Acq*Knowledge*® 5 Software Guide

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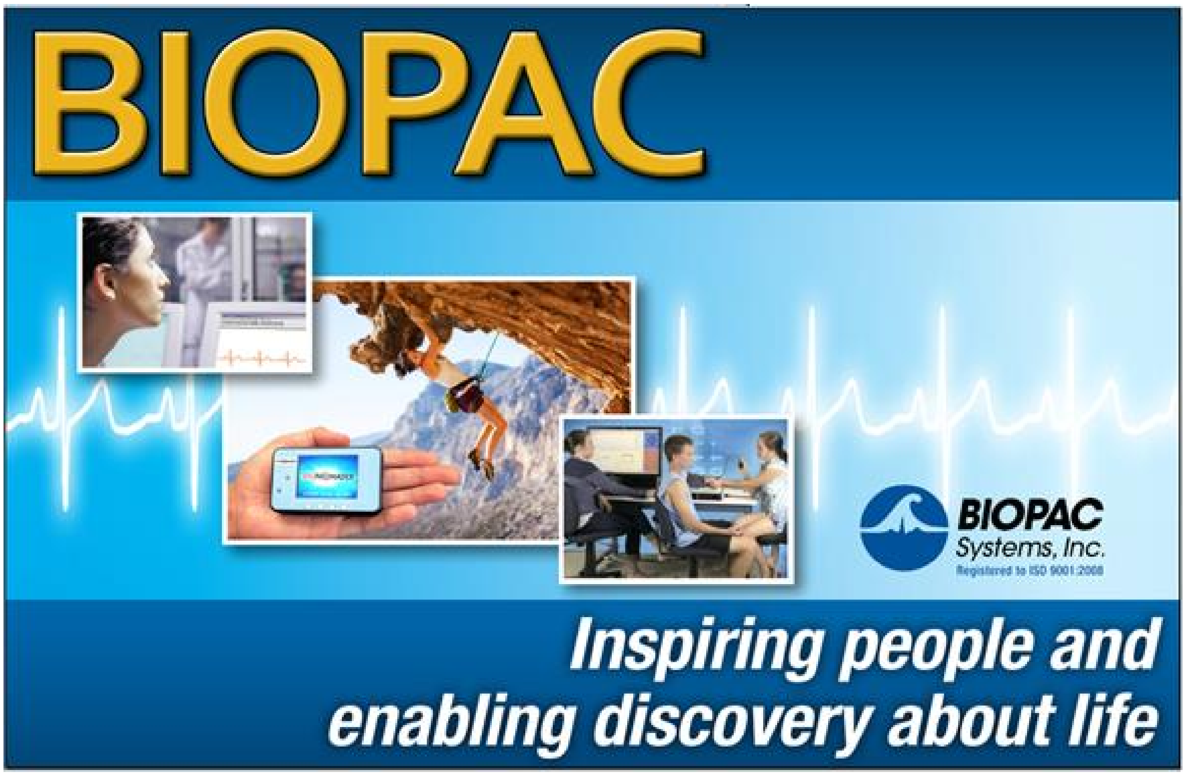
For Life Science Research Applications

Data Acquisition and Analysis with BIOPAC Hardware Systems



Reference Manual for
Acq*Knowledge*® 5.0.1 Software & MP160/MP150/MP36R, BioHarness, Mobita Hardware/Firmware on Windows® 10, 8.x, and 7 or Mac OS® X 10.7-10.11, macOS Sierra

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Preface to Acq*Knowledge* Software Guide

Welcome

Welcome to the Acq*Knowledge* Software Guide. The MP System (MP160, MP150 or MP36R) is a complete data acquisition system that includes both hardware and software for the acquisition and analysis of life science data. The MP System is used for data acquisition, analysis, storage, and retrieval.

In addition to the MP Systems, Acq*Knowledge* also supports BIOPAC

What

Part A

Where do I find help?

The Introductory sections are intended to provide enough information to get up and running with the MP System, and become familiarized with some basic Acq*Knowledge* functions. For detailed in-depth information, the following resources are available.

- *Help menu*

  The online Help menu includes basic information about standard Acq*Knowledge* functions and links to the tutorial, software guide and hardware guide for online searchable Help while running Acq*Knowledge*, plus links to the BIOPAC web site.

  You may also visit BIOPAC

Part A

Human Anatomy & Physiology Society Position Statement on Animal Use

(Adopted July 28, 1995, Modified January 2001, Approved April 29, 2012)

It is the position of the Human Anatomy and Physiology Society (HAPS) that dissection and the manipulation of animal tissues and organs are important elements in scientific investigation that introduce students to the excitement and challenge of their future careers. HAPS supports the use of biological specimens as part of a program of 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.

The mission of the Human Anatomy and Physiology Society (HAPS) is to promote excellence in the teaching of 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 human and animal body.

Consistent with the origins and nature of scientific inquiry, HAPS endorses the use of animals as part of the laboratory experiences in both human anatomy and human physiology.

Historically, an important tool of investigation in human and animal anatomy has been dissection. A complete anatomy learning experience that includes dissection 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. Dissection conveys the inherent variability of living organisms not otherwise observable in simulations and models. Physiology experiments involving humans and 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, analyze results and develop and improve critical thinking and problem solving skills

Since effective teaching requires a diversity of strategies and approaches, HAPS endorses the use of computer atlases and simulations, modeling, and video programs to meet educational objectives and the needs of students. Science educators choosing not to use animals or biological specimens should choose alternatives that are able to convey equivalent anatomical and physiological intricacies to meet their 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 also encourages educators to be responsive to student concerns regarding use of animals and to provide students who object to animal use with alternative learning materials.

HAPS contends that science educators should retain responsibility for making decisions regarding the educational uses of animals and other strategies and techniques for the betterment of their student

Part A

MP36R support

The MP36R is a four-channel data acquisition unit designed to work with Acq*Knowledge* 4.1 and above for the research market. Acq*Knowledge* support for the MP36R unit includes:

- Standard data acquisition and data acquisition features (triggering, multiple channels, variable sampling rate, input values)
- Output control functionality for controlling stimulators, digital channel, and channel redirection to output.
- Standard analog presets for all SS series transducers
- Electrode Check support
- Multiple-MP device support. Similar to multiple MP160/150 support, each graph may acquire from a maximum of one unique MP device.
- Control channel support for changing digital output lines based on calculation channel analysis

MP36R Notes The computer sleep mode should be disabled

Part A

MP System with Acq*Knowledge* Features

The MP System (MP160, MP150 or MP36R) with Acq*Knowledge* software is a complete system for acquiring almost any form of continuous physiological data, whether digital or analog. The MP System can perform a range of recording tasks, from high-speed to long duration acquisitions. For physiological applications, the MP System is limited only by the computer speed and available memory or disk space. Features of the MP System include:

Easy to use	The MP System with Acq*Knowledge* offers power and convenience. In terms of hardware setup the MP System (MP160, MP150 or MP36R) uses simple plug-in connectors and standard interface cables.
Flexible	Acq*Knowledge* can be configured for a wide variety of applications, from single channel applications to multiple-device measurements (up to 16 analog and 16 digital, or multiple MP160s or MP150s). Control the length of acquisition, the rate at which data is collected, how data is stored, and more. Whether measuring alpha waves or collecting zoological data, the MP System with Acq*Knowledge* can meet your needs.
Menu flexibility	Easily customize menu displays to show only necessary functions, thereby reducing the risk of error or confusion in the lab. This is useful for teaching applications, giving instructors the option to hide unnecessary menu items. *See* Appendix D

Part A

Application Features

Use your MP System with Acq*Knowledge* software for a wide array of applications, such as:

Active Electrodes
Allergies
Amplitude Histogram
Anaerobic Threshold
Animal studies
Auditory Evoked Response (AER)
Automate Acquisition Protocols
Automated Data Analysis
Automatic Data Reduction
Autonomic Nervous System Studies
Biomechanics Measurements
Blood Flow / Blood Pressure /Blood Volume
Body Composition Analysis
Breath-By-Breath Respiratory Gas Analysis
Cardiac Output
Cardiology Research
Cell Transport
Cerebral Blood Flow
Chaos Plots
Common Interface Connections
Connect to MP System (MP160, MP150 or MP36R)s
Control Pumps and Valves
Cross- and Auto-correlation
Current Clamping
Defibrillation & Electrocautery
Dividing EEG into Specific Epochs
ECG Analysis
ECG Recordings, 12-Lead
ECG Recordings, 6-Lead
EEG Spectral Analysis
Einthoven

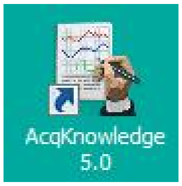
Application Notes

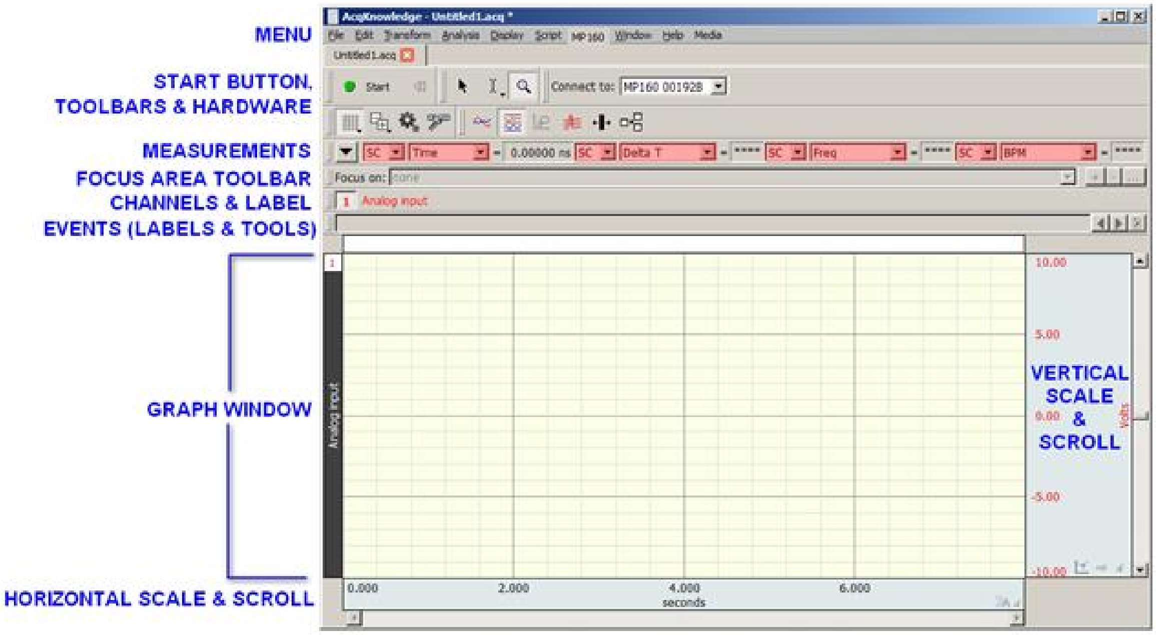
BIOPAC has prepared a wide variety of application notes as a useful source of information concerning certain operations and procedures. The notes are static pages that provide detailed technical information about either a product or application. A partial list of Application Notes follows. You can view or print application notes directly from the *Support* section of the BIOPAC website www.biopac.com/application-note/.

APP NOTE	Application
#AH101	Transducer Calibration and Signal Re-Scaling
#AH102	Biopotential Amplifier Testing w/ CBLCAL
#AH103	Remote Monitoring System (TEL100C)
#AS105	Auditory Brainstem Response (ABR) Testing
#AS105b/c	ABR Testing for Jewett Sequence
#AS108	Data Reduction of Large Files
#AS109	3-, 6-, and 12-Lead ECG
#AH110	Amplifier Baseline (Offset) Adjustment
#AS111	Nerve Conduction Velocity
#AH114	TSD107A* Pneumotach Transducer
#AH114b	TSD107B* Pneumotach Transducer
#AS115	Hemodynamic Measurements

Chapter 2 Acq*Knowledge* Overview

Overview





Acq*Knowledge* software 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 acquisition parameters can be found under the hardware (or MP) menu. The other menu commands pertain to analysis functions such as viewing, editing, and transforming data.

Note: Minor differences exist between the Windows and Mac OS screen displays and keystroke/mouse functionality. These differences are noted throughout this section.

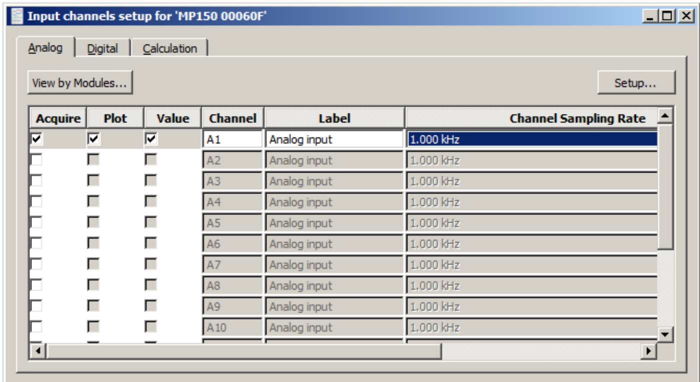
Menu	Functionality	See Page
File	New, Open, Open Recent, Open for Playback, SMI BeGaze Import, Close, Save, Save As, Save Selection As, Save Journal Text As, Send Email as Attachment, Page Setup, Print, Quit	245
Edit	Undo, Cut, Copy, Paste, Clear/Clear All, Remove Last Appended Segment, Insert Waveform, Duplicate Waveform, Select All, Remove Waveform, Create Data Snapshot, Merge Graphs, Clipboard (Copy Measurement, Copy Wave Data, Copy Graph, Copy Acquisition Settings, Copy Data Modification History for All Channels, Copy Data Modification History for Graph, Copy Focus Area Summary, Copy Event Summary), Journal (Paste Measurements, Paste Wave Data, Paste Acquisition Settings, Paste Modification History for All Channels, Paste Modification History for Selected Channel, Paste Focus Area Summary, Paste Event Summary, Manage PDFs, Show Journal)	269
Transform	*operations that primarily modify the data in the graph* Recently Used, Digital Filters, Fourier Linear Combiners, Math Functions, Template Functions, Integral, Derivative, Integrate, Smoothing, Difference, Resample Waveform, Resample Graph, Expression, Delay, Rescale, Waveform Math, Slew Rate Limiter	279
Analysis	*operations that derive data & measurements from the graph* Recently Used, Histogram, Autoregressive Modeling, Nonlinear Modeling, Power Spectral Density, Autoregressive Time-Frequency Analysis, FFT/IFFT, DWT Discrete Wavelets, Principal Component Analysis/Inverse PCA, Independent Component Analysis/Inverse, Find Cycle, Find Rate	

Part A

- To use Acq*Knowledge* without a data acquisition unit (depending on the dialog), choose Cancel, Analyze Only, No Hardware, or set Preferences > Hardware > General to

Part A

Basic Analog Channel Information



By default, all channels are deselected on new graph windows. Usually, you will want to check all three boxes (Acquire, Plot, and Value) for each channel selected to acquire data.

Acquire When the Acquire box is checked for a given channel, data will be collected on that channel.

Plot Determines if data will be plotted in real-time during the acquisition. If the plot box is unchecked, data will be recorded, but the associated channel will remain hidden.

Value Enables a separate Show Input Values window to display the values for each channel in real time, numerically and/or graphically.

Channel This is a dynamic alpha-numeric heading based on the type of channel selected: Analog (or continuous), Calculation, or Digital. In the sample above,

Part A

Starting an Acquisition

Once the channels and channel characteristics have been specified, the next step is to start the acquisition. If a file window is not already open, choose File > New > Graph window.

Status light

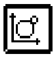
To the left of the Start button is a circular status light. The status light indicates the communication link between the computer and the data acquisition hardware unit.

- If the data acquisition hardware unit is properly connected to the computer and is turned on, the circle will be solid and green.
- If the data acquisition unit is not properly connected or not communicating with the computer, the circle will be solid and gray.
- Start

To start an acquisition, position the cursor over the 

button and click the mouse button, or select **Ctrl+ Spacebar**. If electrodes or transducers are connected to the data acquisition unit, a small value of random signal

Part A

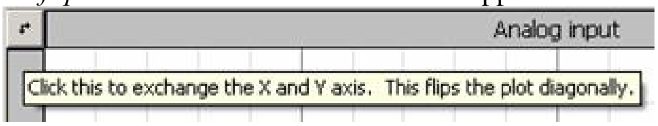
 X/Y mode continued

Plotted channels

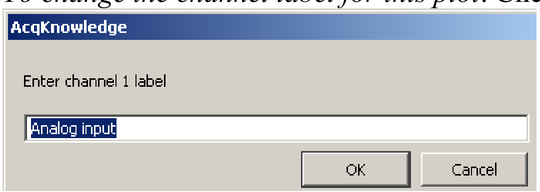
- *To change the channel being plotted*: Click the Channel label once and hold.

X-axis, click *above* the waveform; Y-axis, click *left* of the waveform.

- *To flip the axes*: Click the button in the upper left.



- *To change the channel label for this plot*: Click the Channel label.



Toolbar icons

The center cluster of toolbar items is specific to X/Y mode. The left two buttons in this group are shortcuts for the Autoscale vertical and Autoscale horizontal functions. Adjacent to these buttons are two buttons that perform the center vertical and center horizontal functions.

Tools

Cursor: In X/Y mode, the I-beam tool in the lower right hand corner of the graph window changes into a crosshair. When the crosshair 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 refers to the crosshair coordinate in terms of the horizontal axis, and the Y value describes the location of the cursor in terms of the vertical scale. By pressing the mouse, a crosshair is drawn over the closest data point and the measurement toolbar

Part A

The selected segment is used for all enabled software functions. This means that autoscaling can easily create what looks like a mess if the selected segment is not appropriate for scaling the largest segment. In compound action potential graphs in Stacked Plot, the last segment slice will most often be the largest, so if you select the last segment before autoscaling you will likely get the expected result. The Transform menu is disabled in Stacked Plot mode.

A commonly used data visualization technique for examining the evolution of waveform morphology is the 2D waterfall plot or

Part A

If the table of available slices was being displayed prior to the removal/editing of the last matching slicing event, the table will be emptied and the

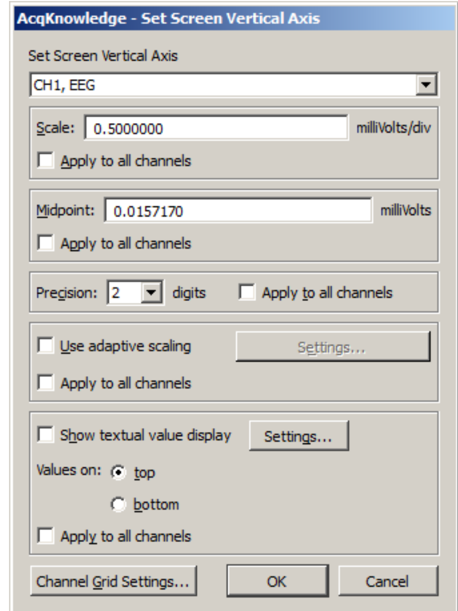
Part A

Analysis

For purposes of illustration, you should open an existing file that contains actual data. Sample files were installed with the software. Select File > Open and choose a file from the list in the dialog. Sample data files can also be selected from the Startup screen by choosing the

Part A

Acq*Knowledge* also allows customization of the vertical scaling, or amplitude, of each waveform. Clicking the vertical scale area produces a dialog (see page 72 for details).



The vertical scale dialog allows you to change the range of amplitude values displayed (scale) and set the value that appears in the center of the vertical scale (midpoint).

You can vary the midpoint and apparent magnitude of each waveform by changing the values in each box. By changing the value in the scale box, a smaller value has the effect of increasing the apparent amplitude. Entering a number about half the current value will cause the amplitude of the wave to appear to double.

- Scale

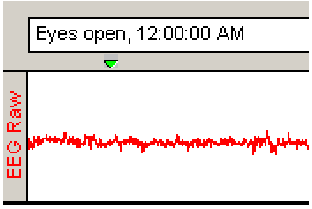
Part A

Zoom

Another way to examine data is to use the

Part A

Events (Markers)



In many instances it is useful to have the software mark 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 software uses

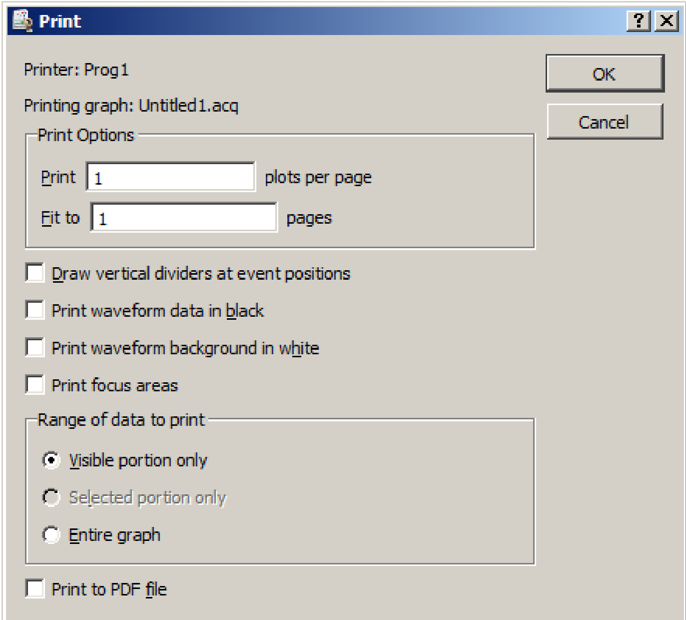
Part A

Journals

The Journal is a general-purpose text editor built into Acq*Knowledge* that works like an

Part A

Print



Acq*Knowledge* allows high-resolution printing of hard-copy graph plots much as they appear on-screen.

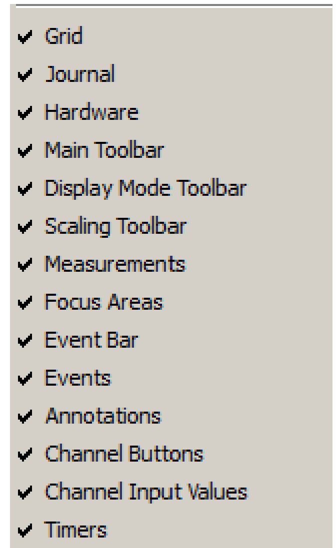
- To print a file, choose Print from the File menu. This will print the contents of the screen on the selected printer.
- To print the entire file, choose Autoscale Horizontal from the Display menu first.
- You must print a journal as a separate command from print graph file.

You may instruct Acq*Knowledge* to print the contents of a file across several pages by entering a value in the Fit to box. Entering

Part A

Toolbars

Many of the most commonly used features in Acq*Knowledge* can easily be executed with a mouse click. The toolbars contain shortcuts for some of the most frequently used Acq*Knowledge* commands. Click an icon to activate it; icons are grayed out when they are not applicable.



By default, a minimal toolbar configuration is presented when Acq*Knowledge* is first launched. The default toobars will appear as follows:

The default toolbars consist of:

- Start/Stop button
- Cursor Toolbar (Arrow, I-beam and Zoom tools)
- Main Toolbar (Grid, Toolbar Display, Preferences and Customize Toolbar buttons)

The full range of available toolbars can be displayed by enabling the checkbox options in the Toolbar Display shortcut button , or via Display > Show and enabling the desired options. Once the toolbar options have been selected, this will be the default toolbar display for all new graphs. All toolbars can be deselected and hidden with the exception of the Start/Stop button and the Cursor Toolbar (Arrow, I-beam and Zoom tools).

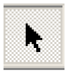
<u>Saved graphs created with different toolbar configurations will open with those toolbar options displayed</u>.

Toolbar position

Part A

Cursor Tools

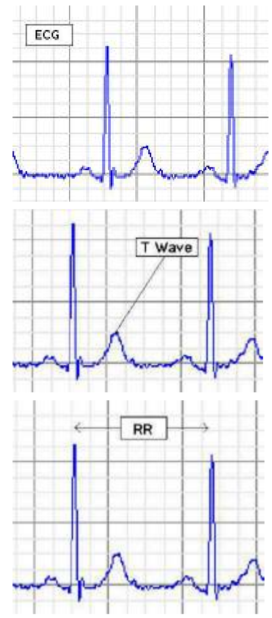
The cursor tools are also accessible via the Display menu (Display > Cursor Style)



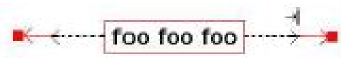
This is a general-purpose

Part A

<table>
<tr>
<td>Text Annotation

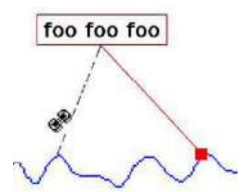
continued</td>
<td>


Connector handles

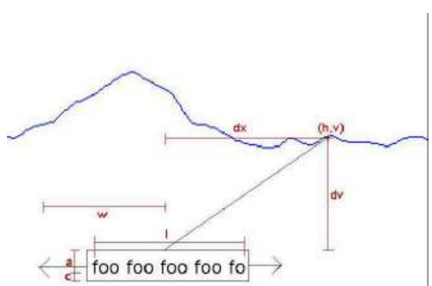


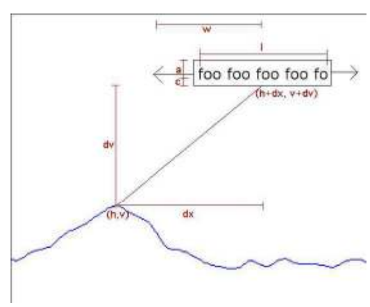
Resize a range

Add a range



Move a connector





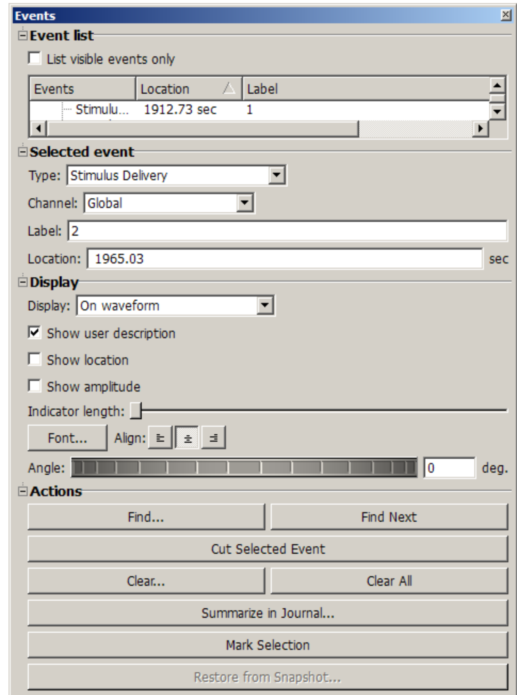
Text annotations are short pieces of text that float above channel data and can be used to draw visual attention to particular areas of interest in a graph. These text annotations can be simple outlined text, can have a connector from the outline boundary to a specific sample point on the waveform, or have a range indicator of a specific width. Each text annotation is tied to a sample of data in a channel; when the data is moved by coping, pasting, or other waveform editing operations, text annotations remain fixed to their corresponding sample positions, similar to channel events.
Although text annotations are tied to horizontal locations like events/markers, they are displayed in a relative fashion. The relative pixel distance between the text annotation outline boundary and the sample of data remains the same under zoom and autoscaling operations.
For example, an annotation that is 20 pixels above a T-Wave peak position will continue to be drawn 20 pixels above regardless of zoom. This allows for flexible data viewing while maintaining text annotation visibility.
Text annotation controls
With the tool active, click in the graph to define a new annotation.
Select   Click an annotation once to select it.
</td>
</tr>
</table>

Part A

Channel Button Toolbar

Toggles the display of channel number and label region.

Event Toolbar



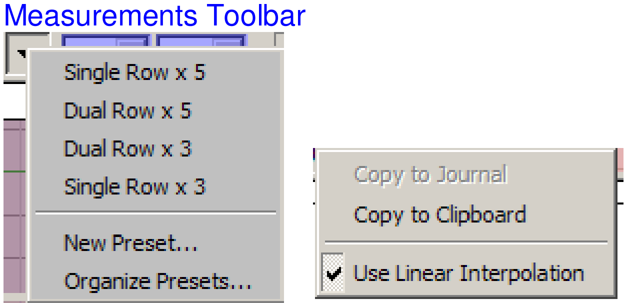
Select an event to enable the toolbar. (Events and Event bar must first be enabled via Display > Show Events and Event bar). Use the arrows to move forward or backward through all event marker types. (If events are placed in the waveform, the arrow navigation will locate events in the selected channel only.)

Click the event palette icon to generate the event palette.

Focus Area Toolbar

Use the Focus Area feature to isolate portions of data that are of particular interest within a graph. Focus Areas can be defined, added, labeled and deleted within any portion of the graph. For more details on creating and using Focus Areas, see page 87.

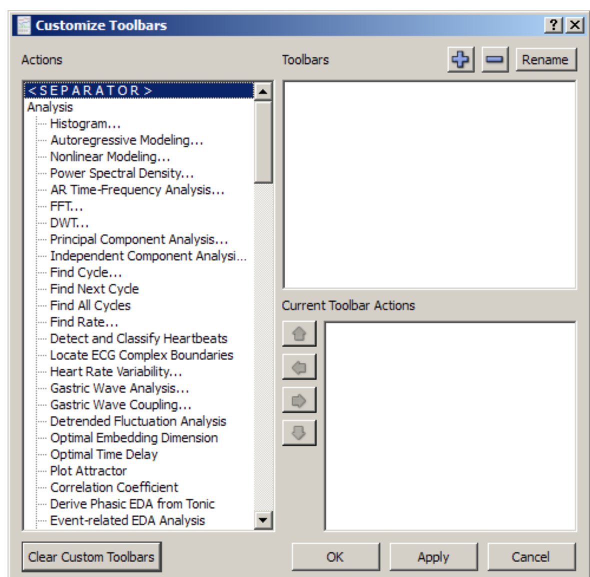
Measurements Toolbar



Click the down arrow for quick access to measurement preset functions, including pre-loaded options for organizing measurement rows and columns. Or create and save custom measurement display presets by choosing New Preset, entering a name for the preset and clicking OK.

Right-click in the measurement bar for quick access to options for copying measurement and using linear interpolation.

Custom Toolbars for Transformations and Analysis



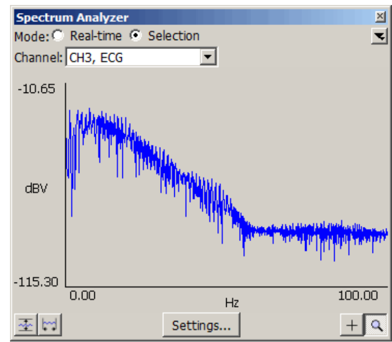
Acq*Knowledge* 4.1 and above allows users to construct new toolbars for triggering transformations and analysis. An arbitrary number of toolbars may be created and populated with buttons that can trigger any menu item in the Transform and Analysis menus. The contents of the text-only buttons match the menu item title. These toolbars will persist for each user and their positions and visibility within the graph window will be retained.

 Transformation toolbars may be accessed via the "Customize Toolbars" button.

Part A

Button Transparency

Scaling, calibration, transformation history, and grid lock buttons may be made semi-transparent to allow units, axis values, and other information underneath the buttons to remain visible. The Preferences > Graph panel includes an



Part A

Menu Option	Windows OS	Mac OS
Integrate		
Smoothing		
Difference		
Resample Waveform		
Resample Graph		
Expression		
Delay		
Rescale		
Waveform Math		
Slew Rate Limiter		
Analysis menu		
Find Cycle	Ctrl + F	⌘ F
Find Next Cycle	Ctrl + E	⌘ E
Find All Cycles	Ctrl + R	⌘ R
Display menu		
Tile Waveforms		
Autoscale Single Waveform	Ctrl + Shift + Y	⌘ Shift Y
Autoscale Waveforms	Ctrl + Y	⌘ Y
Overlap Waveforms		
Autoscale Horizontal	Ctrl + H	⌘ H
Show All Data	Ctrl + Shift + D	Shift ⌘ D
Show Default Scales		
Zoom Back	Ctrl + - (minus key)	⌘ -
Zoom Forward	Ctrl + = (equal key)	⌘ +
Reset Chart Display		
Reset Grid		
Adjust Grid Spacing		
Set Wave Positions		
Wave Color		
Horizontal Axis		
Show > Selection Palette > Location Palette	Ctrl + Shift + = Ctrl + Shift + L	⌘ + Shift + = ⌘ + Shift + L
Customize Toolbars		
Channel Info		
Preferences		
Size Window		
Cursor Style > Arrow > Selection > Zoom	Ctrl + B Ctrl + I Ctrl + G	⌘ B ⌘ I ⌘ G
Create Data View		

Part A

Menu Option	Windows OS	Mac OS
Open Hardware Guide About Acq*Knowledge*		
Cursors I-beam Arrow (pointer) Zoom Grid Event Jump to Annotation	 Ctrl + I Ctrl + B Ctrl + G	 ⌘ I ⌘ B ⌘ G
Horizontal Scroll Location	In chart, scope, or stacked plot mode (i.e., all but X/Y) these keyboard shortcuts can be used to scroll to various parts of the graph.	
Home	Jumps to t = 0 (i.e., places first sample of data flush with left of graph window)	
End	Jumps to the end of the currently selected waveform (i.e., places last sample of data of the selected waveform flush with right of graph window)	
Page Up	Scrolls backward in time one full screen (i.e., places leftmost sample of previous visible area at the right of the new visible area).	
Page Down	Scrolls forward in time one full screen (i.e., places rightmost sample of previous visible area at the left of the new visible area).	

Tooltips

Tooltips is an online assistance feature to help novice users learn how to use Acq*Knowledge*. Text is generated to describe the software functionality of the item under the mouse. Unavailable items/controls will indicate why they are unavailable. Tooltip visibility can be controlled by selecting or deselecting the

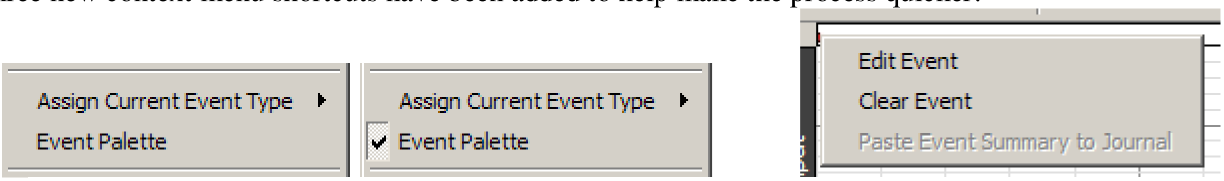
Part A

Cancelling Transformations and Transformation Progress Bar

Transformation cancel support offers Cancel buttons for in-progress dialogs that indicate the completion status of threaded transformations. Progress dialogs have also been enhanced so the textual message includes a graphical progress bar with the percentage that is completed. If the progress message does not contain a percentage, an indeterminate progress bar will be displayed.

Acq*Knowledge* 4.1 and higher extends the analysis package to display dialogs while analysis routines are in progress. This progress dialog contains a cancel button which may be used to terminate the analysis before it is complete.

The event tool allows events to be inserted on a graph with the mouse. When performing event editing, three new context menu shortcuts have been added to help make the process quicker:

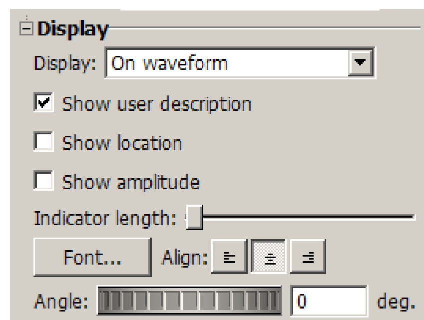


- Assign Current Event Type: Right-click an area with no data to set the type of event that will be inserted on the next left-click of the mouse.

- Event Palette: Toggles event palette displays.

- Edit event: Right-click a specific event to open the event palette to Selected Event controls for the event that was right-clicked.

Typed Event Label Drawing Improvements



The Event system has been enhanced to allow different drawing options for channel-specific events when they are drawn in the data plotting area. These drawing options are applied to event labels, event amplitude markings, and event time location text. The following drawing options may be customized:

- Font (including family, size, italic/bold, and other options)
- Rotation angle of text baseline
- Text alignment (left, center, right)

Choose MP160 and MP150 Help Button

A Help button is available in the

Part A

Chapter 4 Editing and Analysis Features

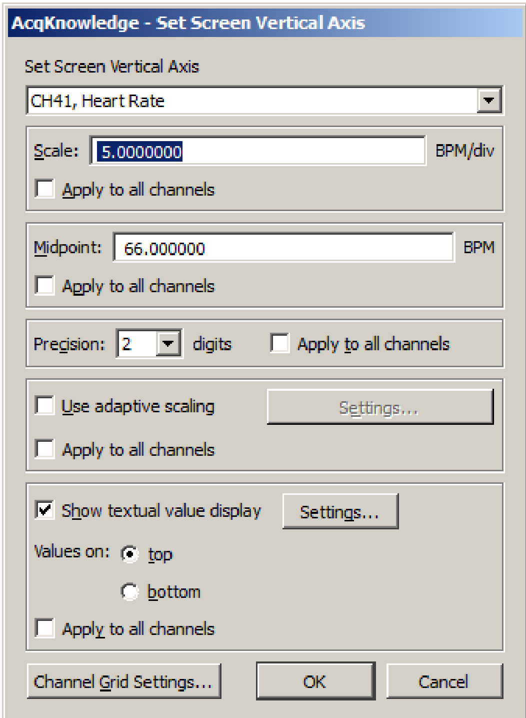
Overview

This section provides a brief overview of some of the most frequently used Acq*Knowledge* features and functions. For more detailed information about specific features, turn to Chapters 9 through 13.

If you are not currently running Acq*Knowledge,* double click the Acq*Knowledge* icon to start it. Choose Open from the File menu and select the file called

Part A

Vertical (Amplitude) axis



Clicking the mouse in the vertical scale area (where the amplitude of each channel is displayed) generates the Set Screen Vertical Axis dialog, where values can be entered for units per division and vertical scale offset.

Scale

Determines the limits of the viewable vertical axis scale (usually Volts). Acq*Knowledge* divides each channel into four vertical divisions. When data is displayed in chart mode, each

Part A

Textual value display in spot measurement mode

Textual value display can be customized for font, color and style, and positioned at the top or bottom of any selected channel. These options can be configured independently per channel or applied to all channels.

- In chart and stacked chart modes, the value display will appear for all enabled channels.
- In scope mode, the value display will appear only if the selected channel has the value display option enabled.
- Textual value display is not supported in XY mode.

To enable textual value display:

Click on the vertical axis area to open the setup dialog and enable the

Part A

Grid Scaling

When the grid is locked, the scaling factors controlling how much data is visible on the screen (the distance between consecutive major lines of the grid and a fixed location for one of the lines of the grid) are specified differently. When the grid is unlocked, these scaling factors do not affect the grid.

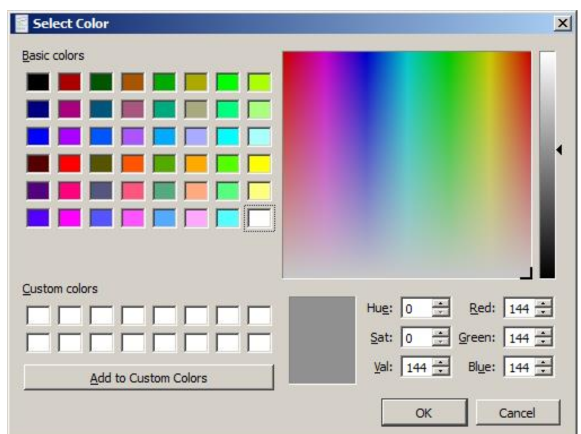
The Grid Spacing option specifies the scaling factors and whether or not to

Part A

- Based on lock status, the dialog will allow you to adjust Horizontal, Vertical or combined settings.
- The values displayed in the dialog correspond to the grid ranges that were just drawn out on the screen with the grid tool if a mouse drag occurred.
- If the mouse was simply clicked, the current grid settings are displayed.
- This dialog allows the grid drawn out with the grid tool to be made more precise.

Grid Reset

To return to the original grid, choose

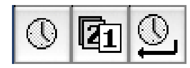


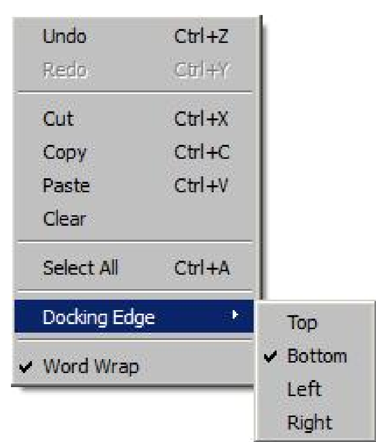
Part A

Journal Details

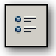
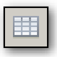
To create a journal, choose **File > New > Graph-Specific Journal** or **Independent Journal** or choose **Display > Show >Journal** or **Edit > Journal > Show Journal**.

Once a Journal is open, text and data can be entered. To enter text, just begin typing when the journal is open. Acq*Knowledge* will automatically





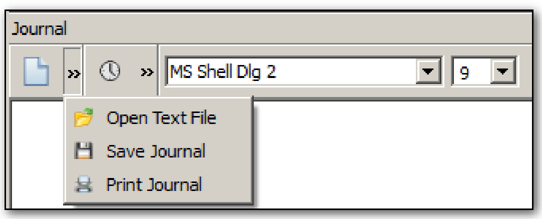
Part A

	Bulleting	Toggles text bulleting on and off
	Increase indent	Increases indent in a bulleted or numbered list*
	Decrease indent	Decreases indent in a bulleted or numbered list
	Insert link	Adds hyperlink to Journal
	Table	Inserts a table into the Journal
	Table row	Adds a row to the table **
	Table column	Adds a column to the table
	Delete table row	Removes selected row from the table
	Delete table column	Removes selected column from the table
	Merge cells	Merges selected cells within the table
	Split cells	Splits selected cells within the table

*Active only when cursor is positioned within a bulleted or numbered list.

**Additional table tools are active only when a table is present.

NOTE: If the Acq*Knowledge* graph or Journal windows are decreased in size, the Journal toolbar will become truncated and some buttons may no longer be in view. Buttons no longer visible on the toolbar can be found in drop-down menus indicated by arrows. (*See below*)



Journal Numerical Table Tools

The Numerical Table Tools function allows easy insertion of measurements and numerical data into a Journal table, which can then be computed and evaluated via basic mathematical operations and expressions. This eliminates the need to export data to a spreadsheet application in order to validate statistics gathered during the course of an experiment.

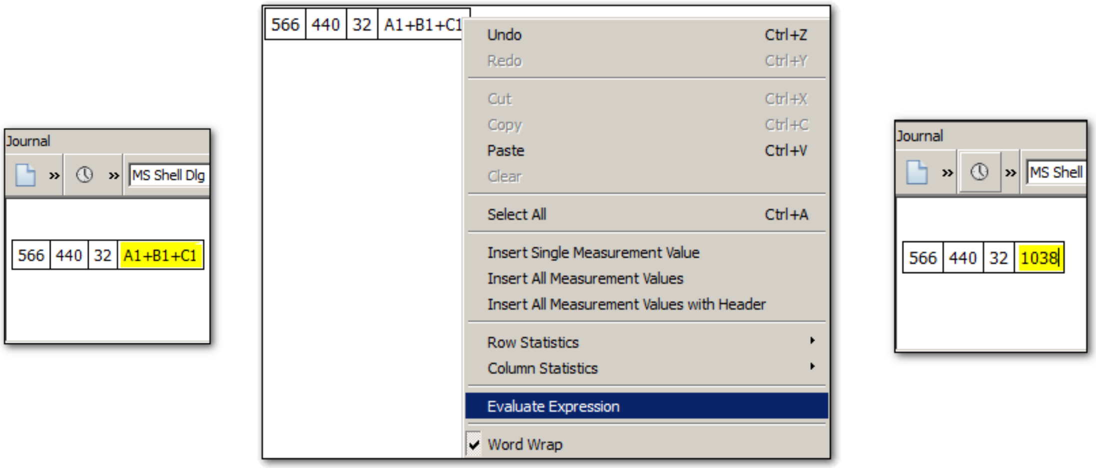
Numerical Tools operations permitted within a Journal table:

- Insert a single measurement value
- Insert all measurement values
- Insert all measurement values with header row
- Sum, Mean and Standard Deviation statistics for table rows and columns
- Expression evaluation

Part A

Example of Evaluate Expression

This feature works very much like Excel®. Simply enter the cell identifiers into an empty cell, then right-click and choose



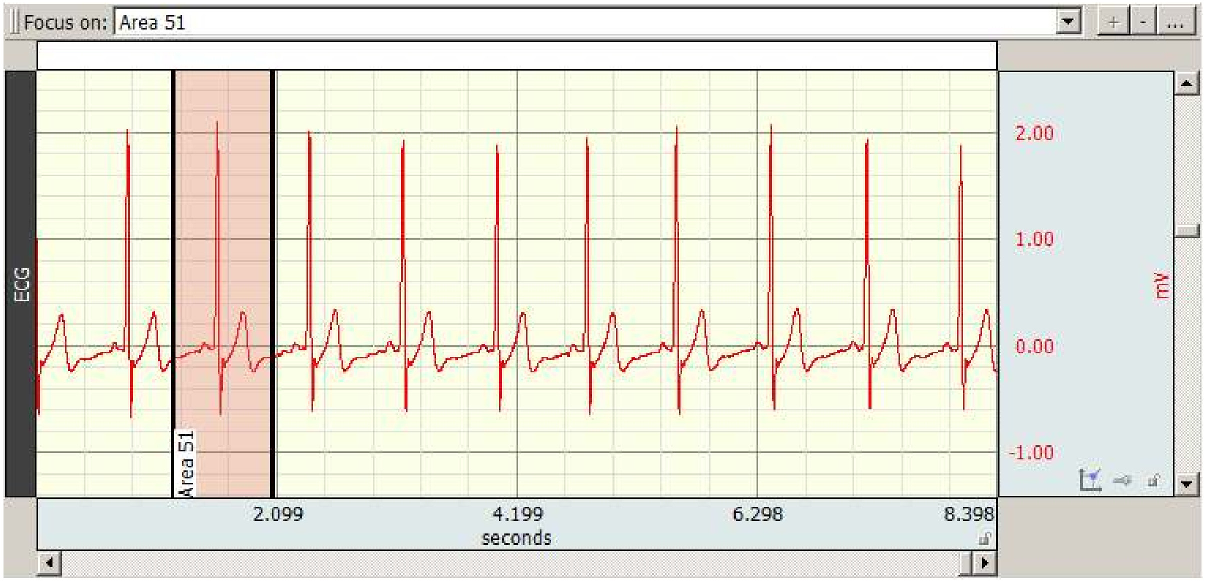
Part A

Select a waveform / channel

Although multiple waveforms can be displayed, only one waveform at a time is considered

Part A

The new focus area and label will appear in the graph.



Multiple and overlapping focus areas can be created by selecting additional data and using the

Part A

Measurement Area

It is important to remember that Acq*Knowledge* is always selecting either a single point or an area spanning multiple sample points. If an area is defined and a single point measurement (such as *Time*) is selected, the measurement will reflect the last selected point.

- Single-point measurements

  When a single point is selected, the cursor will

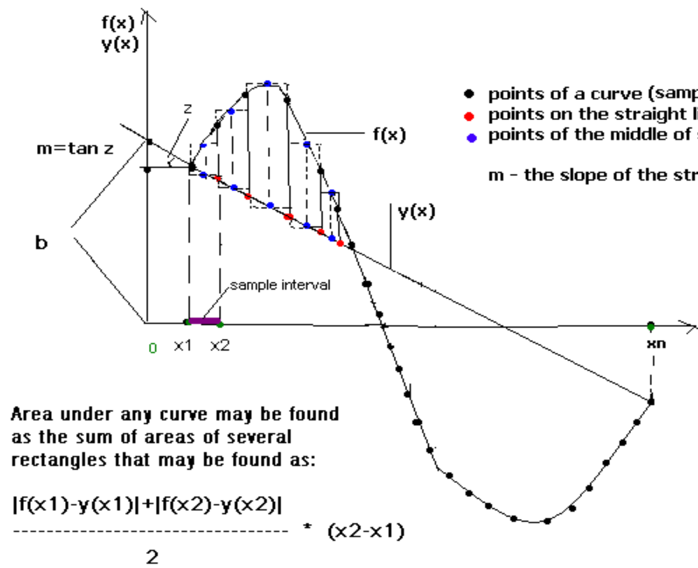
Measurements and Measurement Presets

Measurements are commonly used in conjunction with the cycle detector and other analysis protocols to perform data reduction. In complex data analysis using the cycle detector, often multiple different sets of measurements may be used to perform multiple extraction passes on the data. The measurement presets feature allows users to create multiple predefined measurement configurations and apply them to the graph to change between different configurations. All aspects of the measurement configuration are stored, including measurement functions, any parameters for the measurement, source channel, and number of measurement rows. For more details on this function, see MeasurementsToobar section on page 60.

