LabScribe
USER'S MANUAL

iWorx Systems Inc.
62 Littleworth Road
Dover, NH 03820

Introduction

Welcome

Thank you for choosing iWorx *LabScribe* data recording and analysis software. We are confident that this software will make your data recording and analysis easier, and welcome suggestions for improving our products. Please contact us with comments, concerns or suggestions at (603) 742-2492 Contact us via email at : info@iworx.com

How To Use This User's Manual

This User's Manual assumes you are familiar with basic Windows and Macintosh OSX terminology. The **Table of Contents** lists each chapter and its contents. You can use it or the **Index** to locate pages on a particular subject.

Although it contains some practice exercises and tutorials (especially in the **Advanced Analysis** chapter), this manual is not designed to be a tutorial, or an introduction to *LabScribe*. It is a reference manual covering all of the features and capabilities of the software. Refer to the **Quick Start** guide for a practical overview of *LabScribe's* most commonly used features. Detailed instructions for specific laboratory experiments are included in the *LabScribe* software, and there are a number of video tutorials available in the Customer Area at iworx.com.

System Requirements

- PC –Win10
- Mac OS: OSX 10.13 and above
- Minimum specs: Dual Core processor, 4GB or greater memory.
- Recommended specs: Quad Core 64 bit Processor, 8GB or greater memory.
- Recommended specs for Eye Tracking: Intel i7 or better CPU, 16GB Ram, a 256 GB Solid state drive, Graphics card

User Area

The Customer Area at iWorx.com contains a wealth of resources, including software files, experiments, archived newsletters, hardware documentation, and a complete online catalog of our research and teaching products. You will need to register and choose a password to access the Customer Area. Simply click Register on the Customer Area home page for complete registration information. By registering with us at iWorx.com, you will be notified of updates and new releases, and you will be able to access the free software upgrades you are entitled to for as long as you use LabScribe.

Installation

The *LabScribe* software installer can be downloaded from our Customer Area. Point your browser to http://www.iworx.com and enter the Customer Area (register first if necessary). All installers are available in the Software section of the Customer Area.

You will need to have administrative privileges to install LabScribe on some computers. Contact your IT department for assistance or to confirm your administrator status. Additionally, Windows users will need permissions to write to **C:\Users\USERNAME\AppData\Local\LabScribe**. *Do not connect your iWorx hardware to the computer until* ***AFTER*** *the software installation is complete.*

To install using a downloaded installer from our Customer Area:

- Go the Customer Area on the iWorx.com website. Click on the Software link and select the proper installer for the Windows or Macintosh operating system on your computer. After downloading the *LabScribe* software installer, double click on the downloaded file. It is a self extracting archive, which will automatically launch the installer after it extracts.
- In Windows, follow the prompts to complete installation. Restart your computer once installation is complete.
- In Macintosh OSX, copy the files to your Applications folder.
- Once you have completed the installation process, connect and turn on your iWorx hardware.

Note: *When your hardware is connected for the first time, Windows will advise you "New Hardware found" and proceed to load the driver automatically. If for some reason Windows cannot locate the driver, locate the appropriate drivers for your operating system in the iWorx/LabScribe/****drivers*** *folder in the* ***Program Files*** *folder on your C drive.*

1)

Technical Support

If you cannot find an answer in this User's Guide, please check the list of FAQ's (Frequently Asked Questions) on our website. If you still cannot find a solution to your problem, technical support is available to all registered users at no charge via phone or email. When requesting technical support, please follow the steps listed below:

- Write down your question or problem and the actions you took that created the problem.
- Be prepared to duplicate the problem.
- Note any error messages.
- Save a data file that can be emailed to an iWorx Technical Support representative.
- Note your computer model and operating system version.
- Note the amount of RAM (Random Access Memory) in your computer.
- Note your *LabScribe s*oftware version number.

Following these steps will enable the iWorx support staff to address your issues quickly and efficiently.

Contacting Us

iWorx Systems, Inc.
62 Littleworth Rd.
Dover, NH 03820
USA
www.iworx.com

For Sales:
(800) 234-1757
(603) 742-2492
FAX: 603-742-2455
Email: sales@iworx.com

