y-axis (**Vertical Scale**) appropriately for your experiment.
   - For example, set the "Absorbance" scale to go from 0 to 1, and set the "Concentration" scale to go from 0 to 100 mg/100 ml. Your actual scale settings will depend on your experiment.
   - To set the scales, click in the horizontal and vertical scale regions, respectively.

Setup is now complete and you are ready to plot the curve.

Chapter 6 Set up Acquisitions



Once you have selected the channels to be acquired, the next step is to set up the acquisition parameters under the **MP35** menu. Among other things, these options control where data will be stored during an acquisition, the sample rate for data collection, and the duration (length) of each acquisition. The dialog box that allows these options to be set is generated via **Set up Acquisition** under the **MP35/30** menu. You must establish acquisition parameters prior to pressing the "Start" button. The MP35 > Setup Acquisition menu item is inactive (grayed) during acquisition.

Data storage options

There are three pull-down menus at the top of the **Set up Acquisition** dialog that allow you to control how and where the acquisition data will be saved.

1) **Record/Record last** controls whether the software saves all the data or only the most recent segment.
   - **Record** will store data for the amount of time specified in the acquisition Length box. This is the default and is appropriate for almost all types of acquisitions.
   - **Record last** will acquire data continuously, but store only the most recent segment of data (equivalent to the duration in the acquisition Length dialog box). That is, if the value in the acquisition Length box is 30 seconds and **Record last** is selected, data will be acquired data ad infinitum, but BSL *PRO* will store only the most recent 30 seconds of data.

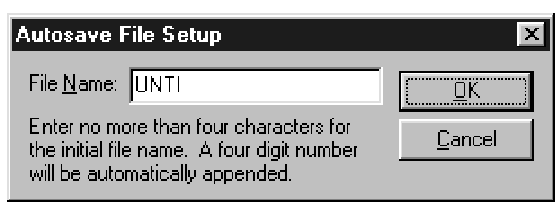
2) **Save once/Autosave file/Append** allows you to vary how the data is saved to a file. By default, BSL *PRO* will append acquisition data to a single continuous file.
   - **Save once** will begin an acquisition when the 

 button is clicked and will stop acquisition either when the acquisition Length has been reached or when the 

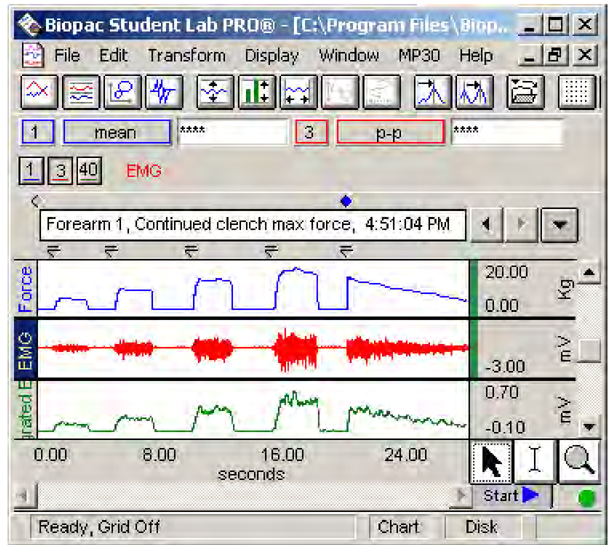
 button is clicked.
   - **Autosave file** enables you to perform several acquisitions one after another and save the data from each acquisition in a separate file.

     When **Autosave file** is selected, a 

 button will appear by the Sample Rate entry box. Clicking on the **File…** button generates an "Autosave File Setup" dialog that prompts you to choose the root file name for the data from each acquisition.



- **Append** allows you to pause the acquisition for arbitrary periods. Append markers are automatically inserted to indicate where each appended acquisition segment begins. (See page 164 to customize append markers and/or preset marker labels.) The **Append** mode is unique in that clicking on the Stop button only *pauses* the acquisition, which can then be restarted by clicking on the Start button. This can be helpful when recording only a few key events that will occur randomly over a long period of time, since it will reduce data storage and transformation processing.



Reset When Append is selected, a **Reset** button is generated in the Setup Acquisition dialog. Clicking on the **Reset** button erases the acquired data file and "continue" the acquisition. (This is essentially the same as saying yes to an "Overwrite existing data?" prompt.)

Each time an acquisition is restarted, an append marker is automatically inserted into the record showing the time at which the MP35 restarted data acquisition.

When Append is selected, the display mode is set to Chart or Scope, and at least one segment of data has been acquired, the **Overlap Segments** icon is enabled on the Toolbar. The Overlap Segments display mode overlaps appended segments of data. See Overlap Segments, page 44.

Although you can pause for any period of time, the Biopac Student Lab *PRO* will only acquire data for the amount of time indicated in the Acquisition Length box.

Data can only be acquired in Append mode while being saved to **PC memory**.

When used in conjunction with the external trigger, the **Append** mode can be a very useful acquisition tool. An acquisition that takes place over a long period of time with brief events which are few and far between can be set up in the following manner: the researcher watches for the events, triggers the acquisition to start, and then lets the pre-defined acquisition length run out. When another event of interest occurs, the researcher triggers the next acquisition. This acquisition will be "appended" onto the end of the first acquisition. Memory is the only limit as to how many "appendages" can be added.

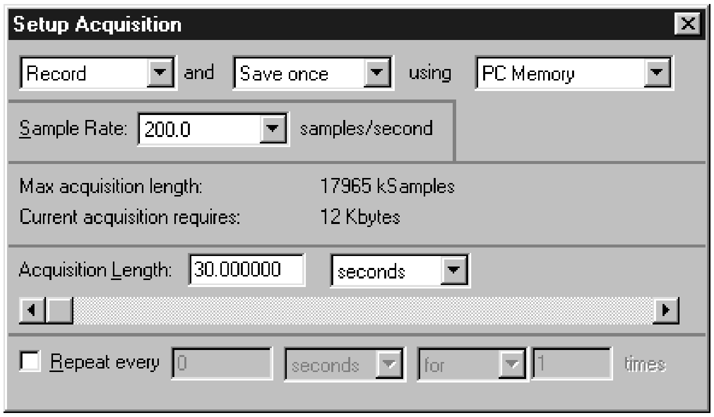
3) **PC Memory/Hard Disk** controls where data is stored *during* an acquisition. The best choice depends in large part on the nature of the acquisition itself and the type of computer being used.

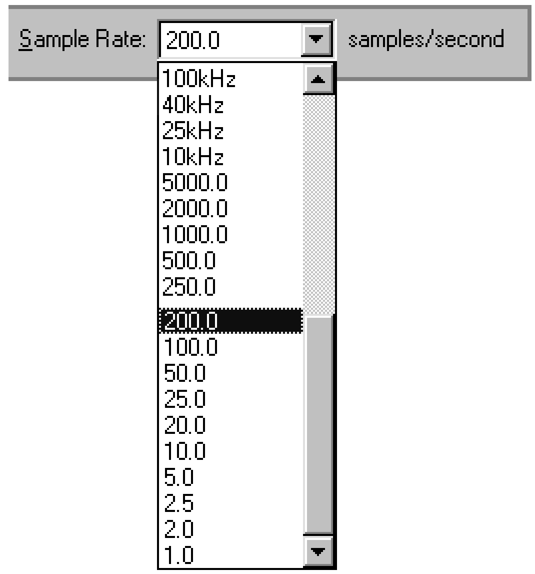
   - **PC Memory** will store data in computer memory (RAM) during an acquisition. After the acquisition is finished you will have to select **Save As...** from the **File** menu to permanently save this to your computer's hard disk. This usually allows for faster acquisition rates, although most computers have less available RAM than disk space.
   - **Hard Disk** will save data directly to the computer's hard disk during an acquisition. **Hard Disk** mode is fast enough (in terms of maximum sampling rate) for many applications, especially when only a few channels are being acquired. Saving data to **Hard Disk** allows for longer acquisitions, since most computers have more hard disk space free than free RAM. An advantage of saving data directly to disk is that if there is a system failure (including power outage), all the data collected up to that point has been saved on the hard disk and can be recovered, whereas data saved to PC Memory would be lost.

— IMPORTANT NOTE —

If you are saving files in **Hard Disk** mode, always be sure to save files under a different name BEFORE you start each acquisition. Otherwise, any previous data in that file will be overwritten. In **PC Memory** mode, you simply go through the standard procedure of saving the file after the acquisition. Once data has been acquired and is stored in a file, it is stored on a hard disk or other similar device.

Sample Rate





The "**Sample Rate**" value indicates how many samples the MP35 should acquire per second on each channel during data acquisition. The default Sample Rate is 200Hz, but can be changed by clicking on the pull-down menu. Use the pull-down menu to select a sample rate between 1 sample/sec. and 100,000 samples/sec. You must select one of the menu options — you cannot enter a custom sample rate. You need to scroll *up* to see the higher sample rates.

> ***MP30 users: It is important to note*** that Sample Rates above 2,000 samples/sec are considered "high speed" rates and the software behaves differently in **High Speed** mode (see page 88).

Depending on the nature of the data being acquired, the "best" choice for Sample Rate will vary.

Technically speaking, the minimum sampling rate should be at least twice the highest frequency component of interest. This means that if the phenomenon you are interested in observing has frequency components (of interest) of 100Hz, you should sample at least 200 times per second. Fourier analysis (FFT) can be used to determine what frequency components are present in the data (see page 215 for a more detailed description of the FFT function). Applications that typically involve higher sampling rates are ECG, EEG and evoked response acquisitions. In less technical terms, slower sampling rates can be used for data with slowly changing values (respiration, GSR, and the like), whereas higher sampling rates should be set for data where values change markedly (either in magnitude or direction).

The disadvantage of acquiring data at high sampling rates is that each sample point takes up memory, whether it is RAM or hard disk space. Moreover, once the file is saved, it will require more hard disk space than a file of similar duration sampled at a slower rate.

The maximum allowable sampling rate is 100,000/second, but rates over 2,000/second are considered "high speed" and do have limitations (see below). Set the Sample Rate from the pull-down menu options.

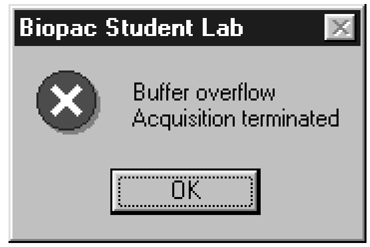
✓ TIP A good rule of thumb is to select a sampling rate at least four times the highest frequency of interest for the signal.

Notes: 1) A waveform is considered "compressed" when more than three sample points are plotted per pixel on the screen. Using the default horizontal scale (which plots eight seconds of data on the screen), any data sampled at more than 250 samples per second would be considered compressed.

Standard VGA displays are 640 pixels wide, so a compressed waveform on this type monitor would be any type of waveform displaying more than 2000 samples (approximately) on the screen at any one time. Use the **Draft mode for compressed waves** option to plot compressed waveforms in draft mode, which results in faster plotting time, although the display is not exact.

2) It is possible to set a Sample Rate that is too high.

The acquisition will begin normally, but the BSL *PRO* System will terminate the acquisition and display a message indicating that the acquisition buffer has overflowed:



Data acquired up to the overflow prompt will have been saved, but the Sample Rate must be set to a smaller value to continue acquisition.

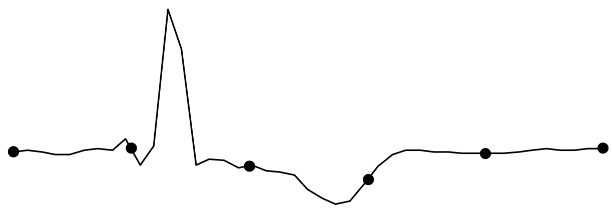
Sample Rate (samples/Sec)	MP35	MP30
1	YES	YES
2	YES	YES
2.5	**NO**	YES
5	YES	YES
10	YES	YES
20	YES	YES
25	**NO**	YES
50	YES	YES
100	YES	YES
200	YES	YES
250	**NO**	YES
500	YES	YES
1,000	YES	YES
2,000	YES	YES
5,000	YES	YES
10,000	YES	YES
20,000	YES	**NO**
25,000	YES	YES
40,000	**NO**	YES
50,000	YES	**NO**
100,000	YES	YES

EXAMPLES OF SAMPLE RATE EFFECT ON ECG WAVEFORMS

The sample ECG waveforms that follow illustrate the effect of different sampling rates on obtaining varying levels of fidelity when reproducing the data.

In the first waveform to the right, the data is sampled relatively slowly, and it is difficult to make out the shape of the waveform.

In the waveform sampled at the faster rate, more samples are taken in the same period of time that allows for higher resolution of some components of the waveform.



Representation of ECG waveform sampled with relatively few samples per second.

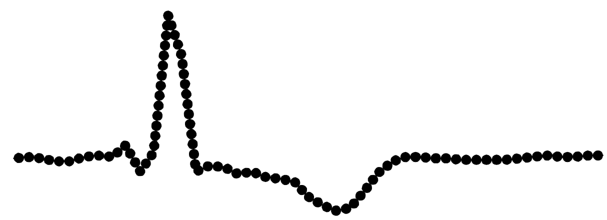
The "true" ECG wave is superimposed over dots that indicate sample points. As you can tell, under-sampling completely misses the QRS complex of this waveform, although it might detect components of the QRS in subsequent beats.

Although this is an extreme example of how under-sampling can affect digitally processed data, it is important to note that the rate at which data is sampled has important implications for the interpretation and analysis of data.

Above waveform as it would look if plotted in BSL PRO (with data points superimposed)

The third waveform to the right illustrates the advantage of sampling data at relatively high rates — namely, increased resolution of the waveform.

Waveform components that were obscured at slow sampling rates are now well defined, and measurements taken on this waveform would be able to better establish the maximum amplitude, time interval between different wavelets, etc.

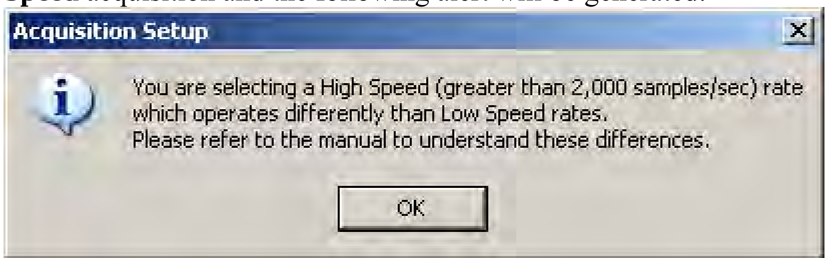


Representation of same ECG waveform sampled at a relatively higher sampling rate.

High Speed Mode—MP30 only

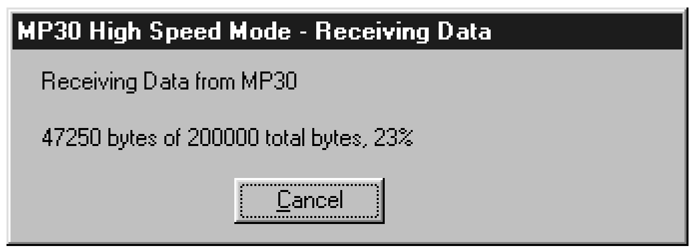
- The MP35 handles all acquisition the same, with no distinction for high speed.

The **High Speed** mode is designed for acquisitions that utilize a high-sample rate/short duration setup, such as nerve conduction and action potential. When you select a Sample Rate over 2,000 samples/sec. it is considered a **High Speed** acquisition and the following alert will be generated:



In **High Speed** mode, the MP30 acquires data and saves to its internal buffer so storage is locked to **MP30 Memory** setting.

The following status window will be generated during **High Speed** acquisition. Data downloads to your PC RAM after the acquisition is completed. Because of that, the current memory size is limited to 100,000 samples or 200,000 bytes.



At or below a Sample Rate of **25,000**, you can mix and match any or all of the four analog channels. At a Sample Rate of **40,000** only one or two analog channels can be active (if two channels are selected, they must be CH1 and CH2). If your Channel Setup is incorrect, you will be prompted to correct it:

At **100,000** samples/sec. only one channel can be acquired. If your setup is incorrect, you will be prompted to correct it:

The following limitations are enforced during **High Speed** acquisition:

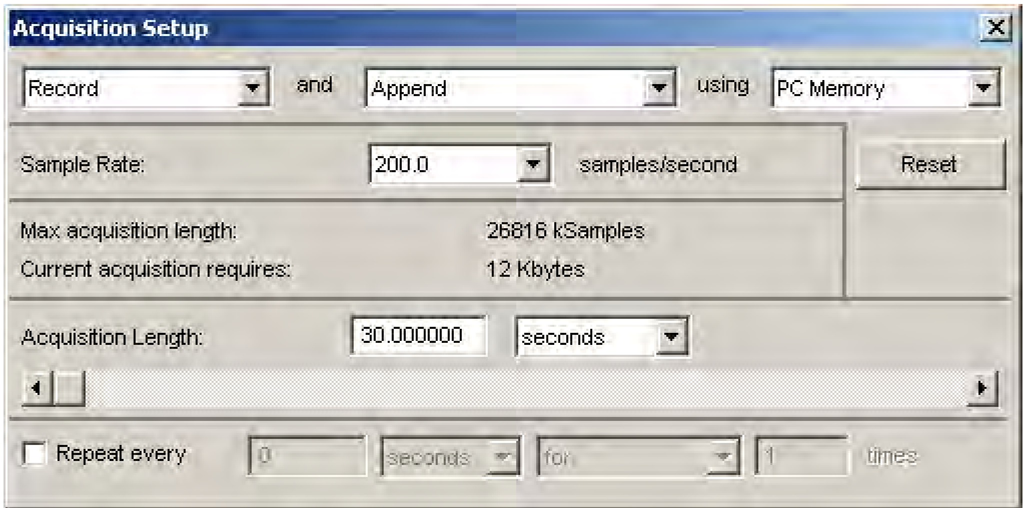
Calculation channels	Cannot calculate channels during High Speed acquisition; channels will be calculated after the data is downloaded from the MP30 to the PC. The calculation lag factor depends on the speed of the computer and the complexity of the calculation.
Marker functions	Disabled during High Speed acquisition; can be added after acquisition.
Real-time digital filters	Not available during High Speed acquisition
Show Input Value	Display is not available during High Speed acquisition.
Plot on Screen	Plot display is not available during High Speed acquisition.
Save options	Cannot save to **PC Memory** or **Hard Disk**.

Stimulator functions

Can only use the “Start/Stop stimulator with Start/Stop of Acquisition” setting; no manual control options are enabled during High Speed acquisition.

The “Start/Stop stimulator with button in Stimulator window” option functions normally when data is not being acquired, but is not available during High Speed acquisition. If the “Start with button” option is selected, the Stimulator window will be grayed (not selectable) during acquisition.

Acquisition Length



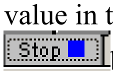
To set the duration of an acquisition, enter a number in the Acquisition Length box. By default, 30 seconds of data will be recorded.

The MP35/30 will automatically limit the maximum recording length to the amount of available memory on the target storage device (PC Memory or Hard Disk). The default is to record one acquisition of the duration specified in the Acquisition Length box.

The pull-down menu to the right of the Length box allows you to scale the duration of the acquisition in terms of milliseconds, seconds, minutes, hours, or samples. Changing this option will not change the length of the acquisition, only the units used to describe it. Thus you can describe the same acquisition as lasting 30 seconds, or 0.5 minutes, or 30, 000 milliseconds. Scaling the duration of an acquisition in terms of samples is essentially the same as the time scaling options, except the length of the acquisition will be expressed in the total number of samples to be collected on one channel.

The maximum acquisition length and, on the PC only, current acquisition requires, are calculated based on all the active channels, the types of channels activated (analog or calculation), and the other acquisition setup parameters. This reference information is displayed above the **Acquisition Length** section of the Setup Acquisition dialog. The BSL *PRO* requires 2 bytes per analog sample and 8 bytes per calculation sample. The memory calculation does not include approximately 25KB per file for header information.

- In the default **Append** mode, "max acquisition length" reflects the total available length—if you are going to record more than one segment, you need to set the acquisition length so that the combined length of all appended segments falls within the specified maximum length.
- If you are using the **Repeat** function, the memory calculation is based on one acquisition; you will need to multiply by the number of repetitions to calculate the total memory required.

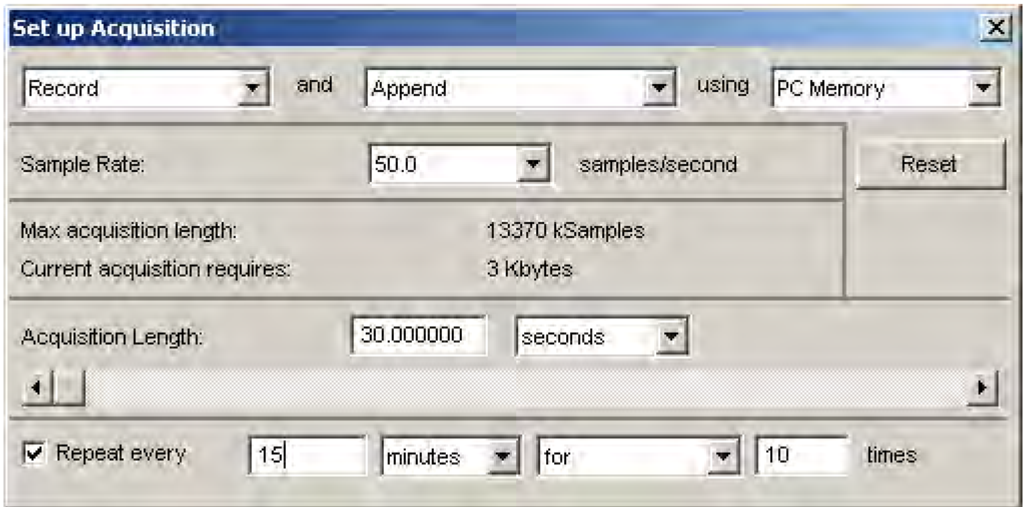
Regardless of what scale you use to determine the length of acquisition, the MP35 will stop acquiring data when the value in the Acquisition Length box is reached. You may also stop the acquisition at any time by clicking on the 

button in the lower right hand corner of the graph window.

Note The Acquisition Length parameter has a somewhat different interpretation in the *Record last* mode; see page 83 for more information about settings for this mode.

Repeat

The **Repeat** mode allows you to acquire data from repeated trials using the same parameters for each trial. When the **Repeat every** box at the bottom of the Acquisition Setup box is checked, a series of menus at the bottom of the dialog box are enabled. These allow you to establish the repetition interval and the number of repetitions.



1) **Repeat every** controls how long the software will pause between the start of one acquisition and the start of the next acquisition. The pull-down menu options are seconds, minutes, or hours.

   It is important to note that this value measures the interval between the start of two adjacent trials, rather than the interval between the end of one trial and the start of the subsequent trial. If the repeat interval is set for 15 minutes and the acquisition Length is set to 60 seconds, then there will be a 14 minute pause between the end of the one trial and the beginning of the next. For the fastest possible interval (least possible delay) between repeating acquisitions, set to repeat every 0 seconds.

   - When **Repeat every** is unchecked, the acquisitions will repeat as soon as possible (usually instantaneously, but slightly longer if data must be saved to a file between trials).

2) **For/Forever** controls how many trials will be acquired. The two general options are to perform a finite number of trials, or to perform an infinite number of trials.

   - **For** will acquire a fixed number of trials equal to the number entered in the box to the right.
   - **Forever** will acquire an infinite number of trials. Trials will be repeated at the specified interval until either a) the acquisition is stopped by clicking on the  button in the graph window or b) there is not enough free memory on the target storage device.

Data for each trial will be acquired according to the acquisition parameters specified in the dialog box. In the preceding dialog, each trial of data will be sampled at 50Hz and will be repeated every 15 minutes for a total of 8 trials.

— IMPORTANT NOTE —

By default, each acquisition will be appended to the data from the previous acquisition. You can change this by selecting the **Autosave file** option from the **Save once/Autosave file/Append** option at the top of the Setup Acquisition dialog. When the **Repeat** option is checked and **Autosave** is selected, the Biopac Student Lab *PRO* will save the data from each trial using the file name and extension indicated by the **Autosave** feature (see page 83 for details).

When Save Once is selected, a prompt to overwrite existing data will be generated at the beginning of each acquisition using a **Repeat/Autosave** setup, so you will probably want to uncheck the **Warn on overwrite** option from the **MP35/30** menu to disable the prompt.

Chapter 7 Channel Presets

In addition to the Preset specific settings, each Parameters dialog includes: Channel Number, Channel Preset, Channel Label, Source, New Channel Preset, and Scaling features, which are detailed here:

Channel Number

This is the selected analog channel or the destination channel for a calculation. It corresponds to the Channel in the Setup Channels dialog.

Channel Preset

The **Channel Preset** entry lists the Preset that was selected from the **Presets** menu. If you edit this field the "New Channel Preset" button will automatically be activated.

Channel Label

This is a modifiable description of the Preset parameters. Any change you make here will be reflected in other label displays for that channel, such as the graph window label or dialog box channel label.

Source

Calculation channels only

This is the source channel for the calculation. The source channel defaults to CH1 but can be changed via the pull-down menu. Source options includes any Analog channels being acquired and any enabled Calculation channels. The units of the Source channel are displayed for easy reference.

The **Math** and **Function** calculations use two source channels and the **Expression** calculation can use multiple source channels.

IMPORTANT!
Calculation Presets can only work in conjunction with Analog input presets, or with other calculation channels that are ultimately pointing to an Analog source channel. You must pay close attention to **Source Channel** and choose it carefully.

New Channel Preset button

The **New Channel Preset** button will be activated if you change the Channel Preset entry. When you click it, the newly named preset will be added to the menu available to every channel. If you change other settings but keep the Channel Preset entry the same, the changes only apply to the selected channel and the original Preset settings will be applied if you select the Preset from the menu again (for any channel).

Scaling… button

When you click the Scaling… button, a **Change Scaling Parameters** dialog will be generates for the selected channel. Scaling is explained in detail beginning on page 78.

See Calibration Guidelines on page 273.

Analog Channel Presets

Default
Accelerometer (5 g's max.)
Accelerometer (50 g's max.)
Airflow (SS11LA)
Airflow (SS52L)
BNC (SS9L, -10 to +10 Volts max.)
Blood Pressure Cuff
BNC (SS9L, -50 to +50 Volts max.)
BNC (SS70L, -10 to +10 Volts max.)
Cardiac Output - Z
Cardiac Output - dZ/dt
Clench Force (kg)
Clench Force (lbs)
Clench Force (N)
CO2 Expired (GASSYS2)
O2 Expired (GASSYS2)
Electrocardiogram (ECG), .5 - 35 Hz
Electrocardiogram (ECG), .05 - 35 Hz
Electrocardiogram (ECG), .05 - 100 Hz, AHA
Electrocardiogram (ECG), .05 - 150 Hz
Electrodermal Activity (EDA), 0 - 35 Hz
Electrodermal Activity (EDA) Change
Electroencephalogram (EEG), .5 - 35 Hz
Electroencephalogram (EEG), .5 - 100 Hz w/notch
Electrogastrogram (EGG)
Electromyogram (EMG), 5 - 250 Hz w/notch
Electromyogram (EMG), 5 - 500 Hz
Electromyogram (EMG), 5 - 1000 Hz
Electromyogram (EMG), 30 - 250 Hz w/notch
Electromyogram (EMG), 30 - 500 Hz
Electromyogram (EMG), 30 - 1000 Hz
Electrooculogram (EOG), .05 - 35 Hz
Finger Displacement (cm)
Finger Displacement (inches)
Goniometer
Goniometer (Intelitool - Flexicomp)
Heel Toe Strike
Microphone (SS17L, .5 - 200 Hz)
Microphone for Speech (SS62L)
MP100/150 Interface (BSLCBL14)
Psychological Response
Pulse Plethysmograph (PPG)
Reflex Hammer Strike
Reflex Hammer (Intelitool - Flexicomp)
Respiration (SS5LB)
Stethoscope (Heart Sounds)
Stethoscope (Korotkoff Sounds)
Stimulator-BSLSTM (0-10 Volts)
Stimulator-BSLSTM (0-100 Volts)
Stroboscope Flash (TSD122)
SuperLab Sync. (SS44L)
Switch
Temperature (deg. C)
Temperature (deg. F)
Temperature Change (deg. C)
Temperature Change (deg. F)
Torsiometer

Airflow (small mouse)
Airflow (mouse)
Airflow (rat/guinea pig)
Airflow (cat/rabbit)
Airflow (small dog)
Airflow (medium dog)
Airflow (large dog)
Blood Pressure (Arterial)
Circuit Probe (Breadboard)
Current Monitor (BSLCBL10)
Displacement (cm)
Displacement (inches)
Displacement (AD Inst. DT-475)
Dissolved O2 (BSL-TCI16)
Earthworm Action Potential
Force (0 - 50 grams)
Force (0 - 100 grams)
Force (0 - 200 grams)
Force (0 - 500 grams)
Force (0 - 1000 grams)
Force (iWorx FT-100)
Nerve Response (BSLCBL3,4,9)
Nerve Response (BSLCBL8)
pH (BSL-TCI21)
Pneumogram
Pressure (+-2.5 cm H2O)
Pressure (+-12.5 cm H2O)
Pressure (+-25 cm H2O)
Tobacco Hornworm (BSLCBL8)

Selecting an Analog **Presets** option automatically configures the Gain, Filter and Coupling options using preset values for the type of data designated for that channel. These preset values are designed to be good starting points for most people, and you may modify them as you see fit. The table beginning on page 250 lists the default Presets for various physiological signals.

The *PRO* software allows you to set a number of hardware parameters for analog acquisitions, including:

Digital Filters

- ➲ For MP30 users, digital filters are only applied if sample rate is 2,000 samples/sec or less

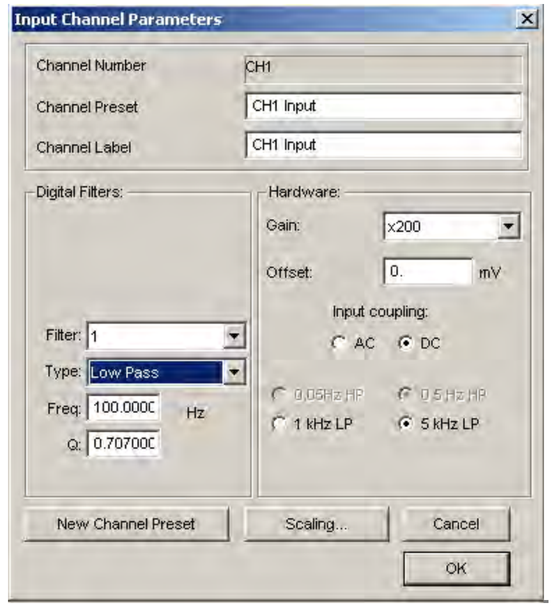
Gain

Offset

Analog Filters

- ➲ Click the View/Change Parameters button in the **Setup Channels** dialog to view or change the preset parameters.

➡ See **Calibration Guidelines** on page 273.



Digital Filters

The *PRO* software allows you to control three types of digital filters and it is important to understand the strengths and weaknesses of each so that the best combination of filter settings can be achieved.

3 types of Digital Filters		
2 Real-time		**1 Post-acquisition**
Hardware Three stage digital filters	Software Calculation channels	FIR filters

Two of the filter types operate in real time (as data is being collected) and of those, one performs the filtering within the MP35/30 hardware itself (before the data is displayed on your computer). This section discusses only this hardware-based filtering. The calculation channels are described on page 73 and the post-acquisition filters are described on page 194. See Appendix E for a general overview of filters.

The MP35/30 hardware-based filter is a cascaded set of three second-order filters that can be set independently. The hardware filtering is designed primarily for basic signal conditioning (e.g., removing 60 Hz noise), rather than for filtering data to retain physiological signals of interest (such as retaining alpha activity from an EEG signal).

The digital filters apply to analog channels and cannot be used to filter data below 30 Hz. Digital filters are disabled and therefore non-selectable during High Speed acquisition.

You must specify a **filter type** (low pass, high pass, band pass, band stop), **filter center point**, and **Q setting**.

As a general rule, if only one filter is to be used, that filter should be a low pass filter set to 1/2 the sampling rate with a Q of about 0.707. If two filters are used, both should be low pass filters, and one should have a Q of 0.5 whereas the other has a Q of 1.

Some common applications of these filters are removing 60 Hz noise and preventing “aliasing.” Other filters are available for broadly limiting the frequency range and removing low frequency “drift” of the incoming signal (see page 98).

The “**Q**” setting refers to the skew of the filter, and an optimally dampened filter has Q of 0.707. In some cases, it may be desirable to over- or under-dampen a filter, depending on the particular requirements.

✓ TIP Choose a Preset that matches your signal of interest to automatically configure all three filters.

More about MP35 Hardware Filters

The MP35 employs three user-configurable, sequential, biquadratic (second order) Infinite Impulse Response (IIR) filters. These filters are typically configured by choosing a Preset via MP menu > Set up Channels >Presets. To change the filter setting(s) to a different bandwidth (than provided by a Preset), select MP menu > Set up Channels > View/Change Parameters for a Channel Preset. In the "Digital Filters" section of the "Input Channel Parameters" dialog that is generated, adjust the *Type*, *Freq*, and *Q* for Filter 1, 2, and/or 3, change the Channel Preset name, and then save as a New Channel Preset.

The MP35 IIR filters are implemented via an internal Digital Signal Processor (DSP). The filters are implemented as 32 bit, fixed point. The MP35 internally samples all input data at a rate of 20kHz, 25kHz, 50kHz or 100kHz, depending on the rate chosen via the BSL software application. For all sample rates less than 20kHz, the MP35 will initially sample the analog data stream at 20kHz and then downsample after the internal IIR filter calculations are performed, before sending the data to the BSL software application.

To insure that the MP35 will not alias input data, the MP35 implements a high-order lowpass FIR filter that has a breakpoint of 45% of the internal sampling rate used by the MP35.

- For example, if the internal rate is 20kHz, the FIR lowpass will have a breakpoint of (0.45)*(20kHz) = 9kHz.

As a further constraint against aliasing, the MP35 also employs an analog lowpass filter in all the input channels, which limits the band edge to 20kHz maximum.

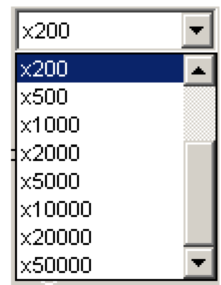
Hardware settings

The **Hardware** settings allow you to control the Gain, Offset, and Input coupling (AC vs. DC) for each channel, as well as two additional hardware filters.

Gain settings

The **Gain** setting specifies the extent to which an incoming signal is amplified. The Gain is automatically set when a data type is selected from the available **Presets**. The preset Gain settings are only educated guesses and should be used as initial starting values. You may need to adjust the gain settings in one direction or another depending on how the amplified signal appears once sample data is collected. Gain guidelines are included in the **MP35/30 Input and Offset Range** table on the next page.

To select a Gain setting for a given channel, choose a value from the pull-down menu next to **Gain**.



The software offers a variety of settings to amplify the raw analog signal from 100 times to 50,000 times.

Larger values are associated with higher gain settings, and thus greater amplification.

The **x100 Gain** setting is range-limited and should not be selected unless absolutely required as the data will not operate under the full range in this mode and will be clipped.

Some types of signals (such as EEG) typically need greater amplification than other types of signals (such as ECG or EMG), although ideal gain settings are best determined on a case-by-case basis.

- ➢ Setting the Gain to a value that is too small for a given signal will result in data that typically appears as a “flat line” centered on 0.
- ➢ Setting the Gain to a value that is too large for the input signal will result in data that is “clipped” or limited at either the extreme positive or negative levels.

For the best resolution, establish Gain such that, allowing for baseline drift (if applicable) and the maximum peal-to-peak of the signal, the maximum signal display is close to the maximum range.

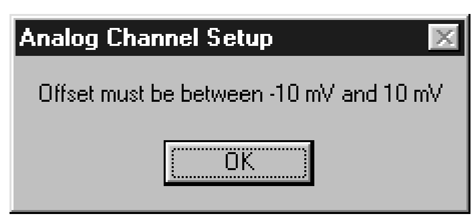
You can use the Range Guide (see page 42) as a visual aid to establish the proper Gain. If the signal is clipped, lower the Gain. If the signal is small compared to the range, increase the Gain to improve signal resolution.

Offset

To correct the offset of an incoming analog signal, you can add or subtract a constant to the signal prior to amplification. Offset can occur if a transducer or electrode has inherent offset, and is especially true of signals collected in DC mode (in AC coupled mode the **Offset** entry has no effect on the data).

By default, **Offset** is set to zero, and the allowable entry range will vary depending on the **Gain** and **Scaling** values. The *PRO* uses the scale and units of the source channel for the offset units.

If you exceed the limits, an error prompt will be generated:



MP35/30 Input and Offset Range

Gain Setting (X)	MP35 Input Signal Range (+/- mV)	MP30 Input Signal Range (+/- mV)	MP35 Input Resolution (uV)	MP30 Input Resolution (uV) (10 bit mode)	MP35 Offset Range (+/- mV)	MP30 Offset Range (+/- mV)	MP35 Offset Resolution (uV)	MP30 Offset Resolution (uV)
10	1000	N/A	30.5	N/A	100	N/A	8.24	N/A
20	500	N/A	15.3	N/A	100	N/A	8.24	N/A
50	200	N/A	6.1	N/A	100	N/A	8.24	N/A
100	100	70*	3.0	195	10	10	.82	78.1
200	50	50	1.5	97.7	10	10	.82	78.1
500	20	20	.61	39.1	10	10	.82	78.1
1000	10	10	.30	19.5	4	10	.32	78.1
2000	5	5	.15	9.77	4	10	.32	78.1
2500	N/A	4	N/A	7.81	N/A	10	N/A	78.1
5000	2	2	.06	3.91	4	10	.32	78.1
10,000	1	1	.03	1.95	4	10	.32	78.1
20,000	.5	N/A	.015	N/A	4	10	.32	78.1
25,000	N/A	.4	N/A	.781	N/A	10	N/A	78.1
50,000	.2	.2	.006	.391	4	10	.32	78.1

Notes: * This is a special case limit of the voltage range only for a gain of 100.
The actual range from unit to unit may vary by as much as 20%.

Input coupling

The Input Coupling hardware setting enables you to record data as AC Coupled or DC Coupled signal values.

- DC Coupling is appropriate for Temperature, GSR, Airflow, BNC, Switch, Pressure, Force, Hand dynamometer, Stimulator, Strain gauges, and similar data.
- AC Coupling is appropriate for ECG, EEG, EMG, EOG, PPG, Respiration, and similar data.

There are a number of technical differences between these coupling settings, but the main issue is Offset. Offsets are values which impact the location of transducer zero. Most distinctions between “absolute” vs. “relative” accuracy are related to Offset.

- DC Coupled signals usually have a non-zero Offset in amplitude that drifts during the course of the recording. DC Coupled measurements can be calibrated directly to account for the Offset.
- AC Coupled signals are centered on zero, so Offset is not a factor.

Other hardware settings, such as Gain values or sensitivities, don't change significantly between AC and DC, but AC Coupled signals can use somewhat higher Gain settings, resulting in slightly higher resolution.

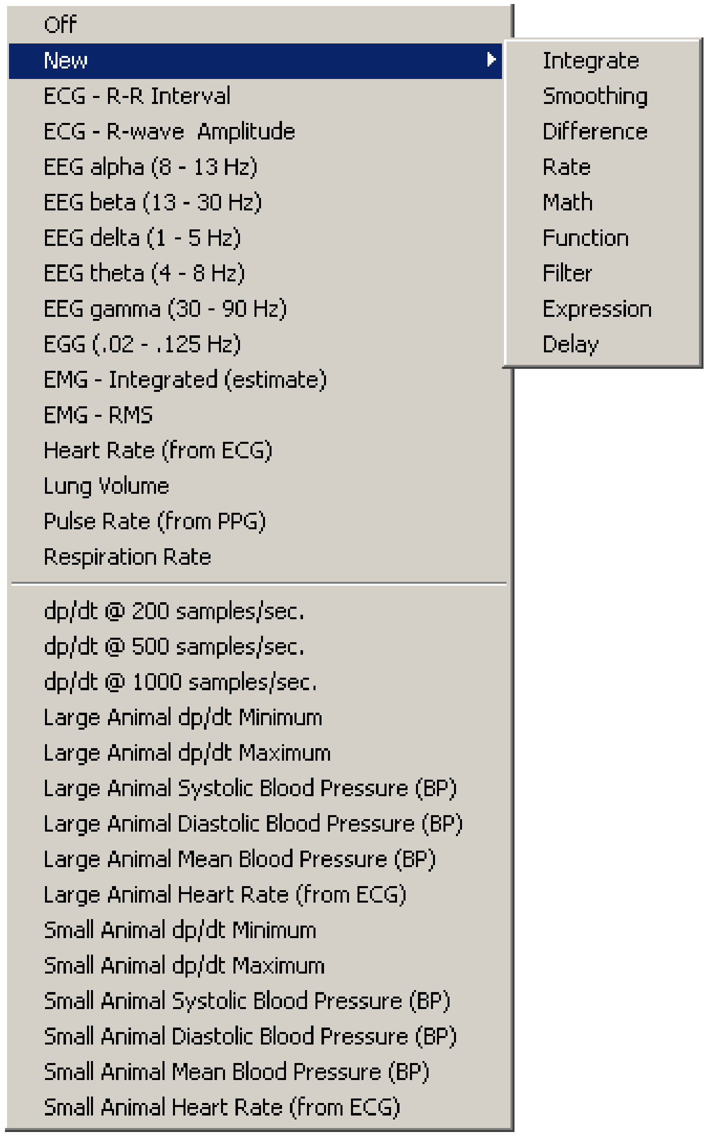
Hardware filters—MP30

In addition to the three programmable digital filters in the setup dialog, there are also two selectable hardware filters that can be controlled from software. One is a switchable 0.05 Hz / 0.5 Hz high pass filter and the other is a switchable 1 kHz / 5 kHz low pass filter.

1) The **0.05 Hz / 0.5 Hz filter** is only enabled when the input channel is AC coupled (see page 97 for a description of this setting). When DC-coupled data is being collected this filter is bypassed.
   - The **0.05 Hz setting** for this filter is appropriate for data ECG and respiration data.
   - The **0.5 Hz setting** is appropriate for EEG, pulse plethysmograph, EMG, and most other types of AC Coupled data.
2) The second filter allows you to select a **1 kHz or 5 kHz low pass filter**.
   - Since the maximum sampling rate of the MP30 is presently limited to 2,000 Hz per channel, the filter should almost always be set to **1 kHz**.
   - You may want to set this filter to **5 kHz** when you are collecting data that will be directed to OUTPUT or when the input channel is being used as a trigger.

When a data type is selected from the **Presets** menu, both the high pass and low pass filters are set to the standard setting for that type of measurement. Of course, you may adjust these if you need to.

Calculation Channel Presets



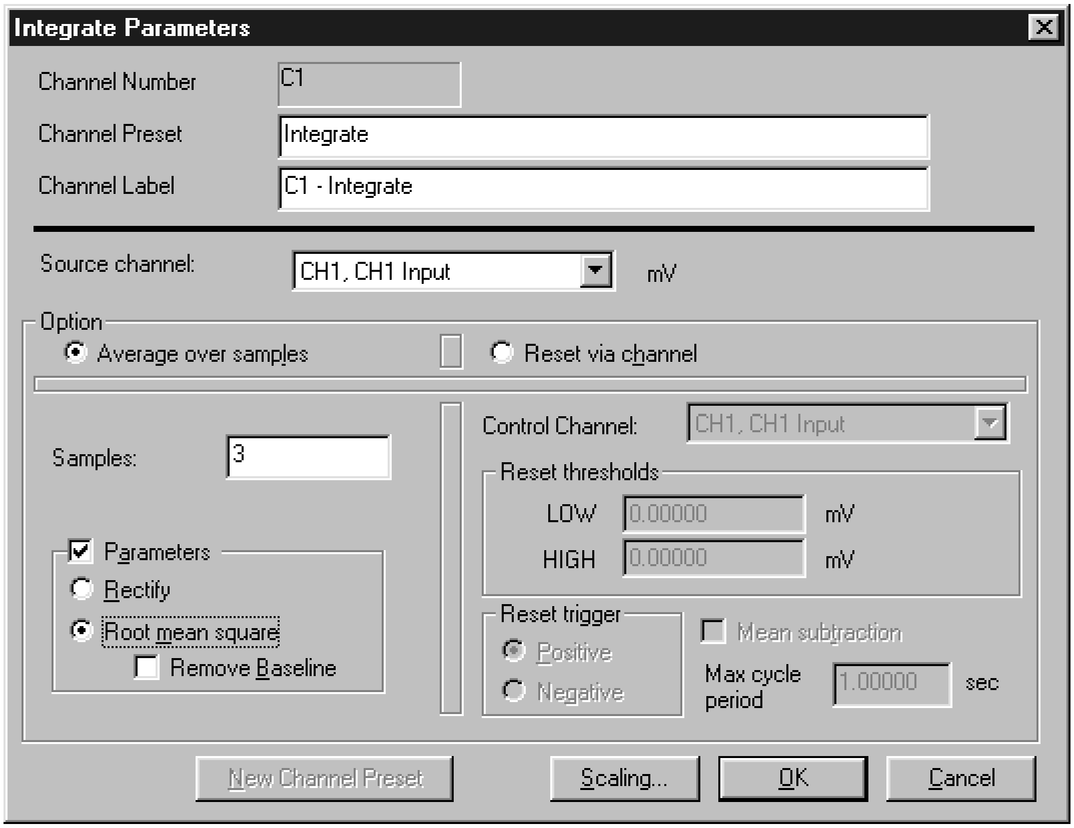
Calculation Channels are OFF by default. To turn a Calculation Channel on, click the Presets button and make a selection from the menu. You must then check the **Acquire** box for each Calculation channel you want to compute (the Plot and Value boxes are optional).

For any Calculation channel, you will (minimally) need to specify the source channel to be transformed and the nature of the transformation.

To view or change the parameters specified for each **Preset**, click the **View/Change Parameters** button in the **Setup Channels** dialog box to generate the corresponding Parameters dialog. The Preset specific settings are discussed on the following pages.

IMPORTANT!
Calculation Presets can only work in conjunction with Analog input presets, or with other calculation channels that are ultimately pointing to an Analog source channel. You must pay close attention to **Source Channel** and choose it carefully.

Calculation Preset: Integrate



Integrate Calculation dialog

<u>*Option*</u>

The online **Integrate** calculation offers two basic operations:

Average over samples

Calculates the moving average (mean) of the specified number of samples. Additional parameters (Rectify; Root mean square) add further functionality. Used typically, these features allow you to process EMG signals and will display the integrated (rectified, then sample averaged) or Root mean square calculation on the original raw EMG data.

This option is useful for smoothing noisy data, real-time “integration” of EMG, real-time “root mean square” evaluation of EMG.

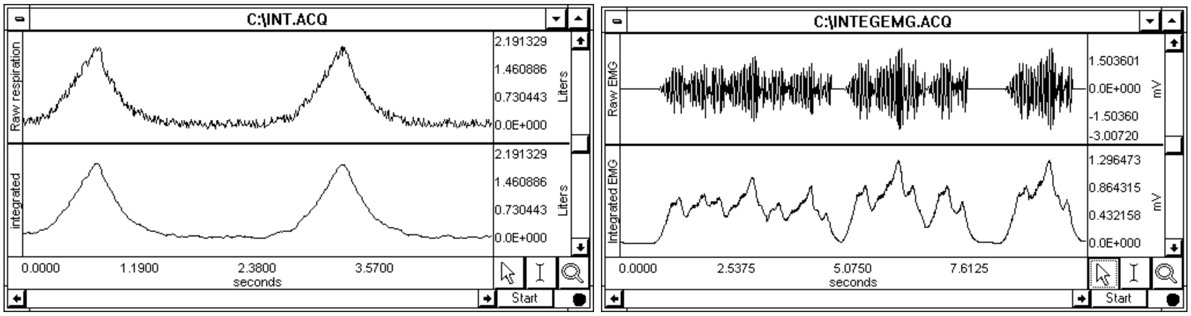
Reset via channel

Permits real-time integration of input data over a data-defined time interval. Perform a real-time integration over a potentially variable number of sample points. This feature is extremely useful for converting flow signals into volumetric equivalents. The integral of flow is volume. For example, when recording airflow with a pneumotach, volume can be precisely calculated as the flow varies in a cyclic fashion.

This option is useful for real-time conversion of flow signals into volume signals (Blood flow → Blood volume; Air flow → Air volume) and any processing involving a need for a cyclic, continuous integral calculated in real time (Acceleration → Velocity; Velocity → Distance; Frequency → Number of cycles; Power → Energy).

Average over samples option

Online sample averaging can be useful when there is a high degree of noise present in the data. At least some of this noise can be “averaged out” by pooling some number of adjacent data points together, taking the average of these points, and replacing the original values with the new averaged values. This process creates a “window” of moving averages that moves across the waveform smoothing the data.



Integration used to smooth noisy data. Online “Average over samples” feature used as an envelope detector

Since an average represents the sum of a series of data points divided by the number of data points present, you can use the **Average over samples** calculation to provide the information needed to create a moving average. When data is averaged in this way, a portion of the data at the beginning of the record (equivalent to the number of samples being integrated) should be ignored, as they will reflect a number of zero values being averaged in with the first few samples of data.

Samples To specify the number of data points to average across, enter a value in the **Samples** box. The number you select will depend in large part on the sampling rate you select and the type of noise present. All things being equal, for slower sampling rates you will probably want to mean average across a smaller number of samples. As you increase the sampling rate, you will probably want to integrate across more and more samples. As the number of samples specified in the samples box increases, the amount of high frequency information contained in the data will decrease.

Parameters Click in the box to the left of **Parameters** to enable the options, then choose an option:

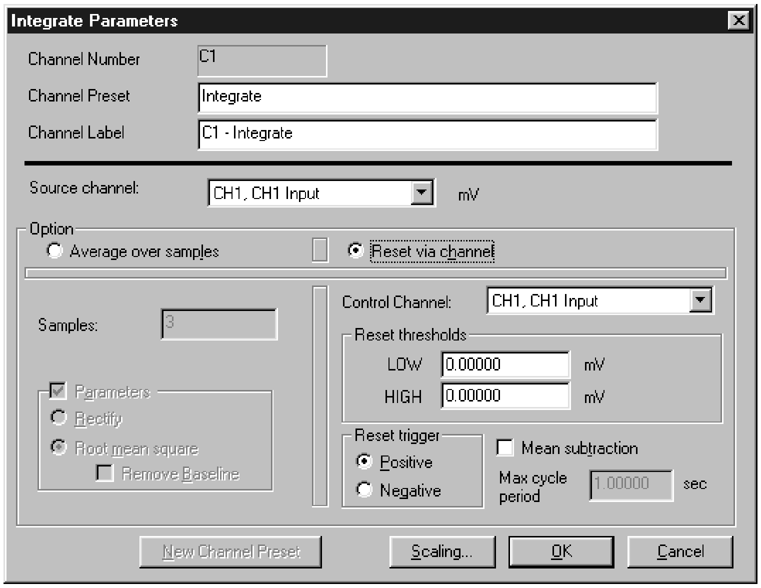
Rectify The **Average over samples** calculation can also be used for producing an envelope of modulated data. For instance, EMG waveforms frequently contain high frequency information, which is often of little interest compared to the low frequency information also contained in the data. When the **Rectify** option is checked, the *PRO* will take the absolute value of the input data prior to summing and a plot of the waveform’s mean envelope over a specified number of samples will be obtained. Typically, this option is only used for processing raw EMG and similar types of applications.

Root mean square This feature provides the exact root mean square (RMS) of the input data (typically EMG) over the specified number of samples.

Remove baseline This feature provides the exact standard deviation of the input data (typically EMG) over the specified number of samples. When the mean of the input data equals 0-0, the standard deviation and the RMS will be equivalent.

Reset via channel option

This feature is used to integrate data over a data-dependent interval. Either the source channel or a different channel can control the integration process.



Control channel: Allows the selection of any active channel as the control channel for the transformation.

Reset Thresholds: The threshold is to be set at points surrounding the flow level.

LOW is typically a negative value close to 0.00

HIGH is typically a positive value close to 0.00

In the case of airflow conversion to volume, the flow signal will vary positively and negatively around zero flow.

Reset trigger: The **Reset trigger** polarity determines on which slope (Positive ↑ or Negative ↓) the integration process will begin and end.

Mean Subtraction: This option will subtract the mean from the data evaluated during the integration period. If this option is selected, the integration will only proceed after all the data in the integration period has been collected. When collected, the mean value of all the data is subtracted from each data point in the integration period. In this fashion, the integral of the corrected data points will result in the integral returning to exactly zero at the end of the integration interval. Although this option will result in “well-behaved” integrations, the integrated data will be delayed by a fixed amount of time, as specified by the max cycle period.

Max cycle period: The max cycle period should be set to a value that is longer than the maximum time expected from trigger event to trigger event in the control data channel.

Integrate — formulas

The **Integrate** formula is the same in the calculation (online, real-time) mode and the transformation (off-line, post-processing) mode, and varies only based on the parameters selected.

Note: For the first points, value of index *"i"* will be *less than or equal to zero;* it means that for summation you have only values beginning with $f(x_1)$.

- ❖ For the first point for summation you have: $f(x_{-1})$, $f(x_0)$, $f(x_1)$.
  $f(x_{-1})$ and $f(x_0)$ - don't exist, so you have only $f(x_1)$.
- ❖ For the second point for summation you have: $f(x_0)$, $f(x_1)$, $f(x_2)$.
  $f(x_0)$ - doesn't exist, so you have only $f(x_1) + f(x_2)$.

1. Via samples, no extra parameters selected

$$F(x_j) = \sum_{i=j-s+1}^{j} f(x_i) * \Delta x$$

Where:

i - index for source values (***the real range is 1..j);

j - index for destination values (1..n);

n - number of samples;

x_i, x_j - values of points at horizontal axis;

$f(x_i)$- values of points of a curve;

$F(x_j)$- integrated values of points of a curve;

s – number of samples to average across;

$\Delta x = \dfrac{x_n - x_1}{n-1}$ - horizontal sample interval;

x_n, x_1 - values at horizontal axis at the endpoints of selected area.

2. Via samples, rectify

$$F(x_j) = \sum_{i=j-s+1}^{j} ABS(f(x_i)) * \Delta x$$

Where:

i - index for source values (***the real range is 1..j);

j - index for destination values (1..n);

n - number of samples;

x_i, x_j - values of points at horizontal axis;

$f(x_i)$- values of points of a curve;

$F(x_j)$- integrated values of points of a curve;

s – number of samples to average across;

$\Delta x = \dfrac{x_n - x_1}{n-1}$ - horizontal sample interval;

x_n, x_1 - values at horizontal axis at the endpoints of selected area.

Integrate formulas, continued…

Note: For the first points, value of index *"i"* will be *less than or equal to zero;* it means that for summation you have only values beginning with $f(x_1)$.

- For the first point for summation you have: $f(x_{-1}),\ f(x_0),\ f(x_1)$.
  $f(x_{-1})$ and $f(x_0)$ - don't exist, so you have only $f(x_1)$.
- For the second point for summation you have: $f(x_0),\ f(x_1),\ f(x_2)$.
  $f(x_0)$ - doesn't exist, so you have only $f(x_1)+f(x_2)$.

1. Via samples, root mean square

$$F(x_j)=\sqrt{\frac{\sum_{i=j-s+1}^{j}\left(f(x_i)\right)^2}{s-1}}$$

Where:

i - index for source values (***the real range is 1..j);
j - index for destination values (1..n);
n - number of samples;
x_i, x_j - values of points at horizontal axis;
$f(x_i)$- values of points of a curve;
$F(x_j)$- integrated values of points of a curve;
s – number of samples to average across.

2. Via samples, root mean square, remove baseline

$$F(x_j)=\sqrt{\frac{\sum_{i=j-s+1}^{j}\left[f(x_i)-\frac{\sum_{m=j-s+1}^{j}f(x_m)}{k}\right]^2}{s-1}}$$

Where:

i and m- indexes for source values (***the real range is 1..j);
j - index for destination values (1..n);
n - number of samples;
x_i, x_j - values of points at horizontal axis;
$f(x_i)$- values of points of a curve;
$F(x_j)$- integrate values of points of a curve;
s – number of samples to average across.
k – coefficient :
For the first few points that have index j < s k=j, for the other points with j > =s k=s

INTEGRATE — EXAMPLE USING AIRFLOW/VOLUME RECORDING

***This is a simplified example. For more complete details, see the Application Note.

Click the **MP35/30** menu and select **Setup Channels**.

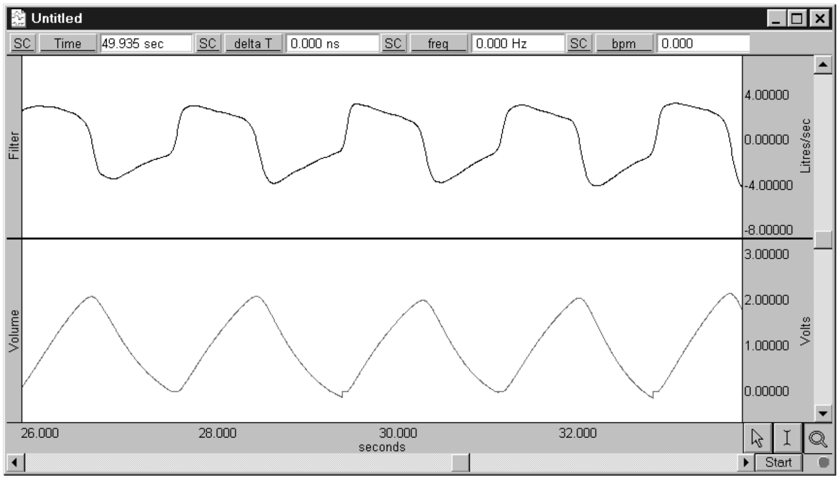
Use the **Preset** pull-down menu to set a calculation channel to **Integrate**.

Set the **Source** channel (Airflow).

If necessary, adjust the **Reset thresholds** to suit the flow signal.

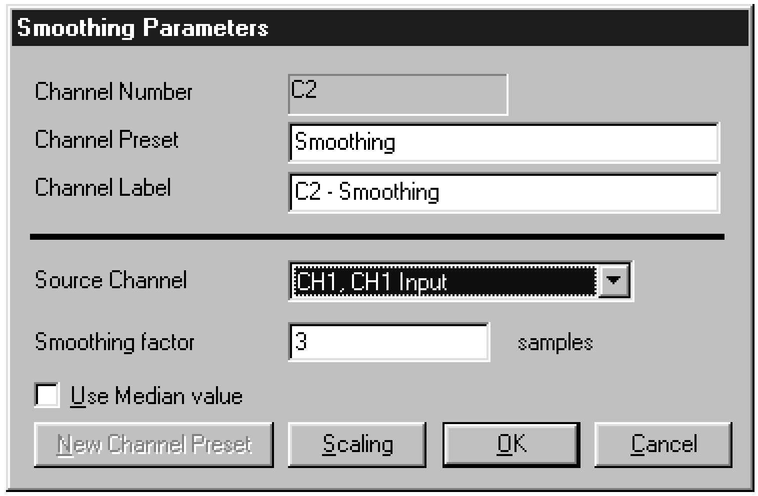
Optionally, to avoid problems caused by a drifting airflow signal, select **Mean Subtraction**. (This will cause a delay in the display because **Mean Subtraction** requires a complete cycle to perform the mean subtraction). The **Mean subtraction** function will remove any offset on a breath-by-breath basis.

The following graph shows an airflow signal with its corresponding volume:



Calculation Preset: Smoothing

The **Smoothing** Calculation functions online and permits Median or Mean smoothing. (Smoothing can also be performed off-line using the smoothing option of the "Transform" menu). This function is very useful if you are trying to remove noise of varying types from a data set.



Smoothing factor Enter the number of samples to use as a smoothing factor.

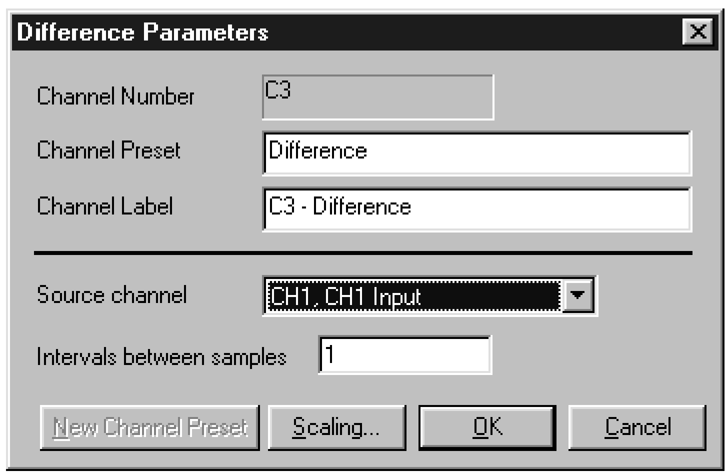
Use Median value The default setting uses **Mean value** smoothing. Use Mean value smoothing when noise appears in a Gaussian distribution around the mean of the signal.

Click in the box to activate **Median value smoothing** if some data points appear completely aberrant and seem to be "wild flyers" in the data set.

Calculation Preset: Difference

The **Difference** calculation returns the difference between two data samples over a specified number of intervals. The **Difference** Calculation is useful for calculating an approximation of the derivative of a data set in real time.

The **Difference** Calculation dialog allows you to specify the source channel and the number of intervals between samples over which the difference is to be taken.



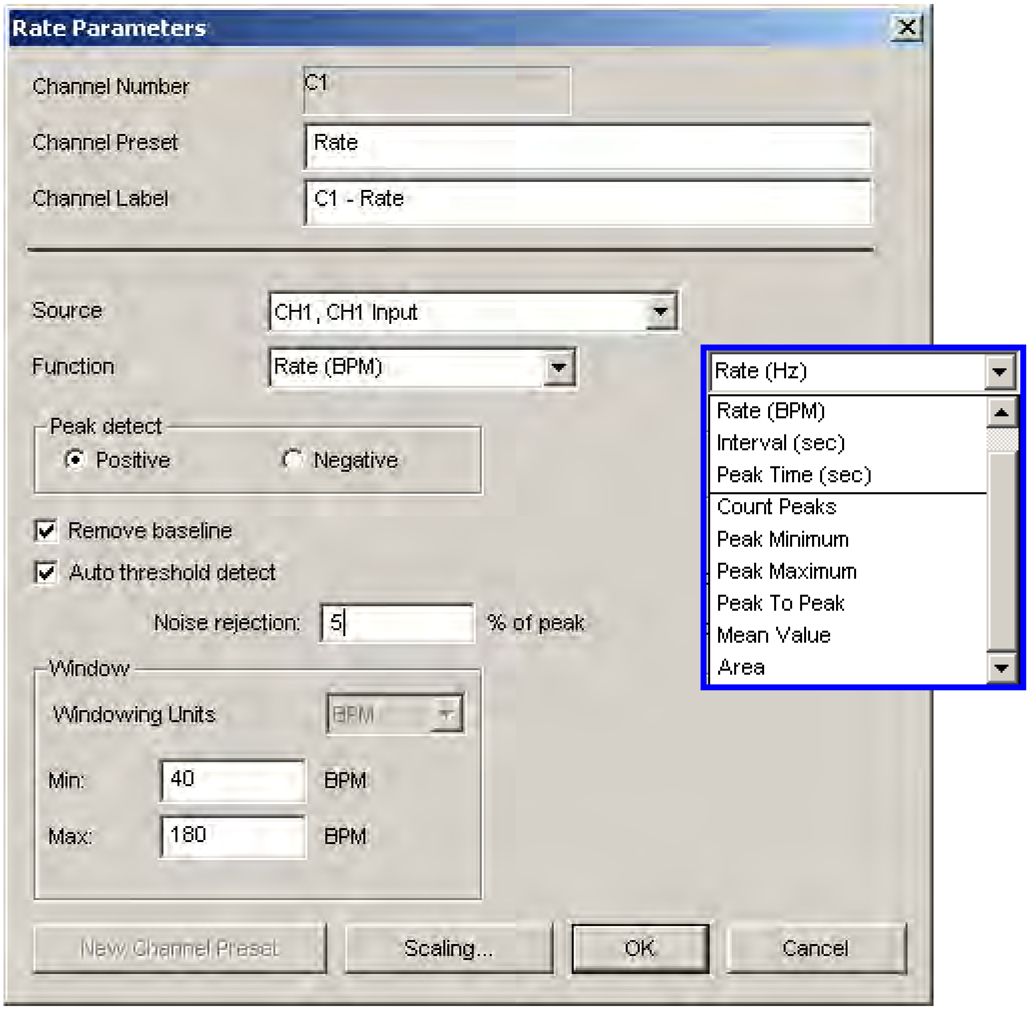
Source When the **Source** channel contains relatively high frequency data, using the Difference Calculation may result in a very noisy response, so it's best to use the Difference Calculation on relatively smooth data.

Interval Difference is calculated with respect to the number of intervals between points (rather than the number of sample points). For instance, two sample intervals span three sample points:

POINT<interval>POINT<interval>POINT

If the Interval is "1" and the source and the output are displayed using Line Plot, then the difference plot will approximate a continuous derivative, shifted one point to the right.

Calculation Preset: Rate



The **Rate** Calculation extracts information about the interval between a series of peaks in a waveform.

Function — The Function pop-up menu includes options to scale the rate in terms of Hz, BPM, Interval, Peak Time, Count Peaks, Peak Minimum/Maximum, Peak-to-Peak, Mean Value, or Area. See the table on page 108 for an explanation of each Rate Function.

Note: Parallel functions can be performed <u>after</u> data has been acquired. All of these Rate Function options are available in the post-acquisition mode through the **Transform > Find rate** function described on page 230.

Peak Detect — For Rate Calculations involving data with positive peaks (such as the R-wave in ECG data), you will want to click the button next to "Positive" in the **Peak Detect** section.

Remove baseline — This will perform a hidden moving difference function on the waveform and is useful for tracing data that has a wandering or drifting baseline.

Noise rejection — Constructs an interval around the threshold level. The size of the interval is equal to the value in the **% of peak** box, which by default is equal to 5% of the peak-to-peak range. Checking this option helps prevent noise "spikes" from being counted as peaks.

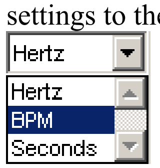
Auto Threshold detect — The most convenient way to calculate a Rate channel online is to use the *PRO* to automatically compute the threshold value (the "cutoff" value used to discern peaks from the baseline). This is done by checking the **Auto Threshold detect** box.

Window — These parameters define the range of expected values for the Rate calculation and are activated when "Auto threshold detect" is enabled. When the Rate calculation is set to automatic, you should also specify a minimum rate and a maximum rate. By default, these are set to 40 BPM on the low end and 180 BPM on the high end. The **Rate** Calculation will use these values to find and track the signal of interest, assuming the input BPM range is reasonably well bracketed by these values. Depending on the shape of the input cycle waveform, the Rate window settings may be closer or further from the expected rates.

Windowing Units are related to the selected "Function."

- Rate Functions related to peak or peak time specify the unit after the Function. This is a fixed unit, so the Windowing Units menu will be disabled.

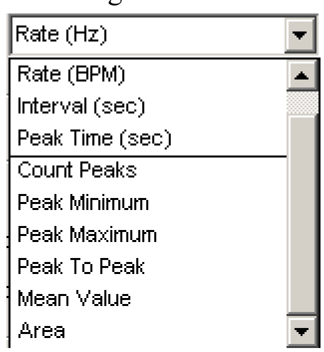
- Rate Functions related to data within a cycle can be specified in units of frequency (Hz) or time (BPM or seconds). The Windowing Units menu will be enabled,a nd when a unit is selected the software will convert the Min and Max settings to the selected units.