Measurement Validation

You can validate measurements with the ValidateMeasurements.acq sample file included with the software. Pay attention to the

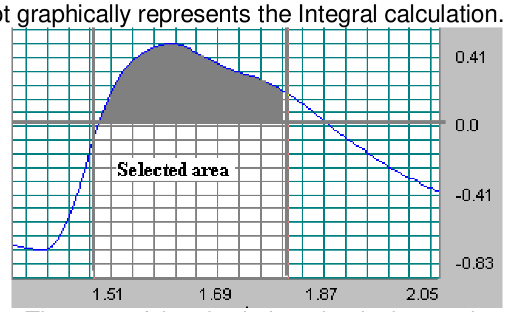
Part A

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: $$BPM = \left(\frac{1}{\left\| x_n - x_1 \right\|} \right) * 60$$ *Where:* x_1, x_n *- values of the horizontal axis at the endpoints of selected area.* *Note:* As mentioned, 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

Part A

Measurement	Area	Explanation
		$f(x_1), f(x_n)$*—values of a curve at the endpoints of selected area.* *<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* *<u>Sample data file:</u> "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	<u>Minimum area</u>: 1 sample <u>Uses</u>: Endpoints of selected area	Delta S returns the difference in sample points between the end and beginning of the selected area. *<u>Results</u>:* This calculation will always return a positive result. *<u>Units</u>: Samples*
Delta T(time) Delta F (frequency) Delta X (arbitrary unit)	<u>Minimum area</u>: 2 samples <u>Uses</u>: 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. *<u>Measurement</u>* — *<u>Horizontal Axis</u>* Delta T — Time Delta F — Frequency (FFT) Delta X — Arbitrary units (Histogram Bins) The formula for Delta T/F/X is: Delta T $= x_n - x_1$ *<u>Where</u>:* x_1, x_n *- values of horizontal axis at the endpoints of selected area.* *<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. 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 71 for details on how to change the horizontal scaling). *<u>Units</u>:* Delta T: *Seconds (sec.)* Delta X: *"arbitrary unit"* Delta F: *Hz* *<u>Sample data file:</u> "ValidateMeasurements.ACQ"* *Result: 0.12 sec. (for whole wave).*
Evt_amp		Extracts the value of the measurement channel at the times where events are defined. The measurement result is unitless. Specify Type, Location, and Extract; see page 225 for details. ▪ The amplitude is always taken from the measurement channel, which may be different from the channel on which events are defined. Evt_amp can be useful for extracting information such as the average T wave height within the selected interval.
Evt_count		Evaluates the number of events within the selected area. The measurement result is unitless. Specify Type and Location; see page 226 for details.
Evt_loc		Extracts information about the times of events. The measurement result uses the units of the horizontal axis. Specify Type, Location, and Extract; see page 226 for details.

Part A

Measurement	Area	Explanation
		<u>Note</u>: It is important to note that this does not compute the frequency spectra of the data. To perform a spectra analysis, use the FFT function (described on page 315). *Freq (or frequency) is only available in time domain windows.* <u>Results</u>: This calculation will always return a positive result. <u>Units</u>: *Hz* <u>*Sample data file:*</u> *"ValidateMeasurements.ACQ"* *Result: 8.33 Hz (for whole wave).*
Inf_Dim		Information Dimension; fractal dimension estimate. (See fractals note at Cap_Dim.)
Integral	<u>Minimum area</u>: 2 samples <u>Uses</u>: 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. Integral is expressed in terms of (amplitude units multiplied by horizontal units) and calculated using the following formula. Integral = $\sum_{i=1}^{n-1}\left[f(x_i)+f(x_{i+1})\right]*\frac{\Delta x_i}{2}$ <u>*Where:*</u> *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.* The following plot graphically represents the Integral calculation.  The area of the shaded portion is the result. <u>Results</u>: The Integral calculation can return a negative value if the selected area of the waveform extends below zero. <u>Units</u>: *Volts—sec.* <u>*Sample data file:*</u> *"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).*
Kurtosis		Kurtosis indicates the degree of peakedness in a distribution, e.g. the size of the

Part A

Measurement	Area	Explanation
		$f(x_i)$- *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

Part A

Measurement	Area	Explanation
		-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 = $\sqrt{\frac{1}{n-1} * \sum_{i=1}^{n} \left(f(x_i) - \bar{f} \right)^2}$ *Where:* *n—number of samples;* *i—index (i = 1.n);* x_i

Part B—Acquisition Functions: The Hardware Menu

Overview

Acq*Knowledge* software adds acquisition and control capability to the complete MP160/MP150/MP36R Systems and other BIOPAC data acquisition hardware, such as wireless BioHarness, Mobita, or BioNomadix. The MP (or Hardware) menu items will vary in appearance depending on the type of data acquisition hardware in communication with the software, and the Hardware menu title will reflect the currently connected hardware type. (It is also important to note that certain features in the MP160/150 and MP36R hardware menus are not supported in all hardware types.) For the purposes of this guide, all supported data acquisition systems will be referred to generically as being under the umbrella of the

Set Up Data Acquisition > Data Acquisition Settings

In Acq*Knowledge*, many key setups are accessed by selecting Hardware menu > Set Up Data Acquisition. This option displays the Data Acquisition Settings window, comprised of the following items:

- Channels

Part B

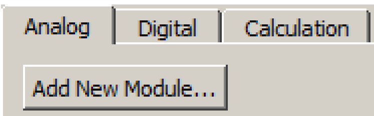
Chapter 5 Set Up Channels

Set Up Channels—The Basics

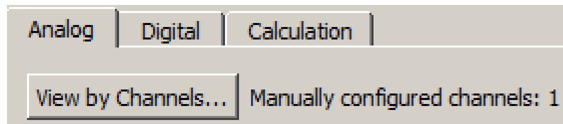
Before you collect data, you need to specify how many channels you will be collecting data on, and at what rate data is to be collected. Both of these functions are accomplished through menu items and dialogues. To enable collection on a given channel, select **Set Up Data Acquisition > Channels** from the hardware menu.

Acq*Knowledge* for MP160 and MP150 offers two methods of analog channel setup:

Module-based setup



View by Channels *see page 108 for details*



If using Acq*Knowledge* with **BioHarness™** or **B-Alert**

Using this information, the module setup automatically sets the scaling and initial visual range to match the physical input units from the module or transducer.

“Apply data alignment corrections” option (Acq*Knowledge* 4.4.2 and higher)

This checkbox option is found at the bottom of the Channels > Add New Module screen and is recommended when using the following hardware modules:

- NIBP100D (via DA100C general purpose amplifier) : adds 50 msec delay.
- NIBP100D-HD (via HLT100C high level transducer module): adds 50 msec delay
- When combining BioNomadix wireless signals with wired signals: adds 12.5 msec delay

Checking this box automatically adds appropriate delays, ensuring all data will be properly aligned when the above combination of hardware is used. This avoids the need to use calculation channels to manually align data when combining hardware types that apply varying amounts of fixed delay.

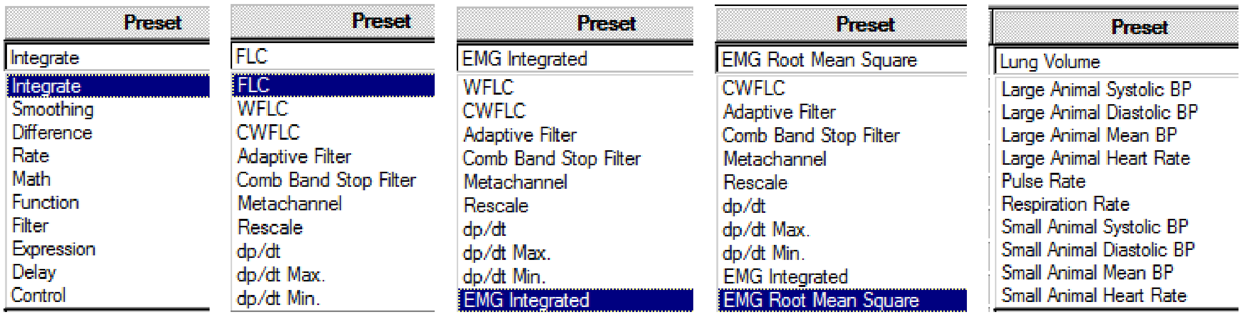
NOTE: If NIBP100D is not being used, or if BioNomadix is being used only with other BioNomadix receivers, then checking this option is not necessary. (It is unchecked by default.)

View by Channels

Channel Type

To specify the channel type

Part B



Calculation Presets

When you select a Preset, the Setup dialog is updated with the corresponding information.

- The Setup dialog reads

Part B

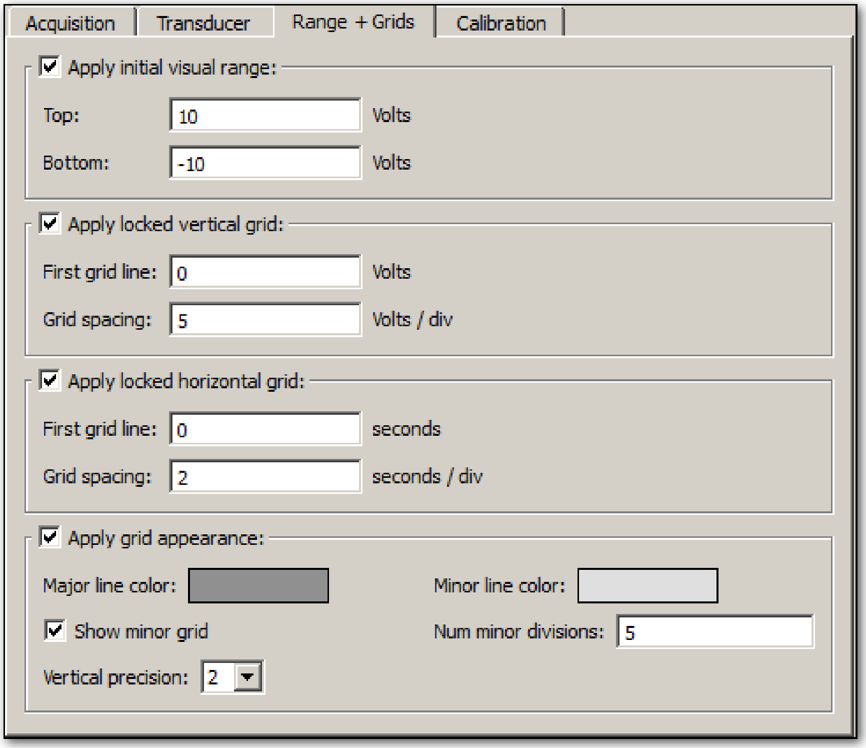
The Input Volts and Map (Scale) Value boxes reflect the value of the incoming signal and how it will be plotted on the screen, respectively. Thus, an incoming signal of +1 Volts would be plotted as 95° F, whereas a signal of 0 Volts would be plotted as 90° F. Acq*Knowledge* will perform linear extrapolation for signal levels falling outside this range (i.e., -2 Volts will be scaled to 80 ° F), as well as perform similar interpolation for values between this range. Enter these numbers in the scaling dialog, type in

Part B

Adjustable, user defined, digital IIR filters for MP36R

The MP36R Unit allows up to three user-configurable, sequential, biquadratic (second order) Infinite Impulse Response (IIR) filters per MP unit channel. These filters are typically configured by choosing a **Preset** but can be changed manually via the Input Channel Parameters dialog (MP36R > Set Up Data Acquisiton > Channels > Setup button). Each of these three filters can be uniquely set up as a low pass, band pass, high pass or notch (band reject) filter.

In the



Range + Grids Tab	Explanation
Apply initial visual range	The initial vertical axis range of plotted data will be set as indicated at acquisition start of the first data segment.
Top	Indicates the maximum vertical visual range in destination channel units.
Bottom	Indicates the minimum vertical visual range in destination channel units.
Apply locked vertical grid	Locked vertical grid settings are applied for the channel. For more details on grid setups, see Grid Details on page 75.
First grid line	Provides the fixed location of the origin of the vertical grid.
Grid spacing	Sets the spacing interval between major vertical grid divisions.
Apply locked horizontal grid	A channel-specific independent horizontal grid will be applied when the channel is added to a graph.
First grid line	Sets the origin location of the horizontal grids.
Grid spacing	Sets spacing between major horizontal grid lines based on the time domain.
Apply grid appearance	Enables options for setting grid color/appearance of major and minor grid lines.
Major line color	Allows customization of major grid line color.
Minor line color	Allows customization of minor grid line color.
Show minor grid	Shows/hides minor gridlines
Vertical precision	Indicates number of digits displayed on vertical axis.
Num minor divisions	Sets the number of minor grid divisions for the channel.

Part B

MP36R Transducer SSID Table

Device Part #	Description	SSID	ISID Name
BSLCBL3A, BSLCBL4B	Recording cable	1	
BSLCBL5	3.5mm phone plug adapter	6	
BSLCBL8, BSLCBL9	High-impedance recording cable	1	
BSLCBL14A	3.5mm phone plug adapter to MP35 Input.	6	
BSLSTMB/A	10 V setting	18	
BSLSTMB/A	100 V setting	19	
BSL-TCI13	Piezo interface cable	1	
BSL-TCI21	pH probe interface	12	
SS1L, SS2L, SS2LA	Electrode lead set	1	
SS2LB	Electrode lead set	N/A	SS2LB
SS3LA	EDA (GSR) finger electrodes	2	
SS4LA	Pulse Plethysmograph finger transducer	3	
SS5L, SS5LA, SS5LB	Respiration Belt (for Chest)	4	
SS6L, SS7L, SS8L	Temperature transducer	5	
SS9L, SS9LA	BNC Adapter	6	
SS10L	Pushbutton switch	7	
SS11LA	Airflow transducer	8	
SS11LB	Airflow Transducer	N/A	
SS12LA	Variable range force transducer	9	
SS13L	Blood Pressure (Arterial)	10	
SS14L	Displacement transducer	11	
SS17L	Piezo microphone	14	
SS19L	Blood Pressure cuff (with Gauge)	10	
SS19LA	Blood Pressure cuff	N/A	SS19LA
SS19LB	Blood Pressure Cuff	N/A	SS19LB
SS20L, SS21L, SS22L, SS23L, SS24L	Goniometer	16	
SS25L, SS25LA	Hand Dynamometer	9	
SS25LB	Hand Dynamometer	N/A	SS25LB
SS26L, SS26LB, SS27L	Accelerometer	17	
SS28L	Heel Toe Strike assembly	9	
SS29L	Multilead ECG cable	1	
SS30L	Stethoscope, electronic	14	
SS31L	Non-Invasive Cardiac Output Module	15	
SS32L	Dissolved Oxygen probe	20	
SS33L	GAS		

Part B

Up to 16 Calculation channels can be acquired, and 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

Part B

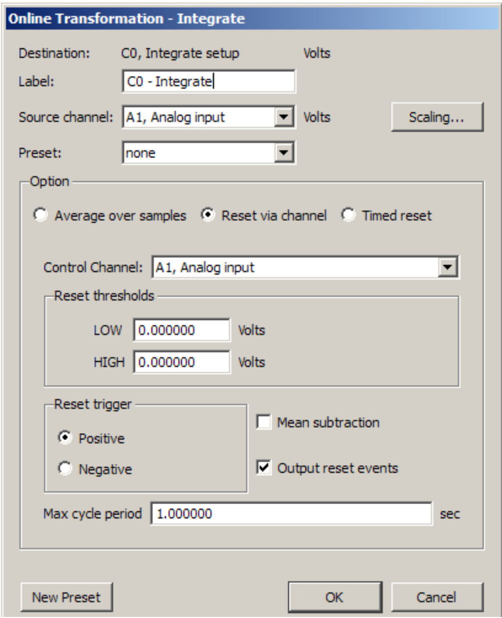
Acq*Knowledge* ***QUICK STARTS***

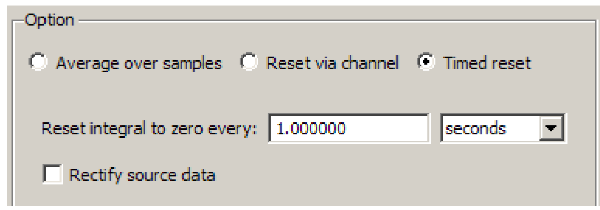
Quick Start templates (.gtl graph template files) are installed to the Sample Data folder. Use ***Quick Start*** files to establish the settings required for a particular application or as a good starting point for customized applications. *See* Open As Graph Template on page 249 for details.

Q##	Application(s)	Feature
1	EEG Sleep Studies	Real-time EEG Filtering Real-time EEG Filtering
2	EEG	Evoked Responses
3	EEG Evoked Response	Event-related Potentials Event-related Potentials
4	Evoked Response	Nerve Conduction Studies
5	Evoked Response	Auditory Evoked response & Jewett Sequence
6	Evoked Response	Visual Evoked Response
7	Evoked Response	Somatosensory Evoked Response
9	Evoked Response	Extra-cellular Spike Recording
10	Psychophysiology	Autonomic Nervous System Studies
12	Psychophysiology	Sexual Arousal Studies
13	EBI Cardiovasc. Hemodynamics Exercise Physiology	Cardiac Output Noninvasive Cardiac Output Measurement Noninvasive Cardiac Output
15	EOG	Nystagmus Investigation
16	EOG	Saccadic Eye Movements
17	Plethsymography	Indirect Blood Pressure Recordings
18A	Plethsymography	Arousal - Female
18B	Plethsymography	Arousal - Male
19	Sleep Studies	Multiple-channel Sleep Recording
20	Sleep Studies ECG Cardiovasc. Hemodynamics	Online ECG Analysis Online ECG Analysis ECG Analysis
21	Sleep Studies	SpO_2 Analysis
22	ECG	Einthoven

Part B

Integrate Calculation





The online Integrate Calculation offers three basic options:

Reset via channel. Perform a real-time integration of input data over a variable number of sample points. This option 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:

a) Real-time conversion of flow signals into volume signals (i.e., Blood flow → Blood volume; Air flow → Air volume)

b) Any processing involving a need for a cyclic, continuous integral calculated in real time. For example: Acceleration → Velocity; Velocity → Distance; Frequency → Number of cycles; Power → Energy

Average over samples. Perform a moving average (mean) and associated processing (Rectify; Root mean square) over the specified number of sample points. This option is useful to process EMG signals to:

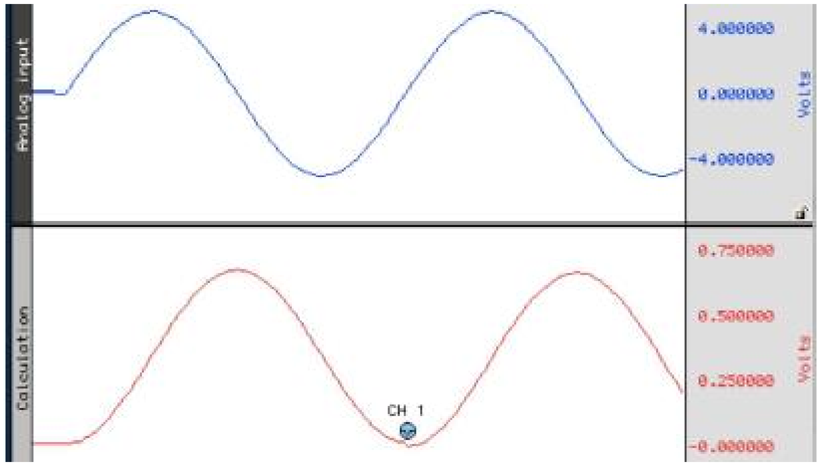
a) Smooth noisy data

b) Display the real-time

Part B

- Threshold crossing on the control channel

  For example: Calculation channel resetting on positive crossings of 0V on CH 1.



- Window expiry when mean removal is enabled

  For example: No threshold crossing within

Part B

- 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 integration scaling should be set to +10 Volts (next to Cal 1) and

Part B

Difference Calculation

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

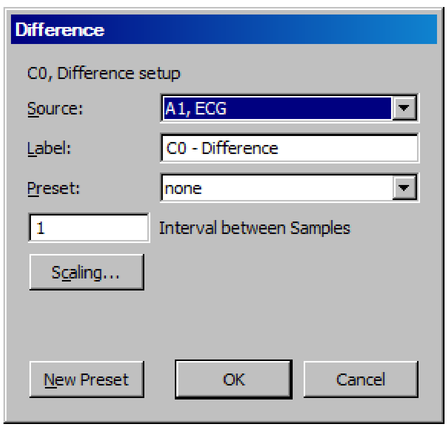
To have Acq*Knowledge* perform a Difference calculation in real time:

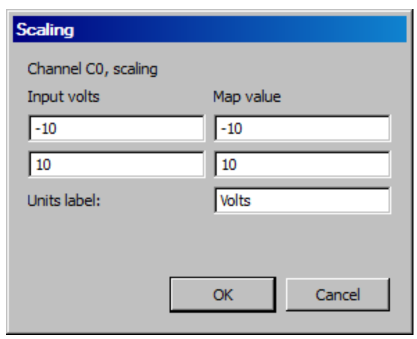
1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the modified data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select Difference.
5. Click the Setup button in the Input Channels dialog to generate the Difference dialog.

(Off-line Difference is available under Transform > Difference.)

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, and also includes the option of rescaling the channel to reflect different units.

Click the Setup button in the Input Channels dialog to generate the Difference dialog:





Source When the Source channel contains relatively high frequency data, the Difference Calculation may result in a very noisy response, so it

Part B

To perform a Rate Calculation in real time:

1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the modified data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select Rate.
5. Click the Setup button in the Input Channels dialog to generate the Rate dialog.

(Off-line Rate calculation is available under Analysis > Find Rate.)

Source

Part B

Math Calculation

The Math Calculation performs standard arithmetic calculations using two waveforms or one waveform and a constant. Calculation channels with lower channel numbers may be also used as a waveform.

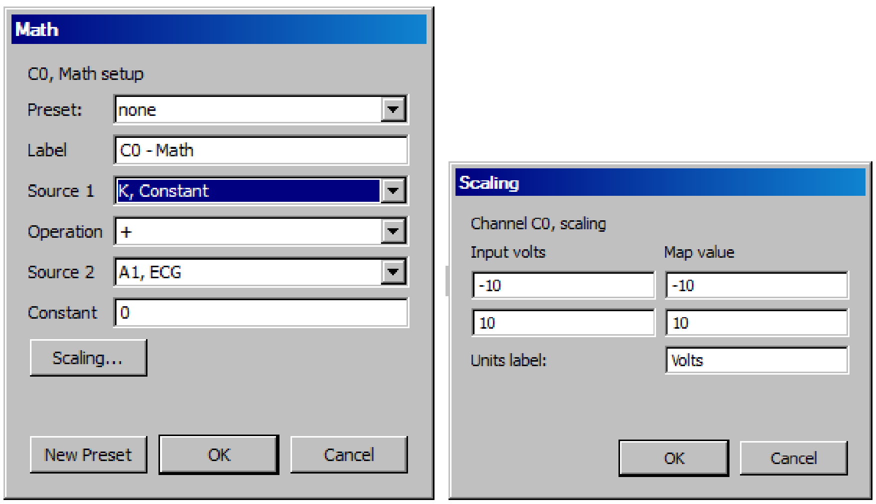
1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the modified data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select Math.
5. Click the Setup button in the Input Channels dialog to generate the Math dialog.

(Off-line Math calculation is available under Transform > Waveform Math.)

Use the pull-down Source menus to select the source channels (Source 1 and Source 2).

The Sample rate line provides the sample rate for the channel selected as Source; the channel sample rate may be different than the acquisition sample rate.

Use the pull-down Operation menu to select a function. In the example below, analog channel 1 (Source: A1) is added to analog channel 2 (Source: A2). To use this summed waveform as an input for another Math Calculation channel. One useful application would be to divide this waveform (C0) by K, where K=2, thus producing an arithmetic average of source channels A1 and A2.



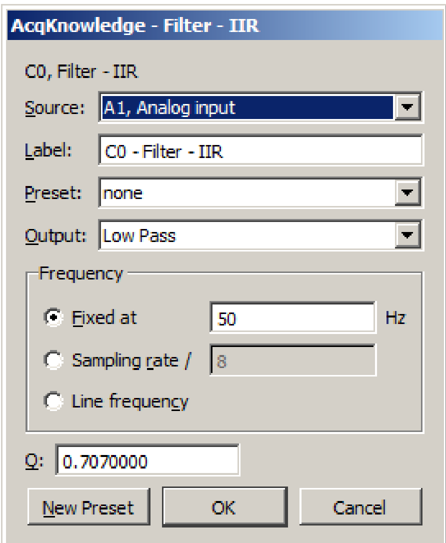
The

Part B

Filter IIR Calculation

The Filter IIR Calculation channel allows you to perform real time digital filtering on analog, digital, or calculation channels. To have Acq*Knowledge* apply a digital Filter IIR Calculation in real time:

1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the filtered data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select Filter.
5. Click the Setup button in the Input Channels dialog to generate the Filter dialog.

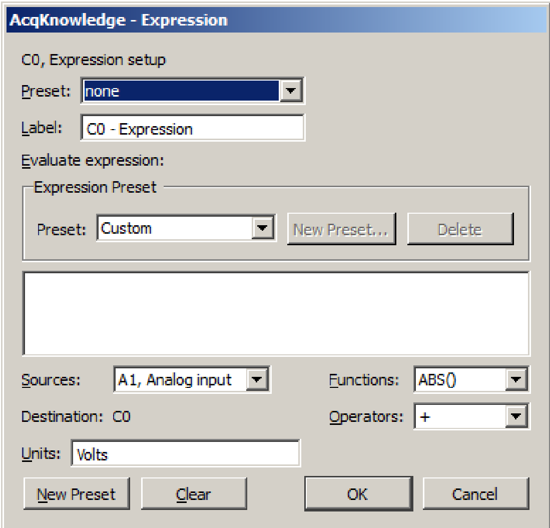


Filter Setup & Output Options

In the dialog above, the signal on analog channel one (A1) is run through a low-pass filter that attenuates data above 50 Hz. The

Part B

Expression



The online Expression calculation channel is available for performing computations more complex than possible in the Math and Function calculations, and is additionally available as an offline transformation and a measurement. (Different attributes may apply to each available Expression type.) The Expression calculation will symbolically evaluate complex equations involving multiple channels and multiple operations. Acq*Knowledge* can perform conditional evaluation, data extraction, logical operations, expressions requiring a range of samples or the results of the previous expression, and evaluation of generic formulas that can be expressed in a closed, recursive form.

Unlike the Math and Function calculations

Part B

Recursive notation

Since transformations and calculation channels replace the source data of the channel with the result of the expression evaluation in sequence, negative offsets are equivalent to returning the final result of the expression that was evaluated a certain number of steps in the past. The channel where the expression results are stored can be thought of as a storage record of the previous evaluation steps. Negative sample offsets, therefore, can be used to compute any formula that can be expressed in closed recursive form. For example, the recursive definition of the Fibonacci sequence is:

$$F_n = F_{n-1} + F_{n-2}$$

To evaluate this as an expression transformation, use the expression:

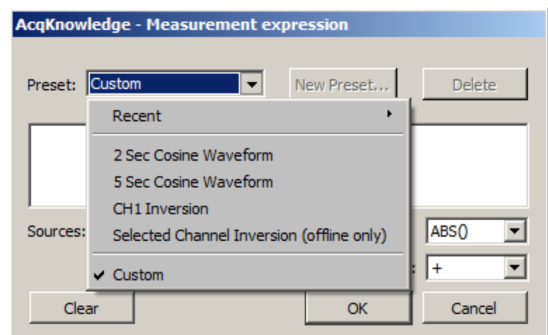
SC(-1)+SC(-2)

Note that to actually get the Fibonacci sequence; the selected channel would need to have a constant value of one prior to the transformation.

Expression Measurement

Measurements are powerful tools for quick manual analysis and also for advanced automated analysis when combined with the Cycle/Peak detector. Expression measurements extend measurements to evaluate simple formulas or complex data reduction. Each Expression measurement has an expression associated with it and the measurement result is derived from computing the Expression(s) on the selected data.

Measurement expression dialog is generated the first time a measurement is set to Expression or when the measurement preset button is clicked.



Preset menu allows access to pre-loaded commonly used expressions and displays user-defined custom presets, along with a list of recently-used expressions.

OK invokes a syntax check. If there is an error, the user will be prompted to correct the error and the error will be selected (highlighted) in the Expression edit field.

Cancel discards any changes to the Expression measurement and reverts back to the previous Expression.

Clear erases the current contents of the expression edit field.

Measurement Channel

Expression measurements can reference the

Part B

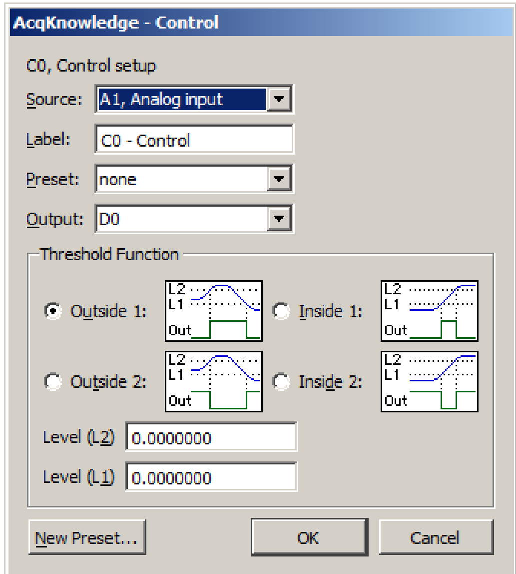
Source	Description
ACQLENGTH	*Calculation only* Acquisition length from Set Up Acquisition; keeps Appended segments the same whereas

Part B

LOG	Computes the natural logarithm of each value
LOG10	Returns the base 10 logarithm of each value
FUNCTION	RESULT
MAXIMUM	Returns the maximum value of all input arguments.
MiINIMUM	Returns the minimum value of all input arguments.
NOT(*x*)	Computes a logical negation of its argument. Evaluates to 1 if x is zero. 0 if x is non-zero.
OR(*x, y, …*)	Evaluates multiple variables; true if any are true. Computes a logical

Part B

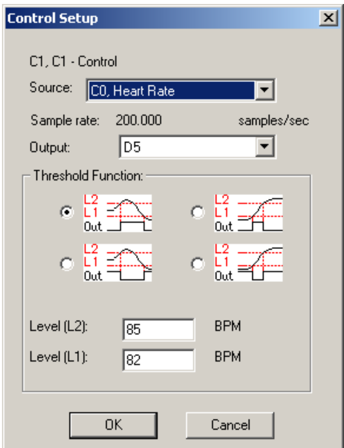
Control Calculation

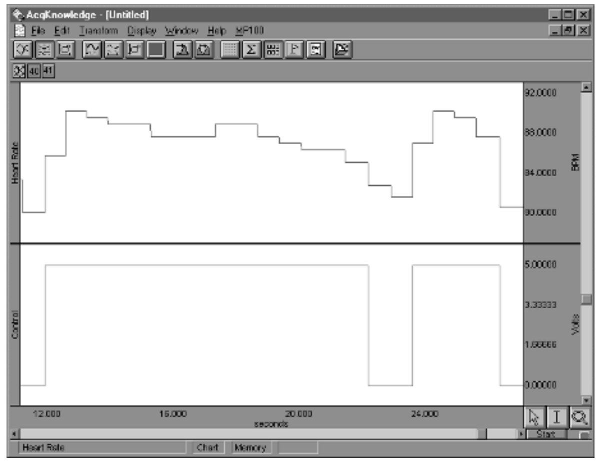


The Control function is used to output a digital pulse when the value for a specified input channel exceeds a certain level, falls inside a given range, or falls outside a given range. This feature is unique in that the output is on a digital channel (which ranges from I/O 0 through I/O 15) rather than a Calculation channel. Also, unlike other Calculation channels, this Control Calculation can only be performed in real time (i.e., while data is being acquired) and cannot be performed in post acquisition mode.

In addition to outputting a signal on a digital channel, the Control Calculation will also plot an analog version of the digital signal on the Calculation channel you specify. For instance, in the example below, Calculation channel C0 is used to perform a control function using analog channel 1 (A1) as an input and digital channel 0 (D0) as an output. In addition to outputting a pulse on D0, the setup below will also produce a plot on channel 40 (the first Calculation channel) that emulates the signal being output on digital channel 0. Since Calculations are analog channels, the Calculation channel does not contain a

As another example, the upper threshold value (L2) is set to 85 and the lower threshold (L1) is set to 83, which means that the threshold will not reset until the signal from the source channel drops below 83. In the following example, the digital line is switched from low to high (from zero to +5 Volts) when the heart rate channel exceeds 85, and stays at +5 Volts for several seconds even though the source channel drops below 85 (but above 83). The digital line does not switch back to zero until the heart rate channel drops below 83 (toward the end of the record). Once this occurs, the threshold is reset and the digital line will switch again the next time the source channel exceeds 85 BPM.





Control dialog and graph showing control channel with "wide" threshold

It is also possible to have the digital line switch when the source channel drops below a certain value. In the example below, a simple threshold is used to switch the digital line high each time the source channel drops below 50 BPM. Since L2 and L1 are set to the same value, this is not a

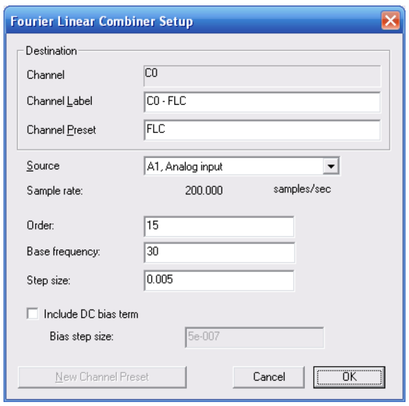
Fourier Linear Combiners: FLC, WFLC, CWFLC Calculations

Fourier Linear Combiners are linear combinations of adaptable sinusoidal functions that are particularly well suited to processing cyclic data. Sine and cosine are harmonics that are multiples of a *base frequency* that are summed together, and the *order* is the fixed number of harmonics used in the model. *Step size* provides mu, the gain factor used to adjust the weights of the harmonics at each processing step. Step sizes must be much less than 1 for the system to converge. As step sizes decrease, relaxation time lengthens. The FLC model is adjusted based on the source data using least means square (LMS) feedback and the *bias* compensates for DC offset.

To have Acq*Knowledge* apply an FLC Calculation in real time:

1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the filtered data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select FLC, WFLC, or CWFLC.
5. Click the Setup button in the Input Channels dialog to generate the appropriate dialog.

➲ For offline calculation, see FLC Transform options, including *Scaled FLC*, on page 289.



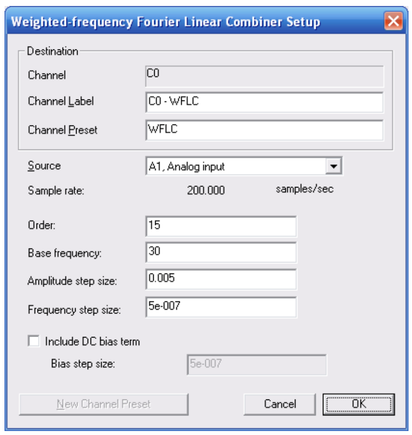
Basic FLC

Simple summation of fixed numbers of sines and cosines; uses harmonics of a fixed frequency and adjusts weighting coeffiicients of the mixture.

Operates on a single channel at a time.

Well suited for extracting data of a known frequency band from a signal with a stable frequency.

- Use as an adaptive noise filter to remove non-periodic and semi-periodic noise uncorrelated to the base harmonic frequency.



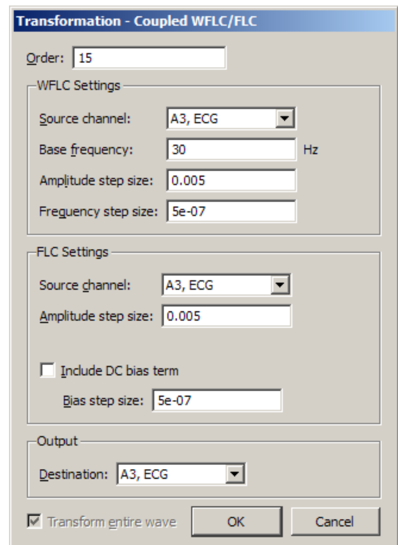
Weighted-Frequency FLC

Base frequency of the harmonics is variable; adapts the frequency in response to the input signal using LMS feedback; the frequencies are similarly adjusted to the amplitudes.

Operates on a single channel at a time.

Well suited for modeling periodic signals of an unknown and potentially varying frequency and/or amplitude.

- No cycle boundaries or frequencies need to be pre-determined.



Coupled WFLC/FLC

Runs a WFLC on the signal to determine the harmonic frequency and then runs the result through an FLC using the computed harmonic.

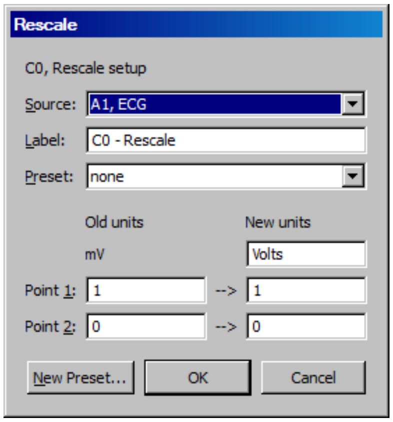
The second FLC can be run on the same or a different channel.

Well suited for real-time extraction of information from one signal based upon the frequencies contained in another signal.

- Use to remove movement noise from ECG.
- Unique configurations can be established with two input signals, one for frequency and one for amplitude.

Part B

Rescale Calculation



Rescale applies two-point linear mapping and allows users to change the measurement units (for example, to change temperature from Celsius to Fahrenheit). The text corresponding to the new units can be manually entered.

To have Acq*Knowledge* apply a Rescale Calculation in real time:

1. Choose Hardware > Set Up Data Acquisition > Channels.
2. Click the Calculation tab.
3. Check an Acquire box for the Calculation channel you want to contain the filtered data. You may also check the Plot and Values boxes as appropriate for each channel.
4. Click the Preset pull-down menu and select Rescale.
5. Click the Setup button in the Input Channels dialog to generate the Rescale dialog.

(Off-line Rescale is available under Transform > Rescale.)

- Use the Rescale transformation (after acquisition) to adjust forgotten calibration of analog channels or reverse incorrect calibrations.
- A "Rescale" Automator action has been added to allow rescaling to be performed in workflows. The Automator function is accessed from the Workflow menu in the Mac version of Acq*Knowledge.* (Not applicable to Windows.)

The rescale formula is:

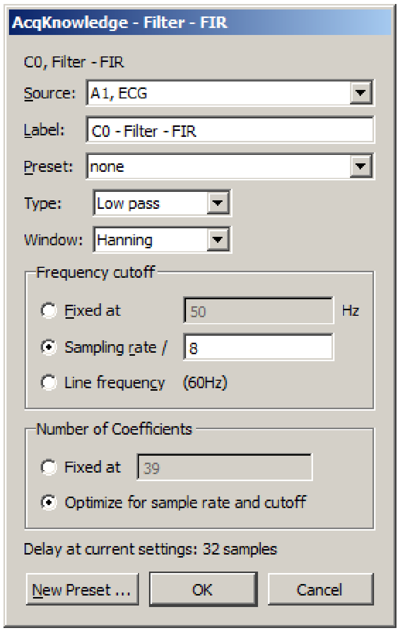
$$v_{new} = \frac{y_{new} - y_{old}}{x_{new} - x_{old}} v_{old} + \left(y_{new} - \frac{y_{new} - y_{old}}{x_{new} - x_{old}} x_{new} \right)$$

Rescale Source	Displays the label and number of the selected channel.
Old Units	Displays the values of the current vertical units of the channel
New Units	Allows for manual entry of the new units to be used. The new units will be displayed in the vertical units of the channel

Note Transform > Rescale: The units cannot be modified when transforming from the selected area because it is not possible to display different vertical units for different time ranges in the same channel.

8. Click OK and run the acquisition. Any artifact that falls outside the boundaries of the maximum/minimum allowed change setting will be eliminated from the recorded data.

Watch the Acq*Knowledge* Slew Rate Limiter video tutorial for a detailed demonstration of this feature.



Filter - FIR

In Acq*Knowledge* 5, FIR Filters are available as an online calculation channel. Until recently, real-time FIR filtering during acquisition wasn

Part B

Each time an acquisition is restarted in Append mode, , an append event is inserted into the recording. Append events can be configured to include user-defined labels and time/date stamps via the Segment Labels setup (see page 235). Although you can pause for any period of time, the Hardware will only acquire data for the amount of time indicated in the Acquisition Length box. Data can be acquired in Append mode while being saved to memory, disk, or the MP hardware unit (but not in Averaging mode).

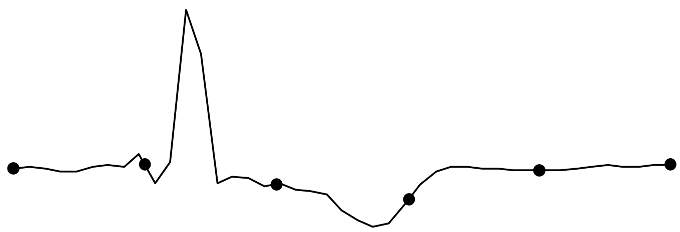
Sample data Acquired in "Append" mode. Events indicate where Acquisition was paused.

Appended segments can be stored to disk, memory, or MP160/150. (MP36R, BioHarness, Mobita, or B-Alert do not support data storage to the hardware unit.)

- **Append to Disk**: In this mode, it is usually best to record all channels at the same rate. If the user stops the acquisition, the length will be the same for all channels

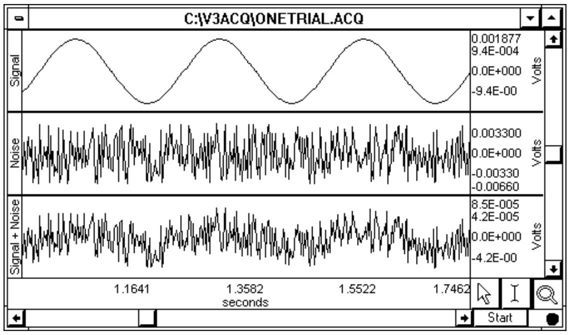
Part B

- Top waveform: data is sampled relatively slowly; difficult to make out the shape of the waveform.
- Bottom waveform: sampled at a relatively high rate; 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 between different ECG complexes, etc.

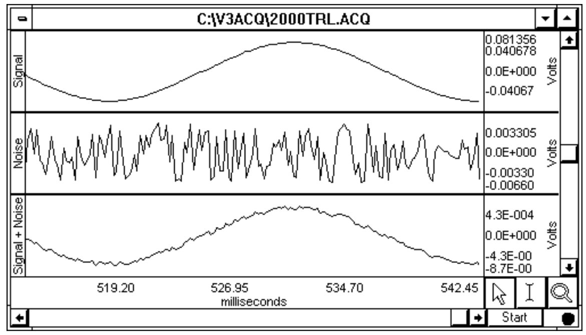


Representation of ECG waveform sampled with relatively few samples per second

Part B



Signal (top) measured in the presence of noise (middle), which results in the bottom waveform when measured in standard Acquisition mode



Same signal averaged in the presence of noise over 2,000 trials to produce the lower waveform.

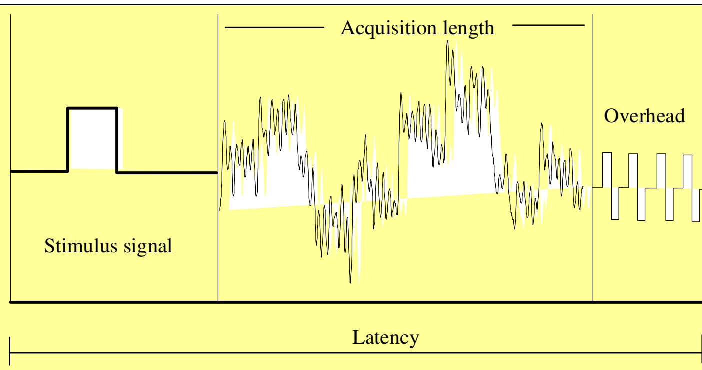
Typically, any averaging acquisition consists of three general components:

(a) the stimulus signal

(b) the duration of the acquired data, and

(c) a small amount of processing time (or overhead) that takes place between acquisitions.

The duration of the stimulus signal and the duration of data to be acquired can be set by the user. The amount of overhead required is a function of the acquisition length, the sampling rate, and the number of channels being averaged.



Stimulus signal	usually some sort of pure tone or pulse; occurs at the beginning or during each trial.
Acquisition length	refers to the amount of data to be acquired during each trial.
Overhead	refers to a period of time after data has been acquired that is needed to perform the mathematical averaging.
Latency	refers to the total time elapsed between the start of one trial and the start of the subsequent trial.

Important usage notes

- **The maximum length of a single averaging pass is restricted to 2 seconds**; if longer averaging passes are required, use regular data acquisition and use the Ensemble Average offline analysis option to generate averages in post-processing.
- **The preferred hardware setup for on-line averaging mode is direct connection to the MP160/MP150** via cross-over cable. To improve stability, avoid interruptions during acquisition:
  - Do not access top-level menus (File, Edit, Transform, etc.) or generate popup dialogs (Setup

Part B

External trigger

To initiate a trial from an External Trigger signal enable the Ext Trigger in the Averaging options dialog as well as the Positive or Negative Edge. The trigger can be set up in the Trigger pane of the Data Acquisition Setting dialog. See page 170.

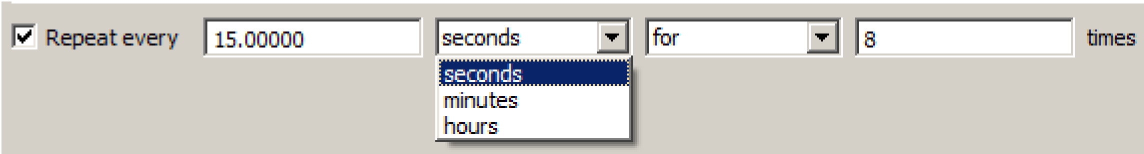
Artifact rejection

Occasionally during an acquisition, extreme levels of unwanted signal artifact may be present. Checking artifact rejection allows you to determine what signal levels constitute artifact, and have the MP System reject these trials. When artifact rejection is enabled, the MP System will ignore any trials that contain signals exceeding the artifact rejection thresholds, keep track of how many trials have been rejected, and add that number of trials to the total number of trials to be acquired. This allows a user to

Part B

Repeating

Use the Repeat mode to acquire data from repeated trials using the same parameters for each trial. Checking the Repeat every box at the bottom of the acquisition setup dialog enables two additional popup menus at the bottom of the dialog. These allow for control of how many times an acquisition will repeat as well as the interval between trials. When this 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).



Interval The entry to the right of the

Starting an acquisition

After setting up the channels and defining the acquisition 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 corner of the screen, next to the 

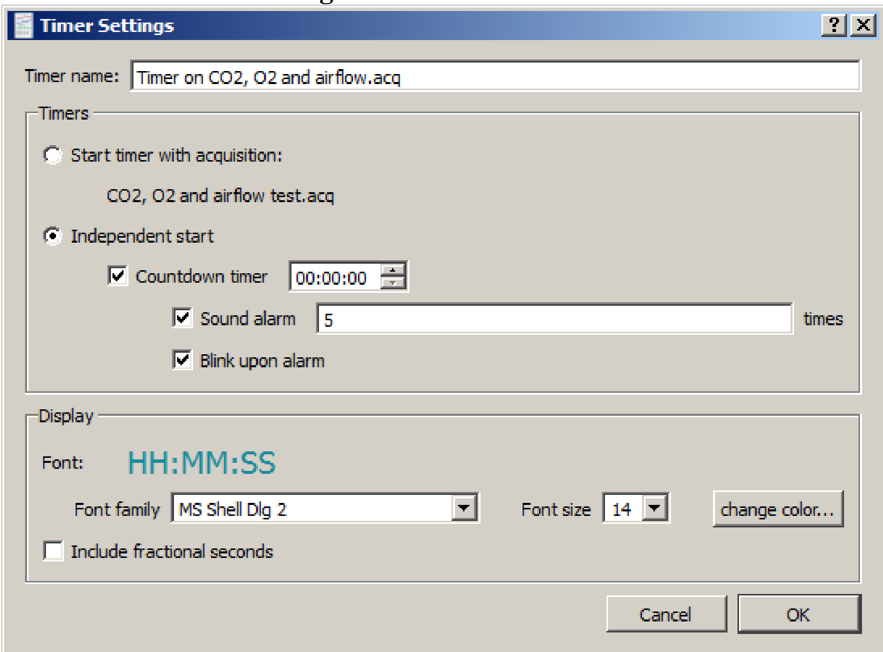
button, you should see a button with a circle to the left of it. The circle indicates the status of the communication link between your computer and the hardware. If the unit is properly connected to the computer and is turned on, the circle should be solid and green. If the unit is not properly connected, a solid gray circle will appear.

Start the acquisition by clicking the 

button or by selecting

Part B

Overview of Timer Settings

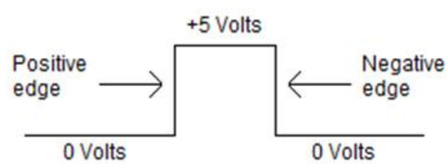


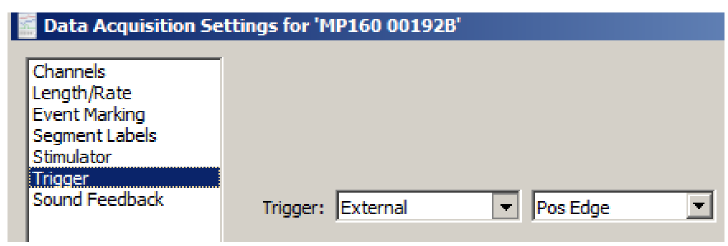
CONTROL	DESCRIPTION
Timer name:	Field for assigning name to timer.
Start timer with acquisition:	Timer will start and stop with data recording only.
Independent start	Timer is started and stopped manually, independent of acquisition status.
Countdown timer	Sets the countdown time duration.
Sound alarm	Selects the audible alarm option and specifies the number of times the alarm will sound.
Blink upon alarm	Enables the timer numbers to flash on and off when the countdown is complete.
Display > Font family: > Font size > change color	Selects timer font style, size and color.
Include fractional seconds	Sets option to display 1/100ths of a second in timer display.