For Technical Support:
(603) 617-2575,
support@iworx.com

Table of Contents

1: Display

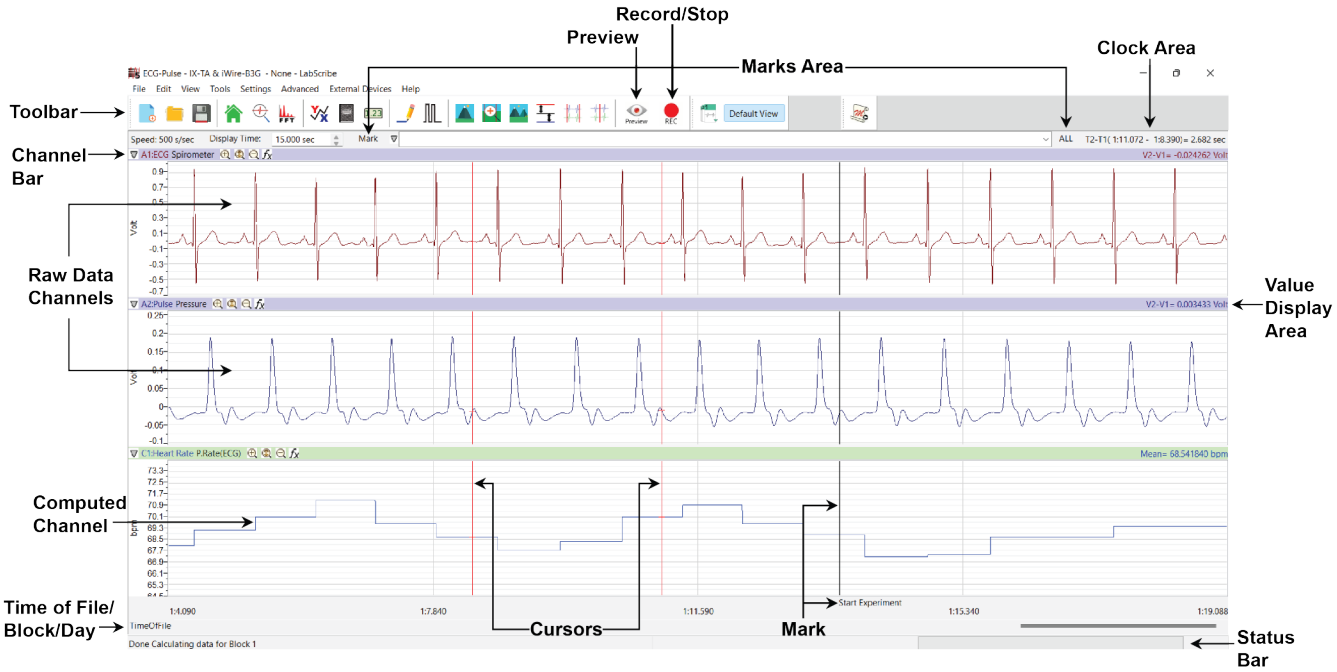
LabScribe both acquires data and uses an intuitive display that makes it possible for the user to view, interpret, and manipulate the recorded data. This chapter discusses how data are displayed in the various windows of the *LabScribe* user interface.

User Interface

The *LabScribe* user interface contains five primary display windows: the **Main** and **Analysis Windows**, the **XY** and **FFT Views**, and the **Journal**. There are also dialog windows and control panels, accessible through **Toolbar** icons and the software **Preferences Dialog** (accessed in the **Edit** menu in Windows, and the **LabScribe** menu on the Macintosh), which displays the **Channel**, **Stimulator**, **Views**, **Sequences**, **Options** and **Events** configurations. The **Marks** icon in the **Toolbar** opens the **Marks Dialog** and the **Stimulator** icon opens the **Stimulator Control Panel** directly beneath the **Toolbar**. The **Meter** icon opens a window that displays selected data values. The **Main Window** and **Toolbar** contain most of the controls necessary for data acquisition.

The Main Window

Most of *LabScribe*'s interface features can be found in the **Main Window**. *LabScribe* can display up to 128 channels of raw and computed data in the **Main Window**.



The LabScribe Main Window.

The Toolbar

Many of the functions of *LabScribe* can be accessed via the icons in the **Toolbar**, which is directly beneath the menu headings on the **Main Window** display. These functions are described in more detail in the relevant parts of this manual.

New File: Opens a new file. Only one acquisition window may be open at a time.

Open File: Opens a previously recorded file.

Save File: Saves data to the file currently open.

Main Window: Brings the **Main Window** to the foreground.

Analysis: Brings the **Analysis Window** to the foreground.

FFT (Spectrum): Opens the **FFT Window.**

XY View: Opens the **XY View**.

Journal: Opens the **Journal** on the right side of the **Main**, **Analysis**, **XY**, and **FFT Windows**.

Meter: Opens the **Meter** to the left side of the **Main Window**.

Marks: Opens the **Marks Dialog**.

Stimulator: Hides or displays the **Stimulator Control Panel** directly beneath the **Toolbar**.

Half Display Time: Reduces the time displayed on the screen by a factor of 1/2 each time the icon is clicked.

Zoom Between Cursors: Zooms to the area between the two cursors in **Two Cursor Mode**.

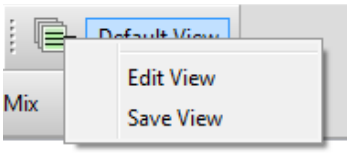
Double Display Time: Increases the time displayed on the screen by a factor of two each time the icon is clicked.

Autoscale All Channels: Autoscales all the channels in the **Main Window**.

Two Cursor Mode: Displays two cursors on the data window. Time and voltage differences between the data points intersected by the cursors are measured and displayed in the **Clock**

and **Value Display Areas**. **Two Cursor Mode** is the default condition, and is the only option available in the **Analysis Window**.

Single Cursor Mode: Displays one cursor on the data window. The absolute voltage at the cursor is displayed in the **Value Display Area**. The time from the beginning of the trace to the cursor is displayed in the **Clock Area**.



Views: Clicking on the arrow next to the **View** name displays the **View** control menu. You can switch the current view from this menu, create a new view from the default view, and duplicate or rename the current view. Selecting **Edit View** opens the **Views** page of the **Preferences Dialog**, where more options are available. A more complete description of **Views** later in this chapter.

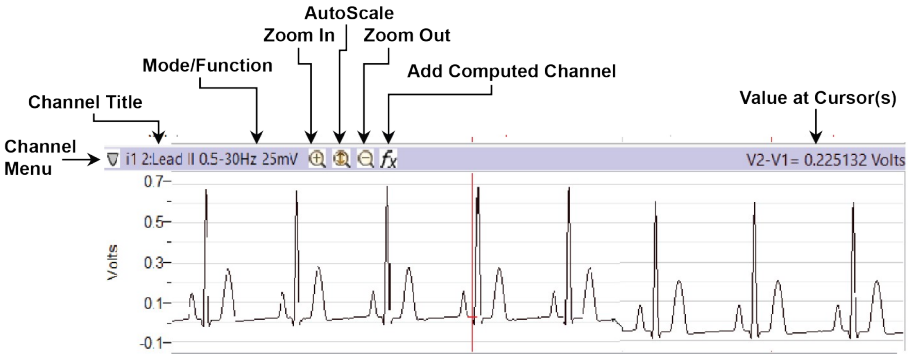
Macros: The **Macros** can be used to automate various functions in LabScribe. See the Macro Chapter for more complete discussions of **Macros**.