See also: Application Note #**PS142** for further information.

Rate > Function Options

The **Function** pull-down menu of the Rate dialog includes the following options:



Area	Computes the area of the signal between two peaks, on a cycle-by-cycle basis.
Count peaks	This peak counting function produces a plot of the number of peaks (on the vertical axis) vs. time (on the horizontal axis). When used with the delta measurements (in the measurement windows), this is a convenient way to calculate how many peaks occur within a selected area.
Interval (sec)	Returns the rate value scaled in terms of a time interval (sec), which is computed as the time difference (delta T) between the two peaks. This is sometimes referred to as the *inter-beat interval* or IBI. This measurement is perfectly correlated with the BPM calculation.
Mean value	Computes the mean of a pulsatile signal on a cycle-by-cycle basis between two peaks. It will also produce a staircase plot.
Peak maximum **Peak minimum**	Tracks the value of the peak. Peak maximum correlates to the systolic pressure in blood pressure readings (the ECG R-wave). **Peak maximum** locks the "Peak detect" option of the dialog to "**Positive**" and **Peak minimum** locks it to "**Negative**."

Peak to peak	Determines the amplitude of a pulsatile signal. It looks at the vertical difference between the maximum and minimum values of the waveform on a cyclical basis.
Peak time (sec)	Returns the time (in seconds) at which the peak occurred. Like the other rate functions (e.g., BPM and Hz), the value of the last peak time will be plotted until a subsequent peak is detected. The resulting plot will resemble a monotonically increasing “staircase” plot.
Rate (BPM)	Equal to 60 times the frequency calculation, or 60/delta T.
Rate (Hz)	Returns the rate value scaled in terms in Hertz (Hz), which is computed by dividing 1 by delta T. This frequency measurement is perfectly correlated with the BPM calculation.

Rate Usage Guidelines

1) One of the most frequent applications of the Rate Calculation is to compute BPM online for ECG, pulse, or respiration data. Waveform intervals can be scaled in terms of BPM (the default), frequency (Hz), or time interval between peaks.
   - The **BPM** (or beats-per-minute) Rate function is used as a measure of peaks or events that occur in a sixty-second period.
   - The **frequency (Hz)** Rate function is commonly used to describe the periodicity of data, or the amount of time it takes for data to complete a full cycle (from one peak to the next peak).
   - The **Interval** Rate function returns the raw time interval between each adjacent pair of peaks, which is essentially the inter-beat interval (IBI), frequently used in cardiology research.

   These three functions essentially provide the same information in different formats, since a frequency of 2Hz is equal to an inter-peak interval of 0.5 seconds, both of which are equivalent to a BPM of 120. Other options allow you to record the maximum or minimum value of all peaks (the peak max/min option), or to count the aggregate number of peaks (the count peaks option).
2) Calculate systolic using the Peak Maximum Rate Function, diastolic using the Peak Minimum Rate Function, and mean blood pressure using the Mean Value Rate Function.
3) For ECG-type data (where the waveform peak is narrow with respect to the waveform period), the Rate window values will closely bracket the expected values.
4) For more sinusoidal data, with the waveform energy distributed over the waveform period (as with blood pressure or respiration), the Rate window will closely bracket the expected rate on the high-end, but can be up to twice the actual measured rate at the low-end.
5) Generally, it's best to use the simplest **Rate** mode that is suitable for your application. If the simplest mode doesn't work, add layers of sophistication one at time. For example, if the "Fixed threshold" mode can't or will not work, use the "Auto threshold detect" mode. If the "Auto threshold detect mode" is similarly impaired, try adjusting the "Noise rejection" or adding the "Remove baseline" option (if selectable).

Find Rate : Operational Mode Suggestions		
If the waveform data has	*Like*	*Use*
Clearly defined positive or negative peaks that are consistently higher (in magnitude) than the rest of the waveform	Respiratory or Air flow data	Fixed threshold
Clearly defined zero-crossing and you want to determine the rate of the crossings	EMG	Fixed threshold
Wide, rounded peaks, but the peaks are otherwise larger in magnitude than other parts of the waveform and/or if the waveform data has a moving baseline	Blood pressure signals	Auto threshold detect *You may need to adjust the **Noise rejection** (Hysteresis) to optimize performance. Noise rejection 5.00 % of peak
High narrow peaks that may or may not be larger in magnitude than other parts of the waveform and/or if the waveform data has a moving baseline	ECG	Remove baseline and Auto threshold detect *You may need to adjust the **Noise rejection** (Hysteresis) to optimize performance. Noise rejection 5.00 % of peak

6) The following stipulations dictate the **Rate Detector** options available:

a) If the **Remove baseline** option is selected, the **Auto threshold detect** option is also selected.

b) The **Auto threshold detect** feature can be used independently of the **Remove baseline** option.

c) The **Noise rejection** setting and the **Window** setting are automatically enabled when the **Auto threshold detect** option is selected.

d) The **Remove baseline** option is disabled when the following measurements are chosen: Peak-Peak, Peak Maximum, Peak Minimum, Area, and Mean.

e) The **Auto threshold detect** option creates a variable threshold for positive or negative peak detection, defined as follows:

Positive peaks: (Peak max - Peak Min)(.75)

Negative peaks: (Peak max – Peak Min)(.25)

In addition, the Rate Detector will construct a moving average of data points defined by 1.5 times the number of samples that can be placed in the largest Window size (time). When the Rate detector loses sync (no threshold crossing inside the Window) the threshold is changed to the mean value of the moving average of data points. This operation permits successful recovery in the event of spurious waveform data values.

f) The **Noise rejection** setting Noise rejection 5.00 % of peak creates hysteresis around the variable threshold as follows:

Hysteresis = Noise rejection (%) • (Peak Max – Peak Min)

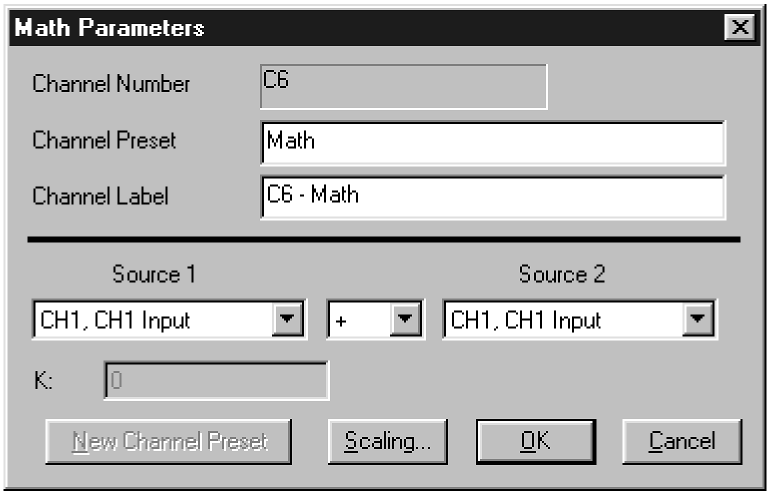
g) The **Remove baseline** option combined with the **Auto threshold detect** option causes the Rate Detector to perform an automatic (and hidden) moving difference function on the waveform data:

(0.025)(sampling rate) = Number of points over which the difference is performed

The difference waveform is then processed as previously described under the **Auto Threshold detect** option.

h) The sample rate must be greater than 40 samples/second for remove baseline and auto-threshold detect to function properly.

Calculation Preset: Math



The **Math** Calculation performs standard arithmetic calculations using two waveforms or one waveform and a constant.

Source To use a summed waveform as an input for another **Math** Calculation channel, select the calculation channel as a Source. The calculation channel used as a Source must have a lower channel number than the **Math** calculation channel.

Operand Use the pull-down operand menu to select a math function.

Operand	Result
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Power

K (constant) Enter a value to be used as the constant for the calculation.

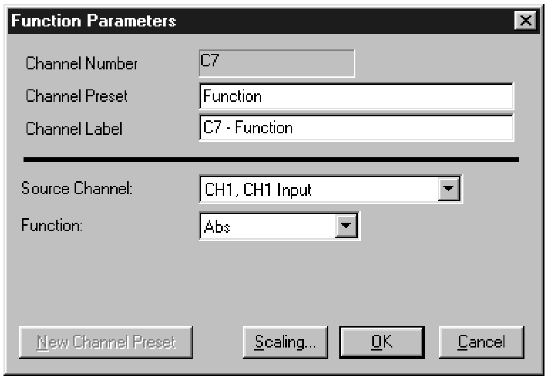
Scaling As an alternative to creating an additional Calculation channel for dividing the summed waveform, you can use the Scaling function to perform the same task. To do this, click **Scaling…** button and then set the **Scale values** for the summed waveform equal to +5 and -5 (to correspond to **Input Volts** values of +10 and -10 respectively). This will effectively plot the sum of channels A1 and A2 as the arithmetic mean of the two waveforms.

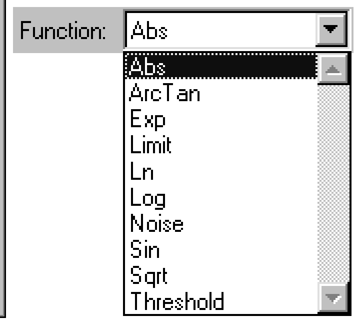
See also…

For additional libraries of online calculation options, consult the sections on **Function** Calculation and the online **Expression** Calculation. These types of calculation channels can be used to perform more complex operations on waveforms. Although calculation channels can be “chained” together to form complex calculations (wherein the output from one serves as the input for another), a separate channel must be used for each function. Additionally, chaining more than three or four channels together can require considerable system resources.

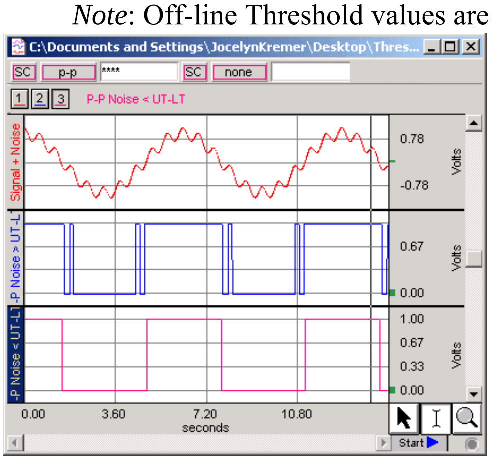
For complex calculations (such as squaring a waveform then adding it to the average of two other waveforms) the **Expression** calculation is a more efficient solution (see page 116). Also, all of the features available online in the **Math** Calculation channels can be computed after an acquisition using the **Waveform Math** option (see page 213), which will eliminate the problem of system overload.

Calculation Preset: Function





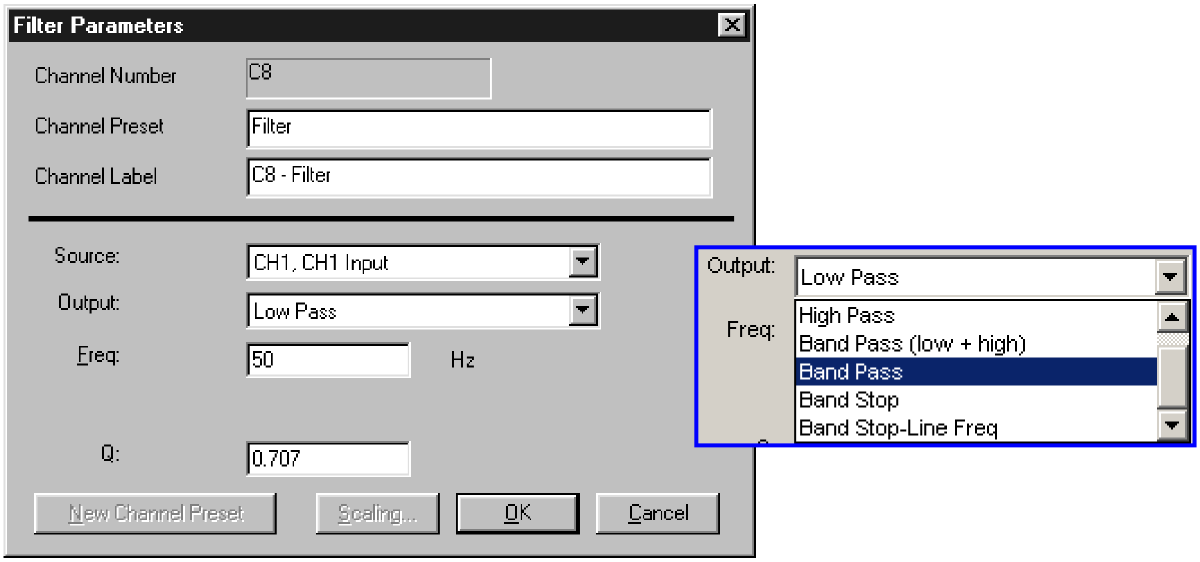
The **Function** calculation can be used to perform a variety of mathematical functions using two waveforms or a waveform and a constant. Function calculation channels compute new waveforms in a manner similar to the Math calculation, but provide access to higher order functions. Like Math calculations, Function calculations can be chained together to produce complex functions (such as taking the absolute value of a waveform on one channel and calculating the square root of the transformed waveform on another channel).

Function	Operation
Abs	Returns the absolute value of each data point
ATan	Computes the arc tangent of each data point
Exp	Takes the e^x power of each data point
Limit	Limits or “clips” data values that fall outside specified boundaries
Ln	Computes the base e logarithm for each data point
Log	Returns the base 10 logarithm of each value
Noise	Creates a channel of random noise with a range of ± 1 Volt
Sin	Calculates the sine (in radians) of each data point
Sqrt	Takes the square root of each data point.
Threshold	Converts above an upper threshold to **+1** while converting data below a lower threshold to **-1**. If the initial data lies between the upper threshold (**UT**) and the lower threshold (**LT**), the output is undefined. *Note*: Off-line Threshold values are +1 and 0 (see page 200).  Top: Signal + Noise Middle: P-P Noise > UT-LT Bottom: P-P Noise < UT-LT

<u>*See also…*</u>

For post-acquisition operations, these functions are available under the **Transform** menu (page 192). Function calculations can be chained together to produce complex calculations, but it is more efficient to program complex functions using the **Expression** calculation; many of these functions are also found in the online **Expression** calculation (see page 116).

Calculation Preset: Filter



The **Filter** Calculation channel performs real-time digital filtering on Analog or Calculation channels.

Output (filter options)

The **Output** pull-down menu lists the four general types of filters: low pass, high pass, band pass and band stop. While the technical aspects of digital filtering can be quite complex, the principle behind these types of filters is relatively simple. Each of these filters allows you to set a cutoff point (for the low and high pass filters) or a range of frequencies (for the band pass and band stop filters).

See filter table on next page.

Freq

This is the frequency cutoff or range (Low/High) for the selected filter type.

Q

The online filters are implemented as IIR (Infinite Impulse Response) filters, which have a variable **Q** coefficient. The **Q** value entered in the filter setup box determines the frequency response patterns of the filter. This value ranges from zero to infinity, and the "optimal" (critically damped) value is 0.707 for the Low pass and High pass filters, and 5.000 for the Band pass and Band stop filters. If you wish, you may change the **Q**. A more detailed explanation of this parameter, and digital filters in general, can be found in Appendix D.

In the dialog box above, the signal on analog channel one (CH1) is run through a Low Pass filter that attenuates data above 50Hz. The "Q" for this filter is 0.707, which is the default.

Note: One possible application of the online filtering option is in conjunction with the **Show Input Values** option (see page 142). Raw EEG data, for instance, can be filtered into distinct bandwidths (alpha, theta, and so forth) using one source channel and multiple Filter calculation channels. The filtered data can then be displayed in a bar chart format during the acquisition using the **Show Input Values** option.

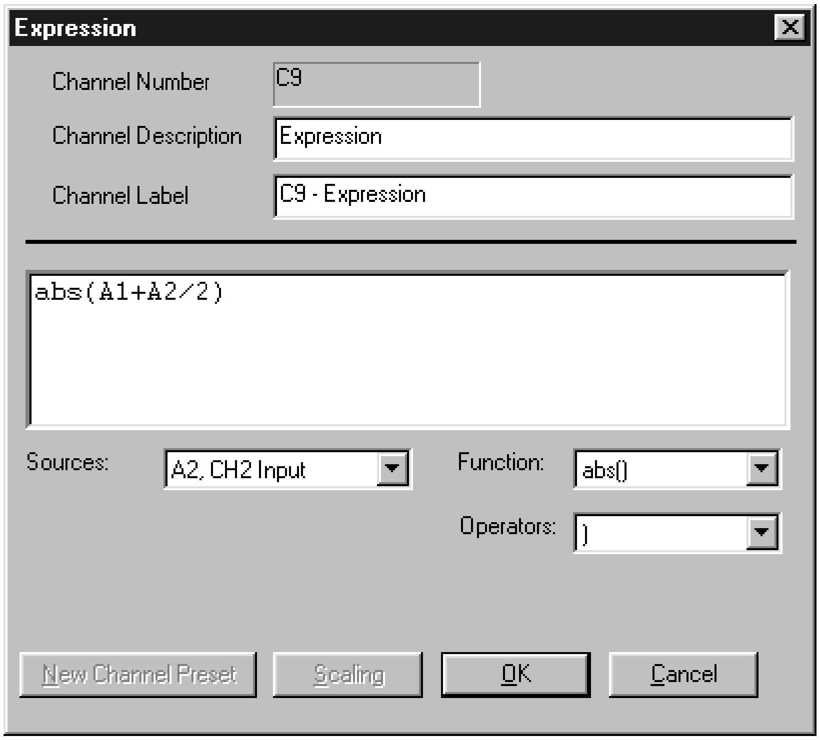
See also…

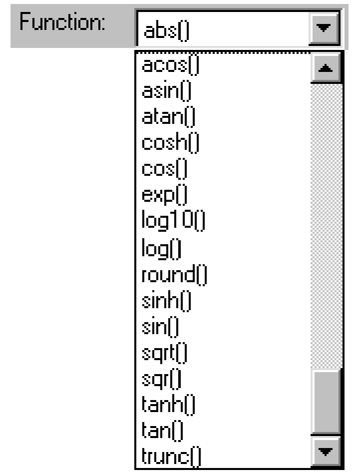
Digital filtering can also be performed after an acquisition using the same types of filters. You can choose from the different filter types by selecting **Digital filters** from the **Transform** menu. The filters available after the acquisition use a different algorithm but operate in essentially the same way.

For more information on digital filters and filters that can be applied after an acquisition, turn to the Digital Filtering section on page 194 or Appendix D.

FILTER Output	Performance
Low Pass	Allows you to specify a frequency cutoff that will "pass" or retain all frequencies below this point, while attenuating data with frequencies above the cutoff point.
High pass	Retains only data with frequencies above the cutoff, and removes data that has a frequency below the specified cutoff (opposite of the Low Pass filter).
Band pass (low + high)	Allows a variable range of data to pass through the filter. For this filter, you need to specify a low frequency cutoff as well as a high frequency cutoff. This defines a range or "band" of data that will pass through the filter. Frequencies outside this range are attenuated. The Band pass (low + high) is actually a combination of a low pass and a high pass filter, which emulate the behavior of a band pass filter. This type of filter is best suited for applications where a fairly broad range of data is to be passed through the filter. For example, this filter can be applied to EEG data in order to retain only a particular band of data, such as alpha wave activity.
Band Pass	Requires only a single frequency setting, which specifies the center frequency of the band to be passed through the filter. When this type of filter is selected, the "width" of the band is determined by the Q setting (previously discussed). Larger Q values result in narrower band widths, whereas smaller Q values are associated with a wider band of data that will be passed through the filter. This filter has a bandwidth equal to Fo/Q, so the bandwidth of this filter centered around 50Hz (with the default Q=5) would be 10Hz. This type of filter, although functionally equivalent to the band pass (low + high) filter, is most effective when passing a single frequency or narrow band of data, and to attenuate data around this center frequency.
Band Stop	Defines a range (or band) of data and attenuates data within that band (opposite of the Band Pass filter). A center frequency is defined and the Q value determines the width of the band of frequencies that will be attenuated.
Band Stop – Line Freq	Defines a band stop at 50 Hz or 60 Hz, based on the line frequency selected during installation.

Calculation Preset: Expression





The online **Expression** evaluator can be used to perform complex computations that cannot be managed with the Math or Function calculations. The **Expression** evaluator uses standard mathematical notation and will symbolically evaluate complex equations involving multiple channels and multiple operations.

Unlike the Math and Function Calculations—which can only operate on one or two channels at a time—the **Expression** calculation can combine data from multiple analog channels and allows you to specify other calculation channels as input channels for an **Expression**. Computations performed by the **Expression** evaluator eliminate the need for "chaining" multiple channels together to produce a single output channel. For example, you can square one channel, multiply it by the sum of two other channels, and divide the product by the absolute value of another waveform on a single Expression Calculation channel, which is more efficient than chaining five Math and Function Calculation channels together.

While the **Expression** evaluator is more powerful than other Calculation channels, each **Expression** Calculation requires more system resources than other Calculation channels do. This essentially means that acquisitions that utilize **Expression** Calculations are limited to a lower maximum sampling rate than acquisitions without Expression calculations.

For each expression, you need to specify at least one Source, the Function(s) to be performed, and any Operators to be used. Make a selection from the pull-down options or type directly into the **Expression** box.

Note: It is important to keep in mind that while different channels, functions, and operators can be referenced, this Expression Calculation cannot reference past or future sample points. That is, data from waveform one can be transformed or combined in some way with data from waveform two at the same point in time, but data from one point in time (on any channel) cannot be combined with data from another point in time (on any channel). See the section on post-acquisition Expression commands (beginning on page 211) for ways around this limitation.

Source

Sources are typically analog channels, but you may select **Time** from the Source menu to return the value of the horizontal axis (usually Time) for each sample point. When the horizontal axis is set to Frequency (in the **Display > Horizontal axis** dialog), the "Time" item will switch to "Freq."

Function

The **Expression** calculation offers the following functions:

Function	Expression result
ABS	Returns the absolute value of each data point.
ACOS	Computes the arc cosine of each data point in radians.
ASIN	Calculates the arc sine of each value in radians.
ATAN	Computes the arc tangent of each sample point.
COS	Returns the cosine of each data point.
COSH	Computes the hyperbolic cosine of each selected value.
EXP	Takes the e^x power of each data point.
LOG	Computes the natural logarithm of each value.
LOG10	Returns the base 10 logarithm of each value.
ROUND	Rounds each sample point the number of digits specified in the parentheses.
SIN	Calculates the sine (in radians) of each data point.
SINH	Computes the hyperbolic sine for each sample point.
SQR	Squares each data point.
SQRT	Takes the square root of each data point.
TAN	Computes the tangent of each sample point.
TANH	Calculates the hyperbolic tangent of each sample point.
TRUNC	Truncates each sample point the number of digits specified in the parentheses.

Operator

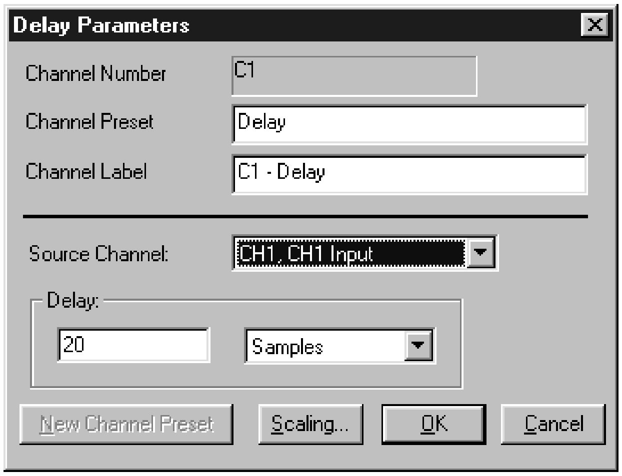
The following operators are available in the **Expression** dialog:

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Power
(	Open parentheses
)	Close parentheses

<u>*See also…*</u>

The same features that are available in online **Expression** calculation are also available under the **Transform** menu for evaluation of complex equations after acquisition. Also, simple calculations such as summing two channels or dividing one channel by another (and so forth) are best performed in either the **Math** calculation channels or the **Function** calculation channels.

Calculation Preset: Delay



Delay allows you to use a calculation channel to plot another channel lagged (delayed) by an arbitrary interval. When a **Delay** channel is recorded, there is a segment at the beginning of the channel (equal to the value of the delay) that will read as 0 Volts. This is normal and occurs because the **Delay** channel is waiting to "catch up" with the original signal. The *PRO* fills this buffer with zeros until the **Delay** channel begins to plot actual data.

Delay The **Delay** interval can be specified either in terms of **samples** or **seconds** and cannot exceed the acquisition length.

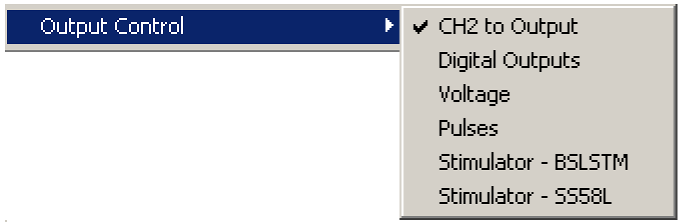
If the **Delay** entry exceeds the acquisition length, an error prompt will be generated. To correct the error, decrease the **Delay** value or increase the **Acquisition Length** entry under **MP35/30 > Setup Acquisition**.

In the graph shown above, the **Delay** channel contains a 0.25-second interval of zeros at the beginning of data file.

Delay plots are useful for producing nonlinear ("chaos") plots in X/Y display mode (see page 45).

✓ TIP Although there is not a parallel function in post-processing mode, the same effect can be obtained by selecting a section of one waveform equal to the desired delay interval and choosing the Edit > Cut function or the Edit > Clear command to remove a section of the waveform.

Chapter 8 Output Control — MP35/30 Menu



The MP35 and the MP30 can output pulses or analog voltages via the **Analog Out** port; this port is also used to connect to BIOPAC's external stimulators. The MP35 has an additional **I/O Port** which is used to output digital (TTL Level) signals.

Parameters for output signals are set via **Output Control**. Access to a specific Output Control is via the **MP35>Output Control** submenu.

There are six Output Controls for the MP35 and four for the MP30:

Output Control	***See page***	**MP35 Functionality**	**MP30 Functionality**
CH# to Output	page 121	Direct analog CH1-4 to output listen to signals	Direct analog CH3 to output
Digital Outputs	page 121	Control 8 digital outputs	Not available
Voltage	page 137	Output Voltage Level (0 – 4 V DC)	Output Voltage Level (0 – 5 V DC)
Pulses	page 123	Use with third-party devices; software can control pulse width and repetition.	Use with third-party devices; software can control pulse width and repetition.
Stimulator - BSLSTM	page 137	Use with BSL Stimulator	Use with BSL Stimulator
Stimulator - SS58L	page 139	Use with SS58L Low Voltage Stimulator; software can control pulse amplitude, width and repetition (-10 to +10 V)	Not available

To open an Output Control, select it from the **MP35>Output Control** submenu. A checkmark appears next to the submenu selection and an **Output Control** panel is displayed, bordered in red beneath the BSL *PRO* Toolbar in the active data window. To close an Output Control, select from the menu again (toggles between display and hide) or right-click in the open control panel and choose **Close**.

Only one Output Control panel may be open at any time. Switching between different data files can change the display and operation of the control panel.

Because some output devices can be used for stimulation on humans and can achieve voltages up to 100 Volts, built-in software logic makes output control as safe as possible.

- **See page 138 for safety notes regarding human subjects.**

The following applies to all Output Controls.

1. The output will not operate unless its software control panel is open.
2. When an Output Control panel is closed, or the BSL *PRO* application is closed, MP35 output goes to 0 Volts, preventing the output device from sending pulses.
3. When an Output Control panel is opened, output is always OFF until activated by a click of the ON/OFF switch in the control panel or, if parameters allow, a click of the Start button in the data acquisition window. (Exceptions are the Voltage Output Control, which outputs immediately, and the Digital Outputs Control when set to the preference "Set each output immediately.")

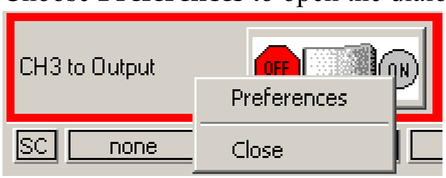
4. Output preference parameters are local and are saved with the data file or a graph template file. The data or template file holds the output parameters as established when the file was saved. (See "Save as Graph Template," page 174.) Switching between other open graphs can change the display and operation of the control panel since the settings in each graph are independent entities.

Controlling Output Signals

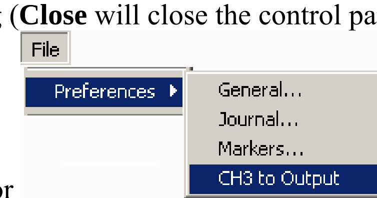
Use both the Output Control panel and its respective Preferences dialog to control the output signal. Output Control **Preferences** dialogs establish the parameters for output. Preferences dialogs are only available when the corresponding Output Control panel is open and active. Voltage does not have Preferences, and on the MP30 only, CH3 to Output does not have Preferences.

To generate the **Preferences** dialog, either:

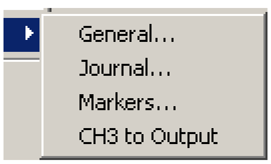
1. Open an Output Control panel and then right-click anywhere in it to generate a pop-up menu. Choose **Preferences** to open the dialog (**Close** will close the control panel).



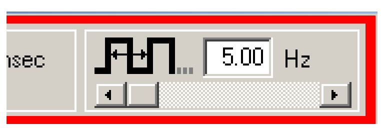
or



2. Open an Output Control panel and then choose **File>Preferences** and select from the submenu to open the dialog.



If a control panel entry box is grayed or disabled, its values may be established, or limited, by settings in the Preferences dialog. If **Preferences** parameters allow, enter values directly in the **Output Control** panel.



a. Key into the entry boxes and then enter the value by pressing the **Enter** key.

b. Use the **Tab** key or mouse to move to another entry box.

c. Click the **OK** button if in the preference dialog.

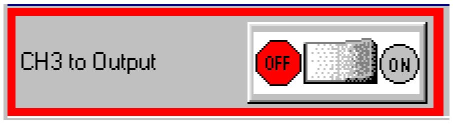
Values entered into a control panel or its Preferences dialog that are outside the specifications of the output device, or outside the limits defined by the Preferences dialog, may change automatically to reflect either the closest value to that requested that the the hardware can achieve, or the closest increment defined by the limits in Preferences. (The system will not check while you type, it checks and may make changes after the value is entered.)

- For example, if a Pulse width of 5 ms is entered into the Pulses Output Control panel entry box, but Preferences defines a range limit of .5 to 2 ms for Pulse width, the system will automatically change the new entry to 2 ms.

Saving Panel settings:

Output Control panel settings will be retained until a file is closed or saved. If a file is closed but not saved, settings will be lost (defaults established); if a file is saved, panel settings will be saved.

CH# to Output Output Control



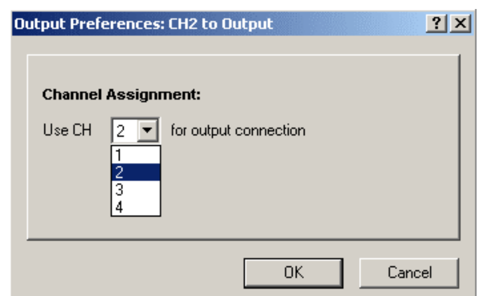
The CH# to Output Output Control redirects an analog input signal to the **Analog Out** port on the back of the MP35/30. The signal from the assigned channel will continue to be recorded and plotted as it normally would.

- MP35 users may use analog input CH1-CH4.
- MP30 users must use CH3.

This Output Control is used mainly when attaching headphones to the MP35/30 to listen to signals coming in on an analog input channel. One common use is listening to the EMG (muscle) signal, a clinical procedure physicians use to actually hear certain problems with muscles.

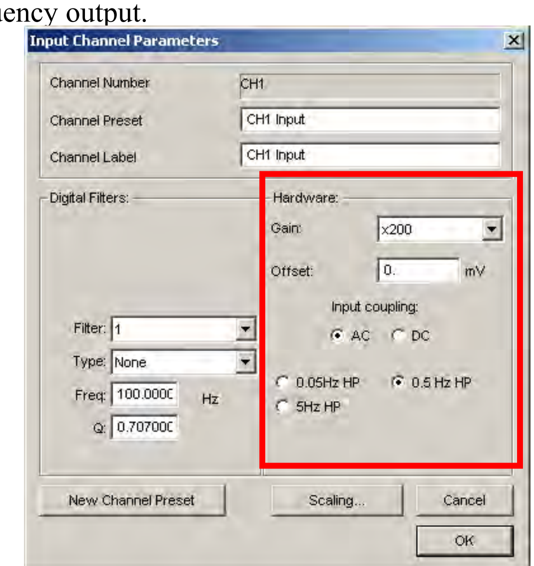
To display this control panel:

1) Choose **MP35>Output Control>CH# to Output** to open the control panel.
   - Channel 3 is the default setting. If another channel N has been designated, the menu will read “CH<N>.”
   - OFF grounds the output so no signal (or sound) should be present.
2) Use the control panel **ON/OFF Switch** to start and stop output.
3) If desired, MP35 users may set **Preferences** to designate which channel to redirect to output.
   a. Open the Preferences dialog (right-click in the control panel or choose **File>Preferences>CH# to Output**).
   b. Use the pull-down menu to select the desired channel CH 1-4 to use for the output.
   c. Click OK to set the output channel and return to the control panel.



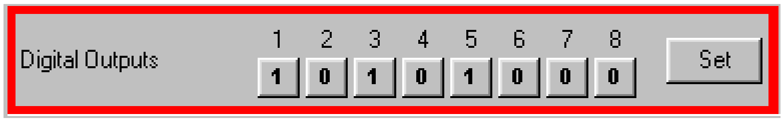
- MP30 Users: The Preferences option is disabled because you may only redirect Channel 3 to output. When outputting the signal, you may want to set the low pass hardware filter to 5 kHz rather than 1 kHz (see page 98) to allow higher frequency output.

Note Only the Hardware settings (Gain, Offset, Input Coupling) from the Input Channel Parameters dialog (MP3X > Set up Channels > Wrench) will be applied since output is established prior to the processing of Digital Filters.



See page 272 for **MP35 Input>Output Scaling** values.

Digital Outputs Control — MP35 only



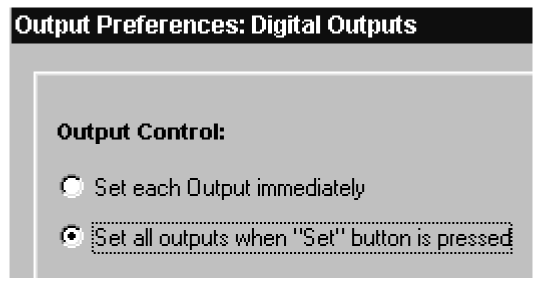
- MP30 Users: The Digital Outputs Control panel is not available when using an MP30.

The Digital Outputs Control allows control of signal output on each of eight digital lines via the **I/O Port** connector on the back of the MP35. Use it to control external devices. The digital output uses stardard TTL levels which correspond to the control panel setting as follows:

Control Panel setting	Output Voltage level (Volts)
0	0
1	+5

To display this control panel:

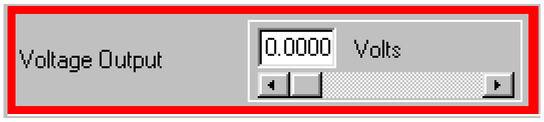
1) Choose **MP35>Output Control>Digital Outputs** to open the Digital Outputs Control panel
2) Click each digital output line to set its digital state to 0 (off) or 1 (on).
3) If desired, you may set **Preferences** for Digital Outputs.
   a. Open the Preferences dialog (right-click in the control panel or choose **File>Preferences>Digital Outputs**).
   b. Select from the following two options:



- **Set each output immediately** (default) allows you to toggle the state of each digital output line between 0 and 1, and change the state **immediately**. In this mode, no **Set** button is available in the control panel. Output for each line is set upon clicking its toggle button.
- **Set all outputs when Set button is pressed** allows you to toggle the state of each digital output line, but the states will not physically be changed until the **Set** button is clicked on the control panel. In this mode, a **Set** button is available in the control panel. When the **Set** button is clicked, all eight digital lines will update simultaneously.

   c. Click OK to set Preferences and return to the control panel.

Voltage Output Control



The Voltage Output Control is used to output a voltage level (DC voltage) via the Analog Out port on the back of the MP35/30 to control another piece of equipment.

To use this control panel:

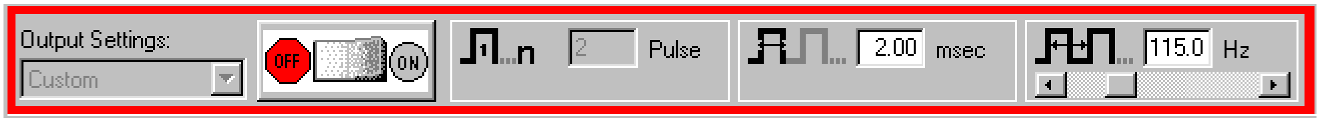
1) Choose **MP35>Output Control>Voltage** to open the Voltage Output Control panel.
2) Enter a value manually, or use the scroll or arrow buttons to increase or decrease values.
   - When using the scroll box, a change will not occur on the output until the mouse button is released.
   - The display shows the value that is to be output. If an entry exceeds the voltage range limits of the MP Acquisition Unit, the value automatically rounds to the nearest obtainable value.

MP Voltage Output		
	MP35	MP30
Range	0 - 4.096 Volts	0 - 5 Volts
Resolution	1 mVolt	19.5 mVolts

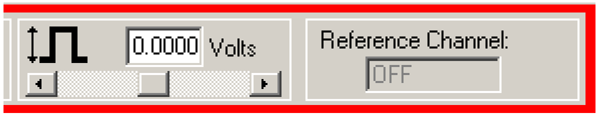
There are no Preferences for the Voltage Output Control.

When multiple graph windows are open, Voltage Output stops (goes to 0 Volts) if the graphs are switched and the new active graph contains its own Output Control panel. When the graph containing the Voltage Output Control panel is made active again, Voltage Output goes back to the previously set level.

Pulses Output Control
Stimulator – BSLSTM Output Control
Stimulator – SS58L Output Control



Control panel options for Pulses, Stimulator – BSLSTM and Stimulator – SS58L



Additional control panel options for Stimulator – SS58L (MP35 only)

The BSL *PRO* System offers a variety of pulse ouput options. Exercise caution when using any of the options with human subjects—see the **Safety Note** on page 138.

- **Pulses Output Control**

  Select this Output Control for general pulse output, or when synchronizing to 3rd-party devices.

  - Use for reaction time measurements, where a subject listens with headphones for a series of "clicks" (pulses) and responds as quickly as possible with a button press. Determine reaction times by calculating the time between the start of the pulses and the responses.
  - Use with the **BIOPAC STP30W** Stimulus Presentation System (SuperLab) to measure responses to visual or auditory stimuli. To perform sophisticated evoked response averaging tests (e.g. P300), pair triggers with different visual or auditory stimuli.
  - Use to trigger another device (automatically send a pulse from the MP35/30 when acquisition starts).
  - Use to control a 3rd-party stimulator. BIOPAC recommends use of the BIOPAC BSLSTM Stimulator with the MP35/30 and BSL *PRO* software. If using the BSLSTM Stimulator, use the **Stimulator - BSLSTM Output Control** instead of this Pulses Output Control.

- **Stimulator – BSLSTM**

  Select this Output Control when using the Biopac Student Lab stimulator (BSLSTM)

  - Use with stimulation electrode HSTM01 for safe stimulation of human subjects (0 – 100 Volts), as well as lower voltage (0 - +10 Volt) general-purpose stimulation, such is used with amphibian muscle or nerve preparations.

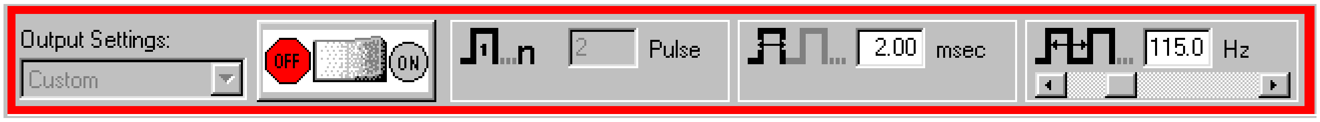
- **Stimulator – SS58L**

  Select this Output Control when using the SS58L connector for low-voltage (-10 - +10 Volt), direct drive stimulation.

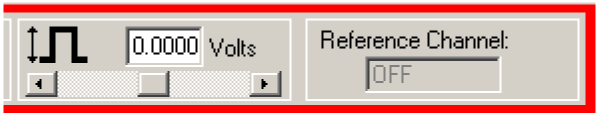
  - Use with stimulator electrode HSTM01for safe, stimulation of human subjects (0 – 100 Volts), as well as lower voltage (0 - +10 Volt) general-purpose stimulation, such is used with amphibian muscle or nerve preparations.
  - Outputs through a BNC connector so it can be used with most stimulation cables (such as those that terminate in a needle probe).

To use one of these control panels:

1. Choose MP35/30>Output Control and then select Pulses, Stimulator – BSLSTM, or Stimulator – SS58L.

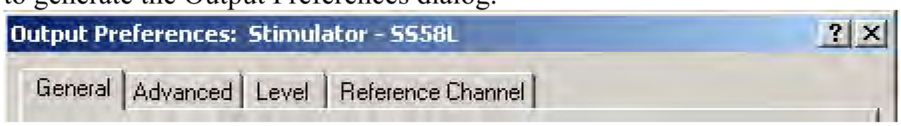


Control panel options for Pulses, Stimulator – BSLSTM and Stimulator – SS58L



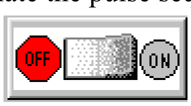
Additional control panel options for Stimulator – SS58L only

2. Right-click in the Output Control panel (or choose **File>Preferences** and select from the sub-menu) to generate the Output Preferences dialog.

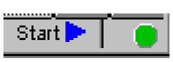


3. Set the **Preferences**.
   - **General**: ON/OFF, Number of pulses, Marker options — see page 129
   - **Advanced**: Pulse width, Pulse repetition (rate) — see page
   - **Level** (SS58L only): Pulse level — see page
   - **Reference Channel** (SS58L only): Channel assignment, signal generation — see page
4. Once configured, Preferences may be saved using the **Save Settings** command, activated by pressing the button at the bottom of the Preferences dialog (see page 128).
5. Confirm the settings in the control panel. Adjust as desired within the parameters established in Preferences.

   Entry limits: Settings entered into the Preferences dialog may establish, or limit, the values in the Output Control panel entry boxes. You may enter pulse settings directly into the control panel only if parameters established in Stimulator Preferences allow. If an entry box is grayed or disabled, its value is set or limited by Preferences.
6. Initiate the pulse sequence as defined in Preferences (see page 129).

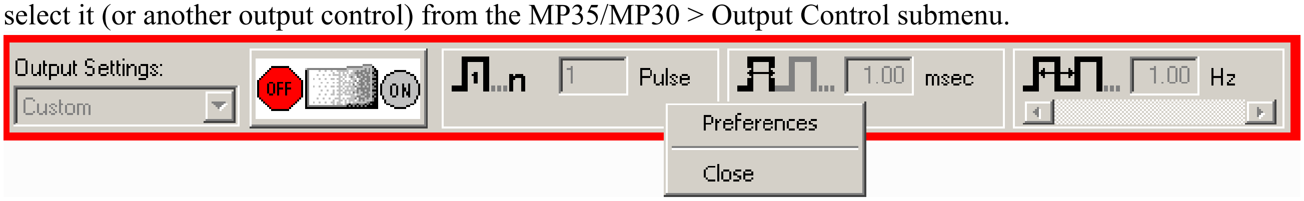
   ON/OFF Button in Output Control Panel uses the switch in the Control panel.

   Recording uses the **Start /Stop** button in the data acquisition window.

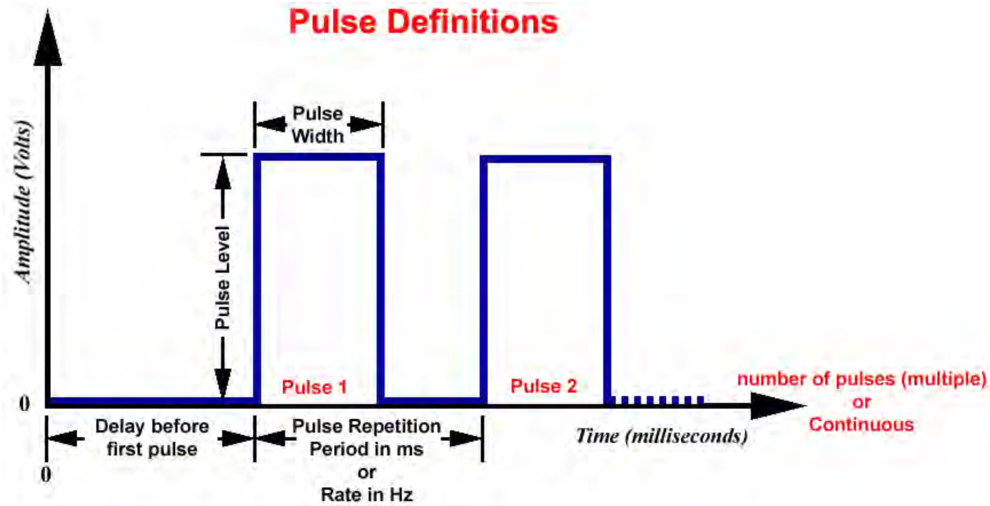
To close an Output Control panel:

Right-click anywhere in the Ouput Control panel to generate a pop-up menu and then choose **Close**, or select it (or another output control) from the MP35/MP30 > Output Control submenu.



Pulse Definitions

The following terms are used in the Output Control panels, Preferences, and guidelines for Pulses, Stimulator – BSLSTM and Stimulator – SS58L.



Delay before first Pulse	Initial delay from start of acquisition to start of first pulse.
Number of pulses	Number of successive pulses that will be sent out at the specified Pulse Width, Repetition and Level. Set for Single (1), Multiple, or Continuous (Cont).
Pulse Level	Amplitude of the pulse, expressed in Volts. ▪ *Note*: The output of the BSLSTM is 0 Volts when the pulse is not active.
Pulse Repetition ***Also called —*** **Events per second** **Pulse frequency** **Pulse sequence** **Pulse train** **Repetition rate** **Sample train**	Can be expressed as **Period** (ms) or **Rate** (Hz). *Period:* Time between pulses; measured in milliseconds from the start of one pulse to the start of the next pulse. *Rate:* Number of pulses that occur in a one-second interval; measured in Hertz. **Rate** relates to **Period** as: Rate (Hz) = 1000 / Period (ms)
Pulse Width	Time that the pulse is in the non-zero or active state.

Output Control

The Output Control panels for Pulses, Stimulator – BSLSTM and Stimulator – SS58L work in conjunction with Preferences to control pulse output. Control panel functions are detailed here:

OUTPUT CONTROL PANELS

General Notes

Pulse parameters can interact with each other.

- For example, the pulse repetition period cannot be set to a value less than the pulse width.

In order to simplify the interaction, the Pulse width entry overrides other entries as required; it is the priority parameter.

- For example, if the pulse width is changed such that it exceeds the pulse repetition period, the pulse repetition period will be automatically adjusted to accomidate the new pulse width entry. If, however, the pulse repetition period is changed such that it is less than the pulse width, the repetition period will be changed, upon attempted entry, to the closest value that can be achieved without changing the pulse width.

Entries are checked and rounded (not truncated) as necessary to meet limitations of the hardware or the Preferences.

When a file is opened, the output device will not turn ON automatically. A user must manually press either the “Record” button or the “Start” button.

- The exceptions are the “Voltage Output” control panel and the “Digital Outputs” control panel if “Set each Output immediately” is selected; these settings will output values immediately.

Output control settings are “local,” which means that they are stored at the data file level, not the program level. Use the save as graph template (File > Save As) option to use existing Preferences in new data files.

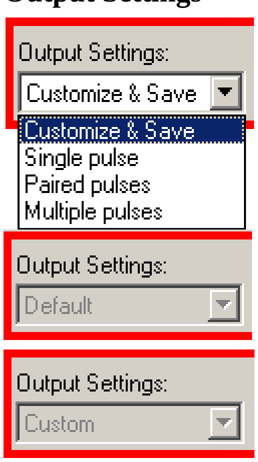
If a file is saved with an Output Control panel visible and then closed, the panel will be visible when that file is re-opened.

Preferences

Right-click a control panel to generate the Preferences dialog, and then select a tab for the settings you want to adjust.

You can also use the File>Preferences menu option to generate the Preferences dialog.

Output Settings



Displays the name of the current Preferences setting. The pull-down menu lists the names of all output Preferences saved using the **Save Settings** button (see page 128). The pull-down menu is not accessible when an output pulse train is in progress.

If no settings configurations have yet been saved, when the Output Control panel is first opened and no parameters are changed, the Output Settings box displays “Default.” If any parameters parameters are changed (but not yet saved), it displays “Custom.”

When output settings are saved, the Output Settings box displays the name of the last selected setting. Use **Organize List** to change the display order of the menu, rename, or delete items (see page 128).

When a saved setting is selected from the pull-down menu, the Output Control panel and all Preferences dialog options will be updated.

For Reference Channel—SS58L only: All Output Settings must use the same

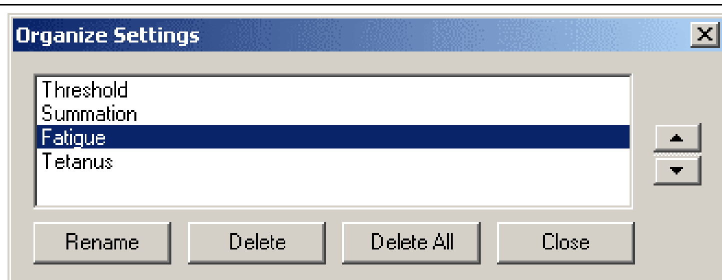
OUTPUT CONTROL PANELS

reference channel assignment; othr paramters can be unique for each setting.

Once configured, Preferences may be saved using the **Save Settings** button at the bottom of the Preferences dialog. **Save Settings** generates a dialog to name and save a defined configuration of Stimulator output settings. Saved configurations are accessible via the Output Settings pull-down menu in the Output Control panel. When a setting is selected from the menu, all current output parameters are updated to reflect the saved settings.

You can save multiple configurations as long as each has a unique name; the Save button will be inactive if the name you enter is not unique.

Output settings configurations are local presets that are saved with the data file or a template file. The data file or template file holds the output parameters as established when the file was saved plus any other named configurations of Output Settings.



Use the **Organize List** button at the bottom of the Preferences dialog to order, rename or delete saved Preferences settings. The up or down arrows are only available if two or more settings have been saved. Select a setting and then click the up and down arrows to set the position, or choose rename or delete. If you choose “Delete All,” all saved settings will be deleted and the default and Custom options will be reactivated.

GENERAL TAB (OUTPUT PREFERENCES)

General Tab

Number of Pulses

Indicates the number of pulses to be output. When the Output Control panel is closed, the pulse output will be immediately stopped.

- **Single** will establish a single pulse for outputting. All pulse repetition options, entry boxes and scroll bars in both the control panel and preferences windows will be disabled (grayed).
- **Multiple** will establish a specific number of pulses for outputting. The selection will activate an entry box where you can enter 1-254 pulses. When this option is selected, the Pulse Repetition scroll bar is activated in the Output Control panel.

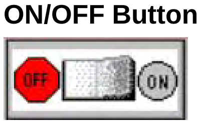
Continuous will establish a continuous pulse train for outputting. When this option is selected, the Pulse Repetition scroll bar is activated in the Output Control panel.

MP30 Only If using High Speed mode (>2,000 s/s) and "Initiate pulse sequence with Recording" is selected, the stimulator cannot be turned off manually since the MP30 will not accept any commands from the computer until the recording has stopped.

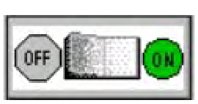
If "Initiate pulse sequence with ON/OFF button in Output control panel" is set, the pulse sequence will be stopped prior to acquisition and will have to be manually turned back on after the recording.

Initiate pulse sequence with…

ON/OFF Button



OFF (red)



ON (green)

AUTOMATIC START

Controls the start and stop of pulses. Changes to Pulse Width and Repetition Rate can be made in the Output Control panel entry boxes during a pulse sequence, and during a recording, if all other Preferences parameters allow it. Any change in the pulse output will occur immediately. ***This lets you change the stimulator output "on the fly."***

When "Initiate pulse sequence with **ON/OFF button**" is selected:

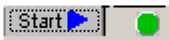
- The ON/OFF button controls pulse output independent of the acquisition status.
- OFF is always available.
- The ON/OFF button reflects the current output state, with one exception: if the pulse sequence lasts less than 0.5 seconds, the button will remain in the "ON" state for at least 0.5 seconds to indicate that the ON state occurred.

GENERAL TAB (OUTPUT PREFERENCES)

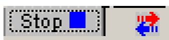
(yellow)

- When the Number of Pulses selected is **Multiple**, ON/OFF acts as a momentary switch. Press the ON (green) button to start pulses;
  it will automatically turn OFF (red) at the end of the specified pulse train.
- The switch defaults to OFF. Saving a data file or saving as a Graph Template will save all stimulator preferences <u>except</u> the status of the pulse switch, which will always be saved in the OFF position.

Recording



Start button



Stop button

When “Initiate pulse sequence with **Recording**” is selected:

If the preference setting “Initiate pulse sequence with: ON/OFF button” is active, the control panel changes will take effect immediately. If settings are changed during a pulse train, changes do not take effect until the next time the stimulator starts.

- Pulse output turns ON and OFF corresponding to the Start and Stop of the recording. In other words, the Pulse output can only occur during a recording.
- When in this mode, and not recording, the ON button will display as yellow , indicating that pulse output will automatically begin at the “Start” of the recording.
- Pulse outputting can be turned OFF during a recording, but it cannot be turned back ON until the end of the recording.
- When a **Repeat** sequence is running, pressing the OFF button will turn OFF the output <u>for the entire recording sequence</u> and the button will display as OFF until after the last sequence, when the switch will display as yellow ON (automatic start) indicating that pulse output will begin again at the “Start” of the next recording sequence. You cannot turn pulse outputting back ON during a repeated recording sequence.
- When the acquisition stops, all stimulator pulses will cease, regardless of the Output Control panel settings.
- The pulse train will stop concurrent with the end of the acquisition, even if the specified pulse train is not completed before the acquisition ends. When a new acquisition is started, the pulse train will start from the beginning.
- In this mode, no changes can be made in the Output Control panel until the recording stops. Changes made after recording stops will take effect when a new recording is started.
- When a pulse is sent out, the marker label and indicator arrow will be generated (if the marker preference is turned ON and markers are displayed).

After initial delay

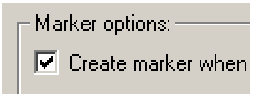
After initial delay of … is enabled only when “Initiate pulse sequence with **Recording**” is chosen. Specify a delay interval from the start of recording to the start of the first pulse. This is useful for viewing data prior to the stimulus pulse. The BIOPAC output device determines the delay range.

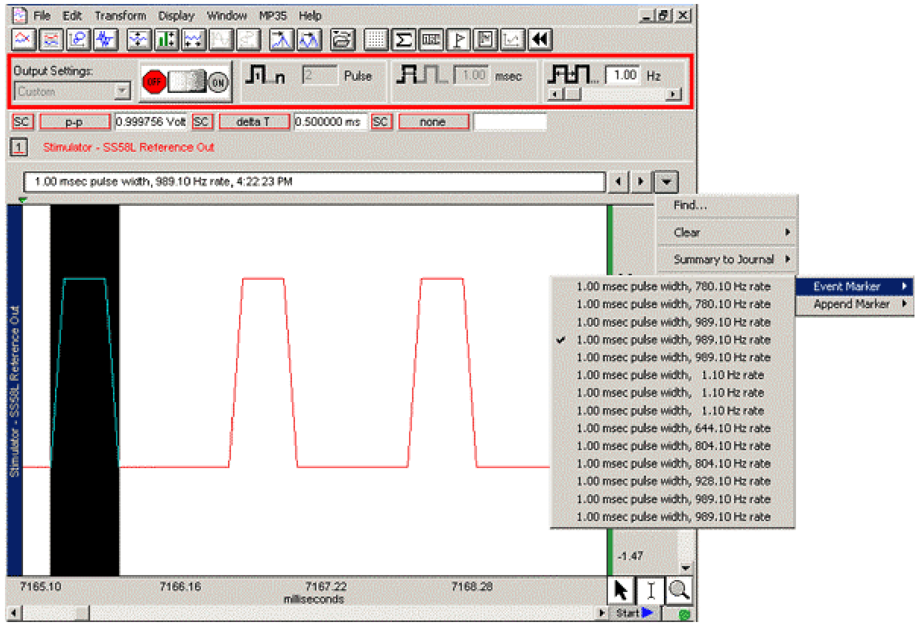
INITIAL PULSE DELAY	<u>MP35</u>	<u>MP30 or BSLSTM</u>
Range	0 - 100 milliseconds	0 or .5 - 100 milliseconds*
Resolution	10 microseconds	1.953 microseconds

*Entries greater than 0 milliseconds must be at least 0.5 milliseconds.

GENERAL TAB (OUTPUT PREFERENCES)

Pulse Markers



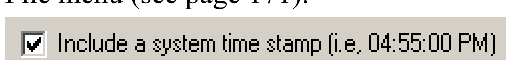


An advantage of using the BSL *PRO* software for output signals is that information regarding the pulse is automatically recorded along with the data. On most chart recorders, information regarding the pulse level (amplitude), pulse rate, and pulse width must be noted by hand, a process that can be inefficient, time-consuming and error-ridden. With the BSL *PRO*:

- The amplitude reflects the output pulse level.
- Markers can be automatically inserted and labeled for each Reference pulse or change in pulse train. The label will contain the Pulse width and Pulse rate (and system time stamp if selected).
- Markers reflect setting changes made during an acquisition.
- All output pulse information is automatically recorded and archived with the saved data.

Set the marker option by clicking in the box to "Create marker when output is changed."

Set the time stamp option with the global Marker Preferences available under the File menu (see page 171).



The marker label accurately captures pulse data, but the marker arrow may not always line up exactly with the leading edge of the pulse; this typically is not a problem because the recording will include the actual stimulus pulse which can be used for timing measurements.

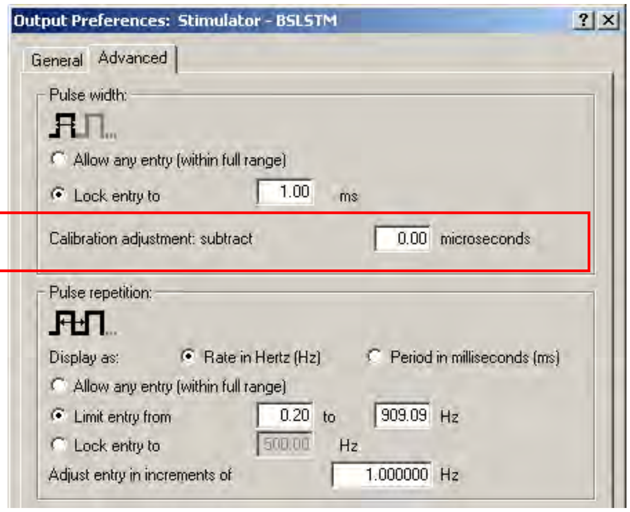
- Depending on the acquisition Sample Rate, the leading edge of the pulse in the recording may not correspond to the exact time the pulse was sent—it may be off by as much as one sample period. If the marker precision is critical for your recording, increase the Sample Rate.
- To display markers, use the toolbar icon or Display>Show>Markers.

The **Range** switch on the front of the **BSLSTM** stimulator should be set to 10V or 100V prior to recording and should not be changed during recording; if using a Preset, the corresponding Preset should also be selected prior to recording. The pulse level can then be determined by moving the decimal to the right or left depending on how the range was switched.

ADVANCED TAB (OUTPUT PREFERENCES)

Advanced Tab

Only for MP30 BSLSTM



Pulse Width

Indicates the Pulse Width setting, which determines the maximum Pulse Rate frequency. You may enter a Pulse Width value, unless limited by Preferences.

- The entry is activated when the value is changed and the Tab or Enter key is pressed; it does not require a stimulator restart to take effect.
- The Pulse width entry overrides other entries as required; it is the priority parameter.
- An entry may be automatically changed if any of the following conditions apply, in which case the closest possible value will be selected:
  - a) It falls outside the allowable range.
  - b) It is rounded to .01 millisecond increments (MP35 resolution).
  - c) Width has been limited by the **Pulse Width: Limit Entry** settings of Preferences.

Allow any entry

Pulse width is limited to the output capabilities of the BIOPAC MP device. This option allows any entry within the allowable range specified below:

PULSE WIDTH RANGE	MP35 unit	MP30 unit
Range	.050 – 100 milliseconds	.049 – 100 milliseconds
Resolution	10 microseconds	1.953 microseconds

Lock entry to

This entry locks the width to a single, specified value (within the allowable range). No other value can be entered.

Calibration adjustment
MP30 BSLSTM only

The pulse width from the MP30 output connector is very accurate, but the BSLSTM hardware may add 0 to 150 microseconds to the pulse width in its internal circuit. This value can vary somewhat from unit to unit but mainly depends on the revision of the BSLSTM which is determined from the serial number on the back of the unit. To adjust for this, the BSL *PRO* software can subtract a specified amount of time from each requested pulse width.

To determine a calibration adjustment value which will get one very close (within +- 5%) of the requested pulse width, refer to the following table:

Serial No.	Calibration adjustment value (microseconds).
<= 308A 5100	70
>= 310A 100	0 (default value)

ADVANCED TAB (OUTPUT PREFERENCES)

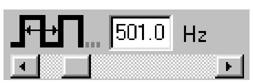
If you are using an older model manual control (no LED) BSLSTM stimulator, try using 110ms—and then contact BIOPAC for a free product upgrade.

If pulse width accuracy greater than +- 5% is required, calibrate your specific BIOPAC BSLSTM stimulator (requires an oscilloscope) and enter a specific adjustment time from 0 to 150 microseconds (entries outside this range will be clipped).

Calibration adjustment—MP30 BSLSTM only

1. Connect a BNC to BNC cable from the BSLSTM output connector to an oscilloscope input.
2. Set the “Calibration adjustment: subtract” to “0.”
3. Specify a pulse width of .2 ms.
4. Send out a stimulus pulse.
5. Measure the actual pulse width out of the BSLSTM stimulator with an oscilloscope.
6. The Manual Test button on the back of the BSLSTM cannot be used to make the oscilloscope measurement.
7. Calculate the time required to make the pulse width exactly .2 ms.
8. Enter this time, in microseconds (1 ms = 1000 microseconds), into the “Calibration adjustment: subtract” entry box.

Pulse Repetition



Indicates the Pulse Repetition period (Hz or ms).

- The **Pulse period** must be greater than the **Pulse width**. See “TBPMIN” in the Output Preference > Advanced Tab Limits table on the next page.
- The full range of acceptable Pulse Rate values is from **.2** to **6,667 Hz (MP35) or .2** to **6,827 Hz (MP30).**
- The maximum Pulse rate (PRPMAX) depends on the Pulse width setting:
  Pulse width 100 ms → maximum Pulse rate = **9 Hz**
  Pulse width .020 ms → maximum Pulse rate = **3333 Hz**
- The formula for pulse width vs. pulse repetition is *PRPMIN = PW + TBPMIN*
  Where: PRPMIN = the MINimum Pulse Repetition Period allowed.
  PW = Pulse Width setting
  TBPMIN = MINinum Time (in ms) between successive pulses for the output device (see device specifications)

  If “Limit changes from ___ to ____” is selected in Advanced preferences, then PRPMAX will be determined by the formula above or the specified limit, whichever is greater.
- An entry may be automatically changed:
  a) If it falls outside the allowable range.
  b) To round it to .01 Hz increments (resolution of system).
  c) To make it at least 0.1 millisecond greater than the Pulse width.
  d) By the **Pulse Repetition Rate**: **Limit entry** Preference.
  e) By the Pulse Repetition: Adjust entry increments Preference.
- You may manually enter any value for pulse width, but when using the scroll bar or arrows, entries will be constrained by the “Adjust entry increments” Preference setting.

ADVANCED TAB (OUTPUT PREFERENCES)	
Pulse Repetition Scroll Bar	The Pulse Repetition **Scroll Bar** adjusts rate or period by the increment of change and limits established in Preferences. With each click of the scroll bar arrows, the rate will be increase by the specified increment. ▪ When "Initiate pulse sequence with **ON/OFF button in Control Panel"** is selected, changes take effect upon release of the scroll box as long as the stimulator is running. ▪ The scroll bar is disabled when Number of Pulses is set to "Single" or Pulse Repetition is set to Lock Entry to..."
Display as	Pulse repetition can be dispalyed as ▪ **Pulse Rate** (expressed in Hz), or ▪ **Pulse Period** (inverse of Pulse Rate, expressed in milliseconds). Pulse Repetition Rate relates to the Pulse Repetition Period as: Pulse Rate (Hz) = 1000 / Pulse Period (milliseconds) The "Display as" **units** selection is also used for: 1. Pulse repetition entries in the control panel. 2. Scroll bar increments. 3. The **Pulse Repetition Rate**: **Limit entry** Preference. 4. The **Pulse Repetition: Lock entry** Preference. 5. The **Pulse Repetition: Adjust entry increments** Preference. When units are changed from Rate in Hertz (Hz) or Period in milliseconds (ms), the limits of the Pulse Repetition range will be converted by the formula: Period increment in ms = Round to nearest whole number [Period Range * (Rate increment in Hz /Rate Range in Hz)] For example, if the Range was 1Hz to 10 Hz with an adjustment increment of 1Hz, the proportional calculation would be Period increment = 900 ms (1Hz / 9 Hz) = 100 ms
Allow any entry	Pulse width is limited to support the output capabilities of the BIOPAC output device. See Output Preference > Advanced Tab Limits table for allowable range.
Limit entry	Establishes minimum and maximum values that can be manually entered or changed with the scroll bar.
Lock entry	Locks the Repetition to a single, specified value (within the allowable range). No other value can be entered in the control panel.
Adjust entry	Controls the scroll bar or scroll arrow increment; does not apply to manual entry.

Output Preference > Advanced Tab Limits

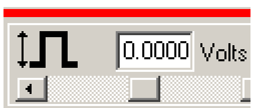
	Pulses MP35	Pulses MP30	BSLSTM MP35	BSLSTM MP30	SS58L MP35 Only
Pulse width					
Range (ms):	.050 – 100	.049 – 100	.050 – 100	.049 – 100	.050 – 100
Resolution (ms):	.010	.001953	.010	.001953	.010
Pulse Repetition					
Rate range (Hz):	.2 – 16,667	.2 – 10,204	.2 - 2,000	.2 – 2,004	.2 – 10,000
Period range (ms)	.060 – 5,000	.098 - 5,000	.500 – 5,000	.499 – 5,000	.10 – 5,000
TBPMIN Minimum time between Pulses (ms):	.010	.049	.450	.450	.050
Resolution (ms):	.010	.001953	.010	.001953	.010
Initial Pulse Delay					
Time range (ms):	0 – 100	0 or .5 - 100	0 – 100	0 or .5 - 100	0 – 100
Resolution (ms):	.010	.001953	.010	.001953	.010

LEVEL TAB (OUTPUT PREFERENCES)

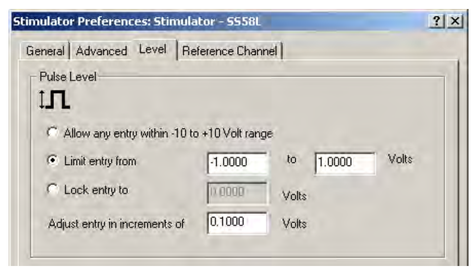
About Level

➲ The SS58L stimulator allows the softare to specify the pulse amplitude. The amplitude can be set to any value within the limits of the SS58L which is -10 to +10 Volts.