All parameters established in the Timer Settings are retained in saved graphs and graph templates.

Chapter 8 Set Up Triggering

During a normal acquisition, the MP hardware will begin collecting data as soon as the Start button is clicked. It is also possible to begin an acquisition in a delayed fashion using a trigger. This feature enables an acquisition to start





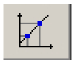
Part B

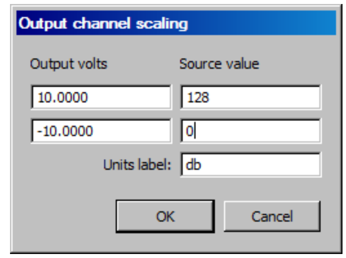
Mode	Once the trigger channel and level have been specified, the final parameter is the delay. Delay can be measured in terms of samples, milliseconds, seconds, or minutes, and may be set to zero if desired. The delay option instructs the hardware to wait a specified period after the trigger level is reached before beginning the acquisition.
Delay	When using a trigger, the default setting is for the acquisition to begin immediately after the trigger pulse or level occurs. You can modify this default by using the Delay option in the Trigger Setup dialog. This feature allows an acquisition to begin a specified period after the trigger level is reached. To start an acquisition one second after a switch closes, set the trigger to external and enter 1.00 in the box next to Delay. The default scale for Delay is seconds, meaning that the acquisition will begin a specified number of seconds after the trigger has been initiated. The scale of the delay can be changed from seconds to samples, milliseconds, or minutes. **NOTE:** Delay option not available in MP36R hardware.
Pretrigger	During normal triggered acquisitions, data is collected only after the trigger has been activated (or after some delay). For some applications, it is useful to collect data on events that occur just prior to the trigger event. As an example, if an acquisition was set to begin when a device (such as a tone generator or flash) sends an output pulse, it might also be important to collect information on the subject

Stimulator Parameters

The Stimulator parameters are set by using the buttons in the right pane of the setup window.

Reset Refresh the display; use after the time scale has been adjusted.

Scaling  Scaling button



Manual Stimulator Control

When an MP160/150 unit is being used, the manual stimulator controls at the bottom of the Stimulator Setup dialog can be used to start and stop stimulators independently of the acquisition. If changes are made to the stimulus wave while a stimulator is running, the stimulator will need to be turned off and then back on to apply the changes to the settings.

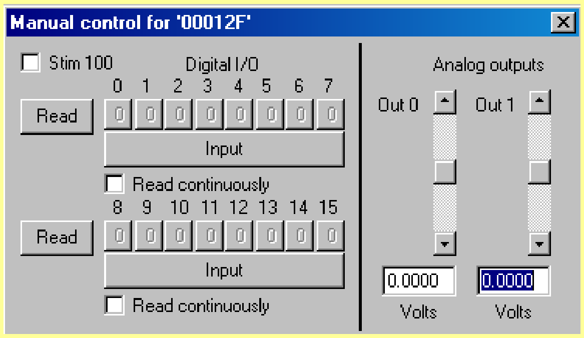
The manual stimulator controls cannot be used if the MP160/150 is set to acquire in averaging mode.

- The stimulator output will start simultaneously with the acquisition.
- The On/Off buttons will start and stop the stimulator output.

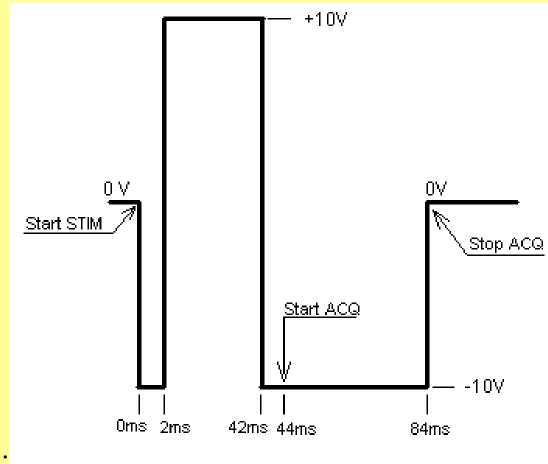
If Dual Stimulator settings are active,

Part B

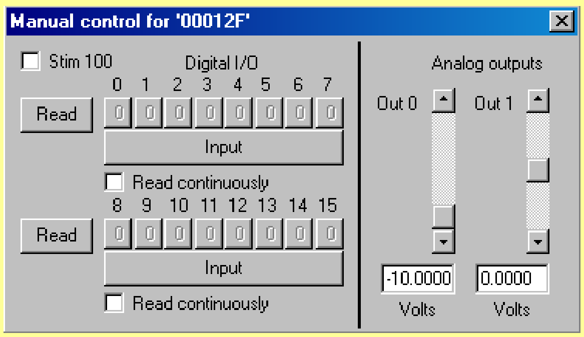
Manual Control list box:

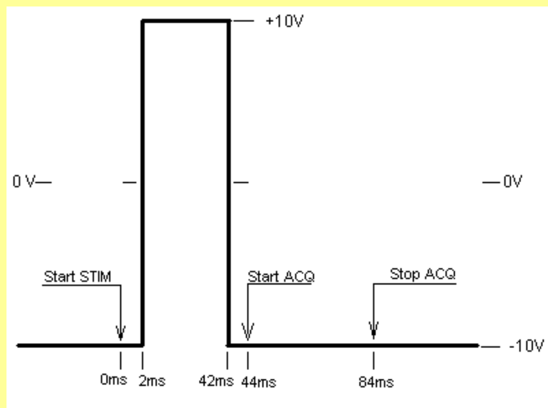


Stimulator Output pattern (using MP160/150)



:

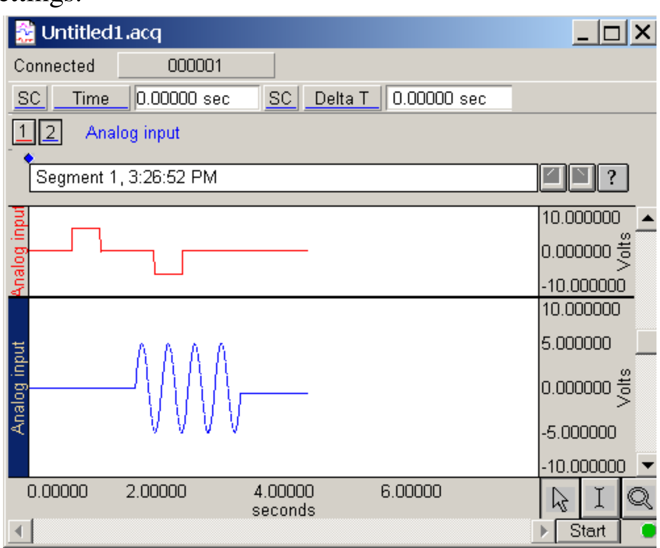




For details on Manual Control, see page 230.

Dual Stimulation

For independent control of two stimuli (such as sound and electrical output), set stimulator functions for Output to A0 and A1 for each MP160/150 unit. Click the tab for each output at the top of the Stimulator Setup dialog and complete independent settings.

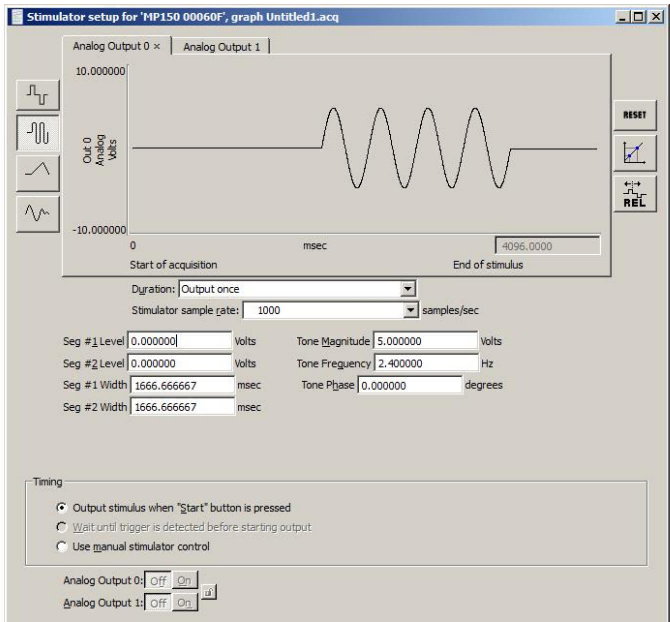


- For additional stimulus paradigms, add MP160/150 units (see Multiple Hardware, page 158).

Part B

Tone Stimuli

Tone waveforms allow for the creation of pure tone signals of any duration, magnitude, and frequency. This option outputs a pure sine wave, which is useful for audiological and stimulus response testing.



A tone waveform is comprised of two segments, with only the second segment being the actual tone itself. This allows you to include a pre-signal delay (by setting the level for Segment #1 to 0 Volts and the duration to a desired value).

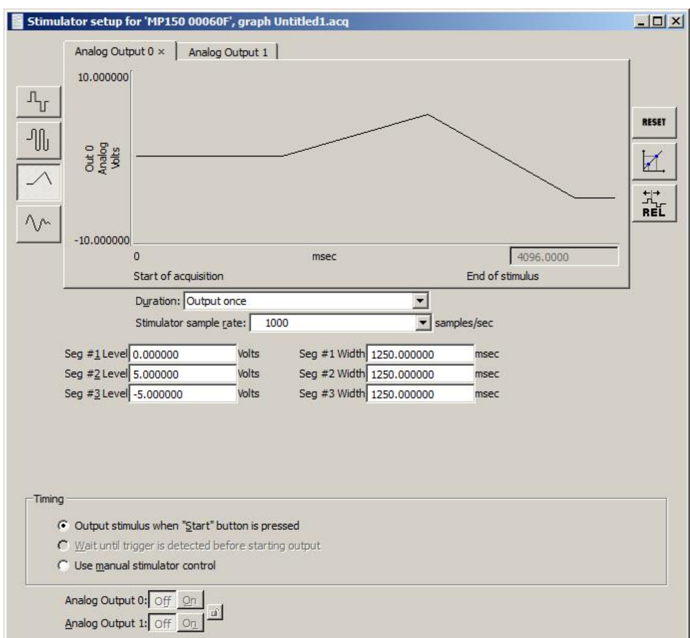
To set the duration of the tone, adjust the length of segment #2 (by changing the Seg #2 Width value box or by clicking and dragging the segments within the window). As shown, there is an additional (uneditable) section of the waveform *after* the second section. This segment returns the last value from segment two, and continues to output that signal level until the acquisition is terminated (if the stimulator is set to output once) or until another signal is output (if the MP System is set to output continuously).

There are three additional parameters for Tone waveforms: frequency; magnitude; and tone phase.

- Tone frequency refers to the frequency of the second segment of the waveform. This can be set to any value, although the most common settings are between 20 Hz and 20,000 Hz.
- Magnitude refers to the peak-to-peak range of the signal, which can range from ± 0 to ± 10 Volts.
- Phase of the stimulus signal can be any value equal to or greater than 0 degrees. Phase settings of more than 359 degrees will be rescaled to fit the 0°-359° range. In other words, setting the phase to 360° or 720° has the same effect as setting the phase to zero degrees.

Ramp Waves

Ramp waveforms are useful for constructing a monotonically increasing or decreasing stimulus signal.



Ramp waves are comprised of three segments and the amplitude and duration can be set discretely for all three sections.

Part B

MP160/150 Stimulator Sample Rates

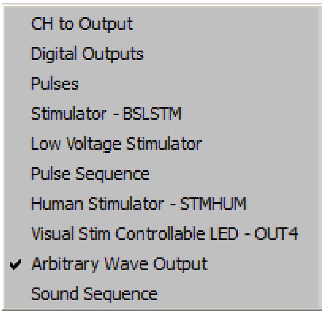
The MP160 or MP150 is the most common data acquisition device used with Acq*Knowledge*, and when combined with the HLT100C/UIM100C and STM100C modules, capable of outputting various waves at different rates, durations and types. As explained ealier in this chapter, there are four basic Stimulator signal types: **Square**, **Sine**, **Triangle** and **Arbitrary** waves. Square, Sine, and Triangle waves are limited to 4096 samples, which may be outputted once or continuously. 4096 samples also define the upper limit of a short burst wave. Arbitrary waves, like the other types, can be outputted once or continuously, but are not subject to the 4096 sample upper limit.

The Stimulator output sample rate is configured in Acq*Knowledge* by choosing MP160/150 > Data Acquisition Set up > Stimulator > Stimulator sample rate. The stimulator sample rate may be the same, lower, or higher than the acquisition sample rate. The output signal can be redirected to an analog input channel. In this case, the number of samples displayed in the graph is determined by the acquisition sample rate. If the source wave can be uploaded entirely to the MP160/150 memory (

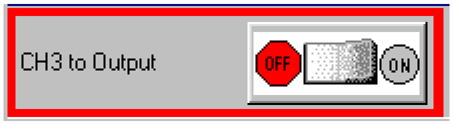
Part B

Chapter 10 Output Control

Note Output Control chapter refers to MP36R hardware only.
For MP160 or MP150, see the previous chapter,



CH# to Output



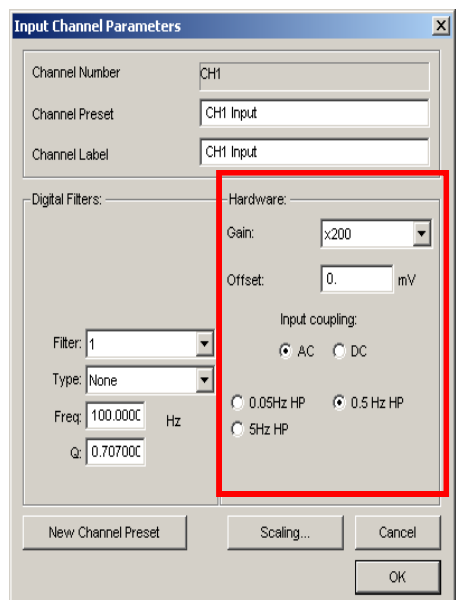
The CH# to Output Output Control redirects an analog input signal to the **Analog Out** port on the back of the MP36R UNIT. The signal from the assigned channel will continue to be record and plot data.

This Output Control is used commonly when attaching headphones to the MP36R unit to listen to signals coming in on an analog input channel; for example listing to the Electromyogram.

To display this control panel:

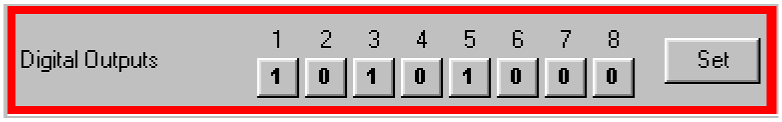
Choose MP 36R > Output Control > CH# to Output to open the control panel.

MP36R users may use analog input CH1-CH4. Channel 3 is the default setting. If another channel N has been designated, the menu will read



Part B

Digital Outputs Control



The Digital Output Control manages the signal output for each of the eight digital lines via the **I/O Port** located on the back of the MP36R. Digital lines are used to control external devices.

The digital output uses standard TTL levels which correspond to the control panel setting as follows:

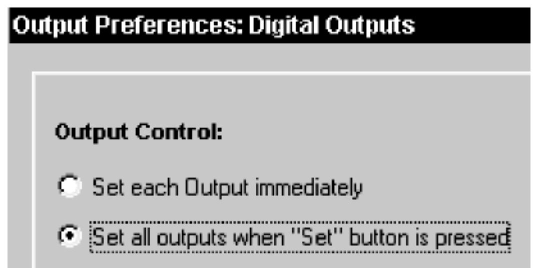
Control Panel setting	Output Voltage level (Volts)
0	0
1	+5

To display this control panel:

Choose **MP36R > Output Control > Digital Outputs** to open the Digital Outputs Control panel

Click each digital output line to set its digital state to 0 (off) or 1 (on).

To set **Preferences** for Digital Outputs, open the Preferences dialog by right-clicking the control panel.



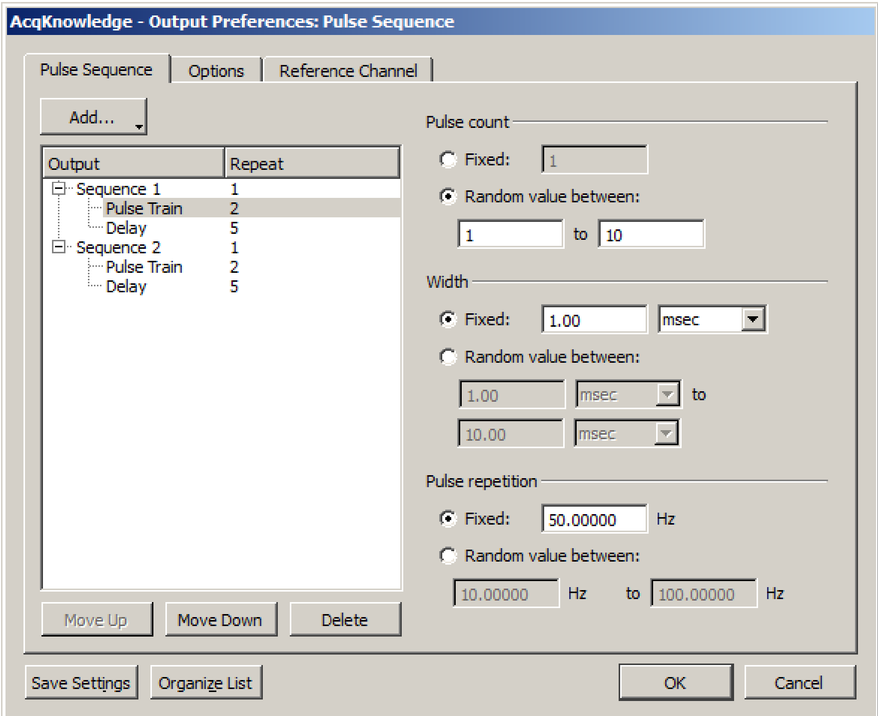
Select from the following two options:

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.

Use with stimulator electrode HSTM01 for safe, stimulation of human subjects (0

Part B



Preferences available in Pulse Sequence tab

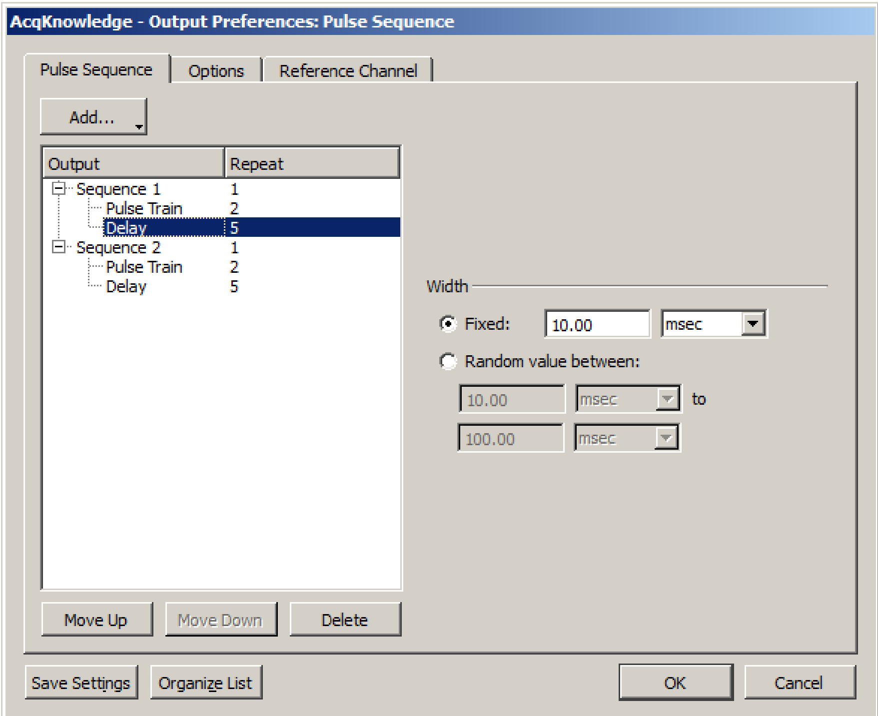
Add: Displays pop-up menu for adding Sequences, Pulse Trains or Delays.

Output: Displays the configured sequences and sequence elements for the current or saved session.

Repeat: Editable field for setting the number of times the pulse train or pulse train element is repeated

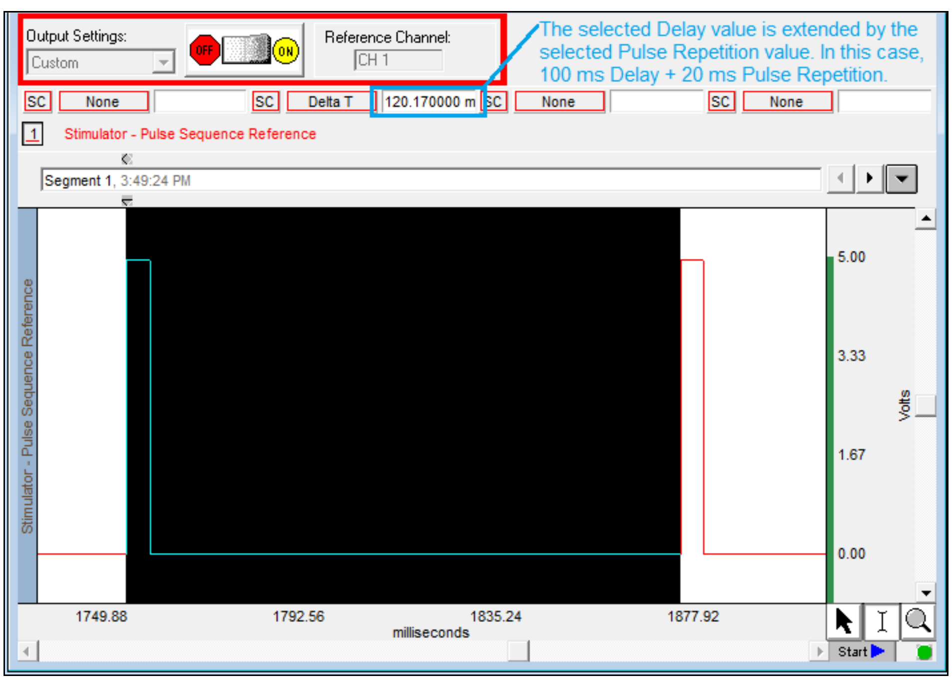
Pulse count: Fixed

Part B



Delay Preferences

About Delay between Pulse Trains:
The amount of actual Delay between pulse trains will vary from the set value depending upon the pulse repetition value that is used. In the example sequence below, a Delay of 100 milliseconds between pulse trains has been set up, combined with a pulse repetition rate of 20 milliseconds. Because the pulse repetition rate is applied before the Delay occurs, the actual Delay between pulse trains in this case will be 120 milliseconds. If it is critical that a Delay reflect an exact value, it is advisable to subtract the selected pulse repetition value when setting up the Delay parameters.



Delay between pulse trains

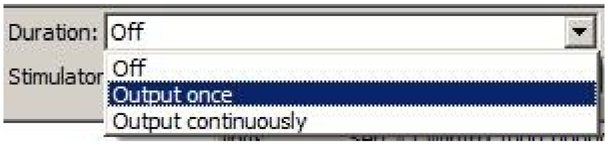
Arbitrary Wave Output

Acq*Knowledge* with MP36R supports signal output through one analog channel while data is being acquired. This is configured by using the Arbitrary Wave Output option.

Four types of signals can be output:

Square waveforms

Duration



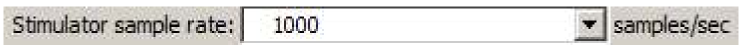
Off: Turn Output OFF (no stimulus signal output).

Output once: Output the stimulus signal once.

Output continuously: Output the stimulus signal for the duration of the acquisition (forever).

When Output continuously is selected, a vertical line is generated at the end of the first section of the waveform in the stimulator window to indicate where the first output signal ends and the second begins. The line can be dragged left or right like a vertical segment in a stimulus waveform to control the duration of the waveform as it is continuously output. Maximum continuous waveform output is 20 kHz.

Stimulator Sample Rate



Use to select the Stimulator sample rate for the generated signal. (The Stimulator sample rate is independent of the acquisition sample rate. See page 182 for sample rate details.)

For more details on all other MP36R Stimulator parameters and functionality, see the previous MP160/150 **Stimulator** chapter on page 173.

See also: Application Note AH162 - Using the Stimulation Features of the MP System.

Sound Sequence Output Control

Sound Sequence Output Control offers users the option of configuring and customizing sounds to be outputted for aural stimulus experiments. The control panel and Preferences dialogs used for Sound Sequence closely resemble that of Pulse Sequence. The built-in sound resource (a default

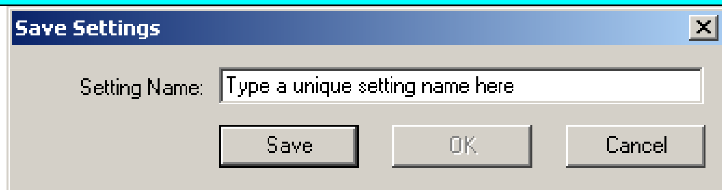
Part B

Pulse Defititions

The following terms are used in the Output Control panels, Preferences, and guidelines for Pulses, Stimulator

Part B

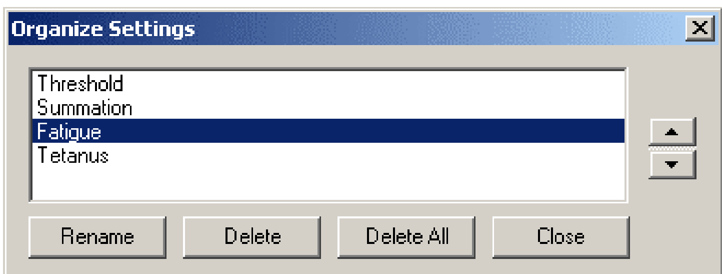
OUTPUT CONTROL PANELS



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.

Multiple configurations can be saved as long as each has a unique name; the Save button will be inactive if the name you enter is not unique.

Settings can be saved locally (to a specific file) or globally. 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. Selecting

Part B

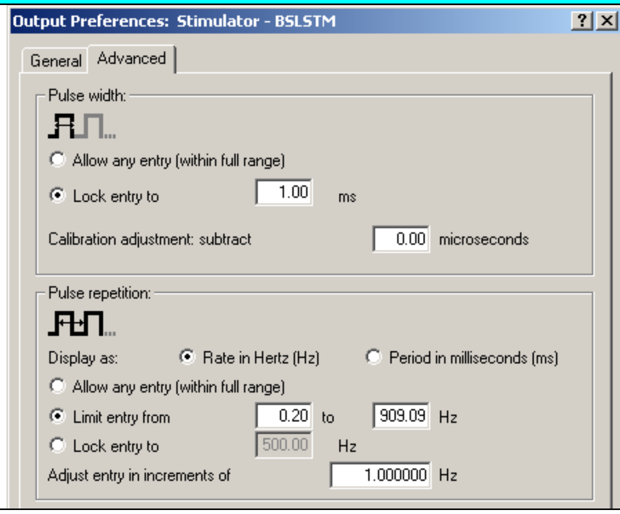
Recording	When
 Start button	
 Stop button	

Part B

ADVANCED TAB (OUTPUT PREFERENCES)

Advanced Tab

(Applicable only to Pulses, Stimulator - BSLSTM, Low Voltage Stimulator and Human Stimulator-STMHUM)



Pulse Width

Indicates the Pulse Width setting, which determines the maximum Pulse Rate frequency. The Pulse Width value is limited by the Preference setting.

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.

An entry may be automatically changed if any of the following conditions apply, in which case the closest possible value will be selected:

It falls outside the allowable range.

It is rounded to .01 millisecond increments (MP36R resolution).

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 MP36R unit. This option allows any entry within the allowable range specified below:

PULSE WIDTH RANGE	MP36R hardware
Range	.050

Part B

Advanced Tab Limits	Pulses	BSLSTM
Pulse width		
Range (ms):	.050	

Part B

For example, if CH1 is set up for ECG data and then selected as the Reference Channel, the ECG parameters will be replaced. If another channel is then selected, CH1 will be reestablished with the default analog input parameters, and the ECG settings would need to be recreated via presets or manual entry.

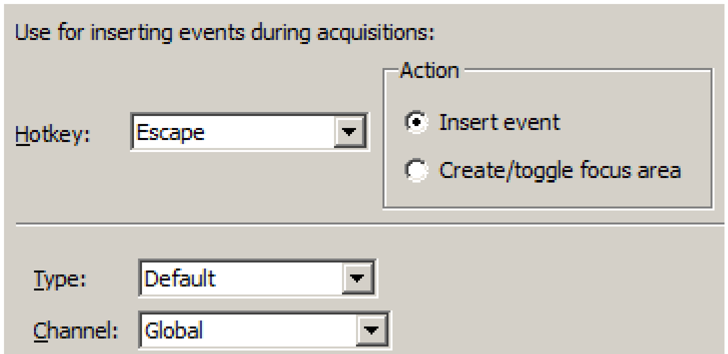
The reference Channel label should read:

Part B

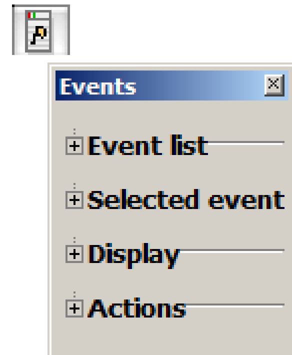
Chapter 11 Set Up Event Marking

Events (Markers)

Event Toolbar



Event Insertion



Event Control

Event (Marker) Overview

For detailed analysis, it can be useful for waveforms to have extra information associated with them. This information might include waveform boundaries from ECG analyzers, spike classifications from a spike sorter, heartbeat classifications, or even detailed user notes. Acq*Knowledge* 4 uses

Part B

- Sort Grouped events

Sorted by time	sorted in order by increasing time
Sorted by label	sorted alphabetically by label

- Include only events visible on the screen

  Determine if the summary is generated for all of the events that are in a graph, or only for those events that are currently visible on the screen. If there are thousands of events in a file, this feature allows the list to be pared down to those of interest.

Event summary options will be saved with the graph if the graph has a graph journal, and can be pasted into the journal using

Part B

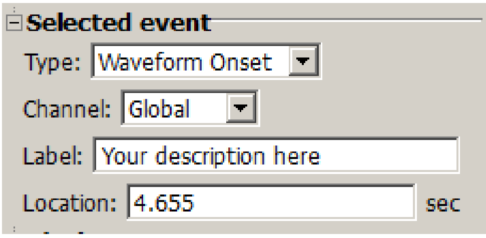
Additional Hotkey Setup Controls	Function
Add	Adds an editable label field to the list.
Rename	Allows renaming of the existing segment label.
Delete	Deletes a selected custom label.
Delete All	Deletes all custom labels.
Up	Incrementally moves a selected label up the list.
Down	Incrementally moves a label down the list.
Top	Moves a selected label to the top of the list.
Bottom	Moves a selected label to the bottom of the list.
Include time	Adds timestamp to labels when checked
Include date	Adds current date to labels when checked

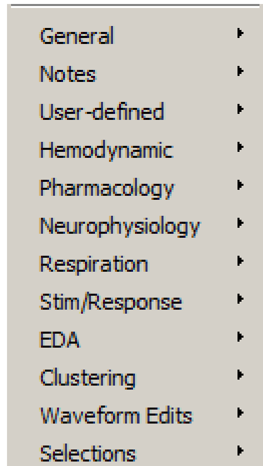
Create/Toggle Focus Area Action

Selecting the

- When disabled, the event list will display all of the events for the entire graph. This can allow for easier navigation through graphs with hundreds of events, such as PhysioBank files.

Selected Event

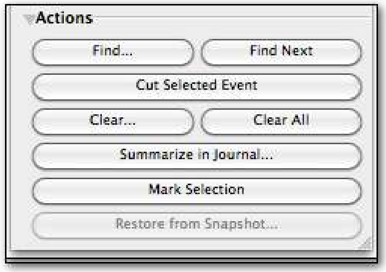


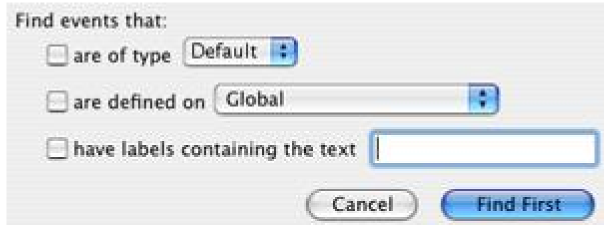


Event type options are detailed on page 221.

When a single event is selected, the type, channel (or

Actions





Actions Button	*Description*
Find	It is easy to create many more events then one can easily scroll through and locate in a list. Find controls the automatic location of events based on established search criteria. Click the Find button to generate the Event search criteria dialog, and then combine or restrict information to define desired events: event type, specific channel location, or label search. Click

Part B

This opens the

Part B

	normal Right bundle branch block Bundle branch block Atrial premature Aberrated atrial premature	 Atrial escape Nodal escape Supraventricular escape Ventricular escape
Hemodynamic > Blood Pressure	Systole Diastole	End Systolic pressure End Diastolic pressure
Hemodynamic > ECG Complexes	QRS onset, peak, and end T-wave onset, peak, and end P-wave onset, peak, and end Q-wave peak S-wave peak	U-wave peak PQ junction J-point ST segment change T-wave change
Hemodynamic > Impedance	A-point B-point C-point	O-point X-point Y-point
Hemodynamic > Monophasic AP	Plateau	Upstroke
Hemodynamic > Other	Start of ventricular flutter Ventricular flutter wave End of ventricular flutter	Pacemaker artifact Isolated QRS-like artifact Non-conducted P wave
Notes	Arrow	

- Amplitude at last event only

- Disabled: prints only the event icon, label, amplitude, and time. No indicator lines will be printed for the event display. The vertical divider can be used in place of indicator line drawing.

Events and Waveform Editing

Waveform editing will adjust event locations for channel-specific events. Waveform editing will never alter the time values for Global events (not associated with any specific channel, such as append events).

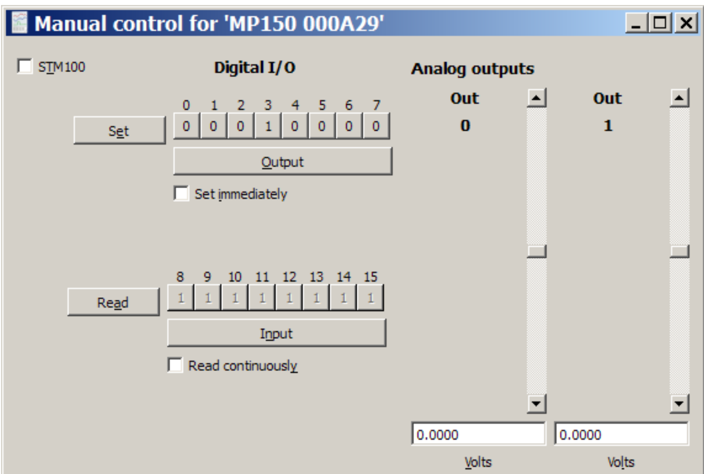
Copy When a portion of a waveform is copied the channel events will also be copied to the clipboard.

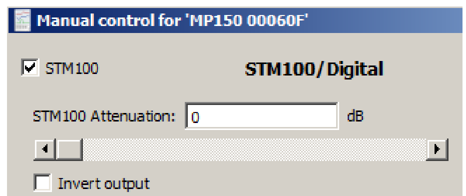
Cut When a portion of a waveform is cut, events within that selected area will be removed and channel events to the right of the removed area will be shifted to the left.

- If waveform editing event insertion is active, a waveform edit event will be inserted at the location of the edit operation indicating a

- **Channel Numbers** will display the channel numbers (A1 for the first analog channel, for example).
- **Units** will display the units for each channel (as indicated in the main graph window).
- **Labels** will display the channel labels (ECG 1, Respiration, etc.) along with the input values. This feature is especially useful when values from multiple channels are being displayed simultaneously.
- **Min/Max** will display the range of values associated with the data. This range corresponds to the upper and lower display limits for each channel as it appears in the graph window.
- **Values** will display number values along with the horizontal or vertical bar chart.

Manual Control (MP160 and MP150 only)





STM100 option

The Manual Control dialog allows you to monitor and/or output pulses through the digital input/output (I/O) channels, as well as manually set the magnitude of the signal on either of the analog output channels. The digital outputs in Manual Control cannot be used to trigger an online Averaging acquisition.

Stimulator Usage Note

Use Manual Control to specify the stimulation output level

a. If the wide range of waveform output options available in the Stimulator Setup dialog cannot match your specifications.
b. For pre-stimulation and post-stimulation.

See page 177 for important Analog Output details.

The 16 digital channels are sectioned off into two blocks, with the first block consisting of I/O channels 0 through 7, and the second block consists of I/O 8 through 15.

- All the channels within a given block are programmed together and can be set as either inputs or outputs.
- The two blocks can be set independently.
  - For example, one block can be set to input data and the other to output data, or one block is inactive and the other block reads or outputs data.

To read incoming values for a given block of digital channels, click the Input button below the row of channels for which you wish to have input values displayed. This enables a block of digital channels to receive incoming data. To read the values for the entire block simultaneously, click the Read button to the left of the channel boxes for that block. Since these are digital channels, the values on the individual channel boxes will toggle between 0 and 1.

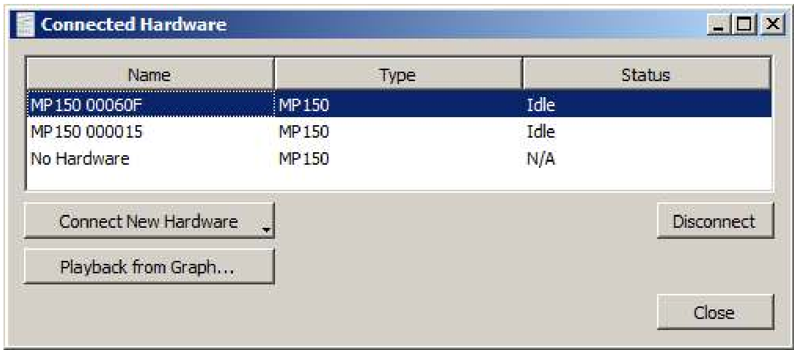
Part B

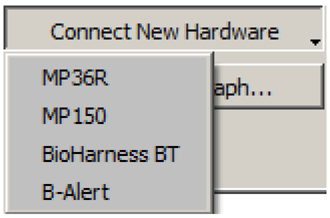
Set Up Linked Acquisitions

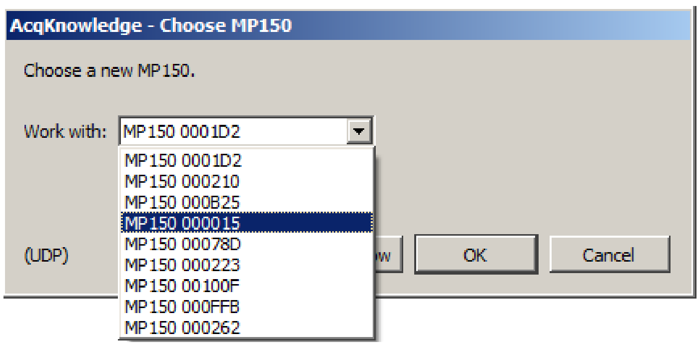
This Hardware menu option allows acquisitions to be configured and recorded simultaneously from multiple hardware devices types over separate graphs. (For example, acquisitions can be simultaneously linked to two MP160/MP150, two MP36R units or an MP160/MP150 and a B-Alert unit..) In order for Linked Acquisitions to function, each selected graph must be connected to a different hardware unit. (If two or more graphs are connected to the same hardware unit, the linked acquisition session will not start.)

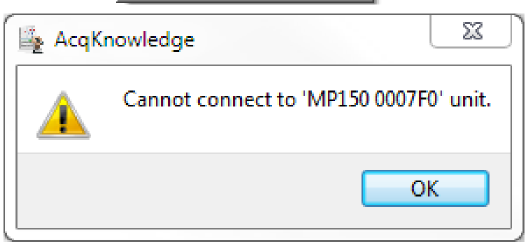
To add or change the hardware device to any open graph, click the

Manage Hardware Connections







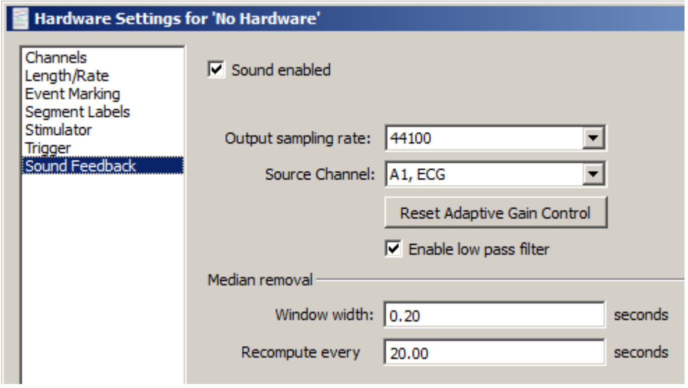


The Manage Hardware Connections option enables easy connection and disconnection of new hardware, and allows switching from a particular hardware unit (or hardware type) to another. The following controls are available:

Connect New Hardware

Choosing

Part B



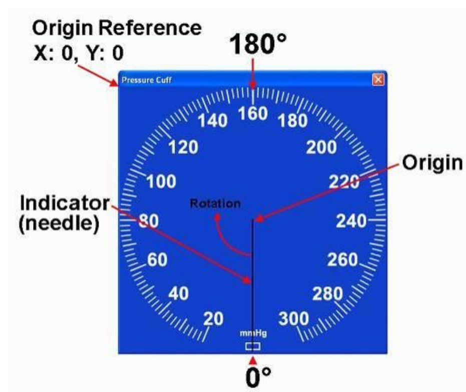
SOUND FEEDBACK CONTROLS	FUNCTIONS
Sound enabled	Turns sound feedback of data on and off.
Output Sampling Rate	Selects from available sampling rates of the default audio device.
Source Channel	Selects the analog, digital or calculation channel from which the audio will be acquired.
Reset Adaptive Gain Control	Resets gain control to adapt to the current level of the signal. Use after sound feedback has started to re-adjust the level after accidental spikes or large artifacts.
Enable low pass filter	Applies a low pass filter at the Nyquist frequency (50% of the acquisition sampling rate). This IIR filter can help smooth out transition artifacts due to upsampling of data to the audio sampling rate. (Enabled by default)
Median removal controls (Window width, Recomputate)	Removes baseline offset from the output signal.
Window width	Sets width of median removal window (in seconds). Must be a positive value.
Recompute every	Provides the time duration (in seconds) after which the median of the data is regenerated from the raw source data. Must be a positive value.

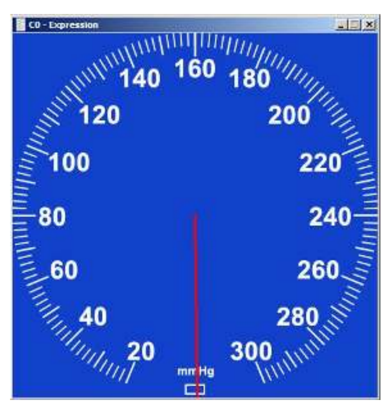
Part B

Channel Provides a pop-up menu for assigning any one of the ENABLED analog or calculation channels.

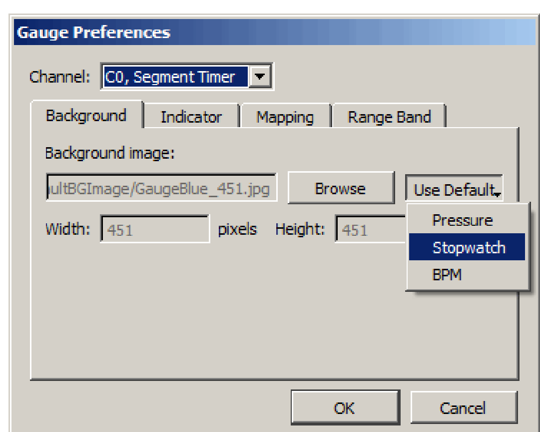
Background Image Displays the path and file name of the current background image. The default image is a blue blood pressure gauge sized at 451 x 451 pixels.

Browse Allows alternative background images in different directories to be used in place of the default gauges. The Browse location will default to the file path used by the currently selected background image. To change the background image, click the





Segment Timer



Warn on Overwrite

Selecting the

Part C

Part C

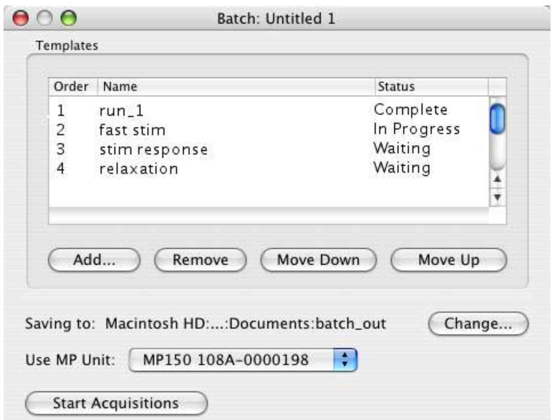
New > Batch Acquisition

Use the Batch Acquisition feature to configure advanced experimental setups and acquire data from a sequence of templates. Each template in the Batch may have different acquisition settings, channel configurations, and stimulator setups. Use a Batch for long duration experiments with hardware setting changes across segments, to automate routines, or to run multiple experiments on the same experimental setup in succession.

- For example, if an experiment has a preparatory period, a stimulus period, and a response period, three graph templates could be batched:
  - A template to acquire for the length of the preparatory period
  - A second template with a stimulator configured for the stimulus period
  - A third template to acquire the response period without stimulation

All three templates could be added in sequence to a single Batch Acquisition, which would then acquire all of the data for all three templates with a single start.

To create a new batch, choose File > New > Batch Acquisition to generate the Batch dialog.



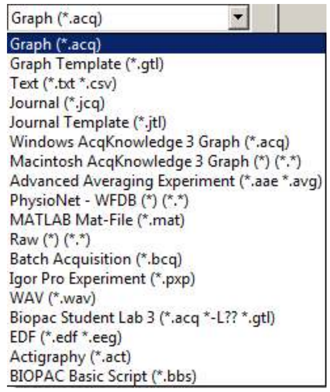
The Templates controls at the top allow you to add, remove, or re-order the templates.

- Double click a template in the list to open the output graph from the most recent acquisition.
- Batch acquisition cannot combine acquisitions that do not end, so the acquisition storage mode for template files cannot be set to

Part C

Open

The File > Open command generates the standard file open menu, and allows you to open a variety of different file formats from the popup menu at the bottom of the dialog.



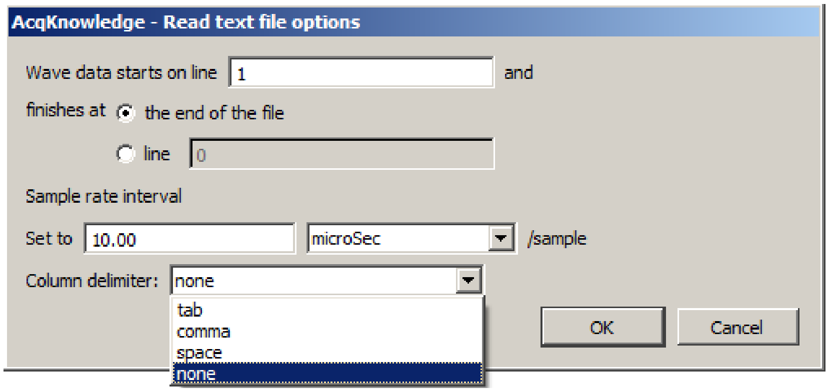
Multiple files

To open multiple files in a single dialog, hold the Control/Command key down and select multiple files. To open consecutive multiple files in a single dialog, select the first file, hold the Shift key down and select multiple files. Acq*Knowledge* can only recognize one Journal file at a time, so multiple selection is disabled when the file type is set to Journal or Journal Template.

Graph The default file formats (*.acq) is referred to as

Part C

When the Files of type: Text option is select, an Options button is activated. Clicking on this button generates another dialog that allows you to control the amount and type of data to be read in, as well as the time scale for data display.



Wave data starts on line

To control how much data is read in, enter a value in the read line box at the top of the dialog. This tells Acq*Knowledge* which row contains the first data point in the series. By default, this is set to 1, although you may want to set it to another value since some applications (usually spreadsheets) generate a

Part C

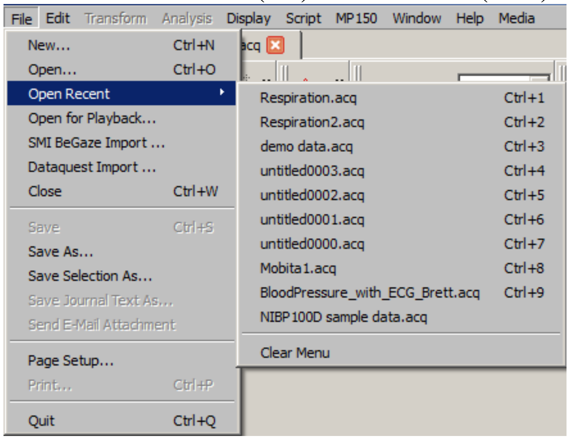
and then click OK to open the file.