Preview and Record/Stop: Clicking **Preview** will display, but not record, the data being acquired. Clicking **Record** will record the data. While recording the **Record** button changes to **Stop**. Clicking **Stop** will stop data recording and create a recorded block.

The main **Toolbar**, the **Views** and **Macro** toolbars, and the **Preview/Record** controls can all be detached and moved to a new location by clicking and dragging on the vertical dotted line on the left side of the respective panel.

Channel Bar

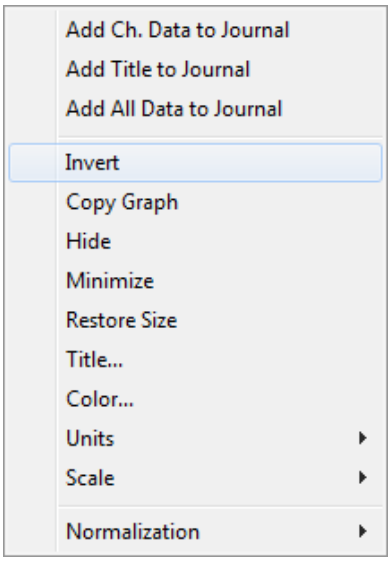
Each channel has its own set of controls located in a **Channel Bar** immediately above the channel's data window. The **Channel Bar** will appear slightly different depending on which window is currently being displayed.



The Main Window Channel Bar

The **Channel Menu** (shown below) contains functions specific to the channel, and is accessed by the arrow on the left of the **Channel Bar**. The **Channel Menu** can also be displayed by right-clicking anywhere in the channel.

The first three options - **Add Ch. Data to Journal**, **Add Title to Journal**, and **Add All Data to Journal** - transfer data values to the **Journal**, and are described in more detail in **Chapter 10: The Journal and Data Export**.



The remaining menu items include:

Copy graph: Copies the graphical channel data in the current screen and sends it to the clipboard. It can then be pasted into the **Journal** or an external application.

Hide: Hides the channel.

Minimize/Restore Size: Reduces the size of the channel to just the **Channel Bar** or restores the full channel.

Title...: Opens a dialog that allows the user to change the name of the channel.

Color: Opens a color palette that allows the user to change the color of the channel's trace.

Units: Choosing this menu item displays the **Units Conversion** options. Clicking in the **Value Display Area** will also display these options. Refer to the **Units Conversion** section beginning on page 13 of this chapter for a complete description of these options.

Scale: Clicking this item displays the options for controlling the vertical scale of the channel. Refer to the discussion beginning on page 30 in **Chapter 3: Acquisition** for a complete description of these options.

Normalization: Choosing **Normalization** opens a submenu allowing the user to access the **Normalization** functions used to calibrate vessel size for the use of wire myographs. **Normalization** is a separately licensed software routine. **Normalization** is discussed in more detail beginning on page 240 in **Chapter 8: Advanced Analysis**.

Refer to the appropriate sections of the manual for descriptions of the **Channel Menu** in the **Analysis Window** (page 99**)**, the **XY View** (page 107), and the **FFT Window (**page 108).

The **Channel Title** is displayed to the right of the **Channel Menu** arrow. The title can be changed with the **Title...** option in the **Channel Menu**.

The **Mode/Function** position displays which input and hardware filters are being used on a raw data channel. Clicking on **Mode/Function** will allow you to change these options. On a computed function channel, **Mode/Function** displays the computed function. Clicking on **Mode/ Function** in a computed

channel will display the list of available computed functions, allowing the user to change the computed function of that channel. Refer to **Chapter 6: Computed Channels** for a more complete discussion.

Zoom In, **Autoscale**, and **Zoom Out** set the vertical scale and are described more fully in the **Managing Amplitude Display** section in **Chapter 3: Acquisition**.

Clicking **add function** adds a computed channel to the display. The functions are discussed in **Chapter 6**: **Computed Channels**.

The **Value Display Area** located to the extreme right on the **Channel Bar** will display different values depending on the state of the program:

While recording, the **Value Display Area** shows the value of the last data point collected.
Offline, in **Single Cursor Mode**, the **Value Display Area** displays the Y-axis value of the data point intersected by the cursor.
In **Two Cursor Mode**, the **Value Display Area** displays the difference between the Y-axis values intersected by the two cursors.

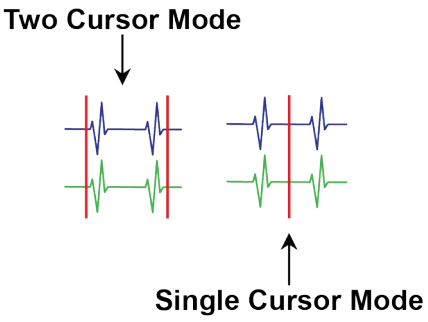
Channel Sizing

The amount of display area allotted to each channel in the **Main Window** can be controlled by clicking and dragging on the top of the **Channel Bar**.