Pulse Level
SS58L only



The **Level entry box** allows the user to manually enter any value within the limits of the system, or within the limits of the Preference settings from the Level tab.



The Level entry box will be inactive (grayed) if:

1. The Level preference “Lock entry to” is active.
2. If “Initiate pulse sequence with Recording” is active (from the General tab) and a pulse sequence is in progress or “wait for trigger” is in progress.

Use the entry box or the scroll bar to set the Pulse level. When a value is entered which is out of range, the value will be rounded to the closest value obtainable after the “Enter” or “Tab” key is pressed.

If “Initiate pulse sequence with ON/OFF button in control panel” is active (from the General tab), then values entered during a pulse sequence will take place immediately.

If “Initiate pulse sequence with Recording” is active (from the General tab), any entry made between acquisitions will take place on the next “Start” of acquisition.

Allow any entry

The level is limited from -10 to +10 V to support the output capabilities of the SS58L. This option allows any entry within that range.

Limit entry

This entry reduces the range (within the -10 to +10 V range limit).

Lock entry

This entry locks the level to a single specified value (between -10 and +10 V).

Adjust entry

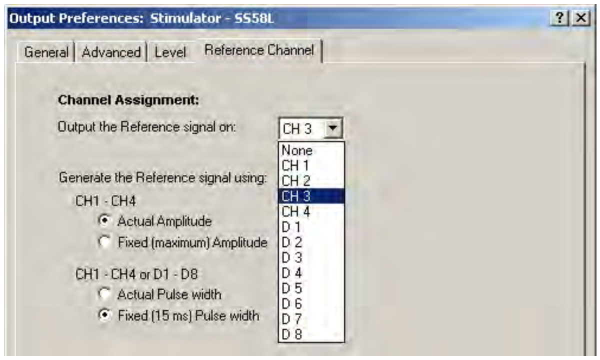
This setting affects the scroll bar or scroll arrow increment only; it does not apply to manual entry.

The smallest increment is 5 mV, as limited by the MP35. The specified increment is used to round manual entries to the closest obtainable value.

REFERENCES TAB (OUTPUT PREFERENCES)

Reference Channel

SS58L only



This option allows you to "Monitor" the output signal on one of the analog or digital input channels without making any physical connections. This is an internal, hardware/firmware, feature that recreates the output signal and allows recording in "real time." The assigned reference channel will override any "real" input signal.

- For example, if a transducer is connected to CH 1, and CH1 is chosen as the reference channel, then the signal coming from the transducer will not be viewable, and will not conflict with the reference signal generated internally.

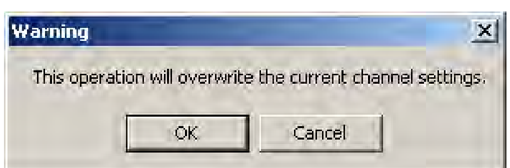
The reference signal is not the real signal, but is a very accurate "estimate" of the real signal. The pulse timing accuracy will be within 100 microseconds. If an analog input channel is used as the reference channel, the pulse level will be accurate within 5%. If the SS58L encounters a load that reduces or distorts the pulse output, the reference signal will not reflect this amplitude distortion.

If a digital input channel is used as the reference channel, only a digital representation of the pulse will be generated. In other word, regardless of the pulse level, when no pulse is occurring, the level will be 0 Volts, and when the pulse is occuring, its level will be shown as +5 Volts.

Channel Assignment

Use the pull-down menu to choose which analog or digital input channel will be used as the output reference channel.

When a new reference channel is assigned, a warning will be generated to alert you that this setting will overwrite the existing Channel Setup parameters for the selected channel.



- For example, if you set up CH1 for ECG data and then select CH1 for the Reference Channel, your ECG parameters will be replaced. If you then select another channel, CH1 will be restablished with the default analog input parameters, and you would need to recreate your ECG settings (by using Presets or manual entry).

The reference Channel label should read: "Stimulator-SS58L Reference Out".

When an Analog Input Channel is assigned as the Reference channel, that channel, as viewed from the MP35>Set up Channels dialog, will be in a "Lock-Out" mode. This means that the Preset pull-down menu icon for that channel will be grayed (inactive). The assigned reference channel will be inactive for "real" inputs until the Reference Channel Preference is changed to "None" or another

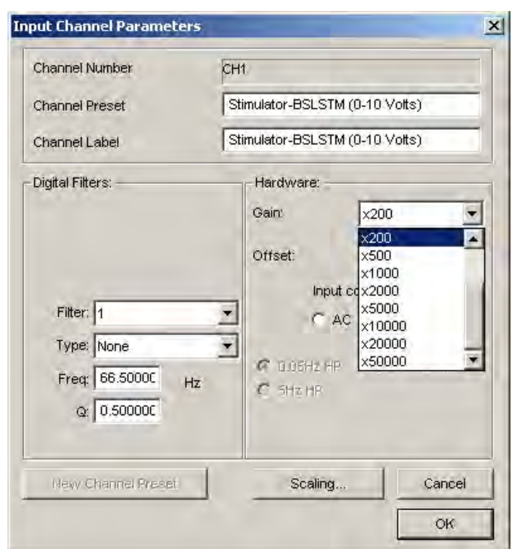
REFERENCES TAB (OUTPUT PREFERENCES)	
	channel. The wrench button, when pressed for the Reference channel, will still allow viewing of the channel parameters, but all entry boxes and pull-down menus will be inactive. When a "Stimulator – SS58L" control panel using an assigned Reference channel is closed, the channel that was assigned as the reference channel will be removed from "Lock-Out" and will automatically change to the default, "CH X Input" settings. The reference channel assignment will be saved in the template or data file, so that if the "Stimulator – SS58L" control panel is reopened, the reference channel will be automatically re-assigned, without any warning prompt given.
Generate using	You can specify how the Reference signal should be shown. ▪ If using **analog** input from CH1 - CH4, you may select actual or fixed (max) amplitude and actual pulse or fixed pulse width. Fixed pulse widths are useful when the pulse width is much smaller than the sample interval (1/sample rate) being used. ▪ For example, for Frog muscle stimulation, you may choose to use a 1 ms pulse width, but a sample rate of 200 samples/sec. to capture the muscle response. At this sample rate, the stimulus pulse could not be reliably recorded. By extending the displayed pulse width to 100 ms, you will be guaranteed to always record the stimulus pulse. ▪ If using **digital** input from D1 - D8, select actual or fixed (15ms) pulse width.

Usage Guidelines & Setup Summary for BSLSTM Output Control

HUMAN SUBJECT SAFETY

- Before using the stimulator on human subjects, it is very important to limit the energy the stimulator outputs. For optimal safety:
- Before powering on the BSLSTM stimulator, set the voltage level to zero by rotating the LEVEL knob on the front of the BSLSTM fully counterclockwise.
- Use BIOPAC HSTM Series Probes. You MUST use these probes order to limit the energy the stimulator can output.
- Never create an electrical path across the heart.
- Never use on subjects with pacemakers.
- Read this manual and the BSL Hardware Guide to become familiar with Stimulator operation.

1. Connect the BSLSTM Stimulator to the MP35/30 and power on both units. (For instructions on how to connect the BSLSTM to the MP35/30 Acquisition Unit, refer to the *BSL Hardware Guide*.)
   a. Connect the Stimulator Trigger cable to the Analog Out port of the back of the MP35/30.
   b. Connect the Stimulator Reference Output cable to an Input Channel on the front of the MP35/30. This channel will be set up in Step 3 as the Stimulator Reference Channel.
      - The **Reference pulse** has a fixed Pulse width of 15 milliseconds, so chosen so that the Sample Rate of the recording may be as low as 100 samples/second and still capture the Reference pulse.
   c. Before powering on the BSLSTM stimulator, set the voltage level to zero by rotating the LEVEL knob on the front of the BSLSTM counterclockwise all the way to the left.
2. Launch BSL *PRO* software to a new data acquisition window.
   a. Confirm that **Markers** are activated.
      - Markers are activated by default. If not activated for a given recording, choose **Display> Show>Markers**.
3. Set up the **Stimulator Reference Channel**. This is the Analog Input Channel on the front of the MP35/30 that receives the Stimulator Reference Output cable from the back of the BSLSTM.
   a. Choose **MP35/30 > Set up Channels**. This will generate a **Set up Channels** dialog.
   b. Select the **Acquire**, **Plot** and **Enable** options for the analog channel to be set up as the Stimulator Reference Channel.
   c. Click **Presets** and scroll to select "Stimulator (0-10V)" or "Stimulator (0-100V)" to match the Range switch setting on front of the BSLSTM.
   d. Click **View/Change Parameters**. This will generate an **Input Channel Parameters** dialog.



      - **Read the entire Stimulator section of this manual and familiarize yourself with the unit and its options before changing any preset parameters.**
      - You may set the **Gain** and other input parameters as desired.
   e. Click OK to accept the parameters.
   f. Close the Set up Channels window.

Adjust the voltage output of the stimulator by using the **Level** control on the front of the BSLSTM.

- Rotate the **Level** knob clockwise to increase and counterclockwise to decrease, reading the voltage in the BSLSTM's digital display.

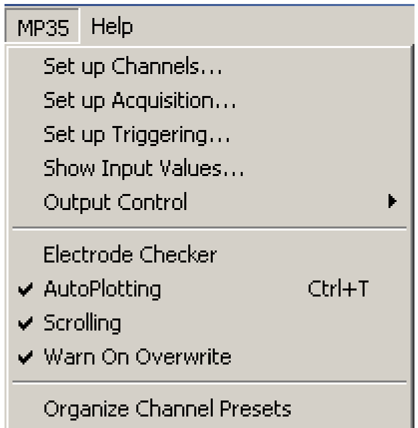
Stimulator Safety Features

- The stimulator cannot operate unless its Output Control panel is open.

The Pulse ON/OFF Switch on the Stimulator Output Control panel must be OFF in order to open and configure Stimulator Preferences.

- If the Stimulator Output Control panel (or the BSL *PRO* application) is closed in the middle of a pulse train while the stimulator is running, the stimulator will shut down and the pulses will stop.
- If another data acquisition window is activated, the stimulator will stop and remain OFF unless restarted using the parameters associated with the new data window. The only exception is that if the stimulator is ON and the data window corresponding to current stimulator parameters is acquiring data, then the stimulator will continue to run until the end of the acquisition.

Chapter 9 MP35/30 Menu — Other Commands



This chapter will cover the **MP35/30 Menu** commands not discussed in the preceding chapters on Setup Channels and Setup Acquisition.

Playback menu – Mac only

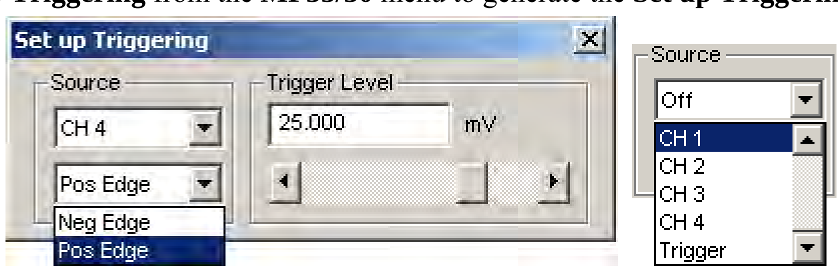
When “Open for Playback” is selected from the File menu, the MP menu changes to a Playback menu and includes options to Capture to QuickTime and Exit Playback Mode. See page 46 for details.

Set up Triggering

Using a trigger allows you to start an acquisition “on cue” from a trigger connected to an analog input channel (CH1 to CH4). By default, the trigger is off, and during a normal acquisition, the MP35/30 will begin collecting data following a mouse click the Start button in the lower right hand corner of the screen. When Set up Triggering is used, acquisition will begin when the established trigger level is reached.

To begin an acquisition with a trigger:

1) Select **Set up Triggering** from the **MP35/30** menu to generate the **Set up Triggering** dialog:



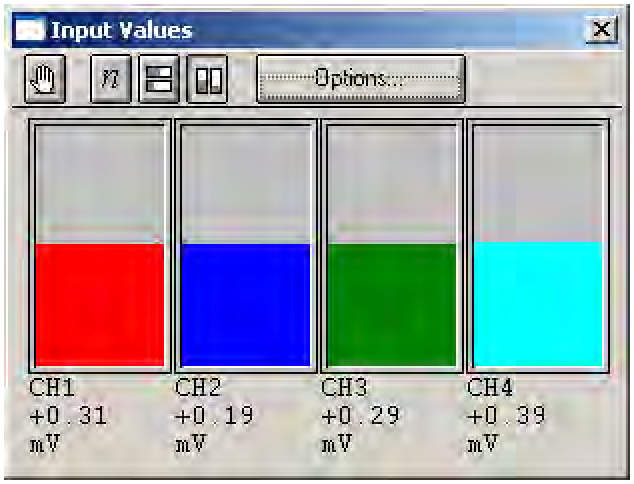
Set up Triggering dialog box and Source options

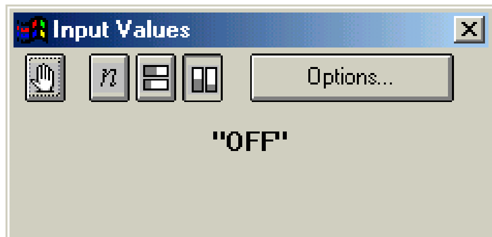
2) Choose a channel from the Source pull-down menu. You can select CH1, CH2, CH3, CH4 (MP35 front panel) or an external Trigger (MP35 back panel).
   - ➲ External Trigger requires a TTL signal from a third-party device such as a stimulator, pump, presentation program or force plate.
3) Choose **Pos Edge** or **Neg Edge** from the menu to indicate whether you want a positive or negative edge to trigger the acquisition. Look at the nature of the signal to determine which is most appropriate.
   - ➲ A **Positive edge** occurs when the signal begins below the threshold and crosses above it.
   - ➲ A **Negative edge** occurs when the signal begins above the threshold and drops below it.
4) Set the **Trigger level** by keying in a value or by moving the scroll bar to adjust the threshold value.

When setup is complete, close the Set up Triggering window and click the Start button to begin acquisition as soon as the trigger is activated.

The dialog box shown above is set to begin acquisition when a level of 25.00 Volts is reached on analog channel 4.

Show Input Values



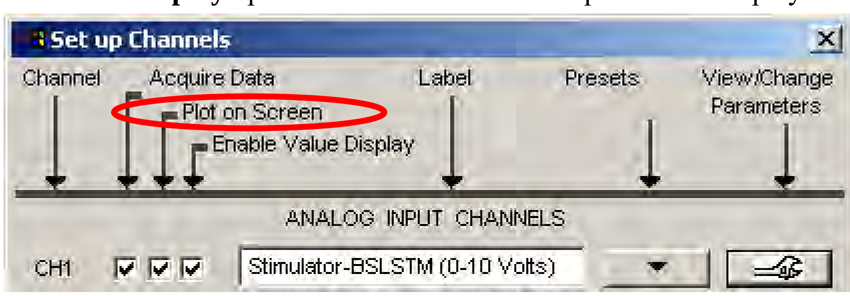


When **Show Input Values** is selected from the **MP35/30** menu, a new window appears on the screen and displays the values of all channels that were setup to **Enable Value Display** (see Note below). The **Input Values** window can be resized and moved to any position on the screen. If the MP35/30 is disconnected or without power, the Input Values dialog will read "OFF."

Values are displayed in real time for the appropriate analog channels whether an acquisition is in progress or not, which allows you to display values prior to or after an acquisition; calculation channels will only be displayed during acquisition.

The table on the following pages explains the **Input Values** (IV) window options.

Note: The IV window is disabled during **High Speed** acquisition (see page 88).
The IV window does not update calculation channels when the recording is stopped or while waiting for a trigger device to reach the triggering level.
The **Enable Value Display** option must be checked for Input Values display to work.



✓ TIP The FFT transformation cannot be performed in real time (i.e., during an acquisition), but you can emulate online spectral analysis using several online filters and the Input Values window.

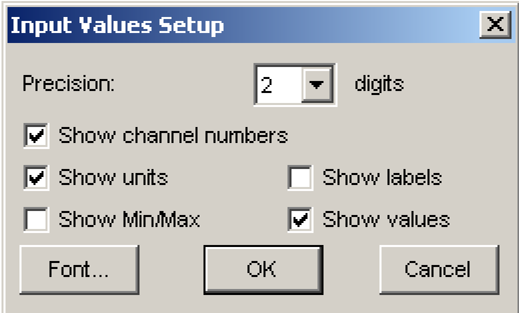
See also…

Save as Graph Template, page 178.

Show Input Values Display options

Incoming data can be displayed either as numeric values or in a "bar chart" format. These options are represented by icons that can be selected from the mode menu at the top of the **Input values** display.

Clicking the **Options** button of the **Input values** display generates an **Input Values Setup** dialog where you can set additional display parameters:



Show Input Values—Window Visibility & Position

The visible state of the Input Values window display…

- for active graphs displaying ".acq" or Lesson data will depend solely on the visible state of the last active graph.
- for ".gtl" graphs will depend on the state when the file was saved, or changed since it was last opened.

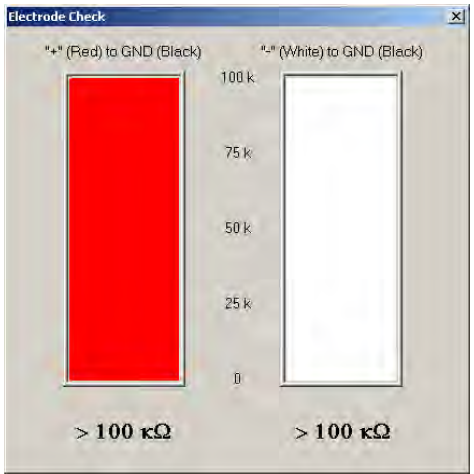
When only one graph is open:

- When opening .acq or lesson files, the Input Values window will be hidden, regardless of how the file was saved. You must choose MP35(MP30) > Show Input Values to make it visible. Once made visible, the Input Values display will appear in the same position as when it was saved.
- When opening .gtl (template) files, the Input Values window will open as it was saved (both visibility and window position).

When more than one graph is open:

- For multiple ".acq" files, if any Input Values window is visible, then the Input Values window will be visible for all graphs regardless of visible state when the graph was saved. The position of the window, however, is graph specific and will depend on the coordinates when saved or where it was moved to since it was opened in that file. If a template file is alos open, the visibility of the Input Values display when the ".acq" file is made the active graph will depend on the last visible state of the active ".gtl" file.
- When switching between open ".gtl" (template) files, the visible state of the Input Values window will appear as it was saved or altered since it was opened (both visibility and window position).

Electrode Checker—MP35



Electrode Checker

The **Electrode Checker**, in conjunction with the MP35/30 unit, measures how well electrodes are making contact with the surface of the skin. To use this feature:

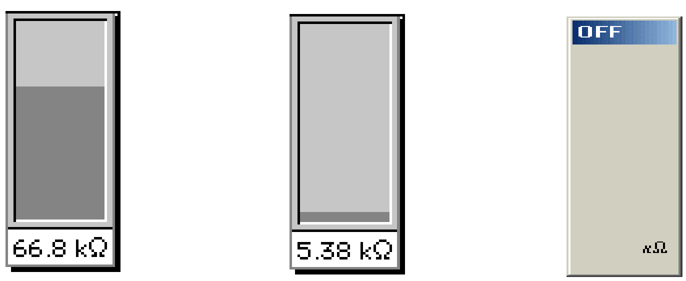
1) Attach the electrodes as you normally would.

2) Connect the electrodes to an electrode lead set (such as the SS2L).

3) Instead of connecting the electrodes to one of the four analog inputs, connect the Simple Sensor end of the electrode lead to the **Electrode Check** port on the front of the MP35/30 acquisition unit.

4) Click the **MP35/30** menu and scroll down to select **Electrode Checker**.

This will generate a small "thermometer-like" display. At the bottom of the display you should see a number with kΩ after it. This value describes the impedance of the electrode/skin contact, with lower numbers being associated with better conductivity. The better the conductivity, the "cleaner" the signal displayed on the screen. If the MP35/30 is off or no nothing is connected to the "Electrode Checker" on the MP35/30 unit, the Electrode Checker display will say "OFF."



MP30 Poor contact ***MP30 Good contact*** ***MP30 Off***

✓ TIP While there are few absolutes as to what constitutes "good" contact, one rule of thumb is that this number should be below 10 kΩ, and the lower the better.

✓ TIP To decrease the impedance of an electrode connection, you may want to "abrade" the surface of the skin with an ELPAD abrasive pad (included with the Biopac Student Lab *PRO* System). This removes a thin layer of dead skin cells and should result in a signal that has relatively little noise.

Autoplotting and Scrolling

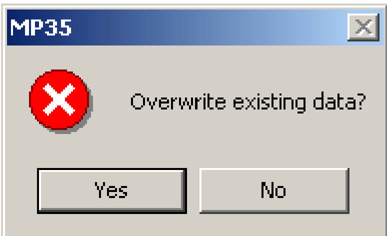
AutoPlotting and **Scrolling** both control how data appears on the screen. By default, the most recently collected data will be displayed first and, if more than one screen of data is collected, the time scale will "scroll" so that the newest data is always on the right edge of the screen.

When **AutoPlotting** is checked and **Scrolling** is deselected, the screen will be cleared when the data reaches the right edge of the screen, and plotting will continue from the left edge again.

When both **Scrolling** and **AutoPlotting** are unchecked, the incoming data will be plotted until the screen is full. Once the screen is full, data will continue to be collected, but only the first screen is displayed. By default, the MP35/30 will display the first eight seconds of the data record, but this can be reset manually by changing the horizontal scale. To turn **AutoPlotting** ON or OFF in the middle of an acquisition, select **Ctrl+T** on the keyboard to toggle AutoPlotting.

Warn on Overwrite

The **Warn on Overwrite** option will prompt you each time you start a new acquisition. The option toggles on/off each time it is selected from the menu.



The **OverwriteYES/NO** prompt appears using **Repeat/Save Once** acquisition setup.

Click **Yes** to overwrite (erase) the current data file with the new acquisition data.

Click **No** if you do not want to erase the file that you are working in, then open a new window.

The **File Exists OK/CANCEL** prompt appears using a **Repeat/Autosave** acquisition setup.

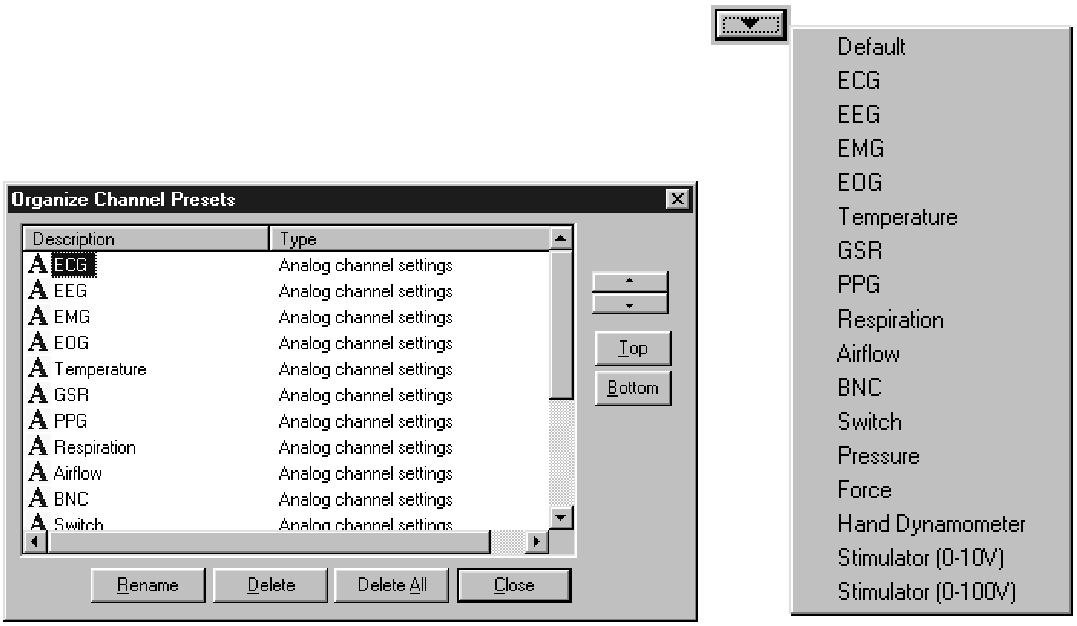
Click **OK** to overwrite (erase) the current data file with the new acquisition data.

Click **Cancel** if you do not want to erase the file that you are working in, and then choose a new file name.

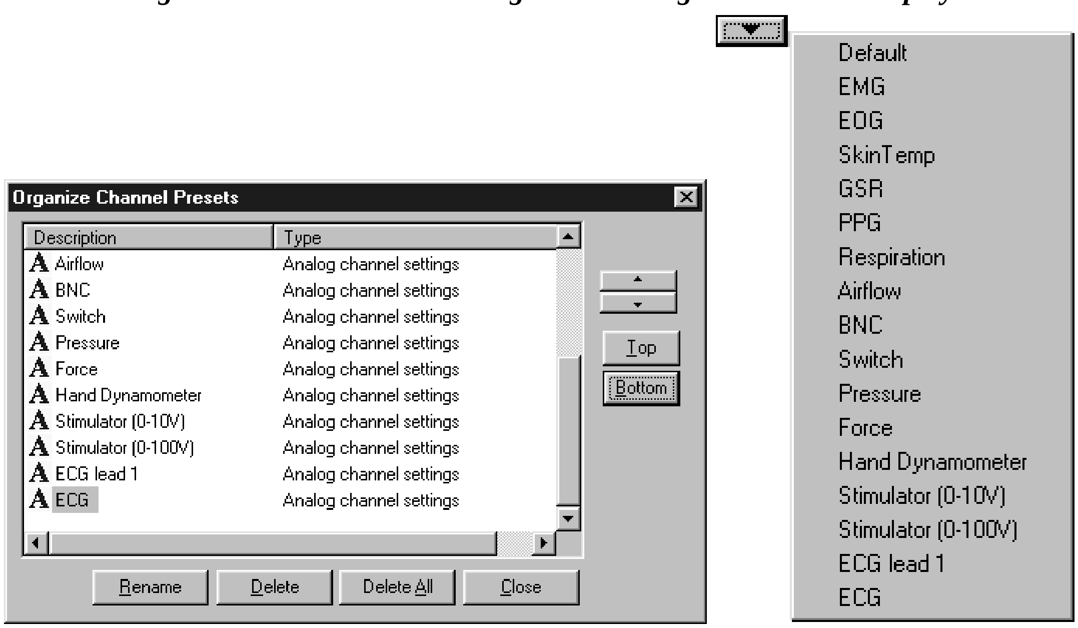
You can uncheck the **Warn on overwrite** option from the **MP35/30** menu to disable the prompt.

Organize Channel Presets

The **Organize Channel Presets** option of the **MP35/30** menu is related to the channel presets in the **MP35/30 > Setup Channels** dialog. You can organize the Presets (established or new) to place the most frequently selected at the top of the menu or to group related Presets, such as the established ECG Presets with any new channel Presets you create. Click a Preset description to select it, and then use the buttons to organize the Presets. The up and down arrows will move your selection one space at a time, and the **Top** and **Bottom** buttons will jump to the start or end of the list.



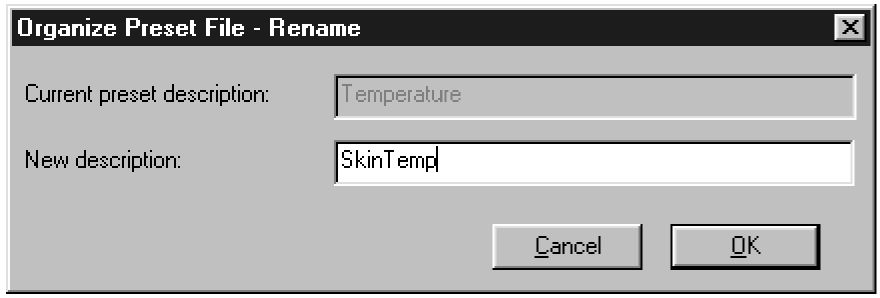
Organize Channel Presets dialog and resulting Presets menu display



Revised Organize Channel Presets dialog and resulting Presets menu display

To delete or rename a Preset, select the Preset name from the listing and click the **Delete** or **Rename** button. Or, click the right mouse button to select the Preset from the listing and scroll to the desired option.

Rename a Preset by typing in a new description and clicking OK.



Delete a Preset by selecting that option. You cannot delete the Default Analog Input preset. When you delete a Preset, you will be asked to confirm the request because it is an irreversible action.

Part D — Analysis Functions

This part describes data analysis functions, which can involve creating, managing, and saving files, as well as editing data, performing mathematical transformations, and displaying data in various ways. In most cases, analysis is performed after the data has been collected. Features that can be computed during an acquisition (primarily transformations and calculations) were discussed in Part C — *Acquisition Functions*.

The menu bar runs across the top of the display window. Menu bar structure is shown below:

Chapter 8 (page 149) provides advanced descriptions of the Measurement, Marker and Grid functions.

Descriptions of specific menu functions can be found in the chapters describing the **File**, **Edit**, **Transform**, and **Display** menus.

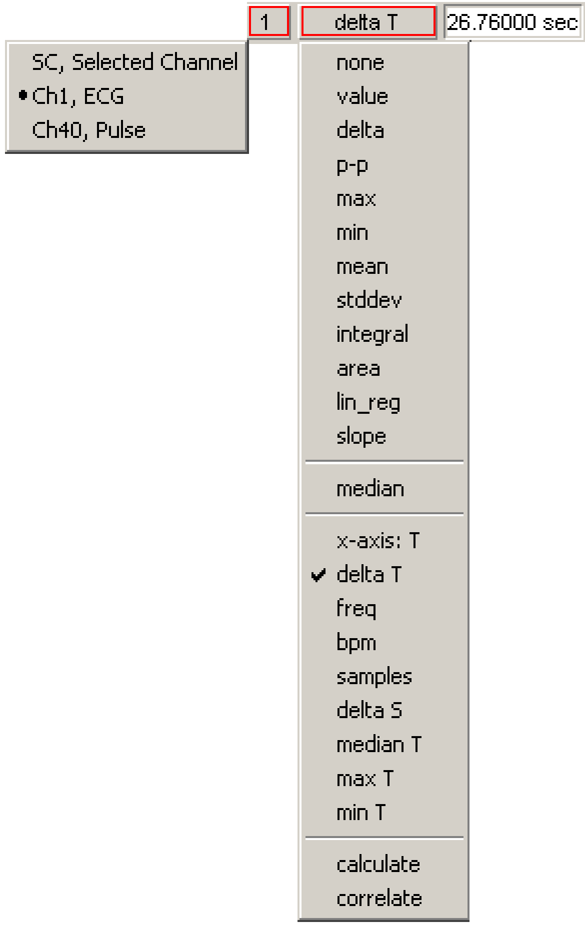
Menu	Details	Type of Commands
File	*page* 171	General file management commands, including opening, saving, and closing files. Export data files.
Edit	*page*184	Cut, copy, and paste between and within files. Export data files.
Transform	*page 192*	Mathematical transformations and functions, from simple arithmetic to digital filtering and spectral analysis.
Display	*page 233*	Control how data appears on the screen either during or after an acquisition.

Note: If you are not yet familiar with the "look and feel" of the Biopac Student Lab *PRO* Software, see **Working With the BSL Software** for a review of these basic functions:

* Data window
* Journal window
* Tools — selection, I-beam, zoom
* Channel display
* Scales
* Scrolling
* Keyboard Shortcuts
* Right-mouse button shortcuts

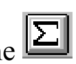
Chapter 10 Measurements, Markers & Grids

Measurement Basics

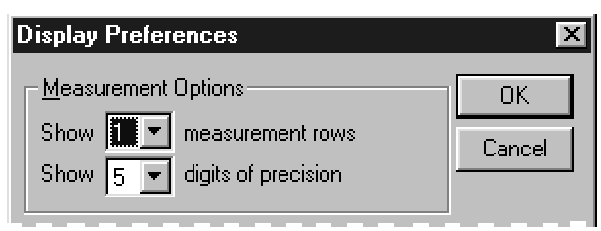


A convenient feature in the BSL *PRO* software is the pop-up measurement windows. A variety of different measurements can be taken, and you can display different measurements from the same channel and/or similar measurements from different waveforms.

Measurement Display Windows

To display the measurement windows in the area above the graph window, click the  icon or select **Display** > **Show** > **Measurements**. The number of measurement windows per row depends on the width of the screen; stretch the display window horizontally to increase the total number of windows per row.

By default, only one row of measurement windows is displayed. To display more measurement rows, choose **File** > **Preferences** > **General**, and choose a number between one and eight from the pull-down **Show __ measurement rows** menu.



When the number of measurement rows is changed under General Preferences, all current measurement settings are cleared (set to “None”).

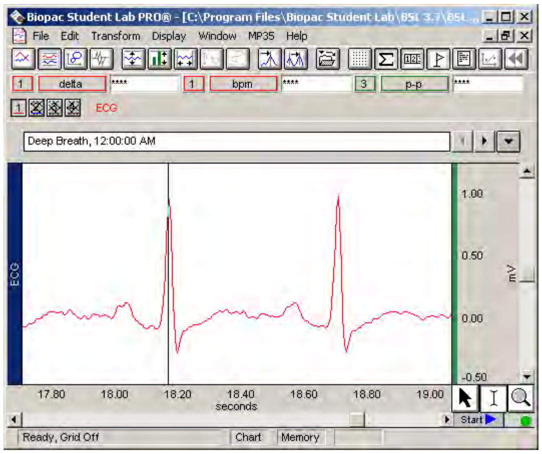
Taking a Measurement

1) **Select a channel for measurement**. The *PRO* software can display measurements for the selected channel (as denoted by an "**SC**" in the measurement box) or for any other channel. By default, the software displays measurements from the selected channel. To select a different channel, position the cursor over the part of the measurement window that reads "SC." Click the mouse button and choose a channel number from the pop-up menu. The channel numbers in the pop-up menu correspond to the numbers in the channel boxes in the upper left corner of the graph window. Note: If "**none**" is chosen as the measurement function in the adjoining box, no measurement value will be displayed.

2) **Select a measurement area**. Use the **I-beam** cursor to select an area to measure. It is important to remember that the I-beam always selects at least one sample point. If a single point measurement function is chosen (such as Time), the measurement will reflect the last selected point in the defined area.

Single-point measurements:

When a single point is selected, there is no area defined and the I-beam cursor will "blink." The graph to the right shows how measurements for a single point can be selected with the I-beam. The cursor will flash when a single point is selected.

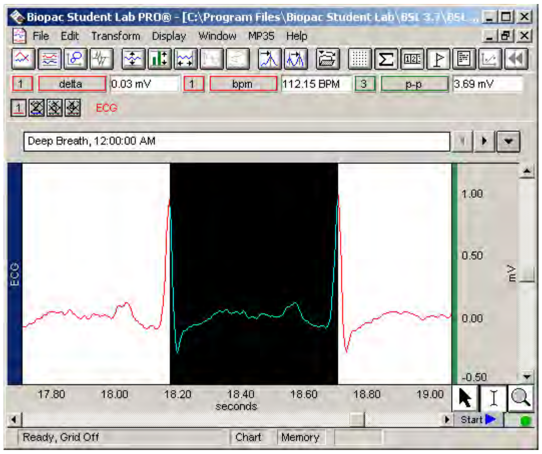


Selected range measurements:

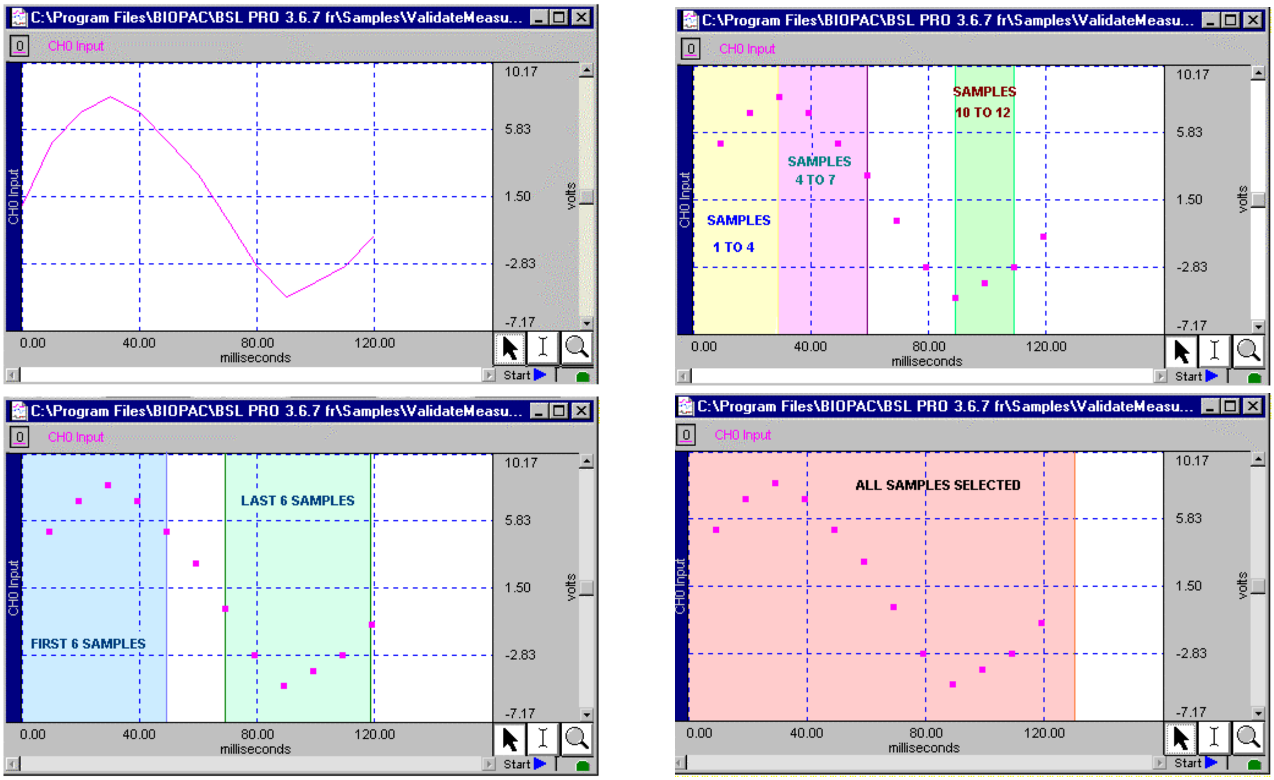
To select an area spanning multiple sample points, click-and-drag the I-beam cursor to highlight the desired area (this is similar to highlighting in a word processor). See page 56 for selection details.

The following window shows how an area can be selected for measurement with the I-beam.

Note: If you have selected an area, but chosen a single point measurement function (such as Time), the measurement will reflect the last selected point in the defined area.



IMPORTANT! **The first data point is "plotted" at time zero (1/2 dot on the left edge of the graph); the first visible data point is sample point 1. The selected areas below demonstrate this concept. The data slection is inclusive of the endpoint selections.**



3) **Select a measurement**, position the cursor on a measurement box and click the mouse button.

Choose a measurement function from the pop-up menu. The measurement function in the upper half of the menu reflect amplitude measurements, or measurements which contain information about the vertical (amplitude) scale. Other measurement functions use information taken from the horizontal axis (usually Time) and are found on the section of the pop-up menu below the dividing line. Some of the measurement options change (or are disabled) if units are selected for the horizontal scale.

Some of the values are single point measurements while others require at least two points to be selected.

Single-point measurements	***Selected range measurements***
Delta S, Lin_reg, Max, Max T, Min, Min T, Samples, Time, Value, X-axis T/F/X	Area, BPM, Correlate, Delta, Delta S, Delta T/F/X (based on units), Frequency (time domain), Integral, Lin_reg, Max, Max T, Mean, Median, Median T, Min, Min T, p-p, Samples, Slope, Stddev

4) **Review the result**. If the measurement unit is cut-off, move the cursor over the result window to display the full measurement result below it.

In some cases, the computations involved in the measurement can produce nonsensical results (such as dividing by zero, or calculating a BPM from a single point). In those cases, you may get a measurement value like **INF** (for infinite). This means that the result was undefined at this point.

The measurement result will display "****" if no data is selected, or if there are not enough data points selected for a meaningful measurement. For a complete description of each of the measurement functions and the minimum samples for each, turn to page 153.

NOTE: You can validate measurements with the **ValidateMeasurements.acq** sample file that was included with the software. Pay attention to the "***Sample data file***" section of the measurement definitions that begin on page 153, and where included, note which sample points to use for validation (i.e., the first four sample points are used to validate the Correlate measurement using the ValidateMeasurements.acq file).

Copying measurements

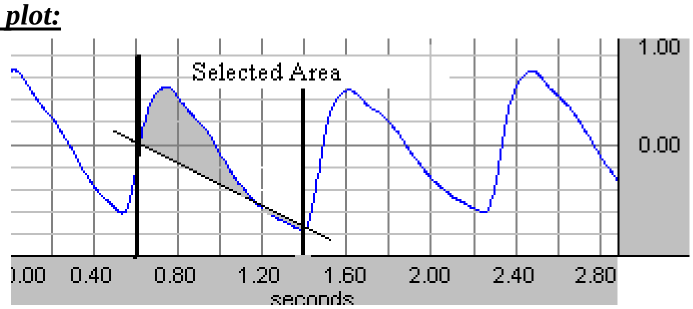
To the journal — One of the most useful options is to paste measurements to the journal. The journal is a general-purpose text editor that allows you to open, edit, and save standard text files. You can "paste" measurements into the journal exactly as appear in the graph window by selecting **Edit > Journal > Paste measurement**.

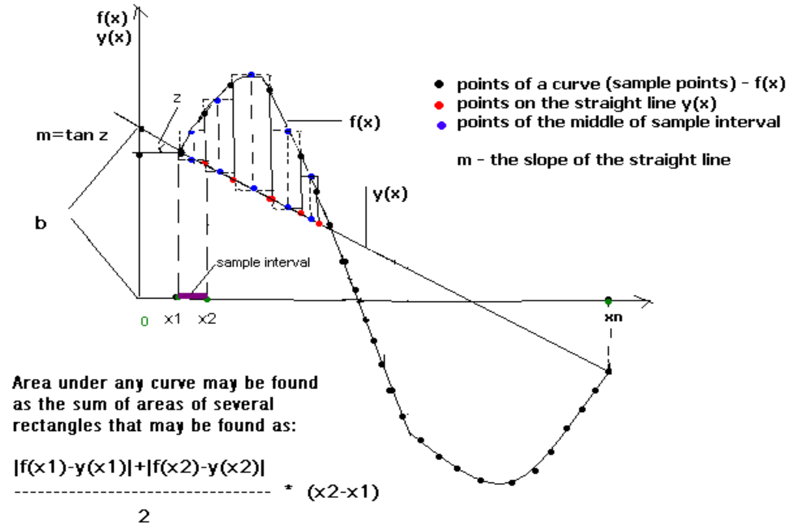
To the clipboard — You can copy measurements to the clipboard, where they are available for other applications. This means you can copy measurements (as they appear on the screen) to the clipboard and then paste the data into a word processor or other application. To do this, select **Edit > Clipboard > Copy measurements** and the values in the measurement windows will be copied to the clipboard.

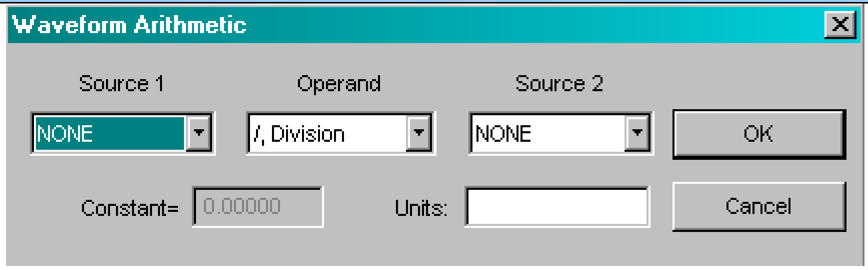
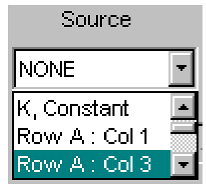
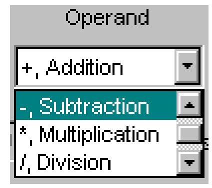
Exporting measurements

One of the most important reasons to take measurements is to save them; Biopac Student Lab *PRO* software allows you to store and export these measurements in different formats. Under the default settings, only the measurement values themselves are copied to the journal or clipboard. You can change the settings to allow the measurement name and other options to be included via **File > Preferences > Journal**.

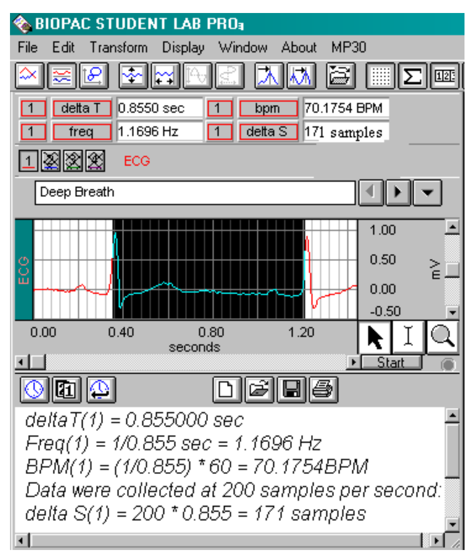
The table below explains the measurement options available and the range required for each.

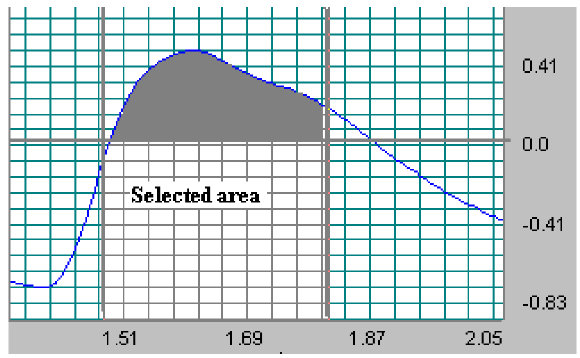
Measurement	Area	Explanation
Area	Minimum area: 3 samples Uses: All points of selected area	**Area** computes the total area among the waveform and the straight line that is drawn between the endpoints. **Area** is expressed in terms of (amplitude units multiplied by horizontal units) and calculated using the formula: $$Area = \sum_{i=1}^{n-1} \left(\left| f(x_i) - y(x_i) \right| + \left| f(x_{i+1}) - y(x_{i+1}) \right| \right) * \frac{\Delta x_i}{2}$$ *Where:* *n – number of samples;* *i – index (i = 1.n-1);* x_i, x_{i+1} *- values of two neighboring points at horizontal axis (* x_1 *– the first point,* x_n *– the last point);* $f(x_i)$, $f(x_{i+1})$ *- values of two neighboring points of a curve (vertical axis);* $y(x_i)$, $y(x_{i+1})$ *- values of two neighboring points of a straight line (vertical axis).* *At the endpoints* $y(x_1) = f(x_1)$ *and* $y(x_n) = f(x_n)$. $\Delta x_i = \frac{\Delta X}{n-1}$ *- horizontal sample interval;* *The value of a straight line can be found by formula:* $$y(x_i) = m * x_i + b$$ $b = f(x_1) - m * x_1$ *- intercept;* $m = \frac{\Delta Y}{\Delta X}$ *- slope of the straight line;* $\Delta Y = f(x_n) - f(x_1)$ *- vertical distance of increase at vertical axis;* $\Delta X = x_n - x_1$ *- horizontal distance of increase at horizontal axis.* ***Sample plot:***  The area of the shaded portion is the result. ***Note:*** The **Area** measurement is similar to the *Integral* measurement except that a straight line is used (instead of zero) as the baseline for integration.

Measurement	Area	Explanation
		 ***Results:*** This calculation will always return a positive result. ***Units:*** *Volts - sec.* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: 0.4533 Volts - sec.*
BPM (Time domain only)	Minimum area: 2 samples Uses: Endpoints of selected area	**BPM** (beats per minute) computes the time difference between the first and last points and extrapolates BPM by computing the reciprocal of this difference, getting the absolute value of it and multiplying by 60 (60 sec). The formula for calculation of **BPM** is: $$BPM = \left(\frac{1}{\lvert x_n - x_1 \rvert} \right) * 60$$ *Where:* x_1, x_n - *values of the horizontal axis at the endpoints of selected area.* ***Note:*** This measurement provides essentially the same information as the *Delta T* and *Freq* measurement. ***Results:*** Only a positive value. ***Units:*** *BPM.*
Calculate	Minimum area: 2 sources Uses: Results of measurements used in calculation	**Calculate** can be used to perform a calculation using the other measurement results. For example, you can divide the mean pressure by the mean flow. When **Calculate** is selected, the channel selection box disappears.  The result box will read "Off" until a calculation is performed, and then it will display the result of the calculation. As you change the selected area, the calculation will update automatically. To perform a calculation, Ctrl-Click (or on PC, right mouse button click) on the **Calculate** measurement type box to generate the "Waveform Arithmetic" dialog.

Measurement	**Area**	**Explanation**
		 Use the pull-down menus to select **Sources** and **Operand.**   Measurements are listed by their position in the measurement display grid (i.e., the top left measurement is Row A: Col 1). Only active, available channels appear in the **Source** menu. You cannot perform a calculation using the result of another calculation, so calculated measurement channels are not available in the **Source** menu. The **Operand** pull-down menu includes: Addition, Subtraction, Multiplication, Division, Exponential. The **Constant** entry box is activated when you select "Source: K, constant" and it allows you to define the constant value to be used in the calculation. To add units to the calculation result, select the **Units** entry box and define the unit's abbreviation. Click **OK** to see the calculation result in the calculation measurement box.
Correlate	Minimum area: 2 samples Uses: All points of selected area	**Correlate** provides the *Pearson* product moment correlation coefficient, r**,** over the selected area and reflects the extent of a linear relationship between two data sets: x_i - values of horizontal axis and $f(x_i)$ - values of a curve (vertical axis). You can use Correlate to determine whether two ranges of data move together. *Association* — *Correlation* Large values with large values — Positive correlation Small values with large values — Negative correlation Unrelated — Correlation near zero The formula for the correlation coefficient is: **Correlate** = $\frac{n*\sum_{i=1}^{n}(x_i * f(x_i)) - \left(\sum_{i=1}^{n} x_i\right)*\left(\sum_{i=1}^{n} f(x_i)\right)}{\sqrt{\left[n*\sum_{i=1}^{n}(x_i)^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right]*\left[n*\sum_{i=1}^{n}(f(x_i))^2 - \left(\sum_{i=1}^{n} f(x_i)\right)^2\right]}}$ *Where:* *n – number of samples;* *i – index (i = 1..n);*

Measurement	Area	Explanation
		x_i – *values of points at horizontal axis (* x_1 *– the first point,* x_n *– the last point);* $f(x_i)$ *- values of points of a curve (vertical axis).* ***Results:*** Returns a dimensionless index that ranges from -1.0 to 1.0 inclusive. ***Units:*** *None* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: -0.74825(for whole wave) and 0.95917 (for first four sample points).*
Delta	Minimum area: 2 samples Uses: Endpoints of selected area	**Delta** returns the difference between the amplitude values at the endpoints of the selected area. $$\textbf{Delta} = f(x_n) - f(x_1)$$ *Where:* $f(x_1)$, $f(x_n)$ *– values of a curve at the endpoints of selected area.* ***Results:*** If the data value at the starting location is greater than the data value at the ending location of the cursor, then a negative delta will result. Otherwise, a positive delta will result. ***Units****: Volts* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: -2 Volts (for whole wave). This result shows the absolute value of change of amplitude (2) and the minus sign means a decrease of amplitude.*
Delta S	Minimum area: 1 sample Uses: Endpoints of selected area	**Delta S** returns the difference in sample points between the end and beginning of the selected area. ***Results:*** This calculation will always return a positive result. ***Units****: Samples*
Delta T(time) **Delta F** (frequency) **Delta X** (arbitrary unit)	Minimum area: 2 samples Uses: Endpoints of selected area	The **Delta T/F/X** measurement shows the relative distance in horizontal units between the endpoints of the selected area. *Only one of these three units* will be displayed in the pop-up menu at a given time, as determined by the horizontal scale settings. *Measurement* — *Horizontal Axis* **Delta T** — Time **Delta F** — Frequency (FFT) **Delta X** — Arbitrary units (Histogram Bins) The formula for **Delta T/F/X** is: $$\textbf{Delta T} = x_n - x_1$$ *Where:* x_1, x_n *- values of horizontal axis at the endpoints of selected area.*

Measurement	Area	Explanation
		Results: If the data value at the starting location is greater than the data value at the ending location of the cursor, then a negative delta will result. Otherwise, a positive delta will result. For **Delta T** measurements with the horizontal axis format set to HH:MM:SS. ✓ For values less than 60 seconds, you will get a value in decimal seconds. ✓ For values greater than 60 seconds, you will see an HH:MM:SS format value (See page 39 for details on how to change the horizontal scaling options). ***Units***: **Delta T:** *Seconds (sec.)* **Delta F:** *Hz* **Delta X:** *"arbitrary unit"* **Sample data file:** *"ValidateMeasurements.ACQ"* *Result: 0.12 sec. (for whole wave).*
Freq (time domain only)	Minimum area: 2 samples Uses: Endpoints of selected area	**Freq** computes the frequency in Hz between the endpoints of the selected area by computing the reciprocal of the absolute value of time difference in that area. The formula for **Freq** is: $$\textbf{Freq} = \left(\frac{1}{\lvert x_n - x_1 \rvert} \right)$$ *Where:* x_1, x_n - *values of horizontal axis at the endpoints of selected area.* The information provided by this measurement is directly related to the *Delta T* and *BPM* measurements, and is related to a lesser extent to *Delta S* measurement. That is, if the *Delta T* interval between two adjacent peaks is calculated, the *BPM and **Freq*** measurement can be extrapolated. If the sampling rate is known, the *Delta S* can also be derived. In this example, you can see *Delta T, Freq* and *BPM* measurements for the selected area. The *Delta S* can also be derived. The graph shows the selected area with measurements that describe the same interval in different terms. 

Measurement	Area	Explanation
		Note: This does not compute the frequency spectra of the data. To perform a spectra analysis, use the FFT function (described on page 215). ***Freq*** *(or frequency) is only available in time domain windows.* ***Results:*** This calculation will always return a positive result. ***Units***: *Hz* ***Sample data file***: *"ValidateMeasurements.ACQ"* *Result: 8.33 Hz (for whole wave).*
Integral	Minimum area: 2 samples Uses: All points of selected area	**Integral** computes the integral value of the data samples between the endpoints of the selected area. This is essentially a running summation of the data. This plot graphically represents the Integral calculation. The area of the shaded portion is the result.  **Integral** is expressed in terms of (amplitude units multiplied by horizontal units) and calculated using the following formula. **Integral** = $\sum_{i=1}^{n-1}\left[f(x_i)+f(x_{i+1})\right]*\frac{\Delta x_i}{2}$ *Where:* *n – number of samples;* *i – index (i = 1.n-1);* x_i, x_{i+1} *- values of two neighboring points at horizontal axis (* x_1 *– the first point,* x_n *– the last point);* $f(x_i)$, $f(x_{i+1})$ *- values of two neighboring points of a curve (vertical axis);* $\Delta x_i = \frac{\Delta X}{n-1}$ *- horizontal sample interval;* $\Delta X = x_n - x_1$ *- horizontal distance of increase at horizontal axis.* ***Results:*** The **Integral** calculation can return a negative value if the selected area of the waveform extends below zero. ***Units***: *Volts – sec.* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: 0.300 Volts -sec.(for first 6 sample points) and –0.155 Volts -sec.(for last 6 sample points – the wave below zero).*
Lin_reg	Minimum area: 2 samples	**Linear regression** is a better method to calculate the slope when you have noisy, erratic data.

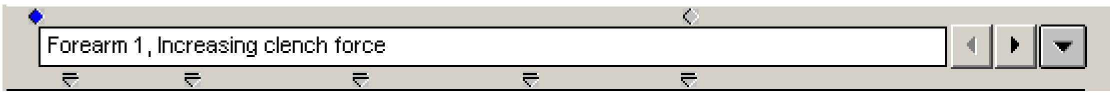
Measurement	Area	Explanation
	<u>Uses</u>: All points of selected area	**Lin_reg** computes the non-standard regression coefficient, which describes the unit change in <u>*f (x)*</u> (vertical axis values) per unit change in <u>*x*</u> (horizontal axis). *For the selected area*, **Lin_reg** computes the linear regression of the line drawn as a best fit for all selected data points using the following formula: $$\text{Lin\_reg} = \frac{n * \sum_{i=1}^{n}\left(x_i * f(x_i)\right) - \left(\sum_{i=1}^{n} x_i\right) * \left(\sum_{i=1}^{n} f(x_i)\right)}{n * \sum_{i=1}^{n}(x_i)^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$ <u>*Where*</u>*:* *n – number of samples;* *i – index (i = 1.n);* x_i – *values of points at horizontal axis (* x_1 *– the first point,* x_n *– the last point);* $f(x_i)$ *- values of points of a curve (vertical axis).* ***<u>Note</u>:*** *For a single point*, **Lin_reg** computes the linear regression of the line drawn between the two samples on either side of the cursor. ***<u>Results</u>:*** If the data value at the starting location is greater than the data value at the ending location of the cursor, then a negative delta will result. Otherwise, a positive delta will result. ***<u>Units</u>****: Volts/sec.* This value is normally expressed in unit change per second (time rather then samples points) since high sampling rates can artificially deflate the value of the slope. If the horizontal axis is set to display *Frequency* or *Arbitrary units*, the slope will be expressed as unit change in corresponding vertical axis values (frequency or arbitrary units, respectively). ***<u>Sample data file:</u>*** *"ValidateMeasurements.ACQ"* *Result: 230.00 Volts/sec. (for 1-4 samples) and –170.00 Volts/sec. (for samples 4-7).*
Max	<u>Minimum area</u>: 1 sample <u>Uses</u>: All points of selected area	**Max** (maximum) shows the maximum amplitude value of the data samples between the endpoints of the selected area. To compare peak heights, select each peak — you can easily see the maximum peak values or paste the results to the journal. Also, since you can simultaneously obtain measurements for different channels, you can easily compare maximum values for different channels. ***<u>Note</u>****:* For a single point, **Max** shows the amplitude value in this point. ***<u>Units</u>****: Volts*
Max T	<u>Minimum area</u>: 1 sample <u>Uses</u>: All points	**Max T** shows the time of the data point that represents the maximum value of the data samples between the endpoints of the selected area. ***<u>Note</u>****:* For a single point, **Max T** shows the time value in this point. ***<u>Units</u>****: Seconds*
Mean	<u>Minimum area</u>: 2 samples	**Mean** computes the mean amplitude value of the data samples between the endpoints of the selected area, according to the formula:

Measurement	Area	Explanation
	Uses: All points of selected area	**Mean** = $\frac{1}{n} * \sum_{i=1}^{n} f(x_i)$ *Where:* *n – number of samples;* *i – index (i = 1.n);* x_i – *values of points at horizontal axis;* (x_1 – *the first point,* x_n – *the last point);* $f(x_i)$- *values of points of a curve (vertical axis).* ***Units***: *Volts* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: 1.538462 Volts (for whole wave).*
Median	Minimum area: 2 samples Uses: All points of selected area	**Median** shows the median value from the selected area. ***Note:*** The median and calculation is processor-intensive and can take a long time, so you should only select this measurement option when you are actually ready to calculate. Until then, set the measurement to "none." ***Units***: *Volts*
Median T	Minimum area: 2 samples Uses: All points of selected area	**Median T** shows the time of the data point that represents the median value of the selected area. ***Note:*** The median and calculation is processor-intensive and can take a long time, so you should only select this measurement option when you are actually ready to calculate. Until then, set the measurement to "none." ***Units***: *Seconds.*
Min	Minimum area: 1 sample Uses: All points of selected area	**Min** (minimum) shows the minimum amplitude value of the data samples between the endpoints of the selected area. ***Note:*** For a single point, **Min** shows the amplitude value in this point. ***Units***: *Volts.*
Min T	Minimum area: 1 sample Uses: All points of selected area	**Min T** shows the time of the data point that represent the minimum value of the data samples between the endpoints of the selected area. ***Note:*** For a single point, **Min T** shows the time value in this point. ***Units***: *Seconds.*
None	n/a	**None** does not produce a measurement value. It's useful if you are copying a measurement to the clipboard or journal with a window size such that several measurements are shown and you don't want them all copied.
P-P	Minimum area: 2 samples	**P-P** (peak-to-peak) shows the difference between the maximum amplitude value and the minimum amplitude in the selected area.

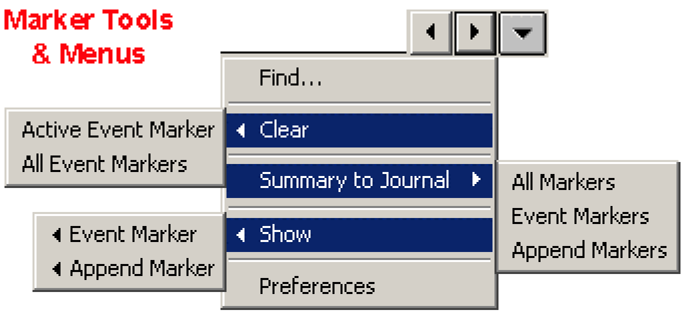
Measurement	Area	Explanation
	Uses: All points of selected area	***Results:*** The result is always a positive value or zero. ***Units***: *Volts* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result*: 13 Volts (for whole wave).
Samples	Minimum area: 1 sample Uses: All points of selected area	**Samples** shows the exact number of samples of the selected waveform at the cursor position—the first data point is not displayed, but is plotted at zero. See page 151 for examples of selected area Samples. ***Note:*** When an area is selected, the measurement will indicate the number samples in the waveform at the last position of the cursor. **Units**: Samples.
Slope	Minimum area: 2 samples Uses: All points of selected area	**Slope** computes the non-standard regression coefficient, which describes the unit change in *f (x)* (vertical axis values) per unit change in *x* (horizontal axis). *For the selected area*, **Slope** computes the slope of the straight line that intersects the endpoints of the selected area and can be found using the formula: **Slope** = $\frac{f(x_n) - f(x_1)}{x_n - x_1}$ *Where:* $f(x_1)$, $f(x_n)$ *– values of a curve at the endpoints of selected area.* x_1, x_n *- values of horizontal axis at the endpoints of selected area.* This value is normally expressed in unit change per second (time rather then samples points) since high sampling rates can artificially deflate the value of the slope. ***Note:*** **Lin_reg** (linear regression) is a better method to calculate the slope when you have noisy, erratic data. *For a single point*, **Slope** computes the slope of the line drawn between the two samples: the selected sample point and the sample point to its left. ***Results:*** If the data value at the starting location is greater than the data value at the ending location of the cursor, a negative delta will result. Otherwise, a positive delta will result. ***Units***: *Volts/sec.* (or corresponding to Freq or Arbitrary setting) ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: 233.33333 Volts/sec. (for samples 1-4)* *-166.66667 Volts/sec. (for samples 4-7) and* *-16. 66667 Volts/sec. (for whole wave).*
Stddev	Minimum area: 2 samples Uses: All points of selected area	**Stddev** computes the standard deviation value of the data samples between the endpoints of the selected area. Variance estimates can be calculated by squaring the standard deviation value. The formula used to compute standard deviation is: **Stddev** = $\sqrt{\frac{1}{n-1} * \sum_{i=1}^{n} \left(f(x_i) - \bar{f} \right)^2}$

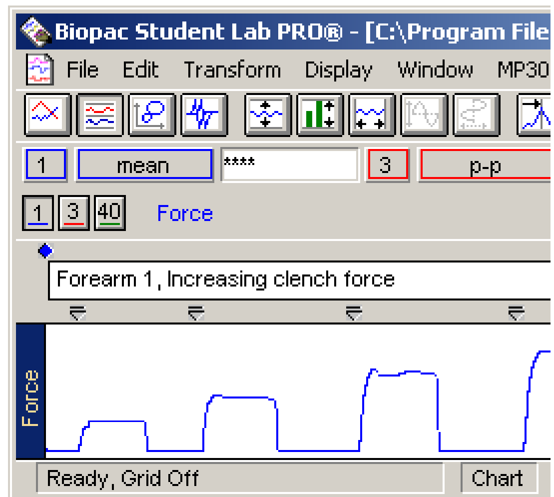
Measurement	Area	Explanation
		Where: *n – number of samples;* *i – index (i = 1.n);* x_i – *values of points at horizontal axis (* x_1 *– the first point,* x_n *– the last point);* $f(x_i)$ *- values of points of a curve (vertical axis);* $\bar{f} = \frac{1}{n} * \sum_{i=1}^{n} f(x_i)$ *- the mean amplitude value of the data samples between the endpoints of the selected area.* ***Results***: The result is always a positive value or zero. ***Units****: Volts* ***Sample data file:*** *"ValidateMeasurements.ACQ"* *Result: 3.09570 Volts (for samples 1-4),* *1.000 Volts (for samples 10-12).*
Time	Minimum area: 1 samples Uses: All points of selected area	See the **X-axis: T** measurement for explanation.
Value	Minimum area: 1 sample Uses: All points of selected area	**Value** shows the exact amplitude value of the waveform at the cursor position. *For the selected area*, **Value** indicates the value at the last position of the cursor, corresponding to the direction the cursor was moved (the value will be the left-most sample point if the cursor was moved from right to left). ***Units****: Volts*
X-axis:T/F/X (horizontal units)	Minimum area: 1 sample Uses: All points of selected area	The **X-axis** measurement is the exact value of the selected waveform at the cursor position, based on the Horizontal Axis setting: *Measurement* — *Horizontal Axis Setting* — *Units* **X-axis: T** — Time — Sec. **X-axis: F** — Frequency — Hz. **X-axis: X** — Arbitrary units — Arb. units For **X-axis: T** measurements, the time value is relative to the absolute time offset, which is the time of the first sample point. The **X-axis: F** measurement applies to frequency domain windows only (such as FFT of frequency response plots). The Freq function for time domain windows is described on page 157. ***Note:*** If a range of values is selected; the measurement will indicate the horizontal value at the last position of the cursor. ***Results:*** This calculation will always return a positive result.

Markers



When **Markers** is selected from the **Show** submenu, the Marker region at the top of the graph window will be activated, and any markers associated with the data file will be displayed.



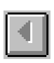


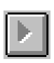
You can insert "markers" into a record that act as bookmarks to record when an event occurs during the record. These markers appear as downward pointing triangles at the top of the graph window, and can be labeled to describe the associated event. Markers can be edited, displayed, or hidden from view.