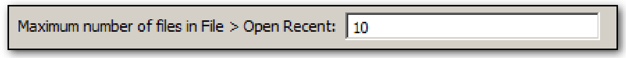
- If Acq*Knowledge* can

Part C

Open Recent

The File > Open Recent command generates a list of recently used files. These files can be opened directly from the list or with a Ctrl (PC) or Command (Mac) keystroke combination.





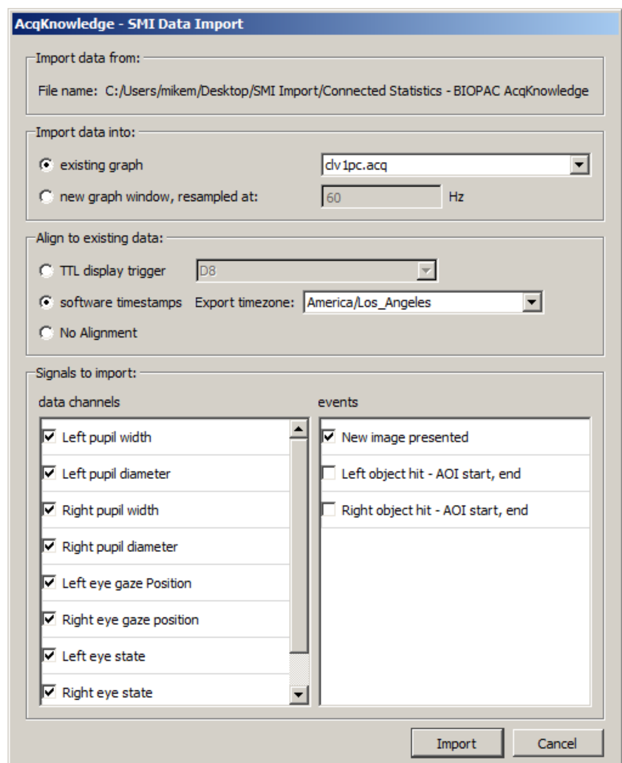
The listed files appear in the order they were opened, with the most recently-opened file appearing at the top. Default number of files appearing in the list can be modified in the Preferences. (Display > Preferences > Other or Main Toolbar)

Open for Playback

The File > Open for Playback command generates a standard file open dialog; see page 40 for Playback details.

SMI BeGaze Import

This option allows for import of SensoMotoric Instruments BeGaze software



Part C

- Import of either waveforms or parameters
- Provides choice of animal subects to be imported

Datquest File Description

Unlike graph files, Dataquest ART saves data as multiple files in a single directory. Each file may be either a continuous recording or consist of multiple segments.

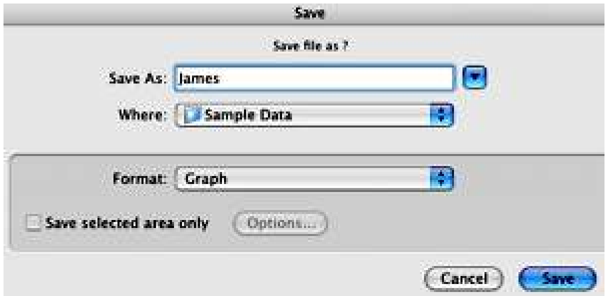
A recording may contain multiple animals/subjects. Each animal/subject is given an animal ID. This animal ID forms the basename of all of the various Dataquest data files.

Two primary types of data are recording for each animal: waveforms and parameters. Waveforms are the semi-continuous raw data recorded from transmitters during the segment. For multi-channel recordings, each channel may have an independent sampling rate and the sampling rate may vary within an individual channel for an individual experiment, but the duration and recording frequency are identical across all channels and animals. Parameters are derived measurements such as heart rates, mean pressure, and other values derived from the raw data. The user's protocol may dictate which type of data will be useful in the analysis, but many DSI customers perform further data reduction on the parameters instead of working with the raw data.

Dataquest splits waveforms and parameters up into separate files. Specific ID parameters are stored into a sequence of files named

Part C

Save



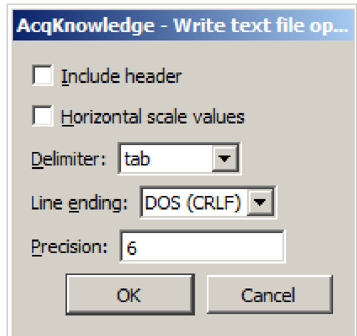
This menu command will save any changes made to a file. If more than one file is open, this command only applies to the active window. For untitled files, you will be prompted to name the file you wish the data to be saved in. The file will remain open after you have saved it, allowing you to continue working.

- The Save menu is dynamic and corresponds to the type of file you are trying to save, i.e. Save Graph, Save Journal.

Files should be less than 2 GB, except Acq*Knowledge* 3.9

Part C

TXT Saves graph data in text format. When Save As Text is selected, an Options button is generated. Clicking on this button generates a Save Options dialog that allows you to control how much data is saved and the format it is saved in.



Include header

When the first box is checked, a

Part C

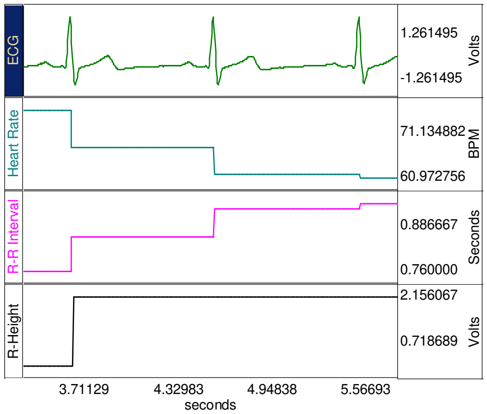
Layout: *Packed sequential*: All of the data for an individual file is located in a single block of the file and multiple channels follow one another.

Interleaved: Data is grouped into a single

Part C

JPG

Acq*Knowledge* also supports formats for saving graphical information. Most drawing, page layout, and word processing programs can read .JPG files. This is particularly useful for writing reports. A. JPG file can be opened in any standard drawing program and can then be embellished or used to highlight any particular phenomena of interest.



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. Since Acq*Knowledge* 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.

Compressed

Saves a compressed Acq*Knowledge* formatted file. The degree of compression varies based on data characteristics, but will generally achieve about 60% compression. Saving small files (less than 200K) may have little effect. Using a sample file as an example:

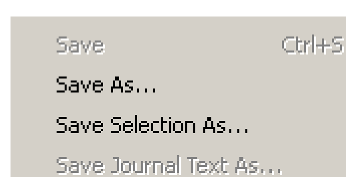
ECGdata.acq	166 KB
ECGdata_Compressed.acq	38 KB

Compressed graphs no longer allow data acquisition and will open with no Start button.

A warning prompt will be generated when you try to compress a graph in which data can be acquired (Start button active):

Excel Spread-sheet

Excel Spreadsheet Export



Send Email Attachment

Use this feature to create an email attachment containing an image of the active Acq*Knowledge* graph, along with the journal contents.

When using this feature:

- The default email program will launch, along with a

Part C

- Print Options
  - **Plots per page**

Part C

Edit menu functionality during acquisition

The following Edit menu functions cannot be performed during acquisition: Undo, Cut, Clear, Clear All, Paste, Insert Waveform, Duplicate waveform, and Remove Waveform.

Undo / Can

Part C

Select All

When Select all is chosen from the Edit menu, the entire selected channel becomes 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 Edit > Clear all is chosen after Edit > Select all. When this occurs, all data from all waveforms will be deleted.

Insert waveform

The Edit > Insert waveform command is useful for copying a waveform (or a section of a waveform) within the same or another graph. However, within the same graph, Duplicate waveform is simpler.To do this, first select the area to be copied using the cursor and the Edit > Copy command. Next open the graph window to insert the waveform into.

Select the new graph and choose Edit > Insert waveform. A new (empty) channel will then be created and the data copied into the empty channel.

- Insert waveform cannot be performed during acquisition.
- This command cannot be undone directly, although selecting the inserted channel and choosing Remove waveform from the Edit menu effectively undoes this operation.

Duplicate waveform

Choosing Edit > 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 highlighted area will be duplicated.

Duplicate waveform may move or alter memory and cannot be performed during acquisition.

- To duplicate the entire waveform, choose Edit > Select all and then select Duplicate from the Edit menu or click the right mouse button and select Duplicate from the pull-down menu.

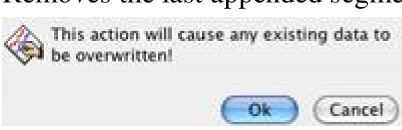
Remove waveform

Deletes the entire selected waveform, regardless of what other options are selected. Remove waveform may move or alter memory and cannot be performed during acquisition.

- The Edit > Undo command does not work for Remove waveform.

Remove last appended segment

Removes the last appended segment. Equivalent to the  Rewind toolbar icon.



- Edit > Undo does not work for Remove last appended segment.

Create Data Snapshot

The Snapshot options store

Part C

Merging graphs as data segments

Individual graphs may also be merged into a single channel as appended segments. This can be useful for concatenating data types that don

Part C

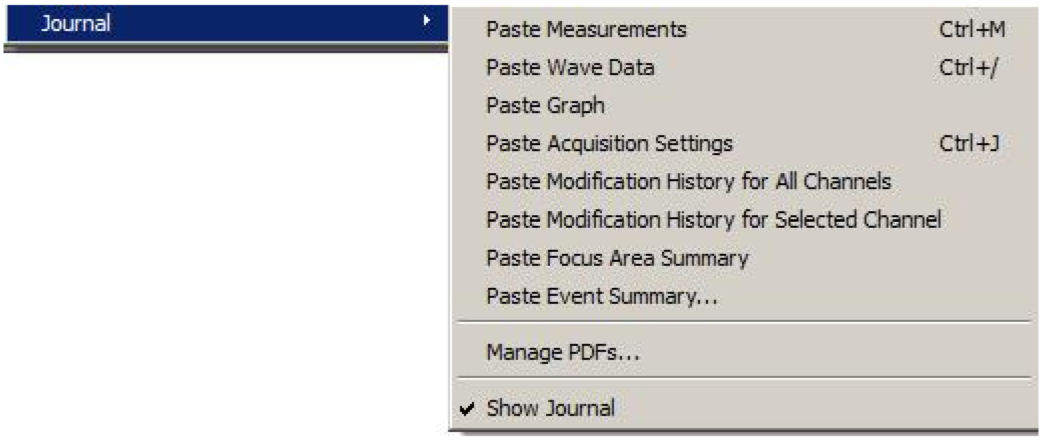
- Copy Focus Area Summary

Copies the starting and ending position of the focus area in horizontal axis units. Summary includes focus area label.

- Copy Event Summary

Copies events to the clipboard as selected in the Event Summary setup dialog.

Journal



The Edit > Journal sub-menu options are similar to those found in the Edit > 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 Measurements

  Choosing Paste Measurements from the Edit > Journal menu will cause all visible measurement windows to be pasted into the journal. Each time this is selected, the measurements and values are pasted into the journal using the precision specified in the Display > Preferences dialog. You can also change the total number of measurements displayed by adding more rows of measurements. Use the Preferences menu (see page 442) to change the number of measurement rows or the measurement precision displayed on the screen.

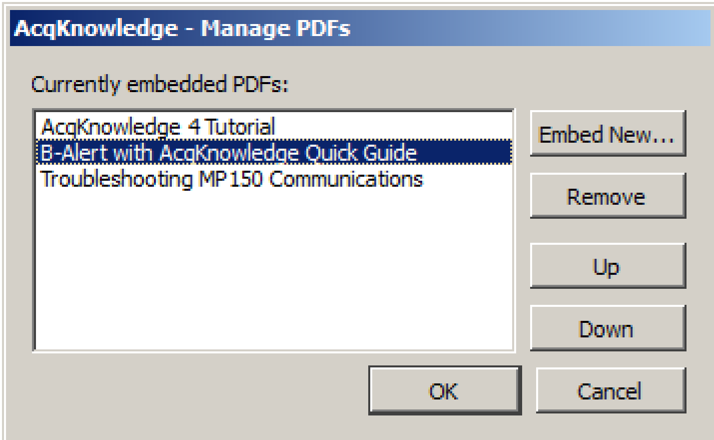
  Paste Measurement shortcuts:

  - Keyboard: Ctrl + M
  - Mouse: Right-click in the Journal and choose

Part C

- Manage PDFs

Use this option to select and import (embed) PDF files into the Journal as tabbed windows. Multiple PDFs may be imported and each PDF appears under its own tab heading. Choose Edit > Journal > Manage PDFs, or right-click in the Journal and choose Manage PDFs. The following dialog will appear:



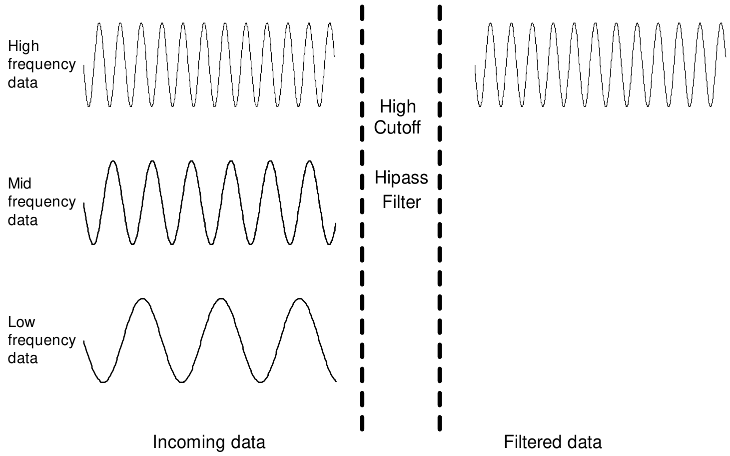
Control	Description
Embed New	Launches a

Part C

Recently Used Transformations

The Transform > Recently Used submenu allows quick access to a user

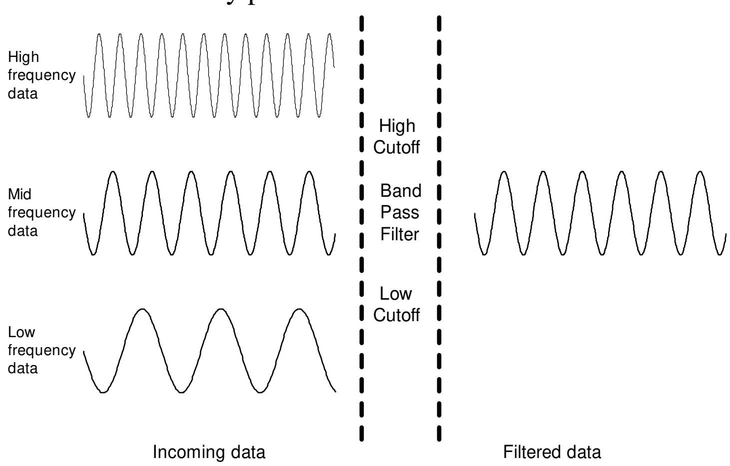
Part C



Whereas the low pass and high pass filters retain data either above or below a given threshold, the next two types of filters work with a range, or band, of data.

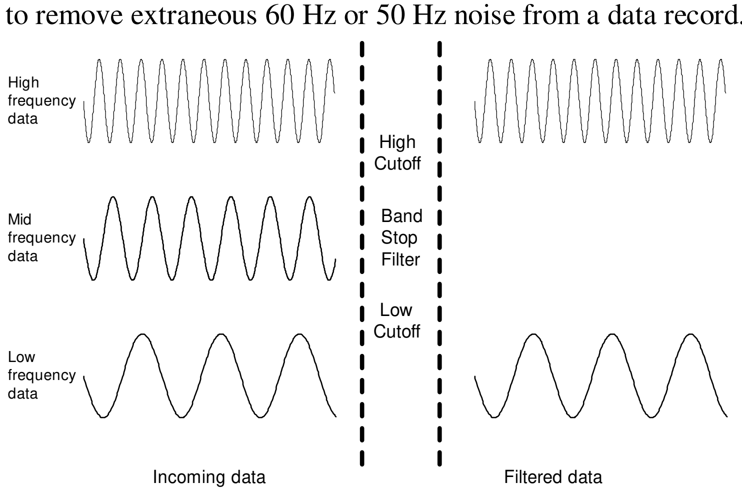
Band pass filter

The band pass filter, allows only the data within the specified range to pass through the filter. A band pass filter is useful when you want to retain only specific waves from an EEG record. For instance, to retain alpha waves, you can set the filter to only pass data between 8 Hz and 13 Hz.



Band stop filter

The band stop filter allows data to pass above and below the specified range. This type of filter is typically applied to remove extraneous 60 Hz or 50 Hz noise from a data record.



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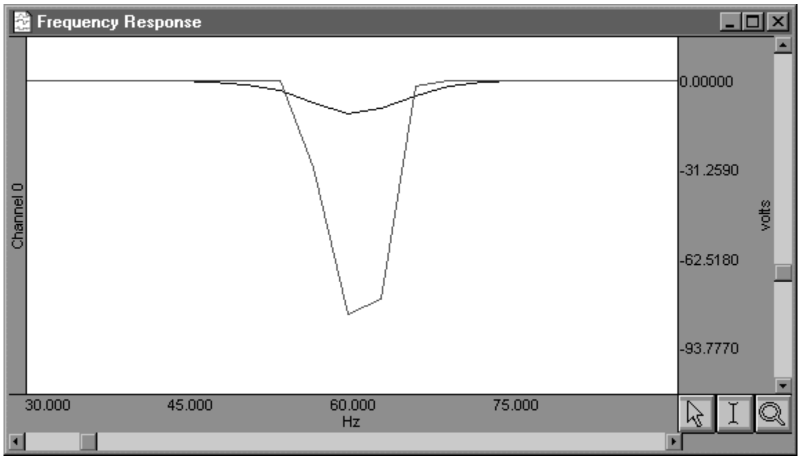
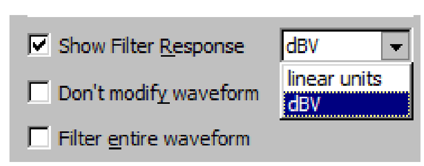
For every filter except the band pass, the lowest frequency cutoff is equal to the specified cutoff frequency for the filter; for the band pass filter, the lowest frequency cutoff is the low frequency cutoff setting. Filters that use a small number of coefficients tend to be less accurate than filters that use a large number of coefficients. Larger coefficients increase filter accuracy, but also increase the processing time required to filter the data.

To see how changing the number of coefficients affects the way data is filtered, it can be useful to examine the filter response patterns. In the example below, data was collected at 500 Hz and the band stop filter was designed to remove 60 Hz noise using a low cutoff of 55Hz and a high cutoff of 65Hz. The same data was band stop filtered using 39 coefficients (upper waveform) and then 250 coefficients (lower waveform).



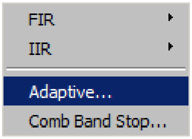
Along the horizontal axis, the units are scaled in terms of frequency, with lower frequencies at the left of the screen. The values along the vertical axis are scaled in terms of dB/V and indicate the extent to which various frequencies have been attenuated.

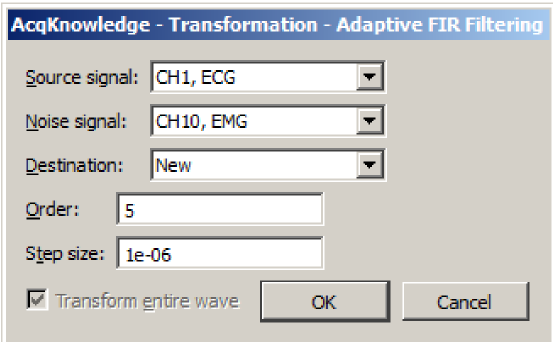
In both filter response waveforms, there is a downward-pointing spike that is centered on 60 Hz. The baseline of the filter response corresponds to a value of approximately 0 on the vertical axis, indicating that the signals significantly above or below 60 Hz were not attenuated to any measurable extent. As you can tell, however, the filter does not



Part C

Adaptive Filtering





➲ See the Adaptive Filtering Calculation Channel on page 151.

Adaptive filtering is a signal processing technique that processes two different signals in relation to one another and can be used for noise estimation, noise reduction, general-purpose filtering, and signal separation. Adaptive filtering creates efficient high-quality filters with a minimal number of terms, which can be very useful in blocking mains interferences or other known periodic disturbances.

- Useful for noise filtering where it is possible to acquire a signal that is correlated to the noise (similar to the way noise-cancelling headphones detect and remove outside noise). Applications include removing EMG from ECG or EOG from EEG.

The weights within an adaptive filter are modified on a step-by-step basis. Acq*Knowledge* uses the N-tap FIR adaptive filter, with coefficients updated using least means squares (gradient) feedback.

Source signal

The source channel will be replaced by the adaptive filter results.

Noise signal

The noise channel is the signal that is correlated with the noise to be eliminated from the Source; it is not modified by adaptive filtering.

Source and Noise channels must have the same sampling rate.

Order

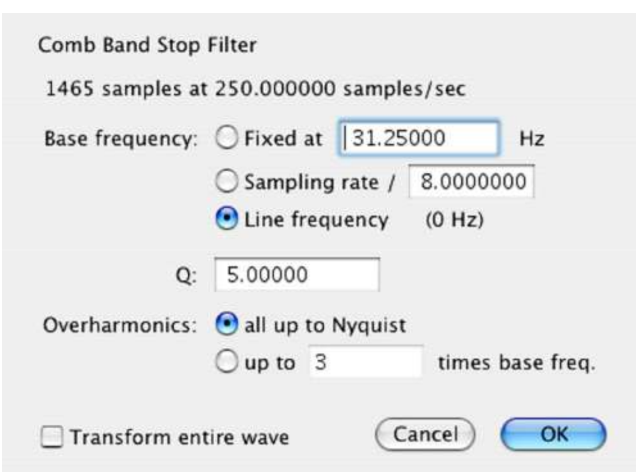
Specify a positive integer for the number of terms to be used in the internal FIR filter.

Step size

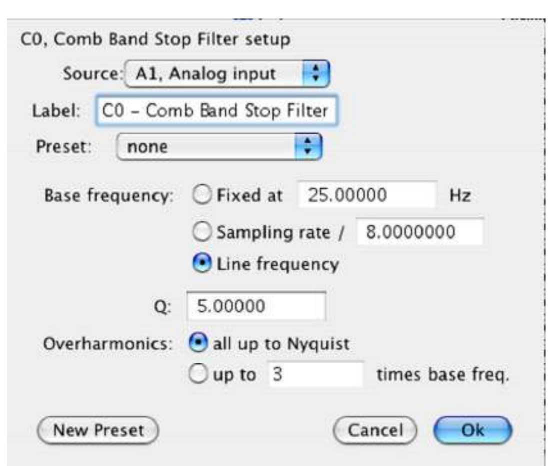
Provides *mu*, the rate of adaptation of the coefficients within the FIR filter.

Comb Band Stop Filter

Comb Band Stop filters out a fundamental frequency and its overharmonics (integer multiples of the base). Resonance, aliasing, and other effects may generate interference at multiples of a base frequency. The Comb Band Stop filter combines all the required filters instead of requiring a separate filter for each interfering overharmonic.



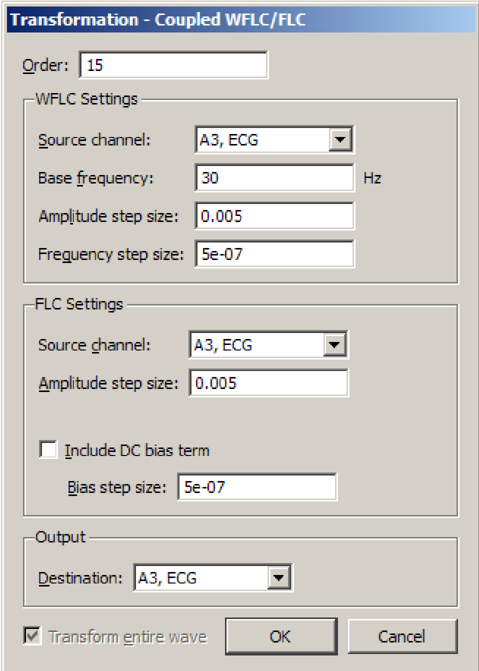
Transformation Dialog



Calculation Channel Dialog

Harmonics	Removes the base frequency and integer multiples of the base frequency up to and including the multiple contained in the edit field • Must be an integer greater than 0 and must not exceed k max • The final multiple must be less than the Nyquist frequency. If it is not, the input will need to be corrected before the comb filter can be applied.
OK	If the settings are valid, executes the comb filter transformation. Verification of certain calculation channel parameters does not occur until the start of acquisition as sampling rates may be changed after calculation channels are configured. Prior to the start of acquisition, the following will be checked: • source channel to ensure it is still being acquired. • base frequency of the comb filter to ensure it is less than the Nyquist frequency of the channel sampling rate. • if the user has manually specified that a fixed number of overharmonics should be used, the number of overharmonics to ensure the highest used overharmonic does not exceed the Nyquist frequency of the channel sampling rate. If any of the parameters are invalid, a prompt will be displayed indicating which settings are incorrect and must be fixed for the acquisition to be started.
Cancel	Quits without modifying any data.
Source	All enabled analog, digital, and lower-index calculation channels.
Label	When the calculation type of a channel is changed to comb filter, the title of the channel will be replaced with the default label

Part C



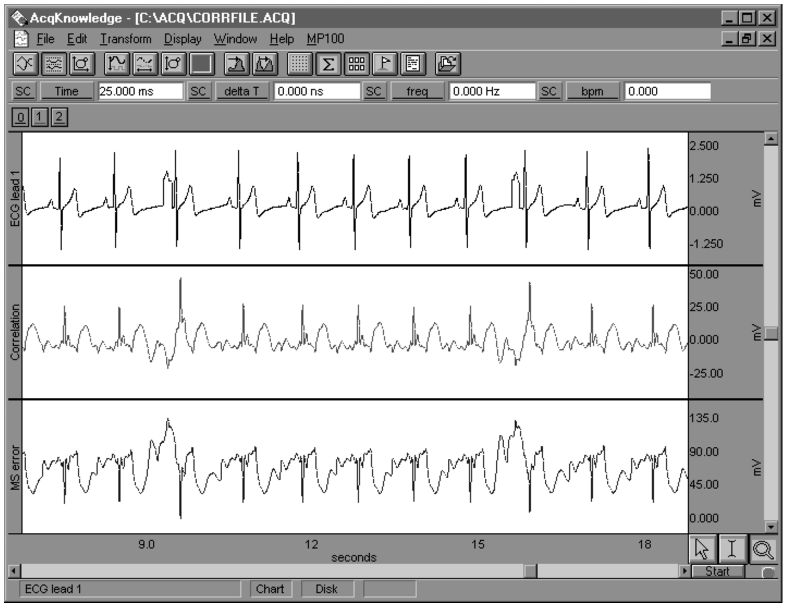
Coupled WFLC/FLC

Runs a WFLC on the signal to determine the harmonic frequency and then runs the result through an FLC using the computed harmonic. The second FLC can be run on the same or a different channel.

The transformation will occur in the channel designated as

Limit (Limit data values)

Part C



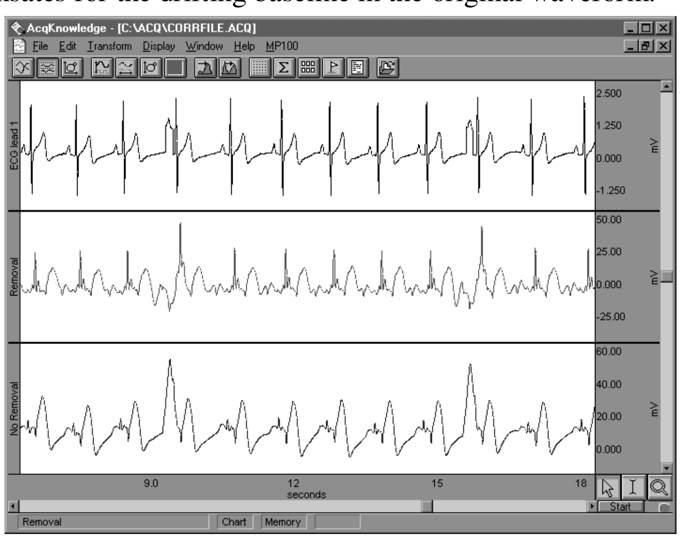
Result of correlation and mean square error functions

5) Use the zoom tool to inspect the abnormalities more closely.

Remove mean

A drifting baseline can be problematic when comparing waveforms. The effectiveness of a comparison of a template or waveform with a slowly drifting baseline will be increased by applying the Remove mean template function. 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. This option is toggled every time it is selected and is enabled when a check mark is present.

For example, the following graph shows the original waveform at the top, the correlated waveform with mean removal in the middle, and the same correlation without mean removal at the bottom. Note how the mean removal effectively compensates for the drifting baseline in the original waveform.



Correlation with and without mean removal

Part C

Remove Projection treats the template in memory as a vector. The projection of the selected area onto the template is computed as a vector dot product. This projection is then removed from the source data. After a remove projection transformation, the remaining data consists of the part of the signal that is the most unrelated to the template.

Remove Projection can be useful for emphasizing signal differences. For example, it may be useful for exploring differences in an arrhythmia in comparison to a normal reference beat. It may also be useful as a denoising building block by removing the projection of a signal against idealized noise in the template.

The number of samples in the template should match the number of samples in the selected area of source data.

- Dot product is undefined for vectors of mismatched dimensions.
- If the template is longer than the selected source data, the template will be shortened (for that single transformation; it will be restored afterward) so its length matches the selection width.
- If the selection is longer than the template, any data occurring after the end of the template will not be transformed.

To create a Remove Projection template:

1. Highlight the portion of data to be used as the reference signal.
2. Transform > Template > Set Template.
3. Highlight the portion of the data to be analyzed.
4. Transform > Template > Remove Projection.

f) Normalized cross-correlation (NCC) is useful when searching for variations in the signal. Regular cross-correlation (Transform > Template > Correlation) can exhibit large amplitude spikes when the energy of a signal varies greatly or amplitudes change suddenly, causing jumps that are not necessarily indicative of a match with the template. Normalized cross-correlation is a statistical method that can help resolve these issues by applying normalization to both the template and signal being searched. This reduces the effect of amplitude variation in the result, making normalized cross-correlation useful for template matching purposes.

This transformation computes the windowed normalized cross-correlation, and results in a value between -1 to 1, which indicates the linear fit of the data set. Normalized cross correlation is defined as:

$$\gamma = \frac{\sum_{i=0}^{L}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=0}^{L}(x_i - \bar{x})^2 \sum_{i=0}^{L}(y_i - \bar{y})^2}}$$

where x = template
y = signal
L = length
$\bar{f}$ = mean value of the signal f

At the end of the transformation, the source data will be replaced with the sliding NCC values. Data outside the selected area will be left unmodified. If the selected area is zero width when the transformation is to be executed, the entire waveform will be transformed.

If selection is shorter than the template, the missing data at the right end of the selected area will be filled with zero padding until it matches the length of the template. This padding occurs in memory and will not affect the source data in the graph. The same zero padding is used when computing NCC at the end of every selected area when the template is running off the end of the data. This zero padding should trend the NCC to zero at the right edge of the transformed area, in most cases.

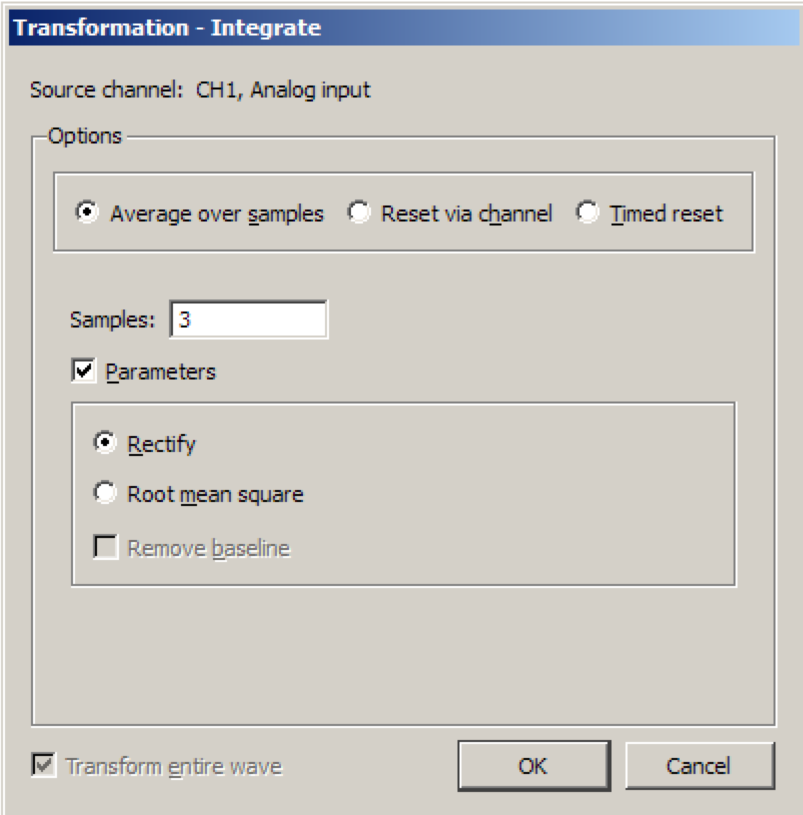
Part C

Output

Show normalized cross correlation values provides access to the sequence of correlation values that is examined by the heuristic for potential matches. Viewing the normalized cross correlation signal can provide feedback that is useful for proper threshold selection and for detecting whether the heuristic has fallen into one of its degenerate cases (e.g. NCC signal hovering around the threshold for extended periods of time). When checked, a new channel will be added into the graph containing the normalized cross-correlation values computed by the algorithm. The channel will be labeled

Part C

Integrate



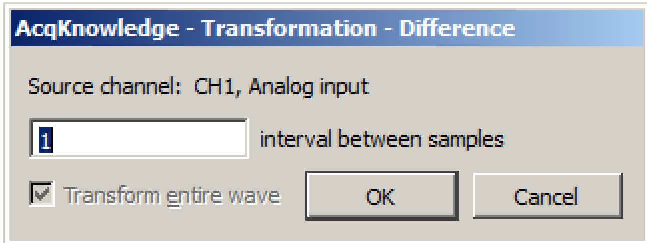
The Integrate transformation operates the same as the Integrate calculation

Part C

Integrate formulas, continued

Part C

Difference



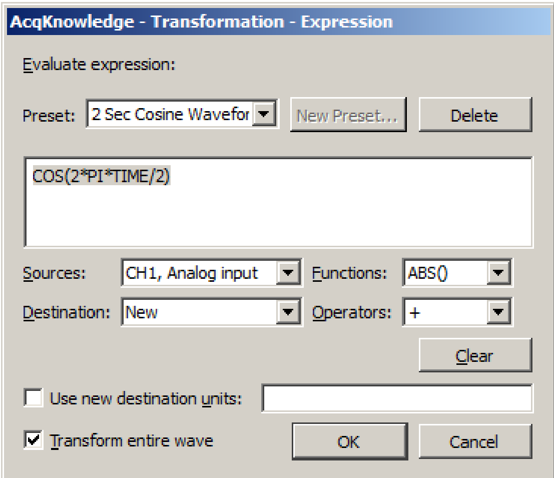
The Difference function measures the difference (in amplitude) of two sample points separated by an arbitrary number of intervals. The difference is then divided by the total interval between the first selected sample and the last selected sample.

When the difference transformation is selected, a difference interval dialog will be generated and the number of intervals between samples can be entered (default of 1).

For data with no high frequency components, a 1-interval difference transformation approximates a differentiator.

The formula for the difference transformation is shown below, where

Expression



See the tables on page 142 for descriptions of sources, operators and functions for the Expression dialog.

The post-acquisition Expression transformation is available for performing computations more complex than available with the Math and Function calculations. The post-acquisition version of the Expression transformation includes all the same features as the online version described on page 138. 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 analog or digital channels, as well as calculation channels with a lower channel number. Also, computations performed by the Expression transformation eliminate the need for

Part C

To add these two waves, select Transform > Waveform Math and set source 1 to channel 14, the operator to addition

Chapter 16 Analysis Menu Commands

Overview

The Analysis menu contains operations that derive data and measurements from the graph

Part C

Nonlinear Modeling

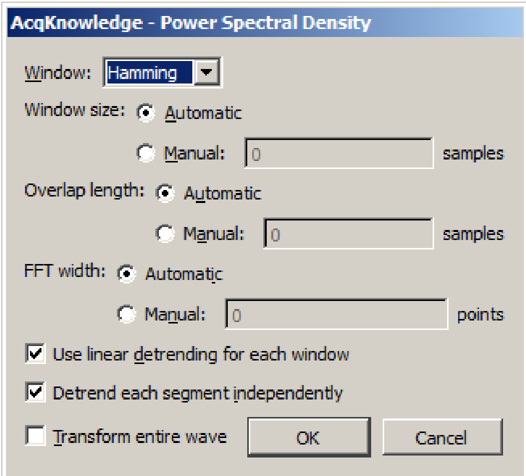
About nonlinear modeling

Modeling is used in physiological data to assess how well data conforms to a theoretical model. This is used to express a sampled signal in a continuous form and to perform data reduction. The nonlinear modeling features in Acq*Knowledge* support more advanced physiological analysis than is possible with the linear regression measurement, which is a rudimentary single order linear model.

Nonlinear modeling is the process of finding the best fit of a mathematical function to an arbitrary data set. Fitting the function

Part C

Power Spectral Density



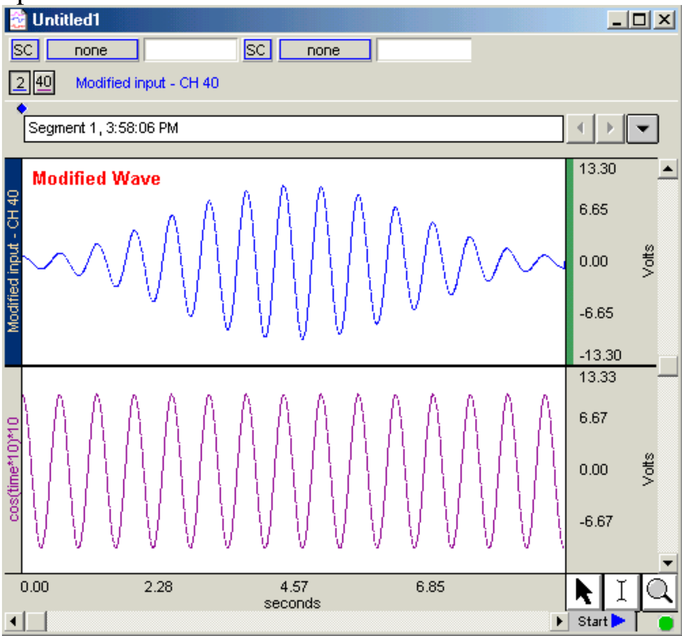
The Power Spectral Density (PSD) function extracts the power present at different frequencies within a signal and is useful for EMG analysis. The PSD transformation approximates the same result as squaring the linear FFT magnitude. PSD is not available when the horizontal units of the source graph are set to Frequency.

Acq*Knowledge* uses the Welsh periodogram to average signal time-sliced portions of the signal and reduce noise effect, and generates a two dimensional graph displaying the wattage of a particular frequency component in a signal. Windowing options are Hanning, Hamming, or Blackman. The graph is plotted as horizontal frequency vs. vertical (units)^2/Hz, where *units* are the vertical axis units of the source data.

Use linear detrending for each window

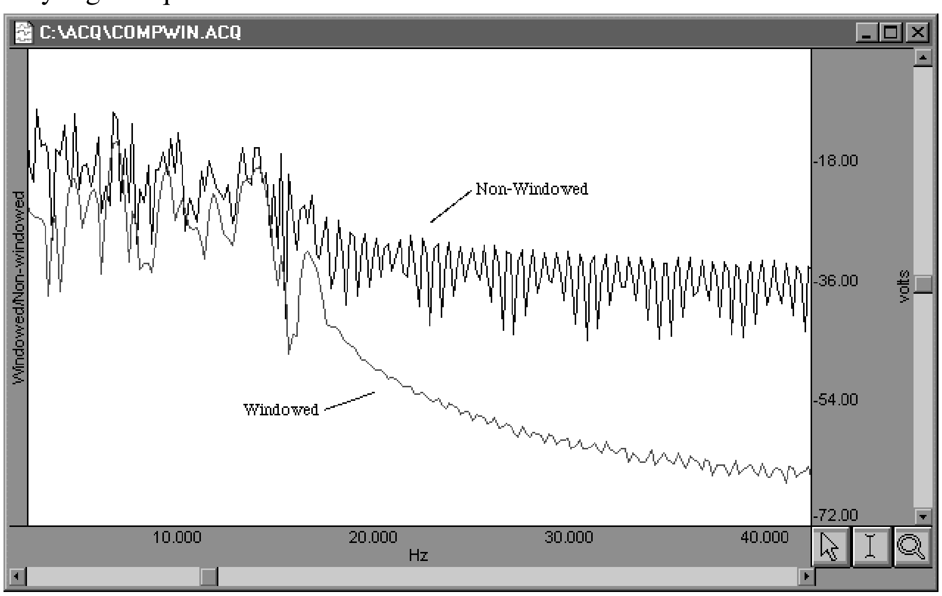
Part C

Show Mod. To view the modified waveform being used as input for the FFT, check the Show modified input box. Whenever possible, it is best to use an input waveform (select an area) that is an exact power of two. The waveform is modified by applying the windowing and padding options. Window functions diminish the discontinuities that occur at either end of the wave.



Window 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. For example, to apply a window transformation to a sine wave whose endpoints do not match up, check the box next to Window and choose a type of window from the pop-up menu. Each of the windows has slightly different characteristics, although in practice each provides similar results within measurement error.

As shown below, the frequency spectra of the windowed and non-windowed data differ significantly when the endpoints are unequal. When data are not windowed, the very low and very high frequencies are not attenuated to the same extent as when windowed.



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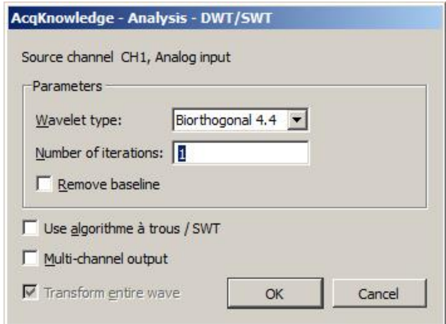
Since the offset of the waveform is often an artifact of the way it was generated, the remove mean option provides a more accurate indication of the true spectral components. This is especially true for applications where low frequency components are of interest. If your data has a large DC offset and 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).

Linear — By default, the FFT output is described in terms of frequency along the horizontal axis and dBV on the vertical axis. The Bell scale (from which dB are derived) is logarithmic, and in some cases it may be useful to have the output scaled in linear units. To do this, click the button next to linear and check OK. The other options in the dialog work as they normally do when the dB scaling option is selected. The relationship between log and linear units is: $dBV_{out} = 20 \log VIN$.

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

DWT/SWT



About Wavelet Transformation

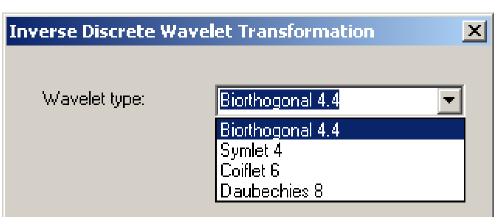
Wavelet transforms are similar to Fourier transforms. Instead of projecting a signal in a space of sines and cosines, wavelet transforms project a signal into a space comprised of orthogonal functions called *wavelets.* Discontinuities are more obvious in wavelet transforms than in sines and cosine analysis, making wavelet transforms a better choice for decomposing a signal to its fundamental form. Wavelet transforms can be used for noise reduction and filtering, extracting features from signals that are not apparent in time or frequency domains, and predicting signal qualities from a small number of data points.

Discrete wavelet transformations (DWT) break a source signal into high-frequency and low-frequency components. Use for ECG and EEG analysis. DWT creates a new graph with wavelet coefficients on the horizontal axis and the amplitude for each coefficient on the vertical axis, pastes acquisition settings to the graph journal, and places an event at each boundary between the high- and low-frequency components produced at each iteration.

Wavelet type Specify Biorthogonal 4.4, Symlet 4, Coiflet 6, Daubechies 8 or Spline 3.

Number of iterations Specify the number of transforms to execute.

Stationary wavelet transformations (SWT) differ from DWT in that the



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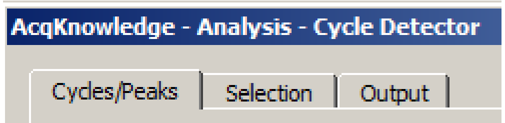
Find Cycle (Peak Detector)

Watch the six-part Acq*Knowledge* Find Cycle video tutorial for a detailed demonstration fo this feature.



The Find Cycle/Peak Detector setup dialog is accessed by choosing Analysis > Find Cycle, or using the Ctrl+F keystroke.

Overview

The advanced Cycle/Peak Detector combines with the powerful Event Marking System. Use it to perform amplitude, time, or event-based measurements. New output options for measurements, averaging, events, clustering (K-means), and 3D surface (cycle data, histogram, FFT, and DWT).

The Find Cycle detector uses three tabbed settings panels to define and automate cycle/peak detection:

Cycles/Peaks Selection Output

Cycle detector settings are graph-independent, which means that find cycle/peak operations can be performed in multiple graphs without needing to re-enter graph-specific settings for each run. By using multiple data views, different find cycle/peak operation can be performed on the same set of data without losing settings between

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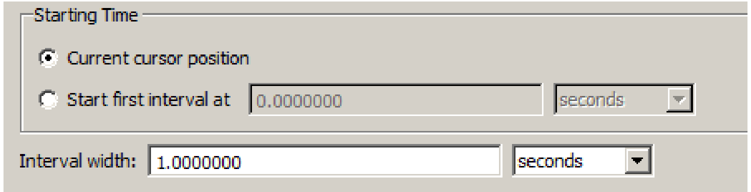
When the cycle location mode is switched on the

Part C



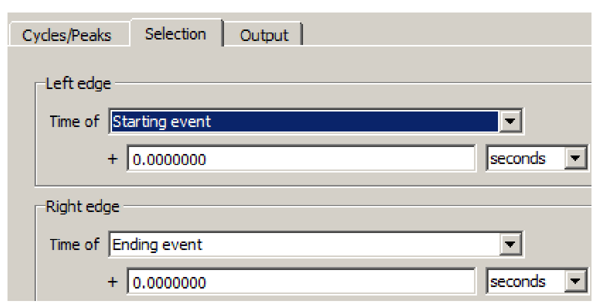
The time units for starting the first interval and setting the interval width can be selected in milliseconds, seconds, minutes or hours.

Selection tab

Use the Selection tab to adjust the range of data that will be analyzed to generate any output. By default, the data range is set to be the entire cycle as located by the settings on the Cycle/Peak tab, but it can be adjusted to analyze only specific portions of the cycle.

The controls on the Selection tab vary based on the settings on the Cycle/Peak tab

Peak When the Cycles/Peaks location method is



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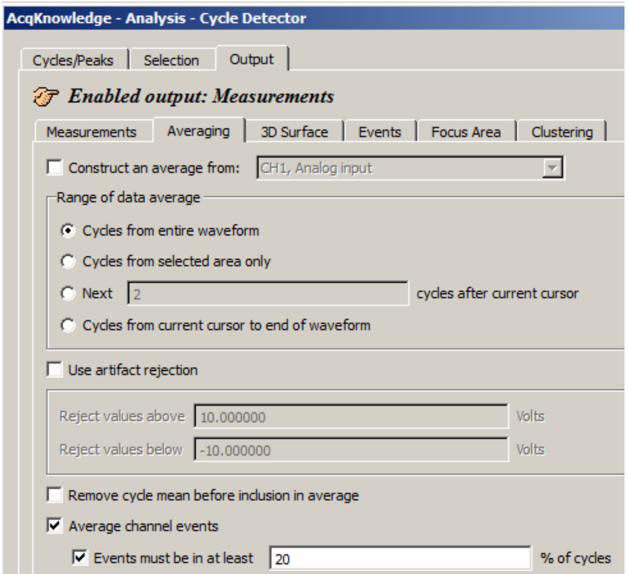
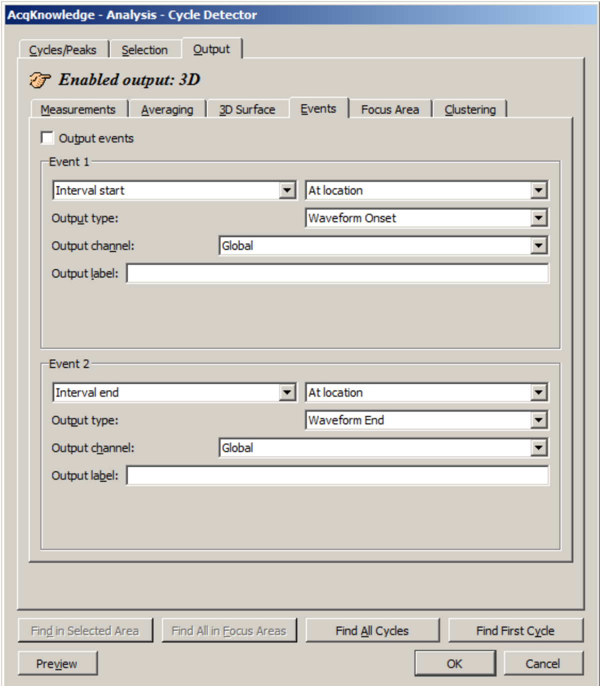
Output: Averaging—Offline



Use Averaging Output

Part C

Output Events



Toggle the

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Event Location Table

Insertion Method	*Location Process*	
Interval, at location	Place an event at the left or right boundary of the selected area, as specified.	
Interval +/- percent offset	Given a particular channel, place an event at the specified time within the selection when the signal increases or decreases by a specific percentage.	
	Interval start +	Place at the time closest to the left boundary of the selection. The percentage is calculated from the value of the signal at the left boundary of the selected area.
	Interval end -	Place at the time closest to the right boundary of the selection. The distance between the event and the right edge of the selection will have an amplitude difference equal to the indicated percentage of the right edge

algorithm partitions the data set into k groups such that the sum of the differences between the centers of each group and its remaining members is minimized.