To change the allocated space for a channel, position the cursor at the top of the **Channel Bar** until it becomes a double-headed arrow.
Click and drag this arrow up or down to resize the channel.

Cursors

Cursors are the vertical lines that pass through all channels. Icons in the **Toolbar** allow you to choose between using **Single Cursor** or **Two Cursor Modes**.



Single Cursor Mode

To access **Single Cursor Mode**, click on the **Single Cursor Mode** icon in the **Toolbar**.
The **Value Display Area** on the right side of each channel bar displays the voltage of the data point that is intersected by the cursor in that channel. The **Clock Area** in the upper right hand corner of the **Main Window** displays the corresponding time.
Single Cursor Mode is used to determine values and to place marks in the record after recording has stopped.

Two Cursor Mode

To access **Two Cursor Mode**, click on the **Two Cursor Mode** icon in the **Toolbar**.

When using **Two Cursor Mode**, the cursor on the left is always **Cursor 1** and the one to the right is always **Cursor 2**. If **Cursor 2** is moved to the left of **Cursor 1**, it becomes **Cursor 1**.

The **Value Display Area** displays the difference in voltage between the data points at **Cursor 1** and **Cursor 2**. The value shown is always the amplitude at **Cursor 2** minus the amplitude at **Cursor 1**, and can therefore be a negative number.

The **Clock Area** reports the difference in time between the two cursors.

In **Two Cursor Mode**, the cursors can also be used to define the left and right boundaries of a selection of data.

Moving Cursors

A cursor may be moved by placing the mouse over the cursor, clicking, and dragging it to the right or left.

Cursors may also be moved using the arrow keys on the keyboard.

Pressing the RIGHT or LEFT arrow key on the keyboard moves the cursor one data point.

In **Two Cursor Mode**, pressing the keyboard's UP arrow changes the cursor that is moved.

In the **Analysis Window**, holding the SHIFT key down while pressing the RIGHT or LEFT arrow causes the cursor to move five data points at a time.

In the **Analysis Window**, holding the CONTROL key down while pressing the RIGHT or LEFT arrow moves the cursor ten points at a time.

Locking Cursor Separation

The cursors may be locked a set duration apart allowing you to look at a consistent amount of data between them. To lock the separation distance, positon the two cursors at the desired separation and choose **Lock Cursor Separation** in the **Tools** menu. To unlock the cursors, click **Lock Cursor Separation** a second time.

CURSOR EXERCISE

2) Record some data using the pulse transducer, as demonstrated in the **Tutorial** exercise that came with your software.
3) Select **Single Cursor Mode** by pressing the **Single Cursor Mode** icon in the**Toolbar**.
4) Record the value that corresponds to the position of the cursor.
5) Click, hold, and drag the cursor over the highest point in a given cycle of the data. Adjust the position of the cursor bar left or right by using the LEFT or RIGHT arrow keys on the keyboard. Adjust the position of the cursor so that the value in the **Value Display Area** reads the maximum value.
6) Enter **Two Cursor Mode** by clicking the **Two Cursor Mode** icon in the **Toolbar**.
7) Position **Cursor 1** so that it is over the minimum value in a given cycle, then position C**ursor 2** over the maximum value of the beat to the right. The value reported will be positive and represents the amplitude of that pulse beat.

8) Now drag **Cursor 2** to the maximum value of the beat to the left of **Cursor 1**. When you release **Cursor 2**, it becomes **Cursor 1** and the new value reported will be of a similar magnitude, but will be a negative number.

Marks

LabScribe can record large amounts of data, so specific data of interest must be easily located and retrieved to be useful. To locate and identify specific sections of data, it is possible to put marks on the data while *LabScribe* is recording. Marks can also be inserted and edited after the recording has stopped.

Marks can be placed on the recording without interrupting data recording.

As soon as the **Record** button is clicked and data recording begins, *LabScribe* sets an active text cursor in the **Marks** text box, to the right of the **Mark** button on the **Main Window**. In the **Marks** text box, the user can type a comment describing an upcoming step in the experiment.

In ScopeMode, existing text in the Marks Text box, will be automatically get added as a mark in the sweep.

The **Mark** is placed on the recording when the ENTER (or RETURN) key on the keyboard is pressed, or the **Mark** button is clicked. The mark will be signified by a vertical black line that is inserted on the data at the moment the ENTER key is pressed or the **Mark** button is clicked.

The channel in which the mark appears can be designated by choosing the channel from the menu that appears when the word **ALL** is clicked. By default, the mark will appear in all channels.
Mark with a ^followed By A (Raw Data), D (Digital Input), S(Stimulator, C(computed) and Channel Number will be assigned to that channel.
ie Test^A3, will place a Mark 'Test' on Raw Data Channel 3., Test^C2, will place a Mark 'Test' on computed Data Channel 2"). Each mark can be assigned to only one channel, but multiple copies of the same mark can be placed on multiple channels by adding more channel information to the mark text. For eg. Test^A1^C2, will place a mark “Test” on channel A1 and a mark “Test” on channel C2

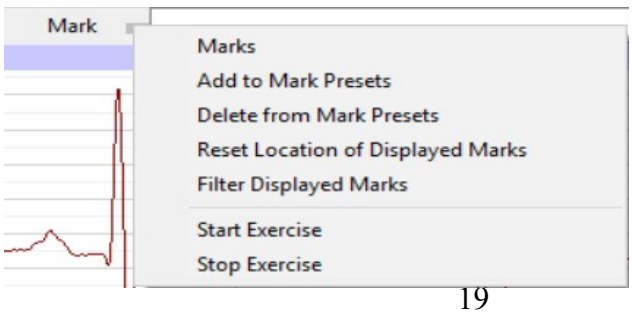
When recording is halted, the typed comment that was loaded into the **Marks** text box prior to the event can be seen in the **Text Display Area** at the bottom of the screen.