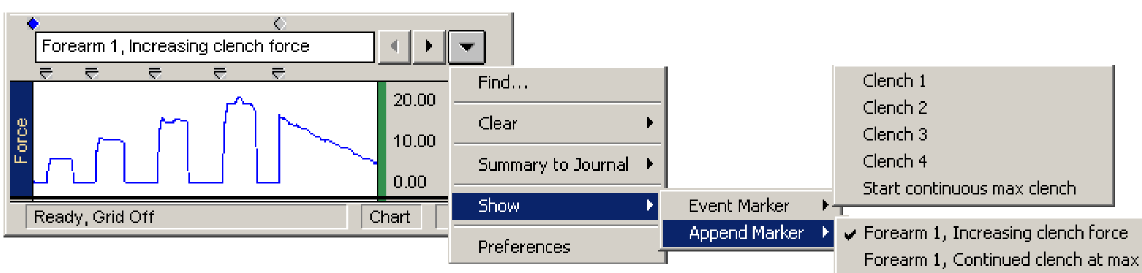
Markers can be inserted during an acquisition (except in high Speed mode) or off-line.

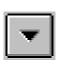
- To add a marker while an acquisition is in progress, click the **F9** key on a PC; the marker will be inserted at the exact time the key is pressed.
- To add markers after an acquisition, position the cursor in the marker area and click the mouse button.

When **Display** > **Show** > **Markers** is selected, icons are generated in the marker region for the following marker tools:

 Finds the previous marker in the record.

 Finds the next marker in the record.



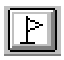
 Generates the **marker pull-down menu**, which lists all markers in the current file. To move to a given marker, scroll to select the desired marker label and release the mouse button.

The **Summary to Journal** feature copies marker information to the Journal. The marker number, marker time, and marker label are copied. This option is not selectable (grayed-out) when the Journal is not open.

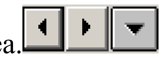
Printing markers: The markers will be printed when the marker display is enabled. To keep the markers from being printed, hide the markers before printing. If the display is compressed, marker labels and/or indicators will be layered when printed to prevent overlapped text.

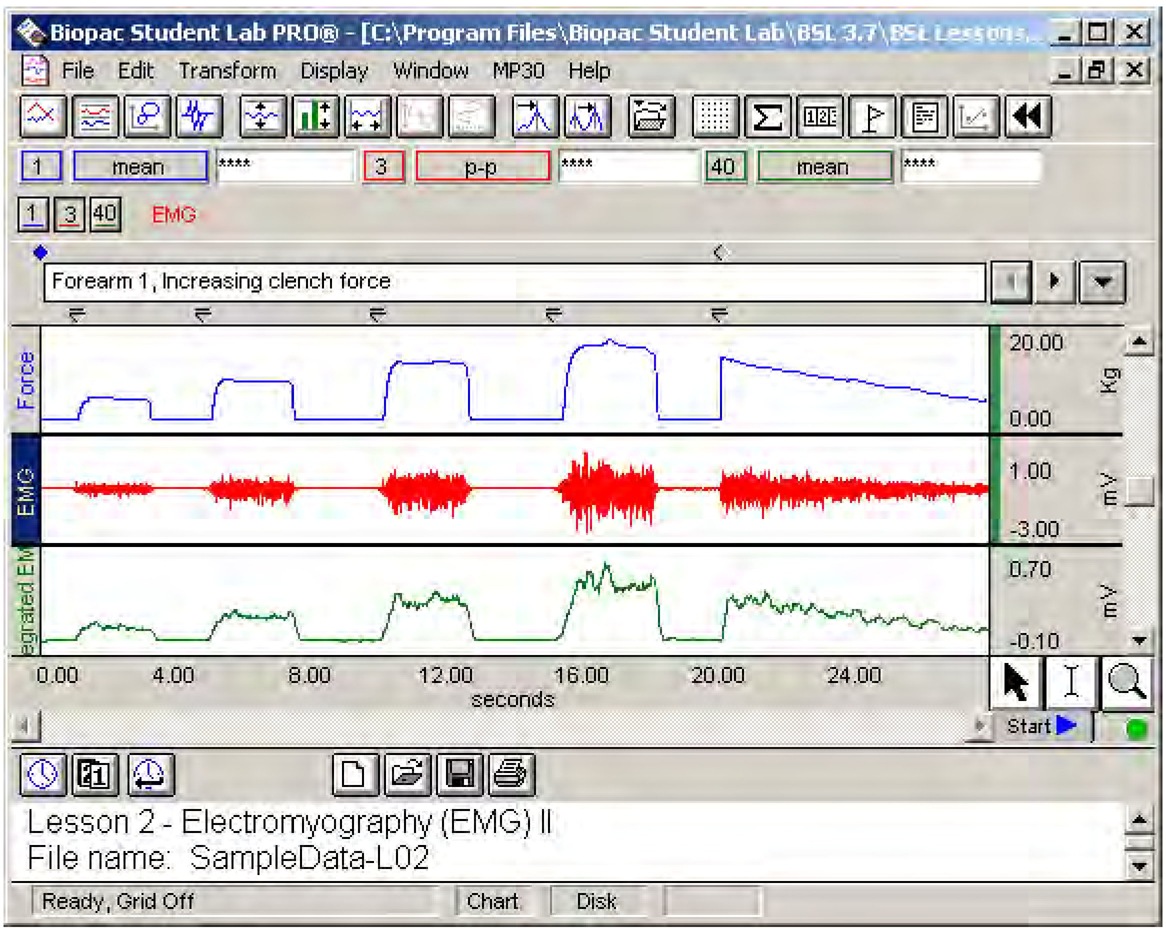
EXAMPLE OF MARKERS

To see how Markers work, open the **4channel.acq** sample file.

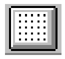

Locate the marker icons near the top right of the display. If the marker icons are not showing, click select the marker (flag) icon from the toolbar or **Display** > **Show**, then drag right and down to select **Markers**. Selecting either of these again will "hide" the marker area.

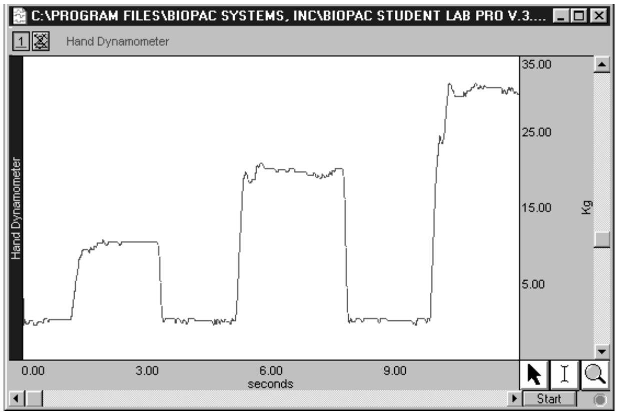
To view the text associated with a given marker, position the cursor arrow over the marker and click the mouse button.

To move from marker to marker, use the arrow buttons in the marker area.

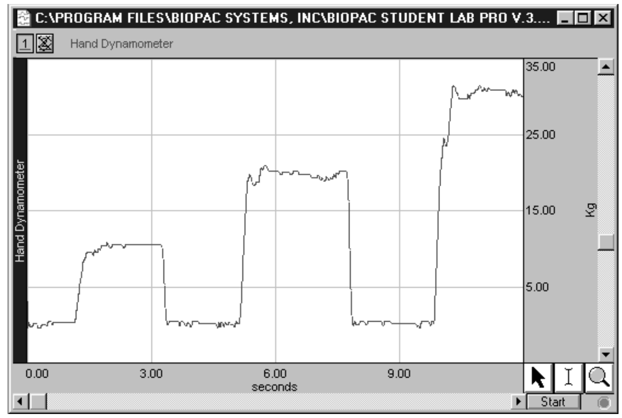


Grids

To activate a grid display, click  in the toolbar or select **Display > Show > Grids**.

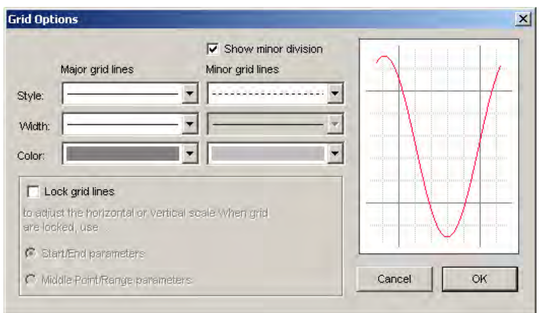


Grid Display Off



Grid Display On (unlocked)

Grid Options

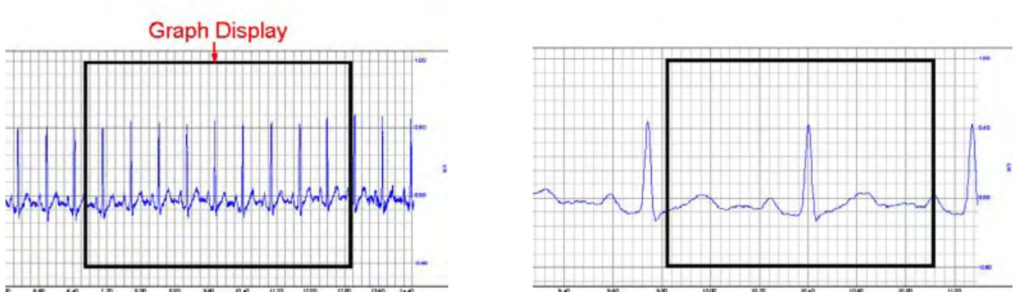


To control the style and functionality of the grid display, select **Display > Show > Grid Options**. The **Grid Options** control grid format (line type, style, width and color), whether or not minor divisions are displayed, grid lock, and scale adjustment when grids are locked.

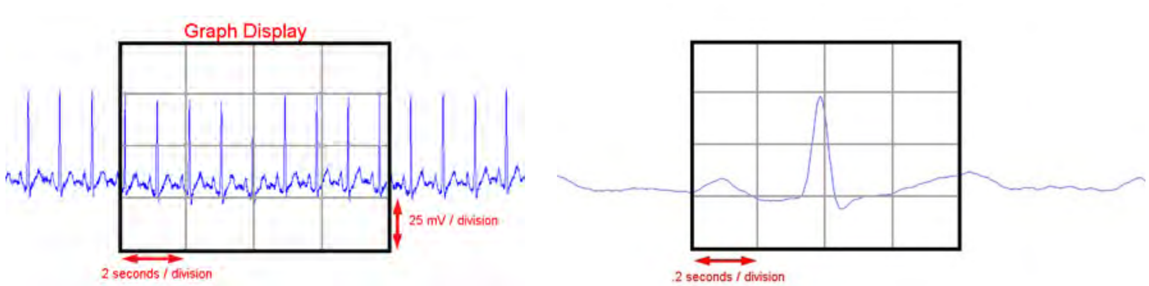
Overview of Locked and Unlocked Grids

Grid functionality and dialog options for Horizontal Scale and Vertical Scale change based on whether grids are locked or unlocked in the Grid Options dialog (see above).

Locked Grid



Unlocked Grid



Unlocked Grids

Unlocked grids help you view the data display on the monitor. The Unlocked setting, enabled by NOT selecting "Lock Grid Lines", displays four major grid divisions across the horizontal and vertical axes, and will generate interval numbers as needed to match the zoom factor. Unlocked grids are more helpful as a visual aid than an analysis tool.

When not locked, the grid always cuts the horizontal scale into four major divisions (four vertical grid lines), regardless of the horizontal axis setting, which can be set to represent time, frequency, or amplitude values for an X variable.

When not locked, the grid cuts the vertical scale into four major divisions (four horizontal lines across the screen) if the display is set to scope mode or X/Y mode; the grid cuts *each track* into four major divisions (four horizontal lines *per waveform*) if the display is set to chart mode.

Beware! Although the unlocked grid will be retained if the waveform is printed, saved as a graphic image or copied to the clipboard, the BSL *PRO* software will "round" the scale values.
This process does not affect the nature of the data, only the scale used to plot it.

Locked Grids

Locked grids are helpful with analysis and printing. Selecting "Lock Grid Lines" locks the grid to the data for all functions. The default settings for the grid when in locked mode are:

For vertical scale:

Base Point = 0;
Major Division = 1/10 full scale range rounded to the nearest whole number.
(For example, with the default setting for Channel, gain of 200, the major division would be set to 10mV / Division.)

For horizontal scale:

Base Point = 0;
Major Division = 1 second if sample rate is <= 2,000 s/s.
= 50 ms if sample rate is > 2,000 s/s.

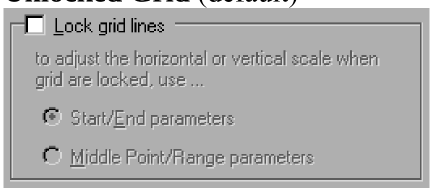
When grids are locked, you may set the grid interval (see next page).

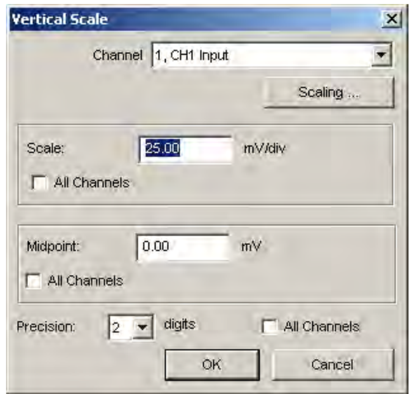
Grid Interval

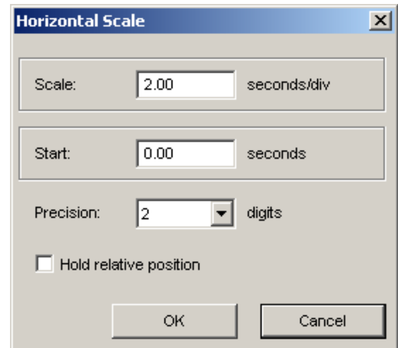
Grid Interval follows the settings established in the Vertical scale and Horizontal scale options for the given channel or for all channels. When grids are locked, interval parameters for the horizontal and vertical scales are determined in the Grid Options dialog. Choose Start/End or Middle Point/Range as the parameters to use and then set the scale range and grid interval options in the Vertical Scale and Horizontal Scale dialogs, respectively. Scaling button generates the scaling dialog, which you may want to use to adjust the display of units. See page 39 for a discussion of Vertical scale and Horizontal scale when grids are unlocked.

Grid Options : Lock option	Vertical scale options	Horizontal scale options

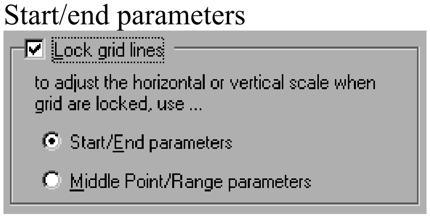
Unlocked Grid (default)



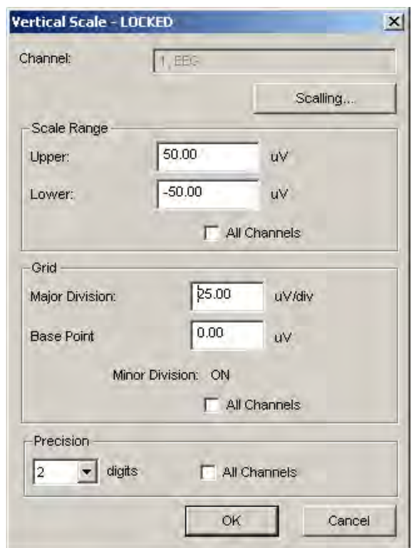


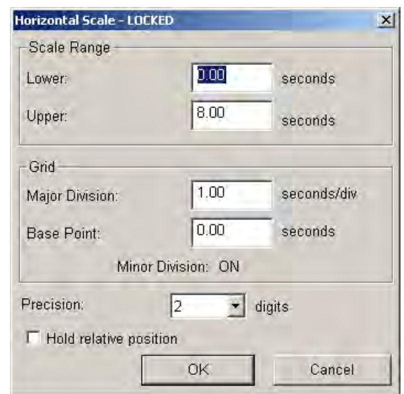


Locked Grid:
Start/end parameters



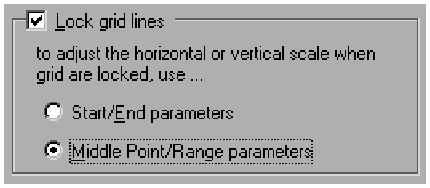
Note: The **Base Point** → is the point from which the first grid line will be drawn.



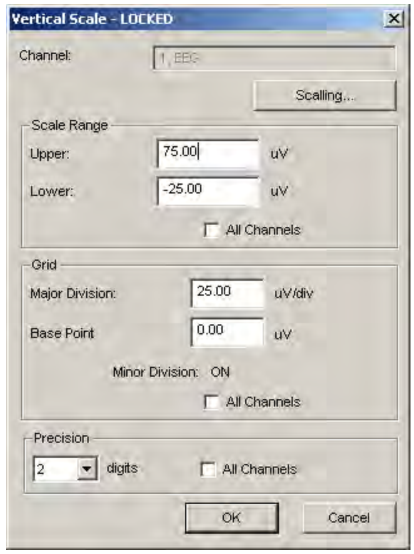


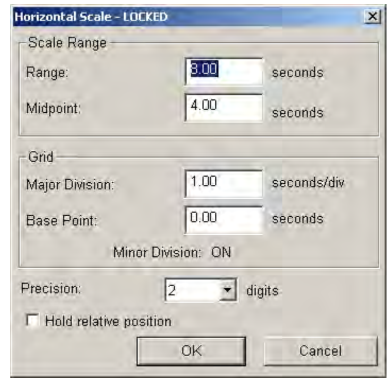
Grid Options : Lock option	Vertical scale options	Horizontal scale options

Lock Grid Lines:
Midpoint/range parameters



Note: The Base Point → is the point from which the first grid line will be drawn.

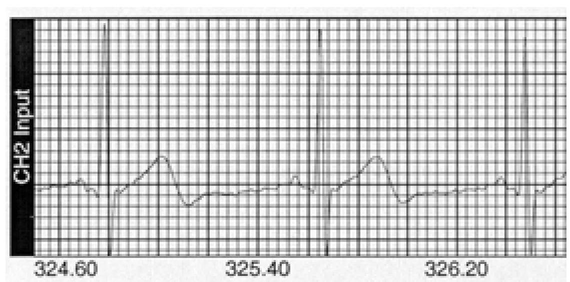


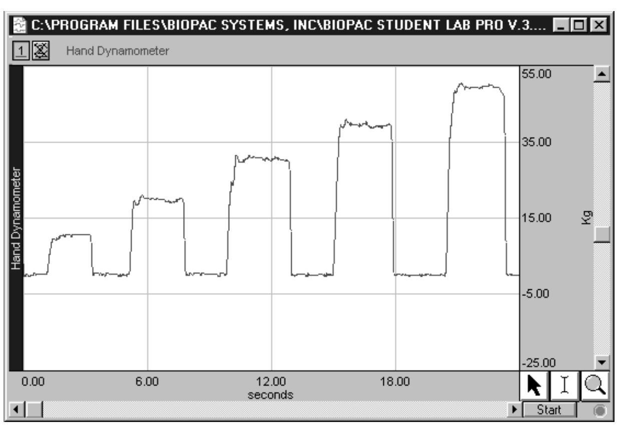


A few Grid Option comparisons follow, but you are encouraged to experiment with grid settings to familiarize yourself with the effect each option has on the data display.

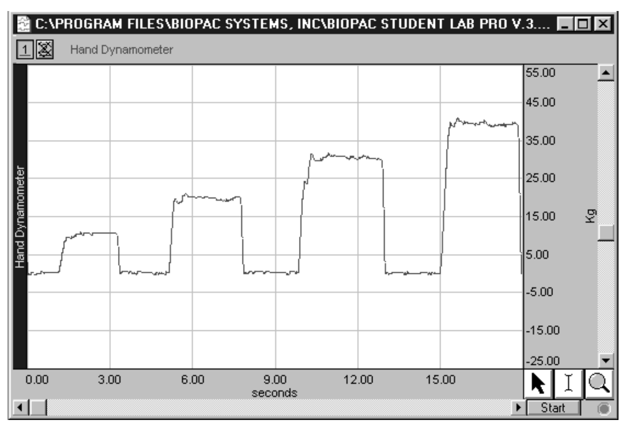
Using **Grid Options** with the **Print Options**, you can very closely match chart recorder output:

Note The standard ("clinical") ECG uses a grid with major divisions of 0.2 sec on the horizontal and 0.5 mV on the vertical, and minor divisions at one-fifth of that, or 0.04 sec horizontal and 0.1mV vertical.

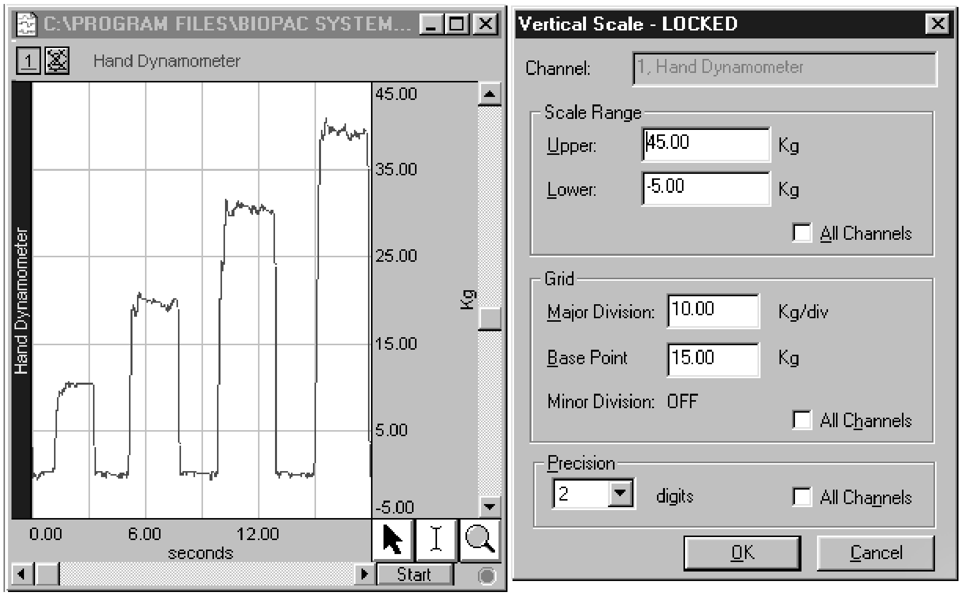




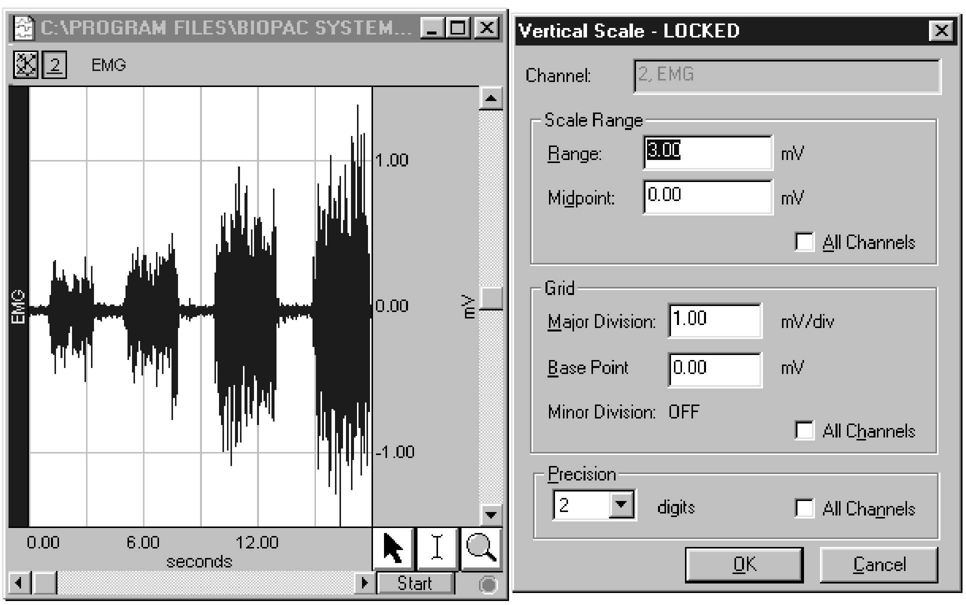
Grids On/Unlocked with Scale increased 2x



Grids On/Locked with Scale increased 2x

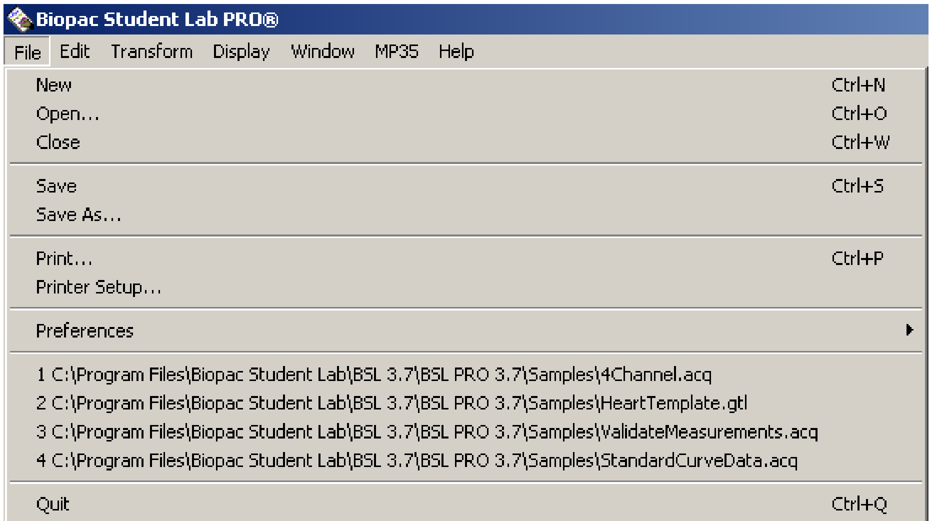


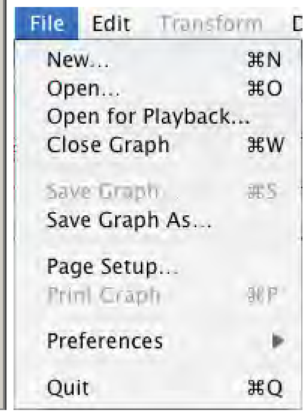
Grids On/Locked using start/end point adjustment



Grids On/Locked using middle point/range adjustment

Chapter 11 File menu commands

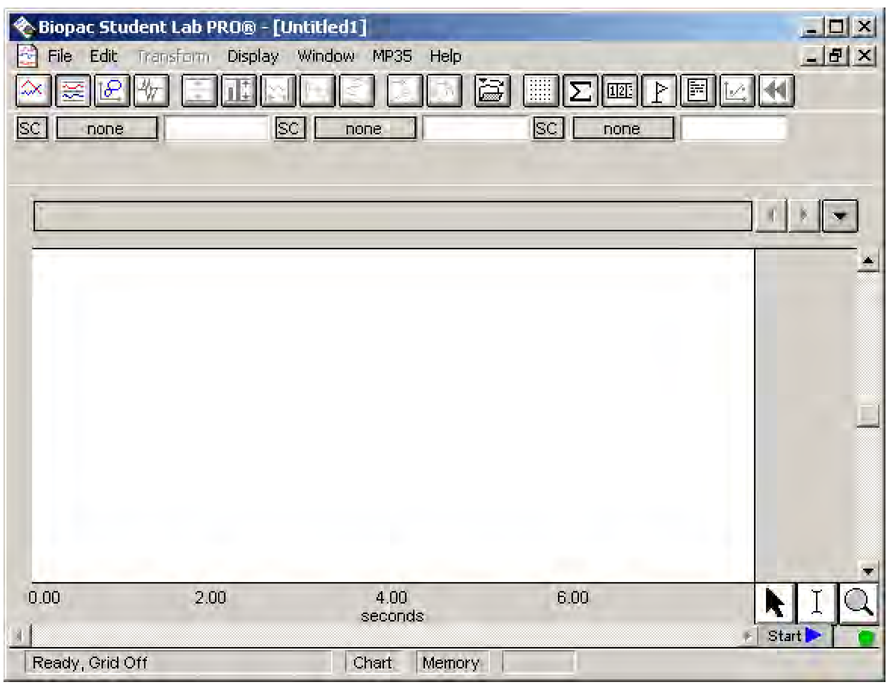




Most **File** menu commands are standard menu items that follow the standard OS conventions.

New

In almost all cases, you will need to create a new graph window before beginning an acquisition so that the data may be displayed on the screen. To create a new graph file, choose **File>New**. A new graph window will be generated similar to the one pictured.



You can modify any of the window parameters, including horizontal scale, vertical scale, window size and position. In addition, you can also set the acquisition parameters for sampling rate, number of channels, and acquisition length. These settings take effect once an acquisition begins.

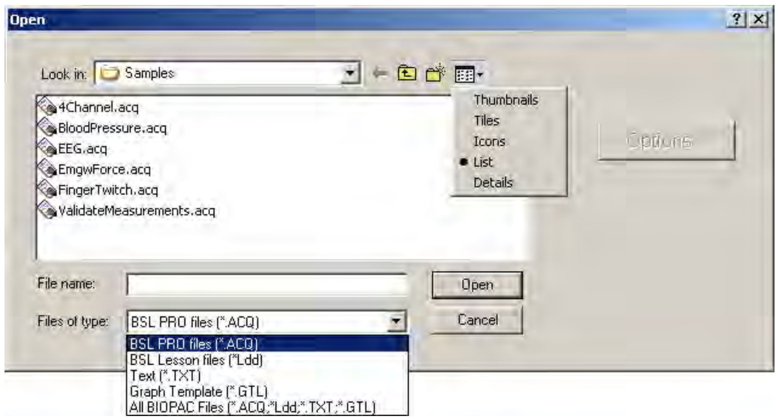
Note Choosing **File>New** from an open, active graph window generates a new window with the same settings as the active window. Choosing **File>New** when all windows are closed generates a new window with the same settings as the last saved window. To generate a new file with the application default settings, you must quit and relaunch the BSL *PRO* application.

You may also open a new **Journal** file, which will be linked to and saved with the Graph window.

To open a new Journal file, click the Journal icon of the graph window toolbar or choose **Display**>**Show**>**Journal. (Mac:** Choose **File>Open>Journal**). The journal window will open below the graph window.

Open

The **File > Open** command generates the standard file open menu, and allows you to open a variety of different file formats from the pull-down menu at the bottom of the dialog box. Data can be read in from either text files or Biopac Student Lab (*PRO* or Lesson) files, and can be saved in text, graphic, or binary format. You can view the files by type from the following options: BSL *PRO* (*.ACQ), BSL Lesson (*.Ldd), Text (*.TXT), Graph Template (*.GTL), or All BIOPAC Files. The **Open** dialog points to the last location used by the BSL *PRO* Open function.



The default display is **BSL *PRO* files (*.ACQ).** The **File type** option you select limits the file listing. If "Text" is selected, only text files are listed; if "GraphTemplate" is selected, only BIOPAC graph template files are listed. If "All BIOPAC Files" is selected, all files in formats that BSL *PRO* can open are listed.

BSL *PRO* files (*.ACQ)

The default file format (**.ACQ**) is referred to as a "BSL *PRO*" file. BSL *PRO* files are stored in the compact .ACQ format that retains information about how the data was collected (i.e., for how long and at what rate) and is the standard way of displaying waveforms in BSL *PRO*. BSL *PRO* files are editable and can be modified and saved, or exported to other formats using the **Save as** command.

When you open a BSL *PRO* file, only the graph window will be displayed by default. To display the Journal that is associated with the file:

PC: Click the icon of the toolbar display or choose **Display>Show>Journal**.

Mac: **Choose File>Open>Journal.**

BSL Lesson files (*.Ldd)

BSL *PRO* can open lesson files generated in the Biopac Student Lab program. When BSL Lesson files are opened, they mimic the "Review saved data" mode of the Student Lab such that the data and journal files are both opened and properly positioned. If you open and make changes to a BSL Lesson file in BSL *PRO*, you cannot save as a Student Lab file. You must save the new file in the BSL *PRO* format or alternate format.

Text files (*.TXT)

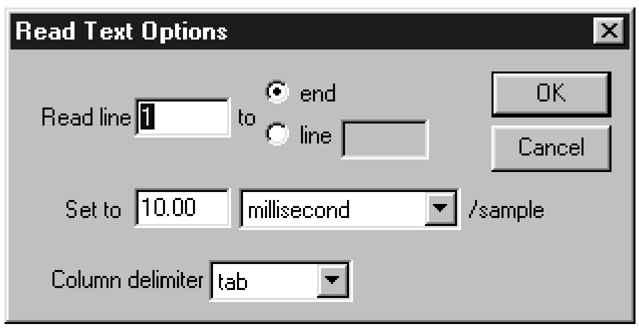
Text files are a useful way to transfer information between applications. BSL *PRO* can both import and export text files. Most spreadsheet and statistics programs are capable of importing or exporting data in a text file format.

BSL *PRO* assumes that the text file to be opened contains numeric data laid out in columns and rows, and that there is some delimiter between each column. It also assumes that each column represents a distinct variable or channel of data. Normally, the values in each row represent the state of each variable at different points in time. When a text file is opened, the numeric values will be plotted as waveform data in a standard graph window and non-numeric values will be ignored. Each column of data is read in as a separate channel.

IMPORTANT! Files saved with headers store the header information on the first line and start data on the second line (not the first). The Read Text Options default reads from Line 1 to the end, so you should adjust the line number if the file has a header.

Text Options

When the "Text files" option is selected, an **Options** button will be activated in the Open dialog. Clicking on this button generates a **Read Text Options** dialog box that allows you to control the amount and type of data to be read in, as well as the time scale for data display.



Read Text Options : File > Open > *.TXT > Options…

Read line This entry controls how much data is read in and indicates which row contains the first data point in the series. By default, text files will be read in starting at line one.

To End/Line By default, text files will be read until the **end** of the file is reached. You may want to set it to another value since some applications (usually spreadsheets) generate a "header," or text information at the top of a file. You can limit the amount of data read in by clicking next to **line** and entering a value in the box that is activated; the value in this box indicates the line to end the data on.

Set to You can control the horizontal scale (usually time) for the text file after it is displayed in the graph window by changing the interval between sample points, which can be expressed either in terms of time or frequency.

For example, if data were collected at 50 samples per second, there is an interval between sample points of 0.02 seconds. The BSL *PRO* software would then assume that there is a 0.02 second "gap" between the data point in row two and the data point in row three (and all subsequent pairs of adjacent rows). Likewise, if you have a data file that spans 10 seconds and has 100 rows of data, the interval between sample points will be 0.01 seconds.

Most files contain time domain data, although some applications generate frequency domain data (the results of a spectral analysis, for example). The principle here is the same as with time data, that there is some interval between different frequencies. If a text file contains 20 sample points covering the range between 0 and 60Hz, then the interval would be set to 3Hz per sample.

Column delimiter This setting determines what characters indicate a "gap" between two columns. All text files must have some sort of column delimiter, unless there is only one channel

Read Text Options : File > Open > *.TXT > Options…

of data present. This can be set to tab, comma, space, or auto.

Tab Tab delimited text files are the most common, and in this type of text file a tab is placed between each column for every row of data. These files are most often generated by spreadsheets and similar packages.

Comma Comma delimited files place a comma between each column of data for each row, much the same way as a tab delimited file. These types of files are frequently created by statistics programs such as BMDP and SAS.

Space Space delimited files are also commonly created by statistics packages, and place some number of spaces (usually two) between each column of data for every row which contains information.

Auto If you are not sure which delimiter to use, select **Auto** and the BSL *PRO* software will automatically select a delimiter.

Note: When either **Tab** or **Comma** is selected, the software will read in a new column each time it sees a delimiter, even if there are no numeric values between delimiters. For example, the following text file will read in three channels of data, although the channels will be of different lengths:

0.301424, 0.276737, 0.045015
0.338723, 0.808811, 0.542627
0.354271, 0.506313, 0.715995
0. 001325,, 0.762115
0.946207,, 0.894992
0.926409,,

Sample text file

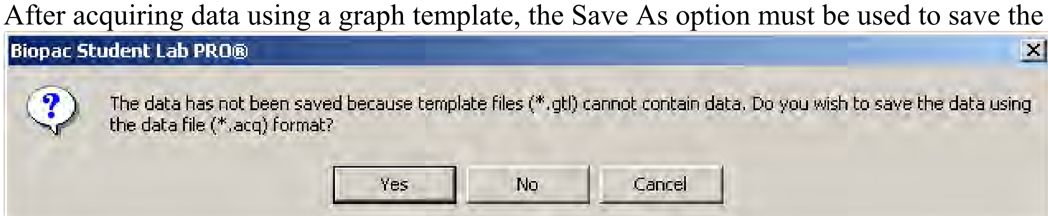
The first channel will contain six data points, the first being 0.301424 and the last value being 0.926409. The next channel will contain three data points, starting with 0.276737 and continuing through 0.506313 (the software considers that there are no other data values for the second channel; notice the double commas). The third channel will contain five data points, starting with 0.045015 and ending with 0.894992.

Graph Template files (*.GTL)

The **Graph Template** option allows you to open a file that contains master settings. **Graph template** files are master files that open to previously saved window positions and setup parameters (as established under the MP35 menu).

When a Graph template file is opened, the graph window does not contain any data. The journal window can contain text saved with the template. The Journal display will use the default Tab setting, so you may need to adjust **Tabs** under **File > Preferences > Journal**.

After acquiring data using a graph template, the Save As option must be used to save the data.



This feature is especially useful for recreating protocols in the classroom. Instructors set up an experiment and save it as a Graph template and then set the Read-only attribute in the file Properties dialog. Students then simply open the Graph template file and click the Start button. See the **Save As Graph template** section for more details.

A sample graph template file is included with the BSL *PRO* installation — see page 249.

Open for Playback

Mac only – see page 46.

Close

You can close the active window without quitting the application by selecting **Close** from the **File** menu.

Alternately, you can click in the  in the upper right corner of the window or use the **Ctrl-W** keyboard shortcut.

Save

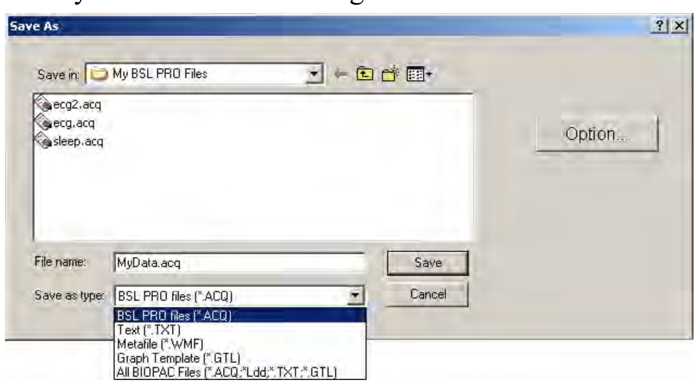
This menu item will save any changes you have made to a file. This includes changes to the Journal, markers, measurements, etc. If more than one file is open, this command only applies to the active window. For untitled files, you will be prompted to name the file you wish the data to be saved in.

The file will remain open after you have saved it, allowing you to continue working. The Graph and Journal are both saved when **Save** is selected. By default, all files are created and saved in the BSL *PRO* file format, a proprietary format used to store binary data.

Saving a file saves the setup parameters (established under the MP35 menu) and window positions, including the Journal window.

Save As…

Choosing **Save As…** produces a standard dialog box that allows you to set the format and location to save the data in. The **Save As** dialog points to the last location used by the BSL *PRO* software Save/Save As function. All **Save** features apply to the **Save As** function. You can use Save As to save a file to a different file name or directory than the default settings.



The default file format for the **Save As…** command is to save data as BSL *PRO* (*.ACQ) files. The other options are to save data as a Text file (*.TXT), a Metafile (.WMF), or a Graph Template (*.Gtl). These options can be selected from the pop-up menu at the bottom of the dialog box.

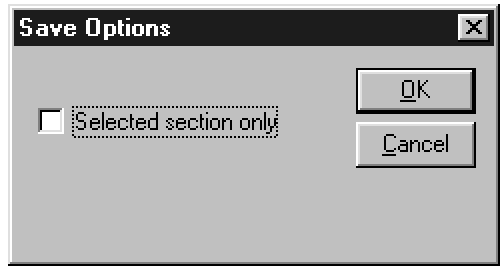
As a rule, saving a file in the BSL *PRO* format saves data in the most compact format possible and takes up less disk space than other file formats. Except in exceptional cases, you will save graph windows in the BSL *PRO* format.

BSL *PRO* files (*.ACQ)

Selecting *.ACQ from the pop-up menu in the **Save As…** dialog box will save a file as a BSL *PRO* file, which is designed to be as compact as possible. These files can only be opened by BSL *PRO* software, but data can be exported to other formats once it has been read in.

Option button

When you **Save As** a BSL *PRO* (*.ACQ) file, an **Option** button is enabled in the **Save As** dialog box. Click the **Option** button to generate a **Save Options** dialog that allows you to control how much data is saved.



Text files (*.TXT)

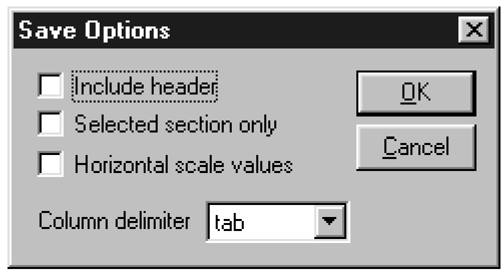
Data from BSL *PRO* graphs can also be saved as text files through the **Save As…** dialog box.

IMPORTANT! The **Save As Text** option will only save the graph data as text, you will lose all journal data. If you have journal data you want to save, you must first save the journal as a separate text file with a unique filename using the Save As option on the Journal Toolbar. Then save the graph data using the Save As Text option.

Options button

When you **Save As** a Text (*.TXT) file, there is an **Options** button in the **Save As** dialog box.

Click the **Options** button to generate a **Save Options** dialog that allows you to control how much data is saved and the format it is saved in.



Save Options : File > Save As > *.TXT > Option…	
Include header	Includes a "**header**" on the first line of the text file that contains information about the sampling rate, number of channels, date created, and other information relating to the data. This information is frequently useful, but some programs will attempt to read in the header information as data, which could result in nonsensical results. You may wish to include the header as it can always be edited out later using a text editor or the journal. With this option, data starts on Line 2.
Selected section only	Allows you to save only a portion of the data file. This saves the area selected with the I-beam tool from all channels as another file and will not affect the current file that you are working in. This is useful for saving a brief segment of a long file. ➢ When only one data point is selected, the entire file will be saved. ➢ If you want to save only a portion of the selected channel, you can either remove other channels or copy the data through the clipboard (see page 188 for more information).
Horizontal scale values	Allows you to include the **horizontal scale values** in the text file, along with the data to be saved. This allows you to produce time series plots in other applications, as well as correlating events to time indexes in graphing and statistical packages. Since a separate row is generated for each sample point, it is possible to exceed the limitations of programs if data is collected at a fast sampling rate (many spreadsheet programs are limited to about 16,000 rows). See page 210 for information on resampling data after an acquisition is completed.
Column delimiter	Controls the type of **delimiter** used to separate columns of data in the text file. When data is saved as a text file, each channel of data is saved as a separate column, with the number values for each data point saved in rows. Select tab, comma, or space from the delimiter menu. By default, a tab is placed between each

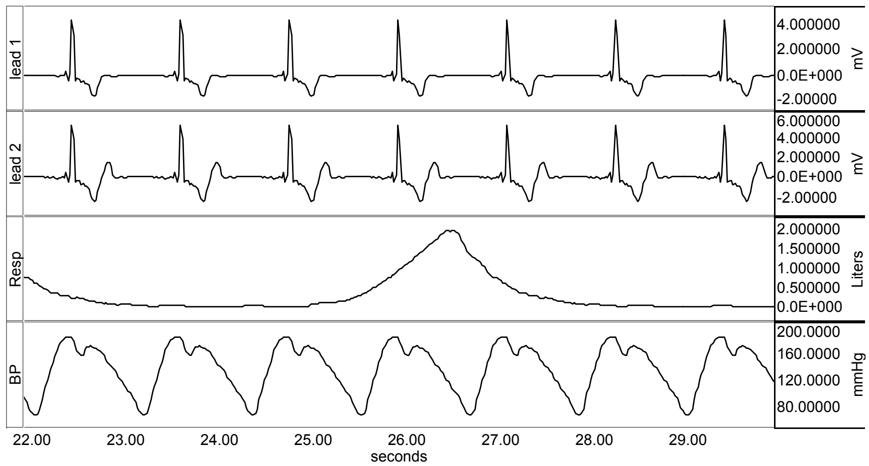
Save Options : File > Save As > *.TXT > Option…

column for every row of data. This format is called a **tab-delimited** text file and almost all applications will read in tab-delimited text files.

Metafile (*.WMF)

In addition to graph and text files, the BSL *PRO* software also supports formats for saving graphical information —Windows Metafile (.WMF). Most drawing, page layout, and word processing programs can read .WMF files. This is particularly useful for writing reports. A .WMF file can be opened in any standard drawing program and can then be embellished or used to highlight any particular phenomena of interest.

This is an example of a Windows Metafile (.WMF) file that was copied to the clipboard, pasted into this Word for Windows document and resized to better fit this page.



When data is saved as a graphic, only the data currently on the screen is saved. So, if you have a data file that spans eight hours but only two minutes is displayed on the screen, only two minutes of data will be converted to a graphic file. To save data in this format, choose .WMF from the pop-up menu at the bottom of the **Save As** dialog box. Since BSL *PRO* uses information about the computer screen in creating the graphic file, the default resolution of the file will be the same as the window. Most word processors and graphics packages allow for some way to resize and scale graphics.

Graph Template (*.GTL)

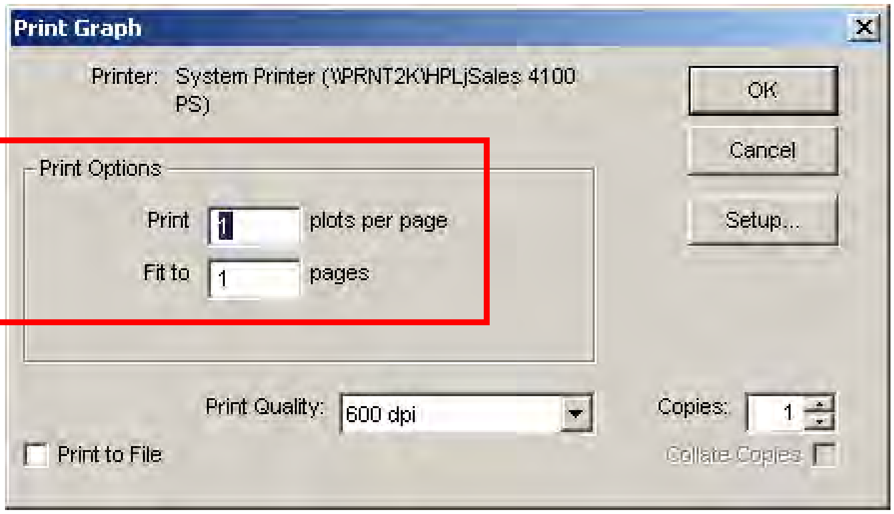
The **Save As Graph template** option saves the setup parameters (established under the MP35 menu) and window positions, including the Journal window. Any windows and controls (such as Input Values, Triggering Setup, and Output Control) that were active when the Graph template was saved will retain the same positions and settings when the Graph Template is reopened.

IMPORTANT! Saving as a Graph Template does not save any data – it only saves the setup parameters and window positions. You must select **Save** / **Save as** to save the graph and/or journal data.

When a Graph template file is opened, it does not contain any data. After data acquisition, the Save option will not be selectable; you must use the **Save As** option. This feature can be especially useful for recreating protocols in the classroom. Instructors can set up an experiment and save it as a Graph template and then set the Read-only attribute in the file Properties dialog., and then students can simply open the Graph template file and click the Start button.

When this feature is used with the **menu.dsc** customization feature (on page 64) it is easy to create your own personal lessons in addition to those featured in the Biopac Student Lab Manual— see page 63.

Print



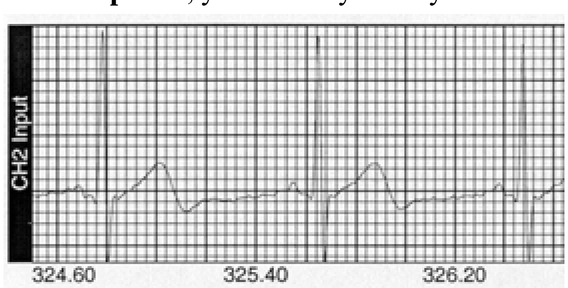
The **Print** menu generated by the BSL *PRO* software is similar to the standard computer print dialog but contains two additional "Print Options" that add functionality.
These two Print Options apply only to graph windows; they do not apply to journals.

Print __ plots per page Allows you to control how many plots appear per page when the file is printed. Printing more than one plot per page has the effect of "snaking" graphs on a page much the same way text appears in a newspaper. This option allows you to print records on considerably fewer pages than standard printouts, and is most effective when only a few channels of data are being printed.

- For example, if this option was selected so that two plots were printed per page, the BSL *PRO* software would divide the amount of data to be printed on that page into two graphs — one graph printing at the top of the page, the second graph printing at the bottom of the page.

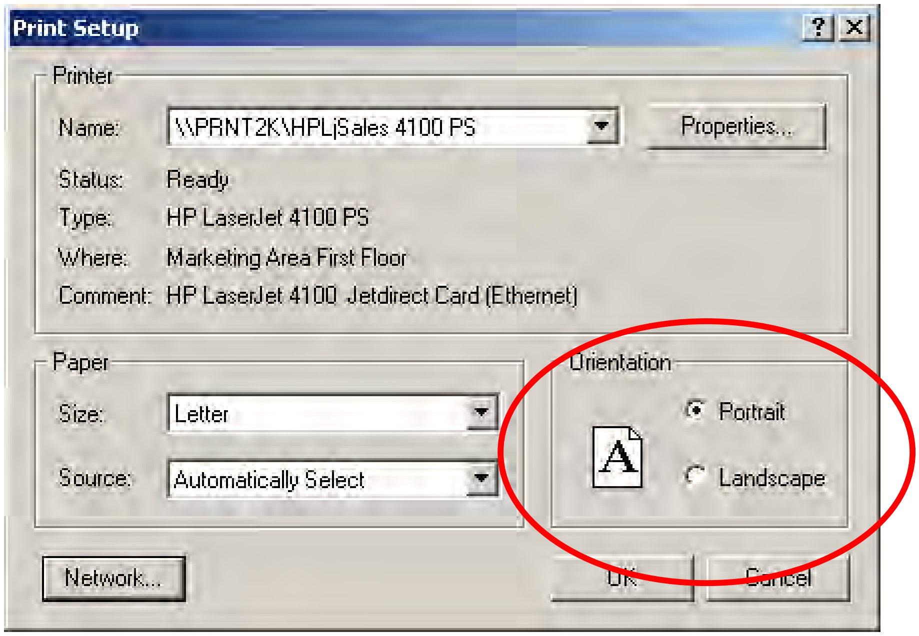
Fit to __ pages Allows you to print the contents of a window across multiple pages by dividing the amount of data on the screen (the amount of data to be printed) by the number of pages entered in the dialog box. The graph on the screen is then printed across the number of pages specified.

Using **Grid Options** with the **Print Options**, you can very closely match chart recorder output:



Printer Setup / Page Setup

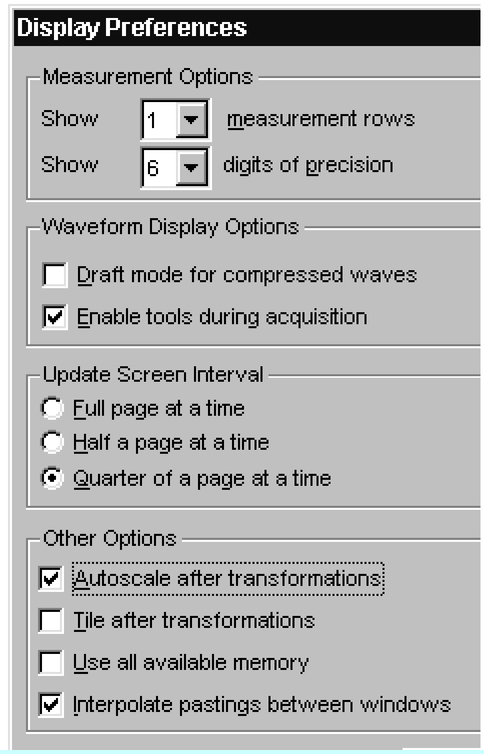
Choosing **Printer Setup** (PC) or **Page Setup** (Macintosh) produces a standard printer setup dialog box that allows you to setup any available printers. All the options in this dialog box function as described in your system manual.



There is also a **Properties** button that allows you to make several printing adjustments with respect to fonts, image orientation, and graphics presentation.

Preferences...

The File>Preferences command displays a sub-menu with three options: General, Journal and Markers. Each option generates its respective Preferences dialog.



The File>Preferences submenu may also display an option for Output Control Preferences, but only if an output control is active. See Output Control on page 120 for more information.

General Preferences

Selecting **File>Preferences>General** generates a **Display Preferences** dialog that allows control of measurement and waveform display, and other BSL *PRO* features.

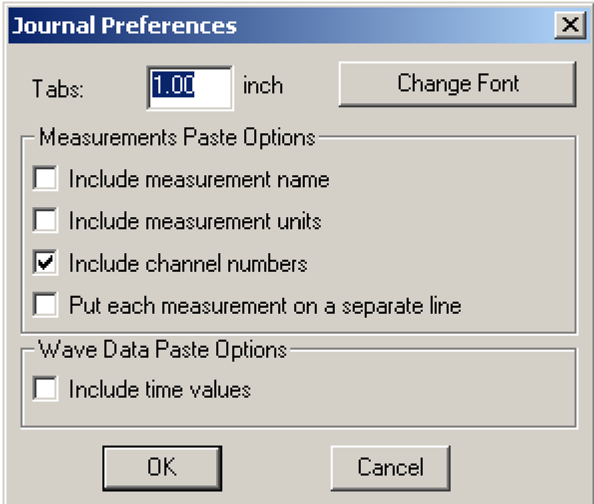
File > Preferences > General: Display Preferences Dialog	
Measurement Options	Measurement Options allows control of the measurement boxes for each channel at the top of the graph window.
Show X measurement rows	Controls how many measurement **rows** are displayed in the window at any one time. By default, this is set to “1” but may be set to any value between 1 and 8 by choosing a number from the pull-down menu. When you change this setting, all the current measurement values are cleared (set to "None"). (Note: To Show or Hide the measurement rows altogether, toggle the option in the **Display** > **Show** > **Measurements** menu. See page 238 for more information.)
Show X digits of precision	Allows control of the precision with which measurements are displayed. The default is 6 digits, but precision can be set to any value between 1 and 8 by choosing a number from the pull-down menu. This option controls the number of digits displayed right of the decimal place for all visible measurement windows. For instance, if this value is set to 3, one measurement window might show 125.187 while another reads 0.475. When the precision is changed, the value will be rounded up or down based on the selected data value. The precision does not alter the data file. For example, if the selected data value is 0.00480000, 4-digit precision will display 0.0048, 3-digit will display 0.005, and 2-digit will display 0.00 (not 0.01 which would be a round-up from 0.005 rather than from the selected value of 0.00480000).
Waveform Display Options	These options control how waveforms are displayed on the screen.
Draft mode	Allows for some (“compressed”) waveforms to be plotted in “draft” mode, which

File > Preferences > General: Display Preferences Dialog	
for compressed waves	results in faster plotting time, although the display is not exact. A waveform is considered compressed when more than three sample points are plotted per pixel on the screen. For example, on a display that is 800 pixels wide, a compressed waveform would be any type of waveform displaying more than 2400 samples on the screen at any one time. Using the default horizontal scale (which plots eight seconds of data on the screen), any data sampled at more than 300 samples per second would be considered "compressed."
Enable tools during acquisition	Activates the selection, I-beam, and zoom tools during an acquisition. The default is to disable these tools during acquisition. Use of tools during an acquisition may create display problems. It is recommended that you only turn on tools for very slow acquisitions.
Update screen interval	The **Update screen interval** option lets you adjust the rate that the screen is updated, which can be useful when you have a large data file (as in sleep studies) and you want to quickly jump through the data.
Full, Half or Quarter page at a time	You can set the interval to update in full page, half page, or quarter page increments. Click in the circle next to the desired interval in the "Update screen interval" section and the screen will update in the selected interval when you scroll through the data using the the horizontal scroll bar.
✓ TIP	Right-click in the Horizontal Scale region and choose the desired screen interval from the menu.
Other Options	There are four "**Other Options**" at the bottom of the dialog. The first two options control the amplitude (vertical) axis after data has been transformed (e.g., filtered or mathematically operated on). Neither option affects the horizontal axis.
Autoscale after transformations	Automatically rescales all waveforms after a transformation to provide the "best fit" along the amplitude axis.
Tile after transformations	Tiles all visible waveforms after any transformation, and is mutually exclusive of the Autoscale command. Waveforms appear to be stacked on top of each other.
Use all available memory	Attempts to use all the available memory for loading data. Otherwise, a variable sized buffer is used to load portions of large data files. This option works best if there is enough free memory to load the entire data file.
Interpolate pastings	Interpolates/extrapolates time base data to fit the sample rate of the destination window when working with data sampled at two different rates.
Note	When you **Interpolate pastings**, you should copy data to a higher resolution window. Although it is possible to copy data in the other direction (from high resolution to low resolution), it is not recommended since some resolution will be lost in the process. ***For example***, if you have one 30-second waveform sampled at 50 samples per second, and another 30-second waveform sampled at 2,000 samples per second, you can copy the contents of one window into another using the **insert waveform** command. This will interpolate one waveform so that both appear to be 30 seconds long. In this example, data would be copied from the 50Hz (low resolution) window to the 2,000Hz (high resolution) window.

Journal Preferences

Selecting the **Journal** option in the **File** > **Preferences** menu generates a dialog that allows you to control the format of data when it is displayed in the journal.

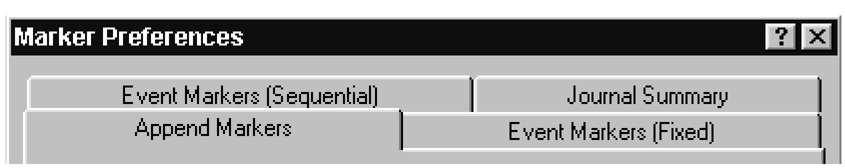
The **Tabs** and **Font** selections will be used to display and print the Journal and ***will be applied to all text within all open Journal windows*** (they are global application settings rather than file specific settings).



	File > Preferences > Journal: Journal Preferences Dialog
Tabs	The **Tabs** setting specifies the number of inches between tabs. The Journal display may or may not appear accurate, but tabs will be accurate for printing.
Change font	You can specify the font to use for journal text display. This button leads to the standard font dialog.
Measurement paste options	
Include the measurement name	Pastes the measurement name (i.e., BPM, delta T, Freq, and so forth) along with the values.
Include the measurement units	Pastes the measurement units (i.e., volts, mmHg, and so forth) after the numeric values.
Include the channel number	Includes the channel number at the top of each column of data.
Put each measurement on a separate line	Uses separate lines in the journal/clipboard.
Wave Data Paste Options	
Include time values option	Copies the horizontal scale values along with the waveform data when data is copied to the clipboard. This means that when you paste data from the BSL *PRO* screen into a spreadsheet or similar application, horizontal scale information is retained.

Marker Preferences

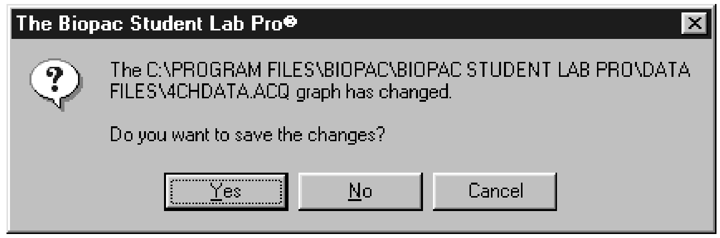
Selecting the **Marker** option in the **File > Preferences** menu generates a dialog that allows you to control the options for markers.



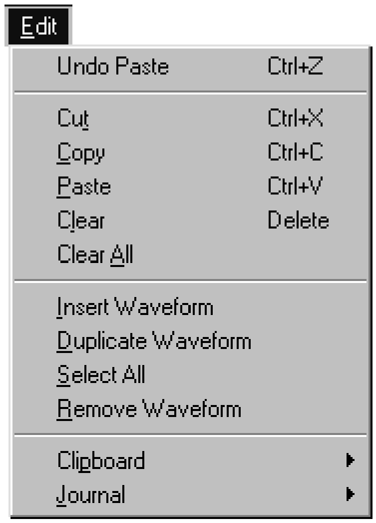
There are four tabs of settings options in the Marker Preferences dialog: Append Markers, Events Markers (Fixed), Event Markers (Sequential), and Journal Summary. For information about using Markers and setting Marker Preferences, see page 164.

Quit

Selecting **Quit** from the **File** menu exits the BSL *PRO* application and prompts you to save any open graph or journal files that have been modified since they were last saved.



Chapter 12 Edit menu commands



One of the most useful features in the Biopac *PRO* software is the ability to edit and work with data by cutting sections and copying sections from one window to another. The **Edit** menu contains options that allow you to work with data much as a word processor lets you work with text.

Undo

With some exceptions, the **Undo** command will undo the last command carried out by Biopac Student Lab *PRO* software. This allows you to restore data that was unintentionally deleted or modified. The **Undo** command applies not only to editing commands, but also to transformations (such as digital filtering and mathematical operations). When Undo is enabled, it will list the command it can undo, such as “Undo Paste.” When a command can’t be reversed, the **Undo** option will read **Can’t undo**.

Can’t Undo

There are some exceptions to the **Undo** command, and you should be aware of them before you choose to use any command. The following commands ***cannot*** be undone:

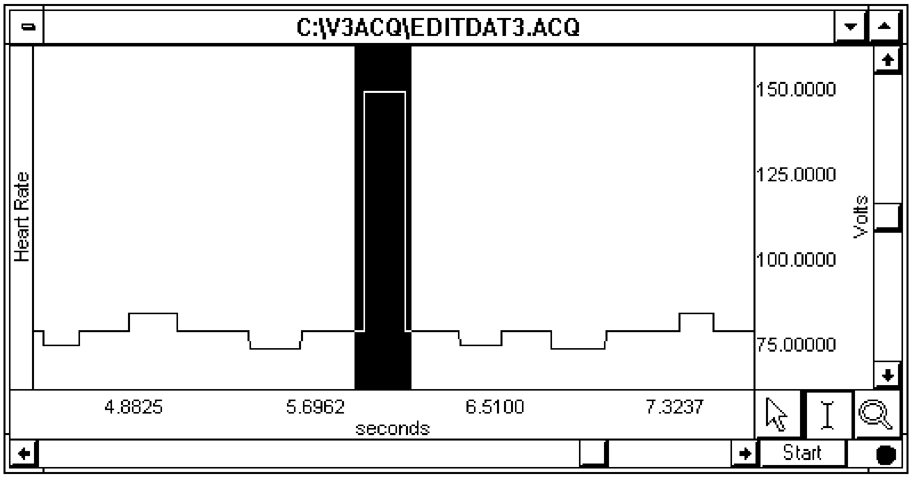
- **Display options** (i.e., changing the horizontal scale or changing the color of a waveform) cannot be undone, since they are easier to manipulate and less drastic than cutting data out of a waveform. If you modify the screen scale (or other display parameters) you will still be able to undo your latest data modification, which is much more difficult to recover than a screen parameter change.
- **Clear All** cannot be undone. It is a good idea to make backup files before performing any editing, especially when using this command.
- **Remove Waveform** cannot be undone. It is a good idea to make backup files before performing any editing, especially when using this command.
- **Insert Waveform** cannot be undone, but selecting the inserted channel and choosing **Remove Waveform** from the **Edit** menu effectively undoes this operation.
- **Rewind button** cannot be undone.

✓ TIP If you accidentally remove a waveform or choose clear all, one way to recover the data is to close the file without saving the changes. The data file can then be reopened as it was when it was last saved; any changes made since it was last saved will be lost.

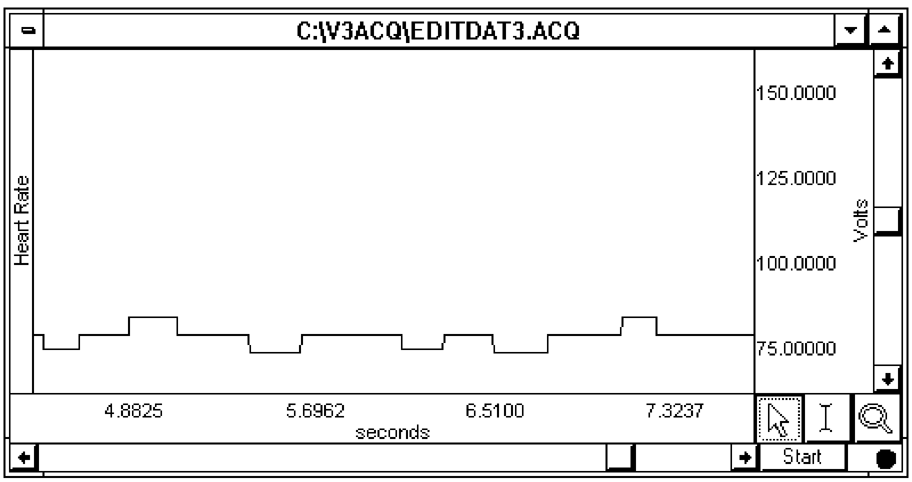
Cut

When **Cut** is selected, the selected (highlighted) area of the active channel (waveform) is removed and copied to a clipboard, where it is available for pasting into other waveforms. When a selected area is cut from a waveform, the data shifts left to "fill in" the deleted area. So, if ten sample points are cut, all data after the selected area will be shifted ten sample points to the left.

✓ TIP The Cut function alters the relationship of events to the time base, so you might want to consider alternatives to cutting sections of data. Other options include transforming the section of the data using smoothing, digital filtering, or the Connect Endpoints functions.



Area selected using editing tool



Same data with selected area deleted. Note that data after the selected area has shifted forward in time.

Copy

Choosing **Copy** will copy the selected area of a waveform to the clipboard without modifying the waveform on the screen. Once the area has been copied, it can be inserted in another waveform using either the **Paste** or the **Insert Waveform** commands. To copy a waveform to another channel in the same graph window, choose the **Duplicate Waveform** command.

Paste

The **Paste** command will take the contents of the clipboard and paste it into the currently active channel at the cursor point. If no point is selected, the data will be pasted at the beginning of the waveform.

Clear

The **Clear** command works much the same way as the **Cut** command, with the key difference being that data is not copied to the clipboard. This function deletes the selected area from the selected channel only. If the entire waveform is selected (as with the **Select All** command), the **Clear** command will delete all the waveform data and leave an empty channel. As with the **Cut** command, the **Clear** function operates on only one channel, and when a portion of the waveform is cleared, the remaining data will shift left. If multiple channels of data are present, one channel will be "shorter" than the others. To remove a selected area of data from multiple channels, use the **Clear All** command.

Clear All

Choosing **Clear All** will delete the selected area from *all* channels. This is similar to the **Clear** function in that data is removed and is not copied to the clipboard. The **Clear All** command, however, removes a section of data from *all* waveforms, not just from the selected channel.

- When **Select All** is chosen prior to performing the **Clear All** function, all waveform data for all channels will be deleted.
- The **Undo** command does not work for **Clear All**.