A basic algorithm description is:

A. Given a total of k clusters, choose k potential cluster centers.

B. Assign each member of the data set to a cluster according to the closest potential cluster center using a Euclidean distance function (sum-of-squares).

C. Adjust the location of the potential center for each cluster to a more optimal value. The most basic method is to assign the new center to match the mean value of all of the members of the set.

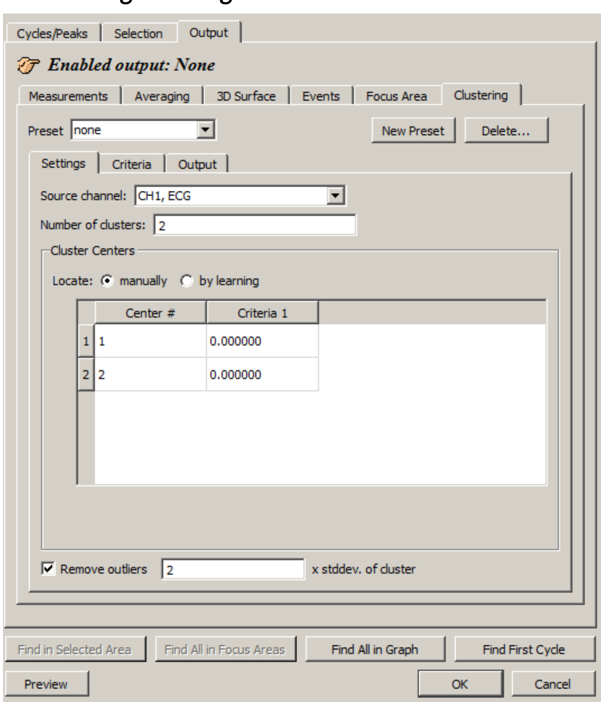
D. Determine if the set of clusters and centers is satisfactory. If not, go to step 2 and repeat the clustering process.

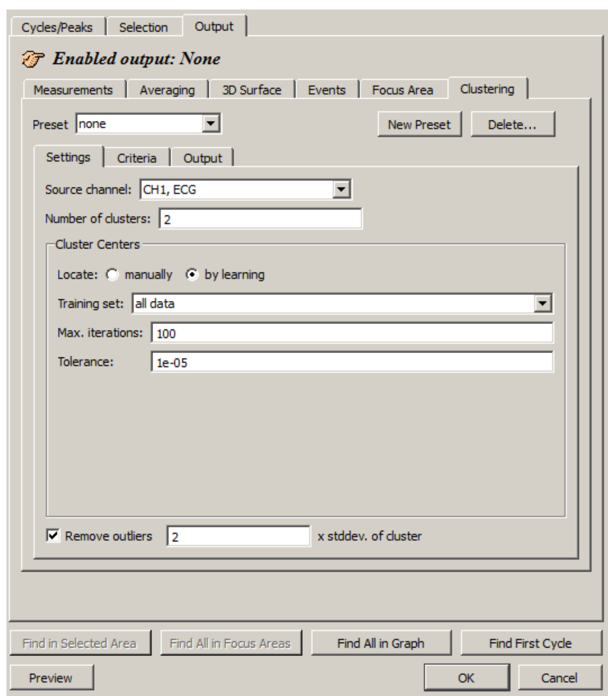
There are many different variations on what constitutes satisfactory ending conditions. The most ideal stopping criteria are when the cluster assignments no longer change with successive iterations. When there is no change in the centers, the solution perfectly minimizes the Euclidean distance sum for each cluster, unique up to variations in ordering of the dimensions. In practice, determining the perfect clustering of a data set is computationally intensive and may require some time to process. Approximations of perfect clustering are quicker to compute and usually produce sufficiently accurate results.

A waveform segment is reduced to a single data point by extracting numerical quantities known as *features*. *Feature clustering* is a very common data reduction method in use by clustering-based spike sorting software. Each feature is a single real-valued number extracted from the data. Examples of features are: maximum amplitude in waveform segment, minimum, time to maximum, time to minimum, peak to peak distance, sum of all values, maximum slope of peak.

A commonly used clustering analysis starts with two features. The features are then calculated for each waveform segment and presented on a scatter plot, allowing the user to visually determine how many clusters may be present. A k-means clustering analysis is then run on these data points to determine the center of the clusters in feature space. With the center known, each waveform segment is then assigned to a cluster depending on the values of its features.

Clustering Settings





Number of clusters

After features have been extracted, data points constructed from the feature are split up into a number of groups. Enter the number of clusters into which the data is to be partitioned.

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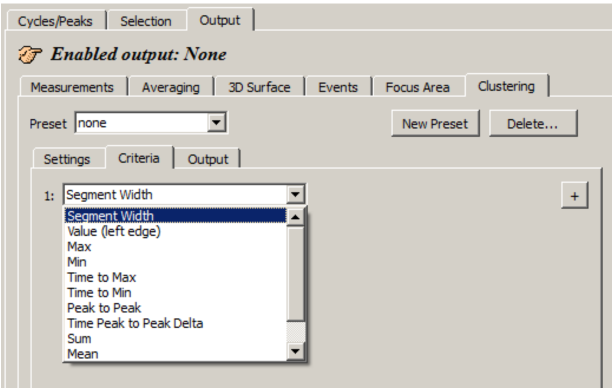
Remove Outliers

The clustering analysis allows for optional removal of outliers, or spurious data points. When enabled, each cluster is assigned a boundary. After each data point has been assigned to the cluster, the standard deviation of the distance of each point from the center of the cluster is computed. When outlier rejection is enabled, any data point that is farther away from the center than a specific number of standard deviations will be removed from the cluster. Enabling outlier removal retains only the points in a cluster that have the strongest association with each other.

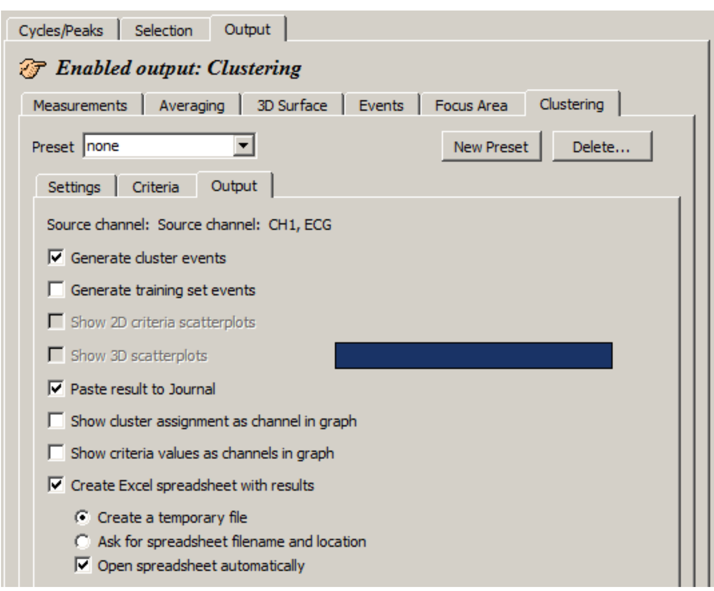
Clustering Criteria



For a particular segment of a waveform, features are extracted based upon user-specified criteria.

Segment Width	Peak to Peak
Value (left edge)	Time peak to Peak Delta
Max	Sum
Min	Median
Time to Max	Mean
Time to Min	Measurement Result

Multiple segments are located using the Find Cycle/Peak functionality. After the criteria have been computed for each segment, clustering is then performed. This allows segments to be partitioned based upon their features. For example,



Part C

The following example details how to detect the positive spike in the QRS complex

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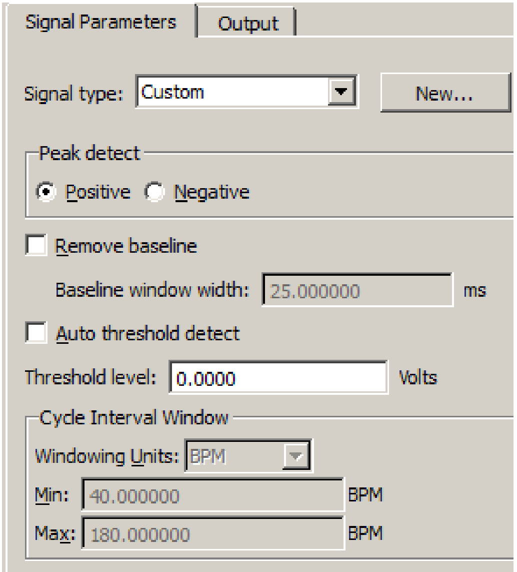
If the Auto threshold detect mode is similarly unavailable, adjust the Noise rejection or add the Remove baseline option.



1) Fixed threshold detect mode:

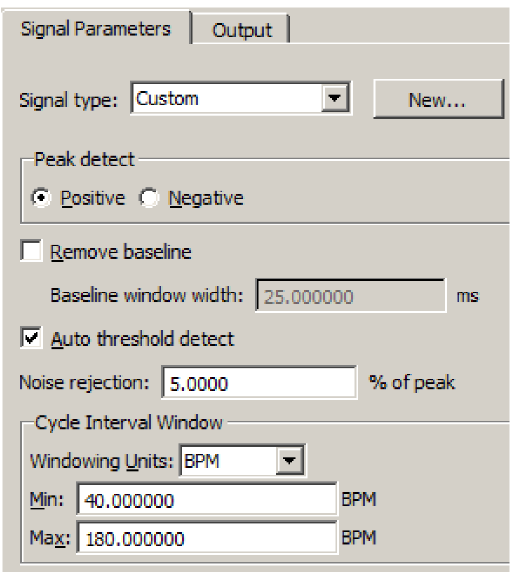
Fixed threshold detect mode is the simplest mode of operation for the Rate Detector. As shown here, the Threshold Level has been set to 0.00 Volts. If the waveform crosses 0 Volts, the Detector will begin to look for Positive or Negative peaks (based on the Peak detect setting).

Not available in Fixed mode:

Noise rejection

Baseline window width

Windowing options



2) Auto threshold detect mode:

Auto threshold detect mode is a more advanced and flexible mode of operation for the Rate Detector. In this case, the Rate Detector will create a variable threshold defined as:

Positive peak search

0.75

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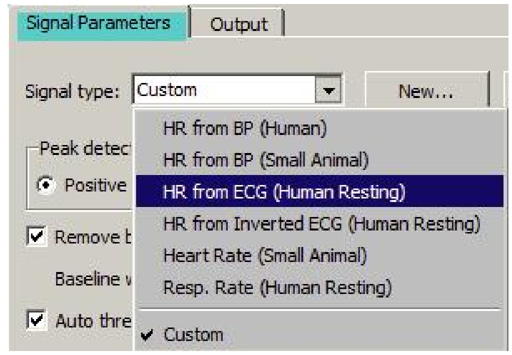
Signal type



The Signal type menu contains parameters for specific human and animal waveform morphologies. All pre-defined and custom signal types are common to both calculation channel Rate (online) and analysis Rate (offline) dialogs. Signal type modifications affect settings in the Signal Parameters tab only, and do not affect the Output tab settings.

Select from six pre-configured signal types or click

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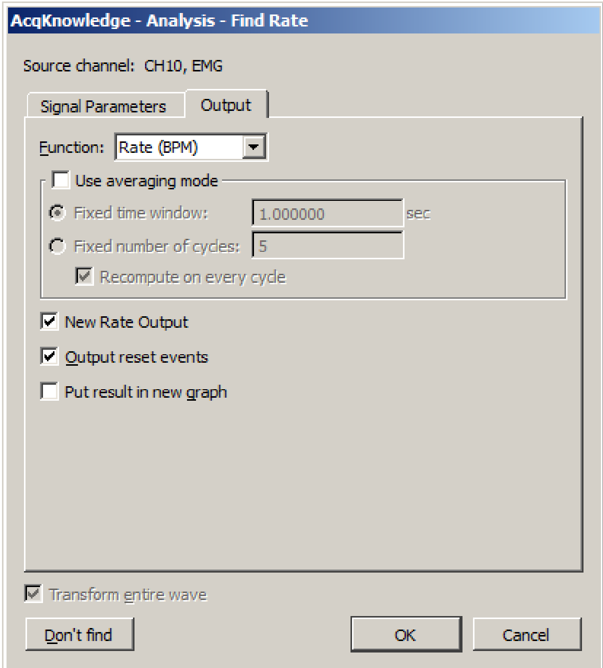
Additional Find Rate Dialog Settings, Output Tab



Function

The Rate Detector Function menu lists a variety of calculations, which are discussed below.

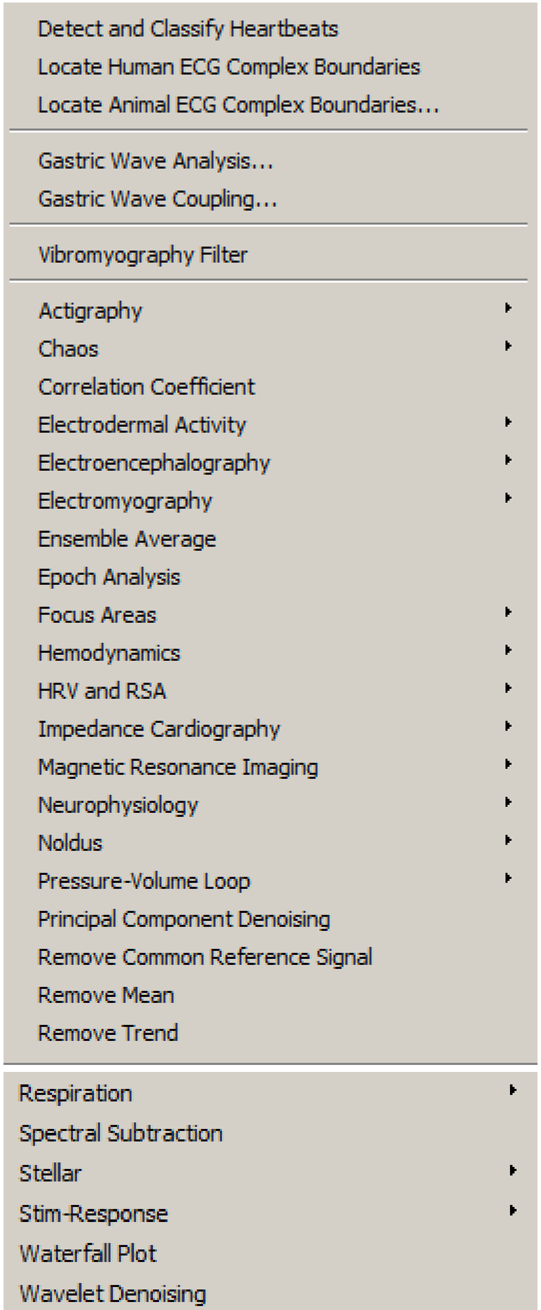
Rate (Hz), Rate (BPM), Interval (sec)

The most commonly used function is the Rate (BPM) option, which calculates a rate in terms of beats per minute or BPM. Rate calculations can also be performed that return a rate value scaled in terms of frequency (Hz) or time interval (sec). When rate is reflected in terms of a time interval, the time difference (delta T) between the two peaks is returned. This is sometimes referred to as the *inter-beat interval* (IBI). The frequency calculation returns the rate in Hertz (Hz), which is computed by dividing 1 by delta T. These measurements are perfectly correlated with the BPM calculation, since BPM is equal to 60 times the frequency calculation, or 60 divided by delta T.

Peak time

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

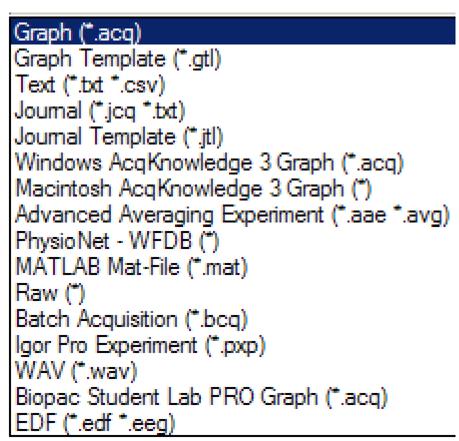
Chapter 17 Specialized Analysis



The Specialized Analysis package includes comprehensive analysis tools to automate analysis to save hours (or days!) of processing time and standardize interpretation of results.

- Acq*Knowledge*

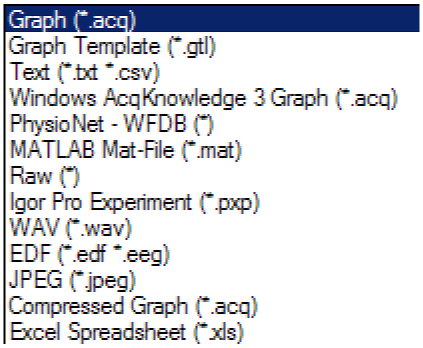
- Detect and Classify Heartbeats
- Locate Human ECG Complex Boundaries
- Locate Animal ECG Complex Boundaries
- Gastric Wave Analysis
- Gastric Wave Coupling
- Chaos Analysis
  - Detrended Fluctuation Analysis
  - Optimal Embedding Dimension
  - Optimal Time Delay
  - Plot Attractor
- Correlation Coefficient
- Electrodermal Activity
  - Derive Phasic EDA from Tonic
  - Event-related EDA Analysis
  - Locate SCRs
  - Preferences: Output Display Format; Phasic EDA Construction Method: Smoothing Baseline Removal or High Pass Filter
- Electroencephalography
  - Compute Approximate Entropy
  - Delta Power Analysis
  - Derive Alpha-RMS
  - Derive EEG Frequency Bands
  - EEG Frequency Analysis
  - Remove EOG Artifacts
  - Seizure Analysis
  - Preferences: Output Display Format
- Electromyography
  - Derive Average Rectified EMG
  - Derive Integrated EMG
  - Derive Root Mean Square EMG
  - EMG Frequency & Power Analysis
  - Locate Muscle Activation
  - Preferences: Output Display Format
- Ensemble Average
- Epoch Analysis
- Focus Areas
  - Define Between Events
  - Define for Appended Segments
- Hemodynamics
  - Classifiers: ABP; LVP; MAP
  - Arterial Blood Pressure
  - Baroreflex Sequence Analysis (licensed feature)
  - Baroreflex Slope Analysis (licensed feature)
  - ECG Interval Extraction
  - Estimate Cardiac Output from ABP
  - Left Ventricular Blood Pressure
  - Monophasic Action Potential
  - Preferences: Output Display Format; LVEDP Location Method; dP/dt pk-pk %; MAP Plateau Location Method; dP/dt MAP pk-pk %
- HRV and RSA
  - Multi-epoch HRV



File Compatibility

- Mac Acq*Knowledge* 3.9and above can open and create PC-compatible Graph (*.acq) and Graph Template (*.gtl) files. Variable sampling rate information and hardware settings are retained, and Journals can be read from and written to PC files. Files must end on a multiple of the lowest channel sampling rate to be fully PC compatible.

Saving files after Specialized Analysis



Saving Files Acq*Knowledge* 4

The default file format for the File>Save as command is to save files as an Acq*Knowledge* file. Selecting Graph (MPWS) or .ACQ (MPWSW) from the popup menu in the Save As dialog will save a file as an Acq*Knowledge* file, which is designed to be as compact as possible. These files can only be opened by Acq*Knowledge*, but data can be exported to other formats.

File > Save Selection As allows you to save only a portion of your file. When this option is enabled, only the data that has been selected with the I-beam tool will be saved. This option saves the selected area to another file and does not affect the current file that you are working in.

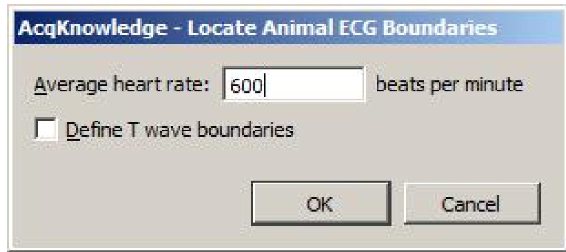
File Compatibility

Windows Acq*Knowledge* 3.9 and above files can be opened with Mac Acq*Knowledge* 3.9 and above, but some advanced features may not transfer.

Mac Acq*Knowledge* 3.9 and above can save as

Part C

Locate Animal ECG Complex Boundaries



Locate Animal ECG Complex Boundaries optimizes the ECG waveform boundary detection for animal input. Smaller animals such as mice often lack a detectable T wave, so in the setup dialog the T wave boundaries are disabled by default. If appropriate to the experiment, T wave detection can be applied by enabling the

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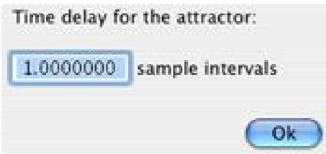
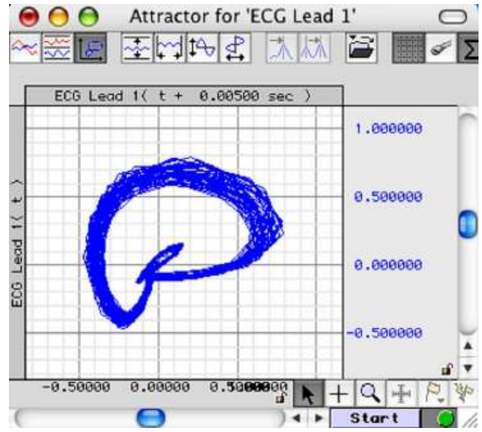
Optimizing the time delay in this fashion picks the shortest delay where the signal exhibits the most independence with respect to its time-delayed version.

The fractal dimension and other chaos-related measurements operate on a single channel of data. In the process of extracting these measures, a signal is compared with a time-delayed version of itself to examine the patterns in dynamics of the data. These measures take a fixed time delay setting. The Optimal Time Delay transformation can be used to choose the best value for the parameter.

Plot Attractor

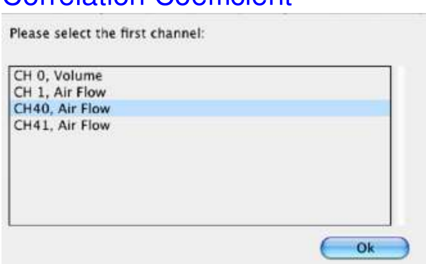


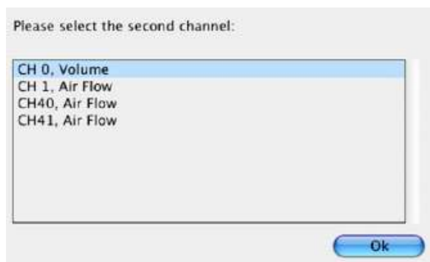


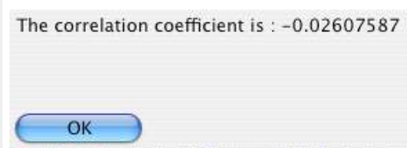
Assists in constructing X/Y plots for the attractors of time delayed data. By visually examining the shape of the attractor at a given time delay, To develop an intuitive sense for the underlying nature of the data and the dynamics of the system.

Plot Attractor functions on the active channel of the graph. It prompts the user for a time delay and then constructs a new graph window with an X/Y plot of the attractor of the original signal against the time delayed version of the signal. It does not perform any additional computation aside from assisting in the setup and configuration of the attractor plot.

Correlation Coefficient







The *correlation coefficient* is a statistical measure related to the degree of variance or covariance between two data series. Given two data series *x* and *y* of length *n*, the correlation coefficient *r* is given by the formula:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}}$$

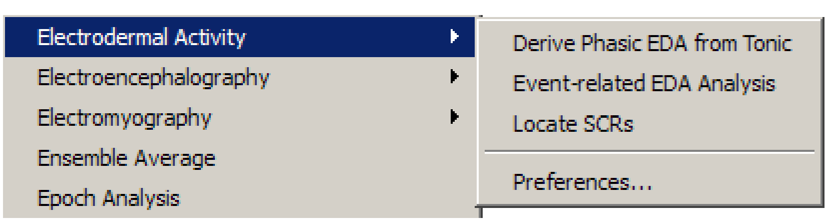
(see http://mathworld.wolfram.com/CorrelationCoefficient.html)

The square of the correlation coefficient can be used to determine the proportion of variance in common between the two signals. As the square gets closer to 1, the signals are a better statistical match for each other.

To derive the correlation coefficient, two channels of data are compared against each other.

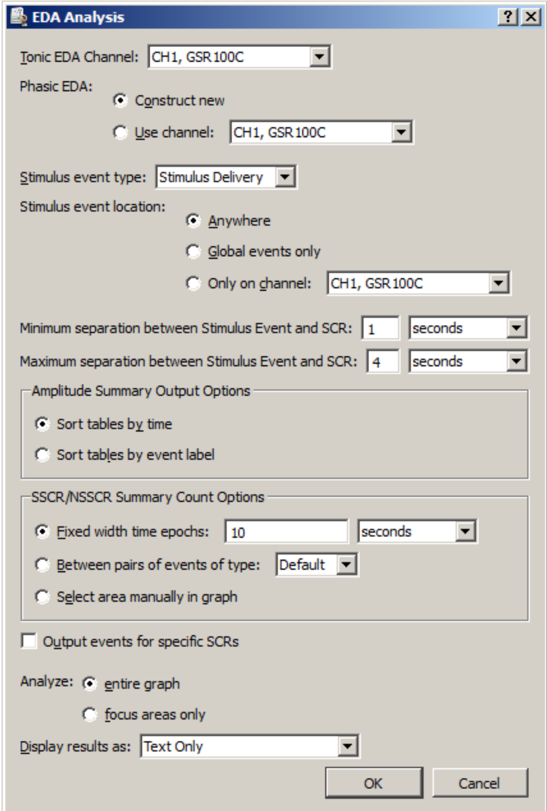
- the channels must have the same length
- the channels must have the same waveform sampling rate
- all of the data of the entire graph for the two channels will be used to compute the correlation coefficient.

Electrodermal Activity



Part C

Event-related EDA Analysis



The Event-related EDA Analysis transformation routine assists in the extraction of EDA measures that are linked to specific stimuli. The stimulus event marks must be included in the file BEFORE using this analysis.

This analysis routine requires four elements:

1. Tonic and Phasic waveforms.

   Tonic EDA Channel: A Tonic EDA signal must be present in the graph.

   Phasic EDA:

   Construct new: Given a tonic EDA signal, a phasic EDA will be automatically constructed using baseline smoothing or high pass filtering (the method currently set in Preferences).

   Use Channel: If the graph contains a phasic waveform, select the appropriate channel.

2. Stimulus delivery events.

   Digital events with a common event type must be located BEFORE using this analysis.

   The Event-related EDA Analysis requires that an event be defined in the graph at the location of the delivery of each stimulus. This event may be defined using the Event Tool, hotkey insertion during acquisition, or any other method of defining events. All of the stimulus delivery locations to be extracted must have the same event type (e.g.

Event-related EDA Analysis Output Options

Enhancements provide more options for multiple stimulus event types and unmatched events, including:

- Labels and additional measures are available in the specific stimulus and SCR analysis table
- Text and Excel tables may be optionally sorted either by time or grouped by stimulus label
- A new table has been added listing stimulus events that were not paired with an SCR
- The SRR/NS.SSR Rate analysis, which counts frequencies of SCRs in specific time periods, may now be driven by time periods defined using pairs of events or a selection in the graph
- A table has been added listing amplitude/frequency percentage statistics for all matched and unmatched stimuli events (e.g. total stimulus count, percentage of stimuli that were pared with an SCR, etc.)
- Additional optional Specific-SCR events may be defined on the tonic EDA waveform at the positions of specific SCRs with labels matching the stimulus to which they were responses. This allows for further peak-detector based runs to perform additional data reduction.

Event Related EDA Event Types:

- Waveform Onset
- Waveform End
- Skin Conductance Response
- Specifc SCR

Waveform Onset and Waveform End events are also available for other Specialized Analysis operations.

Amplitude Summary Output Options

For each specific SCR that is paired with a stimulus delivery event, the following measures are extracted in table format and can be sorted by **Time** or by **Event label**. If text output is enabled in EDA Preferences, the average value of SCL, Latency, SCR Amplitude, and SCR Rise Time will be included as the final row of the table.

Name	*Abbrev.*	*Description*	*Units*
Stimulus Delivery Time	Stim Time	The time within the recording where the stimulus delivery event was located.	seconds
Skin Conductance Level	SCL	Amplitude of the tonic EDA signal at the time when the stimulus was delivered.	µmho
Response Latency	Latency	Time separating the stimulus delivery from the onset time of the corresponding SCR. This latency will always be less than the maximum allowable latency specified as a parameter for the analysis.	seconds
SCR Amplitude	SCR Amplitude	Height of the corresponding SCR as determined by the change in the tonic EDA amplitude from the time of SCR onset to the maximum tonic EDA amplitude achieved during the SCR: [EDA(t_{max})	

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Amplitude/Frequency Percent Summary

The

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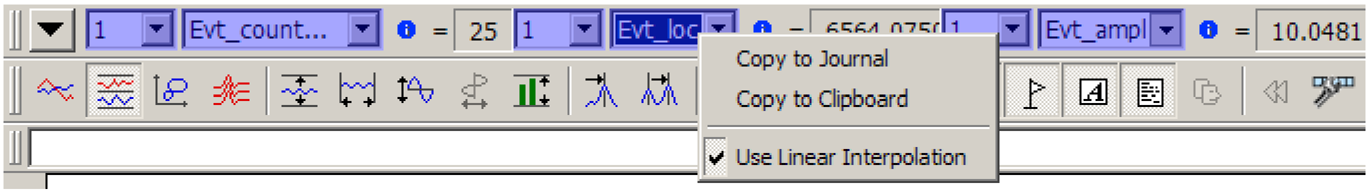
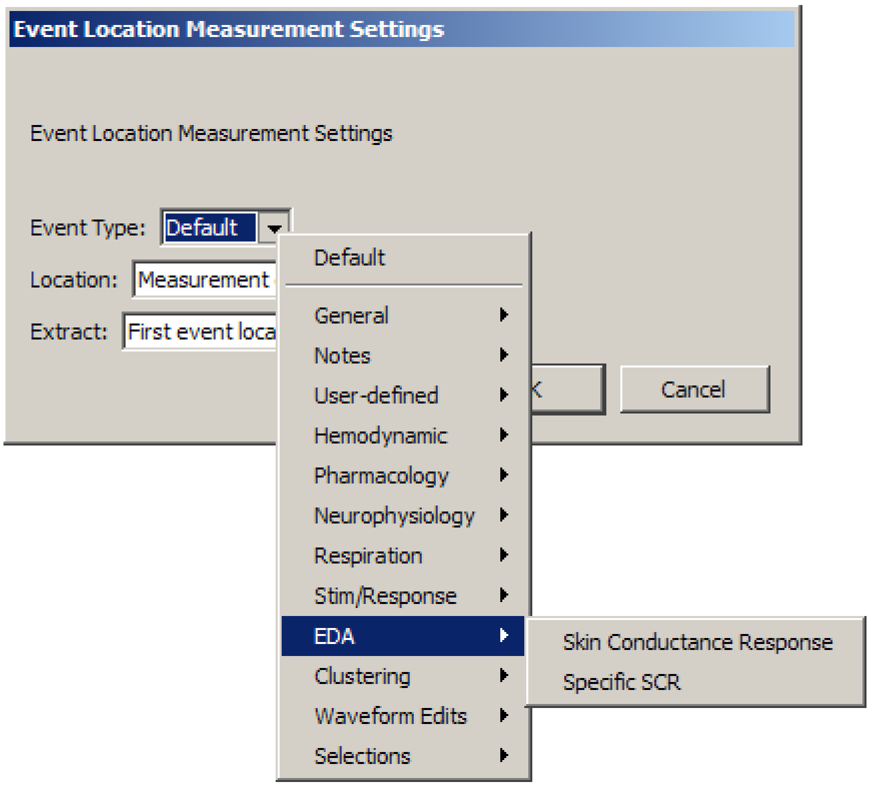
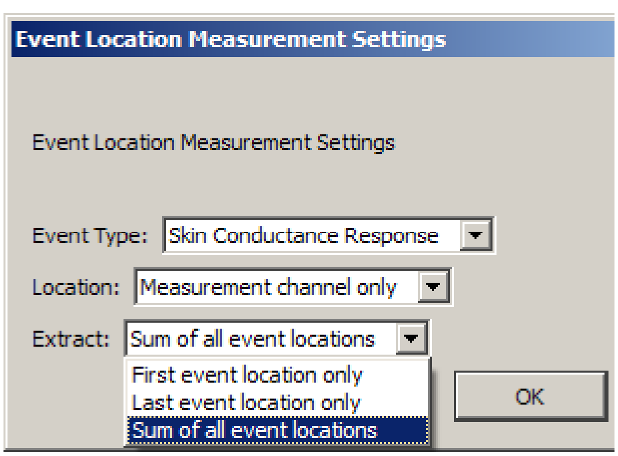
EDA Measurements

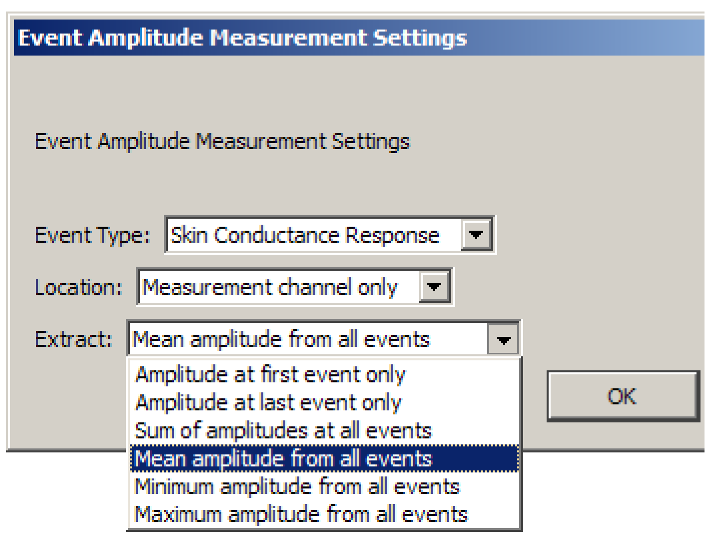
To perform Event-related EDA analysis, choose Analysis > Electrodermal Activity > Event-related EDA Analysis.

To take measurements from the skin conductance response analysis, set measurements for event count, event location and/or event frequency. Set the source channel as the Tonic EDA channel and select the location (measurement channel only, global events only, anywhere) and measurement parameters as desired. This method is useful for spontaneously occurring skin conductance response analyses. Take measurements over a manually selected area or use Find Cycle analysis to take automatically measurements over a user-defined time interval.









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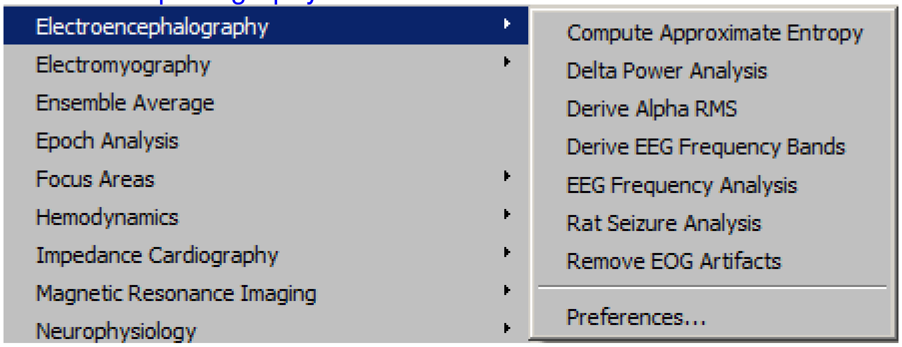
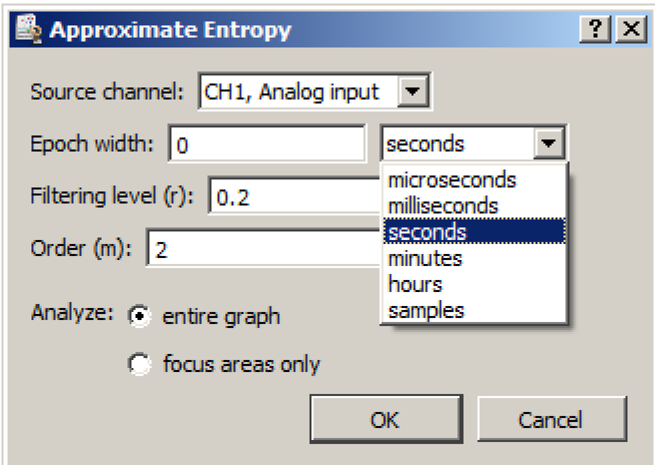
Electroencephalography



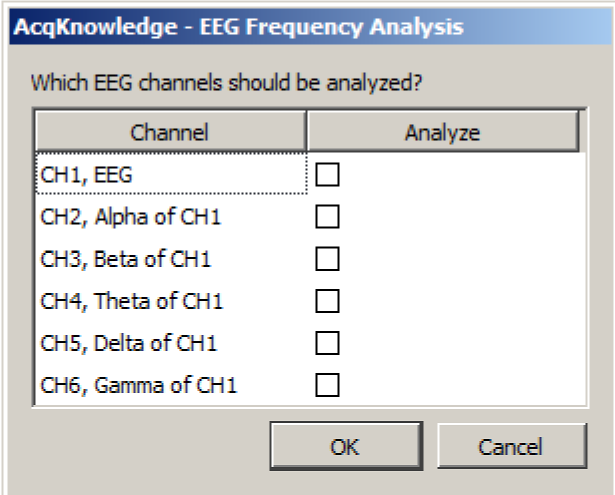
Compute Approximate Entropy



Approximate entropy is a statistical measure that attempts to quantify the predictability of a data sequence. A perfectly predictable data series (such as a pure sine wave) has approximate entropy of zero. Several studies are beginning to examine approximate entropy of EEG data and its relationship to external factors such as drugs and sleep states.

The Compute Approximate Entropy script divides an EEG signal into fixed-width epochs and computes the approximate entropy for each epoch. Derivation of the approximate entropy is a computationally intensive process and may take several minutes or hours to complete. To obtain only the sub-ranges of the EEG data, use the

EEG Frequency Analysis



EEG may be characterized in terms of frequency and the power within specific frequency bands. The EEG Frequency Analysis script performs various feature extractions from EEG signals using FFT and other techniques to examine the power within the EEG signals. This analysis may be performed for multiple EEG leads simultaneously, allowing for either analysis of multiple leads or analysis of multiple EEG alpha, beta, theta, or delta bands from a single raw lead.

The EEG Frequency Analysis script divides the EEG signals into fixed-width time epochs. For each individual time epoch, Acq*Knowledge*

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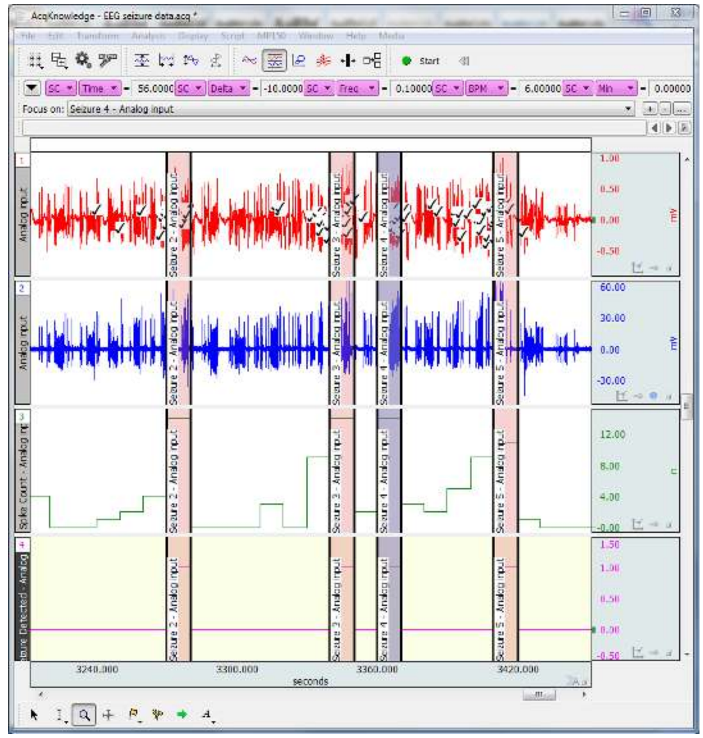
If the EEG Analysis Preferences are set to display results as graph channels, two new channels of data will be created. The first channel shows a tachogram of the number of epileptic spikes identified within the Time epoch. The second channel displays a square wave that runs from 0 to 1; a 1 indicates that an epoch matches the seizure threshold. In the default setting, 20 seizure spikes have to be identified within a 10 second epoch for the epoch to be classified as containing a seizure.



If the

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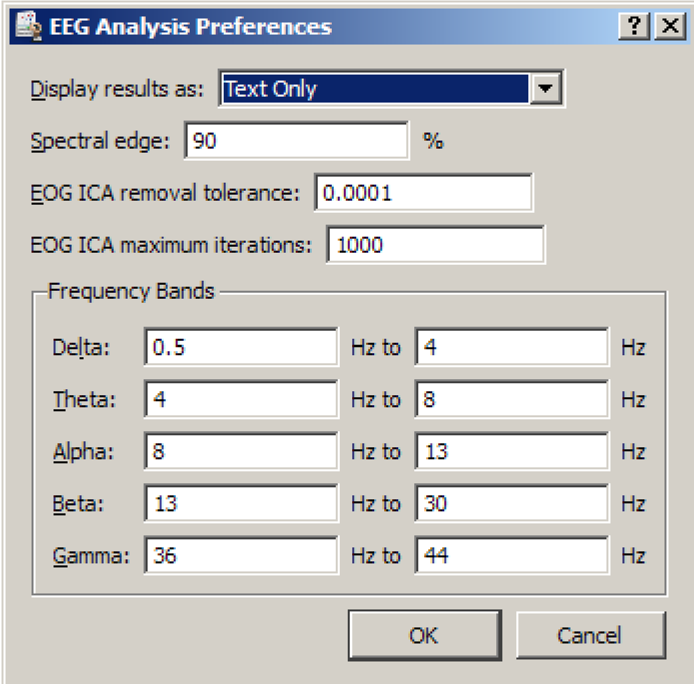
Preferences…



Adjust the EOG ICA Tolerance level and the EOG ICA maximum number of iterations by accessing Transform > Specialized Analysis > Electroencephalography > Preferences. EOG ICA Tolerance is used as the termination condition of ICA signal separation. The EOG ICA maximum number of iterations is another termination condition of ICA signal separation and represents the maximum point at which the search is aborted. For more information on these settings, see the documentation for the Independent Component Analysis transformation.

Because ICA is a statistical technique, any filtered data produced with Remove EOG Artifacts should be carefully verified against other information to ensure that the approximations produced via ICA represent information that is truly correlated to the expected ECG.

The spectral edge percentage indicates the cutoff percentage of the total power at which spectral edges will be placed. The default value is 90%.

The frequency bands of alpha, beta, delta, and theta may be modified to match different analysis protocols. The default frequency ranges are:

- Alpha

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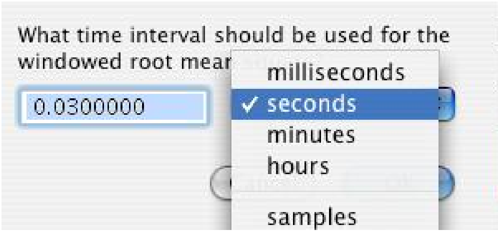
Derive Root Mean Square EMG



Root Mean Square EMG (RMS EMG) is defined as the time windowed RMS value of the raw EMG. RMS is one of a number of methods used to produce waveforms that are more easily analyzable than the noisy raw EMG.

To construct the windowed RMS signal, a time window must be specified for the sliding mean. The default time window setting is 30 milliseconds, but this value can be adjusted depending on the desired amount of smoothing effects in the RMS EMG. It is advisable to closely examine results for time windows larger than 30 milliseconds as it is possible for delay to be introduced into the result.

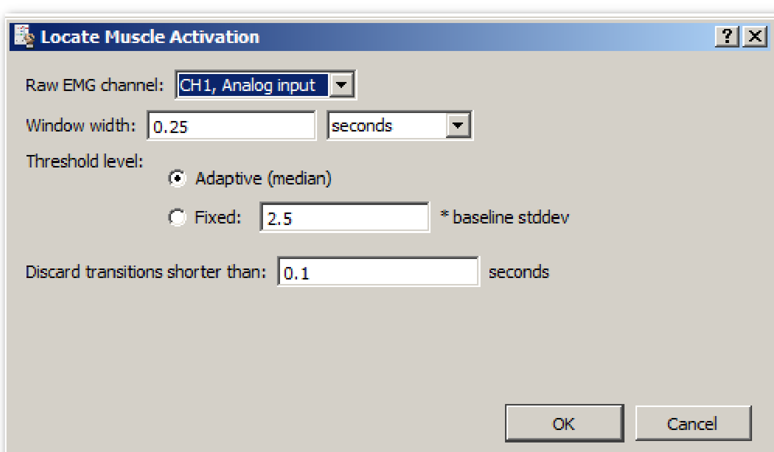
RMS EMG is computed using the Integrate transformation in a Root Mean Square Average over Samples configuration.

EMG Frequency and Power Analysis

Several frequency domain techniques may be used for data reduction of EMG signals. The EMG Frequency & Power Analysis script extracts several measures derived from the power spectrum of an EMG signal. The EMG signal is split up into a fixed number of time periods; within each window, the power spectrum is computed using the Power Spectral Density transformation. For each time period, the following measures are extracted:

Name	*Abbrev.*	*Description*	*Units*
Median Frequency	MedianF	Frequency at which 50% of the total power within the epoch is reached.	Hz
Mean Frequency	MeanF	Frequency at which the average power within the epoch is reached.	Hz
Peak Frequency	PeakF	Frequency at which the maximum power occurs during the epoch.	Hz
Mean Power	MeanP	The average power of the power spectrum within the epoch. (Units Note: V will be replaced with the voltage units in which the EMG was recorded)	$\frac{V^2}{Hz}$
Total Power	TotalP	The sum of the power at all frequencies of the power spectrum within the epoch. (Units Note: V will be replaced with the voltage units in which the EMG was recorded)	$\frac{V^2}{Hz}$

Locate Muscle Activation



When performing gait analysis, exercise physiology, or other research, identification of periods where the muscle is active can allow for correlation of external factors to muscle activity.