The Mark button and text box.

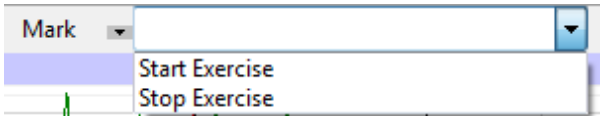
If you know the marks that you will be adding to the record prior to recording, you can store the marks text as preset marks.

To create a preset mark:

Type the mark text in the **Marks** text box, and choose the **Add to Mark Presets** option in the menu that opens by clicking on the arrow to the right of the **Mark** button. This will save the typed text as a preset mark.



The preset mark can be called by clicking on the arrow to the right of the **Marks** text box and choosing the desired preset mark. This loads the **Marks** text box with the desired **Mark** text. Clicking the **Mark** button or striking ENTER (or RETURN) will add the preset mark to the record.



The Preset Marks drop-down menu

You can delete a preset mark by selecting a preset mark (using the arrow to the right of the **Marks** text box) and choosing the **Delete from Mark Presets** option in the drop-down menu next to the **Mark** button.

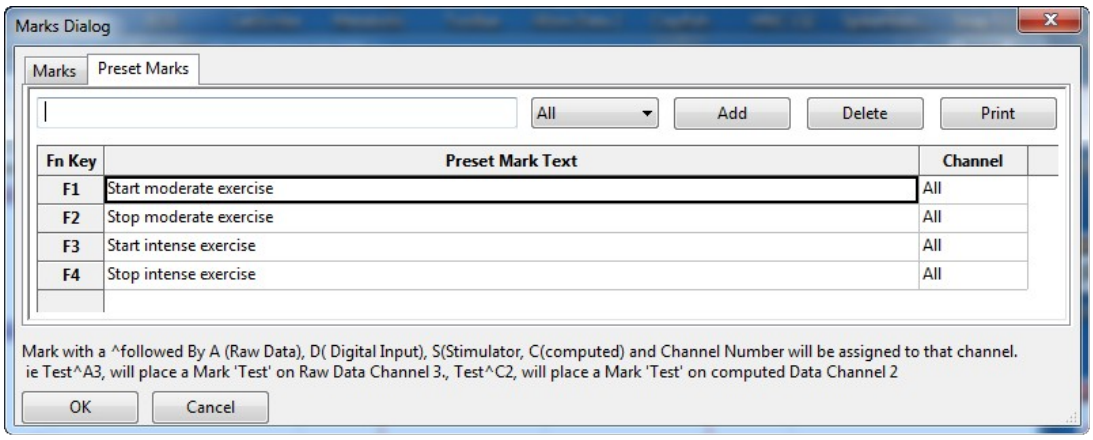
Preset marks can also be entered directly into the **Marks Dialog**:

Click on the **Marks** icon in the **Toolbar** to open the **Marks Dialog**. The **Marks Dialog** can also be opened by choosing **Marks** in the **Marks** sub-menu of the **View** menu.

Select the **Preset Marks** tab.

Enter the comments to be associated with the preset marks into the text boxes. The row sizes in the **Marks Dialog** can be adjusted by placing the computer cursor over a dividing line until it changes to a double-headed arrow. Click and drag the line to its desired location.

Each preset mark is associated with a keyboard function key (or ALT plus a number). Once recording has begun, striking the appropriate function key (or ALT plus a number) enters the associated preset mark into the **Marks** text box. Clicking the **Mark** button or pressing ENTER (or RETURN) on the keyboard will attach the mark to the record.



Preset Marks options in the Marks Dialog.

Making Marks Offline

Marking events as they happen is a necessity for events that are time critical, like drug deliveries or experimental interventions. Information about the experiment that is important, but not time critical, can

be marked on the recording after the recording is completed. An example of the type of comment that could be added later would be a change in room temperature.

To add this information to the record after recording is completed:

Click on the **Single Cursor Mode** icon in the **Toolbar**.

Position the cursor on the record where the mark is to be positioned.

Type the text (a maximum of 50 characters) associated with the new mark in the **Marks** text box. Click the **Mark** button or press the keyboard's ENTER (or RETURN) key, and the mark and its text comment are inserted at the current position of the cursor.

You can also add a mark to the record by selecting **Add Mark** from the **Marks** sub-menu of the **View** menu. Type your text into the window that opens and click **OK**. The mark will be added to the record at the current position of the cursor.

Editing Marks

Marks already on the record can be changed or deleted.

To edit a mark:

Access the **Marks Dialog** from the **View** menu or by clicking the **Marks** icon on the **Toolbar.** The **Marks Dialog** lists all marks in a file.

Both the column and row sizes in the **Marks Dialog** can be adjusted by placing the cursor over a dividing line until it changes to a double-headed arrow. Click and drag the line to its desired location.

Highlight the mark by clicking twice on the mark text, and make the desired changes.