Insert Waveform

The **Insert Waveform** command is useful for copying a waveform (or a section of a waveform) from one window to another. To do this, first select the area to be copied using the cursor and the **Copy** command. Next open the graph window you wish to insert the waveform into; it is possible to insert the waveform into the same graph it was copied from, although the **Duplicate Waveform** is a more straightforward way to do this. Once you have selected the graph you wish to insert the waveform into, choose **Insert Waveform** from the **Edit** menu. A new (empty) channel will then be created and the data will be copied into the empty channel.

The new channel will always take on the lowest available channel number.

- The **Undo** command does not work for **Insert Waveform**, but selecting the inserted channel and choosing **Remove Waveform** from the **Edit** menu effectively undoes this operation.

Duplicate Waveform

Choosing **Duplicate Waveform** will create a new channel in a graph window and copy an entire waveform (or a selected area) to the new channel. When a portion of the waveform is selected, only the selected area will be duplicated. To duplicate the entire waveform, choose **Select All** and then select **Duplicate** from the **Edit** menu.

✓ TIP Right-click a waveform and select Duplicate from the pull-down menu.

Select All

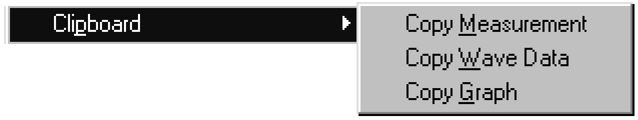
When **Select All** is chosen from the **Edit** menu, the entire selected channel is highlighted. For almost all commands, when a waveform is selected using **Select All**, subsequent operations apply to the selected channel only. The exception is when **Clear All** is chosen after **Select All**. When this occurs, all data from all waveforms will be deleted.

Remove Waveform

The **Remove Waveform** command deletes the entire selected waveform, regardless of what other options are selected.

- The **Undo** command does not work for **Remove Waveform.**

Clipboard



Each clipboard command involves copying data from the Biopac Student Lab *PRO* to the standard OS clipboard, where the contents of the clipboard are made available for other applications. Data can be copied to the clipboard in two formats: alphanumeric and graphic. The **Copy Measurement** and **Copy Wave Data** commands save information to the clipboards in text/numeric format, whereas the **Copy Graph** transfers the image on the screen to the clipboard in .WMF graphic format. In either case, transferring data through the clipboard allows you to copy data to other applications even after you have closed the graph window and/or quit the Biopac Student Lab *PRO*.

Copy Measurement

Copies the contents of all visible measurement pop-up menus, along with the values associated with these windows. By default, three windows are displayed (on most monitors); you can change this by increasing or decreasing the width of the window. Once the measurements have been copied, they can be pasted into any application that allows paste functions, including word processors, drawing packages, and page layout programs. A sample of measurements pasted from the BSL *PRO* into a word processor follows:

BPM = 85.714 BPM   delta T = 0.700 sec   p-p = 0.8170 Volts

Copy Wave Data

Copies wave data (in numeric form) for all channels into the clipboard and includes a header line. When an area is selected, only the data in the selected area will be copied to the clipboard. For example:

Hand Dynamometer	EMG
-0.0293386	-0.0228271
-0.0579655	-0.0170898

When multiple channels of data are copied to the clipboard, the data is stored in columns and rows, with data from each channel stored in a separate column with the channel label as the header for each column. For a four-channel record, four columns of data will be copied to the clipboard.

As with a text file, the BSL *PRO* software will insert a delimiter between each column of data. The default delimiter is a tab; you can change the delimiter to either a space or comma in the **Options** dialog of the **File** > **Save as Text** option (see page 177).

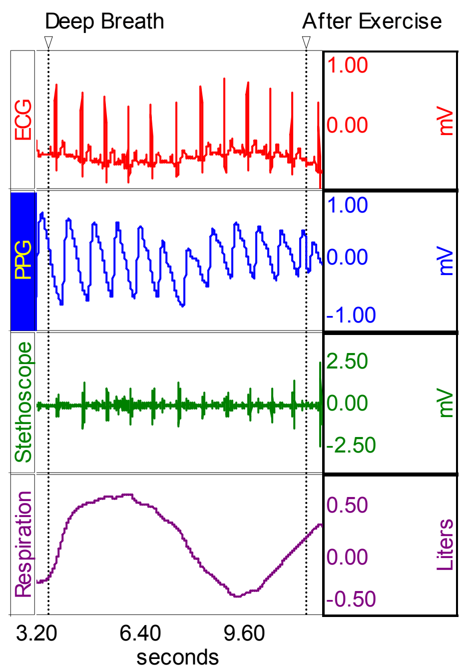
Transferring data through the clipboard performs essentially the same function as saving data as a text file (using the **File** > **Save As** command), with the obvious exception that transferring data through the clipboard does not save data to disk.

Once the data is stored in the clipboard, it can be pasted into virtually any application.

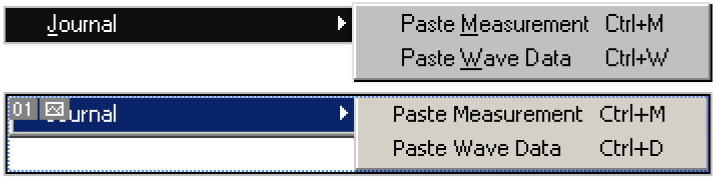
Copy Graph

Copies the graph window as it appears on the screen to the clipboard, where it is stored in Windows Metafile format. The graph label and any associated markers, if displayed via **Show** > **Markers**, will also be copied to the clipboard. You can then place the graphic into a number of different types of documents, including word processors, drawing programs, and page layout programs. Windows Metafiles are common to almost all applications, and images saved in these formats can be edited in most graphics packages and many word processors.

Using the **Copy Graph** function is similar to saving a graph window as a Windows Metafile (using the **File** > **Save As** command), except that using the **File** > **Save** command writes a file to disk, whereas transferring data through the clipboard does not save a file.



Journal



The **Journal** sub-menu has two options: Paste measurement and Paste wave data. Both options are similar to those found in the **Clipboard** menu. The key difference is that data (whether measurements or raw data) is pasted directly into the journal rather than copied to the clipboard.

Paste Measurement

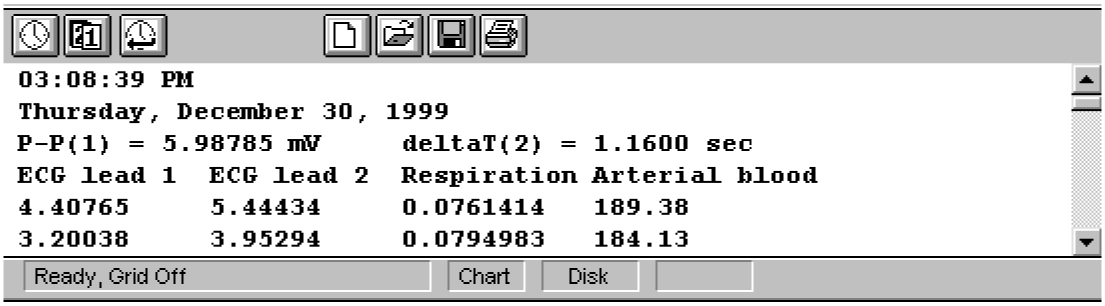
Choosing **Paste Measurement** will cause all visible measurement windows to be pasted into the journal.

- Measurement names and values are pasted into the journal in columns using the Tab spacing specified in the **File** > **Preferences** > **Journal** dialog (see page 182).
- Use the **Preferences** > **General** dialog (see page 181) to change the number of measurement rows displayed (and therefore, available for pasting) or the measurement unit precision. Note that when you change the number of rows displayed, all current measurement settings will be cleared (set to "None") so you should establish the number of rows required prior to selecting measurements.

Measurements for "peak-to-peak" from CH 1 and "delta t" from CH 2 pasted from the open graph to the journal

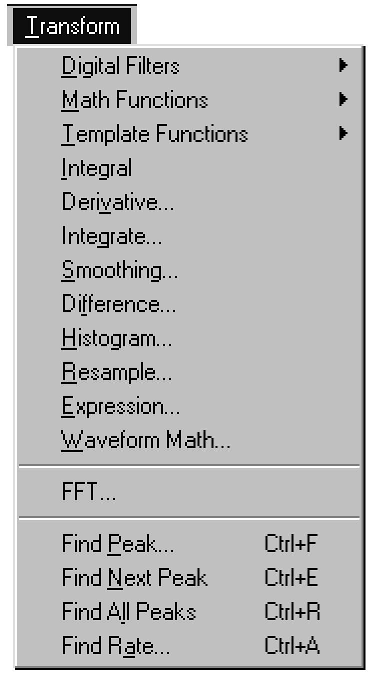
Paste Wave Data

The **Paste Wave Data** option converts the selected area of the waveform to numeric format and pastes it into the journal in standard text file format. This will paste the selected area from all channels, not just the selected channel, and will place a delimiter between the columns when two or more channels are being pasted to the journal. By default, tab characters are used to separate columns; you can change to comma or space delimiters in the **File > Save As > Text Options** dialog. See the **Save As…Text** section on page 177 for more information on how to change the column delimiter.



Wave data (from the previous wave sample) pasted from the open graph to the Journal

Chapter 13 Transform menu commands



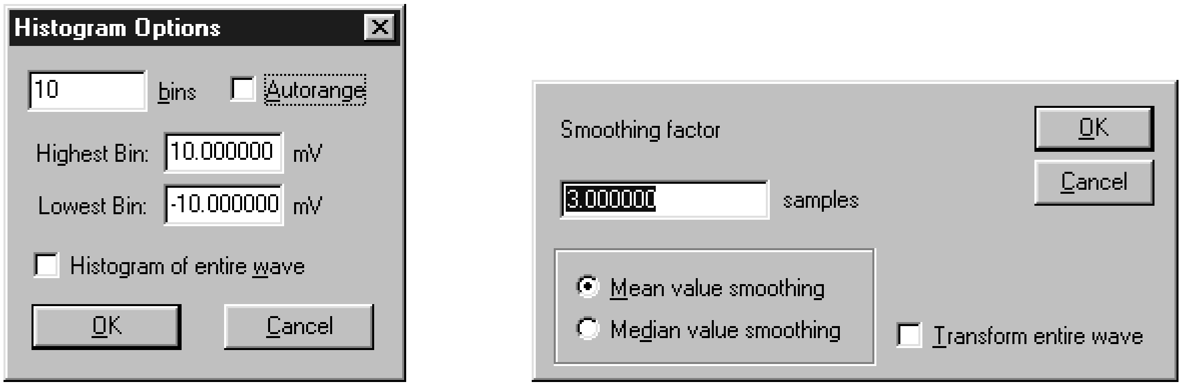
The Biopac Student Lab *PRO* provides a number of options for post-acquisition analysis and transformations. These transformations allow you to perform a range of operations on data, from digital filtering and Fourier analysis to Math Functions and histograms. All of these options can be found under the **Transform** menu, and are disabled while an acquisition is in progress. Unless otherwise noted, all of the transformations described here apply to the selected channel only. Some options (the Expression and Math functions) allow you to specify a channel (or channels) to be transformed.

It is important to remember that the BSL *PRO* software is always selecting at least one point. When a section of a waveform is highlighted, the transformation will apply to that section. If no area is defined, the BSL *PRO* software will always select a single data point. Some transformations can operate on a single sample point (e.g., Math Functions, Waveform Math), and will transform a single sample point when only one is selected. Other transformations can only be performed on a selected area (spectral analysis and digital filtering, for instance), so if a single point is selected the entire waveform will be transformed.

There are two ways to apply a transformation to an entire waveform.

a) The first method involves selecting an entire waveform using the **Edit > Select all** command prior to selecting the transformation. This will work for all of the transformation functions, and is the only way to apply a transformation to an entire waveform for functions that do not produce a dialog box (e.g., Math functions, Integral).

b) The second method can be used for any transformation that does produce a dialog box (e.g., Digital filters, Expression, FFT). These dialog boxes allow you to check a box (located toward the bottom of each dialog box) that will transform the entire waveform (regardless of whether a single point, area, or the entire waveform is selected).



Examples of "entire wave" option in Transform menu dialogs

The table below groups the transformation functions into four general families or clusters. The ***Isolation*** functions perform "data cleaning" in that they perform some sort of filtering or data reduction tasks. The ***Calculation/Math*** transformations perform calculations or other mathematical operations on the data. The ***Search*** functions allow you to search though the data, either for peaks or patterns of data. The ***Summary*** functions provide graphical summaries of the data, either in terms of the frequency spectra of the data or the measures of central tendency and dispersion of waveform data.

RAW DATA			
Isolate data	**Calculation/Math**	**Search**	**Summary**
Smoothing	Expression	Peak Detection Functions	Histogram
Digital Filtering	Waveform Math	Find peak	FFT
Resample	Math Functions	Find Next Peak	Find Rate
	Difference	Find All Peaks	
	Integrate	Template Functions	
	Derivative	Set Template	
	Integral	Remove mean	
		Convolution	
		Correlation	
		Mean Square Error	
		Inverse MSE	

BSL PRO Transformation Functions

Digital Filters

There is a fair amount of arcane terminology and theory surrounding the use and implementation of digital filters. For a general overview, see Appendix D — Filter Characteristics.

Two types of post-processing filters are available under the **Transform** > **Digital filters** submenu: FIR (finite impulse response) filters and IIR (infinite impulse response) filters.

FIR filters are linear phase filters, which means that there is no phase distortion between the original signal and filtered waveforms.

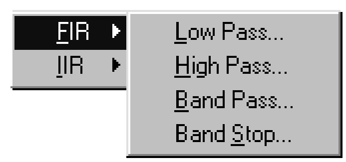
IIR filters are not phase linear filters, but are much more efficient than FIR filters in processing data. The IIR filters are useful for approximating the results of standard biquadric filters of the form:

$$\frac{(as^2 + bs + c)}{(xs^2 + ys + z)}$$

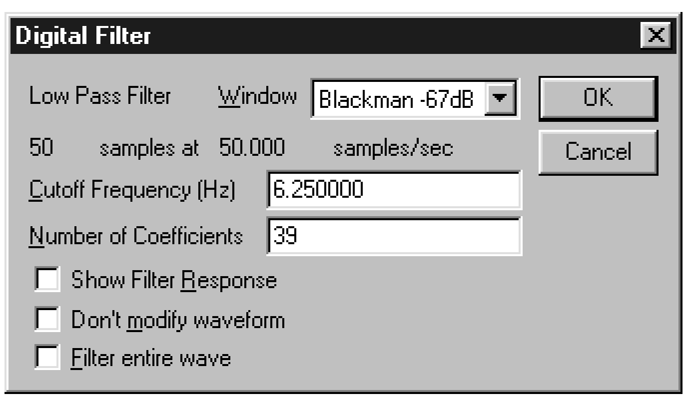
IIR filters can be used to mimic filters commonly implemented in electronic analog circuitry and are also used for online filtering.

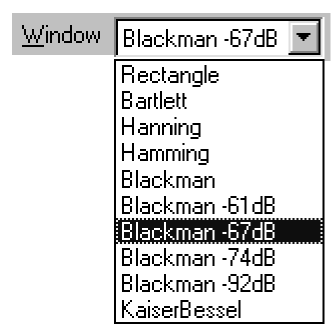
FIR Filters

To access the **FIR** filter dialog box, click the **Transform** menu, scroll to select **Digital Filters**, drag right to **FIR** and drag right again for the filter options. When you select an FIR filter, the corresponding **Digital Filter** dialog box will be generated, allowing you to specify a number of different filtering options.



In most cases, the default settings are optimal, although specific situations may require different settings. The dialog will reflect data for the selected area, for example "50 samples at 50.000 samples/sec."





FIR Digital Filters Dialog	
Window	At the top of the dialog box is a **Window** pop-up menu, which allows you to choose from a variety of **filtering algorithms**. By default, the filter default is set to a "Blackman" type. These different Windows (described in detail in Appendix D) allow you to "fine tune" the filter response. A "window" refers to a computation that spans a fixed number of adjacent data points. Window functions are used to eliminate discontinuities that may result at the edges of the fixed span of points for the FIR filter.
Cutoff Frequency	The second option is to provide a **Cutoff Frequency**, or threshold, for the filter function.

FIR Digital Filters Dialog

Filter Type	Default Cutoff Frequency	Cutoff range
Low-pass	0.125 times the sampling frequency	Between 0.0000000001Hz and 0.5 times the sampling rate
High pass	0.25 times the sampling rate	Between 0.0000000001Hz and 0.5 times the sampling rate
Band-pass	*low*: 0.125 times the sampling rate *high*: 0.25 times the sampling rate	Any values, but low and high cannot be set to the same value

Number of Coefficients

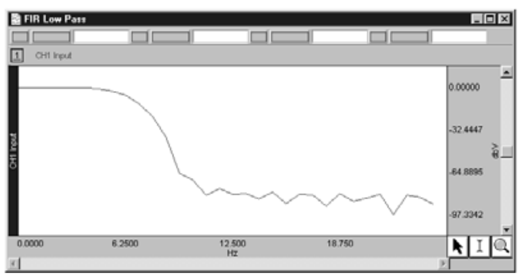
The **Number of Coefficients** determines how well the filter will match the desired Cutoff Frequency (or range). By default, this is set to 39. Filters that use a small number of coefficients tend to be less accurate than filters that use a large number of coefficients. Entering a larger value will result in a more accurate filter; however, as the number of coefficients increases, so does the processing time required to filter the data. To see how changing this value affects the way data is filtered, it can be useful to examine the filter response patterns.

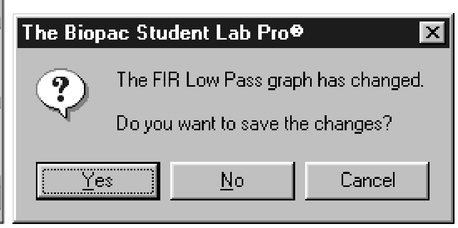
✓ TIP

A good rule of thumb is to use a number of coefficients greater than or equal to two times the sampling rate divided by the lowest cutoff frequency specified. For example, if running a low pass filter at 1Hz on data sampled at 100Hz, choose at least (2 x 100/1) or 200 coefficients in the filter. Additional coefficients will improve the response.

Show Filter Response

The **Show Filter Response** option instructs the software to produce a plot of the filtered data and generates a new graph window for the response plot. You must save the response plot separately.





Don't modify waveform

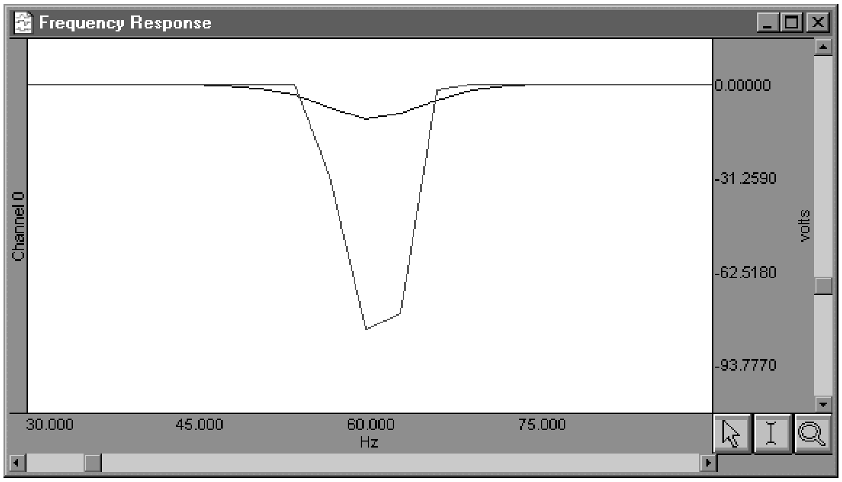
The **Don't modify waveform** option is useful when used with the **Show filter response** option. When both boxes are checked, the software will produce a plot showing the filter response, but will not modify the waveform. This allows you to repeatedly specify different filter options (without modifying the waveform) until the desired frequency response is achieved.

Filter entire wave

The Filter entire wave option will filter the entire wave and replace the original.

➢ If you want to keep the original, you need to duplicate it prior to filtering.

FIR Filter example



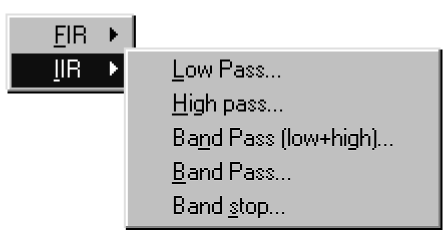
Comparison of 39 coefficient and 250 coefficient band stop FIR filters

In the example above, the same data was band stop filtered using a coefficient range of 39 (upper waveform) to 250 (lower waveform). The data was collected at 500Hz, and the band stop filter was designed to remove 60Hz noise using a low cutoff of 55Hz and a high cutoff of 65Hz. Along the horizontal axis, the units are scaled in terms of frequency, with lower frequencies at the left of the screen. The values along the vertical axis are scaled in terms of dB/V and indicate the extent to which various frequencies have been attenuated. In both filter response waveforms, there is a downward-pointing spike that is centered on 60Hz. The baseline of the filter response corresponds to a value of approximately 0 on the vertical axis, indicating that the signals significantly above or below 60Hz were not attenuated to any measurable extent.

As you can tell, however, the filter does not “chop” the data at either 55Hz or 65Hz, but gradually attenuates the data as it approaches 60Hz. For example, the upper waveform in the filter response plot represents data that was filtered using a value of 39 coefficients. The slope is relatively shallow when compared to the lower waveform, which represents a filter response performed with 250 coefficients. Although the filter that used 250 coefficients took slightly longer to transform the data, the filter response pattern indicates that the data around 60Hz is attenuated to a greater degree. Also, the 250 coefficient filter started to attenuate data considerably closer to the 55Hz and 65Hz cutoffs, whereas the default filter began to attenuate data below 55Hz and above 65Hz.

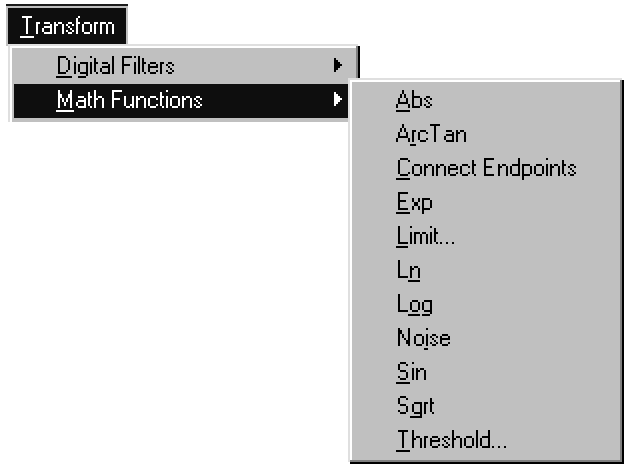
IIR Filters

To access the **IIR** filter dialog box, click the **Transform** menu, scroll to select **Digital Filters**, drag right to **IIR** and drag right again for the filter options.



The IIR filters under the Transform menu are identical to the real-time IIR filters (see the Filter Calculation on page 114) but are applied to existing data, in a post-processing environment. For a more detailed explanation of digital filters in general, see Appendix D — Filter Characteristics.

Math Functions



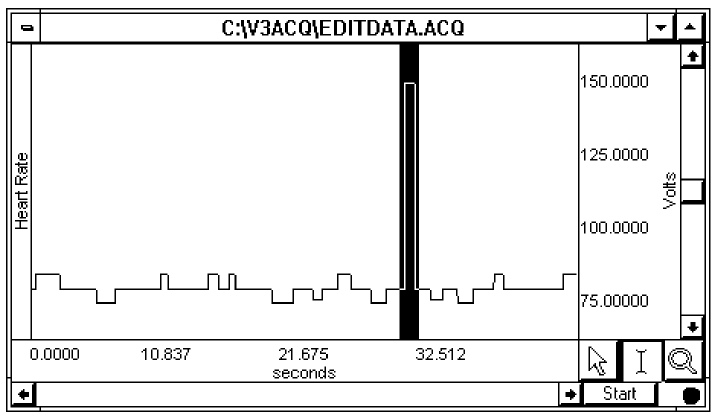
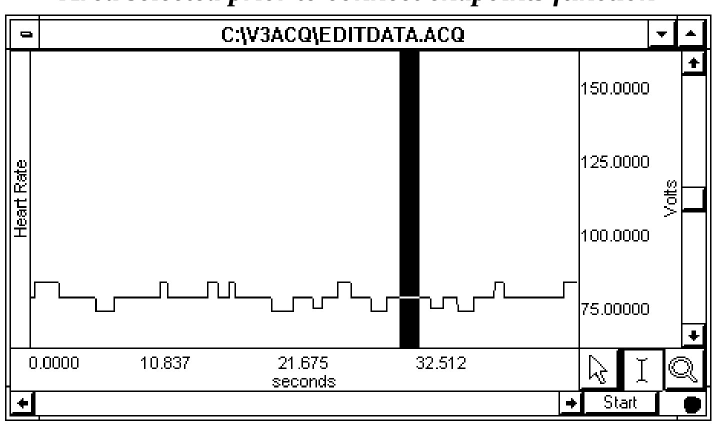
You can perform a wide range of mathematical and computational transformations after an acquisition has been completed with the Biopac Student Lab *PRO*. The table on the following pages explains each **Math Function**.

Unless otherwise noted, each Math function applies only to the selected area of the active channel. If no area is selected (i.e., a single data point is selected) the cursor will blink and the transformation will apply only to the selected point. To perform a **Math Function** on an entire waveform, select a channel and choose **Edit** > **Select All**.

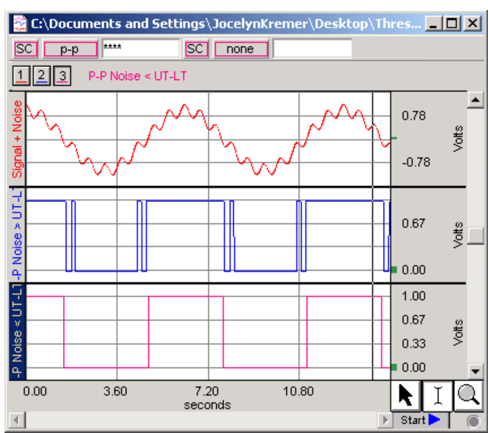
If a **Math Function** is set to divide by zero, a zero will be returned.

✓ TIP For complex transformations involving multiple functions, you may want to use the Expression solver (see page 211 for more information on this feature). Many of the same functions found in the Math functions menu can also be found in the Expression solver.

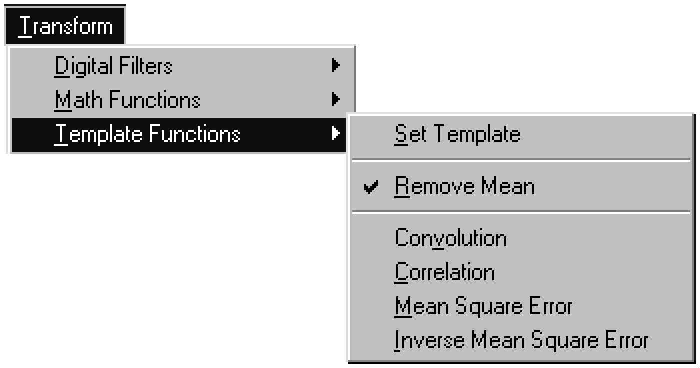
The following table describes the commands available in the **Transform** > **Math Functions** menu:

Math Function	Transformation Result
Abs (Absolute Value)	Computes the absolute value of the data. All negative data values are made positive, with no change in magnitude. This function can be used to rectify data. ***Result***: This calculation will always return a positive result.
ArcTan (Arc Tangent)	Returns the arc tangent of each data point in radians. ***Result***: This rescales the data such that the range is from -π/2 to π/2.
Connect endpoints	Draws a line from the first selected sample point to the last selected sample point and interpolates the values on this line to replace the original data. The *connect endpoints* function is very useful for removing artifacts in the data or in generating waveforms. In the example below, the “noise spike” in the data is an undesired measurement artifact that should be removed. You could cut the section of data, but then all subsequent data points would shift left. In order to preserve the time series of the data, you could use the *connect endpoints* command to draw a straight line (although not necessarily flat) that connects the two extreme sample points of the selected area.  ***Area selected prior to connect endpoints function***  ***Same waveform after connect endpoints transformation*** ***<u>Result:</u>*** A straight line of the equation: $y(x_i) = y(x_1) + n * \Delta y$

Math Function	Transformation Result
	n – number of sample points; *i – index of points of straight line;* $\Delta y = \frac{y(x_n) - y(x_1)}{n-1}$ $y(x_1)$ and $y(x_n)$ - the endpoints.
Exp (Exponential))	Computes the function e^x, where x is the waveform data and e is 2.718281828. This is the base of the natural logarithms.
Limit (Limit data values)	'Clips' data outside the range specified by the set of threshold in the limit dialog box. This function will prompt you for an upper and lower limit. Any data outside these limits will be clipped at the closer limit. Although both an upper and lower threshold must be entered, it is possible to limit only one extreme (upper or lower) while leaving the other extreme unaffected. For example, to limit data so that all negative values are set to zero but the positive values are left unchanged, you need to set the lower threshold to zero and the upper threshold to some other positive value that exceeds the maximum value for that channel. ***Result:*** In the range of upper and lower threshold.
Ln (Ln Natural Logarithm)	Computes *ln x* - the natural logarithm of each point of selected area, where *x*- is any positive value. The inverse of this function is the exponential function (see *Exp*). ***Note***: The result for sample points with negative values is zero. ***Result:*** For x <1 – result is a negative value; for x>1 – result is a positive value.
Log (Base 10 Logarithm)	Computes the base 10 logarithm (lg x) of selected area, where x – any positive value. ***Note***: The result for sample points with negative values is zero. ***Result:*** For x <1 – a negative value; for x>1 – a positive value. In order to perform the inverse of this operation of this function which would be 10^x , use the Waveform Math power operator with the constant k=10 as the first operand and the waveform data as the second operand.

Math Function	**Transformation Result**
Noise	Converts the selected section into random data values between -1.0 and +1.0. This is mainly useful for creating stimulus signals and other waveforms. ***Result:*** In the range -1.0 to 1.0
Sin (Sine)	Calculates the sine of the selected section. The data is assumed to be in radians. ***Result:*** for $0< x < \pi$ - is positive, For $\pi < x < 2\pi$ – negative.
Sqrt (Square Root)	Takes the square root (√) of each data point in the selected section. ***Result:*** Always a positive number.
Threshold (Threshold data values)	Transforms all data points above the upper threshold to **+1** and all points below the lower threshold to **0**. Once the data crosses a threshold it will continue to be set to +1 for the upper cutoff and to 0 for the lower cutoff, until it crosses the opposite threshold. If the initial data lies between the upper threshold (**UT**) and the lower threshold (**LT**), the output is undefined. The most common application of this function is to serve as a simple peak detector, the result of which can be used in rate or phase calculations.  Top: Signal + Noise Middle: P-P Noise > UT-LT Bottom: P-P Noise < UT-LT ***Result:*** The sequence of 1 and 0 value according to data points. *Note*: Real-time Threshold values are +1 and –1 (see page 113).

Template Functions



The **Template Functions** are useful for comparing waveforms. All the template functions perform a mathematical operation of the template waveform on the waveform to be compared, move one sample forward, and repeat the multiplication until the end of the longer waveform is reached. Technically, the template functions provide correlation, convolution and mean square error transformations of a template waveform against another waveform.

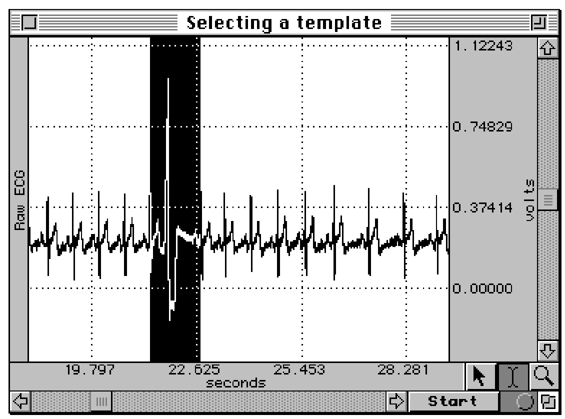
Note: To determine a level of comparison between two waveforms, use the **Correlation** function.

Set template

If you detect an abnormality, you should find out if there are other (similar) abnormalities in the record. To do that, you need to select the pattern you'd like to search for, and then compare that pattern to other data sets in the file. You can use the Zoom tool to inspect the abnormalities more closely.

Establishing the template:

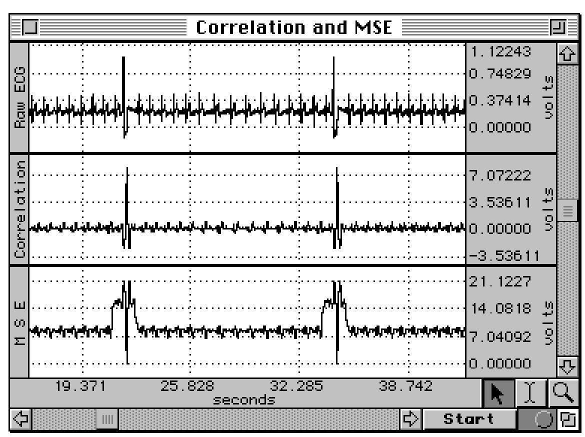
1) Highlight the section to be used as a pattern.
2) Choose **Set template** from the **Transform > Template functions** submenu. This copies the selected portion into a buffer for subsequent template functions.
3) Select the waveform and position the cursor at the beginning of the data.
4) Choose **Correlation** from the **Template functions** submenu.



The center waveform in this graph shows the result of the correlation and mean square error functions:

Note the higher amplitude peaks where the template data more closely matches the waveform. The lower waveform illustrates the mean square error function, which is similar to the correlation function.

This indicates that <u>there are two abnormal beats</u> in the record. The first one appears at about 21 seconds and is the one used as a template, the second one appears at about 33 seconds.



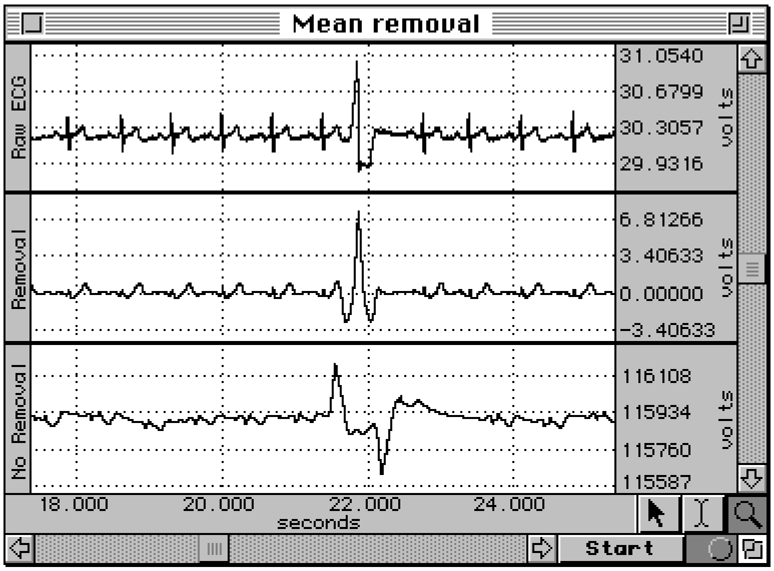
Remove Mean

A drifting baseline can be a problem in comparing waveforms. If you perform a **Template** function and the template or the waveform has a slowly moving baseline, you can increase the effectiveness of the comparison by choosing **Remove mean** from the submenu of the **Template** function.

This option is toggled every time it is selected and is enabled when a check mark is present.

The **Remove Mean** option causes the mean amplitude value of the template and the compared section of the waveform to be subtracted from each other before the sections are compared. This way, a large baseline offset will have very little effect on the comparison.

For example, the following graph shows the correlation with and without mean removal:



The original waveform is at the top, the correlated waveform with mean removal is in the middle, and the same correlation without mean removal is at the bottom.

Note how the mean removal effectively compensates for the drifting baseline in the original waveform.

Template algorithms

The template functions employ four algorithms: correlation, convolution, mean square error, and inverse mean square error.

Correlation

This algorithm is a simple multiplication and sum operation (as shown in the preceding example). The template is first positioned at the cursor position in the waveform to be correlated. Each point in the template waveform is multiplied by the corresponding point in the data waveform (the waveform to be correlated) and summed to produce the resulting data point. The template is then moved one data sample forward and the operation is repeated to produce the next resulting data point. The resulting data points replace the waveform to be correlated.

The **correlation** function algorithm can be expressed by the following formula, where $f_{output}(n)$ is the resulting data point, $f_{template}(k)$ is the template waveform data points, and K is the number of data points in the template:

$$f_{output}(n) = \sum_{k=1}^{K} f_{template}(k) * f_{waveform}(n)$$

Convolution

This function is identical to the correlation function except that the template waveform is reversed during the operation. This function is not generally useful by itself, but can be used as a building block for more sophisticated transformations. The **convolution** function algorithm can be expressed by the following formula, where $f_{output}(n)$ is the resulting data point, $f_{template}(k)$ is the template waveform data points, and N is the number of data points in the template:

$$f_{output}(n) = \sum_{k=-N/2}^{N/2-1} f_{template}(-k) * f_{waveform}(n+k)$$

Mean Square Error

For this function, the template is first positioned at the cursor position in the waveform to be compared. Each point in the template waveform is subtracted from the corresponding point in the waveform to be compared. The result is squared and summed to produce the resulting data point. The template is then moved one data sample forward and the operation is repeated to produce the next resulting data point. The resulting data points replace the waveform.

The **mean square error** function tends to amplify the error (or difference) between the template and the waveform, which can be useful when you need an extremely close match rather than a general comparison. When a match is found, the **mean square error** algorithm returns a value close to zero.

The **mean square error** function algorithm can be expressed by the following formula, where $f_{output}(n)$ is the resulting data point, $f_{template}(k)$ is the template waveform data points, and K is the number of data points in the template:

$$f_{output}(n) = \sum_{k=1}^{K} [f_{template}(k) - f_{waveform}(n)]^2$$

Inverse Mean Square Error

This function simply inverts the result of the **mean square error** algorithm. Accordingly, when this algorithm finds a match between the template and the data, the algorithm returns the inverse of a value close to zero and, typically, a large positive spike will occur at the point of the match.

Integral

The **integral** function is essentially a running summation of the data. Each point of the integral is equal to the sum of all the points up to that point in time.

$$F\left(x_j\right) = \sum_{i=1}^{j} \left[f\left(x_{i-1}\right) + f\left(x_i\right) \right] * \frac{\Delta x}{2}$$

Where:

i - index for source values (1..n);

j - index for destination values (1..n);

n - number of samples;

x_i, x_j - values of points at horizontal axis;

$f\left(x_i\right)$ - values of points of a curve;

$F\left(x_j\right)$ - integrate values of points of a curve;

$\Delta x = \dfrac{x_n - x_1}{n-1}$ - horizontal sample interval;

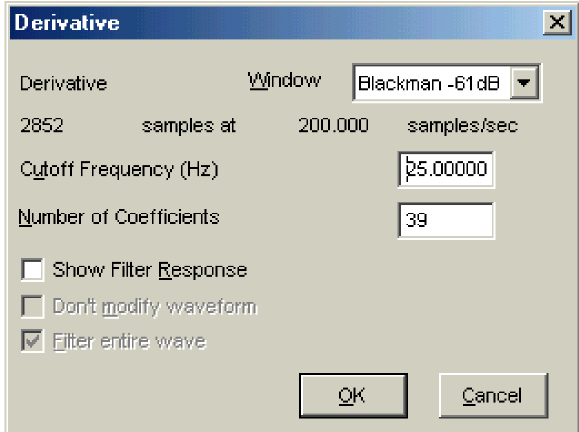
x_n, x_1 - values at horizontal axis at the endpoints of selected area.

Note:

The first destination point is always 0 value.

The **integral** function can be used to compute the area under the curve in a continuous fashion. For instance, if you had data acquired by an accelerometer, the integral of the data would be the velocity, and the integral of the velocity would be the distance. As with all transformations, this function can be applied to either a selected area or to the entire waveform.

Derivative



Transform > Derivative dialog box

The **Derivative** function calculates the derivative of the selected area of a waveform (or the entire waveform if it has been selected).

Window Since high frequency components will give you nonsensical results in a derivative, a low pass filtering function is included in the derivative function. Select a **Window** type from the pull-down menu.

Cutoff Frequency The value should be roughly equivalent to the highest frequency component of interest. (See page 194 for more information on low pass filters.)

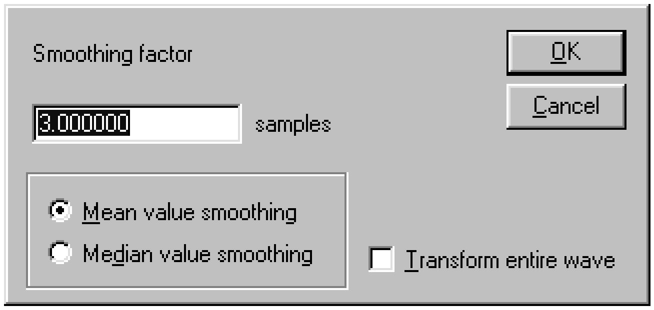
Don't modify waveform This option is only applicable when **Show Filter Response** is selected.

✓ TIP If the data is already "well behaved" (i.e., low pass filtered or contains little or no high frequency information), use the Difference transformation with a 2-sample interval. This will provide results very similar to the Derivative function, but will work much faster.

Integrate

The **Integrate** transformation works the same as the **Integrate** calculation (see page 100 for formulas) and details.

Smoothing



Smoothing computes the moving average of a series of data points and replaces each value with the mean value of the moving average "window." Smoothing has the same effect as a crude low pass filter, but is typically faster than digital filtering. This function is most effective on data with slowly changing values (e.g., respiration, heart rate, GSR) when there is noise apparent in the data record.

Samples

To set the size of the window, enter a value in the **Transform** > **Smoothing factor** dialog box. The BSL *PRO* software allows you to set the width of the moving average window (the number of sample points used to compute the mean) to any value larger than three. By default, this is set to three samples, meaning that the software will compute the average of three adjacent samples and replace the value of each sample with the mean before moving on to the next sample.

✓ TIP For data acquired at relatively high sampling rates, set the smoothing factor to a higher value, since smoothing three sample points when data is collected at 1000Hz will only average across three milliseconds of data, and may do little to filter out noise.

Mean value smoothing

Mean value smoothing is the default and should be used when noise appears in a Gaussian distribution around the mean of the signal. The Mean value smoothing formula is shown below:

Odd number of samples

$$F(x_j) = \frac{\sum_{i=j-(s+1)/2}^{j+(s-3)/2} f(x_i)}{s}$$

Even number of samples

$$F(x_j) = \frac{\sum_{i=j-(s-2)/2}^{j+s/2} f(x_i)}{s}$$

Where:

i - index for source values;

j - index for destination values (1..n);

n - number of samples;

x_i, x_j - values of points at horizontal axis;

$f(x_i)$- values of points of a curve;

$F(x_j)$- integrate values of points of a curve;

s – number of samples to average across.

Note

For points where i<=s, the formula cannot be followed because the indexes of the points involved in the calculation are negative and the points with such indexes don't exist.

More→

Median value smoothing

Use **Median value smoothing** if some data points appear completely aberrant and seem to be "wild flyers" in the data set. The Median value smoothing formula is shown below.

Odd number of samples to smooth across:

The **Median** for **odd** number of the samples to smooth across is a number in the middle of a set of numbers (see formula).

$$F(x_i) = \text{Median}\left(f\left(x_{i-(s+1)/2}\right), f\left(x_{i+(s-3)/2}\right)\right)$$

Where:

i - index (1..n);

n - number of samples;

x_i - values of points at horizontal axis;

$f(x_i)$ - values of points of a curve;

$F(x_i)$ - new values of point of a curve;

s – number of samples to smooth across.

Even number of samples to smooth across:

The **Median** for **even** number of samples to smooth across is an average of the two numbers in the middle of a set of numbers (see formula).

$$F(x_i) = \text{Median}\left(f\left(x_{i-(s-2)/2}\right), f\left(x_{i+s/2}\right)\right)$$

Where:

i - index (1..n);

n - number of samples;

x_i - values of points at horizontal axis;

$f(x_i)$ - values of points of a curve;

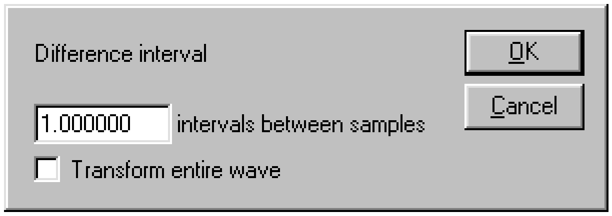
$F(x_i)$ - new values of point of a curve;

s – number of samples to smooth across.

Note

For points where i<=s, the formula cannot be followed because the indexes of the points involved in the calculation are negative and the points with such indexes don't exist.

Difference



The **Difference** function measures the difference (in amplitude) of two sample points separated by an arbitrary number of intervals. The difference is then divided by the total interval between the first selected sample and the last selected sample.

Intervals

The default **Difference** interval setting is 1 interval between samples. Using the default Difference setting of 1 interval will produce a "ΔP/ΔT" waveform when the transformation is applied to a blood pressure or similar waveform.

For data with no high frequency components, a 1-interval difference transformation approximates a differentiator. Since it is not implemented as a convolution, it is much faster than the derivative.

Odd number of samples between the points:

$$F(x_i) = \frac{f\left(x_{i+(s-1)/2}\right) - f\left(x_{i-(s+1)/2}\right)}{x_{i+(s-1)/2} - x_{i-(s+1)/2}}$$

Even number of samples between the points:

$$F(x_i) = \frac{f\left(x_{i+s/2}\right) - f\left(x_{i-s/2}\right)}{x_{i+s/2} - x_{i-s/2}}$$

Where:

i - index for source values(1..n);

j - index for destination values (1..n);

n - number of samples;

x_i, x_j - values of points at horizontal axis;

$f(x_i)$ - values of points of a curve;

$F(x_i)$ - new values of points of a curve;

s – interval between samples.

Note

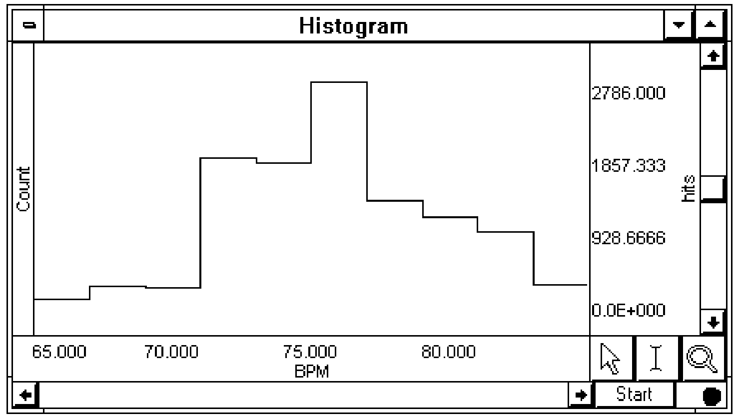
For points where i<=s, the formula cannot be followed because the indexes of the points involved in the calculation are negative and the points with such indexes don't exist.

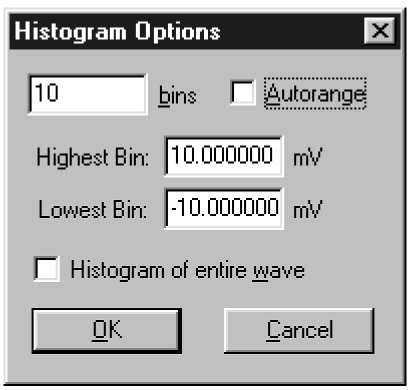
❖ Online, real-time **Difference** is calculated differently because projected values are not available (see page 106).

Histogram

The **Histogram** function produces a histogram plot of the selected area. When a histogram is created, the sample points are sorted into "bins" along the horizontal axis that contain ranges of amplitude values. These bins divide the range of amplitude values into equal intervals (by default, ten bins) and the individual sample points are sorted into the appropriate bin based on their amplitude value.

The Biopac Student Lab *PRO* software then counts the number of "hits" (the number of data points) in each bin and plots this number on the vertical axis. For instance, if a waveform had a range from 65 BPM to 85 BPM, the lowest bin would contain all data points with a value from 65 BPM to 67 BPM. The second lowest bin would hold all data points between 67 BPM and 69 BPM, and so on, until the tenth bin was created.

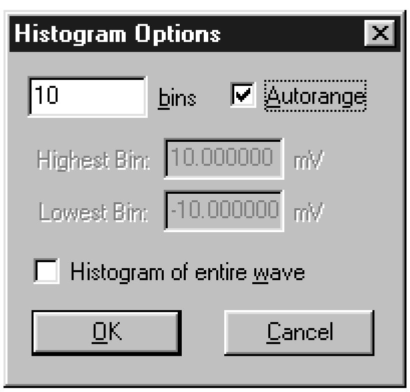




Use **manual range** to fix the bin sizes and **bin range** for predetermined values.

By default, the data is divided into ten bins. You can change this by entering a different number in the box to the left of **bins** at the top of the **Histogram Options** dialog box.

The frequency of occurrence for each bin is displayed on the vertical axis.



When **Autorange** is checked, the software automatically sets the center of the lowest bin equal to the minimum value of the waveform (or the selected area, if a section is highlighted), and centers the highest bin on the maximum value of the waveform (or selected area, if any).

Checking the **Autorange** option will simply fit all the data selected into a bin. The bin sizes are determined by the extent of the data and the desired number of lines.

The BPM and Freq measurements are not available with the Histogram function.

✓ TIP To calculate the cumulative frequency, select the entire histogram waveform and choose Integrate from the Transform menu.

✓ TIP Since the Histogram function sorts sample points into a relatively small number of categories, the histogram window is likely to display a large number of "hits" in each bin, especially if data was collected at a relatively fast sampling rate. If this is the case, you may want to resample the data at a lower rate (using the Transform > Resample function described below). The caveat to this is that resampling the data may cause a bias, unless the data was filtered to remove all frequency components that are more than 0.5 the resampling rate.

Resample

This function **resamples** the entire data file to another rate, which can be used to “compress” data files by saving the data at a lower sampling rate.

- ❖ The minimum rate is based on the total number of samples.
- ❖ The highest sampling rate that a channel can be resampled to is the file acquisition rate (as established under MP35/30>Setup Acquisition)

✓ TIP A good rule of thumb is to select a sampling rate at least four times the highest frequency of interest for the signal.

For example, the alpha component of an EEG signal has a frequency signature of 8-13Hz, so (assuming you have isolated the alpha component using a band pass filter) you would probably want to sample the data (in this case, isolated alpha waves) at a rate of at least 52Hz. The acquisition sample rates are limited and you should choose the next highest option, or in this case 100Hz.

Resampling data maintains the time scale but reduces the number of samples per second. Whenever data is resampled to a lower rate, information is lost.

- ❖ For instance, a 4-channel data file sampled at 250 samples per second for 15 minutes takes up about 1.8 MB of disk space. Resampling to 100 samples per second reduces the file size to about 720 KB of disk space, a considerable reduction.

If data is resampled to a lower rate and then resampled again at a higher rate, the waveform will maintain the resolution of the lower sampling rate, only with more data points.

Resampling and…

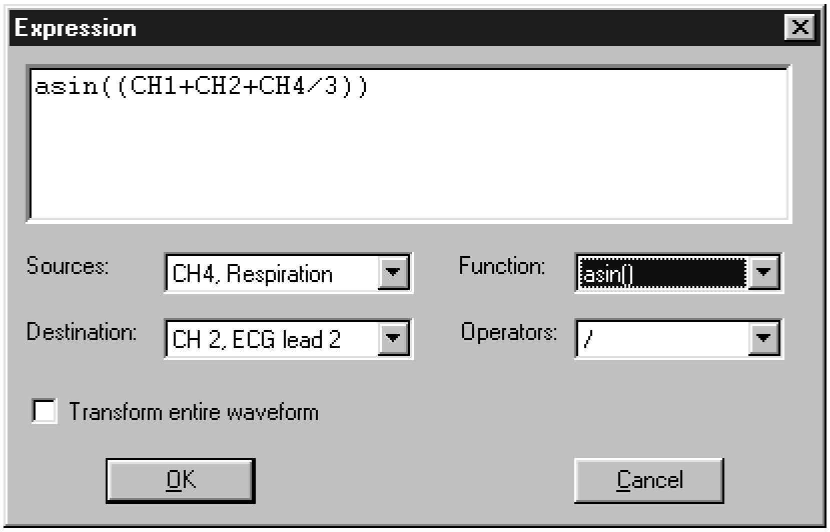
Interval You can use Resample to increase the number of sample points per interval (usually samples per second). When this is done, the BSL *PRO* software will interpolate between sample points to adjust to the new rate. This will add data points — but not necessarily more information.

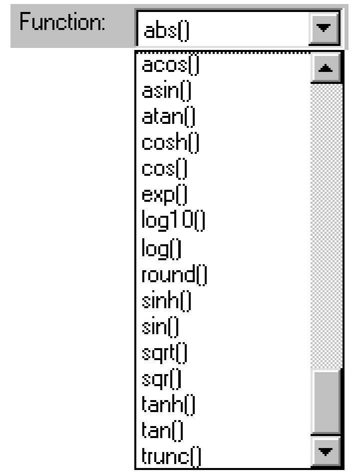
Exporting If you plan to export resampled data, you should use this method of resampling:

1. Select **Find peak** from the Transform menu.
2. Select **User defined interval** and enter a time period for the new sample rate.
3. Set First cursor to **Peak**.
4. Check the **Paste measurements to journal** option.
5. Set the **measurements** for the channel you want to resample.
   - ❖ For example, if you set the Value and Time measurements, the software will take those measurements and paste the Value and Time results from the resampled channel into the Journal.
6. Select **OK** and place the cursor at the beginning of the data file.
7. Select **Find all peaks** from the Transform menu.

Bias Resampling the data may cause a bias, unless the data was filtered to remove all frequency components that are more than 0.5 the resampling rate.

Expression





A post-acquisition **Expression** transformation is available for performing computations more complex than the Math and Function calculation options can manage. The post-acquisition version of the Expression transformation includes all the same features as the online version (described on page 116). The Expression transformation will symbolically evaluate complex equations involving multiple channels and multiple operations.

Unlike the Math and Function calculations, which can only operate on one or two channels at a time, the **Expression** transformation can combine data from multiple analog channels, or specify other calculation channels as input channels for expression channels. Also, computations performed by the Expression transformation eliminate the need for "chaining" multiple channels together to produce a single output channel.

To solve an expression and save the result to a new channel, choose **Expression** from the **Transform** menu. A dialog box will appear allowing you to select input source channels, functions, operators, and output (destination) channels. For each Expression, you need to specify a source channel (or channels), the function(s) to be performed, and any operators to be used. The different components of each Expression can be entered either by selecting items from the pull-down menus in the Expression dialog box, or by typing commands directly into the Expression box.

In the preceding Expression example, the equation took the sum of analog channels 1, 2 and 4, and divided by three to return a mean value for the three channels. The result of this was then arcsine transformed and saved on the next available channel. Of course, more complex operations are possible, and it is possible to divide a complex equation into several steps and perform each part of the equation with a separate channel.

It is important to keep in mind that while different channels, functions, and operators can be referenced when using the Expression transformation, this calculation cannot directly reference past or future sample points. That is, data from a given point in time on waveform one can be transformed or combined in some way with data from the corresponding time index on waveform two. However, data from one point in time (on any channel) cannot be combined with data from another point in time (on any channel). You can operate on waveforms that are lagged in time by an arbitrary number of sample points by duplicating a waveform, and removing some number of sample points from the beginning of the record. This will create two channels that are offset by a constant time interval.

Source Select a Source channel to perform the transformation on.

Function The **Expression** transformation offers the following functions (plus others on Mac):

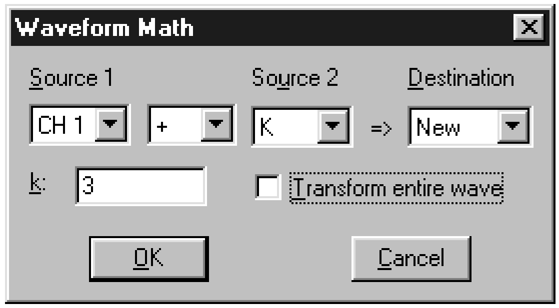
Function	Expression result
ABS	Returns the absolute value of each data point.
ACOS	Computes the arc cosine of each data point in radians.
ASIN	Calculates the arc sine of each value in radians.
ATAN	Computes the arc tangent of each sample point.
COS	Returns the cosine of each data point.
COSH	Computes the hyperbolic cosine of each selected value.
EXP	Takes the e^X power of each data point.
LOG	Computes the natural logarithm of each value.
LOG10	Returns the base 10 logarithm of each value.
ROUND	Rounds each sample point the number of digits specified in the parentheses.
SIN	Calculates the sine (in radians) of each data point.
SINH	Computes the hyperbolic sine for each sample point.
SQR	Squares each data point.
SQRT	Takes the square root of each data point.
TAN	Computes the tangent of each sample point.
TANH	Calculates the hyperbolic tangent of each sample point.
TRUNC	Truncates each sample point the number of digits specified in the parentheses.

Operator The **Expression** dialog uses standard mathematical operators.

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
^	Power
(	Open parentheses
)	Close parentheses

Destination This is the channel to display the transformation result on.

Waveform Math



The **Waveform Math** transformation allows arithmetic manipulation of waveforms. Waveforms can be added together, subtracted, multiplied, divided or raised to a power. These operations can be performed using either two waveforms or one waveform and an arbitrarily defined constant (k).

You can operate on the entire waveform by choosing **Transform entire wave** (or Edit >Select All), or operate on portions of the waveform that have been selected using the cursor tool. If there is no selected area, only one sample point (the one selected by the cursor) will be transformed.

All of the main components of a **Waveform Math** transformation can be selected from pull-down menus in the dialog box.

Source The channels to be used in the transformation are referred to as source channels (**Source 1** and **Source 2**), and can be combined using any of the operators in the pop-up operand menu. Select any of the existing channels in the current window, or a constant (**K**).

Note: If you select two waveforms of unequal length as sources, the length of the resulting waveform will be equal to that of the shortest one. Likewise, if one of the source waveforms extends only into a portion of the selected area, the resultant waveform will only be as long as the shortest source portion. If Waveform Math is performed on a selected area and output to an existing waveform that does not extend into the selected area, the resultant waveform is appended to the destination waveform.

k Enter a value for the constant (K).

Note: If you divide by **k = 0** the software will return a value of zero so that other channels using the result of this channel can be calculated.

Operand Select addition, subtraction, multiplication, division or power functions.

Destination This is where the result of the Waveform Math will be stored. Choose any of the active channels or the “New” option, which will create a new channel (using the next available channel).

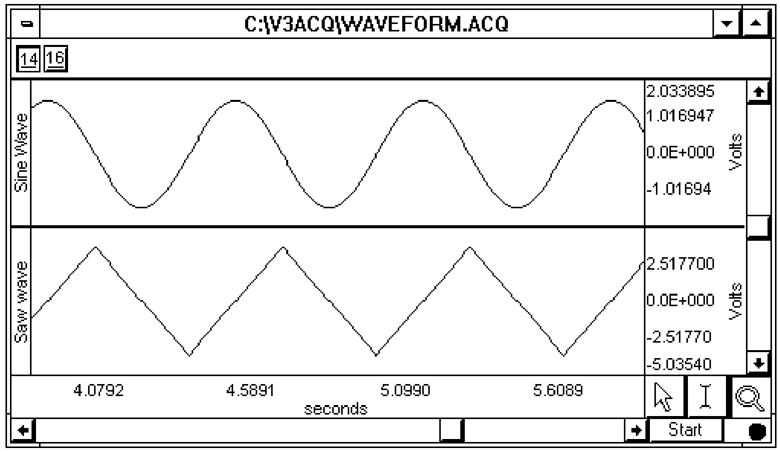
Waveform Math Example

Waveform Math can be used many ways. As one example, two waveforms can be added together.

The graph to the right shows a sine wave in channel 14 and a triangle wave in channel 16. To add these two waveforms:

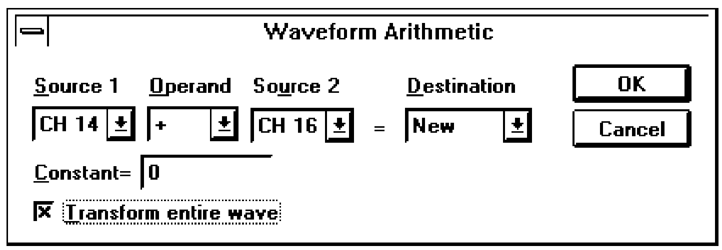
1) Select Transform > Waveform Math.

   This will generate a **Waveform Math** dialog.



2) Set **Source 1**, select an **Operand**, set **Source 2**, and select a **Destination**.

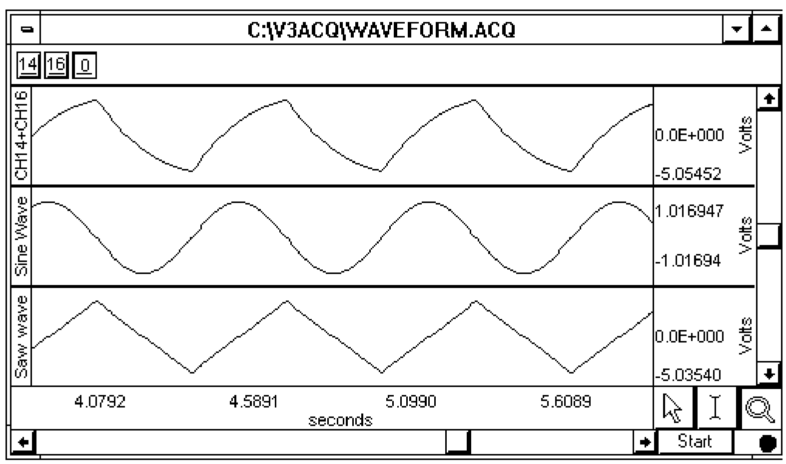
   The dialog shown here will add CH 14 *to* CH16 *and show the result on a* New *channel.*



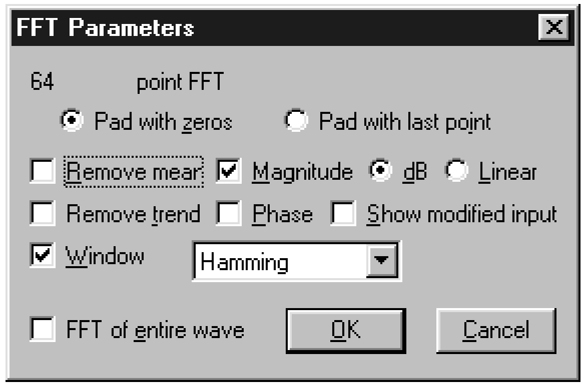
3) Click **OK** to perform the transformation

The graph to the right shows the sum of CH14 and CH16 on a new channel (the top waveform in this example).

By default, Biopac Student Lab displays the frequency of occurrence for each bin on the vertical axis.



FFT Fast Fourier Transformation



The **Fast Fourier Transformation (FFT)** is an algorithm that produces a description of time series data in terms of its frequency components. This is also referred to as the *frequency spectrum* or *spectral analysis*. The output from an FFT appears in a graph window with magnitude (vertical axis) plotted against various frequencies (horizontal axis). A large component for a given frequency appears as a positive (upward-pointing) peak. The range of frequencies plotted is from 0Hz to 1/2 the sampling frequency. Thus, if data were collected at 200 samples per seconds, the BSL *PRO* software would plot the frequency components from 0Hz to 100Hz.

Fourier analysis can yield important information about the frequency components in a data set, and can be useful in making determinations regarding appropriate data cleaning techniques (e.g., digital filtering).

The FFT transformation cannot be performed in real time (i.e., during an acquisition). However, it is possible to emulate an online spectral analysis using several online filters and the **Input Values** window. See page 142 for more information on how to display frequency information in real time.

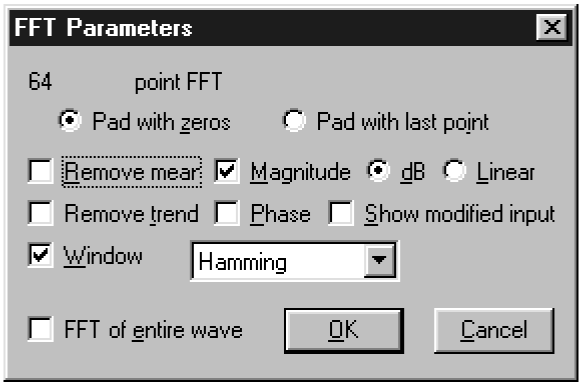
The FFT algorithm assumes that data is an infinitely repeating periodic signal with the end points wrapping around. Thus, to the extent that the amplitude of the first point differs from the last point, the resulting frequency spectrum is likely to be distorted as result of this startpoint to endpoint discontinuity. This can be overcome by "windowing" the data during the transformation. (For more information on the windowing feature, see the Window section on page 217.)

The BPM and Freq measurements are not available with the FFT function.

Pad with zeros / Pad with last point

The algorithm used by the FFT requires that the length of the data be an exact power of two (i.e., 256 points, 512 points, 1024 points, and so on). Whenever possible, it is best to use an input waveform (select an area) that is an exact power of two. If a section of data is selected that is not a power of two, the BSL *PRO* software will always "pad" data up to the next power of two, filling in the remaining data point with either zeros or with the last data point in the selected area. In other words, if 511 data points are selected, the BSL *PRO* software will use a modified version of the waveform as input. The modified waveform will have 512 points, and the last point in the modified wave will be

- a zero, if the **Pad with zeros** option is checked, or
- equal to the 511^{th} point of the original data, if the **Pad with last point** option is checked.

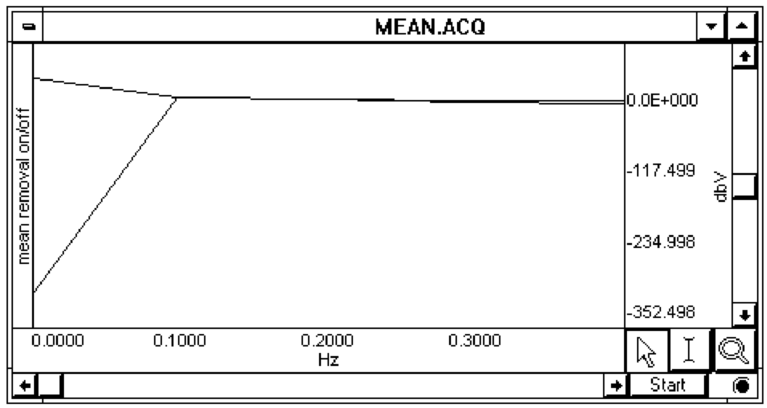


Remove mean

Remove mean calculates the mean of all the points in the selected area and then subtracts it from the waveform. This is generally useful for windowing a waveform that has a large DC offset.

As an example, you might start with a sine wave with a 10-volt DC offset (with a little noise added to broaden the spectrum), and perform the FFT with and without mean removal:

Note the large spectral components at the beginning of the top plot, without mean removal. This is due to the offset of the original data. The bottom plot is with mean removal.



Since the offset of the waveform is often an artifact of the way it was generated, the **remove mean** option provides a more accurate indication of the true spectral components. This is especially true for applications where low frequency components are of interest. If the data has a large DC offset and you plan on windowing the data, you will generally get a more meaningful spectrum if you remove the mean prior to windowing (which is the same order the FFT uses).

dB / Linear

By default, the FFT output is described in terms of frequency along the horizontal axis and dBV on the vertical axis. **dB** are derived from the Bell scale, which is logarithmic.