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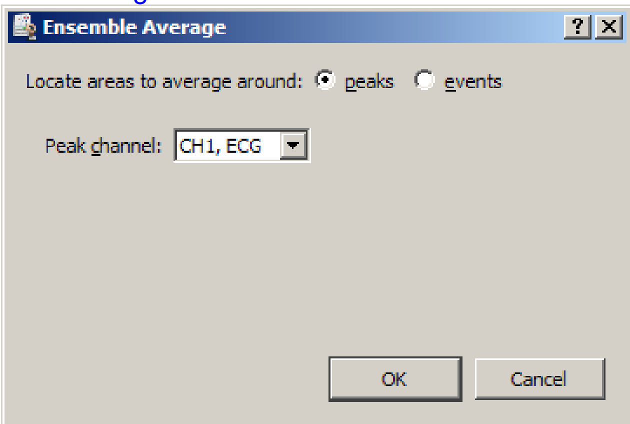
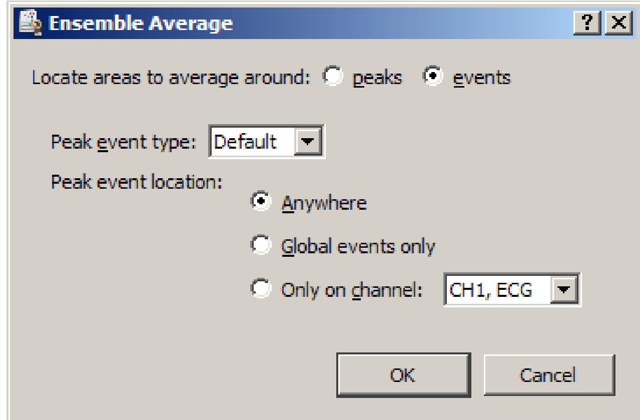
Ensemble Average

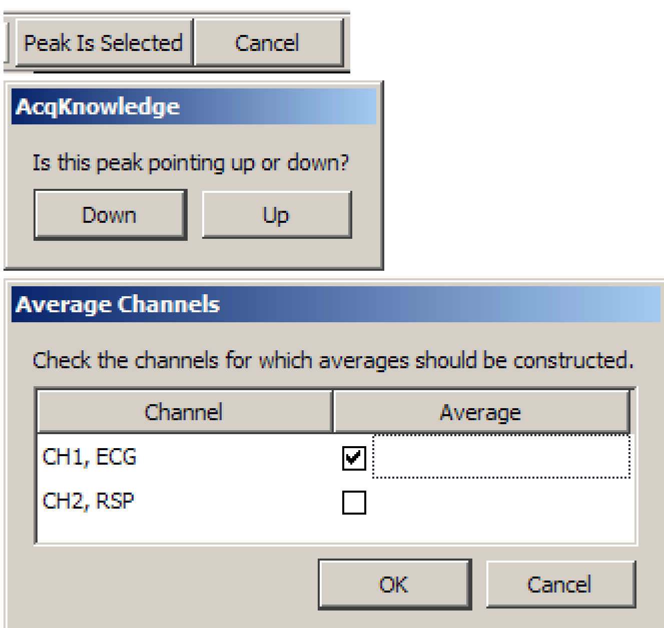


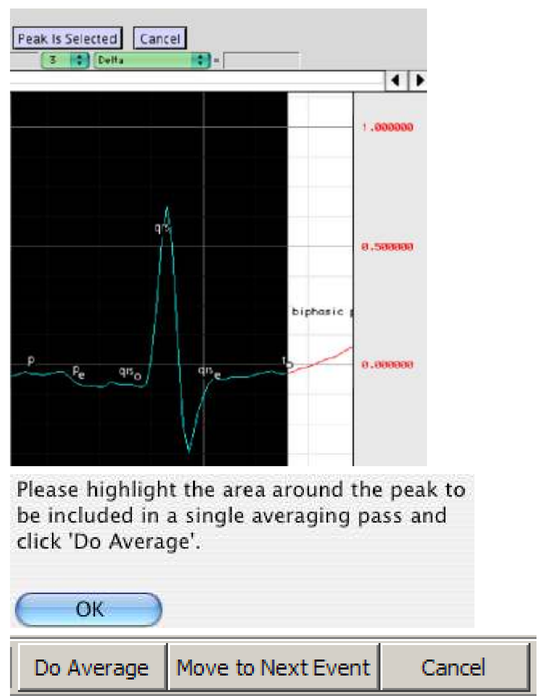


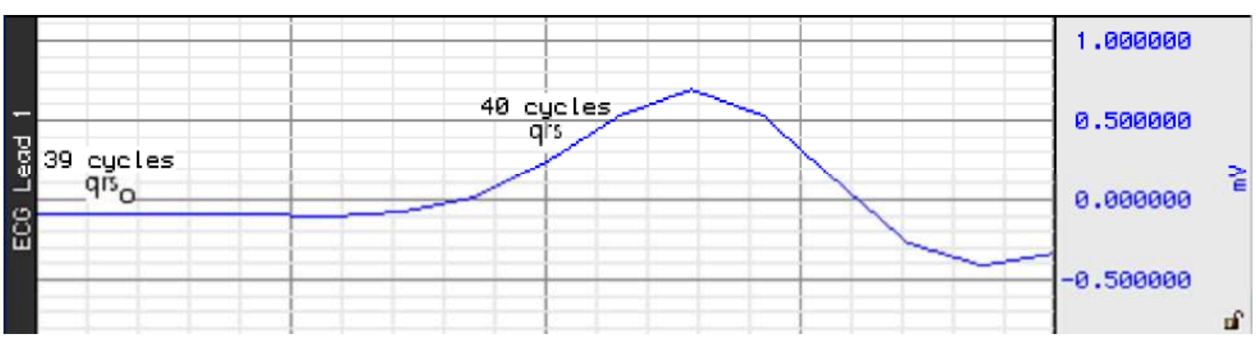
Ensemble Average assists in performing offline averaging. Offline averaging produces an average waveform from a number of cycles, also known as an *ensemble average*. Averages of multiple channels can be extracted simultaneously and be consolidated into a single graph window showing the results. Offline averaging is also available as a function within the Find Cycle feature.

This option provides two methods for locating individual members of the ensemble.

- **Peaks**: Data-driven peak detection with positive or negative peaks in the data. This method automatically derives appropriate threshold levels from a user-selected peak and is useful for constructing averages keyed to periodic signals with strong spikes, such as ECG.
- **Events:** Place members of the ensemble surrounding events in the waveform. Events must be previously defined by the user, either manually or through another automated process. This method is useful for constructing averages keyed to any types of events in a graph.







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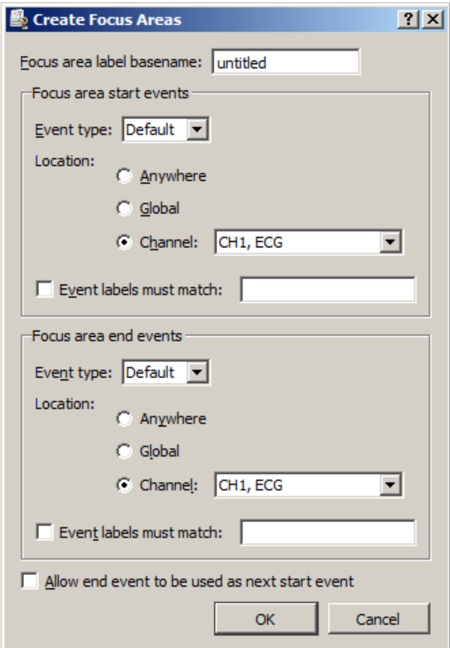
Focus Areas between Events and Segments

In addition to the standard focus area functionalities discussed on page 87, focus areas can also be used as an analysis tool to define areas of interest between certain event types or between appended segments.

Define Between Events

The parameters for defining focus areas using this method are highly customizable, and can be based upon specific event types or titles as well as various event locations in the graph. The following table explains the various focus area start and end event options.



Focus area label basename:

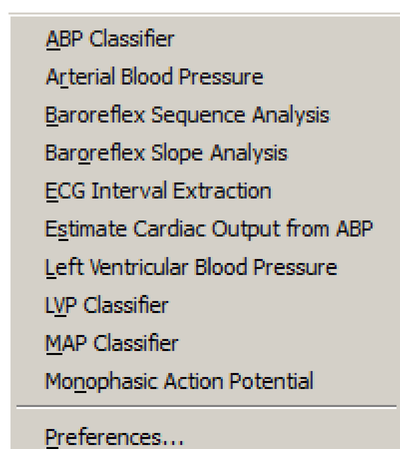
Use to assign a title for the focus areas. Successive focus areas will use the same title with the addition of incrementing numbers.

Event type:

Use to select the type of event for defining the focus area.

Location:

- **Anywhere**



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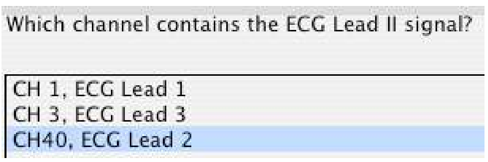
Mean blood pressure	MBP	Mean blood pressure: $P_{diastolic} + \frac{P_{systolic} - P_{diastolic}}{3}$
Minimum dP/dt	dP/dt min	Minimum amount of change in the pressure during the cycle
QA Interval	QA	Time interval between ECG Q wave and the diastolic pressure
Recovery interval	%REC	Time required for the pressure signal to decrease by a user specified percentage of the pulse height
Systolic	-	Maximum pressure occurring during the cycle
Time to peak pressure	TTPK	Time interval between the diastolic and the systolic pressures

When textual output is used, the average of all of these measures will be output as the last row of the table.

ECG Interval Extraction



Extracts cycle-by-cycle time and voltage measurements for various points and intervals between waveforms in the cycle on ECG Lead II signals. This interval extraction is based off of the waveform boundary locations with additional logic for defining explicit Q and S wave events. QRS peak events as output for boundary location are used as the R peak location.

- If the ECG signal was not classified before running the interval extraction analysis, it will be classified automatically.

This analysis extracts the following cycle-by-cycle measures:

Name	*Abbrev.*	*Description*
Corrected QT interval	QTC	QT time interval divided by the square root of the RR interval
Heart rate	HR	RR time interval expressed in BPM
P height	P-H	Amplitude at the peak of the P wave in a cycle
PRQ interval	PRQ	Time between the onset of the P wave to the Q wave
QRS width	QRS	Time between onset of the QRS complex and the end of the QRS complex. Equivalent to the time between onset of Q and end of S
QT interval	QT	Time between the beginning of the Q wave and the end of the T wave
R height	R-H	Amplitude of the R wave in a cycle
RR interval	RR-I	Time between consecutive R peaks in the waveform
ST interval	ST	Time between the S wave to the end of the T wave

At the end of the text table output, the average of all of the cycles will be displayed. Additionally, both text and Excel output will indicate the number of cycles that did not have all three of the QRS, P, and T waves defined. These are cycles where the classifier missed a boundary and are listed as

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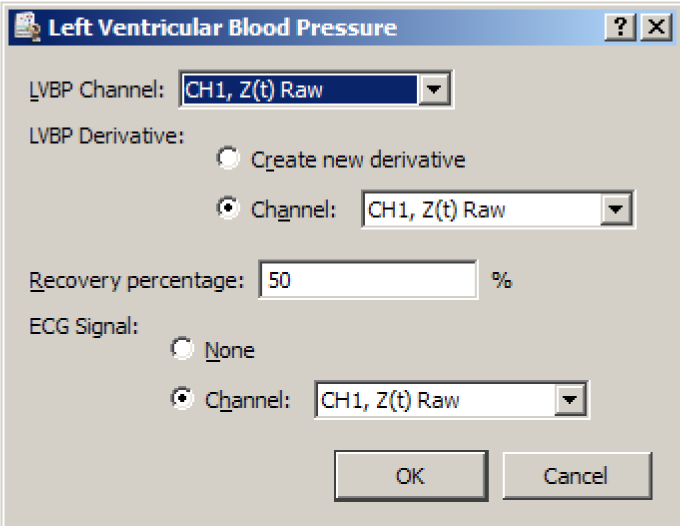
Watch the Acq*Knowledge* Cardiac Output from ABP video tutorial for a detailed demonstration of this feature.

Left Ventricular Blood Pressure



Extracts various cycle-by-cycle cardiac measures of left ventricular blood pressure data, optionally in conjunction with an ECG Lead II signal. Examines the LVP signal, ECG, and derivative of the LVP signal.

- If the LVP and ECG signals have not been classified before this analysis is executed, they will be classified automatically.
- Derivatives of the LVP signal can be pre-existing or can be constructed automatically.
- If an ECG signal is not included, only pressure related measures will be extracted.

The analysis outputs the following information on a cycle-by-cycle basis and the textual output cites the average of all of these cycle-by-cycle measurements:

Name	*Abbrev.*	*Description*
Contractility index	CI	maximum value of dP/dt during the cycle divided by the pressure at that time location
Developed pressure	DP	Amplitude interval between end diastolic pressure and systolic pressure
dP/dt Max	-	Maximum change in pressure over the cycle
dP/dt Min	-	Minimum change in pressure over the cycle
End diastolic pressure	LVEDP	End diastolic pressure for the cycle. This is not necessarily the minimum pressure during the entire cycle. LVEDP is located on the LVP signal using the method set in the preferences.
Minimum pressure	MIN	Absolute minimum pressure occurring during the entire cycle. This is not necessarily equivalent to the end diastolic pressure
QA Interval	QA	Time interval between the Q wave of the ECG and the end diastolic pressure
Rate	-	heart rate in BPM as extracted from the time interval between consecutive end diastolic pressure locations
Recovery time	%REC	Time it takes for dP/dt to increase from the minimum dP/dt location to a user specified percentage of that minimum value
Systolic pressure	SYS	Maximum pressure occurring during the entire cycle
Tau	-	Monoexponential time relaxation constant tau computed on a cycle by cycle basis. See

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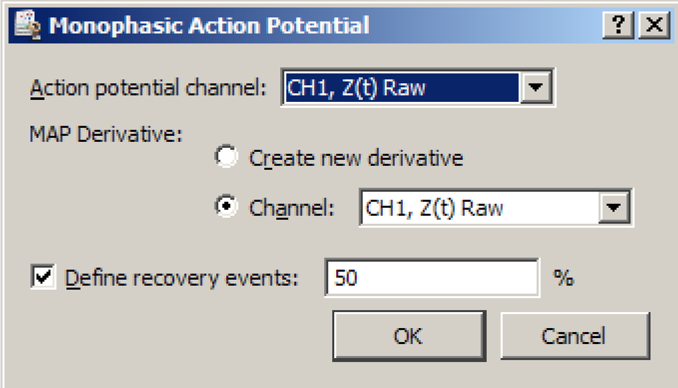
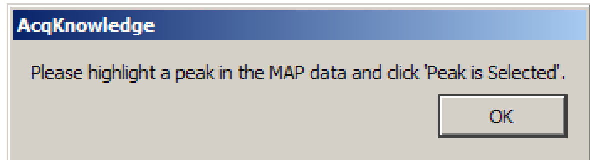
Monophasic Action Potential





Performs classification of MAP data acquired from a human or animal subject and extracts various cycle by cycle intervals. Locates upstroke, maximum, 100% recovery, and user-specified recovery points on the action potential.

- Classification is performed using the action potential with its smoothed derivative; pre-filtering noise with low pass filters may improve classification.
- If upstroke, maximum, and plateau events are already defined on the MAP signal, the classifier is not invoked and only recovery events are defined.

Plateau position

To better handle animal subjects and different potential morphologies, there are two methods for locating the plateau position in monophasic action potential data; use Preferences to set the method. Each method defines recovery percentage time locations depending on the signal between its maximum and the beginning of the plateau. The plateau is located by examining the derivative of the MAP immediately following its maximum value after an upstroke.

- The first method uses an adaptive threshold of zero plus a percentage of the peak to peak change in the derivative between the maximum and the first zero crossing after the maximum. If the signal remains above the upstroke voltage in this interval, a quick algorithm is used to locate 100% recovery and user-specified percentage levels.
- The default percentage is 0.1%, which will place the plateau position very close to the second zero crossing. This slight window around zero helps place plateau start events better for MAP data that has plateaus that continue increasing after their starting position.
- Searches for the second zero crossing after the maximum. If the signal drops below the voltage level of the upstroke in this interval, a different (slower) algorithm is used to ensure the recovery percentage is relative to the upstroke voltage and not the minimum occurring between the maximum and plateau.

The analysis outputs the following information on a cycle-by-cycle basis and the textual output cites the average of all of the cycle-by-cycle values:

Name	*Abbrev*	*Description*
100% recovery period	100% REC	Time interval from the upstroke for the signal to recover back to the upstroke voltage level
dV/dt maximum	dV Max	Maximum change in voltage over the cycle
dV/dt minimum	dV Min	Minimum change in voltage over the cycle
End diastolic voltage	EDV	The value of the signal at the beginning of the upstroke
Max voltage	MAX	The maximum value of the signal over a single cycle
Minimum voltage	MIN	The minimum value of the signal over a single cycle. This may be less than the upstroke voltage depending on the morphology of the action potential
Plateau voltage	PLAT	The value of the signal at the start of the plateau after the completion of the upstroke
Rate	-	This is the heart rate in BPM as extracted from the time interval between consecutive upstrokes
Stroke amplitude	AMP	Voltage interval between the plateau and the upstroke voltage
User recovery period	%REC	Time interval from the upstroke for the signal to recover a specific percentage of the interval between the upstroke and the maximum voltage between the upstroke and the plateau

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ABP Location method (Arterial Blood Pressure)

- **Adaptive template matching**

  This arterial blood pressure cycle location method uses adaptive template matching (see page 297). A single cycle is selected, systolic to systolic, which sets an example template. Subsequent blood pressure cycles are located by correlation to this template with the template adapting to the signal. This may function better if there is artifact in the pressure signal, however may not be as suitable for signals that have significant changes in heart rate. Location may also improve if a different cycle is chosen as the initial template. Adding smoothing or a low pass filter to the signal may improve results for Estimated Cardiac Output, ABP Classifier and Arterial Blood Pressure.

- **Tracking peak pressure level**

  The Tracking peak pressure level ABP location method is similar to the cycle detector's peak location method. This method sets a detection threshold from a selected systole and adjusts the threshold based on a customizable tracking percentage. The default tracking percentage is 60%. If the blood pressure signal is highly variable, this tracking percentage may need to be lowered. If the tracking percentage is set too high, blood pressure cycles may be missed.

HRV and RSA Analysis

Acq*Knowledge* includes flexible options for extracting a wide range of heart rate variability (HRV) and respiratory sinus arrhythmia (RSA) measures. This analysis feature allows you to:

- Extract HRV measures over user-defined areas of data, such as fixed time trials (

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If **Fixed width intervals around events** is chosen, the following setup criteria are available:

- Event type:

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Single-epoch HRV – Spectral

Single-epoch HRV

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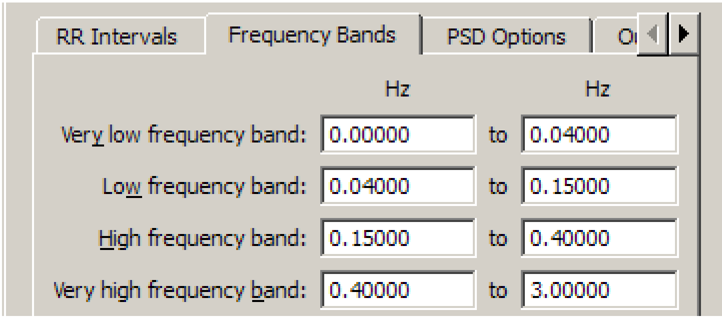
When using events, the built-in QRS detector is not used; the exact positioning between the events on the channel is used to extract the RR intervals.

By using events, it is possible to use other QRS detectors within Acq*Knowledge* for performing HRV analysis. It is also possible to apply spectral HRV-style analysis to data in other domains as long as intervals can be reduced to events.

Spline resampling frequency

For highest accuracy, set to no less than twice the topmost frequency of the very high frequency band.

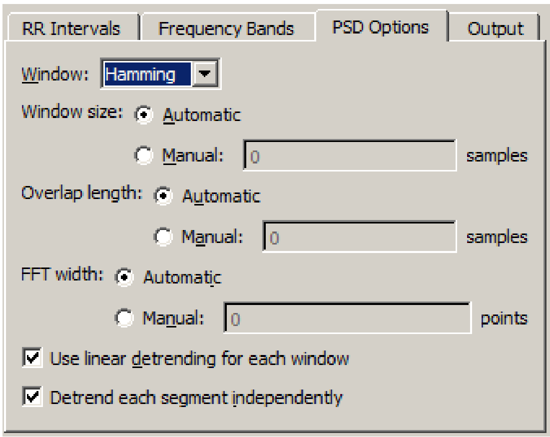
Frequency Bands



Enter the start and end of each specified frequency band to adjust the boundaries of the frequency analysis. They are preset to the frequency ranges recommended by the European Heart Journal (1996) 17, 354-381. Output of derived parameters is presented in a dialog and may also be pasted as text to the Journal.

- Very high frequency band, usually used in rat studies, is disabled if the spline resampling frequency is less than the upper bound of the very high frequency range.

PSD Options



PSD Options establish parameters for the power spectral density transformation used to compute the spectrum from the interpolated tachogram; the options contained in this tab mirror the controls of the Analysis > Power Spectral Density transformation.

The use of linear detrending in each individual segment of source data prior to the windowed periodogram analysis can be enabled or disabled. When disabled, the algorithm may be tuned to correspond to implementations that do not apply linear trending, such as MATLAB, which uses windowing only. The same PSD options are available via Analysis > Power Spectral Density so users can regenerate the spectrum from either the raw or interpolated tachogram output as necessary.

After the user modifies the parameters for the PSD transformation, those parameters will become the new default values each time the dialog is displayed. When the application is relaunched, the default settings will be used (user changes are not persistent).

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Use linear detrending for each window When enabled, linear regression detrending is applied for each individual segment prior to the FFT computation. When disabled, windowing only is applied.

Detrend each segment independently *This option is only available when "Use linear detrending" is enabled.* When this option is enabled, detrending is applied independently for each segment; when disabled, detrending from the previous segment will be incorporated into the next segment.

Transform entire wave When enabled, the entire waveform is delayed. When unchecked, only the selected area is delayed.

- If there is no selection in the graph, the checkbox is enabled and dimmed.
- As the selection changes in the graph with the selection palette, the state of this checkbox is updated.

Improvements to PSD Options (Acq*Knowledge* 4.3 and higher)

- The PSD output is now scaled so power values are scaled by the sampling rate. That is: $PSD_{new} = \frac{PSD_{old}}{f_s}$
- Reporting a sum for a frequency range when computing the power in an individual band has been changed. Given a frequency range f_{low}, f_{high}

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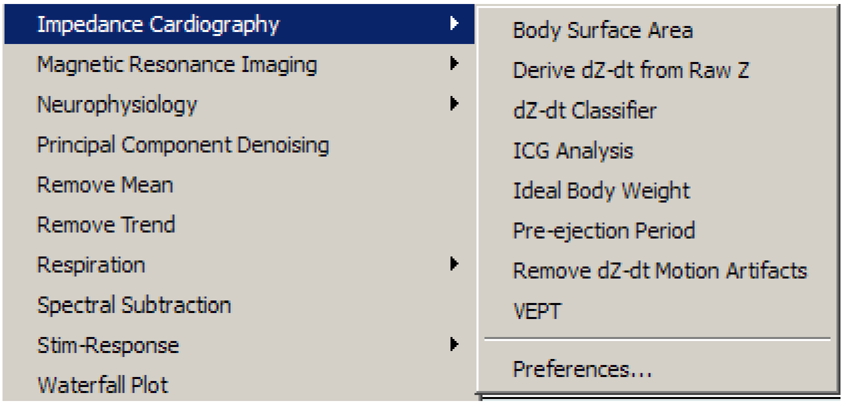
Impedance Cardiography Analysis

The Impedance Cardiography analysis package assists in the analysis of cardiac output and other hemodynamic parameters using noninvasive bioimpedance monitoring techniques; signals must be sampled at 5 kHz or below to be analyzed with this package. This analysis offers a variety of approaches for estimation of cardiac measures.



Body Surface Area

Determines the body surface area estimation in square meters for a subject of a given height and weight, using the formula set in Preferences. It can be used to calculate body surface area independent of any of the other analysis routines, which may be useful for validation purposes or other derived calculations.

Body Surface Area equation

Use the Preferences option to select an algorithm for estimating body surface area of a subject and deriving stroke volumes from impedance data.

Method	*Formula*
Boyd	$BSA = 0.0003207 \times Height(cm)^{0.3} \times Weight(g)^{0.7285-0.0188\log(Weight(g))}$
DuBois and DuBois	$BSA = 0.20247 \times Height(m)^{0.725} \times Weight(kg)^{0.425}$
Gehan and George	$BSA = 0.0235 \times Height(cm)^{0.42246} \times Weight(kg)^{0.51456}$
Haycock	$BSA = 0.024265 \times Height(cm)^{0.3964} \times Weight(kg)^{0.5378}$
Mosteller	$BSA = \sqrt{\dfrac{Height\ (cm) \times Weight\ (kg)}{3600}}$

dZ/dt Derive from Raw Z

This is a convenience utility for working with impedances recorded using the BIOPAC EBI100C amplifier or the raw impedance output of the BIOPAC NICO100C module. When computing derivatives from raw impedance signals from an EBI100C, this will apply appropriate filtering for a thoracic impedance signal and properly invert the derivative to match traditional dZ/dt presentation.

dZ/dt Classifier

Places events at common inflection points on a dZ/dt waveform to derive other measures.

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C-point Location

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- If both a raw impedance and a dZ/dt signal are present, the baseline impedance will be derived on a cycle-by-cycle basis to improve the accuracy of the analysis.
- If no raw impedance signal was acquired, a default fixed baseline impedance can be used.
- If a NICO100C amplifier is used, it is recommended that both the raw impedance and dZ/dt signals be acquired to improve analysis accuracy.
- To automatically apply motion filtering to the dZ/dt signal, use Preferences to enable Motion Filtering (see page 400).
- ICG Preferences must first be selected in order to generate the main ICG Analysis setup window.

In addition to the minimal set of signals, it is also possible to use arterial blood pressure, central venous pressure, and pulmonary arterial pressure signals to improve the quality of the algorithm results. If any of these signals are not present, default fixed estimated values can be substituted for the mean pressures instead of deriving pressures on a cycle-by-cycle basis.

ICG Analysis may potentially perform classification of both the dZ/dt and the ECG Lead II signals. The various notes for understanding the limitations of these classifiers apply and should be understood to properly interpret failures in the analysis.

ICG Analysis will produce the following information on a cycle-by-cycle basis:

At the end of the textual table an average of all of the cycle-by-cycle values will be appended.

Name	*Abbv.*	*Description*	*Units*	*Formula*
Acceleration index	ACI	Maximum blood acceleration	1 / sec^2	$\dfrac{\dfrac{d^2Z}{dt^2}_{\max}}{TFI}$
Cardiac index	CI	Normalized cardiac output	m^2 / min	$\dfrac{CO}{BSA}$
Cardiac output	CO	Volume of blood pumped each minute	l / min	$SV \times HR$
Heart rate	HR	Heart rate in BPM as computed from the RR interval.	BPM	$\dfrac{60}{RR_i}$
Left cardiac work	LCW	Work exerted by the left ventricle each minute	kg m	$(MAP - PAP) \times CO \times 0.0144$
Left cardiac work index	LCWI	Normalized left cardiac work	kg m / m^2	$(MAP - PAP) \times CI \times 0.0144$
Left ventricular ejection time	LVET	Time interval between B and X. Time interval between aortic valve open and close.	sec	*Not applicable*
Mean blood pressure	MBP	Mean blood pressure as measured on the arterial blood pressure signal, or fixed estimate if no ABP signal is present.	mmHg	$P_{diastolic} + \dfrac{P_{systolic} - P_{diastolic}}{3}$
Mean central venous pressure	CVP	Mean central venous pressure over cycle, or default value if no CVP signal is present.	mmHg	*Not applicable*
Mean pulmonary arterial pressure	PAP	Mean value of the pulmonary arterial pressure of a cycle, or default value if no PAP signal is present.	mmHg	*Not applicable*

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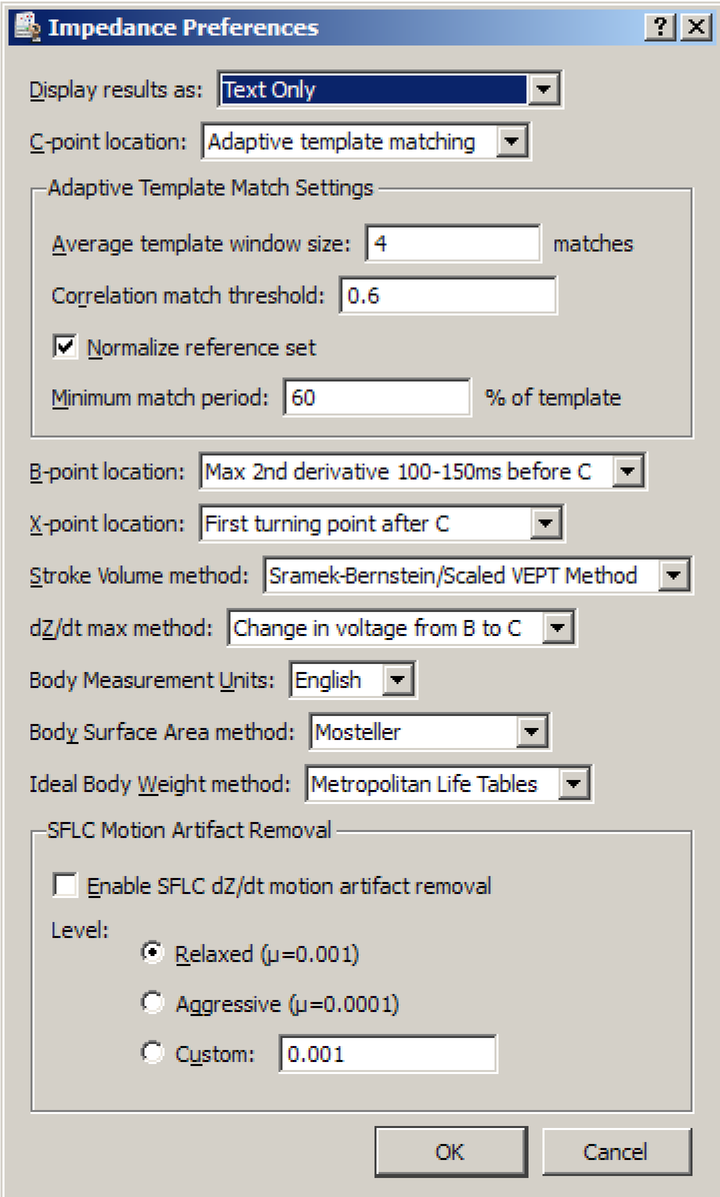
Name	*Abbv.*	*Description*	*Units*	*Formula*
Systemic vascular resistance index	SVRI	Normalized afterload	dynes sec m^2 / cm^5	$80 \times \frac{MAP - CVP}{CI}$
Systolic time ratio	STR	Ratio between electrical and mechanical systole	none	$\frac{PEP}{LVET}$
Thoracic fluid content	TFC	Electrical conductivity of the chest cavity	1 / Ohms	$\frac{1}{TFI}$
Thoracic fluid index	TFI	Mean value of the raw impedance over the cycle, or fixed baseline value if no raw impedance signal is present.	Ohms	*Not applicable*
Velocity index	VI	Maximum velocity of blood flow in the aorta.	1 / sec	$\frac{\frac{dZ}{dt}_{\max}}{TFI}$ **Note** $\frac{dZ}{dt}_{\max}$ may be either the absolute maximum or the BC delta in amplitude, as set in Preferences.

Ideal Body Weight

Body Weight is derived from a person

Part C

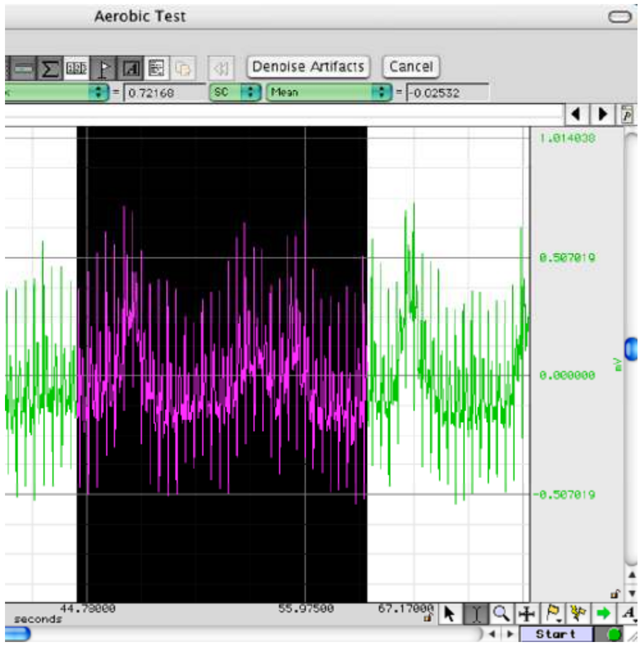
Preferences



Display results as

- Textual tables in the journal
- Channels of data inserted into the graph.

C-point location



Two large sources of interference in MRI recordings are the current induced by the MRI magnetic field and the RF pulses used for triggering molecule alignment. While the overlap of this interference may be difficult to separate in the time domain, the MRI interference may have a distinctive signature in the frequency domain.

Artifact Frequency Removal is a frequency domain adaptation of the ensemble projection removal of the Artifact Projection Removal transformation. It attempts to cancel out MRI artifact by removing the frequencies most strongly associated with the MRI signal.

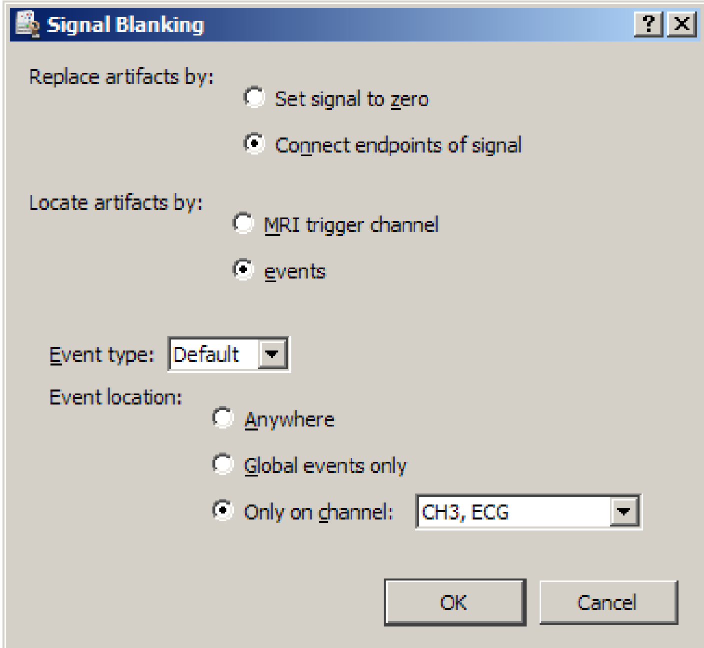
For each channel of data to be denoised, either the MRI trigger signal or event positions are used to locate periods of MRI activity for constructing an ensemble average. The FFT of this ensemble average is computed, and the magnitude of the average FFT is set as the reference. Cyclic mean removal is applied to each period of artifact to compensate for baseline drift or signals with expected DC offset. A second pass is then made through the data. For each individual artifact, the FFT of that artifact is computed and the projection of that FFT onto the average FFT is removed. After projection removal, negative Fourier components are discarded and a time-domain signal is reconstructed using the inverse Fourier transform. This reconstructed, filtered signal is used to replace the MRI artifact in the original data.

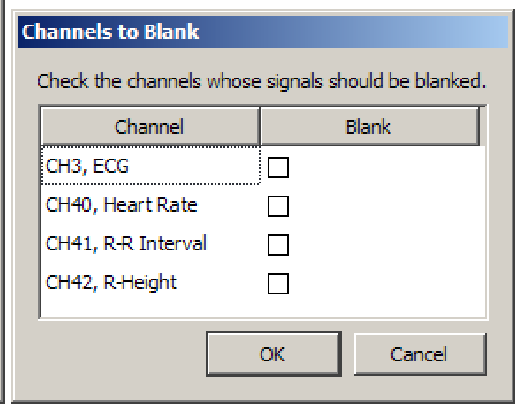
Application of projection removal in the frequency domain has similar limitations to applying it in the time domain, that is, it assumes that the MRI interference is stationary (which is not necessarily the case). Variations in the MRI interference may cause this method to fail.

IMPORTANT Artifact Frequency Removal requires an MRI triggering signal or artifact onset events to locate artifact positions.

Part C

Signal Blanking





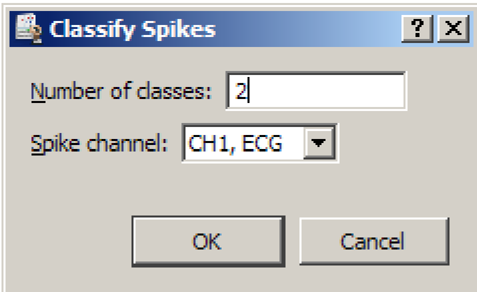
MRI artifact can grossly distort low level physiological signals, and this distortion can be several orders of magnitude larger than the signal of interest. A common practice for analyzing the physiological data is to discard the MRI artifacts and only examine the portions of the signal in between the MRI artifacts. One approach for this is outlined in BIOPAC MRI application note AH223.

Signal Blanking provides an alternate approach for discarding MRI artifacts from the signal. Using the MRI triggering signal or artifact event locations, this analysis option will locate the periods of MRI activity and

Part C

- On classified signals, the resulting ensemble averages will have multiple channels.
  - The first channel will be the overall average of all of the spike episodes.
  - The remaining channels show the average of the members of each individual spike class.
- On unclassified signals, a graph will be produced with a single channel showing the average of all of the spike episodes.

Classify Spikes



This analysis option will automatically classify action potentials in microelectrode data and divide them into different spike classes.

If the Locate Spike Episodes option wasn

Part C

1. Obtain mean value of the entire signal.
2. Obtain standard deviation of the entire signal.

   OR: Obtain an Amplitude/Half Width Discriminator of the entire signal. See Neurophysiology Preferences for more information (page 408).
3. Detect spikes where the signal rises above a fixed threshold determined by adding a multiple of the standard deviation to the mean.
4. Position the episode around the threshold crossings according to the width and offset entered previously.

A

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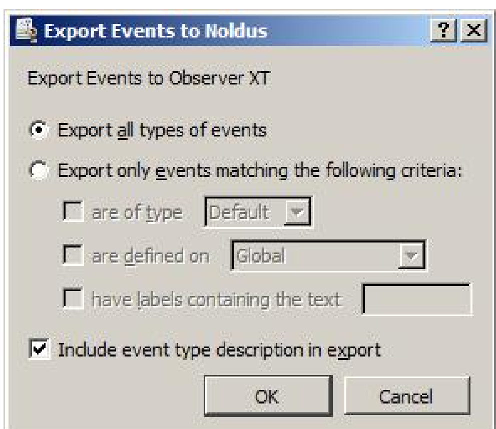
Preference	*Description*	*Default Setting*
Default Episode Width	The first time that any of the spike detection is run on a graph, the time width of each fixed width episode must be specified. This preference provides the default value that is seeded in the dialog. The episode width for an individual graph does not need to match this default.	10 ms
Default Episode Offset	Each fixed width episode is located around one of the spikes in the signal. The offset allows for the episode to begin before (or after) the spike threshold crossing so the leading edge of the spike can be captured. Negative numbers indicate episodes are to start before the spike threshold crossing, positive numbers indicate episodes that start after.	-2 ms
Default Number of Spike Classes	The Classify Spikes script requires the user to input the number of classes into which the spikes will be partitioned. This preference allows the default number to be modified. The number of classes that wind up being used does not need to match this default.	2

Noldus Format

Supports import and export of files in Noldus Observer format. Noldus is a popular Human Behavioral analysis software package and the Acq*Knowledge* Noldus feature allows behavioral markers to be imported from Noldus into Acq*Knowledge* and Acq*Knowledge* marker information to be exported into Noldus. The following options are available:

Export Events to Noldus XT



Acq*Knowledge* events can be exported to Noldus by

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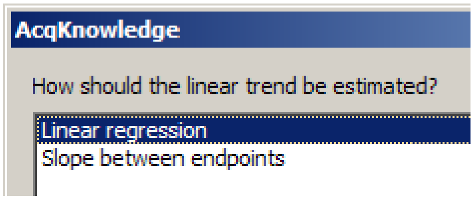
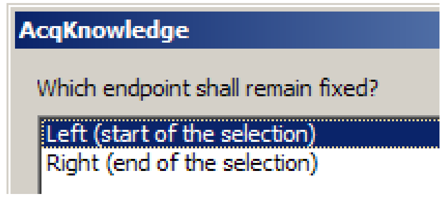
Remove Mean

Remove Mean allows for mean subtraction to be performed for the selected area (or entire wave if no data is selected). It will result in the mean value being the new zero value for the waveform.

Remove Trend





Remove Trend helps to remove baseline drift or other linear trends from data. This tool makes it easier to apply trend removal to only specific segments of a waveform. Given a selected segment of data, or an entire waveform, it computes the trend between the two endpoints (similar to the Slope measurement) and then removes this trend from the selected area such that the endpoints of the selection lie at the same voltage.

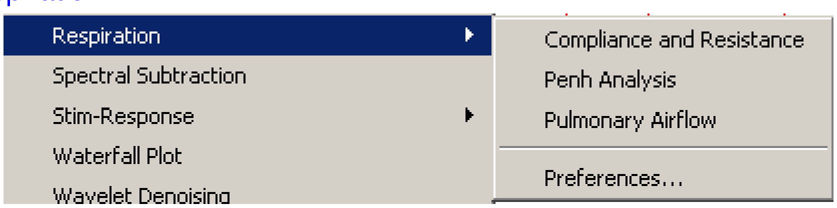
Linear Regression

Use linear regression to estimate the trend to be removed from the waveform.

Slope between endpoints

- **Left** keeps the starting point of the selection fixed at the same voltage. The software adjusts the data from left to right such that the right endpoint is aligned with the initial starting voltage.
- **Right** keeps the ending point of the selection fixed at the same voltage. The software adjusts the data from right to left such that the left endpoint is aligned with the initial ending voltage.

Respiration



***IMPORTANT—*Respiration analysis assumes a bidirectional airflow signal that records both inhale and exhale. Unidirectional respiration signals cannot be analyzed at this time.**

The respiration analysis package helps to analyze respiration- and airflow-related data. Other tools exist for respiration related analysis including Acq*Knowledge* transformations and the Respiratory Sinus Arrhythmia analysis in the Hemodynamics analysis package.

Compliance and Resistance

Compliance and Resistance analysis can be used to extract pulmonary resistance and pulmonary compliance in addition to basic airflow measures. This analysis requires an airflow signal and a pressure signal. The analysis will extract all of the measures of the Pulmonary Airflow analysis for the airflow signal. It also will locate apnea periods after exhalation using the same user-configurable threshold method as the Pulmonary Airflow analysis.

***IMPORTANT—* The flow signal must be recorded correctly for Compliance and Resistance analysis to work.** Compliance and Resistance analysis assumes positive flow indicates inhalation and negative flow indicates exhalation (the flow conventions of the recommended connections for a BIOPAC TSD107 pneumotach or a TSD117 airflow transducer).

- If the flow signal was recorded with exhalation positive instead of inhalation positive, multiply the flow signal by -1 to invert the signal.

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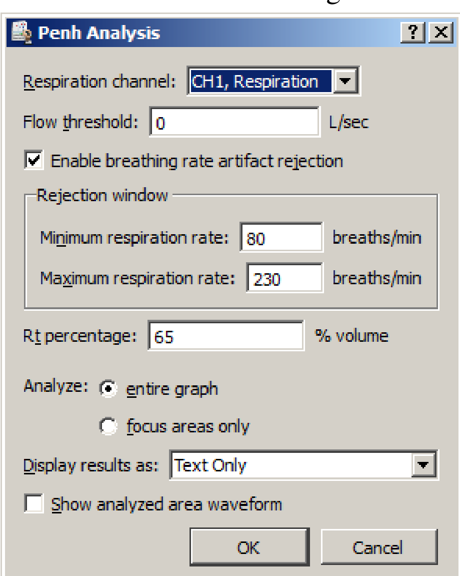
Name	*Abbrev.*	*Description*	*Units*
Inspiration time	IT	Time interval between the start of inhale and the start of exhale.	seconds
Exhalation time	ET	Time interval between the start of exhale and either: - start of apnea (if apnea present) - start of subsequent breath (if no apnea present)	seconds
Total breath time	TT	Time interval between the start of inhale and the start of inhale of the following breath. This is the sum of the inhalation time, exhalation time, and apnea time.	seconds
Apnea time	AT	Time after end of exhalation where the airflow signal remained within the apnea threshold defined at the start of the analysis.	seconds
Pulmonary resistance	RES	Change in pressure divided by change in flow at the isometric volume locations: $\frac{\Delta p}{\Delta f}$	mmHg/ (liters/ sec)
Pulmonary compliance	Cdyn	Tidal volume divided by the change in pressure between exhale and inhale locations in the breath: $\frac{TV}{\Delta p}$	liters/ mmHg

If text output is being generated, an additional row will be added containing the average values of the measures. Time and count are not output as waveforms in the graph since they can be found in the horizontal axis.

Penh Analysis

Penh Analysis script assumes standard recording methodology for a full body plethysmograph. Positive flow is treated as exhalation and negative flow is treated as inhalation.



Penh Analysis extracts measures from data recorded in a full body plethysmograph. It operates on a single channel of data recorded from an airflow transducer connected to the plethysmograph. The analysis takes a single parameter: the Rt percentage. This percentage is used to locate the plateau, or

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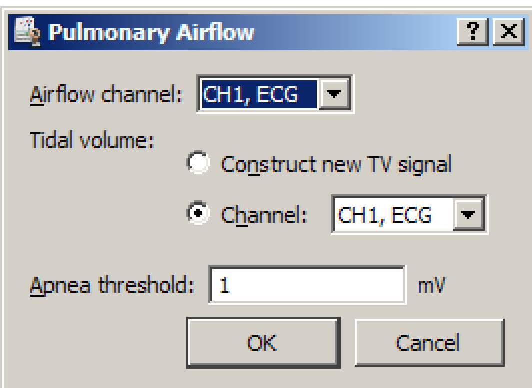
Name	*Abbrev.*	*Description*	*Units*
Enhanced pause	Penh	Pause scaled to be relative to the strength of the inhale and exhale. This helps take breathing variability into account. Computed using the following formula: $\frac{PEF}{PIF} * Pause$	

The Penh analysis excludes the following exhale cycles from the analysis:

- Exhale cycles that do not have a preceding inhale (may occur for partial cycles at the start of the data recording).
- Exhale cycles that do not have a corresponding recovery time (often occurs during apnea).
- Cycles that fall outside the boundaries of the selected flow threshold and artifact rejection parameters.

In addition, during periods of apnea, the analysis may produce invalid results, such as zero width recovery times. These results may be excluded from the analysis by either using waveform editing to remove apnea periods, discarding all events during apnea periods and rerunning the analysis, or deleting the corresponding rows from the Excel output.

Pulmonary Airflow



The Pulmonary Airflow analysis follows the flow conventions of the recommended BIOPAC connections for a TSD107 pneumotach or a TSD117 airflow transducer. Positive flow is assumed to indicate inhalation; negative flow is assumed to indicate exhalation.

The Pulmonary Airflow analysis extracts basic parameters from a calibrated airflow signal, such as would be recorded using a pneumotach or airflow transducer. In addition to inspiration and expiration, Pulmonary Airflow also can be used to examine apnea. Apnea is defined in this analysis as pauses in breathing that occur after an exhalation.

When performing the analysis, an airflow signal f is chosen. An apnea threshold a_f is also entered. Inhalation is defined to begin at the point where $f > a_f$. Exhalation is defined to begin at the point where $f < -a_f$. Apnea is defined to be the period between exhalation and inhalation where the flow lies within the apnea threshold: $f \in \left(-a_f, a_f\right)$. At least two consecutive samples must occur within the apnea threshold for a period of apnea to be defined. This allows for valid transitions from exhalation to inhalation to occur even if one of the samples in the transition happens to fall within the apnea threshold due to sampling.

The Pulmonary Airflow analysis will generate a tidal volume waveform if it is not present in the graph. It also will add Inspire Start and Expire Start events on the airflow signal if they are not present. New Apnea Start events will be defined each time the analysis is performed.

Individual breaths are defined as the period between consecutive Inhale Start events. Airflow units are assumed to be the standard liters/sec.

For each breath period, the analysis will extract the following:

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Spectral Subtraction

Spectral subtraction is a denoising technique that operates on data projected into the frequency domain. It is frequently used in speech analysis denoising applications. Spectral subtraction examines a reference noise signal and performs a Fourier transform to get the noise frequency distribution. To denoise a signal, the Fourier transform of the signal is performed. The noise estimate frequency distribution is then subtracted from the source signal. The resulting processed spectrum with the noise frequencies removed is then reconstructed into a time domain signal using the inverse Fourier transform.

Spectral subtraction performs noise removal on the entire channel in a single Fourier transformation, which allows for denoising where the noise is stationary; there is no provision for sliding window spectral subtraction at this time.

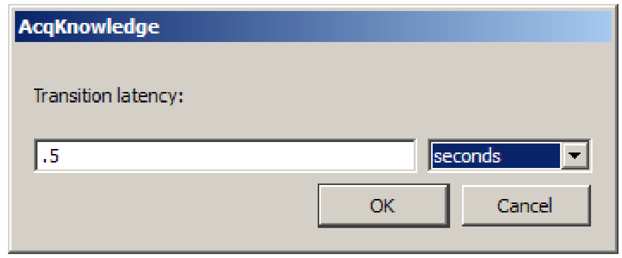
The spectral subtraction is performed using a formula with two adjustable parameters. Given a frequency spectrum F_{noise} and a mixed signal F_{mix}, the denoised frequency spectrum is computed using the following formula:

$$F_{denoise} = \left[F_{mix}{}^{\gamma} - \alpha F_{noise}{}^{\gamma} \right]^{\frac{1}{\gamma}}$$

where

Alpha is the

Part C



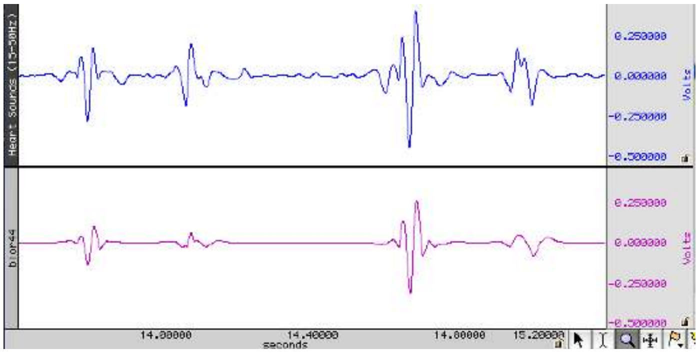
Digital line decoding can be two byte (using all 16 digital lines) or single byte (on either the low eight or high eight digital lines). Big endian bit and byte ordering are used, with digital line 0 representing the least significant bit.

When the stimulus labels are constructed, all numbers are zero-prefixed. All stimulus events will have the same number of base-10 digits with leading zeros, regardless of magnitude. This provides each stimulus event type with a unique label that can be used with the Cycle Detector (which uses substring matching).