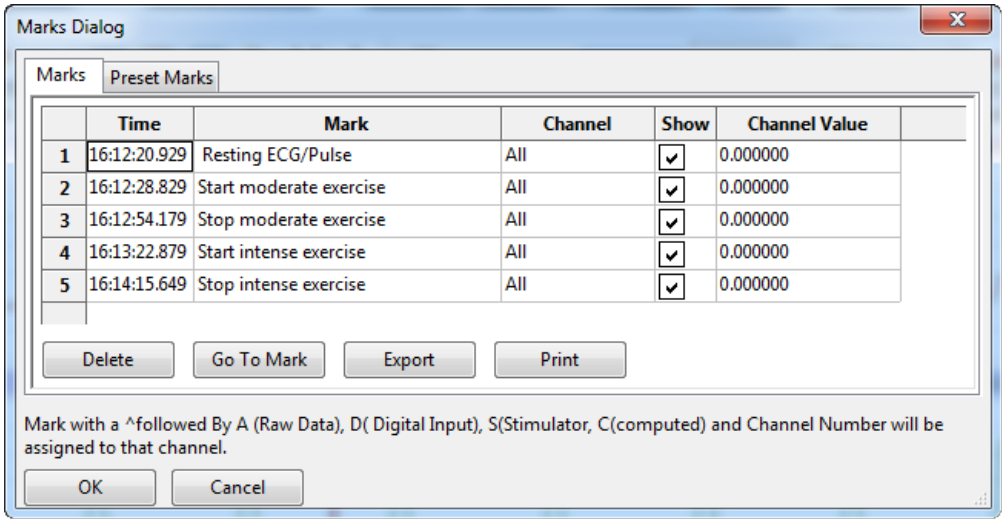
Click **OK** to exit the dialog.

To delete a mark:

In the **Marks Dialog**, select the mark you'd like to delete by clicking on the number to the left of the row.

Click on **Delete**.

Click **OK** to exit the dialog.



The Marks Dialog.

Navigating by Marks

Marks that are placed on the recording can serve as “sign posts”, indicating where important sections of data are located. You can use the marks to navigate between important areas of an experiment without hunting or scrolling for the areas of interest.

To navigate by marks:

Click on the arrow next to the **Mark** button and choose the mark you want to “go to”. *LabScribe* will find the data point associated with that mark and display that section of data in the **Main Window**.

You can also filter the marks shown in the dropdown list by choosing **Filter Displayed Marks.**

Alternatively, select the mark in the **Marks Dialog** and click on **Go To Mark**.

Positioning Mark Comments

On presentations or printed copies of the data record, it is useful to position the text of the comment associated with a mark directly over the data to which it applies. This is particularly useful if more than one channel of data was recorded and the mark does not apply to all channels.

To position marks on the trace:

After recording has stopped, the mark text associated with the mark immediately preceding the displayed data appears in the **Text Display Area** at the bottom of the **Main Window.** Click on the mark text in the **Text Display Area** and drag it up into the data area of the record, allowing the mark to be read and printed in any window in which the data appear.

Sometimes, it is necessary to return the marks in a particular view to the **Text Display Area** at the bottom of the **Main Window**. To do this, click on the arrow next to the **Mark** button and choose **Reset Location of Displayed Marks**. This command returns only the marks on the data window of the visible screen of data to the bottom of the **Main Window**. All other marks will remain where they were originally positioned.

You can also reset the location of marks from the **Marks** sub-menu of the **View** menu.

Sorting and Exporting Marks

The **Marks Dialog** displays the time that a mark was made, the text comment attached to the mark, the channel on which the mark was made, and the value of the amplitude at the mark. Marks can be sorted by time, channel, or the text comment of the mark by clicking on the column titles. Click once to organize marks in ascending order and a second time to change to descending order.

To export marks to a text file or spreadsheet program, select the mark in the **Marks Dialog** and click the **Export** button.

MARKS EXERCISE

1) Click **Record** and record a few minutes of pulse transducer data as demonstrated in the **Tutorial** exercise that came with your software.

2) As data are being recorded, type “Test 1” on the keyboard and strike the ENTER (or RETURN) key on the keyboard.
3) Wait one minute, type “Test 2" and strike the ENTER (or RETURN) key.
4) Click **Stop**. Scroll through the data using the scroll bar at the bottom of the **Main Window** until you locate “Test 1” in the **Text Display Area**.
5) Click on the arrow next to the **Mark** button and choose “Test 2". Notice that the data in the **Main Window** has moved to the “Test 2" mark.
6) Using the mouse, click and hold on the comment “Test 2" at the bottom of the screen. Continue holding the mouse button down, and drag the comment to a new position on one of the available channels.
7) Release the mouse button and the mark text is locked on the selected channel. Comments positioned in this way will remain where they are placed and will print exactly as you see them.

8) Try this exercise again with a mark created off-line. To create an off-line mark, open **Single Cursor Mode** by clicking the **Single Cursor** icon in the **Toolbar**. Position the cursor where the off-line mark is to be positioned. Type some text on the comment line at the top of the screen, and press the ENTER (or RETURN) key. The mark appears at the cursor location and the comment appears at the bottom of the screen.

Views

The number of channels of raw data that *LabScribe* can acquire and display is limited to the number of inputs on the hardware in use, but it can calculate data on up to 128 channels. The extra channels can be used to display computed functions that are mathematically derived from the raw data.

For example, the arterial pressure from four different animals could be recorded on Channels 1- 4. Simultaneously, the **Rate** function could be used on Channels 5-8 to calculate the heart rate of each animal from its recorded blood pressure on Channels 1-4. Displaying more channels means there is less space on the display for each one. In the case of a 16-channel **Main Window** display, it is hard to resolve detail in the recorded data on each channel.

LabScribe solves this problem by allowing the user to create many different arrangements of channels that are displayed on the screen at one time. Each arrangement of channels that is displayed is known as a **View**. Using the example from the previous paragraph, a view could be created that displayed only the arterial pressure from Channel 1 and the calculated heart rate for the same animal displayed on Channel 5. The data from Channels 1 and 5 would appear in the first and second data display areas, respectively. The other six raw data and computed heart rate channels would not be displayed. For the data recorded from another animal on Channel 2, another view with Channels 2 and 6 (its matching rate channel) can be created.