To scale the output in **linear** units, click the button next to **linear** and click **OK**. Linear means that the interval between any two sample points in the filtered waveform will be exactly equal to the distance between the corresponding sample points in the original waveform.

The relationship between log and linear units is:

$$dBV_{out} = 20 \log VIN.$$

Magnitude /Phase

The standard FFT produces a plot with frequency on the horizontal axis and either dB/V or linear units (usually Volts) on the vertical axis. In some cases, it may be useful to obtain phase plots of the waveform (as opposed to the default magnitude plots). Phase plots display frequency along the horizontal axis, and the **phase** of the waveform (scaled in degrees) on the vertical axis. This option functions exclusive of the magnitude option — you can check either independently, or if you check both, two plots will be produced (a magnitude plot and a phase plot).

Show modified input

Check the **Show modified input** box to view the modified waveform being used as input for the FFT.

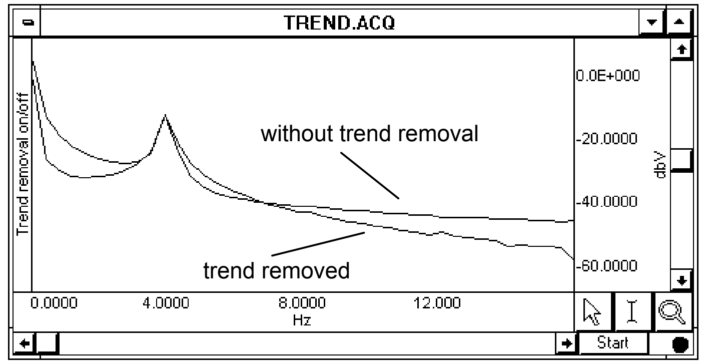
Remove trend

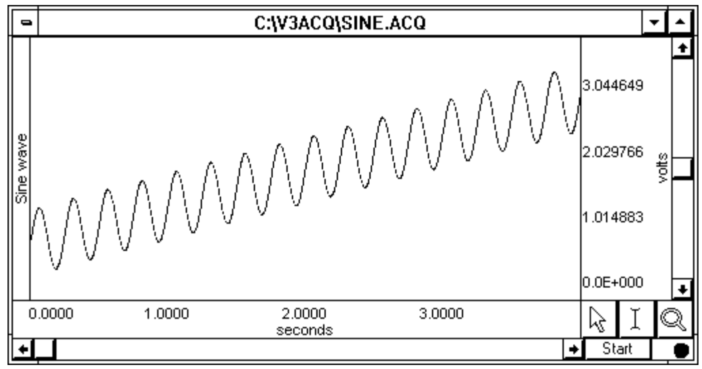
Sometimes, data contains a positive or negative trend that can cause extraneous frequency components to "leak" into the frequency spectrum. For example, the following sine wave has an upward trend through the data (positive trend component).

In this case, you could select **remove trend** when you perform the FFT, which would draw a line through the endpoints, and then subtract the trend from the waveform.

The second screen shows FFTs of the skewed sine wave data with and without the trend removed:

Note that the spectrum of the data without the trend removal has gradually decreasing frequency components, while the data with the trend removed has far fewer frequency components except for the single spike due to the sine wave.

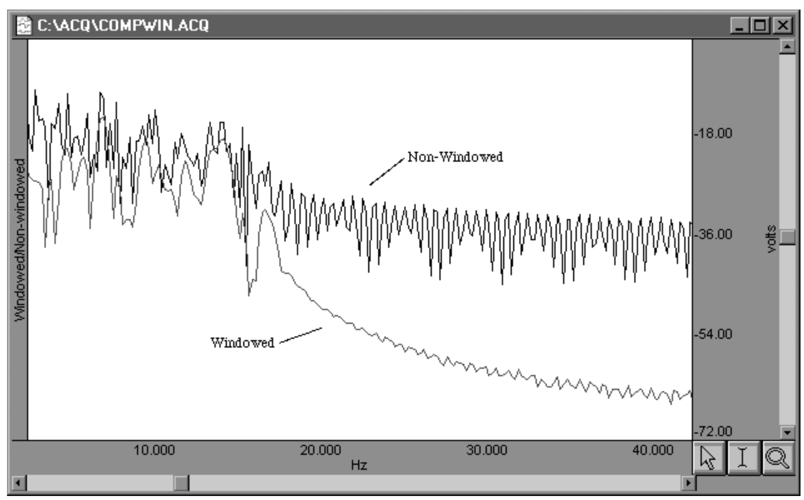




Window

A "window" refers to a computation that spans a fixed number of adjacent data points. Window functions are used to eliminate discontinuities that may result at the edges of the fixed span of data points for the FFT.

To apply a window transformation, check the box next to Window and choose a type of window from the pull-down menu. Each of the windows has slightly different characteristics, although in practice each provides similar results within measurement error.



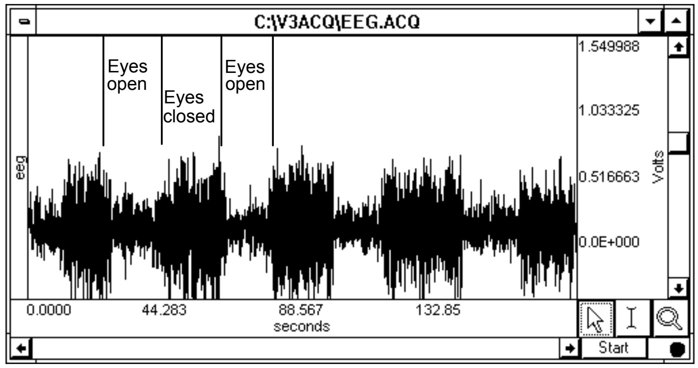
As noted earlier, the FFT algorithm treats the data as an infinitely repeating signal with a period equal to the length of the waveform. Therefore, if the endpoint values are unequal, you will get a frequency spectrum with larger than expected high frequency components due to the discontinuity. Windowing these data minimizes this phenomenon.

As shown here, the frequency spectra of the windowed and non-windowed data differ significantly when the endpoints are unequal. When the data are not windowed, the very low and very high frequencies are not attenuated to the same extent as when the data are windowed.

FFT EXAMPLE

The raw data, prior to FFT:

This electroencephalogram (EEG) signal was acquired as the subject alternated between eyes open and eyes closed states. Typical results suggest that higher levels of alpha activity (with frequency components between 8Hz and 13Hz) are to be expected when a subject's eyes are closed.



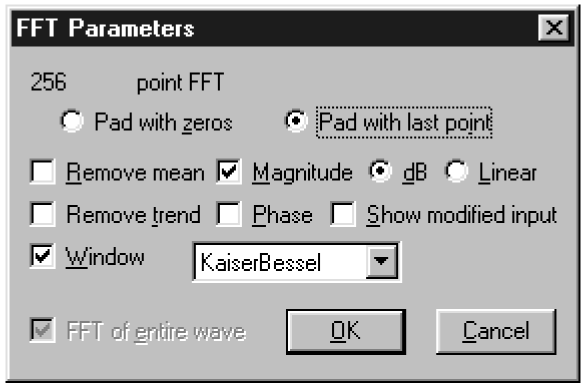
To perform the FFT:

1) Click the **Transform** menu and scroll to select **FFT**.

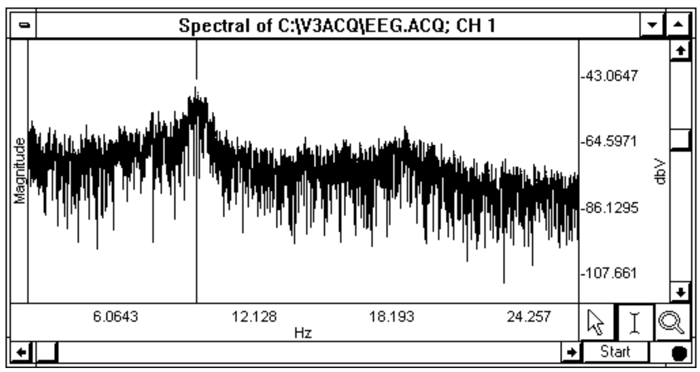
This will generate the **FFT Parameters** dialog.

2) Establish the FFT parameters (the **Window** type used here is KaiserBessel, but you could choose any type).

3) Click **OK.**

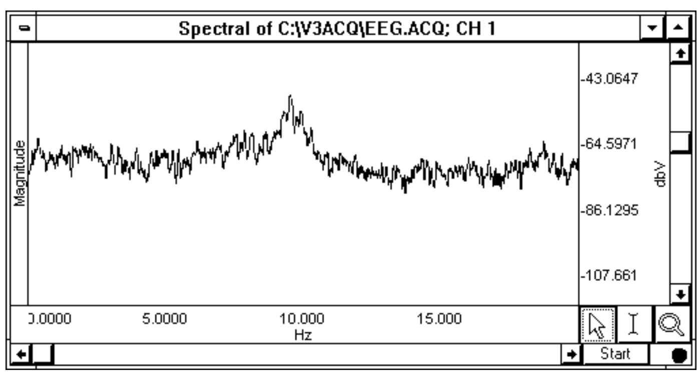


4) A frequency domain window (a graph window that places frequency rather than time along the horizontal axis) will be generated, showing the spectrum of the input data. The window is named "Spectral of (the original window name)" and ends with the channel number, as shown here. The resulting magnitude value for each component is equal to the peak value of the sine wave contributing to that component.

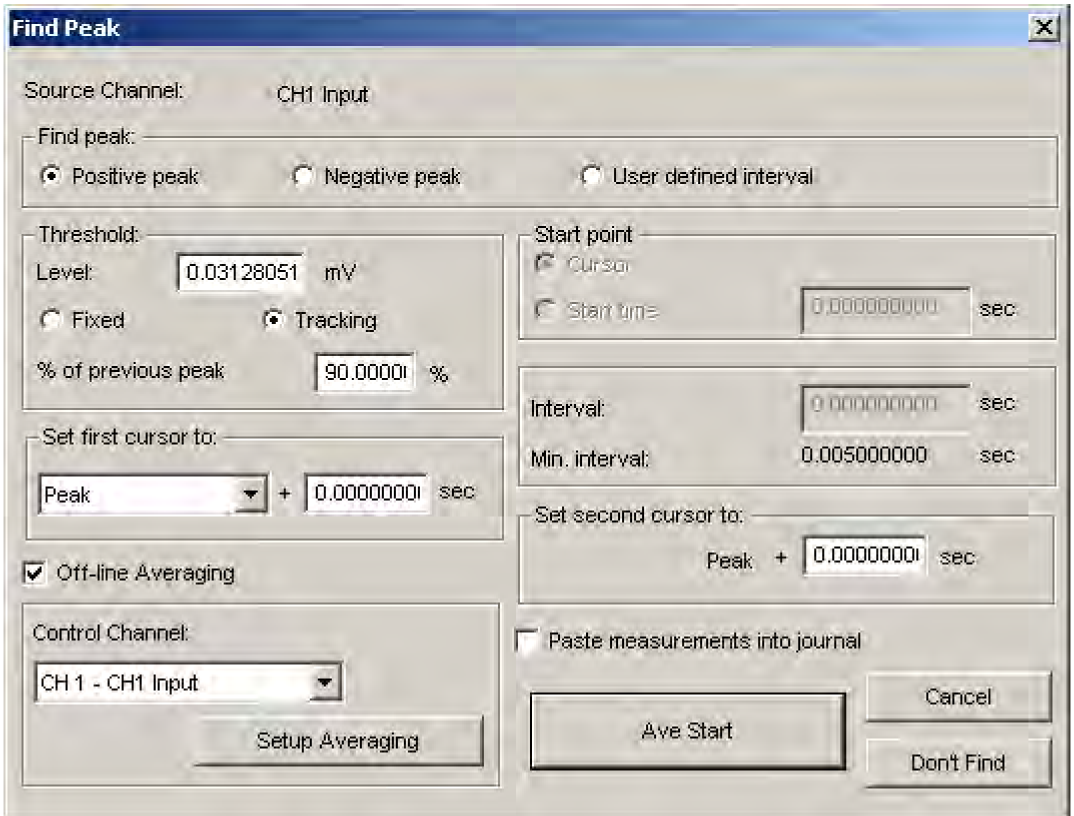


The entire pattern of frequency components is known as the **frequency spectrum** of the data. The somewhat erratic appearance of the spectrum is usually due to small-scale variations in the original waveform. This "noise" can be removed by applying a **smoothing** transformation to the FFT output.

In this example, there is a pronounced frequency component centered on 8Hz, which corresponds to the alpha wave frequency band (8Hz - 13Hz). The frequency spectrum (0-20Hz shown) used 20-point smoothing.



Find Peak (Peak Detector options)



The **Find Peak** function is the primary tool used for waveform data extraction or reduction. It can be used on a selected area or the entire data file. This function can **automatically analyze the data based on user-defined time intervals**.

The peak detector provides a variety of mechanisms to automatically control the I-beam selection tool. In other words, Find Peak can be used to automate tasks which otherwise would have to be performed manually using the I-beam selection tool and the respective pop-up measurements.

There are two basic methods by which the Peak Detector operates. Both of these modes provide powerful strategies for reducing data.

Find Peak: Positive peak or negative peak

- Useful for automatically analying in-vitro tissue bath data, spike counting, ECG analysis, and EMG analysis.

Places the cursor (or selected area) at a a specified time offset to locate positive peaks or thresholds or negative peaks (valleys) in the data file. Use when you want the waveform data itself to drive the waveform data reduction process.

In this mode, the algorithm will find positive or negative peaks or thresholds and move the I-beam to that found peak or threshold, offset in time by some fixed time delta. If the pop-up measurements are set to certain functions, the value returned by those functions will be present in the respective pop-up measurement result box.

Find Peak: User Defined Interval

- Useful for hemodynamic data, psychophysiological data, sleep data, and any other applications where measurements need to be taken at pre-defined intervals.

Places the cursor (or selected area) at a specified time offset to regular, pre-specified time intervals.

This mode is very useful when the waveform data reduction requirements necessitate examining the data around many equally sized data segments. This mode is very similar to the "Find Peak: positive peak or negative peak" mode, but instead of referencing the I-beam to a peak or threshold in the data, the algorithm will reference the I-beam to pre-selected time intervals which can be set to "chop" the waveform data into equal chunks.

✓ **TIP** See Application Notes PS161 In-Vitro Tissue Bath Data Analysis and PS148 ECG Complexes. Application Notes are available through our web site, or contact BIOPAC for a hard copy.

Don't Find — Allows you to retain the search parameters (peak value, valence, and so forth) when you exit the peak detection dialog box. This is useful for setting parameters with an area of a waveform (described above) and then repositioning the cursor at another point in the record.

Find Peak: Positive peak / Negative peak

Threshold Level Enter the threshold parameter in the threshold box (the units are those of the waveform to be peak detected).

Threshold mode

— Fixed The Fixed threshold mode uses a fixed value as the threshold point.

— Tracking The Tracking threshold mode modifies the threshold after it finds a peak, depending upon the value of the new peak, and will compensate for a slowly drifting baseline.

The amount that the Tracking mode changes the threshold is specified by the **% of previous** value.

Set first cursor to The selection area can be modified and set to a fixed-distance and offset from the reference point. In this mode, the first cursor can be set to any one of the following four options, plus or minus a fixed-interval of time:

a) Previous peak c) Previous Threshold

b) Peak d) Threshold

Set Second cursor to The second cursor can be set to a peak or threshold plus a fixed-interval of time, as long as the first cursor is referenced to a peak or threshold, respectively.

Paste measurements Values can be automatically written to the Journal by clicking in the box next to "Paste Measurements into Journal."

Find Peak: User-defined interval

Start Point The Start Point can be specified at either the existing cursor (I-beam) location or at a specified time. This will work on a selected area.

Interval The Interval is the reference point of the cursor (I-beam). The cursor will move by the specified time Interval as the Peak Detector algorithm automatically moves the cursor.

The "Minimum Interval" is calculated as 1/Sample Rate.

Set first cursor The selection area can be modified and set to a fixed-distance and offset from the reference point. In this mode, the first cursor can be set to either of the following options, plus or minus a fixed-interval of time:

a) Previous peak b) Peak

Set second cursor The second cursor can be set to peak plus a fixed-interval of time. In this mode, "peak" refers to the location of the next user-defined interval.

Paste measurements Values can be automatically written to the Journal by clicking in the box next to "Paste Measurements into Journal."

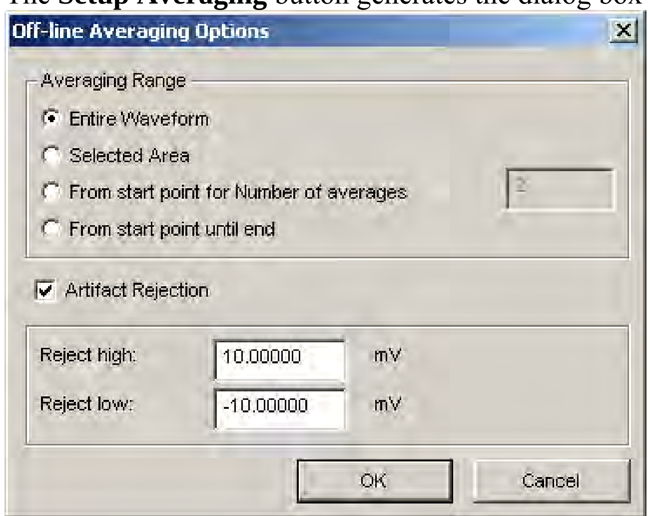
Off-line averaging

The Off-line Averaging option works with all peak detection modes. With this option selected, you will be able to average waveform data together from different reference points in the complete data record.

- For instance, if the **Find peak: Positive peak** mode is selected for the purposes of evaluating an ECG record, the off-line averaging feature will generate a composite ECG cycle. This composite will be the "average" cycle of some specified number of separate ECG cycles, where each cycle is referenced to the peak in the QRS wave.

Control Channel The **Control Channel** (Trigger channel) pull-down menu lets you select a channel to use as a trigger while performing the average on the selected channel. To select a channel, click the channel box above the display window.

Setup Averaging The **Setup Averaging** button generates the dialog box shown below:



Averaging Range

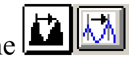
Entire waveform	Use all relevant data in the entire waveform to generate an average
Selected area	Use only relevant data from the selected area of the waveform to generate an average
From start…#	Collect relevant data at the start point and continue until the specified number of averages is reached.
From start…end	Collect relevant data at the start point and continue until the end of the data file is reached.

Artifact rejection

Artifact rejection is used to eliminate suspect data from the averaging process. Suspect data is identified as any sample value in a relevant data block that is higher or lower than the respective Reject High and Reject Low levels.

Ave Start The OK button switches to "Ave Start." Click the button to activatethe asettings after choosing the control channel and establishing the averaging options.

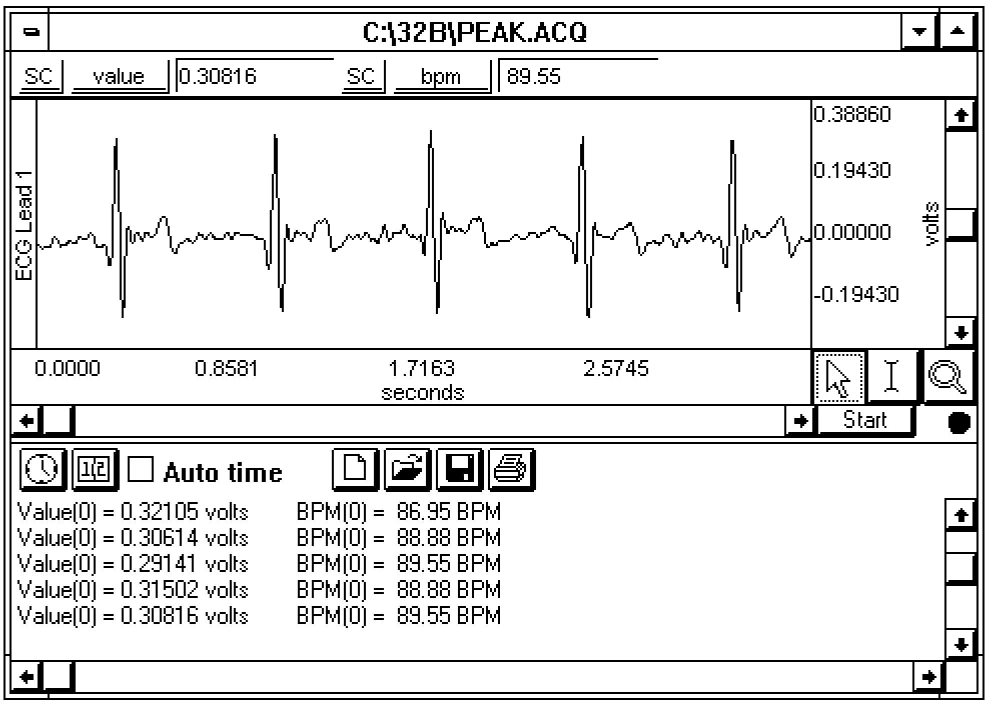
Find Next Peak

If you select **Find Next Peak** from the **Transform** menu (or select the  icon), both cursors will move one peak to the right while staying above the threshold. The measurement values will show the selected measurements and will automatically update when each new peak is found.

Next, repeat the above peak search with the automatic journal entry option enabled. Start as before by selecting the first peak and choosing **Find Peak** from the **Transform** menu. Check the **Paste measurements into journal** option and click **OK**. The journal will now contain the measurement values from the new peak.

Find All Peaks

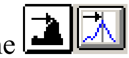
When you choose **Find All Peaks** from the **Transform** menu, the software will find all peaks through the end of the selected area (or the entire file, as designated) and paste the measurement values into the journal each time a peak is found, as shown here:

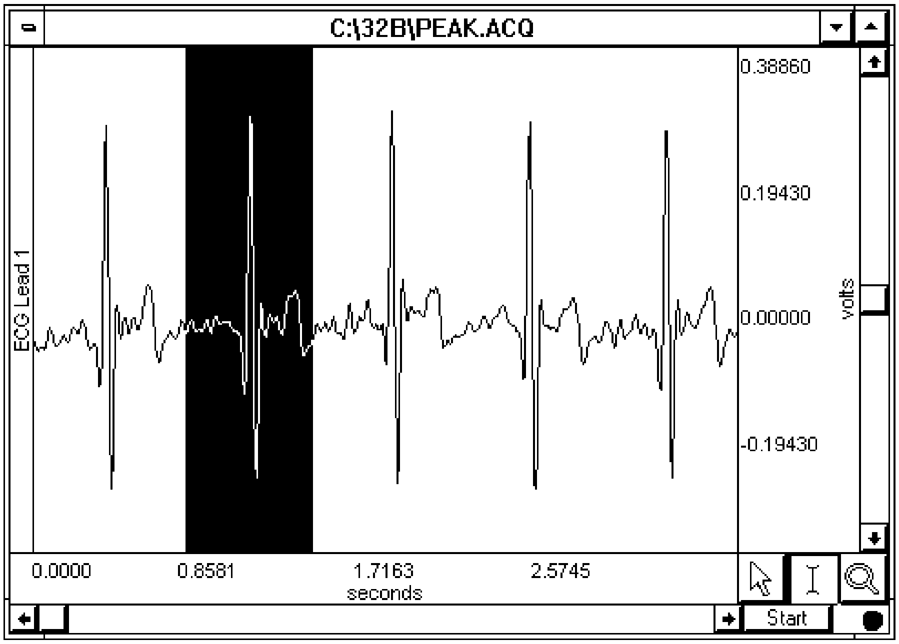


The process uses the default cursor settings to select the area between two adjacent peaks. In this mode, one cursor tracks the current peak location while the other cursor marks the location of the previous peak (these “cursors” are internal to the software and only appear in the graph window as “borders” for the propagating selected area).

Each column in the Journal corresponds to the measurement values selected (in this case, Value and BPM). If the data file is very large, it may take some time to find all the peaks, since the BSL *PRO* loads data from disk while it scans for the peaks.

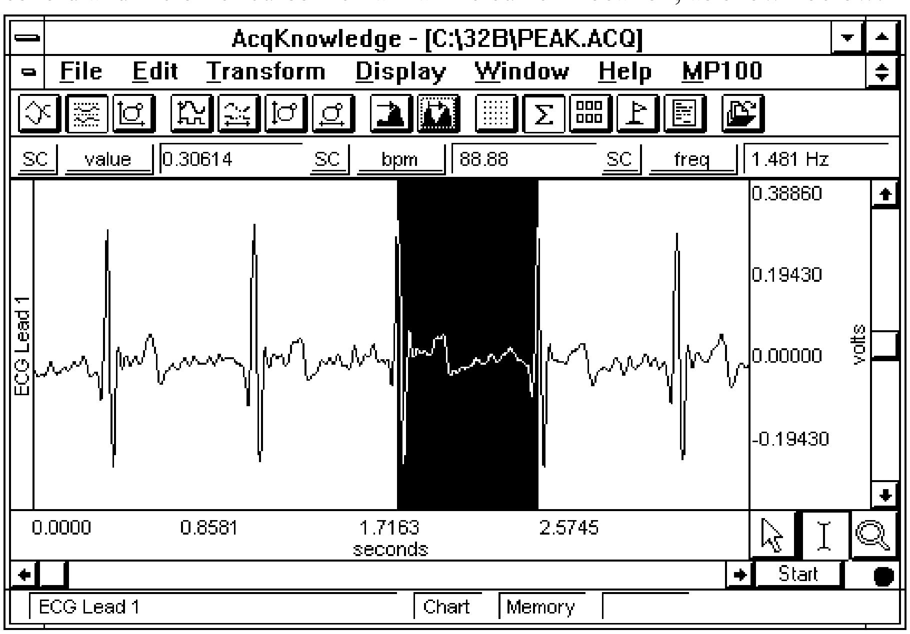
FIND PEAK EXAMPLE TO DETECT THE POSITIVE SPIKE IN THE QRS COMPLEX

The easiest way to start is to select the area around a peak and then select the  icon, or you could choose **Find Peak** from the **Transform** menu.



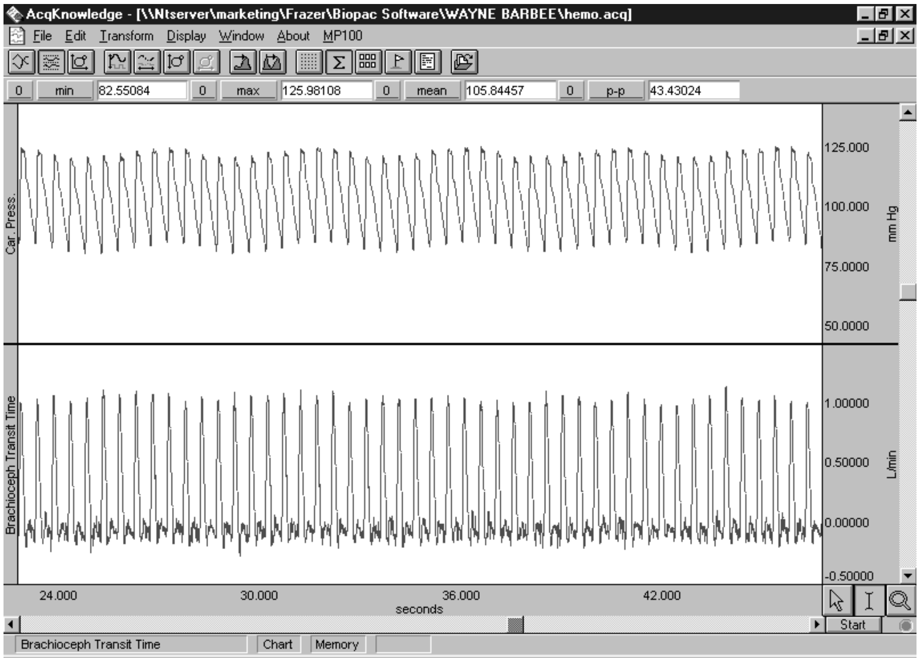
The peak detection dialog will appear and automatically compute a threshold value. If you don't want the peak detector to automatically set the threshold, then make sure that no portion of the waveform is selected prior to choosing **Find peak**.

At this point, you can select **Transform** > **Find All Peaks** or **Transform** > **Find Next Peak** or you can click the **Find Peak** icon in the toolbar. You will see one cursor move to the next peak value above the threshold and the other cursor remain at the current location, as shown below:



FIND PEAK -- DATA REDUCTION EXAMPLE USING HEMODYNAMIC DATA

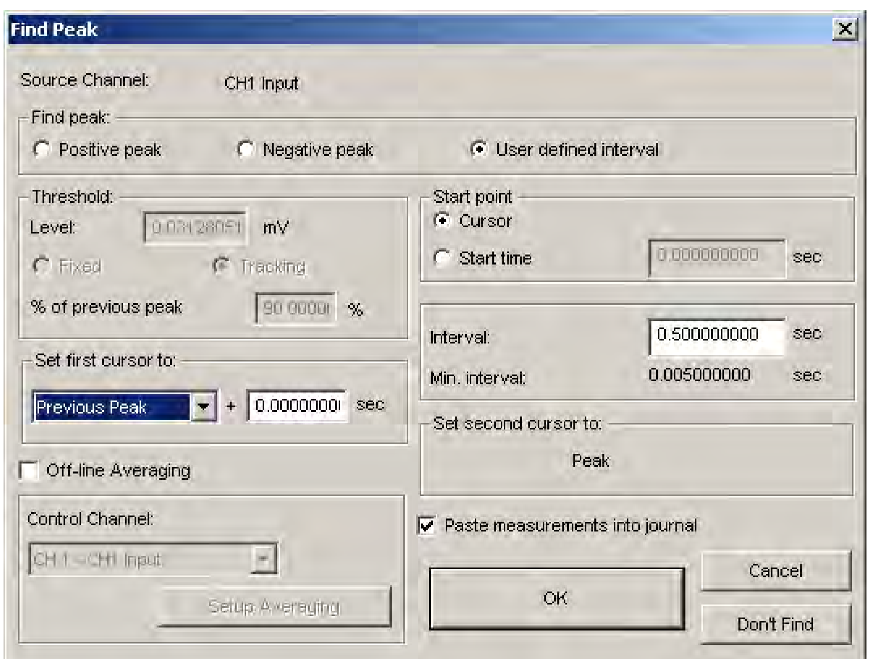
The following example will show you how to automatically reduce a large hemodynamic data file down to 5-second measurements. In the example, **min**, **max**, **mean**, and **p-p** measurements will be taken for each 5-second interval.



Hemodynamic data: Carotid pressure and Brachioceph blood flow

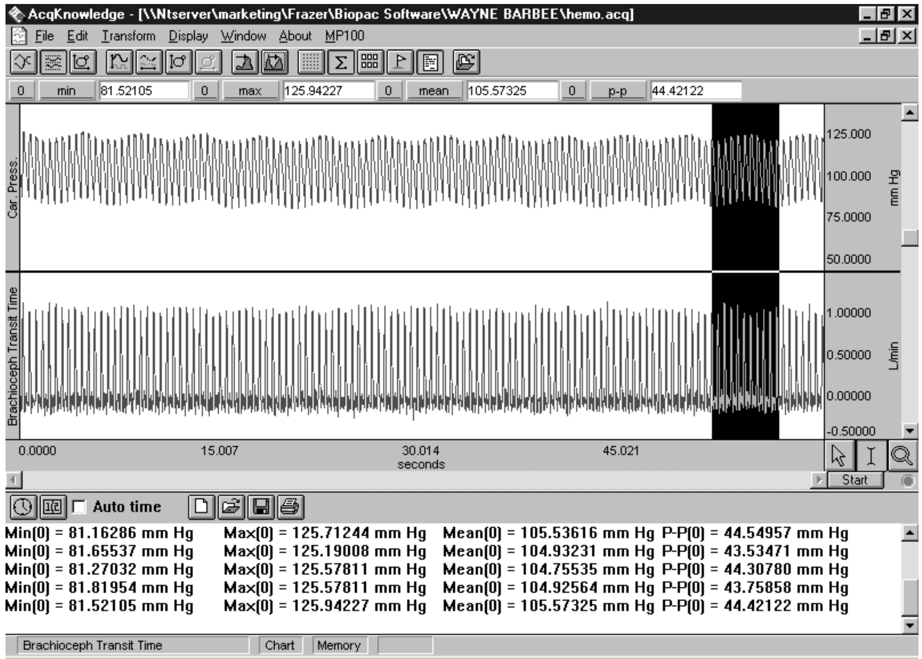
From the **Transform** menu, select **Find Peaks** and check the "User defined interval" option. The dialog box will allow you to enter a measurement Interval. In this case, 5.00 seconds was entered.

The time interval is based on the horizontal time axis. If the time scale is set to minutes, the interval will be in minutes. However, by zooming in and changing the horizontal scale to seconds, you can set the interval to seconds. Check the "Paste measurements into journal" box and click **OK**. Now choose **Find All Peaks** from the Transform menu.

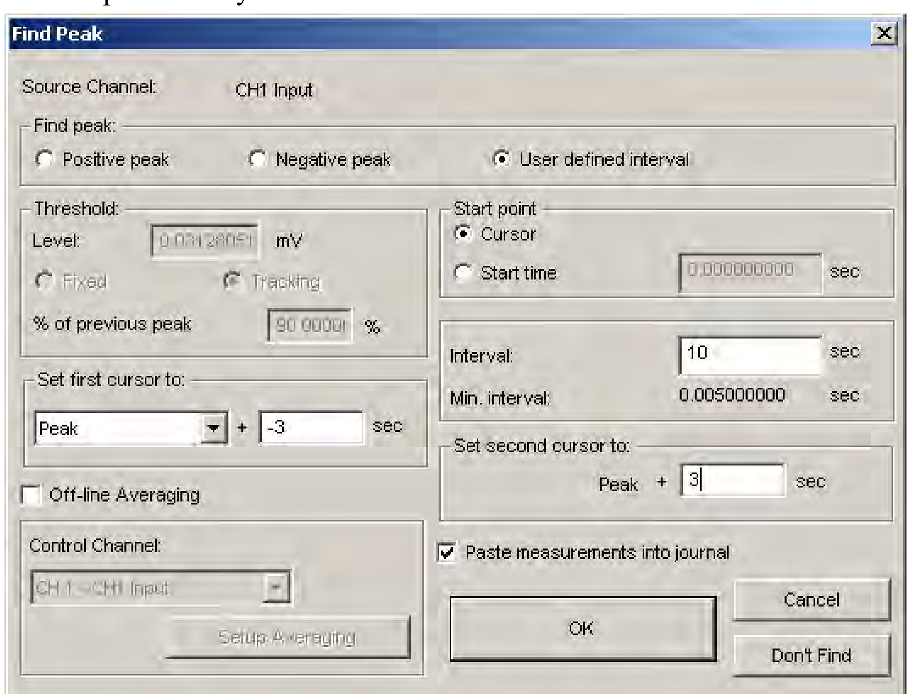


Peak detector settings for data reduction of hemodynamic data

As the following window shows, measurements will be pasted to the journal in a row and column format, ready for export to your favorite statistical package. It is possible to paste the measurements into the journal without the additional text (name, unit, etc.). The journal file will be saved in a text file format.



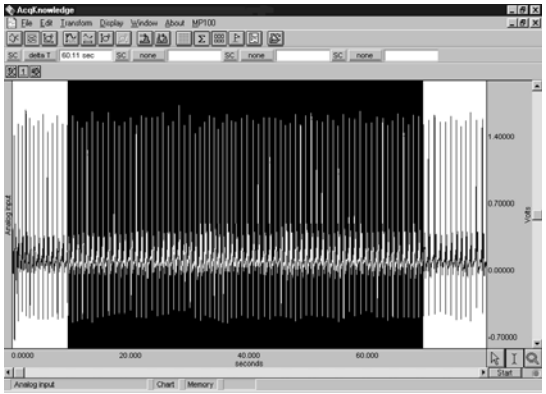
As an option, you can select “Peak” from the Set first cursor to menu. This allows you to set a time window before and after the user-defined time interval. If a larger time interval is used, 10-seconds in this example, it is possible to select a window 3 seconds before and 3 seconds after, providing a 6-second measurement period every 10 seconds.

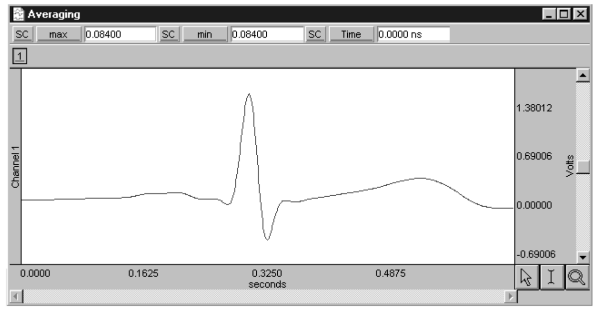


FIND PEAK -- OFF-LINE AVERAGING EXAMPLE USING ECG DATA

See also: Application Note #PS177.

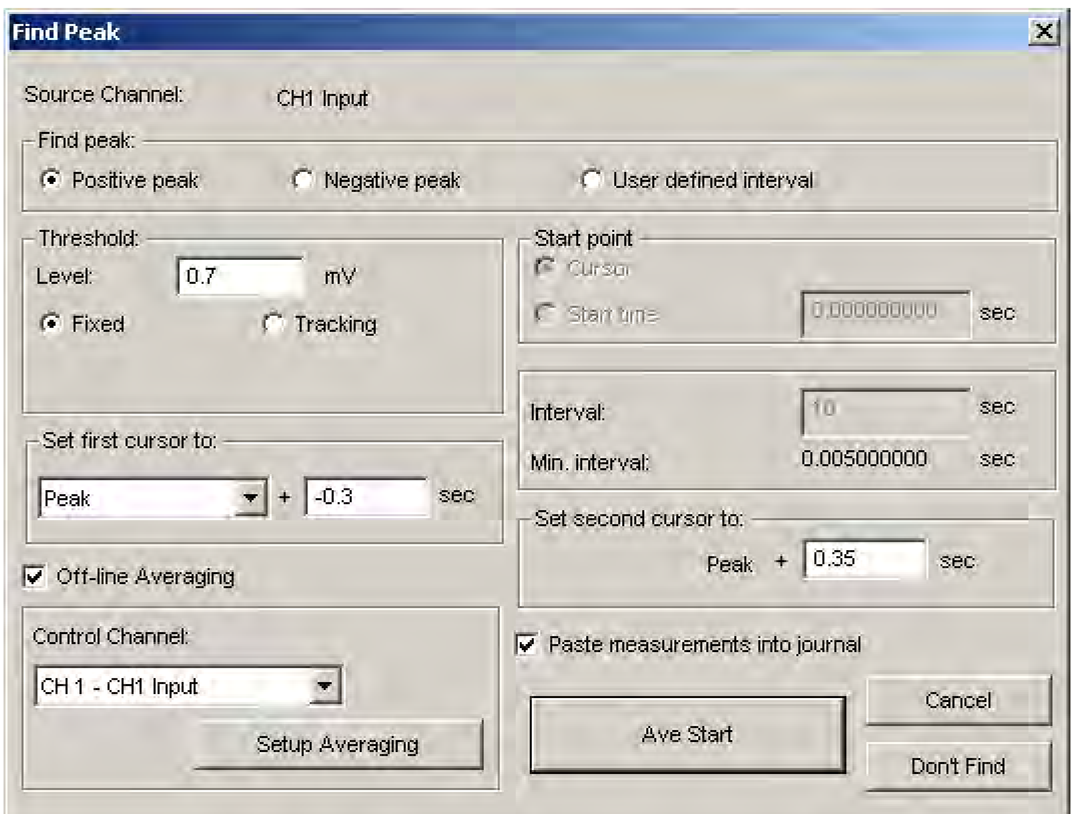
The following example shows how to average a one-minute segment of ECG data.





One-minute section of ECG data and result of Off-line Averaging

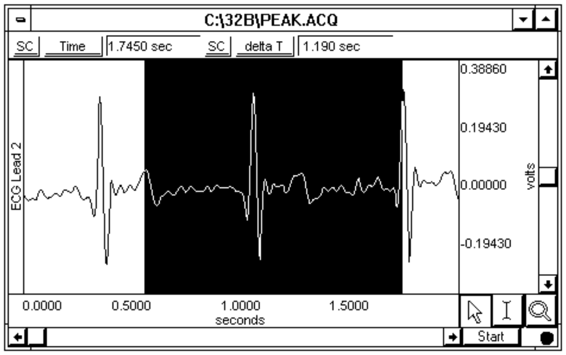
Select **Find Peaks** from the **Transform** menu. For this example, a Fixed threshold of 0.7 Volts was used. Select **Off-line Averaging** and the dialog box will allow you to enter a time window prior to the R-wave and after the R-wave. In this example, an averaging window of –0.3 sec before the R-wave (first cursor) and .35 sec after the R-wave (second cursor) was used. From Setup Averaging, we also chose "Selected Area" for the averaging range.

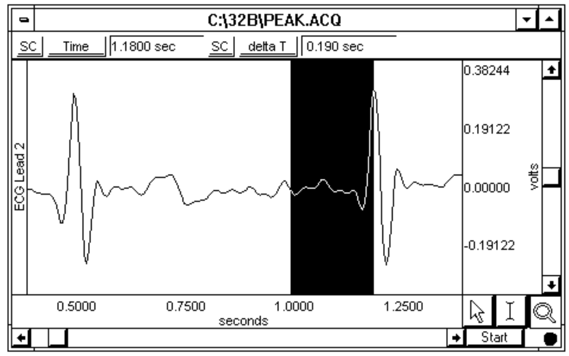


Peak detector dialog setting for Off-line Averaging example

TIME OFFSET EXAMPLE

One measurement option is to change the time offset of the first cursor. To do this, enter a value in the text box next to the **Set first cursor to:** area. Entering a value of -0.5 will result in the first cursor being set to a point 0.5 seconds *prior* to the previous peak, and when the **Find next peak** command is selected, the graph should like somewhat like that shown below left:

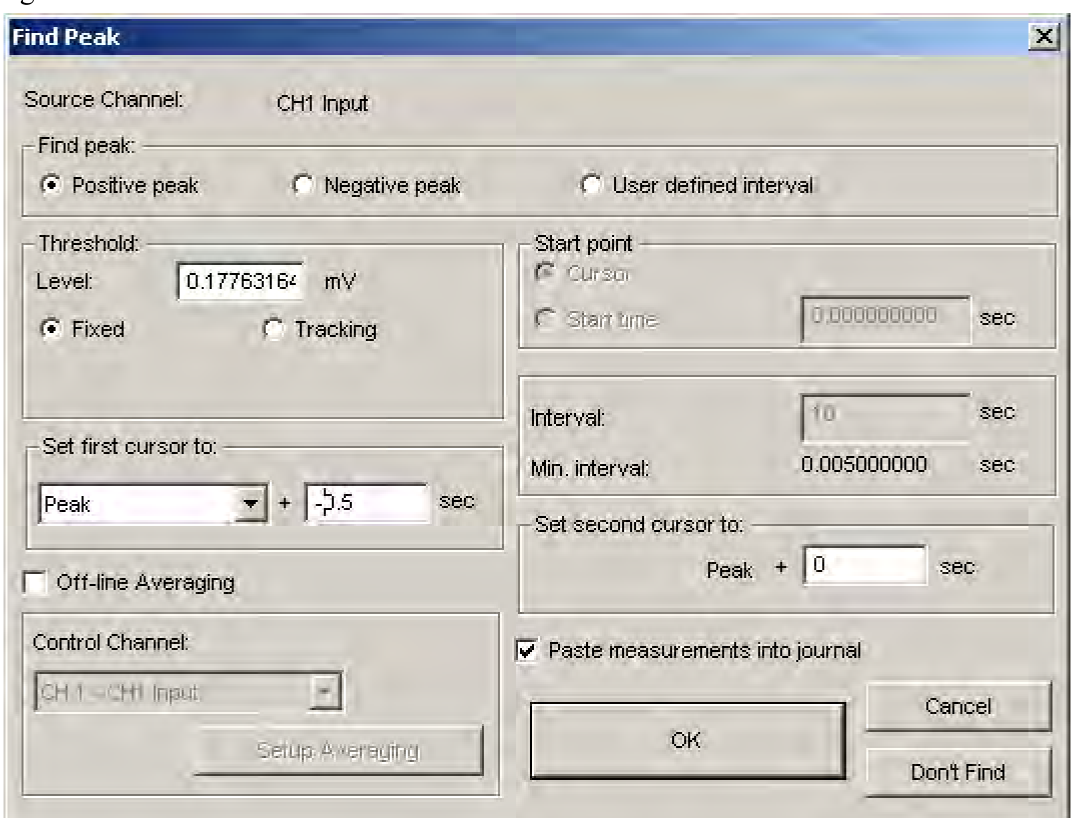


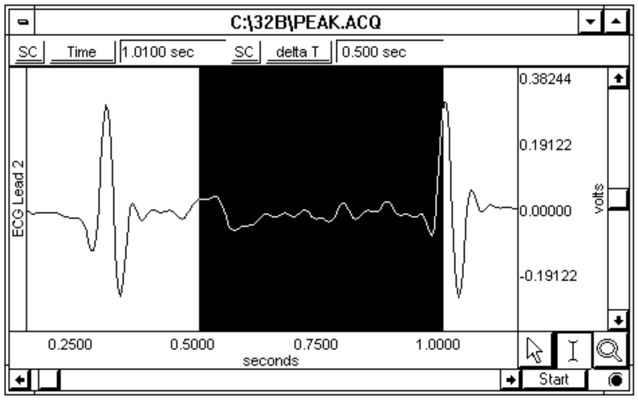


Likewise, setting the offset of the first cursor to a positive value will result in a selected area similar to that shown above right.

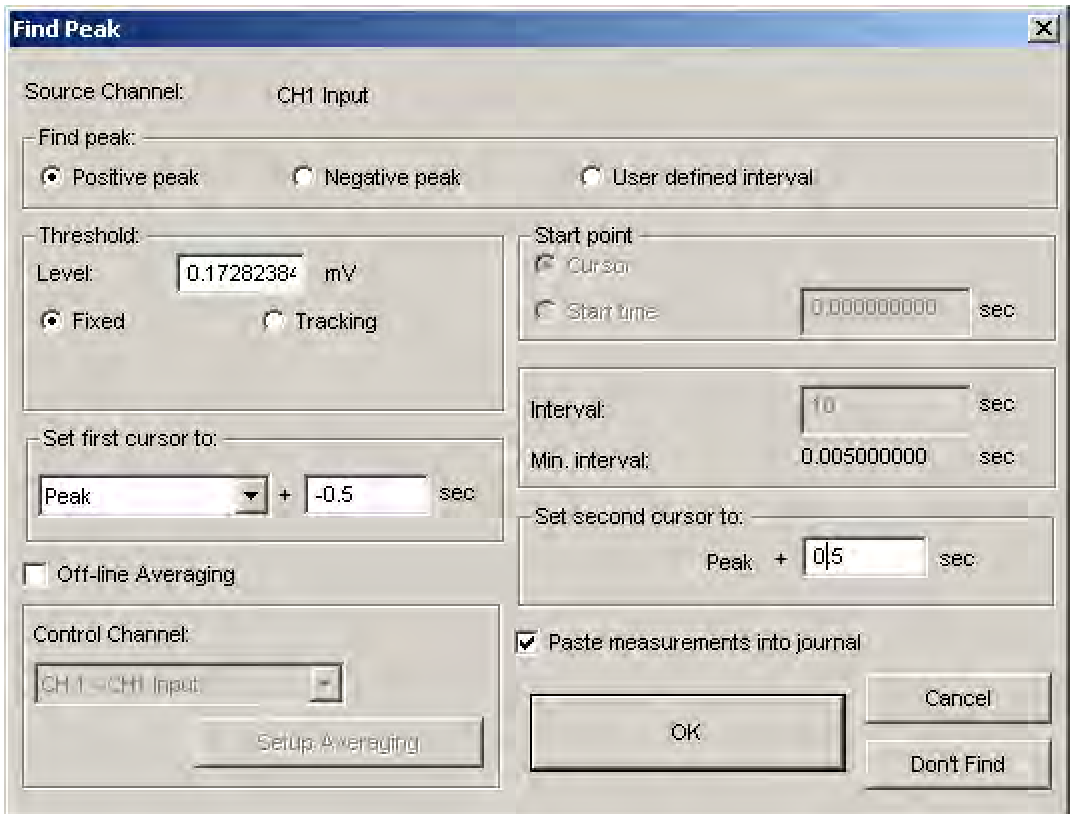
Alternatively, you can choose to locate both cursors at the found peak, and define an interval around the peak. To do this, go to the **Set first cursor to:** portion of the dialog box, and select **Peak** from the **Previous peak/Peak** pop-up menu. This causes the options for the second cursor to change by adding a time offset option. When both cursors are set to the found peak and the offsets are each set to zero seconds, the **find peak** command will select a single point at the peak maxima of the next found peak.

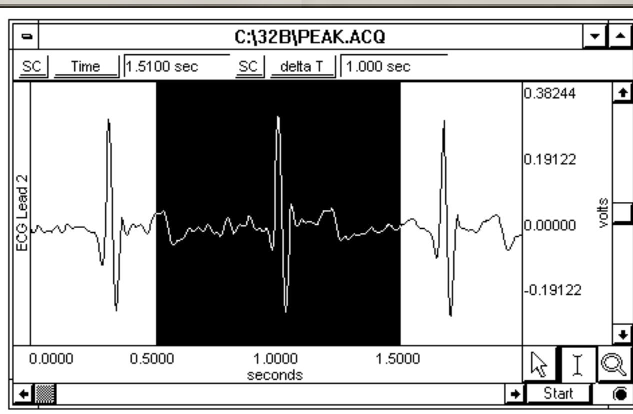
As before, it is possible to include a time offset for the first cursor. This offset may be either positive or negative, and can be set to an arbitrary time value. In the following example, the second cursor was set at the found peak, while the first cursor was set 0.5 seconds prior to the peak. The dialog box and resulting waveform are also shown.



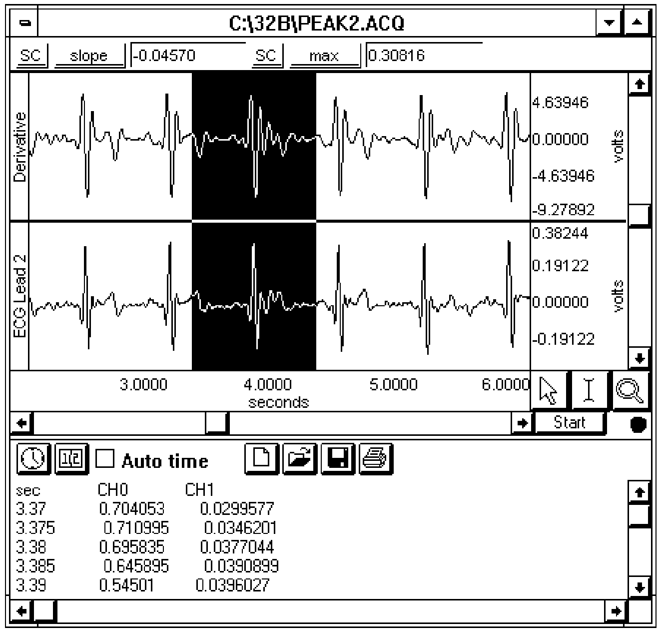


A **time offset** can be added to the second cursor, which allows for areas around a peak to be selected. The time offset associated with the second cursor must be either zero or positive, whereas the first cursor can be a positive value, zero, or a negative value.



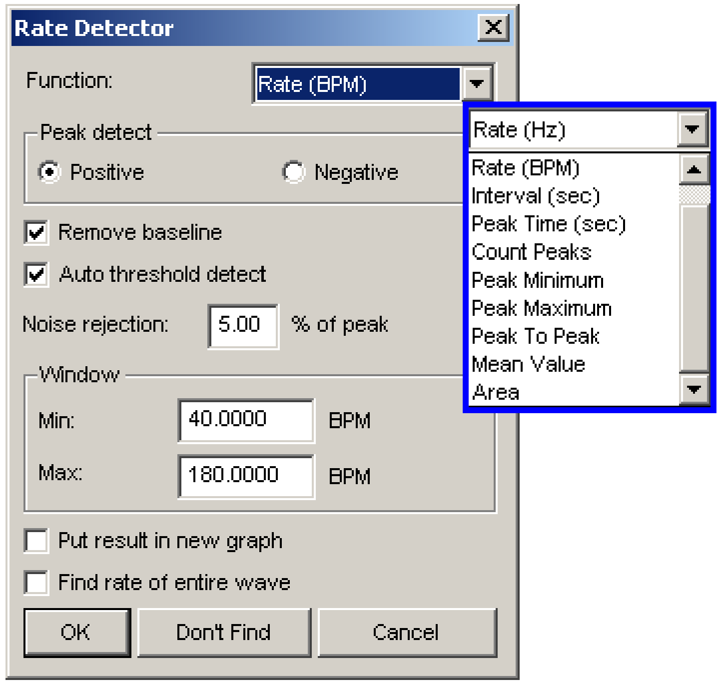


Since a selected area covers all channels, it is possible to highlight an area based on the location of a peak found on one channel and take measurements from other channels. For example, suppose ECG data was acquired and the derivative of the data was calculated on channel 0. The **Find peak** command could be used to locate peaks on the ECG channel, and measurement windows could display a value for the corresponding area on the derivative channel as shown in the following graph:



Moreover, it is also possible to paste data from other channels using only data within the selected area. In the example shown, an area of +/- 0.5 seconds was selected based on the location of the peak found on channel 2 (ECG). Measurements were displayed for the slope and max of the derivative channel. Data from both channels were then pasted to the journal along with the horizontal scale values.

Find Rate



The **Find Rate** function allows you to compute rate calculations (including BPM) for data that has already been collected. Although this function uses the same algorithm as the online Rate calculation, it can be advantageous to perform rate calculations after the data has been acquired. One benefit is that off-line rate computations do not require that a separate channel (i.e., a calculation channel) be acquired. Since the number of acquired channels is reduced, other data can be collected and/or data can be sampled at a higher rate. The **Find rate** function produces the following **Rate Detector** dialog, which has the following options:

See also: Rate Usage Guidelines in the Rate Calculation section on page 110.
Application Note #PS142 for further information.

Function The Function menu lists a variety of calculations. The most commonly used function is the **Rate (BPM)** option, which calculates a rate in terms of beats per minute or BPM. Other Rate Functions are discussed in detail in the **Rate** calculation section on page 108.

Peak detect By default, the peak detector searches for positive peaks (upward pointing, such as the R-wave of an ECG signal) to calculate the rate of a waveform. In some instances, however, you may have to base the rate calculation on negative peaks (downward pointing). To do this, select “negative” in the **Peak detect** section of the dialog box.

Remove baseline The **Remove baseline** option applies the optimal high pass filter based on the other settings. This option is useful for signals with a slowly fluctuating baseline.

Auto threshold detect To control for this, check the **Auto threshold detect** box in the find rate dialog box. When this option is selected, Biopac Student Lab will automatically compute the threshold value using an algorithm that accentuates peaks and uses information about the previous peak to estimate when and where the next peak is likely to occur. This threshold detector is typically more accurate than a simple absolute value rate calculation function, and is able to compute a rate from data with a drifting baseline and when noise is present in the signal. For a detailed description of how the calculation is performed, contact BIOPAC Systems, Inc. for the complete Application Note.

Enabling **Auto threshold detect** enables **Noise rejection** and **Window** options.

Noise rejection Biopac Student Lab constructs an interval around the threshold level when **Noise rejection** is checked. The size of the interval is equal to the value in the noise rejection text box, which by default is equal to 5% of the peak-to-peak range. Checking this option helps prevent noise "spikes" from being counted as peaks.

Window The **Window** section prompts you to specify an upper and lower limit for the rate calculation. By default, these are set to 40 BPM for the lower criterion and 180 for the upper criterion, but may be adjusted as necessary. Setting the upper and lower bounds for the "window" tells Biopac Student Lab when to start looking for a peak. Biopac Student Lab will try to locate a peak that matches the automatic threshold criteria within the specified window. If no peak is found, the area outside the envelope will be searched and the criteria (in terms of peak value) will be relaxed until the next peak is found.

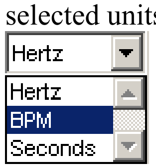
For instance, once the first peak is found, Biopac Student Lab will look for the next peak in an interval that corresponds to the range set by the upper and lower bounds of the window. The interval with associated with the upper band of 180 BPM is 0.33 seconds (60 seconds ÷ 180 BPM), and the interval for the lower band is 1.5 seconds (1 minute ÷ 40 BPM). If a second peak is not found between .33 seconds and 1.5 seconds after the first peak, then Biopac Student Lab will look in the area after 1.5 seconds for a "smaller" peak (i.e., one of lesser amplitude). For those rate functions that require a window interval in seconds, you will probably want to enter numbers like .33 seconds and 1.5 seconds (which correspond to the BPM defaults of 40 and 180). These numbers will be suitable for detecting the heart rate of an average subject.

A simple peak detector uses what is called a *threshold-crossing algorithm*, whereby each time the amplitude (vertical scale) value exceeds a given value, the peak detector "remembers" that point and begins searching for the next event where the channel crosses the threshold. The interval between the two occurrences is then computed and usually rescaled in terms of BPM or Hz. This is how the Biopac Student Lab Rate Calculation functions when all options are unchecked.

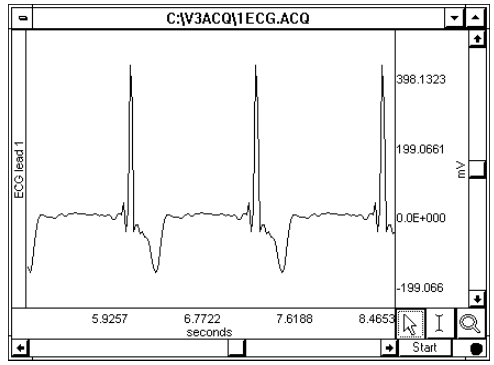
Windowing Units are related to the selected "Function."

- Rate Functions related to peak or peak time specify the unit after the Function. This is a fixed unit, so the Windowing Units menu will be disabled.

- Rate Functions related to data within a cycle can be specified in units of frequency (Hz) or time (BPM or seconds). The Windowing Units menu will be enabled,a nd when a unit is selected the software will convert the Min and Max settings to the selected units.

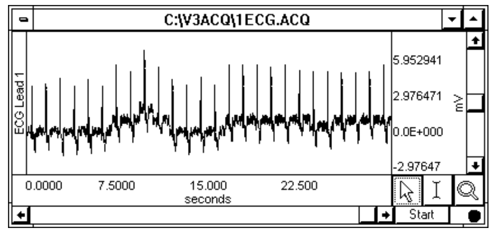


In the sample waveform here, the threshold was set to 390 mVolts to detect of the peaks of the waveform and provide an accurate rate calculation. Since it only recognizes signals greater than 390 mVolts as a peak, this 390-mVolt threshold is referred to as an "absolute threshold."



Most waveforms are not so well behaved, however, and artifact can be introduced as a result of movement, electrical interference, and so forth.

Combined with actual variability in the signal of interest, this can result in "noise" being included with the signal, as well as baseline "drift" which can render absolute threshold algorithms useless.

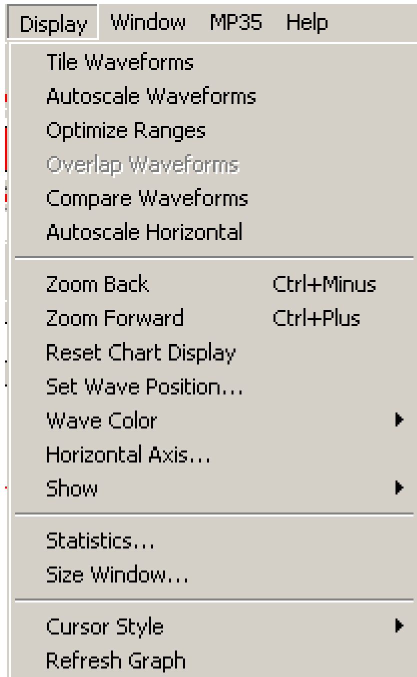


Put Result in New Graph When this option is checked, the results from the find rate calculation are plotted in a new graph window with data displayed in X/Y format, with time on the horizontal axis. By default, this option is unchecked and the resulting transformation is placed in the lowest available channel of the current graph.

Find Rate of Entire Wave When this option is checked, the rate (or other function from the **Find Rate** command) will be calculated for the entire wave (other than the selected area, if any).

Don't Find The **Don't Find** button is useful when you realize you have not selected an area, or you want to change the selected area to perform the Find Rate function on. When you click Don't find, the dialog settings will be saved so that you can close out of the dialog and select an area. When you reopen the dialog, the settings will be established as before, and you can click the OK button to perform the Find Rate function. This is useful for setting parameters using an area of a waveform (described above) and then repositioning the cursor at another point in the record.

Chapter 14 Display menu commands



The Display menu includes a number of features that control how the waveforms appear on the screen and how much data is displayed at a time. Although these options change the appearance of the data, they do not change the data itself. In other words, changing the color of a waveform or showing only a portion of the data on the screen will not alter the data stored in the file.

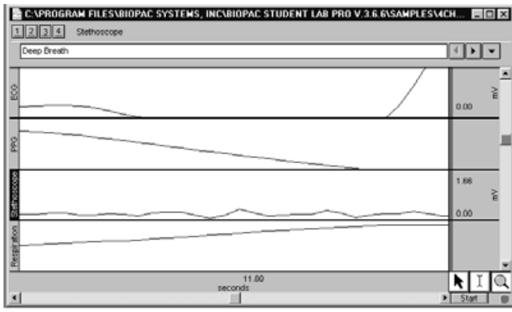
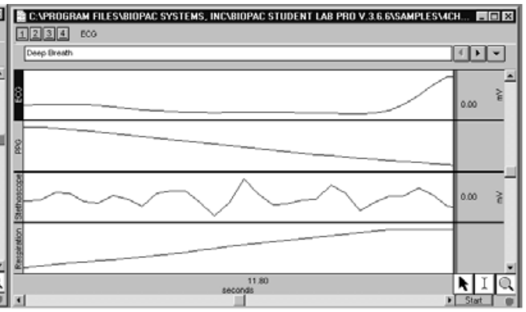
✓ **TIP** Click the right mouse button in the data window to generate a shortcuts menu that includes some display options.

Tile Waveforms

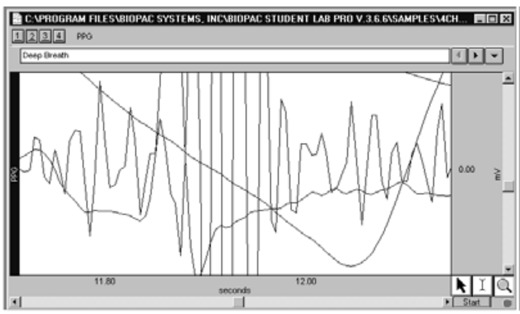
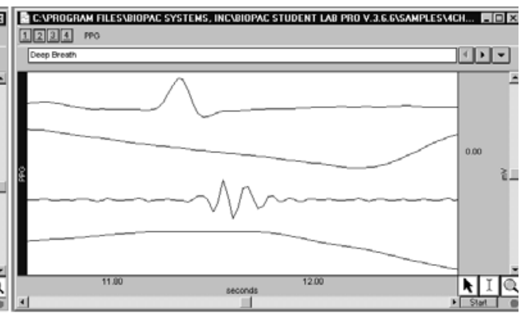
Choosing **Tile waveforms** centers the waveform in the display window by adjusting the vertical offset of the selected waveform. In **Chart** mode, if there are multiple waveforms displayed, the waveforms will be centered in their tracks. In **Scope** mode, display is optimized to show all the visible waveform data with no overlap. **Tile waveforms** is not available in X/Y mode.

Before **Tile Waveforms** ***After*** **Tile Waveforms**

Chart Mode

Scope Mode

TILE WAVEFORMS	In Chart Mode	In Scope Mode
Applies to	Selected channel	All active (visible) channels
Effect on Horizontal (Time) Scale	None	None
Effect on Vertical (Amplitude) Scale	When multiple waveforms are displayed, each waveform is centered in its "track." If tracks were resized, this function will reset (equalize) the tracks and then center each waveform in its track.	Display is optimized to show all the visible waveform data with no overlap. Waveforms are spaced evenly along the vertical axis of the screen. Each channel's data is completely visible and is separated from the other channels.
Channel order (top to bottom)	Numerical order (Top=low, Bottom=high) unless channel order was manually changed via Display>Set Wave Position.	Numerical order (Top=low, Bottom=high) unless channel order was manually changed via Display>Set Wave Position.
Limitations	None	None
When to use	When the vertical offset has shifted the channel in its track.	When multiple waveforms are overlapped and hard to distinguish, especially if displayed in the same color. This pulls the waveforms apart, in order to view each channel.

Autoscale Waveforms

When **Autoscale waveforms** is selected, BSL *PRO* determines the best fit for each displayed waveform. The software adjusts the vertical offset so that each channel is centered in the window (or within the channel tracks in the chart mode) and adjusts the units per division on the vertical axis so that the waveform fills approximately two-thirds of the available area.

In **Chart** mode, the screen is evenly divided into horizontal channel tracks and each waveform is autoscaled to fit the division without overlapping. To apply to only the selected waveform, hold the **CTRL** key down before selecting **Autoscale waveforms.**

In **Scope** mode, if more than one channel is active, the channels will overlap but each waveform will autoscale as if it were the only waveform in the display. This is useful when overlapping waveforms that have different units and scales. The vertical scale shown is that of the active channel; to change the scale, select another channel.

Optimize Ranges

When **Optimize Ranges** is selected from the Display menu, the Vertical Scales will be automatically adjusted for <u>all channels</u> that have a Range Guide (green band) showing, such that the range limits are set to the upper and lower viewable limits of the Vertical Scales. This allows you to quickly see the total Range of each input channel. This menu item is active when data is present AND at least one data channel has an active Range Guide.

This item is also selectable using the toolbar icon  or the right-click mouse shortcut. When selected with the icon or the right-click, this item only optimizes the Range Guide of the <u>active channel</u>.

Note: The Range Guide is the green vertical band that appears in the Vertical Scale region for analog input channels only (not for duplicated, copied/pasted, or Calculation channels); see page 42.

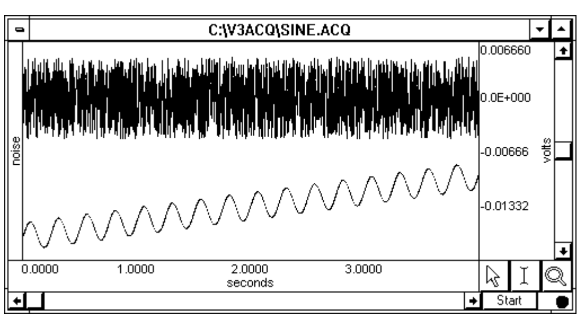
Overlap Waveforms

In **Scope** mode, when **Overlap waveforms** is selected, all the currently displayed waveforms are "overlapped" into one graph window with the same vertical scale and offset. This allows you to compare waveforms by setting all channels to the same vertical scale. The overall chosen scale for all the displayed waveforms will be a function of the pk-pk value of the combined waves. **Overlap Waveforms** is best used when comparing similar units. One use, for example, is to examine the calculated diastolic, systolic, and mean calculation channels "overlapped" with the raw blood pressure waveform.