Some systems that trigger digital lines such as parallel ports may not be able to do so instantaneously; they may require a time window before the transition from one state to another is fully complete. A

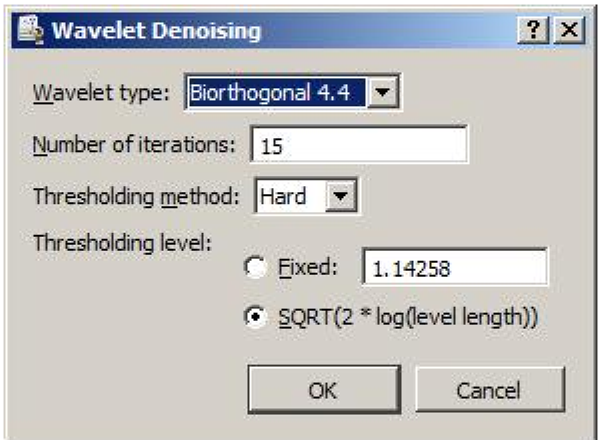
Part C

Wavelet Denoising



Sample output

Wavelet Denoising applied to heart sounds data may help clarify S_1 and S_2, as shown:



Wavelet Denoising uses the forward and reverse wavelet analysis operations to project source data into the wavelet domain, modify the wavelet coefficients (called

Part C

OSEA QRS Detector

➲ OSEA QRS detector and beat classification library

Since the release of software version 3.9, Acq*Knowledge* incorporates the open source OSEA QRS detector and beat classification library.

The OSEA library is a set of routines provided by EP Limited (http://www.eplimited.com). This C++ based software library provides robust QRS complex detection and rudimentary beat classification. This library is well documented and tested. The QRS detector uses a standard Tompkins-based filtering and derivative detection algorithm and has been in development since about 1985; the beat classifier development began in 1997. This algorithm development is sponsored by the NIH.

This algorithm is fairly robust against arrhythmias, baseline drifts, discontinuities, and other artifacts in the ECG signal. It achieves a 90% success rate on identifying QRS complexes on sample arrhythmia databases. The algorithm is tuned to human ECGs.

The QRS detector is optimized for 200 Hz sampled data. If the sampling rate is lower or higher, data will be internally resampled to 200 Hz before processing. The sampling rate difference may result in slightly different placement of beat events for different sampling rates.

QRS detection can be performed by selecting the desired channel of ECG data and choosing Transform > Specialized Analysis > Detect and classify beats. Acq*Knowledge* will execute the OSEA beat detector on the source data and output a sequence of events on that channel of ECG data. You will only be able to see this output if you have events shown.

Source code for the QRS detector is released under an LGPL license and can be found on the Acq*Knowledge* CD.

Open Source Licensing

The ecgpuwave and OSEA algorithms are available as open source, which means that their source code is publicly available. The source code can only be used, however, under conditions of their licenses.

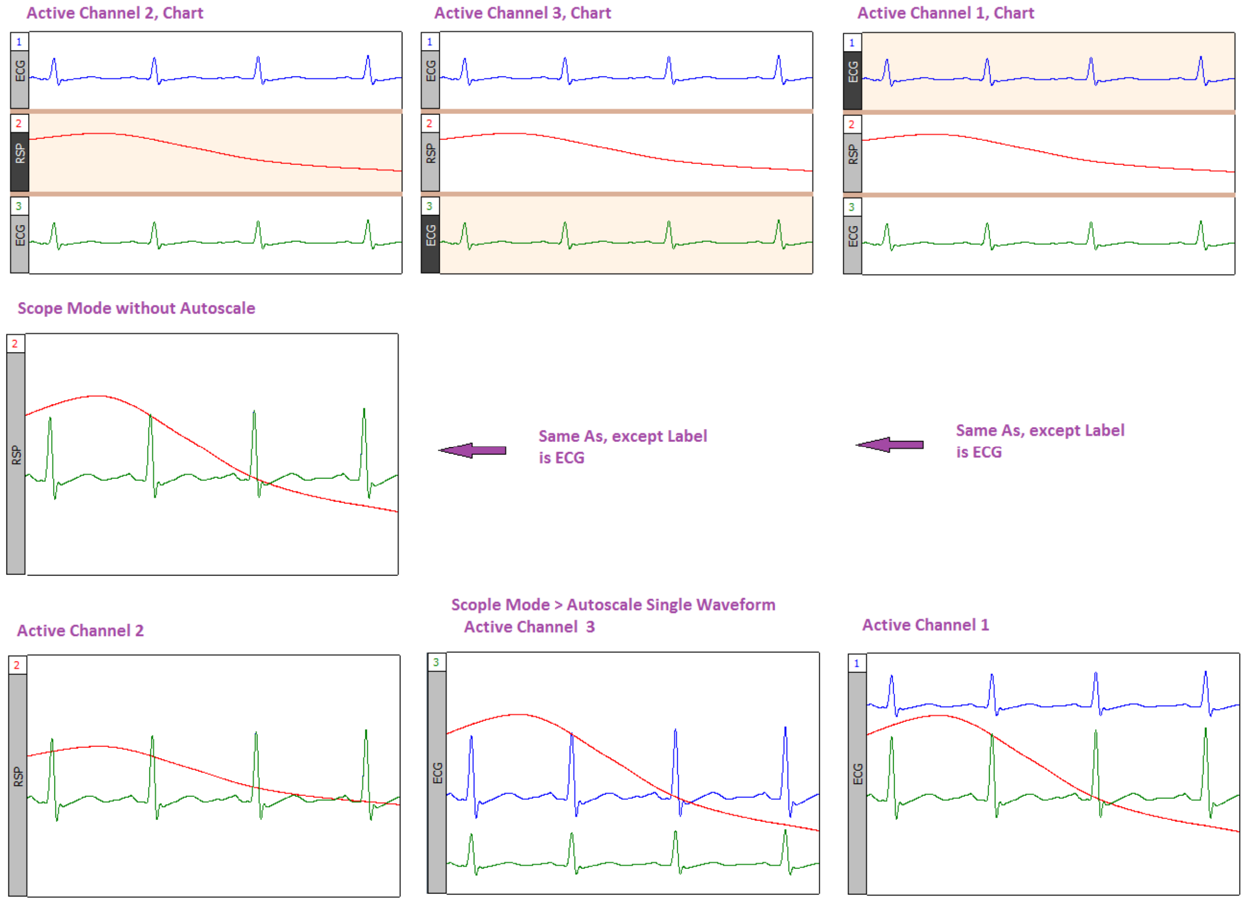
- ecgpuwave is under the GPL license
- OSEA is under the LGPL license

For the full text of both licenses, visit the Free Software Foundation (http://www.fsf.org).

Tile Waveforms

Tiling is an operation performed on all waveforms to visually separate them on the screen. Tile Waveforms adjusts the vertical offset to center waveforms in the display; if there are multiple waveforms displayed in chart mode, the waveforms will be centered in their

Part C



Autoscale Single Waveform

Use this option to perform the above autoscaling operations on a single selected channel rather than on the entire graph.

Overlap Waveforms

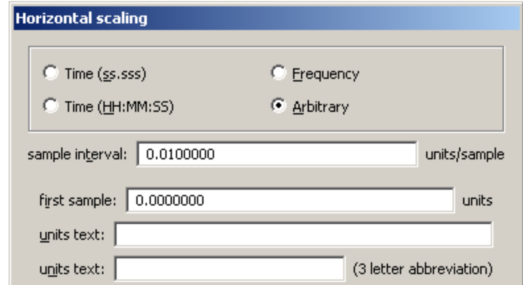
Overlapping waveforms places all of the waveforms at the same scale and midpoint so that the plotting location of a specific voltage on screen is at the same spot for every channel. Overlapping is useful for examining closely associated waveforms, such as the calculated diastolic, systolic and mean calculation channels

Part C

Reset Chart Display

The Reset Chart Display option redistributes the chart displays evenly after the boundaries have been changed so that each channel

Horizontal Axis



Horizontal Axis generates the Horizontal Scaling dialog. Set the axis in terms of time, frequency, or arbitrary units, and set the horizontal sample interval (the amount of time between two sample points) and the first sample (sample offset).

Time domain scaling has two options to store and display data:

- **(ss.sss)**

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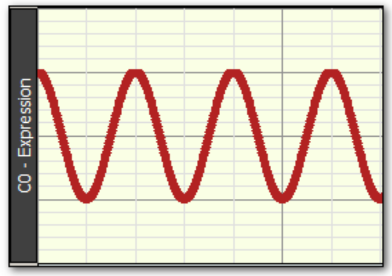
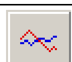
Show Option	Shortcut	Explanation
Line Plot	Right-click menu	Connects each sample point with a line to create the waveform. Waveforms that are displayed in line plot mode match a true analog plot (as closely as possible). This is the default display mode for most waveforms, except histogram plots, which are displayed in Step Plot mode (see 310). The line options can be changed by clicking the right mouse button, which will generate a menu displaying several commonly used features.
Line Thickness	Right-click menu	 Line thickness is enabled when Line or Step plot are enabled. Use to specify the plot thickness in pixels.  Sine wave set to thickness of 5 pixels
Main Toolbar		Controls visibility of Main Toolbar buttons (Grid, Show/Hide, Preferences and Customize Toolbar).
Measurements		Displays the measurement popup menus and windows above the graph window (see pages 47 and 89).
Scaling Toolbar		Controls visibility of Scaling Toolbar shortcut buttons (Autoscale Vertical, Autoscale Horizontal, Show All Data, Center Data Vertically, Center Data Horizontally).
Scope		Activates the scope display mode (see page 35).
Selection Palette		

Many tools within the Acq*Knowledge* environment are based around the selection. The selected range of data in the graph is used as the source for measurements, waveform editing, transformations, and other operations. The Selection Palette is a floating dialog that can be used to precisely enter the selection.

- The Selection Palette can be used to adjust the selection at times when it is not possible to use the selection tool in the graph window, such as when transformation dialogs are being displayed for the graph.
- The selection palette offers a way to change the selected area without having to cancel the transformation setup and lose any parameters typed in the dialog.

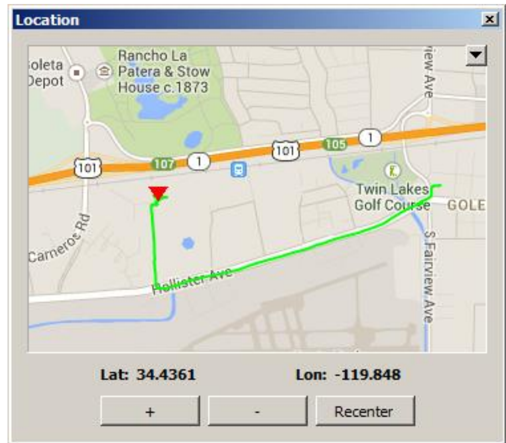
To display the Selection Palette, choose Display > Show > Selection Palette. This dialog contains two edit fields that display the location of the left and right edges of the selection using the measurement units currently displayed in the horizontal axis. As the selection is changed, the new selection boundaries are shown.

The Selection Palette also can be used to manually type in the edges of the selection. Double-click the edges and type in the new horizontal position of the edge of the selection. Press

Part C

After Import:

- Browsing GPS graph data with the I-beam selection tool will relocate the red navigation arrow to the map location occupied by the subject at that exact point of the experiment.
- The map view is zoomable, and any of three different map servers can be selected in the preferences.



Location palette showing coordinates, zoom and recenter tools

To log GPS data:

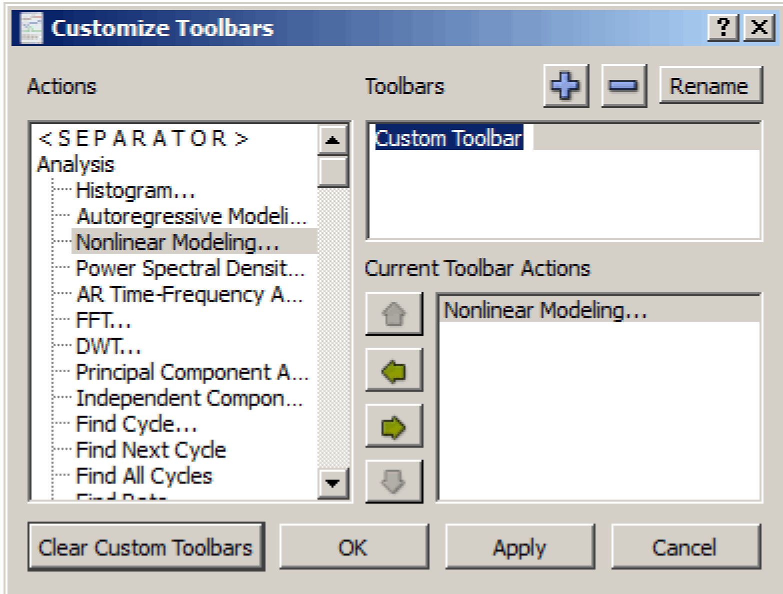
1. Attach the GPSTRACK device to the subject and turn on the power.
2. Run the experiment. (For example, subject walks, runs, or bicycles an assigned geographical route during an exercise study where data is being acquired into Acq*Knowledge* via a wireless logger.)
3. At the conclusion of the experiment, turn off the GPSTRACK and remove it from the subject.

To import GPS data into Acq*Knowledge*:

1. With the exercise study graph open in Acq*Knowledge*, launch the Location palette (Display > Show > Location Palette).
2. Connect the GPSTRACK to the computer

Part C

Customize Toolbars



Use the Customize toolbar feature to create custom toolbars for easy access to post-processing Analysis and Transform actions. Toolbars are dockable and custom toolbar placeholders can be named independently of toolbar actions.

- **Actions**

Part C

Settings

Part C

Channel Information

The Display > Channel Info

Part C

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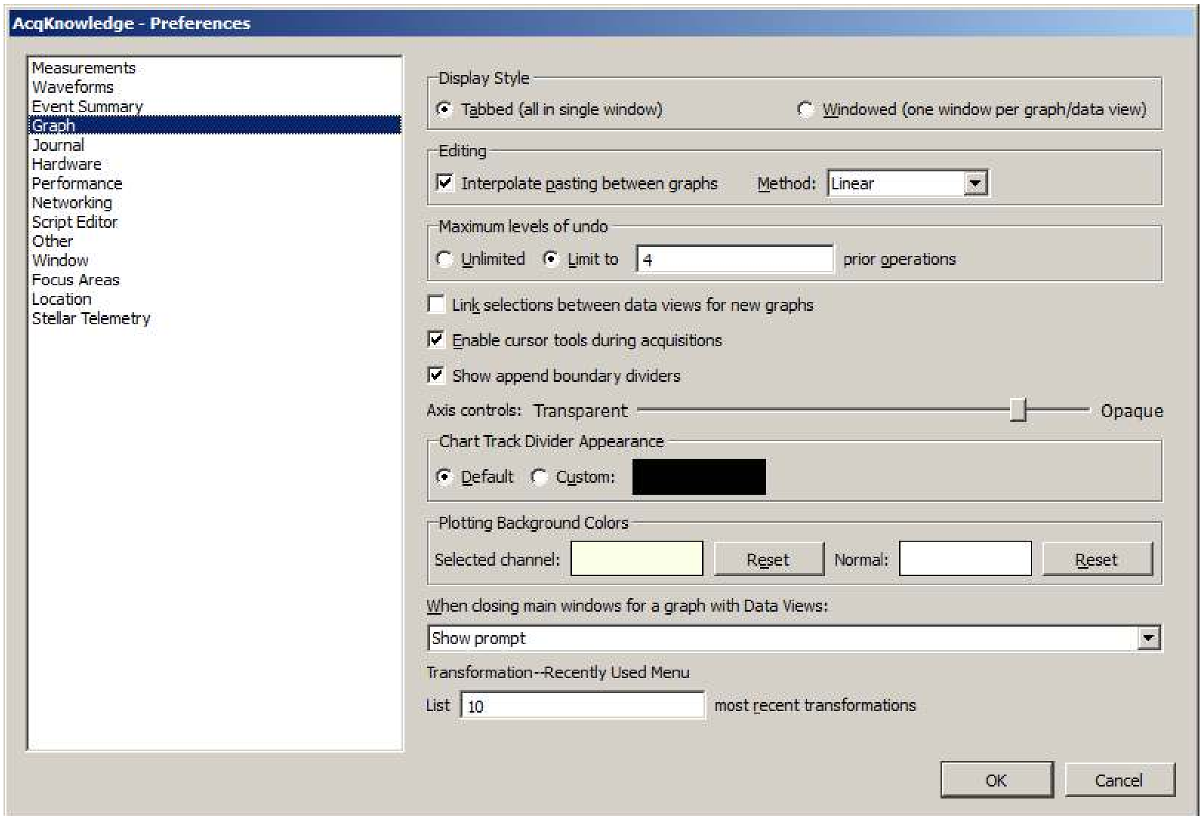
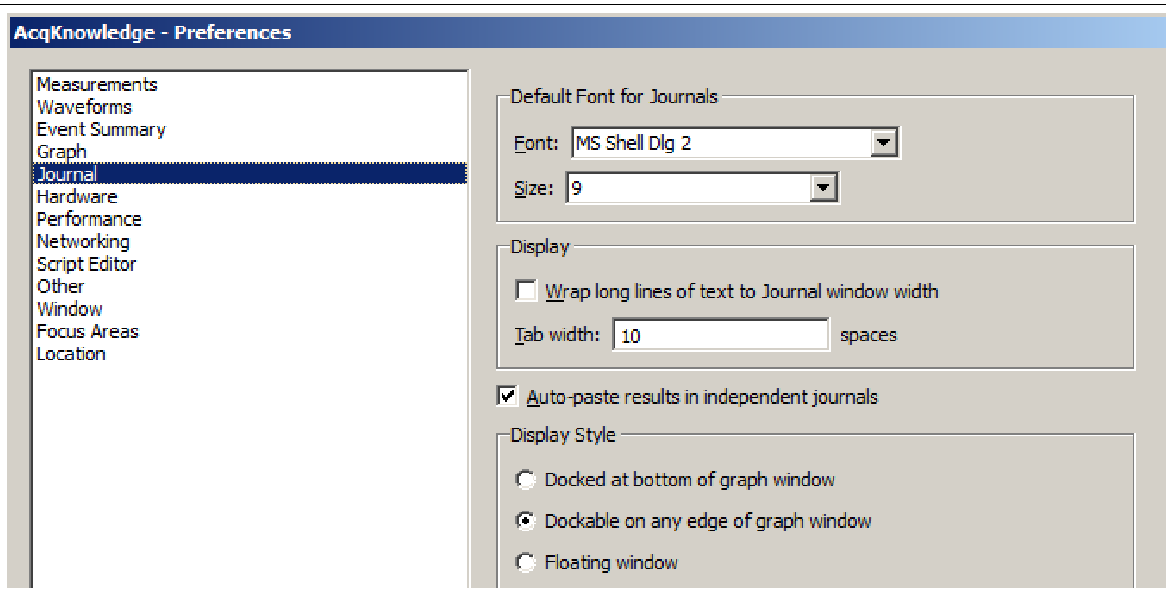

AcqKnowledge - Preferences
Measurements
Waveforms
Event Summary
Graph
Journal
Hardware
Performance
Networking
Script Editor
Other
Window
Focus Areas
Location
Stellar Telemetry
Display Style
Tabbed (all in single window)
Windowed (one window per graph/data view)
Editing
Interpolate pasting between graphs
Method:
Linear
Maximum levels of undo
Unlimited
Limit to
4
prior operations
Link selections between data views for new graphs
Enable cursor tools during acquisitions
Show append boundary dividers
Axis controls: Transparent
Opaque
Chart Track Divider Appearance
Default
Custom:
Plotting Background Colors
Selected channel:
Reset
Normal:
Reset
When closing main windows for a graph with Data Views:
Show prompt
Transformation--Recently Used Menu
List
10
most recent transformations
OK
Cancel

449


AcqKnowledge - Preferences
Measurements
Waveforms
Event Summary
Graph
Journal
Hardware
Performance
Networking
Script Editor
Other
Window
Focus Areas
Location
Default Font for Journals
Font:
MS Shell Dlg 2
Size:
9
Display
Wrap long lines of text to Journal window width
Tab width:
10
spaces
Auto-paste results in independent journals
Display Style
Docked at bottom of graph window
Dockable on any edge of graph window
Floating window

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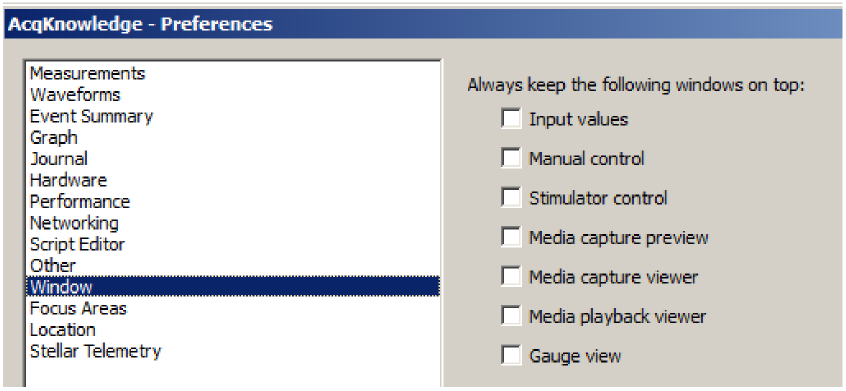
<tr><td>450</td><td>
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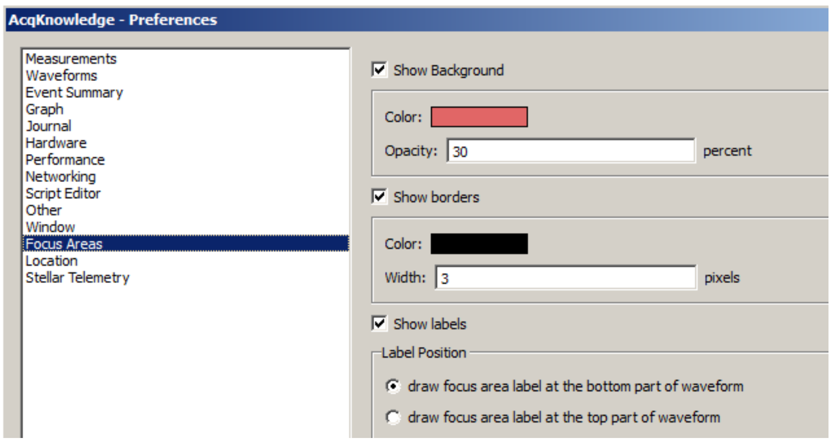
<tr><td>451</td><td>
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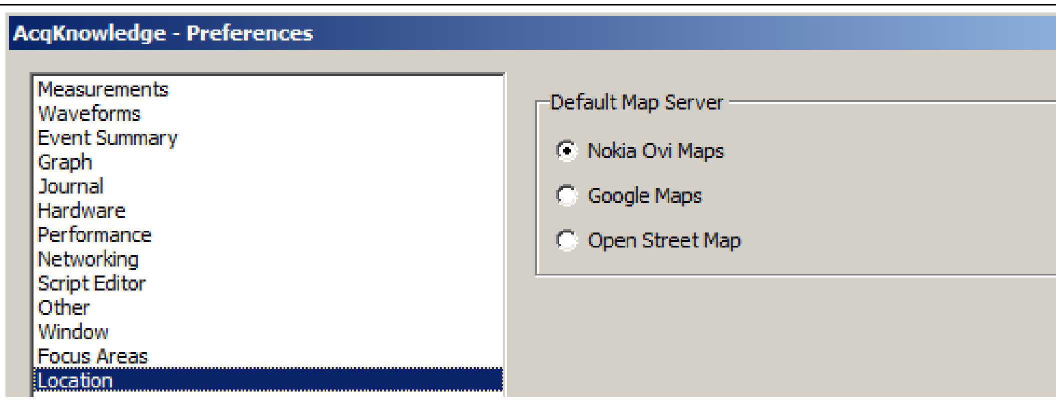
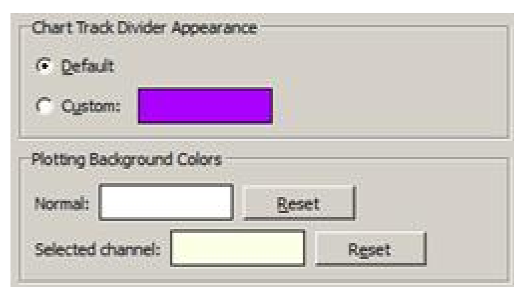
<tr><td>451</td><td>
</td></tr>
</table>

Measurements Preferences

- **Measurement rows**

Part C

- **Mark selection with events in graph**



Part C

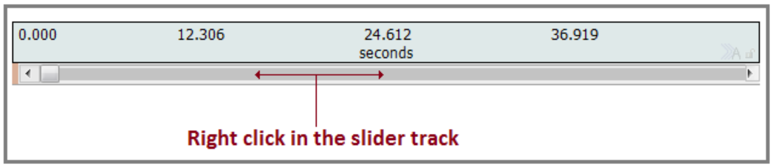
All channel types may be exported (analog, digital, and calculation) channels. Acq*Knowledge* will continue to function normally while data transfer is in progress, displaying the new data in the graph window and performing any autoscrolling.

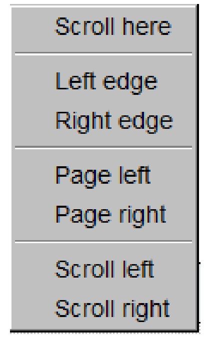
Respond to auto-discovery

Part C

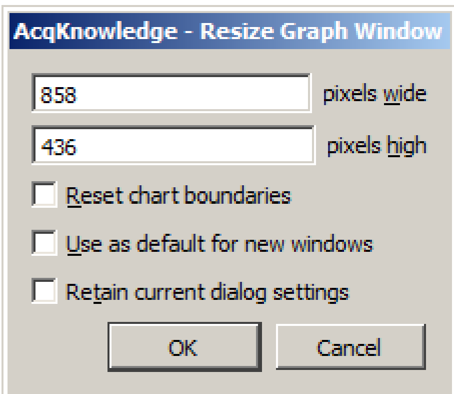
Scroll options

The Scroll options help navigate through large data files. Right-click below the horizontal scroll track to generate the contextual menu with scroll options.





Size window...



The Size Window function is useful for setting exact dimensions for the size of the graph window. Use this to create consistently sized windows for pasting into documents.The two text box fields are used to enter interior screen width and height, both of which are scaled in terms of pixels.

Each operating system may add additional dimensions as necessary to put in window adornments depending on the appearance configuration preference of the user (e.g. extra space for title bar of the window, any additional space put around the edges of the window frame, etc.).

When the Reset chart boundaries box is checked, the boundaries between the waveforms will be reset so that each channel

Part C

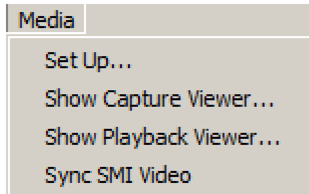
Chapter 19 Program & OS Menus

Acq*Knowledge* menu

Mac OS only

Part C

Chapter 20 Media Menu



Also applicable to multi-camera systems and CAM-HFR-A high-speed camera. For Media Menu setup for CAM-HFR-A, see page 462.

Media functionality allows users to capture and playback video and/or audio with a USB web cam or firewire DV device and synchronize it with physiological information from an hardware device. The key functionality is a strong link between the video and data cursor when graphs are being used in post-acquisition mode; changing the selection in the graph window will automatically jump the video to the time corresponding to the cursor position. The reverse tie is also in place where scrolling the video will move the data cursor to the corresponding data point in the graph.

For synchronized playback of media player with Acq*Knowledge* cursor in data view, BIOPAC recommends that the users sample the hardware unit at least as fast as the video frame rate 30Hz. In this case, any measurement errors are limited to the basic frame rate error window (1/30 sec). For exact match of Video and Data samples, BIOPAC recommends frame rate 25 fps and acquisition rate 25 samples/second (or its derivatives).

Set Up Establish Sources, Output and Media parameters. Set device type for audio and or/video. Use refresh after connecting a new device to make it a selectable option. Browse using standard file open/save functionality to specify media files. If desired, set a Delay between file segments.

Show Capture Viewer Use for video signal directly from a video camera; this option is disabled (grayed) in the record mode when both the Capture video and Capture audio options in the Media Setup dialog are off.

Show Playback Viewer Use to play back media from the disk (stored media files); this option is disabled (grayed) if there is no media assigned to the file.

Sync SMI Video This feature is used specifically for synchronizing video exported from SMI BeGaze eye tracking software. The SMI video is synced by using timestamp information extracted from the exported BeGaze data file. For more information about SMI Begaze Import/Export, see page 255.

Video Playback and Capture preview include a right-mouse contextual menu item

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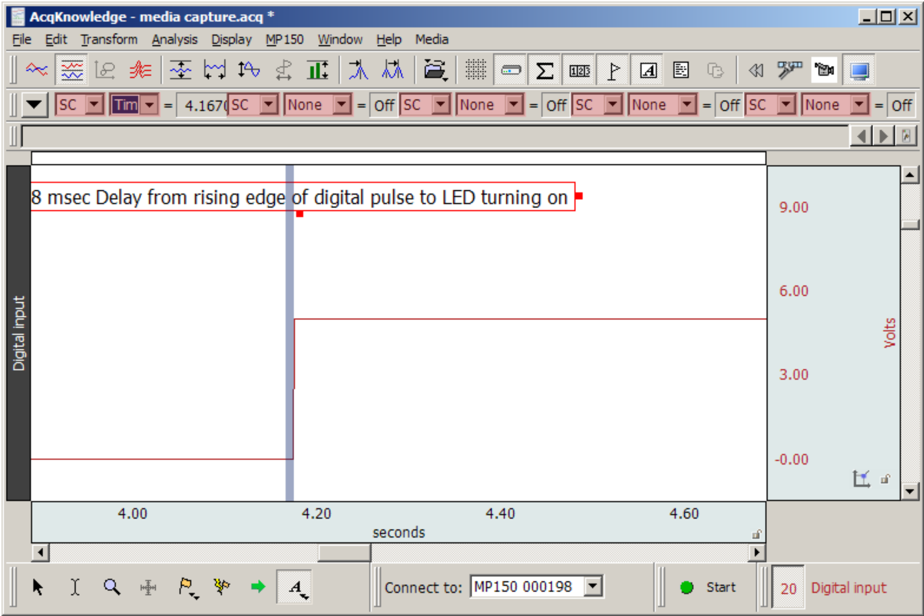


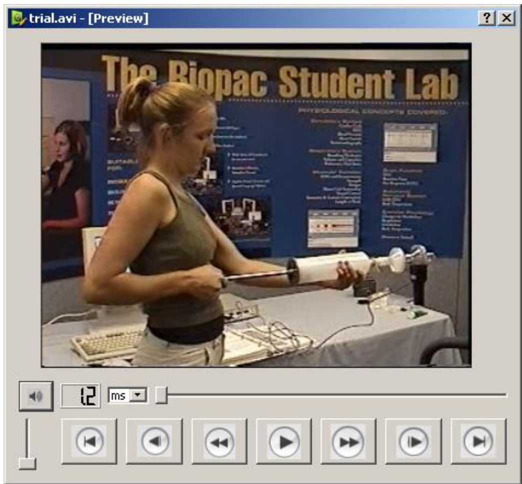
Media > Set Up

Source

Use this dialog to select media source and select audio and video to record. Click Refresh to update the list if a video or audio device is connected after the dialog was opened. When video/audio for capture is selected, an output file must also be selected. Input file name and click OK; this will close the Media Setup dialog and automatically open the media window if the Capture option is ON.

All video camera, audio (microphone) input parameters can be setup by user with the UI provided by camera manufacturer, or use the

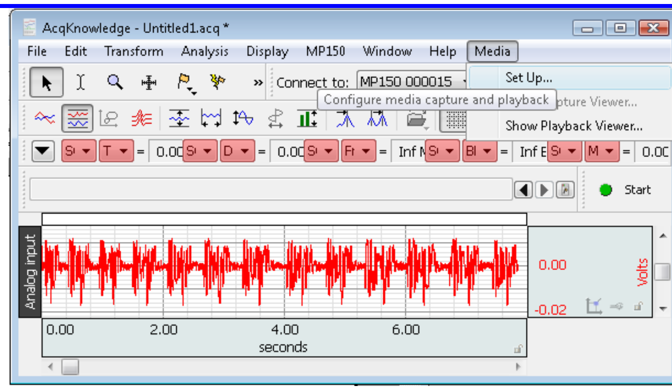
The Playback viewer uses standard media player controls.



	Go to previous segment / go to beginning of segment
	Step backward a frame/sample
	Fast backward / reverse rewind
	Play/ pause
	Fast forward
	Step forward a frame/sample
	Go to following segment
	Mute sound

Media Playback Example

1. Launch Acq*Knowledge*.
2. Open a saved acquisition file.



3. Select Media > Show Playback Viewer.
4. Here you can play with contents:
   - Select I-beam cursor on graph and push

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Media Capture Setup with CAM-HFR-A High Speed Camera

The CAM-HFR-A is a high speed camera capable of capturing more precise video at rates up to 100 frames-per-second. Acq*Knowledge* versions 4.3.1 and higher support use of this camera. The Media setup procedure differs from that of a standard USB camera, with the Acq*Knowledge* Stimulator providing a

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Part D

Part D

NDT is a basic method for allowing third party applications to tap into the data stream being generated by both the MP unit and Acq*Knowledge* during data acquisitions. NDT provides

- networking facilities that allow for integration into a distributed application environment
- basic control facilities to allow external applications to query and control the Acq*Knowledge* application state.

The NDT system is split into two separate types of connections: data connections and the control connection.

A. Data connections deliver data from Acq*Knowledge* to external applications during acquisitions.

B. Control connections are made from external applications to Acq*Knowledge* to query application state and adjust data connections.

The *server* refers to the Acq*Knowledge* process and the computer on which it is running. The *client* refers to the custom application that is to receive data from Acq*Knowledge* and the computer on which it is running.

All connections should be made using standard network protocols, either TCP or UDP. Single system image architectures should make connections using the loopback interface. It is assumed that network implementations have appropriate IP networks in place with routing between machines that can be identified either by IP address or by hostname. Firewalls must be properly configured to allow network communications between the client and server. Appropriate network configuration is the user

Part D

XML-RPC

The XML-RPC transfer type allows clients to explicitly request data from the server. Instead of data being automatically pushed to clients, the client must post an XML-RPC function call to the server. This allows the client to query the server for the most recently acquired data sample value for a particular channel. Clients that do not require continual data streams or interact with only slow moving data may wish to use this method communication method. This method returns values only; no information about sample indexes or lengths is returned.

XML-RPC has significant overhead for both client and server, so this transport method cannot handle more than a few requests per second. If faster response time is required, the client should implement either the single connection or multiple connection streaming methods.

XML-RPC is not a true data connection as it does not involve the server constructing a streaming connection to the client.

Transport Protocol

Data connections offer a choice of using either TCP or UDP as the transport protocol for delivering data to the client. Choice of protocol depends on application requirements. When a client is receiving data, it is assumed that all data connections are using the same transport protocol.

TCP/IP

TCP is the preferred transport protocol. As TCP guarantees reliable, ordered delivery, all data is simply transferred from the server to the client without any additional information. Data is streamed continuously as it becomes available. TCP is recommended for all clients that require a guarantee of receiving all information. It is also recommended for any configuration using up to two computers. The port number used for data connections is specified by the client using the control connection prior to the start of acquisition. Once a client passes along port information, the client should begin listening for connections on that port.

When using TCP data connections, the start of acquisition is signaled to clients by the establishment of a connection on an appropriate port to the client. The end of an acquisition is signaled by the termination of the connection.

UDP

UDP is a connectionless protocol that does not guarantee either delivery or properly ordered reception of packets by clients. Data connection is allowed to be switched to UDP delivery mode. The primary benefit of using UDP datagrams is that a single data stream can be multicast to a number of computers. Multicasting is not offered implicitly by the Acq*Knowledge* data connection protocol but can be achieved implicitly by requesting a data connection be bound to a broadcast address.

UDP delivery used fixed size datagrams. The default size is 512 bytes. Clients can modify this size to any fixed number of bytes prior to the start of acquisitions. The UDP packet size is stored in the template and is different for each graph. UDP clients that require a specific packet size should set that packet size prior to the start of each acquisition.

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It is only the time between the physical time corresponding to a sample and its delivery to the client application that is variable.

Clients that require strict real time guarantees or more predictable latencies should investigate using the hardware API on their local machine.

Data Formats

It is assumed that the data transfer feature is used in a mixed host environment, potentially with clients running in environments that have restricted data types. The sampled information delivered by a data connection is allowed to be controlled to appear in a variety of different formats for the client:

- 64 bit floating point

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```
        <member>
                <name>index</name>
                <value><int>2</int></value>
        </member>
</struct>
```

Querying Acquisition Parameters

The calls for querying acquisition parameters are intended to allow clients to request information required for them to fill out appropriate parameters and to verify that previous control requests have been properly applied. The following control calls are recognized:

getMPUnitType

Method name: acq.getMPUnitType
Parameters: None
Return value: int

Retrieves the type of MP unit to which the server is connected. This may be zero (indicating no unit is connected, e.g.

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getTransportType

Method name: acq.getTransportType
Parameters: None
Return value: string

Retrieves the transport type that is being used to deliver data from the server to the client. The transport type is a string that is one of the following: tcp, udp. Note that the XML-RPC data delivery method may be used in addition to this transport type if channels are enabled.

changeTransportType

Method name: acq.changeTransportType
Parameters: string
Return value: 0 if successful, else fault code

Change the transport type that is used to deliver data from the server to the client. The transport type is a string that has one of the following values: tcp, udp. XML-RPC last value data delivery may be used in addition to this type provided channels are enabled properly.

getUDPPacketSize

Method name: acq.getUDPPacketSize
Parameters: None
Return value: int

Returns the current size in bytes of UDP packets that is delivered to clients. Datagrams are always this fixed byte length although each individual datagram may contain varying amounts of data.

setUDPPacketSize

Method name: acq.setUDPPacketSize
Parameters: int
Return value: 0 on success, fault on error

Changes the size in bytes of UDP packets that are delivered to clients. Each individual datagram will always be this fixed length although the amount of data sent in specific packets may vary.

getUDPBroadcastEnabled

Method name: acq.getUDPBroadcastEnabled
Parameters: None
Return value: boolean

Determine if UDP packets are sent only to the client or are broadcast to the broadcast IP of the network. Broadcasting is supported only when the transport type is UDP.

changeUDPBroadcastEnabled

Method name: acq.changeUDPBroadcastEnabled
Parameters: Boolean
Return value: 0 if successful, fault code on error

Modify whether UDP packets are sent only to the client or are broadcast to the broadcast IP of the network. Broadcasting is supported only when the transport type is UDP.

getSingleConnectionModePort

Method name: acq.getSingleConnectionModePort
Parameters: None
Return value: integer

Returns the port number on which the server will connect to the client to deliver data. This port is used only when the connection mode is set to

Part D

Changes the port on which the individual connection is made by the server to the client to deliver the data for the channel specified in the parameters. This style of connection is used only if the data connection method is set to

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Toggles data acquisition in the frontmost graph. If data acquisition is in progress, it is halted. If none is in progress, data acquisition is started in the graph.

Note that this function invocation may block if physical user interaction is required to start the acquisition in the graph, such as dismissing an overwrite warning, warnings on incompatibilities between different MP unit types, specifying a save location for acquisition to disk, etc. If the implementation of the XML-RPC binding used by the client supports timeout capabilities, it is highly recommended to enable timeouts for this function.

setOutputChannel

Method name: acq.setOutputChannel
Parameters: channel index structure, float output value
Return value: 0 on success, else fault code

Changes the voltage on the specified output channel of the MP device. For analog outputs, the value should be in the range (-10, 10) for the voltage level. For digital outputs, a value of 0 will turn the specified line off, a non-zero value will turn it on. The latency of when the output line is changed is variable and non-guaranteed. Additionally, the output channel may be modified by other areas of the software including control channels, manual user intervention, configured stimulators, etc.

The valid output channels are dependent on the type of MP device that is connected.

- MP160/150 units allow analog 0, 1 and all digital output channels
- MP36R units allow no analogs and digital 0-8.

Part D

Post-Analysis Selection Adjustment

After the analysis completes, the waveform sampling rate of the selected waveform will be reduced by a factor of 32. As this reduction occurs, the selected area or cursor will adjust to the nearest sample point in the processed VMG channel.

Data Modification History Name

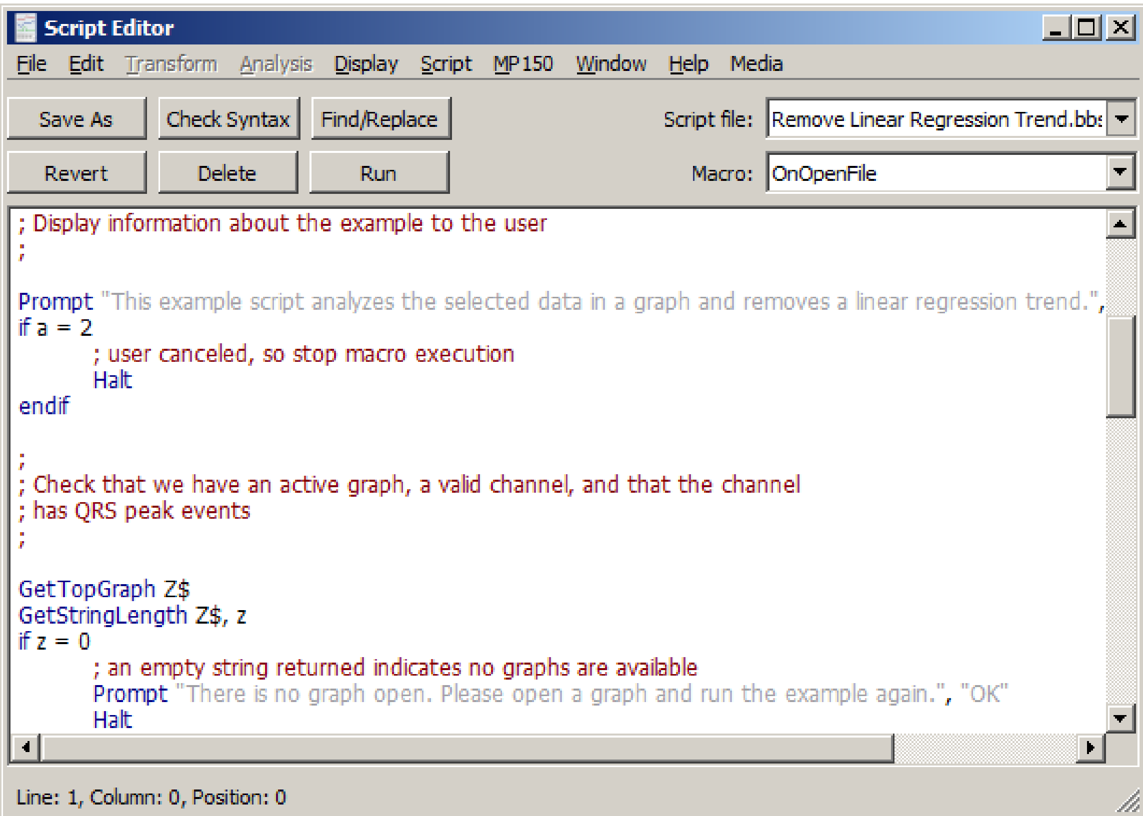
This operation will be displayed in data modification logs (Display > Channel Info) as

Part D

Chapter 23 Licensed Functionality: Scripting

Scripting functionality is available through an optional license available with Acq*Knowledge* 5. The Scripting license must be authorized to access Script functionality for executing, authoring, and debugging BIOPAC Basic scripts. To add a Scripting license to an existing MP System, please contact BIOPAC.

BIOPAC Basic Scripting is a scripting language development option for Acq*Knowledge* that allows for viewing of runtime variables, creating new script files and editing existing script files, triggering of individual script functions for testing and single step functionalities. Only users that have licensed the BIOPAC Basic feature may run user-generated scripts; if the feature is not available only digitally signed BIOPAC scripts may be executed. Scripting is available in any hardware supported in Acq*Knowledge* but configuration commands may not be available for non-MP hardware.

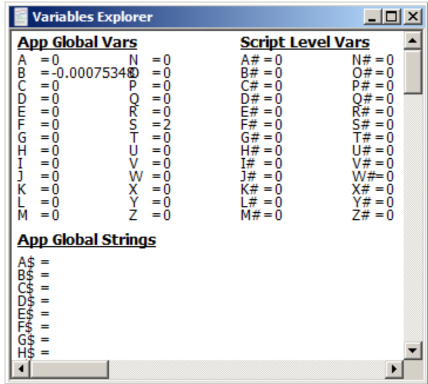


The Scripting license

- enables the Script menu
- adds the Calculation channel Preset

Part D

Variables Explorer



Variables Explorer Window

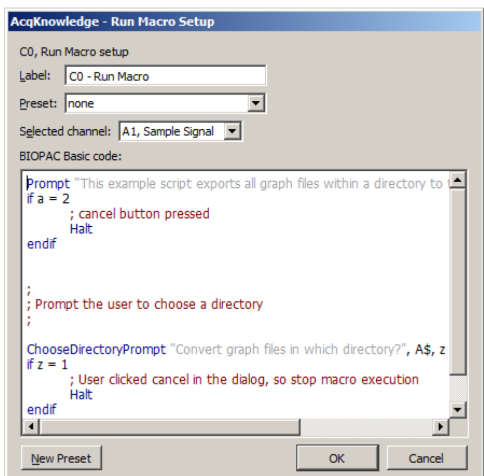
The **Variables Explorer** window (Script > Variables Explorer) shows the contents of the scripting language variables.

Single Step Execution mode (Script > Single Step execution) halts execution after each individual line of a macro, which allows for stepping through macros line by line for debugging and development purposes.

Example Scripts

Several BIOPAC example scripts and macros are available in this menu. When a script file is selected, the scripting language for the selected script is displayed in the Script Editor.

Run Macro Calculation Channel



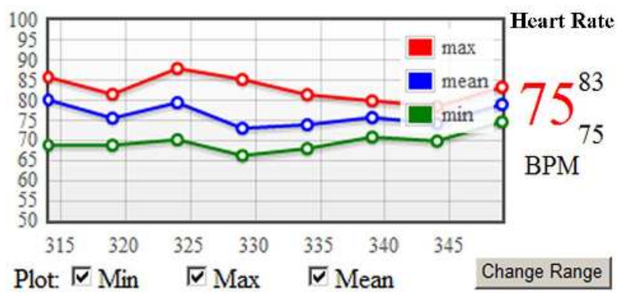
Run Macro Calculation Channel Setup Dialog

The

Part D

Chapter 24 Licensed Functionality: Remote Monitoring

Remote Monitoring functionality is available through an optional license available with Acq*Knowledge* 5. The license must be authorized to access Remote Monitoring functionality. To add a license to an existing MP System, please contact BIOPAC.



Acq*Knowledge* MP devices are generally tethered to specific computers where data acquisition is performed. In some laboratories, this computer may not be in the same location as the researcher performing the experiment. In MRI situations, for example, the data acquisition computer may be in the MRI control room but the researcher may be in a separate area. Acq*Knowledge* Remote Monitoring offers researchers the capability of checking on critical parameters from an alternate location.

Remote Monitoring is a client/server application capable of locating and connecting to computers running Acq*Knowledge* on the same network. It consists of a simple browser interface, from which acquisitions can be started, stopped and remote data viewed during and post-acquisition. Remote Monitoring is supported in MP160/150 hardware only.

About Remote Monitoring

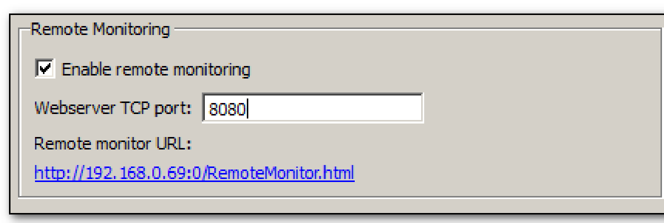
- Remote Monitoring is licensed functionality and must be activated by BIOPAC.
- Remote Monitoring is for viewing of data only. Transformation and specialized analysis of graph data is not supported within the Remote Monitoring interface.

The Remote Monitoring web interface consists of three primary pages:

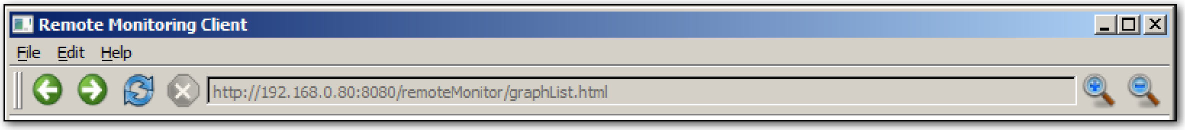
- A list of open graph windows
- Configuration settings for an individual graph
- The data monitoring page.

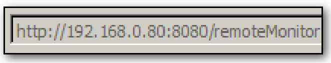
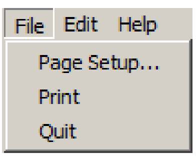
Remote Monitoring in Acq*Knowledge* Networking Preferences

Remote Monitoring is enabled by default in Acq*Knowledge* Networking Preferences (Display > Preferences > Networking > Remote Monitoring). The **Enable remote monitoring** checkbox option activates the local machine on the network, making it visible to other local network machines also running Acq*Knowledge* Remote Monitoring.



The **Webserver TCP port** is the numerical port on which Acq*Knowledge* listens for remote requests. (This port is set to 8080 by default.) The **Remote monitor URL** is a clickable link that opens Remote Monitoring in the local machine



Icon	Button Function	Explanation
	Back	Moves browser back one page
	Forward	Advances browser ahead one page
	Refresh	Reloads the current page
	Stop	Stops loading of current page
	Address bar	Displays I.P. address of currently-connected computer
	Zoom in	Master control for enlarging size of browser content
	Zoom out	Master control for decreasing size of browser content
	File, Edit, Help menus	**File** contains Page Setup and Print controls for Remote Monitoring chart displays. Quit exits the Remote Monitor. **Edit** contains a Copy option. (Copy function not supported in Windows version) **Help** displays

Control	Description
Return to Graph List	Returns browser to list of currently-open graphs. Serves the same function as the browser

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Controls in Visible Range (Change Range) dialog

Control	Description
Return to Monitor page	Clickable link for paging back to the Monitoring screen.
Show seconds of data	Determines visible horizontal time scale in chart display.
Number of horizontal divisions	Sets the number of horizontal divisions in chart.
Horizontal axis precision	Sets number of decimal places following horizontal time values.
Vertical lower endpoint	Determines low end of vertical graph scale.
Vertical upper endpoint	Determines high end of vertical graph scale.
Number of divisions	Sets the number of vertical divisions in chart.

NOTE: **Remote Monitoring** plots are only updated in the data monitoring window while an acquisition is in progress. Once a Remote Monitoring acquisition is stopped, the graph will remain visible only as long as the browser page is displayed. After navigating away from the page, the plot will not be retained or reconstructed. To save a Remote Monitoring plot for future reference, printing a hard copy or printing to a PDF file is recommended.

*For Remote Monitoring technical support, contact BIOPAC Systems, Inc at (805) 685-0066 or support@biopac.com

Part D

Acq*Knowledge* software is used to view, record and analyze data acquired with the B-Alert unit.

To launch software with B-Alert hardware:

1. Connect the **B-Alert** dongle to a USB port and turn the X10 headset unit

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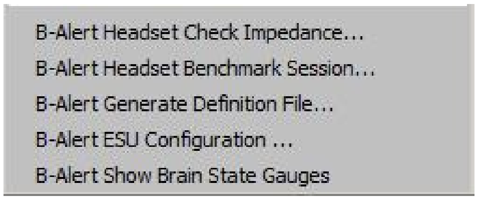
B-Alert-specific Hardware Menu Options



B-Alert Headset Check Impedance

This item is found in the B-Alert menu, (which replaces the MP menu in B-Alert hardware configuration) and is used to initiate an impedance check to verify the headset

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B-Alert ESU Configuration

The B-Alert ESU unit is a multi-channel external synchronization unit that serves as a communication interface between the B-Alert unit and the computer. It allows for synchronization of data between the B-Alert hardware and other third-party data acqusitition devices.

For more information about the B-Alert ESU unit, see the B-Alert with Acq*Knowledge* Quick Guide or the B-Alert Software Manual.

NOTE: Before configuring the ESU settings, the ESU must be paired with the B-Alert unit via a Bluetooth connection.

- B-Alert headsets are shipped paired to either a B-Alert Dongle or an ESU. If the pairing is lost, the devices must be re-synced using the

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Output to ABM File Format

Acquisition setup options are available for controlling data output to a separate B-Alert ABM file format, which contains an

Part D

Linked Acquisitions in B-Alert

Linked acquisitions are supported in B-Alert. In a Linked Acquisition session, different hardware device types can acquire data simultaneously into individual graphs. B-Alert acquisitions can be synchronized with and triggered by an MP160/150 unit and the multiple data recordings merged into one graph at the end of the session.

NOTE: In order to use

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Chapter 26 Licensed Functionality: PV Loop Analysis

PV (Pressure-Volume) Loop Analysis is available through an optional license available with Acq*Knowledge* 5. The license must be authorized to access this Analysis tool. To add a license to an existing MP System, please contact BIOPAC.

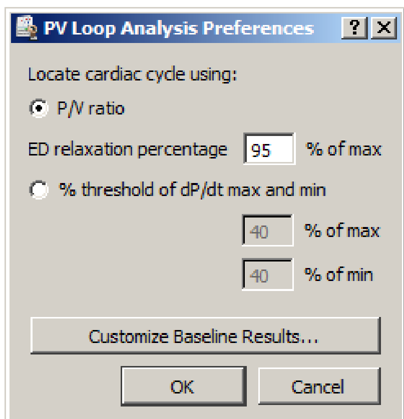
Pressure-volume loops (a.k.a. PV Loops) measure blood pressure and flow from a catheterized system. This analysis tool extracts various measures of heart function, including contractility, elasticity and ventricular characteristics. Sophisticated algorithms in this advanced analysis feature help circumvent the laborious visual process of identifying loop ranges while allowing the inclusion or exclusion of individual loops in the analysis output. Extracted measurements can be saved to an Excel spreadsheet, and selectable XY data views clearly show a wide range of outputted data. A pressure-volume loop graph template containing the necessary analog/calculation channels, data views and custom toolbars is included with the feature. (Q46-Pressure Volume Loop.gtl) PV Loop Analysis is supported in MP160/150 hardware only.

Loop Location

The two primary time locations for an individual PV loop range from the end systole (ES) point where the aortic valve closes, and the end diastole (ED) point where the mitral valve closes. On a PV loop XY plot, the end systole point is located at the top left corner of the loop and the end diastole is at the bottom right corner of the loop. An individual loop is defined as the extent from one end diastole to next end diastole, the equivalent of one heart beat.

PV Loop Analysis Preferences

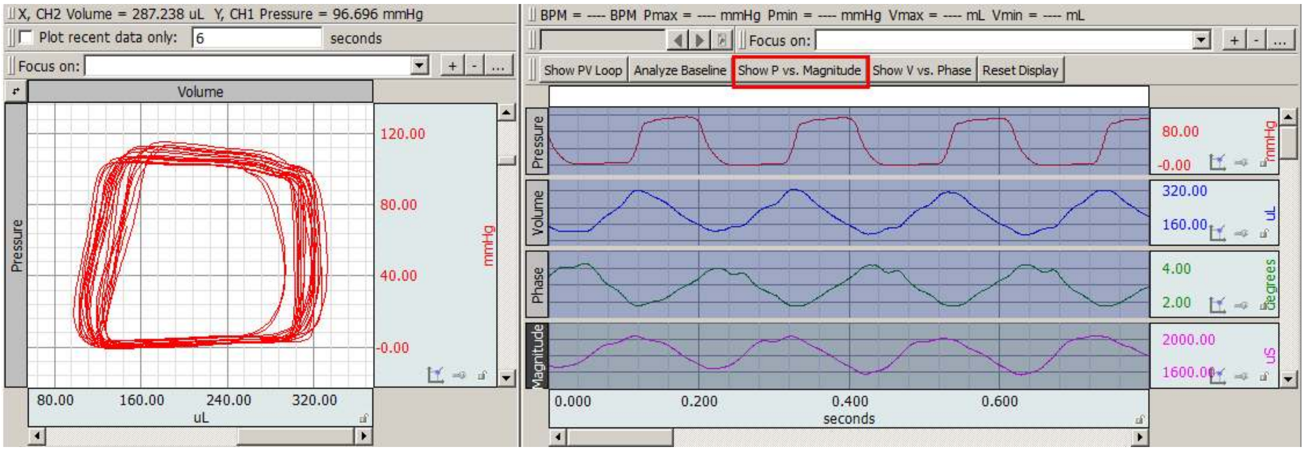
PV Loop Analysis Preferences are accessed via the Analysis > PV Loop menu and offer two methods for locating cardiac cycles.



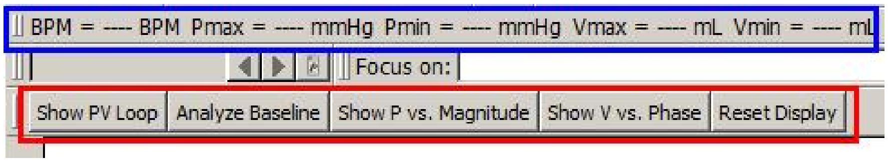
PV Loop Analysis Preferences dialog

PV Loop Analysis Preference Controls	Description
P/V ratio	When selected, ES and ED are located by analyzing the ratio of pressure over volume.
ED relaxation percentage	Percentage that P/V ratio must fall from ES in order to locate ED.
% threshold of dP/dt max and min	When selected, ES and ED are located using the pressure signal derivative only.
% of max	Defines percentage of the positive pressure derivative local maximum for ED.
% of min	Defines percentage of the negative pressure derivative local minimum for ES.
Customize Baseline Results	Displays a checkbox dialog for selecting measures to be included or excluded from baseline analysis. (See next page for complete list of available measures)

Baseline Analysis



PV Loop Quickstart showing graph data and Pressure vs. Magnitude XY data view



The above figure shows the additional toolbars present in the PV Loop Quickstart template, with toolbar functions explained below.

- Recent Values toolbar (outlined in blue)

The Recent values toolbar extracts the following measurements in real time from the cardiac calculation channels 42-46. (Values are displayed during acquisition.)

Heart Rate (BPM)

Maximum Pressure (mmHg)

Minimum Pressure (mmHg)

Maximum Volume (mL)

Minimum Volume (mL)

- Custom Button toolbar (outlined in red)

This toolbar provides quick access to the following functions during recording and in post-processing

Show PV Loop	Displays the Pressure Volume Loop in XY view. Plot shows most recent 6 seconds of pressure (X) vs. volume (Y). Useful for viewing experimental effects or determining catheter positioning.
Analyze Baseline	Performs baseline analysis on selected graph data. (A shortcut to choosing Analysis > Pressure Volume Loop > Baseline Analysis.)
Show P vs. Magnitude	Displays the Pressure vs. Magnitude data in XY view. Plot shows most recent 6 seconds of pressure (X) vs. Magnitude (Y). Useful when positioning the catheter.
Show V vs. Phase	Displays the Volume vs. Phase data in XY view. Plot shows most recent 6 seconds of pressure (X) vs. phase (Y). Useful for viewing oscillating muscle contributions in the signal.
Reset Display	Sets the display back to the default view.

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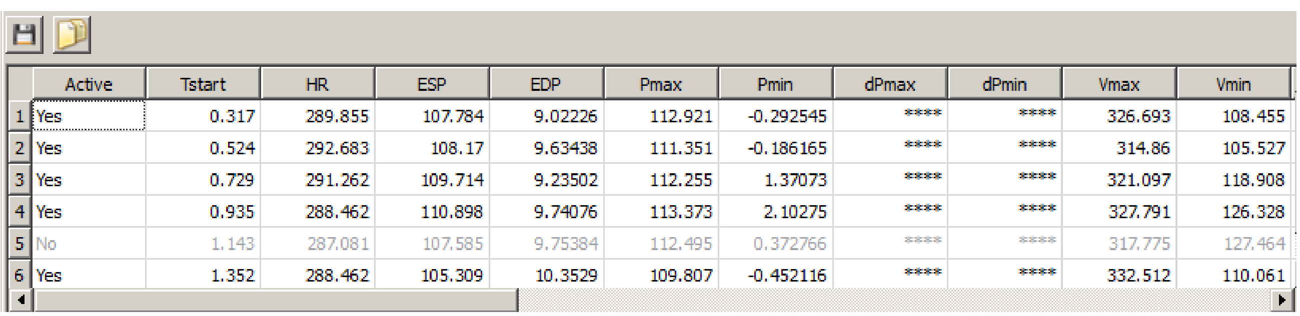
Use the controls in the upper left of the loop display region to autoscale vertically, horizontally, and zoom data.

Multiple loop measures

Once a set of loops has been identified, various models are constructed showing ideal boundaries of pressure and volume extents for varying cardiac cycles. Additional relationships between per-loop measures are also extracted to help assess overall cardiac condition. Multiple loop measures include the following relationships and controls:

ESPVR (End Systolic Pressure Volume Relationship)	Theoretical maximum pressure for any given volume.
Type	Use to select the equation upon which to base the PV loop curve fit: Linear or quadratic.
Ees	Index of overall myocardial contractility.
V0	Theoretical volume of loop at zero pressure.
EDPVR (End Diastolic Pressure Volume Relationship)	Passive filling properties of ventricle, reciprocal of ventricular stiffness.
PRSW (Preloadable recruitable stroke work)	Pressing displays a plot showing linear regression between stroke work and diastolic volume between loops.
dpMax vs. EDV	Pressing displays a plot showing maximum change in pressure vs. end diastolic volume.
PVA vs. EDV	Pressing displays a plot showing pressure volume area vs. end diastolic volume.
PVA vs. ESP	Pressing displays a plot showing pressure volume area vs. end systolic pressure.
Other controls	Pressing copies the loop-specific measures to the clipboard. Pressing saves the loop-specific measures to an Excel file.

Per loop measures



	Active	Tstart	HR	ESP	EDP	Pmax	Pmin	dPmax	dPmin	Vmax	Vmin
1	Yes	0.317	289.855	107.784	9.02226	112.921	-0.292545	****	****	326.693	108.455
2	Yes	0.524	292.683	108.17	9.63438	111.351	-0.186165	****	****	314.86	105.527
3	Yes	0.729	291.262	109.714	9.23502	112.255	1.37073	****	****	321.097	118.908
4	Yes	0.935	288.462	110.898	9.74076	113.373	2.10275	****	****	327.791	126.328
5	No	1.143	287.081	107.585	9.75384	112.495	0.372766	****	****	317.775	127.464
6	Yes	1.352	288.462	105.309	10.3529	109.807	-0.452116	****	****	332.512	110.061

The bottom pane of the analysis window contains a table display of individual loop analysis results. Each loop occupies one row. Comparative measures are automatically updated upon any changes to included loops.

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Measure	***Abbrev.***	***Formula***	***Units***	***Description***
Cardiac output	CO	$SV * HR = \frac{60[V(t_{ED}) - V(t_{ES})]}{(t_{ED} - t_{start})}$	ml / minute	Amount of blood pumped per unit time.
Ejection fraction	EF	$100\frac{SV}{EDV}$	(none)	Percent of the end diastolic volume ejected during each contraction.
Maximum power	MaxPwr	$max(P(t)\dot{V}(t)), t \in (t_{start}, t_{ED}]$	$\frac{mmHg * ml}{s}$	Maximum cardiac power within the loop, left endpoint exclusive right endpoint inclusive. With appropriate factors may be converted into Watts.
Parallel power	PlPwr	$\frac{MaxPwr}{V(t_{ED})^2}$	$\frac{mmHg}{ml * s}$	
Stroke work	SW	$\sum_{t=t_{start}}^{t=t_{ED}-\delta} \frac{(P(t+\delta) - P(t))(V(t+\delta) + V(t))}{2}$ where $\delta = intersampleinterval$	mmHg * ml	Work performed by the ventricle to eject the stroke volume. Equivalent to the area of the PV loop.
Arterial elastance	Ea	$\frac{ESP}{SV}$	mmHg / ml	Measure of arterial load for measuring coupling between heart and arterial system.

Part D

Comparative Measures

After multiple loop measures are extracted, the following additional measures may be extracted for each loop to examine its relationship to the volume-relationship analyses of a set of loops and expected theoretical baselines. These measures are based upon various multiple loop measures and should be recomputed any time they are changed due to modifications to the set of loops included in the analysis: (See following page.)

Measure	***Abbrev.***	***Description***	***Units***
Pressure volume area	PVA	Provides a measure of the total mechanical energy produced by a ventricular contraction. From the set of loops the ESPVR model provides the theoretical baseline volume at zero pressure $V0$. The PVA for a loop is then determined from the following formula: $\frac{P(t_{ES})[V(t_{ES}) - V0]}{2} - \frac{P(t_{ED})[V(t_{ED}) - V0]}{4} + SW$ where SW is the stroke work for the loop.	mmHg * ml
Potential energy	PE	Provides a measure of the elastic potential energy built during the systole and stored in the ventricular wall at the onset of relaxation. From the set of loops the ESPVR model provides the theoretical baseline volume at zero pressure *V0*. The PE for a loop is then determined from the following formula: $PVA - SW$ That is the total mechanical energy minus the actual work used to eject the stroke volume.	mmHg * ml
Efficiency	Eff	Provides the fraction of the total mechanical energy used to eject the stroke volume: $\frac{SW}{PVA}$	(unitless)
Maximum time varying elastance	Emax	The normalized time varying elastance for an individual loop is adjusted from the theoretical baseline volume at zero pressure *V0* and is given by the Suga and Sagawa formula: $E(t) = \frac{P(t)}{V(t) - V0}$ For a given loop, the maximum value of E(t) will occur when pressure is highest and volume is lowest, or at the time of ES: $E_{max} = \frac{P(t_{ES})}{V(t_{ES}) - V0}$ This is also the slope of the line connecting V0 with ESP within the XY loop plot[1].	mmHg / ml

See the Acq*Knowledge* PV Loop Analysis video tutorial for a detailed demonstration of this feature.

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Baroreflex Slope Analysis

The **Baroreflex Slope** analysis method uses linear regression to determine a measure of Baroreflex sensitivity (BRS). The analysis output area displays the current BRS estimate and the slope of the best linear regression fit to all of the cardiac cycles included in the analysis.

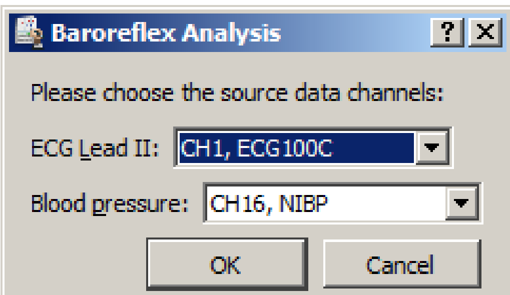
First, a source time interval is defined in the cardiac recording, generally located around regions of induced change in blood pressure. The pairs of heart rate and systolic pressure within this time interval are extracted. A linear regression of these coordinates is computed, with pressure as the x coordinate and heart rate interval as the y interval. BRS is defined as the slope of the best fit linear regression, in units of ms/mmHg.

The slope method is useful when correlating with studies using this method, performing validations, or when areas to be measured are very well known. This method can only be used on an area of selected data. If attempted on unselected data, a dialog will appear prompting for data selection with the I-beam tool or a defined focus area.

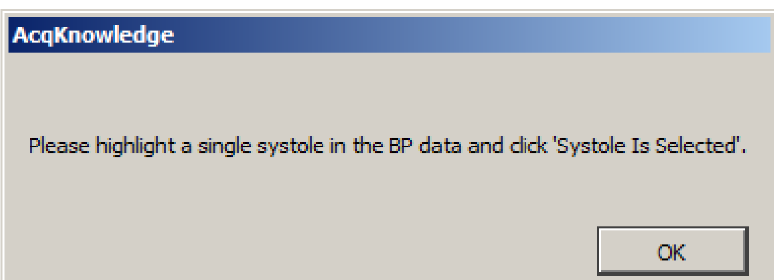
Baroreflex Slope Analysis description references can be found on page 516.

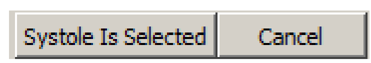
Slope Analysis Setup Dialog

Choosing the Baroreflex Slope Analysis option produces the following dialogs:

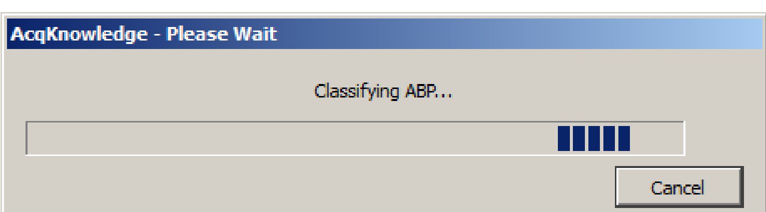


In the initial dialog, the ECG and blood pressure channels are selected (above).





The subsequent dialogs prompt for the highlighting and selection of a systole in the BP data (above).



Following systole selection, the arterial blood pressure events are scored. This can take some time, depending on the width of the selected area (above).

An interactive plot (see next page) will appear, and displays the best present linear curve fit and the cardiac cycles as points on an XY plot of systolic blood pressure versus heart rate.

Include or exclude points from analysis by checking or unchecking the numbered cardiac cycle boxes, or by clicking on individual ponts while holding down the ALT key. When individual points are excluded or included, the best linear fit will be automatically recalculated. The cardiac cycle table at the bottom of the analysis window provides a tabular spreadsheet view, and includes:

- Active (checked) or hidden (unchecked)

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Baroreflex Sequence Method Description

The **Baroreflex Sequence** method is described in the following papers:

Kuusela, Tom;

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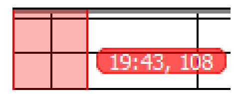
Importing Raw Accelerometer Data

Acq*Knowledge* records raw accelerometer data which must be imported and processed into activity counts for use in actigraphy analysis.

To import data from an external accelerometer sleep study file, click the  toolbar button in the Actigraphy Analysis window, navigate to the raw data file



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Actigraphy Analysis Settings

As stated in the previous section, choosing

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Sleep Derived Measures (Sleep Analysis)

After the primary sleep period has been located, it will be further subdivided into

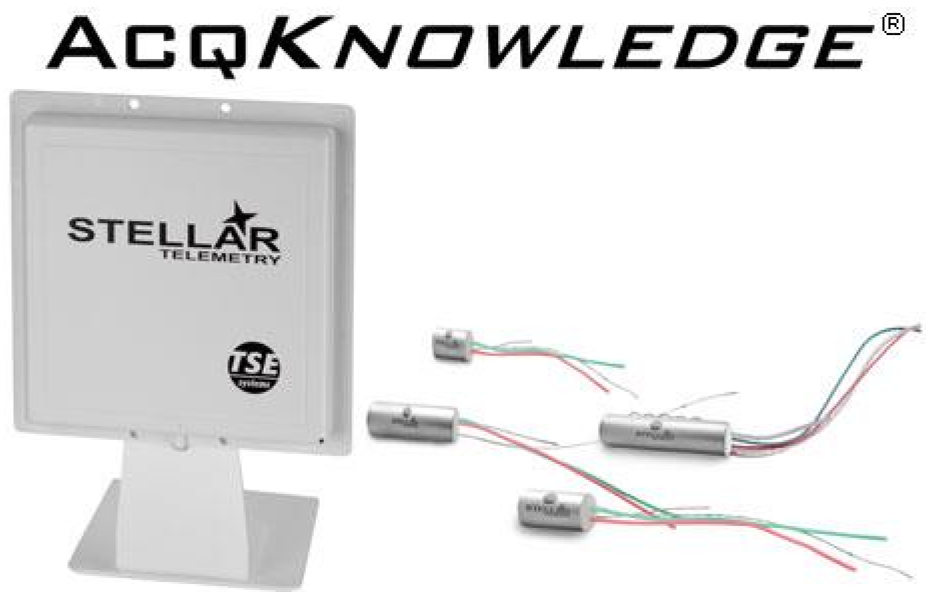
Part D

- **Create New Analysis**

Part D

Chapter 30 Stellar Telemetry

Stellar Telemetry Control interface for existing Stellar Small Animal Telelemtry System & Implants is available through optional licensing available with Acq*Knowledge* 5. The license(s) must be authorized to access functionality for the specified number of implants. Please contact BIOPAC to discuss licensing options.



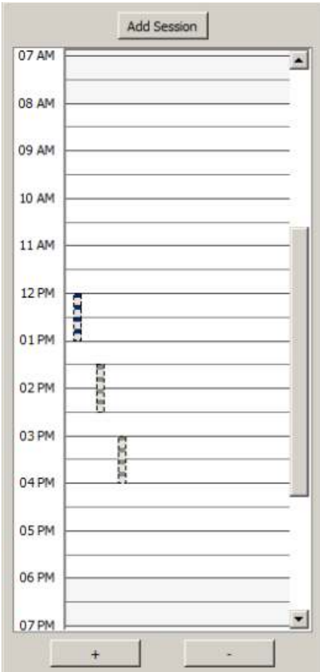
Stellar Telemetry System

The Stellar Telemetry System wirelessly acquires and logs physiological data from single or multiple animal subjects. The system consists of a small implantable recording device with an antenna and USB base station for communicating with the implanted units. Acq*Knowledge* software is used to configure Stellar experiments and analyze blood pressure, ECG, temperature, and accelerometer data imported from the logging sessions. Specific data recording parameters, such as the desired signal type, recording schedule, duration/repetition interval, and selection of animal subjects are set up beforehand in Acq*Knowledge*, whereas the import, display and analysis of resulting data are performed following the logging session. Stellar Telemetry is a licensed feature of Acq*Knowledge*, and activated with a BIOPAC-provided iLok USB License Key. The number of *animal units* (allowable animal subjects controlled per experiment) is determined by the specific quantity of animal units purchased in the software license.

This chapter describes how Acq*Knowledge* software is used with the Stellar Telemetry System. For information on the Stellar System hardware (setup of implantable devices, antenna and base station), see the Stellar Telemetry User Guide. For Access Point hardware driver installation and troubleshooting, see the Access Point Configuration Guide.

Before you begin: *It is important to note* that the Stellar Telemetry System may lose communication with the Access Point if the computer is allowed to go to sleep, resulting in a loss of data. To prevent this from occurring, disable the computer

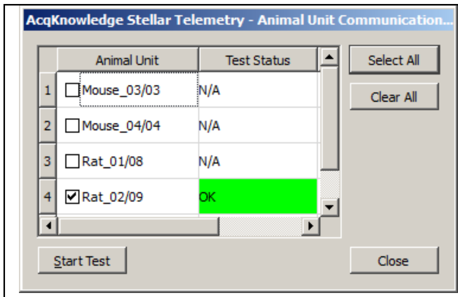
Part D



Graphical Day View supports the following contextual menu items. To display the contextual menu, right-click a session bar in the Day View.

- **Delete:** Removes the selected session
- **Clone**: Shortcut to the

Part D

	• Animal unit may be in use for a recording by another access point. • Animal unit may be frozen and require a magnetic reset. • Animal Unit battery may be dead (in which case the unit must be replaced).
Automatically download data on acquisition completion	After the final session is completed, data is automatically downloaded from active animal units into the output directory. (Currently, this option cannot be disabled.)
Set Output Directory button	Chooses directory where Acq*Knowledge* graphs containing downloaded data will be stored. If undefined, the default path is the user's Documents directory.

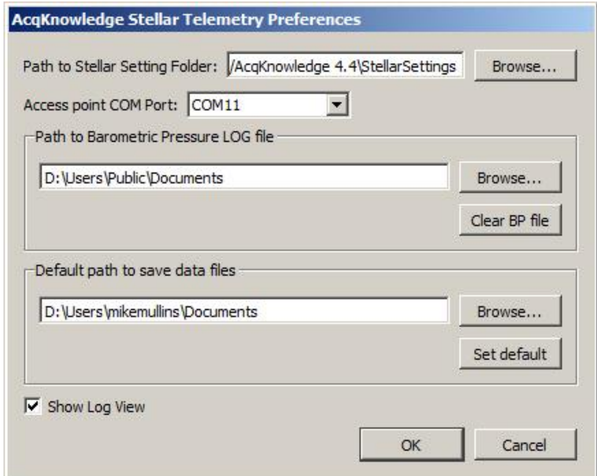
Stellar-specific Setup Window Menus

File Menu	
> New Experiment	Creates a new experiment window.
> Open Experiment...	Displays a

Part D

Tools Menu

> Stellar Preferences



Set the following important parameters in the Stellar Preferences dialog:

Path to Stellar Setting Folder

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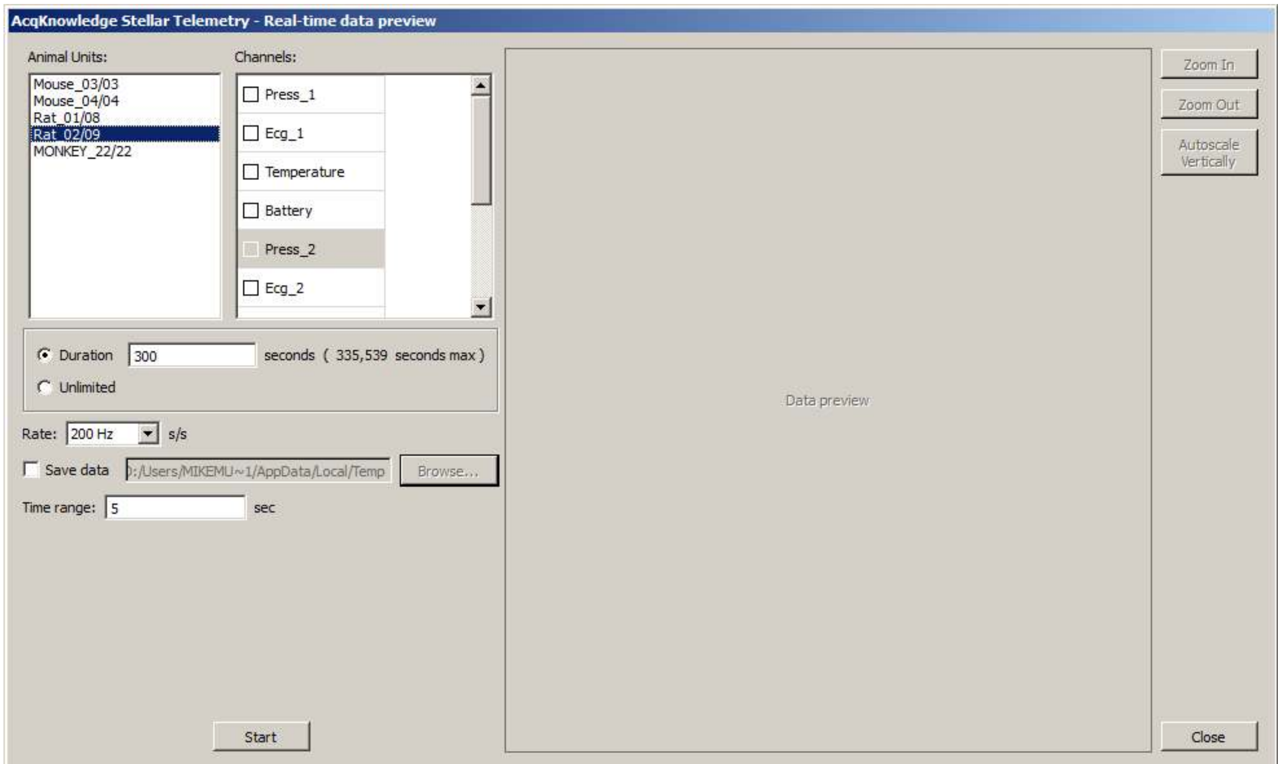


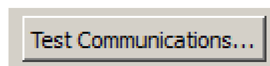
Real time data preview setup options

Animal Units	Displays the animal units available for preview. Only one animal unit at a time may be selected.
Channels	Displays the channels available for preview. Multiple channels may be selected.
Duration	Sets the length of preview in seconds.
Unlimited	Choosing this option allows the preview to run until manually stopped.
Rate	Use this option to select the sample rate for the data display. Sample rates of 100, 200, 500 and 1000 s/s are supported.
Save data	Use this option to choose a path to save the preview data to a *.txt file format. This option is available when the duration is set to seconds. It is not supported for unlimited data previews.
Time range	Use this option to set a horizontal scale range for the data preview display. (Horizontal autoscaling is not supported in the preview graph.)
Start	Toggles between Start/Stop of data preview. When clicking Start/Stop it may take a few seconds for the application to respond before starting or stopping the preview. When this occurs, a

Part D

Running a Stellar Experiment

The example below is a guide to scheduling and conducting a Stellar experiment. These steps assume that the Stellar hardware is set up correctly, and successful hardware connection between the Access Point and the Animal Unit has been established. For hardware setup instructions, see the



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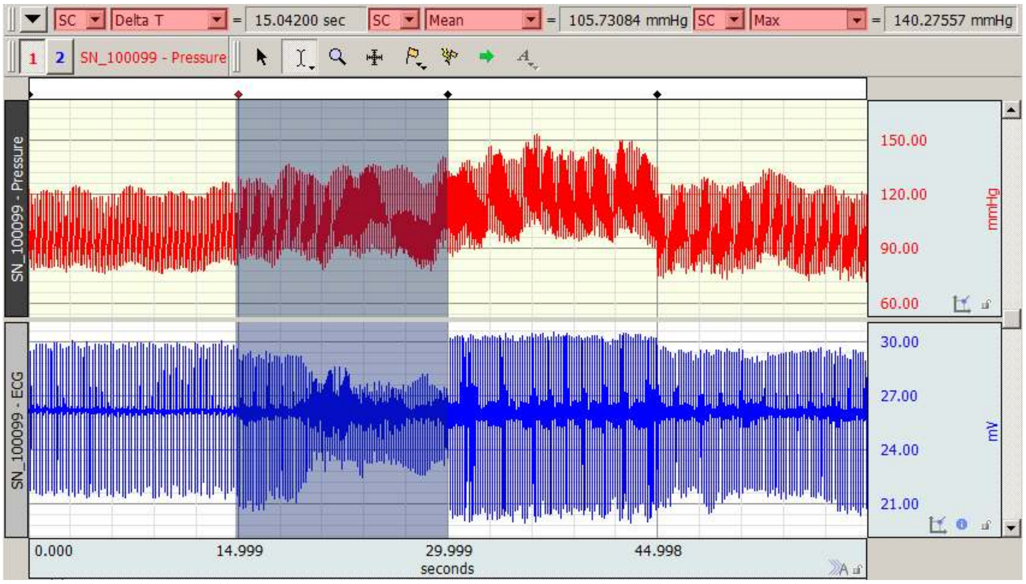
Import and Display of Stellar Data in Acq*Knowledge*

Following completion of a scheduled experiment, the logged Stellar data is downloaded to an Acq*Knowledge* graph for review and analysis. Stellar-optimized analysis tools enable selective viewing and spreadsheet output of recorded data for all selected animal units.

- Physiological signals extracted from the Stellar experiment are imported into an Acq*Knowledge* graph and displayed as separate channels.
- Repeated recordings (for example, 15 seconds every 15 minutes for the duration of the session), are displayed as appended segments.



Saving Graphs and Settings from Stellar Experiments

<u>It is important to note</u> that Stellar experiment data files and Stellar experiment settings are stored separately. Graphs containing data imported from Stellar experiments are in standard Acq*Knowledge* *.acq or *.gtl format, and like all Acq*Knowledge* graphs, are opened and saved via the main application window

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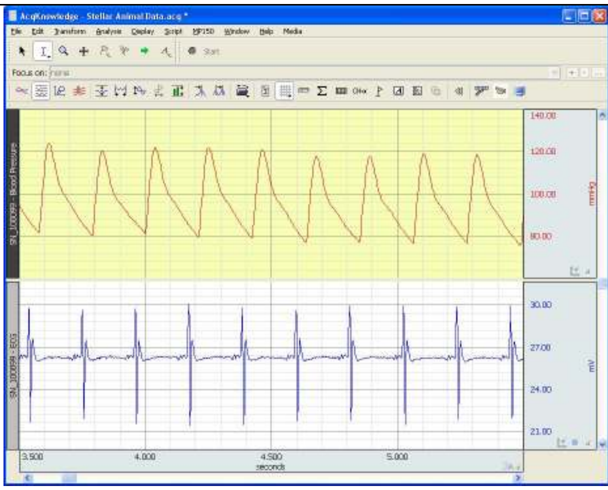
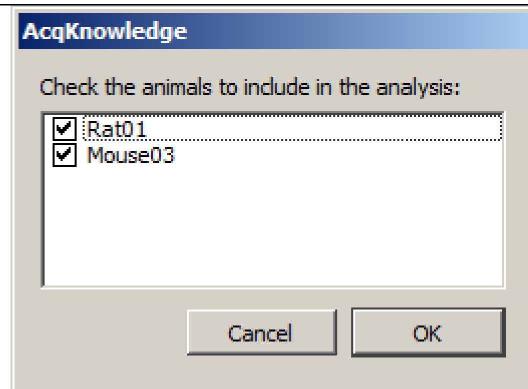
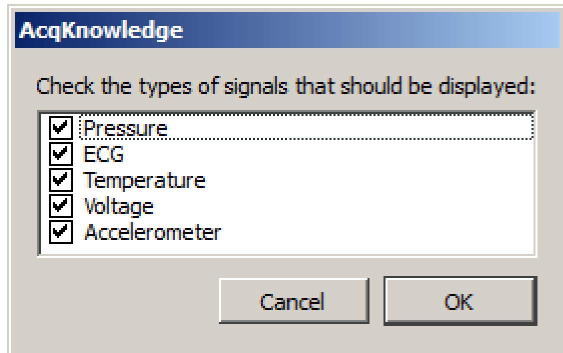
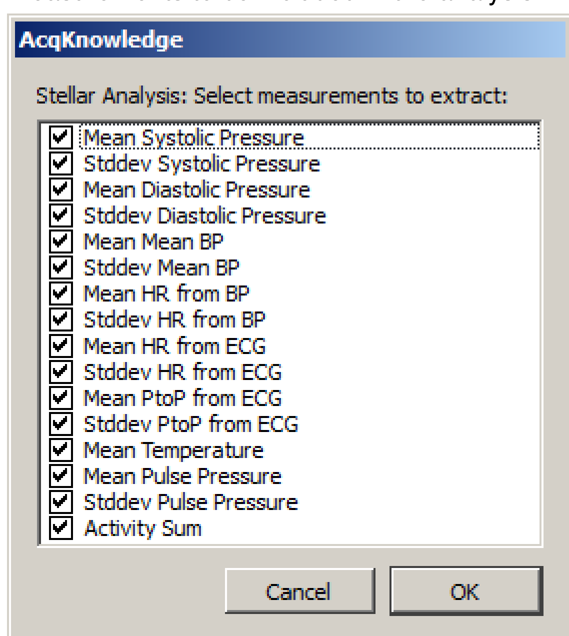
<table>
<tr>
<td></td>
<td>

The above option selects the animal units to be included in the graph. Unchecking an animal unit hides the graph channel containing the deselected unit.


Show or hide the various signal type channels acquired during the session for a better view of a particular signal.</td>
</tr>
<tr>
<td>Preferences > Stellar Analysis: Select measurements to extract</td>
<td>Use this option to select or deselect the measurements to be included in the analysis.

</td>
</tr>
</table>

Part D

Chapter 31 Mobita

Mobita is a portable wireless system for acquiring ECG, EMG, EEG, EOG, EGG and accelerometer data via a dedicated WiFi network. This hardware system is controlled by a specially-licensed version of Acq*Knowledge* (versions 4.4 and greater only).

The Mobita package consists of:

- Acq*Knowledge* software
- Battery-powered data acqusition unit
- USB WiFi dongle
- Detachable docking station (for charging unit, and connecting to computer via USB interface to download logged data and change the recording configuration)
- Detachable

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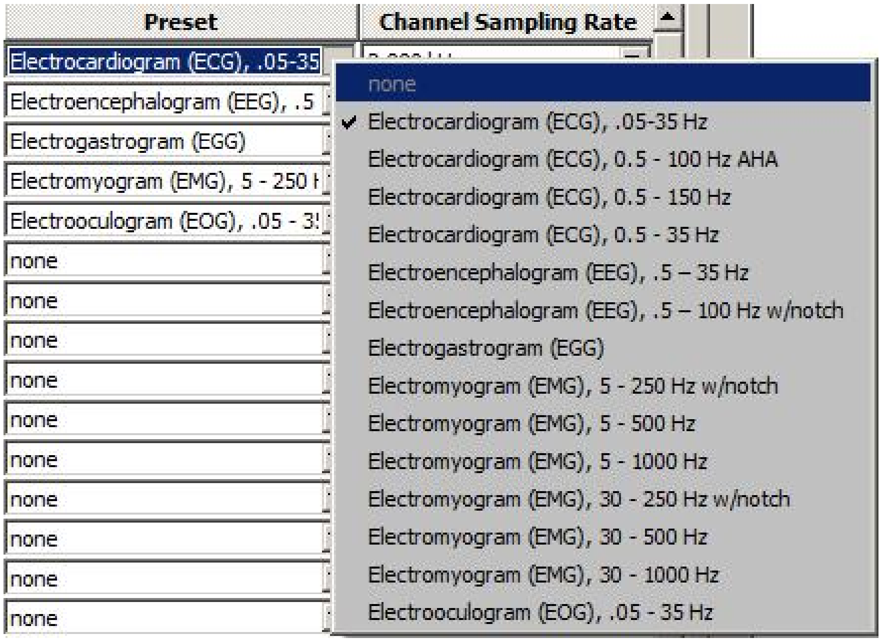
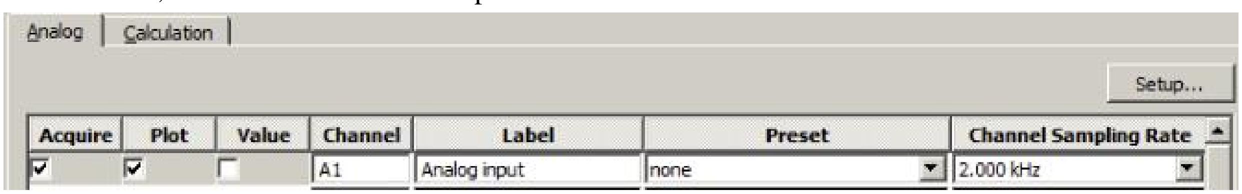
Mobita Analog Channels Setup

Up to 32 analog channels are available, with the following available presets and default filtering:



In Mobita, (as in other Acq*Knowledge* hardware types) channel labels, sample rates and setups are customizable, and user-defined channel presets can be created and saved.



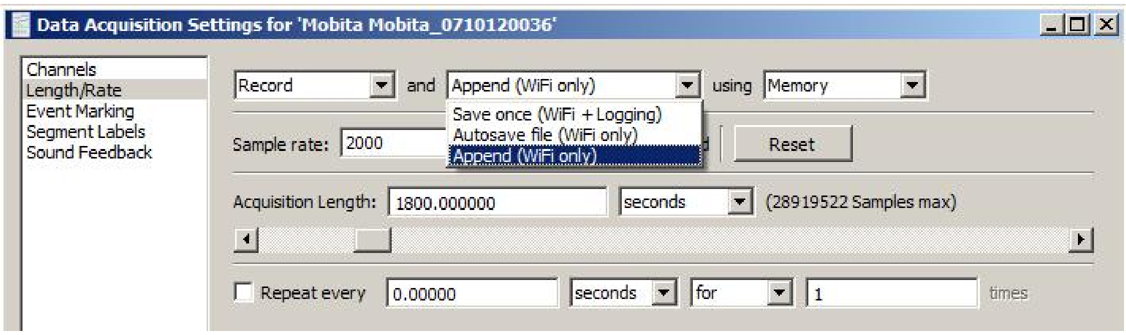
Note Mobita accelerometer channels are fixed at absolute levels and have no configurable preset options.

Analog Channel Digital Filters

The Analog tab

Part D

Mobita Acquisition (Length/Rate) Settings



The following acquisition modes are supported in Mobita hardware:

Append and Autosave

Append and Autosave modes are available for WiFi communication only, with no data stored to the Mobita hardware. Memory or disk storage options are supported both acquisition modes.

Save once (WiFi + Logging)

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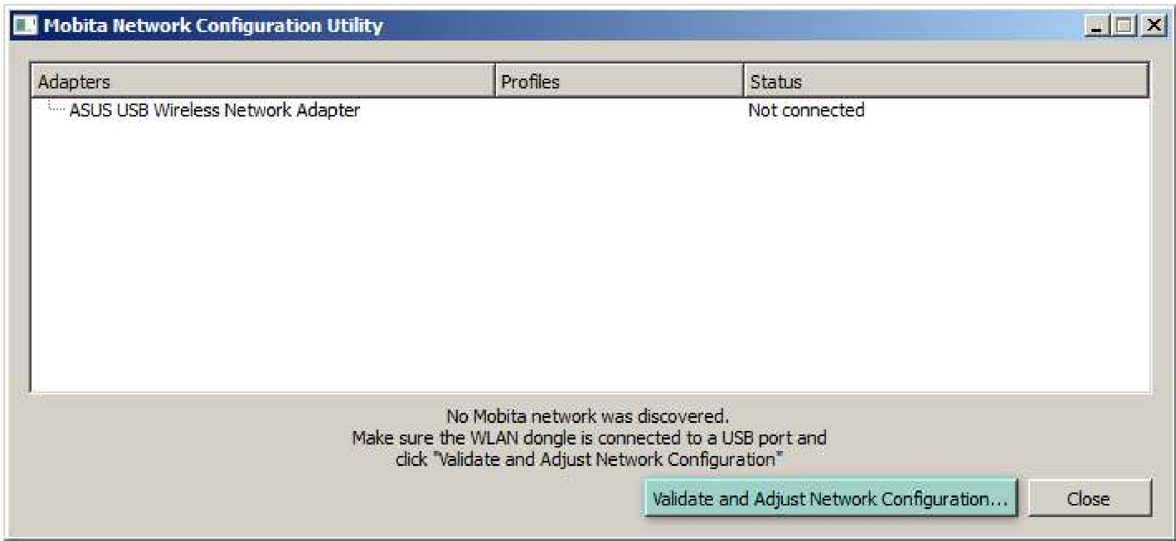
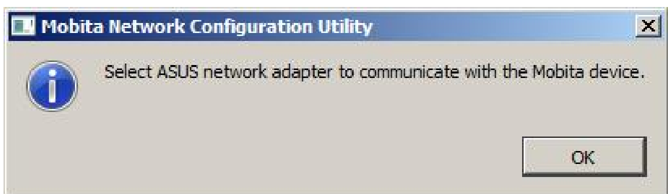
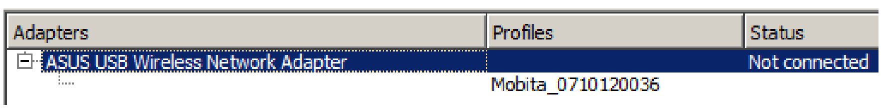


3. If the USB adapter connection needs to be re-established, you may see the following communication prompt:





4. If this prompt appears, highlight the ASUS USB adapter in the

Part D

Chapter 32 FaceReader

FaceReader™ with Acq*Knowledge* is available through optional licensing in Acq*Knowledge* 5. Contact BIOPAC for licensing details.

FaceReader

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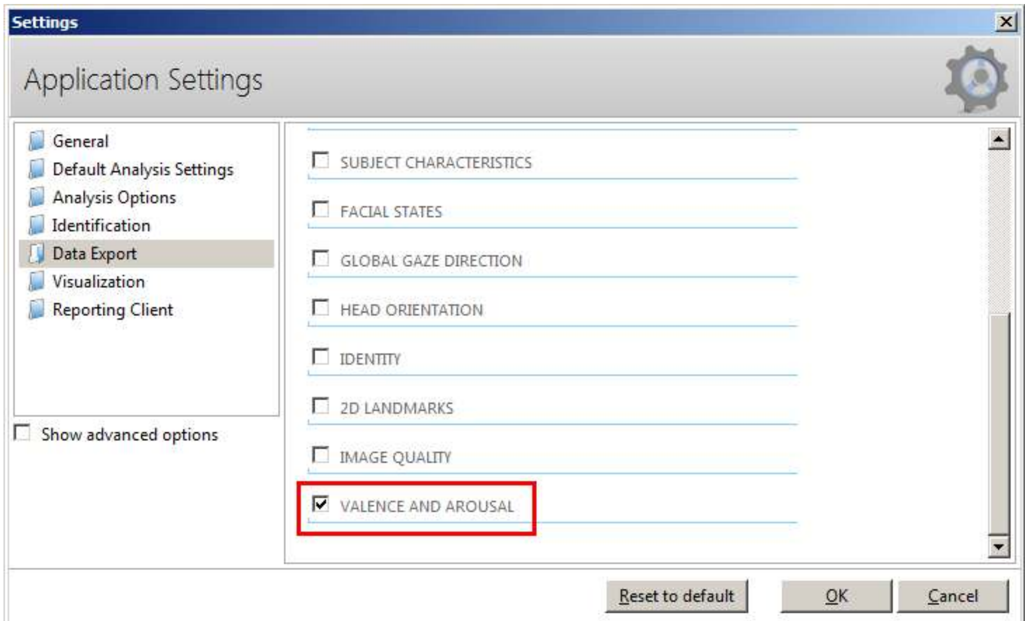


6. Click OK to exit the Application Settings screen.

Creating a FaceReader Project and Recording in Acq*Knowledge*

1. After performing the above configuration steps 1-5, launch the FaceReader software and choose

Part D

If

Part D

Part E

Part E

Appendix B - Filter characteristics

Filter types

Acq*Knowledge* employs two types of digital filters:

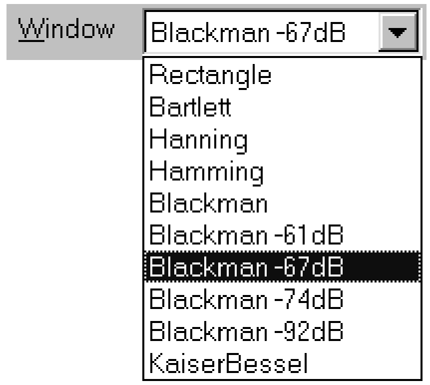
(a) Finite Impulse Response (FIR) perform filtering calculations online (during an acquisition) or post-processing (after an acquisition).

(b) Infinite Impulse Response (IIR) perform filtering calculations online (during an acquisition) or post-processing (after an acquisition).

Although the similarities between the two types of filters outweigh the differences, some important distinctions remain.

1. IIR filters tend to be less accurate than FIR filters. Specifically, IIR filters tend to cause phase distortion or

Part E



Bartlett implements triangular windowing and Rectangle does not window the data. The

Part E

Appendix D - Customizing Menu Functionality

Acq*Knowledge* now includes a powerful customization feature 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 choose to remove the

Part E

Unlocked An MP160/150 automatically

Part E

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V

W

WARRANTY

BIOPAC Systems, Inc. warrants its hardware products against defects in materials and workmanship for a period of 12 months from the date of purchase. If BIOPAC Systems, Inc. receives notice of such defects during the warranty period, BIOPAC Systems, Inc. will at its option, either repair or replace the hardware products that prove to be defective. This warranty applies only if your BIOPAC Systems, Inc. product fails to function properly under normal use and within the manufacturer