Creating and Editing Views

To create a new view:

Make any desired changes to the **Main Window** by resizing the channels, or by hiding or minimizing a channel from the **Channel Menu** in the channel's **Channel Bar**.

Click on the arrow next to **Default View** in the **Toolbar** and choose **New View**.

Name the view in the **Edit View Name** dialog.

Views can also be copied, renamed or deleted from the same menu.

It is also possible to create and edit a view from the **Views Preferences Dialog**. This dialog can be accessed by clicking on the down arrow next to **Default View** in the **Toolbar** and choosing **Edit View**. To use the **Views Preferences Dialog** to create and edit a view**,** or edit an existing view:

Click on **New View...**, or select an existing view from the drop-down menu.

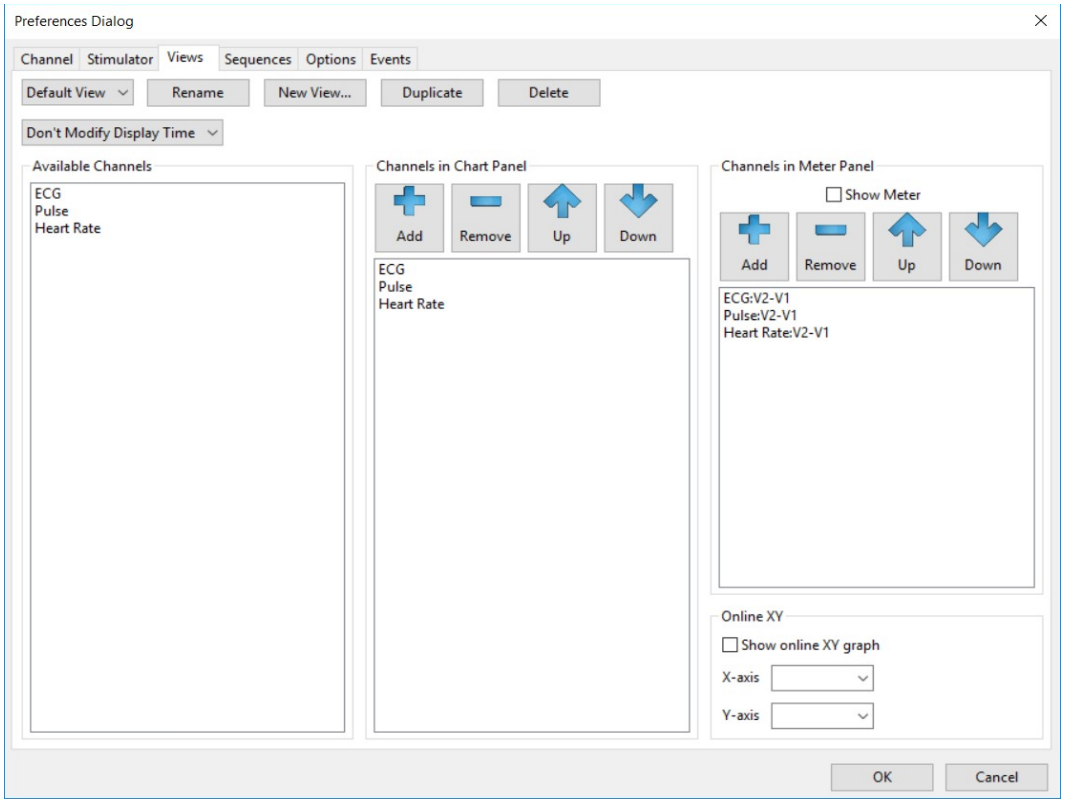
Use the controls in the dialog to change the amount of time displayed, add or remove the channels available in the view, and change the vertical organization of the channels.

Each view can display a **Meter** (see page 16 for information about the **Meter**) and you can choose which channels are displayed in the **Meter** and their positions.

An online **XY graph** can be created from two selected channels.

Any of the views can be renamed.

The **Views Preferences Dialog** can also be accessed by choosing **Preferences** in the **Edit** menu in Windows or in the **LabScribe** menu on the Macintosh and clicking the **Views** tab.



The Views Preferences Dialog.

***Note:** Any changes to the default view will also be made to the preferences and vice-versa.*

Units Conversion

When used with iWorx hardware, *LabScribe* functions as a calibrated voltmeter, which means the software will accurately display the exact voltage that the user presents to the analog-to-digital converter. The displayed (and default) units will always be volts. While this is useful in many cases, it is not always the appropriate unit for the data being recorded.

If *LabScribe* is used to record the output of a transducer designed to measure a physical parameter, such as force or pressure, other units are more appropriate. In these cases, volts can be converted into milligrams, grams, or any other units. *LabScribe* can handle these conversions easily, provided that the function that converts voltage into units appropriate to the transducer is linear.

LabScribe offers several options for Units Conversion. They are listed in the **Units** submenu of the **Channel Menu**.

The menu items above the horizontal line specify the data value to be displayed in that channel's **Value Display Area** and provide an option to add a meter value to the Meter display that is activated by clicking the **Meter** icon in the **Toolbar**.