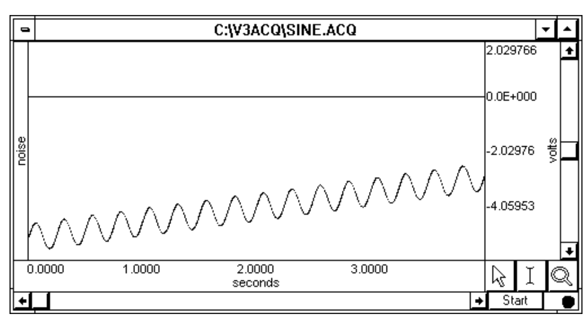
Compare Waveforms

It is often useful to compare multiple waveforms by placing them all on the same amplitude (vertical) scale, but discount the effect of waveform offset (or baseline). **Compare waveforms** will automatically set the scale to be the same for all channels, and adjust the offset for each channel to center all displayed waves. The scale of all the displayed channels is determined by the channel with the largest pk-pk range in the display interval.

***Before* Compare Waveforms**



***After* Compare Waveforms**



The preceding example shows two waveforms that appear to have approximately the same magnitude before **Compare waveforms** is performed. After using **Compare waveforms**, you can easily see that the magnitude is not actually the same — one waveform (the sine wave) has a significantly greater baseline and range relative to the other (noise) waveform.

Autoscale Horizontal

The **Autoscale Horizontal** command is a convenient way to display the entire data file (in terms of duration) on the screen. When this is selected, the display will be adjusted so that the duration of the entire waveform fits in the graph window. For long waveforms, this can take some time to redraw. You can cancel plotting at any time by pressing the escape **Esc** key.

Note: You cannot **Undo** the Autoscale Horizontal function, but you can use the **Display** > **Zoom back** menu command to revert to the previous display settings.

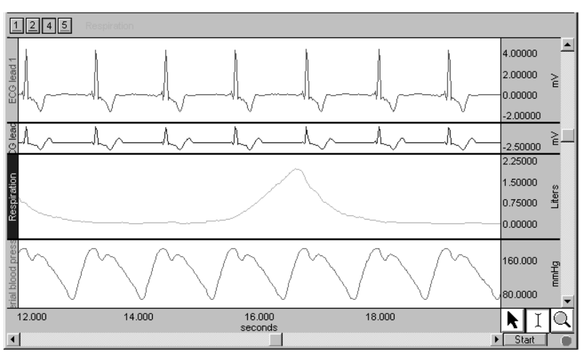
Zoom Back / Zoom Forward

The **Zoom Back** and **Zoom Forward** functions perform “undo” and “redo” commands for the zoom tool and any other functions that change the amount of data displayed (either in terms of time or amplitude). This effectively undoes changes in the horizontal scale, the vertical scale, or both. You can use the keyboard shortcuts of **Ctrl-minus** or **Ctrl-plus**, or click the right mouse button in the data window to generate a shortcuts menu and make the appropriate zoom selection. Changing mode resets the zoom scale.

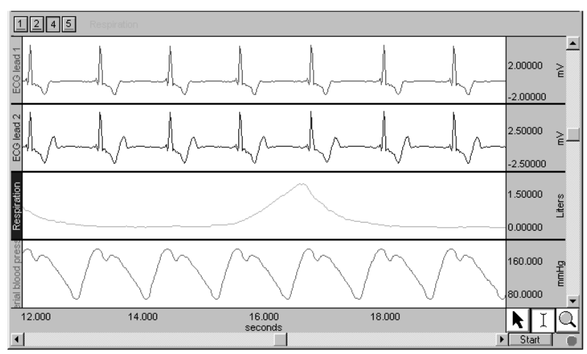
Reset Chart Display

The **Reset Chart Display** option will redistribute the chart displays evenly so that each channel’s vertical size is the same after you have changed the boundaries. This function, which only works in *Chart Mode*, can be useful if you need to expand a display region for analysis and then return to the original display.

Before **Reset Chart Display**



After **Reset Chart Display**



Set wave positions...

By default, channels are arranged on the screen based on their channel numbers, with the lower number channels being displayed at the top of the screen. You can change the ordering so that waveforms are placed in an arbitrary order.

The **Set Wave Position** option of the **Display** menu generates the **Set Waveform Order** dialog, which contains a scrolling list of all stored channels. The on-screen position of the waveforms is the same as the ordering shown in the **Set Waveform Order** dialog (from top to bottom). You can scroll through the list by clicking on the vertical scroll bar at the right. The list will scroll if you move past the top or bottom when clicking and dragging the waveform positions.

The “**Tile**” checkbox to the left of each channel enables tiling and autoscaling for each channel when checked. Click the checkbox to toggle the enable. This can be useful if you have some waveforms which you don’t want autoscaled with others.

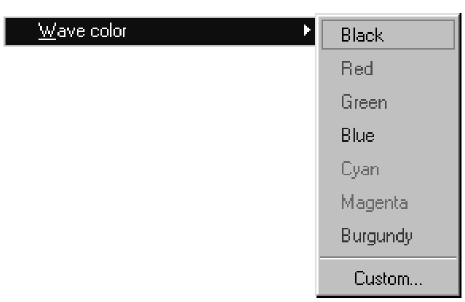
You can reposition the waveforms by reordering the channel labels as they appear in this dialog box. To change the order of any waveform, click the channel label (e.g., Ch. 4 Respiration), hold down the mouse button, and drag the highlighted label to the desired position.

Set Waveform Order dialogs and corresponding displays

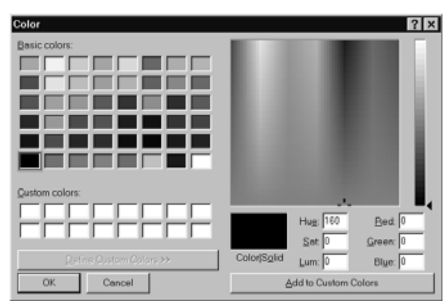
Repeat this operation until the waveforms are in the desired order, then click **OK** to apply the selected order to the display screen. **Cancel** will reset all waveform positions to those set before the dialog was opened.

- In **Chart** mode this will result in vertical ordering of the individual waveforms.
- In **Scope** mode this will result in vertical ordering of the individual waveforms after a tiling or autoscaling operation.

Wave color



The **Wave Color** option of the Display menu lets you use color to discriminate between waveforms. When you add a new waveform, the software assigns the waveform color — but you can use this function to change the color.

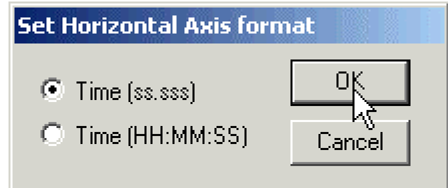


To assign a new color to a selected waveform, choose **Wave Color** and then selecting the desired color from the menu that is generated.

Depending on the type of graphics adapter on your computer, you may or may not be able to choose "**Custom**" to display a palette of color options. **Wave color** is disabled on computers with grayscale monitors.

You can use color to identify the selected waveform because the vertical scale, channel text, channel units and measurement pop-up menus take on the same color as the selected waveform. The channel label (along the left edge of the display) will be highlighted in the color for that channel.

Horizontal Axis...



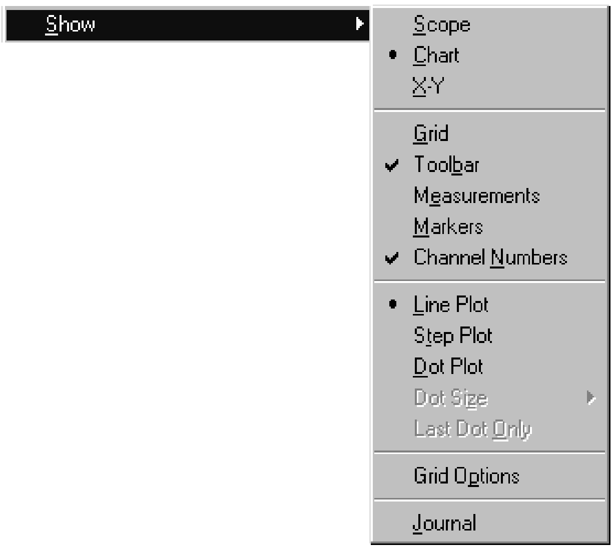
This option generates a "Set Horizontal Axis format" dialog with two time format options.

Time (ss.sss) is the default. 

Time (HH:MM:SS) displays as 

and rounds as necessary to fit this format.

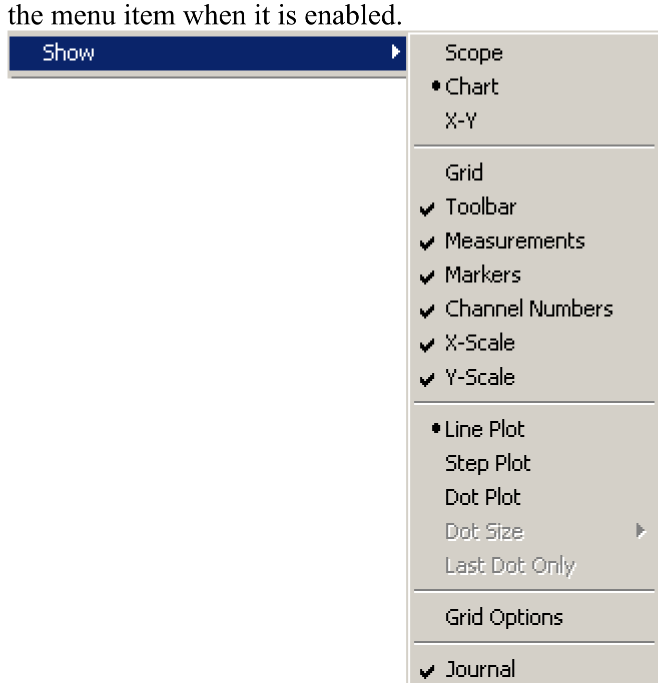
Show...

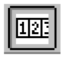
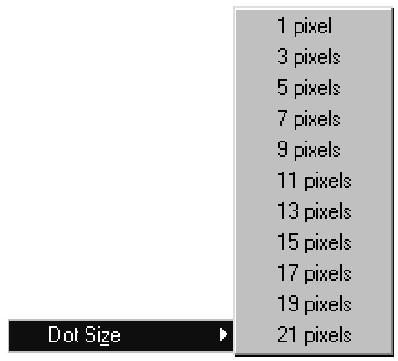
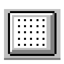
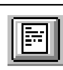
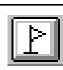
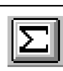
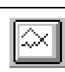


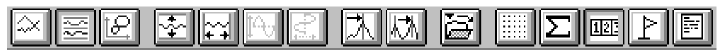
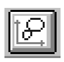
When **Show** is selected from the **Display** menu, a submenu appears that allows you to control a number of options related to how data is displayed and what additional information is displayed in the graph window.

To enable an item, scroll to select it from the **Show** submenu.

A bullet (•) or check mark (✓) appears next to the menu item when it is enabled.

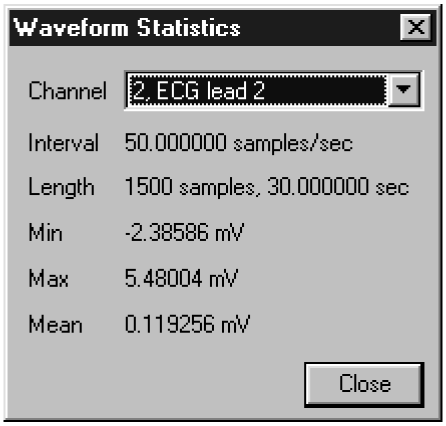


SHOW Option	Toolbar / Shortcut	Explanation
Channel numbers		Activates the channel box display above the graph window.  See page 55.
Chart		Activates the **Chart** display mode. See page 43.
Dot plot	Click the **right** mouse button and scroll to choose **Dot plot** ➢ Hold the **Ctrl** key when you select to apply to all channels.	Allows you to view data in a "dot" format. The software will create user-defined, discrete points that map out the selected waveform. This is often useful for demonstrating the concept of discrete digital sampling by dividing the waveform up into data points or "dots."
Dot size	Click the **right** mouse button and scroll to choose **Dot size**	 Use to specify how large each dot will be for Dot Plot. Each dot is measured by the number of monitor pixels it occupies. If you select a large number (like 21 pixels), then the waveform will look like a series of large dots.
Grid		Superimposes a set of horizontal and vertical lines on the graph window that correspond to horizontal and vertical scale divisions. Grids are a useful visual aid to help with measurements and when selecting an area. See page 166.
Grid Options	Click the **right** mouse button and scroll to choose **Grid buttons**	Activates the Grid Options Dialog with options to **lock** or **unlock** grid lines and control the width and color of major and minor grid lines. See page 166.
Journal		Opens a Journal window below the data window.
Last dot only	Click the **right** mouse button and scroll to choose **Last dot only**	Enabled with **Dot mode**, plots only the most recently acquired data point. This is useful when viewing data as it is being acquired and when using the X/Y display mode.
Line plot	Click the **right** mouse button and scroll to choose **Line plot** ➢ Hold the **Ctrl** key when you select to apply to all channels.	Plots the waveform by connecting each sample point to the next with a line. **Line plot** waveforms match a true analog plot (as closely as possible). This is the default display mode for most waveforms—except histogram plots, which are displayed in Step plot (see page 209).
Markers		Activates the marker region display and the marker tools.  See page 164 for Marker details.
Measurements		Displays the measurement boxes above the graph window. See page 149 for an overview of the measurement process and page 153 for an explanation of each measurement.
Scope		Activate the **Scope** display mode. See page 43.

SHOW Option	Toolbar / Shortcut	Explanation
Step plot	Click the **right** mouse button and scroll to choose **Step plot** ➢ Hold the **Ctrl** key when you select to apply to all channels.	Draws waveforms using a "step" plot which connects sample points with either vertical or horizontal lines. **Step plot** is most useful for displaying histograms and similar plots, but since it displays data much as it appears to a digital processor (like the MP35/30), it can also be useful for examining the effects of various sampling rates. **NOTE**: **Step plot** is mutually exclusive of **Line plot**.
Toolbar	Click the **right** mouse button at the top of the display by the menu items.	Generates the toolbar display across the top of the data window. The Toolbar has shortcut buttons for commonly used features. See page 35 for an explanation of the buttons. 
X-Scale		Shows/Hides the Horizontal Scale. Hiding the X scale when desired allows for use of full screen for X/Y plots.
Y-Scale		Shows/Hides the Vertical Scale. Hiding the Y scale when desired allows for use of full screen for X/Y plots.
X/Y		Switches the display to X/Y mode. See page 44.

Statistics...

The **Statistics** command generates a message box with information about the selected channel.



Channel number: the active channel

Channel label: associated label text (if any)

Interval: sampling rate used for data storage

Length: waveform duration in samples and time

Min: minimum value for the waveform data

Max: maximum value for the waveform data

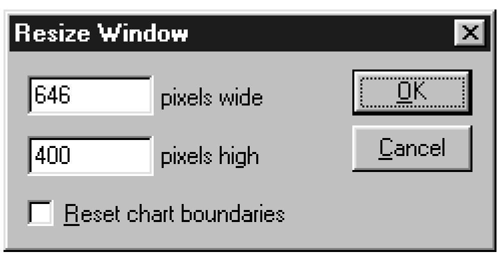
Mean: mean value for the waveform data

Generally, the sampling rate and waveform length information is the same for all channels, although this is not always the case. It is possible to shorten waveforms by editing out sections of the waveform (using **Edit** > **Cut** and/or **Edit** > **Clear** functions).

The interval specified in this message box reflects the sampling interval the BSL *PRO* software uses to store the data, which is not necessarily the same rate at which it was collected. If data was imported or saved in a format other than .ACQ, the sample interval data was not stored, and the software will use the default of 100 samples/sec. to plot the data.

To modify the sample Interval, you can use the **Resample** function (described on page 210) or paste data collected at one sample rate into a graph with data sampled at a different rate.

Size window...



The **Size Window** function lets you specify exact dimensions for the size of the graph window. You can use this to create consistently sized windows for pasting into documents.

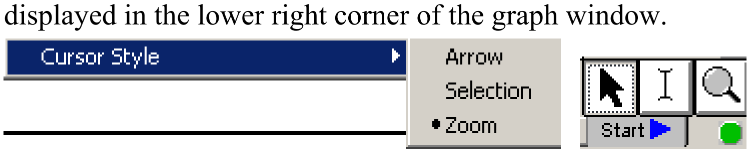
The two text boxes allow you to enter screen width and height, both of which are scaled in terms of pixels. Standard computer displays have 72 pixels per inch (28.3 pixels/cm), so a graph window that is 360 pixels wide by 216 pixels high would be 12.7cm tall and 7.6cm wide.

When the **Reset Chart Boundaries** box is checked, the boundaries between the waveforms will be reset so that each channel "track" is the same size. This function only works in **Chart** mode.

Note: The **Reset** function is also a first-order **Display** menu option. See page 236 for an example.

Cursor Style

The Cursor Style option generates a sub-menu with options for the three general cursor styles that are displayed in the lower right corner of the graph window.



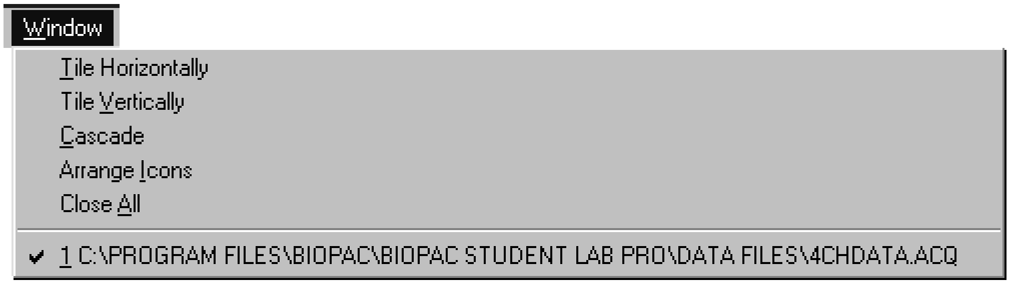
Refresh Graph

This will refresh the screen display. Use this option to erase residual I-beam lines on the graph.

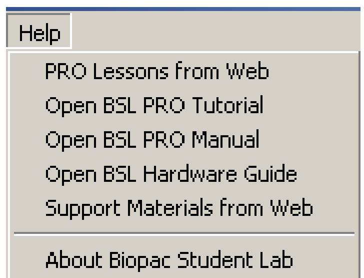
Chapter 15 Window Menu & Help Menu

Window menu

The **Window** menu is a standard Windows® function with window display options. This menu lists all open files, which can be useful for file selection when multiple files are open, and also includes several display options. See your Windows® Manual for details.



Help menu

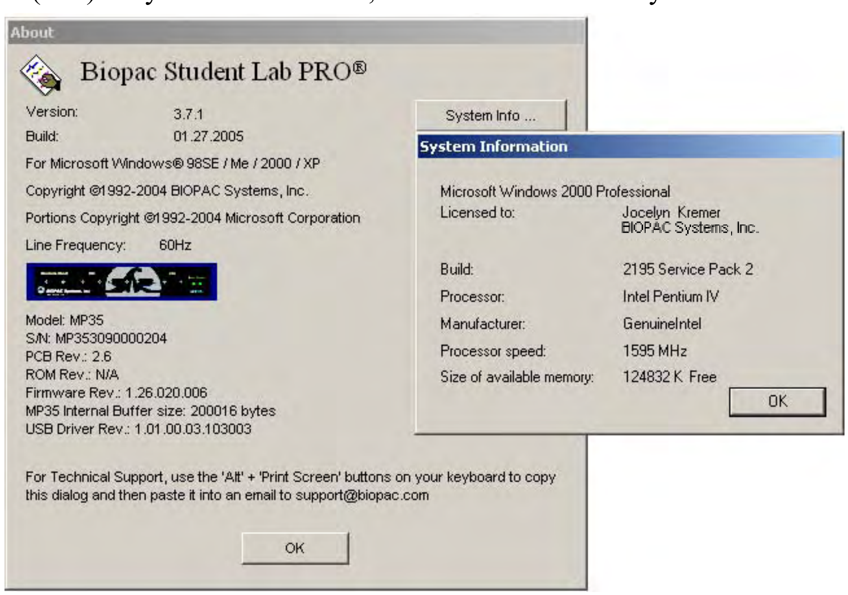


The **Help** menu lists the BIOPAC support options available while you are running the program. The Tutorial, Manual and Guide files are in PDF format and can be easily searched.

- You must have an active "browser" to use the "from Web" options.
- If you have not installed Adobe Acrobat Reader (free at www.adobe.com) or it has never been used on your OS, you must install or activate Acrobat to see the PDF menu options.

About command

The **About** command of the **Help** menu (under the BSL *PRO* menu on a Mac) generates a dialog with information about the BSL *PRO* software and firmware versions being used and your system parameters, which can be useful if you need to call BIOPAC for any reason. This dialog also contains the serial number (S/N) for your MP35/30 unit, which can be useful if you need to make a service call.



Part E — Appendices

Appendix A — Sample Data Files

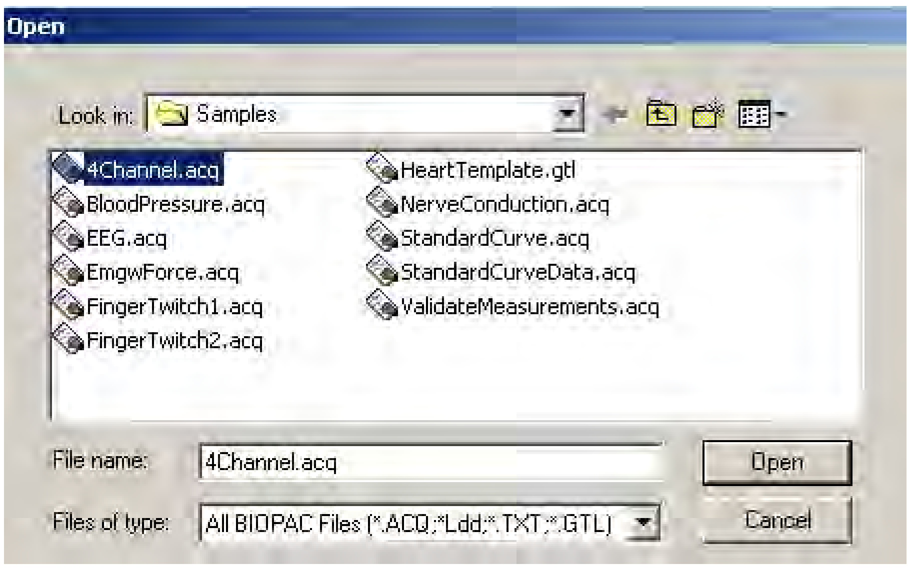
Sample data files

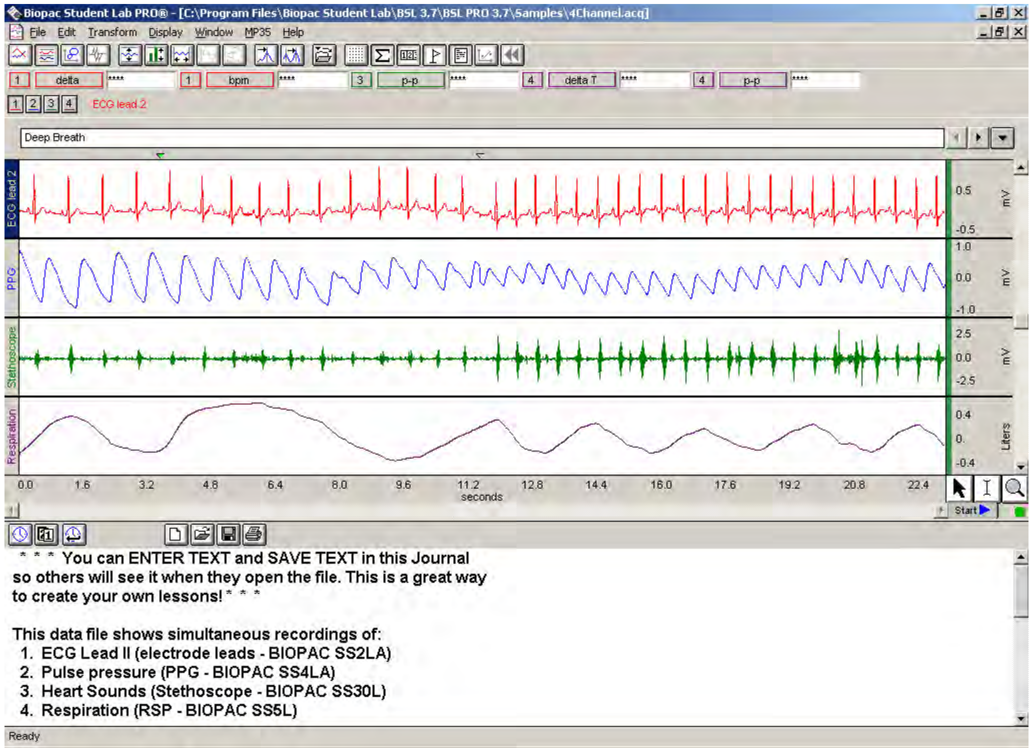
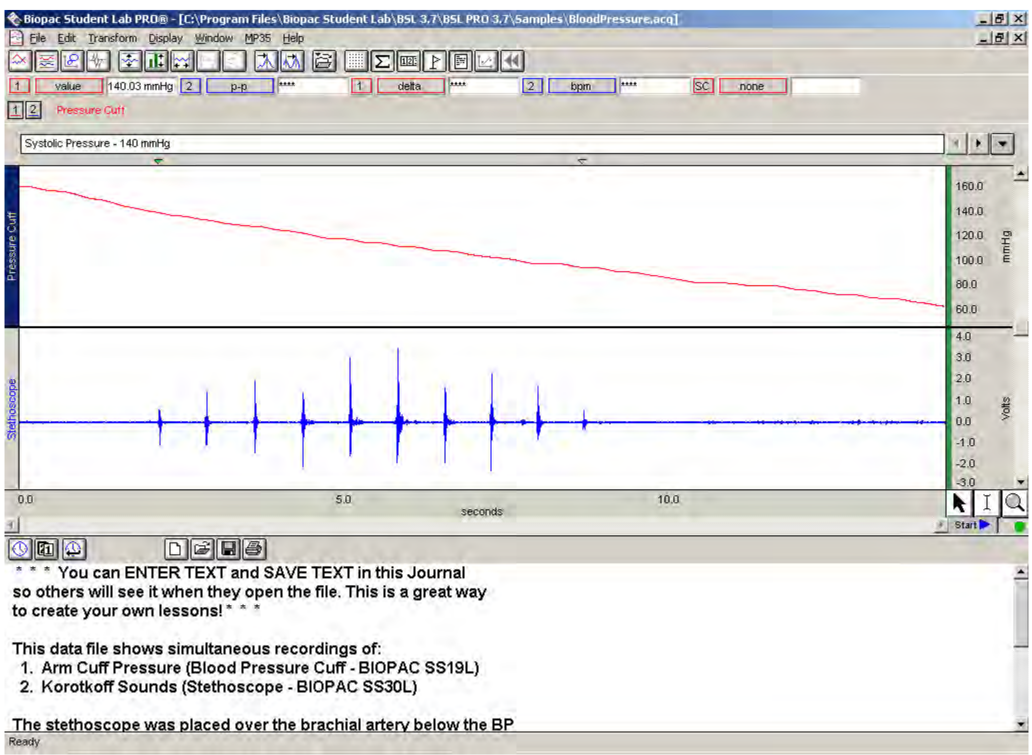
The Biopac Student Lab *PRO* installation includes the following sample data files, which you are encouraged to open and review as you familiarize yourself with the BSL *PRO* System.

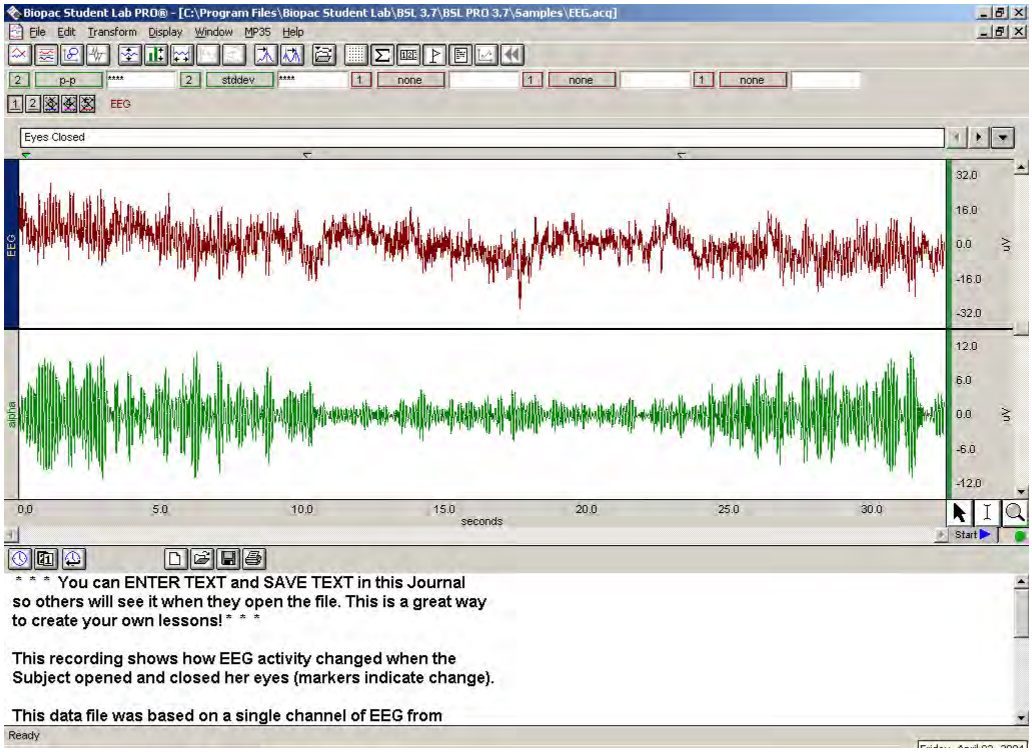
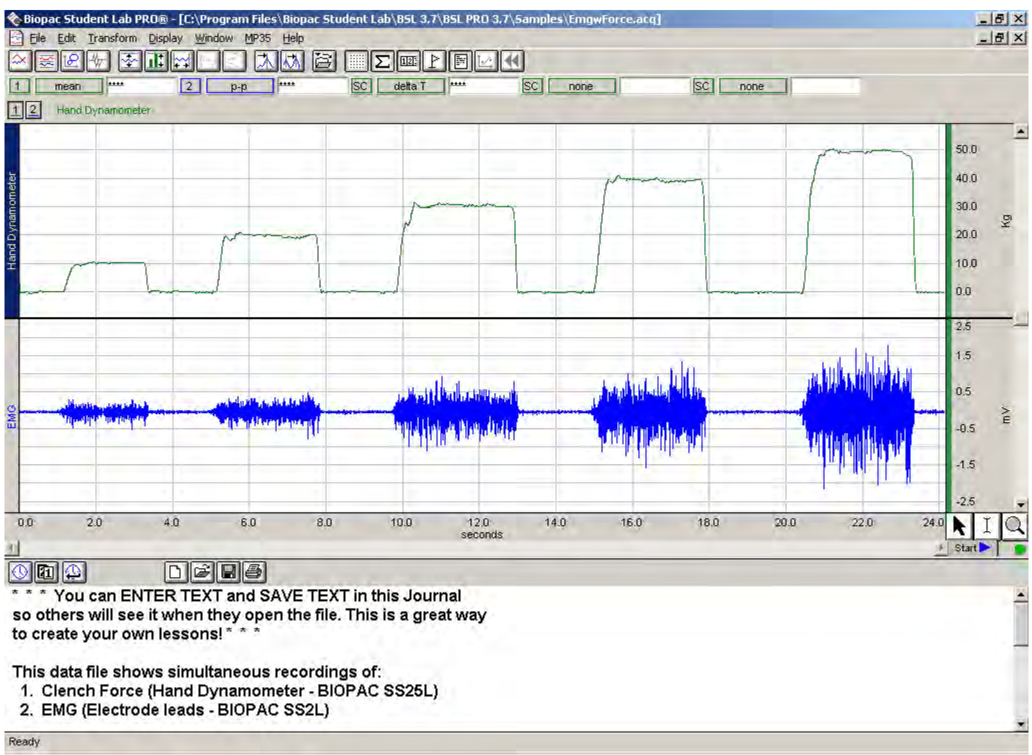
The "**Samples**" folder is installed to the Biopac Student Lab *PRO* v.3.6.6 folder. The path to the folder (from default installation) is:

C:\Program Files\Biopac Student Lab\BSL 3.7\BSL PRO 3.7\Samples

- *Ten sample acquisition (.acq) files are installed with the PRO.*
- *A graph template file is also installed—see page 249.*

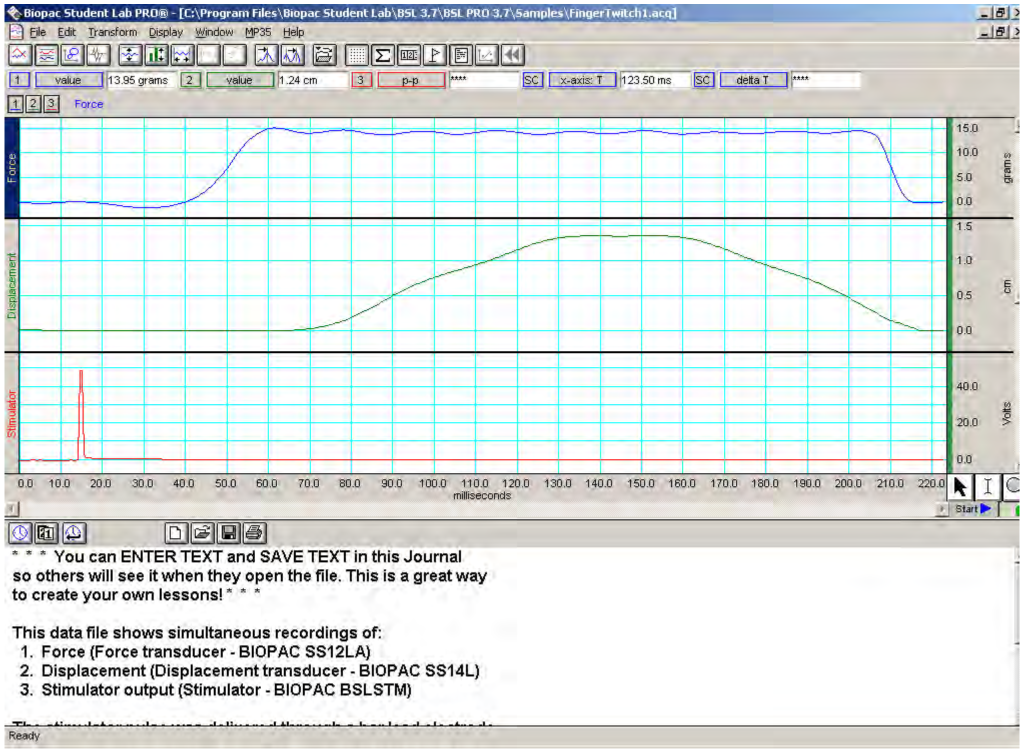


Data file name	Screen Shot
4Channel.acq	
BloodPressure.acq	

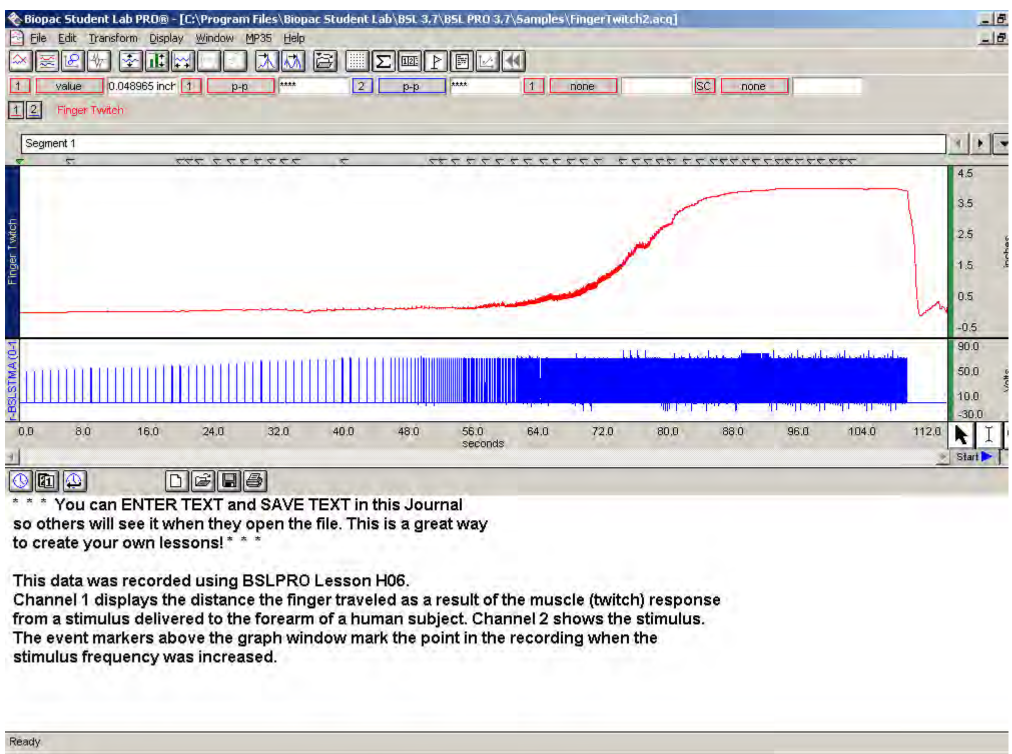
Data file name	Screen Shot
EEG.acq	
EMGwForce.acq	

Data file name	Screen Shot

FingerTwitch1.acq



FingerTwitch2.acq

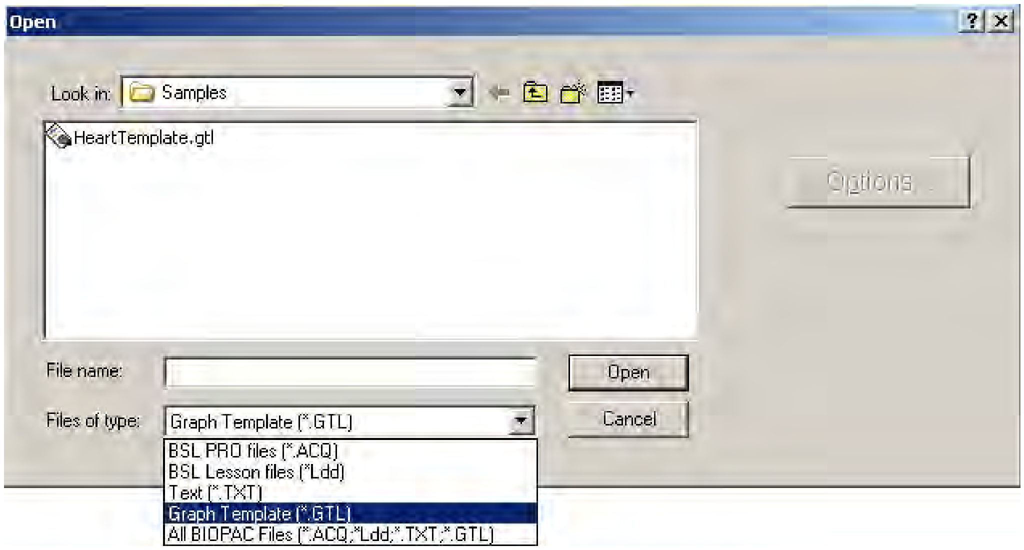


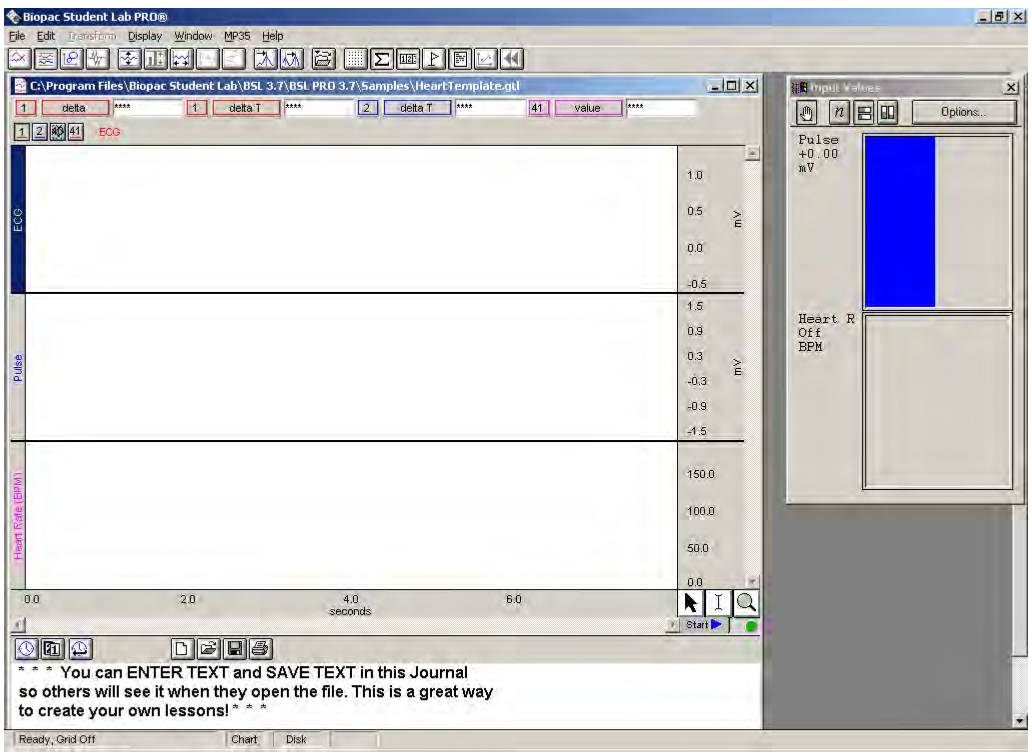
Data file name	Screen Shot

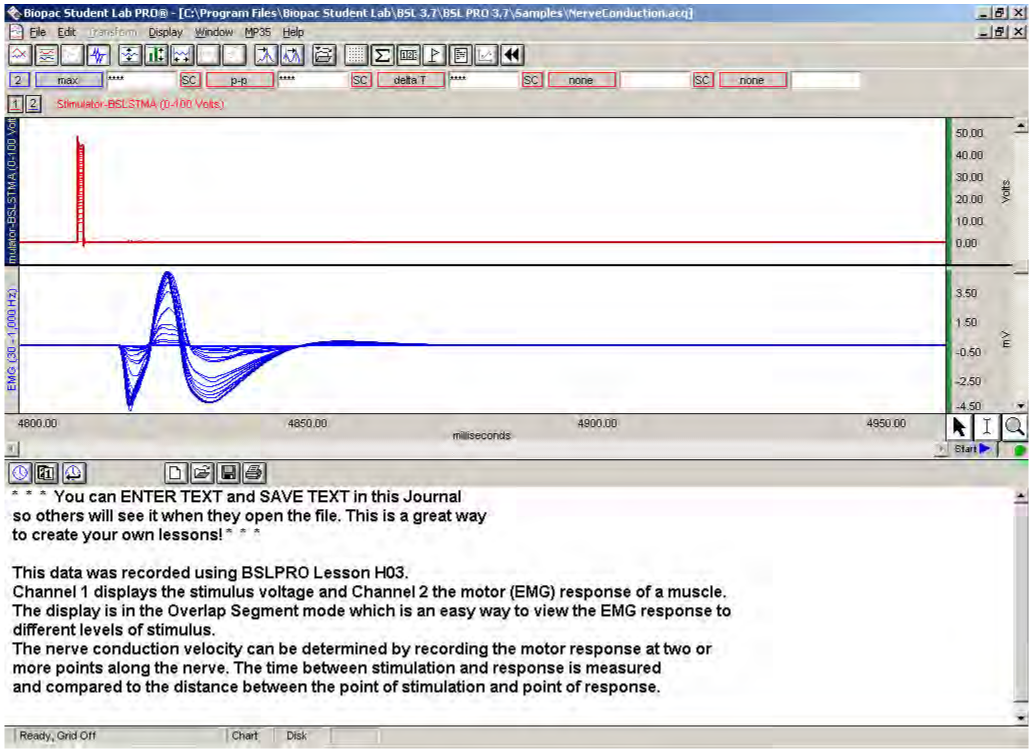
HeartTemplate.gtl

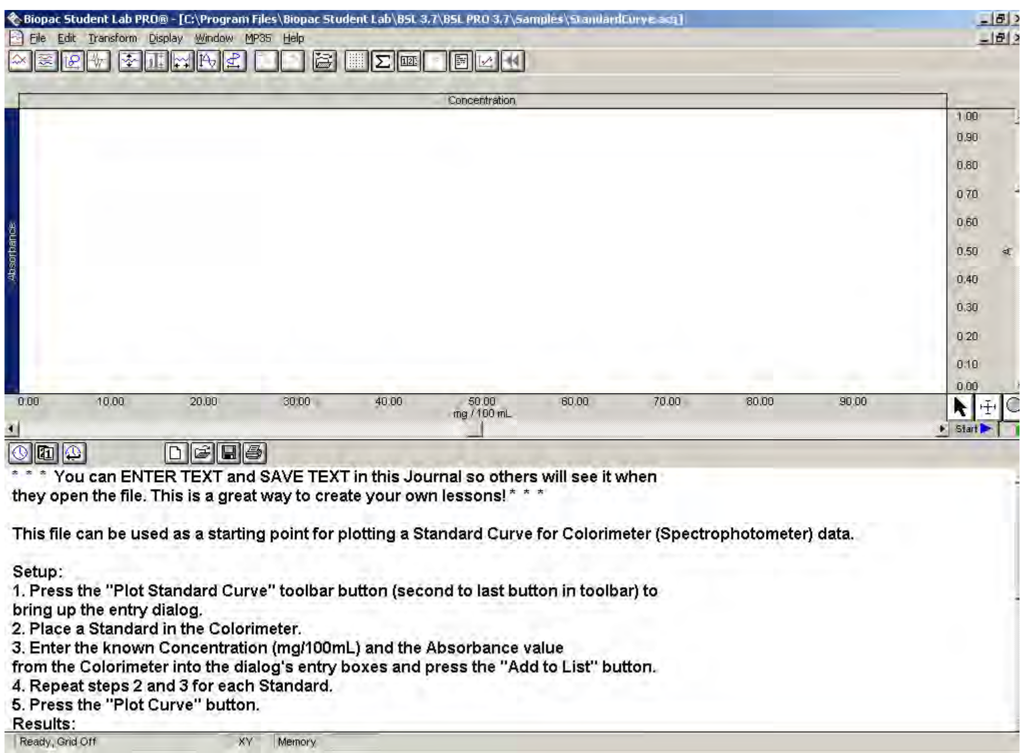
One graph template (.gtl) file is installed with BSL PRO. See page 174 for a discussion of graph templates.

You must select **"Files of type Graph Template"** *to select this file"*

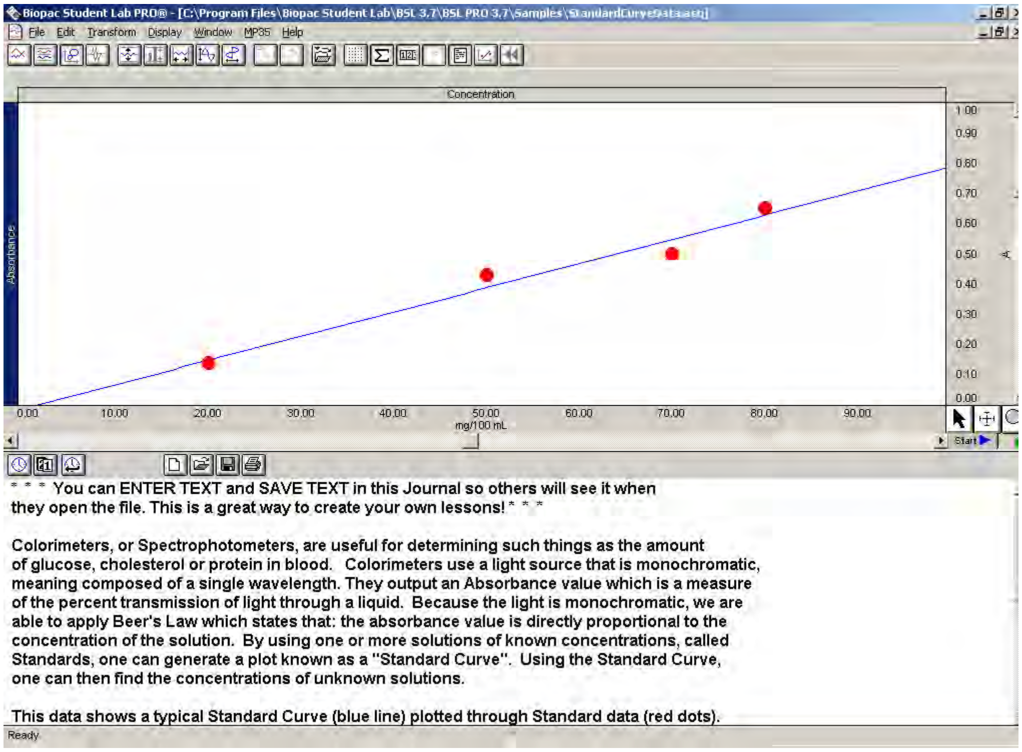
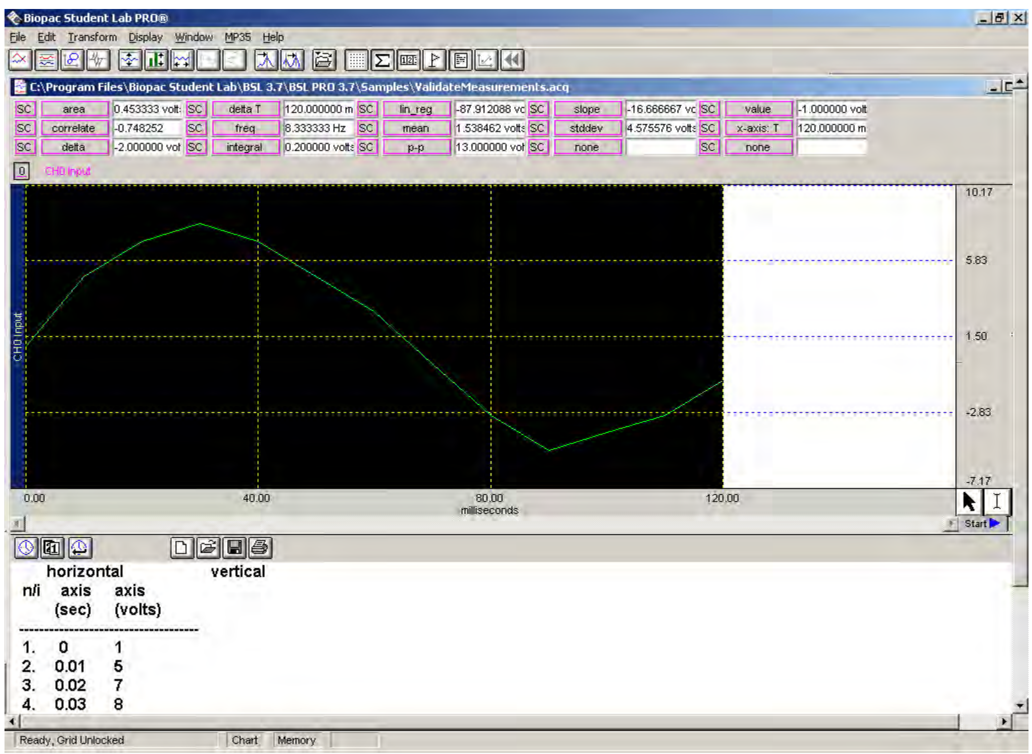




<table>
<tr><th>Data file name</th><th>Screen Shot</th></tr>
<tr><td>NerveConduction .acq</td><td>


</td></tr>
<tr><td>StandardCurve.acq</td><td>


</td></tr>
</table>

Data file name	Screen Shot
StandardCurveData .acq	
ValidateMeasure- ments.acq	

Appendix B — Table of Analog Presets for MP35 (Preset parameters may differ slightly for MP30)

Notes

* Notch Filter is either 50 Hz or 60 Hz as determined by the Line Frequency specified when the BSL *PRO* software was installed. It is used to filter out the interference signal introduced from electrical power sources.

** The transducer must be calibrated before the recording begins. Typically this involves using the “scaling” dialog (accessible via MP35/30 > Setup Channels > View/Change Parameters > Scaling…), but more involved calibration may be required. Refer to the *BSL Hardware Guide* or Application Notes available on the BIOPAC Web Site (www.biopac.com).

The Band Stop Frequency will be 50 Hz or 60 Hz, based on the Line Frequency specified when the BSL *PRO* software was installed.

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Default	This preset can be used as a starting point when no other preset is applicable or when input amplitude and offset are unknown. It is set to maximum bandwidth, and a low gain allowing one to record and view almost any Physiological signal that falls within a +-50 mV input range. Min. Sample Rate: 2X maximum frequency expected or desired.					
Accelerometer (5 g’s max.) Accelerometer (5 g), 3 CH Use with the BIOPAC SS26L, 0 to 5g, Accelerometer	500	DC 1K LP	BP	11 mV > 1 10 mV > 0	g’s	Calibration required** Min. Sample Rate: 100 S/S
Accelerometer (50 g’s max) Accelerometer (50 g), 3 CH Use with the BIOPAC SS27L, 0 to 50g Accelerometer.	500	DC 1K LP	BP	7.5 mV > 10 6.5 mV > 0	g’s	Calibration required** Min. Sample Rate: 100 S/S
Airflow (SS11LA) Airflow transducer Can be used with the “Lung Volume” Calculation Channel preset to obtain Volume data.	5,000	DC 1K LP	BP	-3000 uV > -10 3000 uV > 10	liters/sec	Min. Sample Rate: 100 S/S
Airflow (SS52L) Airflow (SS52L) SS52L System*:* Airflow (75 kg, exercising adult) <+-8000 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 192.5 mV > 1	liters/sec	
Airflow (small mouse) Airflow (small mouse) SS45L System*:* Airflow (30 gm, small mouse) <+-12 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 1.285 mV > 10	ml/sec	
Airflow (mouse) Airflow (mouse) SS46L System*:* Airflow (50 gm, mouse) <+-20 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 0.770 mV > 10	ml/sec	
Airflow (rat/guinea pig) Airflow (rat/guinea pig) SS47L System*:* Airflow (350 gm, rat/guinea pig) <+-60 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 0.289 mV > 10	ml/sec	
Airflow (cat/rabbit)						

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Airflow (cat/rabbit) SS48L System*:* Airflow (750 gm, cat/rabbit) <+-150 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 1.05 mV > 100	ml/sec	
Airflow (small dog) Airflow (small dog) SS49L System*:* Airflow (5.5 kg, small dog) <+-350 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 0.462 mV > 100	ml/sec	
Airflow (medium dog) Airflow (medium dog) SS50L System*:* Airflow (15 kg, medium dog) <+-1200 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 1.155 mV > 1000	ml/sec	
Airflow (large dog) Airflow (large dog) SS51L System: Airflow (25 kg, large dog) <+-3000 ml/sec.> Airflow	1,000	DC 1K LP	BP	0 mV > 0 0.482 mV > 1000	ml/sec	
Blood Pressure (Arterial) Blood Pressure (Arterial) Use with the SS13L for measuring direct blood pressure in animals. Can be used with several Calculation Presets for real-time recording of heart rate, Systolic, Diastolic, and Mean BP, along with changes in pressure with respect to time (dp/dt).	1,000	DC 1K LP	BP	0 mV > 0 2.5 mV > 100	mmHg	Calibration required** Min. Sample Rate: 100 S/S
Blood Pressure Cuff Blood Pressure Cuff Use with the BIOPAC SS19L, Blood Pressure Cuff.	500	DC 1K LP	BP	0 mV > 0 2.5 mV > 100	mmHg	Calibration required** Min. Sample Rate: 100 S/S
BNC (SS9L, -10 to +10 Volts max. BNC Adapter (for MP30) <divide by 1000> Use when connecting up to external devices using the BIOPAC SS9L BNC adapter. Voltage amplitudes should be greater than +- 1 Volt, and less than +- 10 Volts.	1,000	DC 5K LP	None	-1 mV > -1 1 mV > 1	Volts	Min. Sample Rate: At least 2X highest frequency of interest
BNC (SS9L, -50 to +50 Volts max.) BNC Adapter (for MP30) Use when connecting up to external devices using the BIOPAC SS9L BNC adapter. Voltage amplitudes should be greater than +- 10 Volts, and less than +- 50 Volts.	200	DC 5K LP	None	-1 mV > -1 1 mV > 1	Volts	Min. Sample Rate: At least 2X highest frequency of interest
BNC (SS70L, -10 to +10 Volts max.) BNC Adapter (for MP35), Isolated <divide by 10>	10	DC	None	-1000 mV > -10 1000 mV > 10	Volts	

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Cardiac Output – dZ/dt Cardiac Output – dZ/dt	200	DC 1K LP	BP	0 mV > 0 5 mV > 2	Ohms/sec	
Cardiac Output – Z Cardiac Output – Z Non-Invasive Cardiac Output Module	200	DC 1K LP	BP	0 mV > 0 50 mV > 100	Ohms	
Circuit Probe (Breadboard) Circuit Probe MP3X Circuit Probe and Power Cable for Breadboard	200	DC 5K LP	N/A	-50 mV > -5 50 mV > 5	Volts	
Clench Force (kg) Clench Force Use with the BIOPAC SS25LA Hand Dynamometer.	500	DC 1K LP	BP	0 mV > 0 3.50 mV > 100	kg	Calibration required** Min. Sample Rate: 100 S/S
Clench Force (lbs) Clench Force Use with the BIOPAC SS25LA Hand Dynamometer.	500	DC 1K LP	BP	0 mV > 0 3.50 mV > 220	lbs	Calibration required** Min. Sample Rate: 100 S/S
Clench Force (N) Clench Force (Newtons) Hand Dynamometer Clench Force Use with the BIOPAC SS25LA Hand Dynamometer.	500	DC 1K LP	BP	0 mV > 0 3.50 mV > 981	N	Calibration required** Min. Sample Rate: 100 S/S
CO2 Expired (GASSYS2) GAS - CO_2 (Used on GAS-System2)	200	DC 1K LP	BP	1.027 mV > 0.04 11.02 mV > 1	% CO2	
Current Monitor (BSLCBL10) Current/Voltage Drive & Monitor Cable. (DSUB 9M + DSUB 9F to clip leads)	200	DC 5K LP	None	0 mV > 0 50 mV > 50	micro Amp	
Displacement (cm) Displacement; use with SS14L.	500	DC 1K LP	BP	0 mV > 0 1 mV > 1	cm	
Displacement (inches) Displacement; use with SS14L.	500	DC 1K LP	BP	0 mV > 0 1 mV > .394	inches	
Displacement (AD Inst. DT-475) Displacement	500	DC 1K LP	BP	0 mV > 0 9 mV > 1	inches	
Dissolved O_2 (BSL-TCI16) Dissolved O_2 using BIOPAC RXPROBE02 and Vernier (BT (RH) connector)	200	DC 1K LP	BP	0 mV > 0 25 mV > 100	% O2	
Earthworm Action Potential Earthworm Action Potential	10,000	AC 5 Hz HP, 5 HP, 5K LP	HP, 50, .707	-10 uV > -10 10 uV > 10	micro V	100,000

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Electrocardiogram (ECG), .05 - 35 Hz Use when recording Human ECG signals using the BIOPAC SS2L Electrode Leads. This preset will preserve more of the ECG component amplitude than the (.5 – 35 Hz) filter, but with more baseline drift. Works well if subject is completely relaxed and motionless. Can be used with the ECG Calculation presets to obtain real time Rate, R-wave amplitude, etc.	2,000 1000	AC .05 HP, 1K LP	BP	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 100 S/S
Electrocardiogram (ECG), .05 - 100 Hz, AHA *American Heart Assoc.* ECG (.05 – 100 Hz, AHA)	2,000 1,000	AC .05 HP, 1K LP	LP, 100, .707	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	
Electrocardiogram (ECG), .05 - 150 Hz ECG (.05 – 150 Hz) Use when recording Human ECG signals using the BIOPAC SS2L Electrode Leads. This preset is mainly used when measuring amplitudes and timing of the components of the ECG. It can only work if the subject is completely relaxed and motionless (no interfering EMG signals), and no power line (50/60 Hz) interference is present.	2,000 1,000	AC .05 HP, 1K LP	LP, 150, .707	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 500 S/S
Electrocardiogram (ECG), .5 - 35 Hz ECG (.5 – 35 Hz) Electrode Cable with 3 Leads Use when recording Human ECG signals using the BIOPAC SS2L Electrode Leads. This preset will give a clean recording with minimal baseline drift, however the components of the ECG may have a slight reduction in amplitude due to the added filters. Can be used with the ECG Calculation presets to obtain real time Rate, R-wave amplitude, etc. Additional Calculation Channel Presets can be created to filter out unwanted EMG interference.	2,000 1,000	AC .5 HP, 1K LP	BP	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 100 S/S
Electrodermal Activity (EDA), 0 - 35 Hz EDA (0 – 35 Hz) EDA (GSR) finger electrodes EDA (GSR) with electrode pinch leads: Use any Preset from SS3LA Use when recordingelectrodeermal activaty/ Galvanic Skin Response(GSR) using the BIOPAC SS3LA transducer. Changing baseline may be make this preset hard to work with. If only changes in the GSR are desired, use the “EDA (GSR) Change” preset.	2,000	DC 1K LP	BP	0 uV > 0 1000 uV > 10	micro Mho	Calibration required** Min. Sample Rate: 100 S/S

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Electrodermal Activity (EDA) Change EDA Change Use when recording changes in the elecrtodeermal activity (EDA/GSR) using the BIOPAC SS3LA transducer. Baseline drift is minimized with the .05 Hz High Pass Filter.	5,000	AC .05 HP, 1K LP	BP	0 uV > 0 1000 uV > 10	delta micro Mho	Calibration required** Min. Sample Rate: 100 S/S
Electroencephalogram (EEG), .5 - 35 Hz EEG (.5 – 35 Hz) Use when recording Human EEG signals using the BIOPAC SS2L Electrode Leads. Can be used with the EEG Calculation presets (alpha, beta, delta, and theta) to extract the specific EEG frequency bands.	25,000 20,000	AC .5 HP, 1K LP	BP	-10 uV > -10 10 uV > 10	micro V	Min. Sample Rate: 100 S/S
Electroencephalogram (EEG), .5 - 100 Hz w/notch EEG (.5 - 100 Hz, w/notch) Note: This bandwidth is needed for extracting the gamma frequency band using the calculation channel preset: EEG gamma (30 - 90 Hz).	25,000 20,000	AC .5 HP, 1K LP	LP, 100, .707 BSLF	-10 uV > -10 10 uV > 10	micro V	
Electrogastrogram (EGG) EGG	5,000	DC	BP	-1000 uV > -1 1000 uV > 1	mV	
Electromyogram (EMG), 5 - 250 Hz w/notch EMG (5 – 250 Hz w/notch)	1,000	AC 5 HP	LP, 250, .707 BSLF	-1 mV > -1 1 mV > 1	mV	
Electromyogram (EMG), 5 - 500 Hz EMG (5 – 500 Hz)	1,000	AC 5 HP	LP, 500, .707	-1 mV > -1 1 mV > 1	mV	
Electromyogram (EMG), 5 - 1000 Hz EMG (5 – 1000 Hz)	1,000	AC 5 HP	LP, 1000, .707	-1 mV > -1 1 mV > 1	mV	
Electromyogram (EMG), 30 - 250 Hz w/notch EMG (30 – 250 Hz w/notch) Use when recording general EMG signals using the BIOPAC SS2L Electrode Leads. Bandwidth is limited to 250Hz so that a sample rate of 500 S/S can be used. Notch filter is added to minimize electrical interference, but may distort the EMG signal. Can be used with the EMG Calculation Channel presets to obtain “Integrated” or “RMS” data.	2,000 1,000	AC .5 HP, 5 Hz, 1K LP	HP, 30, .707 LP, 250, .707 BSLF	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 500 S/S

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Electromyogram (EMG), 30 - 500 Hz EMG (30 – 500 Hz) Use when recording EMG signals using the BIOPAC SS2L Electrode Leads. This preset will give maximum EMG accuracy, but will require a high sample rate. No Notch filter is added so electrical interference may pose a problem. Can be used with the EMG Calculation Channel presets to obtain "Integrated" or "RMS" data.	2,000 1,000	AC .5 HP, 5 HP, 1K LP	HP, 30, .707 LP, 500, .707	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 2000 S/S
Electromyogram (EMG), 30 - 1000 Hz EMG (30 – 1000 Hz)	2,000 1,000	AC .5 HP, 5 HP, 5K LP	HP, 30, .707 LP, 1000, .707	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	
Electrooculogram (EOG), .05 - 35 Hz EOG (.05 – 35 Hz) Use when recording EOG (eye movement) signals using the BIOPAC SS2L Electrode Leads.	2,000 1,000	AC .05 HP, 1K LP	BP	-1000 uV > -1 1000 uV > 1 -1 mV > -1 1 mV > 1	mV	Min. Sample Rate: 100 S/S
Finger Displacement (cm) Finger Displacement	2,000	DC 1K LP	BP	0 uV > 0 300 uV > 8.89	cm	
Finger Twitch transducer Finger Displacement (inches) Finger Displacement	2,000	DC 1K LP	BP	0 uV > 0 300 uV > 3.5	inches	
Force (0 – 50 grams) Force Use with the BIOPAC SS12L, Variable Range Force Transducer.	500	DC 1K LP	BP	0 mV > 0 5 mV > 50	grams	Calibration required**
Force (0 – 100 grams) Force Use with the BIOPAC SS12L, Variable Range Force Transducer.	500	DC 1K LP	BP	0 mV > 0 5 mV > 100	grams	Calibration required**
Force (0 – 200 grams) Force Use with the BIOPAC SS12L, Variable Range Force Transducer.	500	DC 1K LP	BP	0 mV > 0 5 mV > 200	grams	Calibration required**
Force (0 – 500 grams) Force Use with the BIOPAC SS12L, Variable Range Force Transducer.	500	DC 1K LP	BP	0 mV > 0 5 mV > 500	grams	Calibration required**
Force (0 – 1000 grams) Force Use with the BIOPAC SS12L, Variable Range Force Transducer.	500	DC 1K LP	BP	0 mV > 0 5 mV > 1000	grams	Calibration required**
Force (iWorx FT-100) Force measurment using WPI, AD Instruments (CB Sciences) and iWorx (8 pin, Female)	1,000	DC 1K LP	BP	0 mV > 0 2.5 mV > 250	grams	
Galvanic Skin response – GSR *See* Electrdermal Activity – EDA						

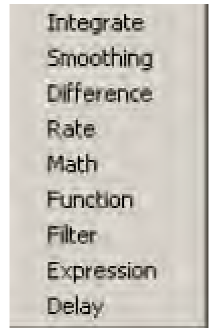
Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Goniometer Goniometer (110 mm max.), 2 CH Wrist or ankle, +- 180º Use with the BIOPAC SS20L, SS21L and SS24L Goniometers.	2,000	DC 1K LP	BP	-2250 uV > -90 2250 uV > 90	degrees	Calibration required** Min. Sample Rate: 100 S/S
Goniometer (Intelitool - Flexicomp) Goniometery measurement using Intelitool (6 pin mini DIN, Female)	200	DC 1K LP	BP	0 mV > 90 5 mV > 150	degrees	
Heel/Toe Strike Heel/Toe Strike assembly	1,000	DC 1K LP	BP	-5 mV > -1 5 mV > 1	Impulse	
Microphone (SS17L, .5 – 200 Hz) Microphone Piezo Microphone Use with the BIOPAC SS17L Microphone to record Physiological Sounds (such as heart and Korotkoff sounds).	200	AC .5 HP, 1K LP	LP, 200, .707	-10 mV > -10 10 mV > 10	mV	Min. Sample Rate: 500 S/S
Microphone for Speech (SS62L) Microphone	200	AC 5 HP	HP, 30, .707 LP, 3500, .707	-10 mV > -10 10 mV > 10	mV	10,000
MP100/150 Interface (BSLCBL14) MP100/150 Interface	10	DC	None	-1000 mV > -10 1000 mV > 10	Volts	
Nerve Response (BSLCBL3, 4, 9) Nerve Response Nerve Conduction Recording Cable (DSUB 9M to 3x Banana Plugs) <divide by 10> Input Range (MP30) = +-700 mV Input Range (MP35) = +-10 Volts	2,000 1,000	AC .5 HP, 5K LP	None	-1000 uV > -10 1000 uV > 10 -1 mV > -10 1 mV > 10	mV	100,000
Nerve Response (BSLCBL8) Nerve Response High Impedance Cable						
O2 Expired (GASSYS2) O2 Expired GAS - O_2 (Used on GAS-System2)	200	DC 1K LP	BP	0 mV > 0 20.64 mV > 20.93	% O2	
pH (BSL-TCI21) pH pH Probe (Generic, BNC style) use with RXPROBE01)	200	DC 1K LP	BP	0 mV > 7 35 mV > 14	pH	
Pneumogram Pneumogram transducer SS67L = SS41L + RX110 + tubing	500	DC 1K LP	BP	0 mV > 0 6.55 mV > 10	cm H2O	
Pressure (+- 2.5 cm H2O) Pressure SS40L Diff. Pressure Transducer +-2.5 cm H20	1,000	DC 1K LP	BP	0 mV > 0 1.638 mV > 1	cm H2O	

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Pressure (+- 12.5 cm H2O) Pressure SS41L Diff. Pressure Transducer +-12.5 cm H20	500	DC 1K LP	BP	0 mV > 0 0.655 mV > 1	cm H2O	
Pressure (+- 25 cm H2O) Pressure SS42L Diff. Pressure Transducer +-25 cm H20	500	DC 1K LP	BP	0 mV > 0 0.327 mV > 1	cm H2O	
Psychological Response Psych. Response Indicator SS43L Variable Asessment Transducer	200	DC 1K LP	BP	0 mV > 0 50 mV > 9	Response	
Pulse Plethysmograph (PPG) PPG (Pulse) Use with the BIOPAC SS4L Pulse Plethysmograph (PPG) finger transducer to record variations in blood density. Can be used with the “Pulse Rate” Calculation Channel preset to obtain real time pulse rate data.	5,000	AC .5 HP, 1K LP	BP	-1000 uV > -1 1000 uV > 1	mV	Min. Sample Rate: 100 S/S
Reflex Hammer Reflex hammer strike SS36L Reflex Hammer	2,000	DC 1K LP	BP	-1000 uV > -1 1000 uV > 1	mV	
Reflex Hammer (Intelitool - Flexicomp) Reflex Hammer	200	DC 5K LP	N/A	-10 mV > -10 10 mV > 10	mV	
Respiration (SS5LB) Respiration Belt (for Chest), Version 3 Respiration Use with the BIOPAC SS5LB Respiratory Effort Transducer to record changes in thoracic or abdominal circumference. The .05 Hz High Pass filter helps to minimize baseline drift. Can be used with the “Respiration Rate” Calculation Channel preset to obtain real time rate data.	1,000	AC .05 HP, 1K LP	BP	-10 mV > -10 10 mV > 10	mV	Min. Sample Rate: 100 S/S
Stethoscope (Heart Sounds) Stethoscope Use with the BIOPAC SS30L electronic Stethoscope for recording Heart Sounds.	2,000	AC .5 HP, 5 HP, 1K LP	HP, 40, .707 LP, 60, .707	-1000 uV > -1 1000 uV > 1	mV	Min. Sample Rate: 200 S/S
Stethoscope (Korotkoff Sounds) Stethoscope Normally used with the BIOPAC SS19L for recording and determining Systolic and Diastolic Blood Pressure.	2,000	AC .5 HP, 5 HP, 1K LP	HP, 50, .707 LP, 100, .707	-1000 uV > -1 1000 uV > 1	mV	Min. Sample Rate: 200 S/S

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Stimulator - BSLSTM (0 – 10 Volts) Stimulator Stimulator Reference cable from BSLSTMA or BSLSTMB(MP35 only) Use for recording the "Reference Output" Pulse of the BIOPAC BSLSTMA Stimulator. This preset is used when the Range switch on the front of the BSLSTM is in the "0-10V" position. The amplitude of the pulse reflects the Stimulator output voltage. Note that there will be some overshoot on the leading edge of the pulse. If this is not desirable, then change the Analog Filter to 1KHz.	200	DC 5K LP	None	0 mV > 0 50 mV > 10	Volts	Calibration: optional to obtain greater accuracy. Min. Sample Rate: 200 S/S
Stimulator - BSLSTM (0 – 100 Volts) Stimulator Use for recording the "Reference Output" Pulse of the BIOPAC BSLSTM Stimulator. This preset is used when the Range switch on the front of the BSLSTM is in the "0-100V" position. The amplitude of the pulse reflects the Stimulator output voltage. Note that there will be some overshoot on the leading edge of the pulse. If this is not desirable, then change the Analog Filter to 1KHz.	200	DC 5K LP	None	0 mV > 0 50 mV > 100	Volts	Calibration: optional to obtain greater accuracy. Min. Sample Rate: 200 S/S
Stroboscope Flash (TSD122) Stroboscope Flash	200	DC 5K LP	None	-50 mV > -10 50 mV > 10	Volts	
SuperLab Sync. (SS44L) SuperLab Interface Cable for MP30 SuperLab Sync. Note: Superlab interface assembly for MP35 (consists of 1-SS59L; see BNC SS9L preset)	200	DC 1K LP	None	0 mV > 0 25 mV > 5	Volts	
Switch Pushbutton Switch Use when recording Pushbutton Switch State using BIOPAC SS10L PushButton HandSwitch. This is useful for Response testing, etc.	1,000	DC 1K LP	LP, 30, .707 BSLF	-1 mV > -1 1 mV > 1	Volts	Min. Sample Rate: 200 S/S
Temperature (deg. C) Temperature Skin Temperature (fast response) Response time = .6 seconds Use when recording Skin Temperature in degrees Celsius using the BIOPAC SS6L Temperature Transducer. Calibration required**	2,000	DC 1K LP	BP	0 uV > 32.22 1000 uV > 35	deg C	Min. Sample Rate: 100 S/S

Analog Preset Name Channel Label Applicable Calc. Presets	**Gain X**	**Hardware Filters** AC or DC .05 or .5 HP 1K or 5K LP	**IIR Filters** Type, Freq., Q	**Scaling (Mapping)**	**Units label**	**Recommended Calibration & Sample Rate** (Samples/sec)
Temperature (deg. F) Temperature Use when recording Skin Temperature in degrees Fahrenheit using the BIOPAC SS6L Temperature Transducer. Calibration required**	2,000	DC 1K LP	BP	0 uV > 90 1000 uV > 95	deg F	Min. Sample Rate: 100 S/S
Temperature (waterproof, vinyl) Response time = 1.1 seconds *Use any preset from SS6L*	-	-	-	-	-	
Temperature Change (deg. C) Temperature Change Use when recording Skin Temperature changes in degrees Celsius using the BIOPAC SS6L Temperature Transducer. Because only the skin temperature difference is important, calibration to obtain absolute temperature is not required.	2,000	AC .05 HP, 1K LP	BP	0 uV > 0 1000 uV > 2.78	delta deg C	Min. Sample Rate: 100 S/S
Temperature Change (deg. F) Temperature Change Use when recording Skin Temperature changes in degrees Fahrenheit using the BIOPAC SS6L Temperature Transducer. Because only the skin temperature difference is important, calibration to obtain absolute temperature is not required.	2,000	AC .05 HP, 1K LP	BP	0 uV > 0 1000 uV > 5	delta deg F	Min. Sample Rate: 100 S/S
Tobacco Hornworm (BSLCBL8) Tobacco Hornworm	10,000	AC .5 HP, 5 HP, 1K LP	HP, 10, .707 LP, 250, .707 BSLF HP, 30, .707 LP, 250, .707 BSLF	-10 uV > -10 10 uV > 10	micro V	
Torsiometer Torsiometer (110 mm max.), 1 CHI Neck, +- 90° Use with the BIOPAC SS22L and SS23L Torsiometers.	2,000	DC 1K LP	BP	-2250 uV > -90 2250 uV > 90	degrees	Calibration required** Min. Sample Rate: 100 S/S

Appendix C — Table of Calculation Presets

Calculation Preset Name; Label; Source CH	**Calculation Function** Enabled Options; Parameters	**Units label**	**Scaling (Units)**
New		• New calculation channel details start on page 73. • To create a new calculation channel preset, see page 76.	
dp/dt @ 200 samples/sec. dp/dt @ 200 s/s Source: Blood Pressure (Arterial) only when sample rate is 200 s/s Computes the change in pressure with respect to time (derivative of pressure), so it works in conjunction with a pressure source channel. Normally this is used when the pressure source channel is measuring direct blood pressure from animals.	**Difference** Intervals between samples: 1	0 > 0 1 > 200	mmHg/sec
dp/dt @ 500 samples/sec. dp/dt @ 500 s/s Source: Blood Pressure (Arterial) only when sample rate is 500 s/s	**Difference** Intervals between samples: 1	0 > 0 1 > 500	mmHg/sec
dp/dt @ 1000 samples/sec. dp/dt @ 1000 s/s Source: Blood Pressure (Arterial) only when sample rate is 1000 s/s	**Difference** Intervals between samples: 1	0 > 0 1 > 1000	mmHg/sec
ECG – R-R Interval Computes the R wave to next R wave time interval for an ECG source channel. This preset is optimized for Human ECG (40 – 180 BPM range).			
ECG - R-wave Amplitude R Amplitude Source: Any Human ECG preset listed for SS2L. Tracks the R wave amplitude for an ECG source channel. This preset is optimized for Human ECG (40 – 180 BPM range).	**Rate** Function: Peak Maximum Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 180	N/A	mV*
EEG alpha (8 - 13 Hz) Alpha Source: Any Human EEG preset listed for SS2L. Filters out all frequencies except the specific alpha band (8 to 13 Hz), which can indicate relaxed and alert states.	**Filter** Output: Band Pass (l + h) LowFreq: 8, HighFreq: 13 Q: 0.707	N/A	Units of source channel**
EEG beta (13 - 30 Hz) Beta Source: Any Human EEG preset listed for SS2L. Filters out all frequencies except the specific beta band (which is from 13 to 30 Hz). Frequencies in the beta band can indicate levels of alertness and higher amplitudes can occur during deep sleep (REM).	**Filter** Output: Band Pass (l + h) LowFreq: 13, HighFreq: 30 Q: 0.707	N/A	Units of source channel**

Calculation Preset Name; Label; Source CH	**Calculation Function** Enabled Options; Parameters	**Units label**	**Scaling (Units)**
EEG delta (0.5 - 4 Hz) Delta Source: Any Human EEG preset listed for SS2L. Filters out all frequencies except the specified delta band (from 0.5 to 4 Hz). Frequencies in the delta band are often of higher amplitude when a subject is sleeping.	**Filter** Output: Band Pass (low + high) LowFreq: 0.5, HighFreq: 4 Q: 0.707	N/A	Units of source channel**
EEG theta (4 - 8 Hz) Theta Source: Any Human EEG preset listed for SS2L. Filters out all frequencies except the specific theta band (which is from 4 to 8 Hz). Frequencies in the theta band are often of higher amplitude when a subject is sleeping.	**Filter** Output: Band Pass (low + high) LowFreq: 4, HighFreq: 8 Q: 0.707	N/A	Units of source channel**
EEG gamma (30 - 90 Hz) Gamma Source: Requires the higher bandwidth (Electroencephalogram (EEG), .5 - 100 Hz w/notch) preset.	**Filter** Output: Band Pass (low + high) LowFreq: 30, HighFreq: 90 Q: 0.707	N/A	Units of source channel**
EGG (.02 - 125 Hz) EGG (.02 - .125 Hz) EGG Source: Any Human EGG preset listed for SS2L.	**Filter** Band Pass (low+high) LowFreq: 0.02 HighFreq: 0.125 Q: 0.707	N/A	Units of source channel**
EMG - Integrated (estimate) Integrated (est.) Source: Any Human EMG preset listed for SS2L. Used as an indication of the EMG output level. Each data point of Integrated EMG is calculated using 20 samples of data from the EMG source channel. Each data point used is first Rectified (all negative values are inverted), then the Mean value is computed. *Note*: The algorithm performs an average rectified value (AVR) to approximate an integration.	**Integrate Parameters** Average over samples Samples: 20 Parameters: Rectify	-10000 > -10 10000 > 10	mV
EMG - RMS EMG – RMS Source: Any Human EMG preset listed for SS2L. Used to measure the Standard Deviation of an EMG signal, which is an excellent way to compare EMG output levels. Any baseline information is removed from the data. Each sample point of RMS data is calculated using 20 samples of data from the EMG source channel. The baseline value is first determined, then each computed difference between data point and baseline is squared and summed. The square root of this sum is then determined.	**Integrate Parameters** Average over samples Samples: 20 Parameters: Root mean square, Remove baseline	-10000 > -10 10000 > 10	mV
Heart Rate (from ECG) Heart Rate Source: Any Human ECG preset listed for SS2L. Computes the Heart Rate in beats per minute (BPM) for an ECG source channel. It computes BPM based on the R wave to next R wave interval. This preset is optimized for Human ECG (40 – 180 BPM range). *Note*: When recording starts, the data displayed will not be accurate until the second R wave is obtained.	**Rate** Function: Rate (BPM) Peak detect: Positive Remove baseline Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 180	N/A	BPM*

Calculation Preset Name; Label; Source CH	**Calculation Function** Enabled Options; Parameters	**Units label**	**Scaling (Units)**
Large Animal dp/dt Minimum dp/dt Min. Source Channel: "dp/dt @ # samples/sec." calculation channel. Tracks the minimum value for the dp/dt source channel, giving one the minimum change in pressure with respect to time (derivative of pressure).	**Rate** Function: Peak Minimum Peak detect: Negative Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	mmHg/sec*
Large Animal dp/dt Maximum dp/dt Max. Source Channel: "dp/dt @ # samples/sec." calculation channel. Tracks the maximum value for the dp/dt source channel, giving one the maximum change in pressure with respect to time (derivative of pressure).	**Rate** Function: Peak Maximum Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	mmHg/sec*
Large Animal Systolic Blood Pressure (BP) Systolic BP Source: Blood Pressure (Arterial) Tracks the Systolic Blood Pressure (or maximum pressure), of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 40 – 250 beats per minute range.	**Rate** Function: Peak Maximum Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	mmHg*
Large Animal Diastolic Blood Pressure (BP) Diastolic BP Source: Blood Pressure (Arterial) Tracks the Diastolic Blood Pressure (or minimum pressure), of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 40 – 250 beats per minute range.	**Rate** Function: Peak Minimum Peak detect: Negative Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	mmHg*
Large Animal Mean Blood Pressure (BP) Mean BP Source: Blood Pressure (Arterial) Tracks the Mean Blood Pressure pressure of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 40 – 250 beats per minute range.	**Rate** Function: Mean Value Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	mmHg*
Large Animal Heart Rate (from ECG) Heart Rate Source: Any of the human ECG Presets can be used. Computes the Heart Rate in beats per minute (BPM) for an ECG source channel. It computes BPM based on the R wave to next R wave interval. This preset is optimized for large animals with a heart rate in the 40 – 250 beats per minute range. *Note*: When the recording starts, the data displayed will not be accurate until the second R wave is obtained.	**Rate** Function: Rate (BPM) Peak detect: Positive Remove baseline Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 250	N/A	BPM*

Calculation Preset Name; Label; Source CH	**Calculation Function** Enabled Options; Parameters	**Units label**	**Scaling (Units)**
Lung Volume Volume Source: Airflow (SS11LA) Computes Volume from an Airflow source channel by using a special form of integration. This calculation is fairly sensitive, and the procedure given in the Manual should be closely followed. Note: Airflow signal must be bidirectional (Inhales and Exhales) in order for this preset channel to work properly.	**Integrate Parameters** Reset via channel Control Channel: Reset thresholds LOW 0.00000 HIGH 0.00000 Reset trigger: Positive	-10000 > -10 10000 > 10	Liters
Pulse Rate (from PPG) Pulse Rate Source: Human Pulse (PPG) Computes the Pulse Rate in beats per minute (BPM) for a PPG (Pulse) source channel. It computes BPM based on the peak to next peak interval. This preset is optimized for Human pulse rates that fall in the 40 – 180 BPM range. *Note*: The data displayed will not be accurate until the second peak is recorded.	**Rate** Function: Rate (BPM) Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 180	N/A	BPM*
Respiration Rate Source: Respiration Respiration Transducer (SS5LB) Airflow (SS11LA) Airflow (SS52L) Pneumogram Pressure (+- 25 cm H2O) Or, if the sensor is placed at the nostril to measure air temperature: Temperature (deg. C) or Temperature (deg. F) Computes the Respiration Rate in breaths per minute (BPM) for a Respiration source channel. It computes BPM based on the peak to next peak interval. This preset is optimized for Human respiration rates that fall in the 6 – 20 BPM range. *Note*: The data displayed will not be accurate until the second peak is recorded.	**Rate** Function: Rate (BPM) Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 6 Max: 20	N/A	BPM*
Small Animal dp/dt Minimum dp/dt Min. Source Channel: “dp/dt @ # samples/sec.” calculation channel Tracks the minimum value for the dp/dt source channel, giving one the minimum change in pressure with respect to time (derivative of pressure).	**Rate** Function: Peak Minimum Peak detect: Negative Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	mmHg/sec*
Small Animal dp/dt Maximum dp/dt Max. Source Channel: “dp/dt @ # samples/sec.” calculation channel Tracks the maximum value for the dp/dt source channel, giving one the maximum change in pressure with respect to time (derivative of pressure).	**Rate** Function: Peak Maximum Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	mmHg/sec*

Calculation Preset Name; Label; Source CH	**Calculation Function** Enabled Options; Parameters	**Units label**	**Scaling (Units)**
Small Animal Systolic Blood Pressure (BP) Systolic BP Source: Blood Pressure (Arterial) Tracks the Systolic Blood Pressure (or maximum pressure), of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 100 – 600 beat per minute range.	**Rate** Function: Peak Maximum Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	mmHg*
Small Animal Diastolic Blood Pressure (BP) Diastolic BP Source: Blood Pressure (Arterial) Tracks the Diastolic Blood Pressure (or minimum pressure), of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 100 –600 beat per minute range.	**Rate** Function: Peak Minimum Peak detect: Negative Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	mmHg*
Small Animal Mean Blood Pressure (BP) Mean BP Source: Blood Pressure (Arterial) Tracks the Mean Blood Pressure pressure of a direct blood pressure source channel. This preset is optimized for animals with a heart rate in the 100 – 600 beat per minute range.	**Rate** Function: Mean Value Peak detect: Positive Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	mmHg*
Small Animal Heart Rate (from ECG) Heart Rate Source: Any of the human ECG Presets can be used. ECG (100 – 600 BPM range) Computes the Heart Rate in beats per minute (BPM) for an ECG source channel. It computes BPM based on the R wave to next R wave interval. This preset is optimized for small animals with a heart rate in the 100 – 600 beat per minute range. *Note*: When recording starts, the data displayed will not be accurate until the second R wave is obtained.	**Rate** Function: Rate (BPM) Peak detect: Positive Remove baseline Auto threshold detect Noise rejection: 5% of peak Window: Windowing Units: BPM Min: 40 Max: 600	N/A	BPM*

Scaling (Units) Notes

* The units shown will not necessarily be seen in the Change Scaling Parameters dialog. They will be inserted automatically at the start of the first acquisition segment.

** The units will be the same as the source channel units, but may not be reflected in the Change Scaling Parameters dialog.

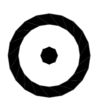
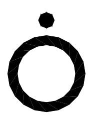
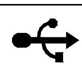
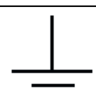
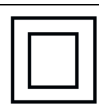
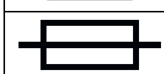
Appendix D — MP35/30 Specifications

MP35/30 ACQUISITION UNIT

The MP35/30 data acquisition unit is the heart of the Biopac Student Lab *PRO* System. The MP35/30 has an internal microprocessor to control data acquisition and communication with the computer. The MP35/30 unit takes incoming signals and converts them into digital signals that can be processed with your computer. There are four analog input channels, one of which can be used as a trigger input. You will need to connect the MP35/30 to your computer and connect electrodes, transducers, and I/O devices to the MP35/30. You are encouraged to take a few minutes to familiarize yourself with the MP35/30 prior to making any connections.

The MP35 Data Acquisition System is a physiological data recorder designed for medical educational purposes. This system is used in medical education and research facilities. This system is not used for the mitigation, cure or diagnosis of disease. This device is NOT used in the home. Subject to IEC60601-1, the MP35 Data Acquisition System is CLASS II, type BF equipment.

SYMBOLS — MP35

Symbol	Description	Explanation
	**Type BF Equipment**	Classification
	**Attention**	Consult accompanying documents
	**On** (partial)	Turns MP35 on assuming AC300A power adapter is powered by the mains
	**Off** (partial)	Turns MP35 off if but AC300A power adapter remains powered by the mains
	Direct current	Direct current input
	**USB**	USB port
	**Functional Earth Ground**	Functional Earth Ground Connection
	**Class II Equipment**	Class II Medical Equipment, as established by IEC60601-1
	**Fuse**	Equipment Fuse

COMPLIANCE

SAFETY

The MP35 satisfies the Medical Safety Test Standards affiliated with IEC60601-1. The MP35 is designated as Class I Type BF medical equipment

EMC

The MP35 satisfies the Medical Electromagnetic Compatibility (EMC) Test Standards affiliated with IEC60601-1-2.

TYPES OF INPUT DEVICES

There are three types of devices that connect to the MP35/30: electrodes, transducers, and I/O devices.

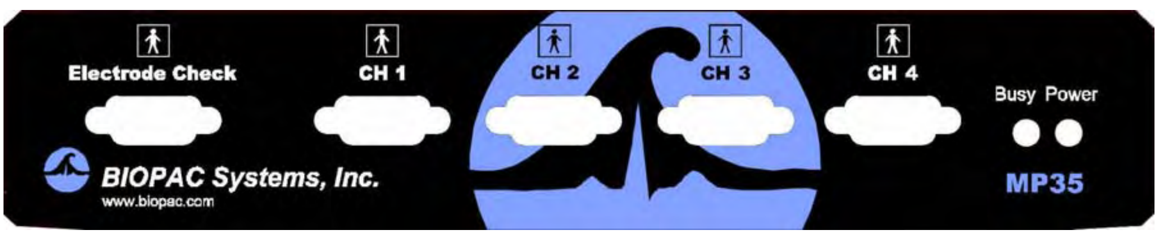
- Electrodes are relatively simple instruments that attach to the surface of the skin and pick up electrical signals in the body.
- Transducers, on the other hand, convert a physical signal into a proportional electrical signal.
- Input/Output devices (I/O for short) are specialized devices like pushbutton switches and headphones.

SIMPLE SENSOR CONNECTORS

Regardless of the type of device connected, every sensor or I/O device connects to the MP35/30 using a "Simple Sensor" connector. Simple Sensor connectors are designed to plugs only one way into the MP35/30, so you don't have to worry about plugging things in upside down or into the wrong socket.

- Electrodes, transducers, and the pushbutton switch all connect to the channel input ports on the front panel of the MP35/30.
- Headphones and the stimulator connect to the "Analog out" port on the back panel of the MP35/30.
- MP35 only: A digital device may connect to the "I/O Port" on the back panel
- MP35 only: A trigger device may be connected to the "Trigger" port on the back panel.

FRONT PANEL



Front Panel, MP35

The front panel of the MP35/30 has an electrode check port, four analog input ports, and two status indicators.

Electrode Check

- The Electrode Check port is a diagnostic tool used with the BSL *PRO* software to determine if the electrodes are properly attached to the subject. See page 143.

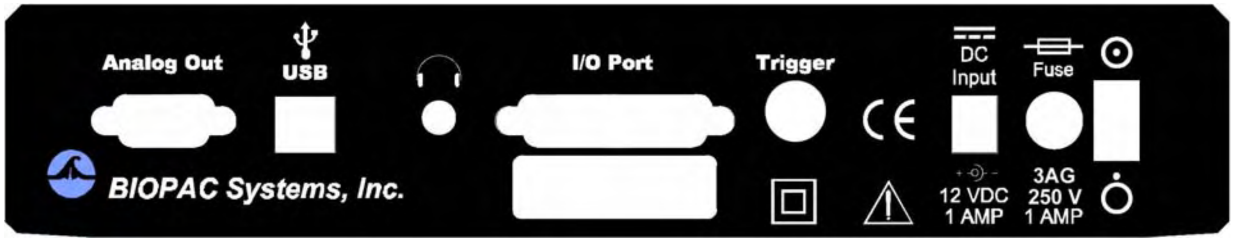
Input ports: CH 1, CH 2, CH 3, and CH 4

- The inputs on the MP35/30 acquisition unit are referred to as Channels. There are four 9-pin female analog input ports on the front of the MP35/30. The Biopac Student Lab Lessons software will always check to see that you have the proper sensors connected to the appropriate channel.

Status indicators

- The Busy status indicator is activated when the MP35/30 is acquiring data and also during the first few seconds after the MP35/30 is powered on to indicate that a self-test is in progress. (When the MP35/30 passes the power-on test, the Busy light will turn off.)
- The Power status indicator is illuminated when the MP35/30 is turned on.

BACK PANEL



Back Panel, MP35

The back panel of the MP35 has an analog output port, a USB port, an I/O Port, a Trigger Port, a DC input, a fuse holder, and a power switch, and the unit's serial number.

The back panel of the MP30 has an analog output port, a serial port, a DC input, a fuse holder, and a power switch, and the unit's serial number.

Analog Out port

There is one 9-pin male "D" analog output port on the back of the MP35/30 that allows signals to be amplified and sent out to devices such as headphones.

USB port (MP35 only)

The MP35 connects to the computer via a USB Port, located just below the word USB.

- Uses a standard USB connector.
- Should only be used to connect the MP30 to a PC or Macintosh.

Serial port (MP30 only)

The MP30 connects to the computer via a serial port, located just below the word Serial.

- Uses a standard MINI DIN 8 connector.
- Should only be used to connect the MP30 to a PC (with ISA or PCMCIA card) or Macintosh.

Headphone Output (MP35 only)

- Accepts a standard (1/4" or 6.3mm) stereo headphone jack.

I/O Port (MP35 only)

- Accepts a DB 25 Female connector.
- Input/Output port used to connect digital devices to the MP35.

Trigger Input (MP35 only)

- Accepts a male BNC connector.
- Input port used to send trigger signals from another device to the MP35.
- Used to synchronize MP35 units when more than one MP35 is used.

DC Input

Use the DC Input to connect an AC300A power adapter or BAT100 battery to the MP35. Use the DC Input to connect an AC100A power adapter or BAT100 battery to the MP30.

- The power supply requirements for the MP35/30 are 12 VDC @ 1 Amp. Only use the AC300A power adapter with the MP35. The AC300A is a 12 VDC @ 1.25 Amp power supply adapter that can connect to any mains rated as 100-250 VAC @ 50/60Hz, 40VA.
- The receptacle is configured to accept a "+" (positive) input in the center of the connector and a "-" (negative) input on the connector housing.
- The functional earth ground on the AC300A Power Adapter is tied to Mains earth ground and accessible metal parts on the MP35 unit.
- The AC300A power adapter is Class II and when it is used to power the MP35, the MP35/AC300A combination is Class II. The MP35 unit also incorporates an additional level of isolation between the AC300A power adapter and the Subject.

Fuse holder

The fuse holder contains a fast-blow fuse that helps protect the MP35/30 from shorts on its power, analog, and digital I/O lines. The MP35 uses a 1.0 A, 250 V, 3AG, fast-blow fuse and the MP30 uses a 2.0 A, 250 V, 3AG, fast-blow fuse.

- To remove the fuse, use a screwdriver to remove the fuse cover located below the word Fuse.

Power switch

- ON position — powers up the MP35/30
- OFF position — cuts the flow of power to the MP35/30

MAINS POWER DISCONNECTION

To completely disconnect the MP35 unit and the AC300A power adapter from all poles of the supply mains, extract the power cord plug from the mains outlet. Extract the plug by grasping the plastic shell of the plug and pull firmly away from the mains outlet in a direction perpendicular to the face of the mains outlet. Take care not to touch the metal blades associated with the plug. This procedure will fully power down (de-energize) the MP35 unit and AC300A power adapter. Please note that the power switch on the back of the MP35 unit turns power ON and OFF to the MP35 unit only.

CLEANING PROCEDURES

Be sure to unplug the power supply from the MP35/30 before cleaning. To clean the MP35/30, use a damp, soft cloth. Abrasive cleaners are not recommended as they might damage the housing. Do not immerse the MP35/30 or any of its components in water (or any other fluid) or expose to extreme temperatures as this can damage the unit.

Sterilization and Disinfection

Disposable, sterile, single-use-only, accessories are used with the MP35 for educational (teaching) applications. Non-disposable accessories can be disinfected, if required, with Cidex® or equivalent.

Specifications

SAFETY NOTE

BIOPAC Systems, Inc. instrumentation is designed for educational and research oriented life science investigations. BIOPAC Systems, Inc. does not condone the use of its instruments for clinical medical applications.

Instruments, components, and accessories provided by BIOPAC Systems, Inc. are not intended for the cure, mitigation, treatment, or prevention of disease.

The MP35/30 is an electrically isolated data acquisition unit, designed for biophysical measurements.

Exercise extreme caution when applying electrodes and taking bioelectric measurements while using the Biopac Student Lab with other external equipment that also uses electrodes or transducers that may make electrical contact with the Subject.

Always assume that currents can flow between any electrodes or electrical contact points. In case of equipment failure, it is very important that significant currents are not allowed to pass through the heart.

If electrocautery or defibrillation equipment is used, it is recommended that the BIOPAC instrumentation be disconnected from the Subject.

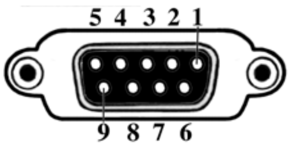
Specification	MP35 Unit	MP30 Unit
Front Panel		
ELECTRODE CHECKER Resistance Range (Vin+ and Vin- to GND)	0-100 KΩ	0-100 KΩ
ANALOG INPUTS Number of channels	4 isolated (front panel CH 1–CH 4), 2 unisolated (auxillary)	4 (front panel CH 1–CH 4)
SAMPLE RATE Maximum Minimum Trigger Input Threshold	 100K samples/second 1 samples/second Analog or digital channel Adjustable threshold; Positive or Negative Trigger	 2K s/s (8K aggregate on four ch.) 1 samples/second CH 4 input only Adjustable threshold; Positive or Negative Threshold
A/D resolution (before digital filtering)	24 bits	10 bits
Signal to noise ratio	> 90 dB (nominal)	> 90 dB
Voltage resolution Gain dependent	1.192 microvolts /bit (Gain 10) to 0.024 nanovolts /bit (Gain 50,000)	0.400 microvolts/bit (Gain 100) to 0.200 millivolts/bit (Gain 25,000)
Input voltage range (Gain dependent)	400 microvolts to 2.0 Volts p-p	4.0 millivolts to 0.2 Volts p-p
Input accuracy	±0.01% of Full Scale Range (FSR)	±0.05% FSR
Input protection; current limited	± 1 mA/V	± 1 mA/V
Maximum Input Voltage (between Vin+ and Vin-)	2V p-p	130mV p-p
Differential Input Impedance (between Vin+ and Vin-)	2 MΩ	2 MΩ
Filters (automatic or user adjustable)	3 two-pole IIR digital filters per channel	3 two-pole IIR digital filters per channel

Specification	MP35 Unit	MP30 Unit
Common Mode Input Impedance (between Vin+/Vin- and GND) DC AC (50/60 Hz)	 11 MΩ 1,000 MΩ	 11 MΩ 1,000 MΩ
Gain ranges (automatic preset or user adjustable)	10 – 50,000	100 – 50,000
Baseline adjustment (automatic or user adjustable)	Gains 10, 20, and 50: ±100mV Gains 100 to 50,000: ±10mV	±10mV all Gains
Electrode offset potential tolerance	Gains 10, 20, and 50: ±2V Gains 100, 200, 500: ±200mV Gains 1,000 to 50,000: ±80mV	±70 mV all Gains
Back Panel		
ANALOG OUTPUT Number of channels D/A resolution Accuracy Output impedance Output voltage Output drive current	 1 12 bits ±0.0125% of FSR 50Ω 0 - 4.096 V ±10 mA maximum	 1 8 bits ±0.2% of FSR 50Ω 0 - 5.000 V ±100 mA maximum
SERIAL INTERFACE Transmission type Transmission rate	 USB Type 2.0 full speed	 RS422-clocked asynchronous 524,000 bits per second (KBPS)
HEADPHONE (MP35 only)	Drives low-impedance standard stereo headphones	N/A – MP35 only
I/O PORT (MP35 only)	8 TTL compatible inputs and 8 TTL compatible outputs	N/A – MP35 only
TRIGGER (MP35 only)	TTL compatible input and synchronization port	N/A – MP35 only
DC INPUT	Power input; requires 12 VDC @ 1 Amp. Use the AC300A 12 VDC @ 1.25 Amp power supply adapter to connect to any mains rated as 100-250 VAC @ 50/60Hz, 40VA.	Power input; requires 12 VDC @ 1 Amp. Use the AC300A 12 VDC @ 1.25 Amp power supply adapter to connect to any mains rated as 100-250 VAC @ 50/60Hz, 40VA.
FUSE	1.0 amp fast-blow fuse	2.0 amp fast-blow fuse
MP UNIT Dimensions Weight	 7 cm x 29 cm x 25 cm 1.4 Kg	 7 cm x 29 cm x 25 cm 1.4 Kg

MP UNIT PIN-OUTS

Electrode Check — *Front Panel*

9-PIN FEMALE DSUB

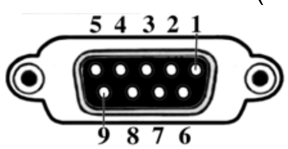


Pin	MP35 and MP30	
2	Vin+	Electrode connection
3	GND	
4	Vin-	Electrode connection

MP Input — *Front Panel*

CH 1, CH 2, CH 3, CH 4

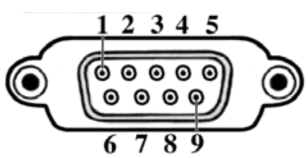
9 PIN FEMALE DSUB (1 of 4)



Pin	MP35	MP30
1	Shield drive	Shield drive
2	Vin+	Vin+
3	GND	GND
4	Vin–	Vin–
5	Shield drive	Shield drive
6	+5 V (100 mA max aggregate)	+5 V (50 mA max)
7	ID resistor lead 1; I^2C SCL	ID resistor lead 1 (+5 V)
8	ID resistor lead 2; I^2C SDA	ID resistor lead 2
9	–5 V (100 mA max aggregate)	–5 V (50 mA max)

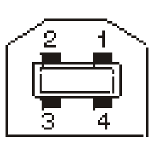
MP Analog Output — *Back Panel*

9 PIN MALE DSUB



Pin	MP35	MP30
1	Buffered AC output Z out = 2,200 µF Cap V out range MP35: (+/- 2.0 V)	Buffered AC output Z out = 2,200 µF Cap MP30: (+/- 2.5 V)
2	Buffered DC output Z out = 50 Ω V out range MP35: (0 to 4.096 V)	Buffered DC output Z out = 50 Ω MP30: (0 to 5 V)
3	GND	GND
4	+5.0 V (100 mA max)	+7.5 V (100 mA max)
5	Buffered digital output Z out = 1 kΩ V out range (0 to 5 V)	Unbuffered DC output Z out = 1 kΩ V out range (0 to 5 V)
6	+12 V (100 mA max)	Not used
7	I^2C SCL	Not used
8	I^2C SDA	Not used
9	Not used	Not used

MP Serial Connector — *Back Panel*



MP35

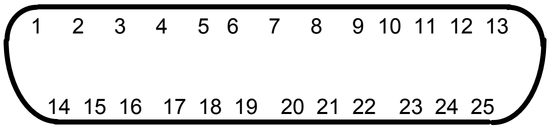
MP30

Pin	MP35	MP30
1	+5	Digital Output 1
2	-Data	Digital Output 2
3	Data +	Digital Output 3
4	GND	Digital Output 4
5	n/a	GND Unisolated
6	n/a	GND Unisolated
7	n/a	RS-232-RX
8	n/a	+5 V Unisolated

MP UNIT PIN OUTS *continued*

I/O Port — *MP35 Back Panel*

DSUB 25 (male)



Note: BSL 3.7.0-3.7.1 does not support Pins 7, 9, 18, 19, 20 and 21.

Pin	MP35 Only
1	Digital Output 1
2	Digital Output 2
3	Digital Output 3
4	Digital Output 4
5	GND Unisolated
6	GND Unisolated
7	RS-232-RX
8	+5 V Unisolated
9	I^2C-SDA
10	Digital Input 1
11	Digital Input 2
12	Digital Input 3
13	Digital Input 4
14	Digital Output 5
15	Digital Output 6
16	Digital Output 7
17	Digital Output 8
18	Analog Input — Right
19	Analog Input — Left
20	RS-232-TX
21	I^2C-SCL
22	Digital Input 5
23	Digital Input 6
24	Digital Input 7
25	Digital Input 8

MP35 Input>Output Scaling

The full range of the MP35 input (which varies with Gain) is mapped to the full range of the output (4.097) with an Input to Output Offset shift of 2.05 V. As an example, at a Gain of 100, a 1mV pk-pk signal would be displayed as a 20.48 pk-pk signal with an offset of 2.05 V.

Gain	Input Range (mV)		Output Scale Factor
x10	Min: -1 Volt	Max: +1 Volt	2.05
x20	Min: -500	Max: +500	4.097
x50	Min: -200	Max: +200	10.24
x100	Min: -100	Max: +100	20.48
x200	Min: -50	Max: +50	40.97
x500	Min: -20	Max: +20	102.42
x1,000	Min: -10	Max: +10	204.85
x2,000	Min: -5	Max: +5	409.7
x5,000	Min: -2	Max: +2	1024.25
x10,000	Min: -1	Max: +1	2048.5
x20,000	Min: -0.5	Max: +0.5	4097
x50,000	Min: -0.2	Max: +0.2	10242.5

Calibration

BIOPAC transducers can provide accurate "relative" measures without calibration.

- For example, the voltage output of the EDA/GSR transducer (SS3LA) will change by 1 mV given a change of 10 micro Mhos across the electrode(s) connected to the transducer.

For accurate "absolute" measurement, the voltage output of the transducer must be correlated exactly to a physical parameter (such as air flow) and must adjust for temperature, pressure, humidity, and orientation (gravity effects)—all of which can vary greatly. Factors beyond the transducer's accuracy also influence "absolute" measurement, such as connections in the system or to the subject. While the MP35 is a very sensitive, DC stable acquisition unit, too many factors influence true "absolute" measurement to achieve it without calibration.

Calibration Guidelines

Calibration is required if **ALL** of the following are true:

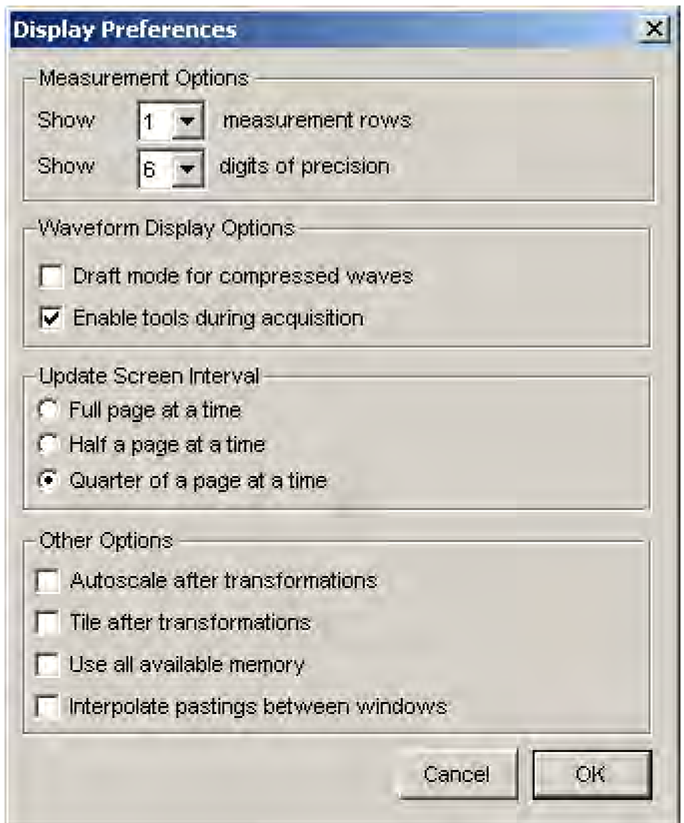
1. Precise, absolute, measurements are required.
   - "Precise" is considered better than 5% accurate; some transducers may provide better than 5% accuracy without calibration.
   - "Relative" measurements are often acceptable. Measurements on humans can vary so greatly from person to person that in most cases a "relative" measure of change is sufficient.
     - For example, when measuring EDA with the SS3LA, the preset: "Electrodermal Activity (GSR) Change" is often used and no calibration is required.
2. The transducer will be plugged into an Analog Input channel.
   - Communication between the MP35 and transducers that can be plugged into the "I/O Port" on the back of the MP35 (such as the noninvasive blood pressure cuff) occurs serially; since A/D conversion is not used, readings will directly match the output of the connected device.
3. The operational bandwidth of the transducer extends down to 0 Hz (DC).
   - The Input Coupling hardware setting (see page 97) enables you to record data as AC Coupled or DC Coupled signal values.
     - DC Coupling is appropriate for Temperature, GSR, Airflow, BNC, Switch, Pressure, Force, Hand dynamometer, Stimulator, Strain gauges, and similar data.
     - AC Coupling is appropriate for ECG, EEG, EMG, EOG, PPG, Respiration, and similar data.
   - There are a number of technical differences between these coupling settings, but the main issue is Offset. Offsets are values that influence the location of transducer zero. Most distinctions between "absolute" and "relative" accuracy are related to Offset.
     - DC Coupled signals usually have a non-zero Offset in amplitude that drifts during the course of the recording. DC Coupled measurements can be calibrated directly to account for the Offset.
     - AC coupled signals are centered on zero, so Offset is not a factor.
   - Other hardware settings, such as Gain values or sensitivities, don't change significantly between AC and DC, but AC Coupled signals can use somewhat higher Gain settings, resulting in slightly higher resolution.
   - When an AC Coupled Preset is selected for a transducer, "relative" measurements are taken and calibration is not required.

Appendix E - Frequently Asked Questions

Q: I have a large data file and it seems to take a long time to redraw the screen. Is there anything I can do to speed it up?

A: Yes. You can choose from four possible remedies for this:

1) The simplest solution is to check the **Draft mode for compressed waves** and **Use all available memory** boxes in the **Display Preferences** dialog (**File > Preferences > General**). Checking these two boxes will cause the BSL *PRO* software to plot data faster (at the expense of some precision) and use as much available memory as possible. You can cancel the plotting at any time by holding down the **ESC** key.



2) You can reduce the time interval per division, which causes less data to be displayed on the screen at one time, and should reduce plot time.

3) If the data still takes too much time to redraw and you have a color monitor, try reducing the number of colors displayed.

4) If you have a high-resolution video card (one capable of displaying many thousands of colors), you may want to reduce the resolution to speed up plotting time.

Q: Can I use other software with the Biopac Student Lab* PRO *hardware? Can I use Biopac Student Lab* PRO *software to control other data acquisition hardware?

A: No. The Biopac Student Lab *PRO* hardware was designed to work with the Biopac Student Lab *PRO* software. However, the BSL *PRO* software can read in previously acquired text files generated by the Biopac Student Lab *PRO* or any other software.

Q: I have a device that outputs an RS-232/RS-422 signal. Can I connect this to the digital I/O line?

A: No. These types of digital output devices have their own communication protocols and are more complex than the digital pulses that the Biopac Student Lab *PRO* can accept as inputs.

Q: I imported a text file and the time scale is wrong. What happened?

A: When a text file is imported, the Biopac Student Lab *PRO* software assumes (by default) that the data was sampled at 100Hz or 100 samples per second. This is arbitrary, and there are two ways to adjust this. Both methods involve calculating the interval between sample points. To calculate the sampling interval, you need to know the rate at which the data was originally sampled. The sampling interval is calculated by dividing one by the sample rate. You can adjust the sampling interval to the appropriate value via the **File > Open** dialog box before the data is read in, or if the data is already present, change the time scale in the **Display > Horizontal Axis** dialog box.

For instance, if 20 minutes of data was originally collected at 2Hz and imported as a text file, the software will interpret this as data collected at 100 samples per second. To set the time scale to accurately reflect the data, change the sampling interval from 0.01 to 0.5 seconds per sample.

To change this setting before data is read in, click the "Options" button in the **File > Open> Text** dialog box and change the value in the **Sampling Interval** dialog box. To change the time scale after data has been read in, adjust the units per division in the **Display > Horizontal axis** dialog box. If the data are time-domain data, you can adjust the seconds/sample interval at the bottom of the dialog box. This value defines the interval between sample points, and can be changed to fit the rate at which the data was originally acquired.

Q: I just filtered a waveform and now my data file is huge. Why is that?

A: When any type of transformation is performed (e.g. digital filtering, waveform math), the entire waveform is converted from integer format (two bytes per sample) to floating-point format (eight bytes per sample). Since each sample point in the waveform now takes up four times as much space, the file should be approximately four times as large. The Biopac Student Lab *PRO* software still saves the file as compactly as possible, and since some of the information stored describes the time base, the file size will not increase by exactly a factor of four.

Q: My MP35/30 seems to be connected, but I can't acquire data. What should I do?

A: This can be caused by one of several conditions:

a) Check to make sure that the MP35/30 is ON and, if so, that all the connections to the MP35/30 were made properly. When the MP35/30 is powered up, a light on the front panel of the MP35/30 will illuminate. If the power light will not illuminate, check to make sure the proper power supply is connected. The power supply that comes with the MP35/30 is rated at 12 VDC @ 1 Amp, and using other power supplies may result in damage to the MP35/30.

b) If the proper power supply is connected but the power light still does not illuminate, disconnect the power supply and check the fuse in the back of the MP35/30. The fuse is a standard 2.0 Amp fast blow fuse, and can be changed by unscrewing the fuse cap and replacing the fuse.

c) If the power light does illuminate, the next step is to see if the "Busy" status light (next to the "Power" light on the front panel of the MP35/30) illuminates when the MP35/30 is powered up. When the MP35/30 is powered up, the "Busy" status light should illuminate for three or four seconds and then extinguish.

Q: I set up the channels but I only seem to be acquiring noise. What's wrong?

A: A number of phenomena can cause this:

1) Check to make sure that the settings in the **Setup Channels** dialog box (under the **MP35/30** menu) correspond to the direct analog connections to the MP35/30.

2) Another possible cause is that the Gain settings are too low and should be increased.

   To access the Gain settings: pull down the **MP35/30** menu, select **Setup Channels**, click the **View/Change Settings** button to access the Parameters dialog, and use the **Gain** pull-down menu to select another setting.

3) You may also want to select **Autoscale waveforms** from the **Display** menu.

   This will automatically adjust the waveforms to provide the "best fit" in terms of scaling the data to fit in the available window space.

4) It is also possible that the electrodes/transducers themselves are the source of the noise.

   Proper electrode adhesion techniques involve abrading the skin and securing the electrode in place to reduce movement artifact. See page 283 for more information about electrode noise.

Appendix F - Hints for Working with Large Files

It is not uncommon for large data files to be generated (on the order of several megabytes) through some combination of (a) high-speed acquisitions, (b) long acquisitions, and (c) multi-channel acquisitions. You may encounter system limitations (such as storage space limitations) and find such files difficult to work with and slow in loading to memory.

The Biopac Student Lab *PRO* software stores the data in as compact a format as possible. Each analog sample takes up roughly two bytes of storage space and calculation channel samples take up roughly eight bytes of storage space. When a waveform (or a section of a waveform) is transformed (i.e., filtered or integrated) each data point takes up roughly eight bytes. As a result, file size can change drastically after transforming one or more waves.

The following tips can help you get the most out of the Biopac Student Lab *PRO* when working with large data files.

Use virtual memory	Most computers are able to take advantage of the virtual memory feature. While this is slower than conventional memory, it will at least make it possible to load some files that might otherwise be impossible to load.
Remove waveforms	Since each waveform adds to the total size of the file, try removing (or copying to another file) some of the waveforms from a multi-channel file. This is especially true if you would like to perform transformations of some sort on at least one of the waves.
Sample slowly	Theoretical and methodological concerns will, to a large extent, dictate sampling rate. However, if you can reduce the sampling rate, choose to do so. You may also want to resample data after it has been collected by using the **Transform** > **Resample** command (page 210).
Display preferences	Check the “Use all available memory” and the “Draft mode for compressed waves” options under the **File** > **Preferences** > **General** sub-menu. This should decrease the time it takes to redraw waveforms and allow the software to access all available memory for storage.
Store to hard disk	Although slightly slower than storing to PC Memory (RAM), acquiring data directly to Hard Disk allows you to recover data in the event of a power loss to the Biopac Student Lab *PRO*. Furthermore, much larger data files can typically be stored directly to Hard Disk than to PC Memory.
Use the Append mode	The **Append** mode allows you to pause the acquisition for arbitrary periods. This can be helpful when recording only a few key events that will occur randomly over a long period of time, since it will reduce unnecessary data.
Stop plotting and change the scale	If the screen is taking a long time to redraw (because the data files are large), you can stop plotting and decrease the horizontal scale value before redrawing. To stop plotting, use the **ESC** key.

Appendix G — Filter Characteristics

Filter types

The Biopac Student Lab *PRO* software employs two types of digital filters:

1) Finite Impulse Response (FIR) perform all post-acquisition filtering
2) Infinite Impulse Response (IIR) perform online calculations (filtering performed during an acquisition)

Although the similarities between the two types of filters outweigh the differences, some important distinctions remain.

IIR filters are typically more efficient (faster) than FIR filters.

This means that IIR filters can filter data faster than FIR filters, which is why IIR filters are used for online calculations.

IIR fillers tend to be less accurate than FIR filters.

Specifically, IIR filters tend to cause phase distortion or "ringing." When the phase of a waveform is distorted, some data points on a waveform are shifted (either forward or backward in time) more than others. This can result in the intervals between events (such as the Q-R interval or the inter-beat interval in an ECG waveform) being slightly lengthened or shortened compared to the original signal. In practice, however, the effect of this distortion is usually minimal since the frequencies which are most distorted are also attenuated the most.

By contrast, FIR filters are phase linear, which means that the interval between any two sample points in the filtered waveform will be exactly equal to the distance between the corresponding sample points in the original waveform.

IIR filters have a variable Q setting

The Q setting defines the filter response pattern, but FIR filters do not have a Q component. The optimal Q of an IIR filter is 0.707, with lower values resulting in a flatter response and higher values resulting in a more peaked response. The default Q for all IIR filters is 0.707 (except for Band pass filters where Q defaults to 1), which is appropriate for nearly all filter applications.

In the examples on the following page, the filter responses of several different types of filters are compared. All of the filters are 50Hz low pass filters operating on the same data.

IIR filters are also used for real-time filtering in the MP35 and MP30 hardware. The following processing rates correspond to the sampling rate:

Sample Rates (samples/Sec)	**Possible with MP35**	**Possible with MP30**	**MP35 DSP I.I.R. Filter Proc. Rate (Sample/Sec)**	**MP30 DSP I.I.R. Filter Proc. Rate (Sample/Sec)**
1	YES	YES	20,000	2,000
2	YES	YES	20,000	2,000
2.5	NO	YES	N/A	2,000
5	YES	YES	20,000	2,000
10	YES	YES	20,000	2,000
20	YES	YES	20,000	2,000
25	NO	YES	N/A	2,000
50	YES	YES	20,000	2,000

100	YES	YES	20,000	2,000
200	YES	YES	20,000	2,000
250	NO	YES	N/A	2,000
500	YES	YES	20,000	2,000
1,000	YES	YES	20,000	2,000
2,000	YES	YES	20,000	2,000
5,000	YES	YES	20,000	N/A
10,000	YES	YES	20,000	N/A
20,000	YES	NO	20,000	N/A
25,000	YES	YES	25,000	N/A
40,000	NO	YES	N/A	N/A
50,000	YES	NO	50,000	N/A
100,000	YES	YES	100,000	N/A

Frequency Cutoff

When setting up any IIR filter, a good rule of thumb is to limit the HIGHEST frequency cuttoff in the filter to be some value less than or equal to the sample rate of the acquisition or data divided by four.

- For a sampling rate of 200Hz, the cuttoff for a lowpass filter should be no greater than (200/4) or 50Hz. Alternatively, for a lowpass filter of 30 Hz, the acquisition (sample) rate should be no less than (30*4) or 120Hz.
- For a high pass filter of 250Hz, the acquisition (sample) rate should be no less than (250*4) or 1000Hz.
- For a band pass filter of 100Hz to 500Hz, the acquisition (sample) rate should be no less than (500*4) or 1,000Hz.
- For a single frequency band pass (or notch) filter of 60Hz, the acquisition (sample) rate should be no less than (60*4) or 240Hz.

If this rule of thumb is not followed, it becomes increasingly more likely that the data from the output of the IIR filter will be meaningless. If the acquisition (sample) rate drops below two times the highest cuttoff frequency associated with the filter, the data will be completely corrupted. The zone for acquisition rate being between two and four times the highest cuttoff frequency associated with the IIR filter is somewhat functional, but the filter break-points will begin to deviate from the expected break-point. The deviation will result in effectively REDUCED upper frequency cuttoff for the IIR filter, the extent of the reduction being more pronounced as the acquisition rate approaches two times the highest cuttoff frequency for the IIR filter.

When an IIR filter is established as a calculation channel, the specified minimum frequency (Freqmin) determines the minimum effective Sample Rate (SRmin) as follows:

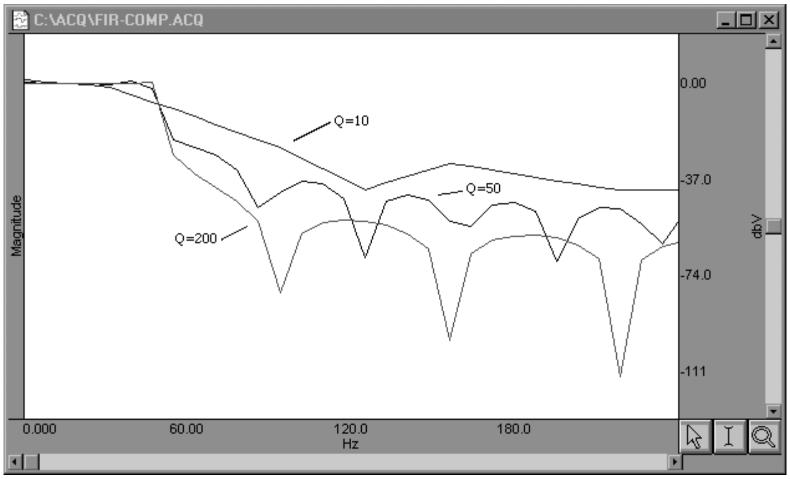
SRmin = 4 * Freqmin

where SRmin is the frequency specified for Low Pass, High Pass, Band Pass and Band Stop and is the lower of the two frequencies for Band Pass (low + high) filter

If the sample rate is lower than this, there is no guarantee as to what will happen to the data because the filter can become unstable and huge numbers can be generated.

The first graph shows how the number of filter coefficients in FIR filters (Q) affects the filter's frequency response.

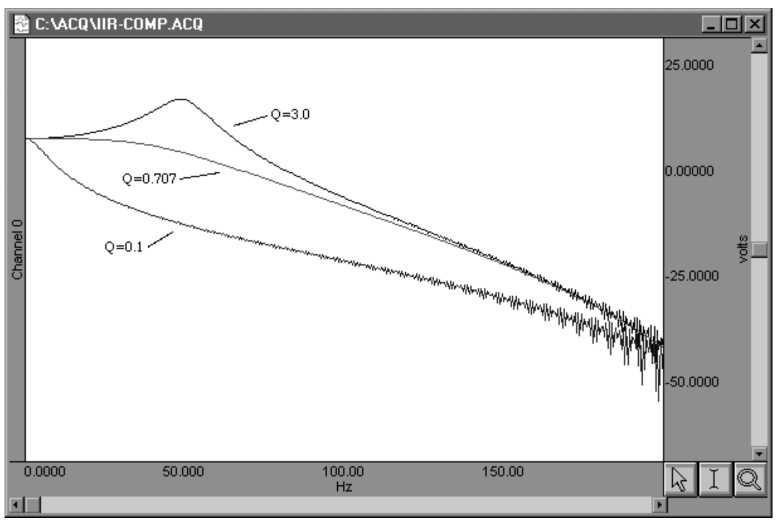
Note that as the number of coefficients (Q) increases, the filter becomes more accurate.



FIR filter performance as a function of number of coefficients (Q)

The second graph shows how the pole or zero locations of the filter, as related to filter "peaking" (specified by Q), affect the frequency response of the filter. The "Q" in this case is <u>not</u> to be confused with the Q from the FIR filter.

Note how increasing "Q" in the IIR filter case affects filter "peaking."



FIR filter performance as a function of changes in pole or zero locations

Coincidentally, the FIR (Q = 10) and IIR (Q = 0.707) filters have very similar responses in this case.

Technically, the coefficient setting for FIR filters determines the number of multiplies performed by the filtering algorithm. In practical terms, it determines how "steep" the frequency response of the filter is. Filters with a large number of coefficients have a steep roll-off, whereas the frequency response of filters with a smaller number of coefficients is not as steep.

Window Functions (Filter Characteristics)

A “window” refers to a computation that spans a fixed number of adjacent data points. Typically, window functions are used to eliminate discontinuities that may result at the edges of the fixed span of points of the digital filter function (FIR filters) or the data points of the FFT.

The following formula, where $n = \overset{N-1}{\underset{0}{n}}$ and A, B, C and D are constants that define the “shape” of the window, is used to describe all windows except the Bartlett window:

$$A - B\cos\frac{2\pi n}{N} + C\cos\frac{2\pi 2n}{N} - D\cos\frac{2\pi 3n}{N}$$

The table below illustrates the different parameter values for most Window types:

Window Type	Parameter Values A	B	C	D
Blackman	0.42323	0.49755	0.07922	0.00000
Blackman -61	0.44959	0.49364	0.05677	0.00000
Blackman -67	0.42323	0.49755	0.07922	0.00000
Blackman -74	0.40217	0.49703	0.09392	0.00183
Blackman -92	0.35875	0.48829	0.14128	0.01168
Hamming	0.54000	0.46000	0.00000	0.00000
Hanning	0.50000	0.50000	0.00000	0.00000
Kaiser-Bessel	0.40243	0.49804	0.09831	0.00122
Rectangle	0.00000	0.00000	0.00000	0.00000

Window functions are used for three purposes in the Biopac Student Lab *PRO* software:

a) Window functions are applied to the impulse response in the FIR **digital filtering** functions.

b) Window functions are applied as part of the **FFT** function.

c) Window functions are applied as part of the **Derivative** transformation.

Digital filtering

When a window is used in digital filtering, the impulse response of the filter (rather than the data itself) is modified. When the impulse response smoothly approaches zero at both the beginning and end of the data, this works relatively well.

When the impulse response is not so well behaved, edge effects occur. To minimize edge effects:

— Window, or force the edges of the impulse response to smoothly approach zero. The exact process depends on the **Window** selected (see previous page).

— Increase the number of coefficients for the FIR filter used to transform the data.

FFT

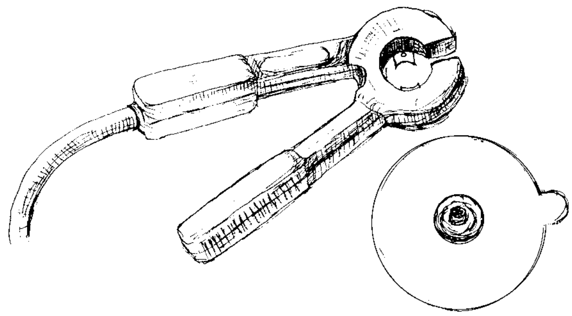
The FFT function also windows data, although the nature of the windowing function is somewhat different in the sense that the window operates on the data. One of the assumptions of the FFT is that the input data is an infinitely repeating signal with the endpoint wrapping around. In practice, the endpoints are almost never exactly equal. You can check this by choosing the **Delta** measurement item from the measurement pop-up menus, which returns the amplitude difference between the first selected point and the last. To the extent that the endpoints differ, the FFT output will produce high frequency components as an artifact of the transformation.

By windowing the data, the effects of this phenomenon are greatly diminished. When data are windowed, a window is moved across the data, much as the smoothing function moves across the data. Whereas the smoothing function simply takes the average of a specified number of points, each type of window weights the data somewhat differently.

Appendix H — About Electrodes

The purpose of an electrode is to act as a “connector” between the Subject’s skin (where electrical signals are easiest to detect) and the MP35/30 acquisition unit (via the SS2L lead cable). If an electrode makes good contact with the skin, the signals that are generated will be relatively accurate.

Although they sound complex, electrodes are very simple devices that consist of a small piece of metal designed to make indirect contact with the skin and a larger adhesive plastic disk. Each electrode is about 1 inch (2.5 cm) in diameter, and is sticky on one side so it will adhere to your skin. The **electrode lead** (cable with connector end) is the interface between the electrode and the MP35/30 acquisition unit.



Electrode lead connector and electrode

If you look closely at the electrode, you can see that there is a small piece of plastic mesh filled with a bluish gel. Since gel conducts electricity (better than your skin, in fact) and is more flexible than the metal part of the electrode, your skin can flex and change shape somewhat without losing the electrical connection with the metal part of the electrode.

BIOPAC disposable electrodes are standard disposable electrodes and are widely used in clinical, research, and teaching applications. These electrodes come in strips of ten, and you should not remove an electrode from the backing until you are ready to use it.

The following directions will help you get good data from the electrodes by explaining how electrodes work and how to attach the electrodes and electrode leads to obtain the best signal.

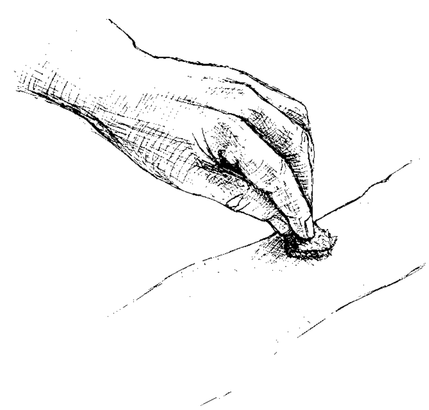
Electrode placement

There are two basic methods of electrode placement: monopolar and bipolar.

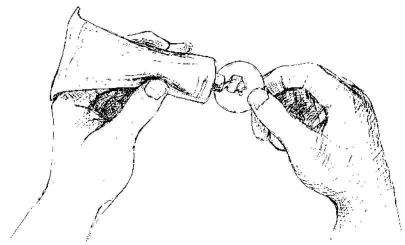
- In a **monopolar** recording, an active electrode is placed over the region of interest and a “reference” electrode is attached to a more distant part of the body.
- In a **bipolar** recording, the voltage difference between two electrodes, placed over the regions of interest, is measured with respect to the third “reference” electrode. Leads I, II, and III are standard bipolar electrode configurations, and are explained in more detail when used in a Lesson.

Preparing the Electrode Site

One way you can improve electrode connections is to gently rub the area where the electrode is to be placed. This is known as **abrading** the skin, and removes a thin layer of dead skin from the surface of the skin. Since dead skin doesn’t conduct electricity very well, removing it improves the connection between the electrode and the skin. You can use an **ELPAD** electrode pad (included with the Biopac Student Lab) to abrade the selected surface.



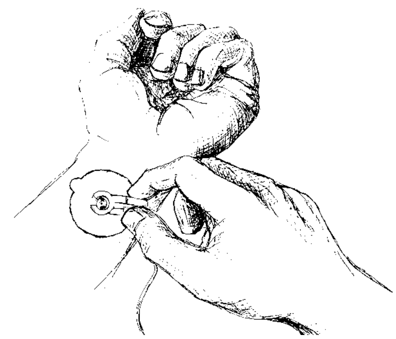
Attaching electrodes



To attach an electrode, peel the electrode from its backing and place it on the area indicated in the lesson. Once in place, press down firmly on the electrode with two fingers and rock the electrode back and forth for a few seconds. This will ensure that it is adhering to the skin as much as possible.

➢ To help insure that the electrode will make good electrical contact with the skin, you may want to squeeze a drop or two of **electrode gel** onto either the surface of the skin or onto the electrode (without allowing any to get on the adhesive).

Connecting the Electrode Lead



Each electrode lead cable is a different color and each pinch connector on the end of the cable needs to be attached to a specific electrode. Note that the connector is polarized and needs to be clipped on such that the metal extensions inside the clip are on the down side to make surface contact with the electrode. The pinch connectors work like a small clothespin, but will only latch onto the nipple of the electrode from one side of the connector. You should follow the figure provided in the lesson to ensure that you connect each lead cable to the proper electrode.

Reducing Electrode "Noise"

If an electrode does not adhere well to the skin, the signal plotted on the screen may appear "fuzzy." This is referred to as "**noise**," and although it always exists to some degree, it is best to reduce noise as much as possible. Electrodes have no moving parts, so there is nothing you have to do to get an electrode to "work" but there are several things you can do to reduce noise when electrodes are connected:

* Place the electrodes where there is the least amount of hair and/or choose the subject with the least amount of hair. A common problem is that something on the surface of the skin is interfering with the electrode contact. If there is too much hair (for instance) between the outer layer of skin and the electrode, the electrical activity taking place below the surface of the skin may not be detected.
* Make sure that everything is connected properly.
* Attach the electrodes a few minutes before you are going to use them. The best results are achieved by putting the electrodes in place about five minutes before you begin recording data. This gives the electrodes time to establish contact with the surface of the skin.
* Position the electrode lead cables such that they are not pulling on the electrodes. Connect the electrode cable clip (where the cable meets the three individual colored wires) to a convenient location (can be on the Subject's clothes). This will relieve cable strain.
* The Subject should not be in contact with nearby metal objects (faucets, pipes, etc.), and should remove any wrist or ankle bracelets.

Removing Electrodes

Once you have completed a lesson, disconnect the electrode cable pinch connectors, peel the electrode off the skin, and dispose of the electrode (BIOPAC electrodes are not reusable). Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours. This is normal, and does not indicate that anything is wrong.

Electrode Check

The front panel of the MP35/30 unit includes an Electrode Check port. Use this diagnostic tool with the BSL *PRO* software to determine if the electrodes are properly attached to the subject (see page 143).

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Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

T

U

V

W

X

Z

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