The remaining menu items (described below) include:

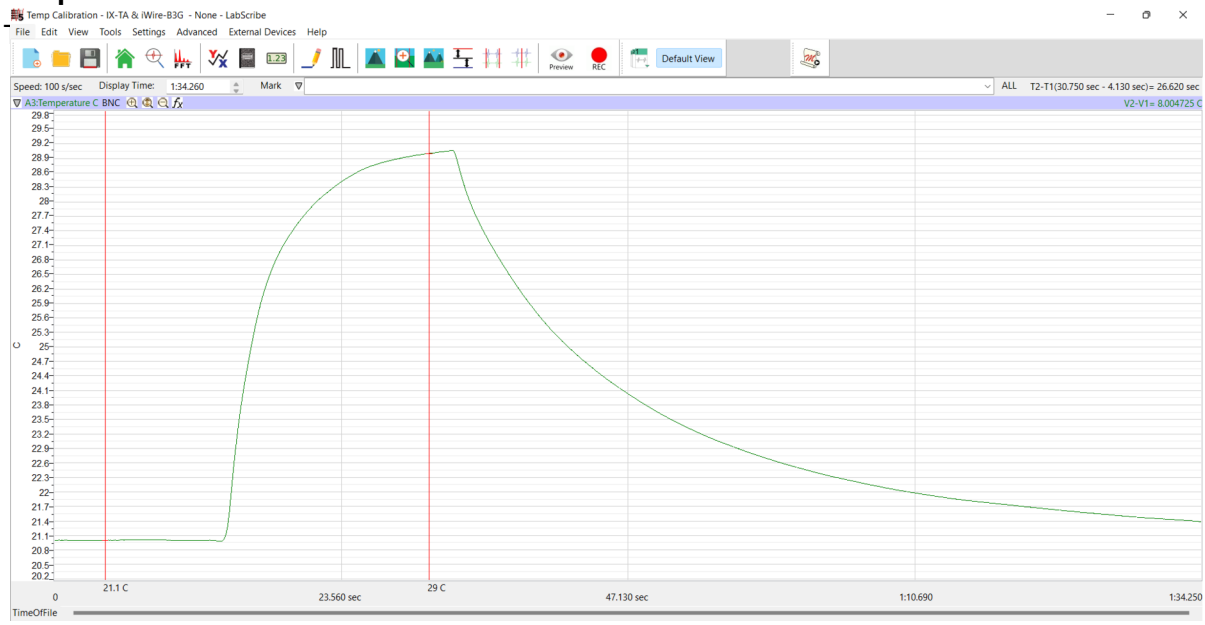
Invert: Inverts the trace.
Simple... : Opens the **Simple Units Conversion** dialog.
Advanced...: Opens the **Advanced Units Conversion Dialog**.
Set Offset...: Allows the user to set an offset required by certain transducers.
Off (all blocks): Turns all units conversions off.

Inverting the Trace

When recording physical parameters, such as temperature, pressure, or force, it is best if the polarity of the data display matches the real-world behavior of the parameter. For example, if the observed temperature goes up, the trace on the computer screen should go up. Increasing pressure or force should also produce a positive or upward deflection of the trace.

Depending how sensors and amplifiers are wired, this may or may not be the case. In the event that the data display has the wrong polarity, the trace can be inverted by selecting Invert from the Channel Menu, Units sub-menu, or the right-click menu in any data channel. The Invert function can be switched off at any time by selecting Invert a second time.

Simple Units Conversion



Data file from temperature sensor with cursors positioned at two known temperatures.

Record a portion of data at two known values. In the case of a temperature probe, record the output at two known temperatures. The recorded trace may look something like the figure above.

Once recording is complete, proceed to **Two Cursor Mode** in the **Main Window** by clicking on the **Two Cursor** icon in the **Toolbar**. The **Units Conversion** dialog window cannot be entered without being in **Two Cursor Mode**.

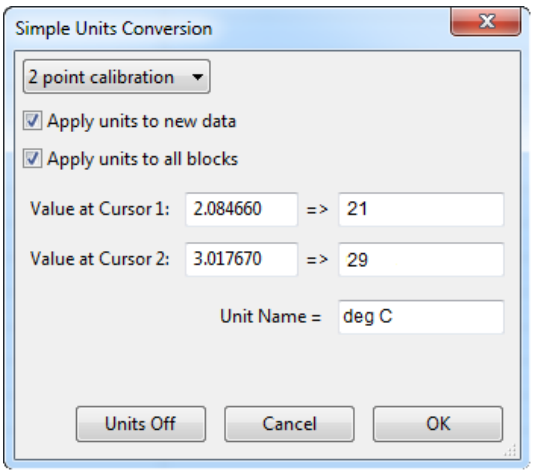
Position **Cursor 1** over one of the known values, and **Cursor 2** over the other known value.

Open the **Channel Menu** by clicking on the arrow on the left end of the **Channel Bar** or right-click anywhere in the data channel and select **Units** from the **Channel Menu**. The **Units** menu can also be accessed by left-clicking on the **Value Display Area** of the **Channel Bar**.

Select **Simple...**. to open the **Simple Units Conversion** dialog window.

Select **2-point calibration** from the drop-down menu of the **Simple Units Conversion** dialog.

Below that menu is an area where the values for the positions of the cursors are listed. The values on the left are the voltage values at the positions of **Cursors 1** and **2**. Enter the corresponding values in real units into the two value boxes on the right.



In the **Name** area, enter the name of the unit to be displayed on the Y-axis. If a unit name is not entered, volts will be used as the default name.

The units are always applied to the selected data block(s). To apply the units to all blocks, select the **Apply units to all**

blocks checkbox. To apply units to new data which will be recorded select the **Apply units to new data** checkbox.

Click **OK** to exit the dialog.

Advanced Units Conversion

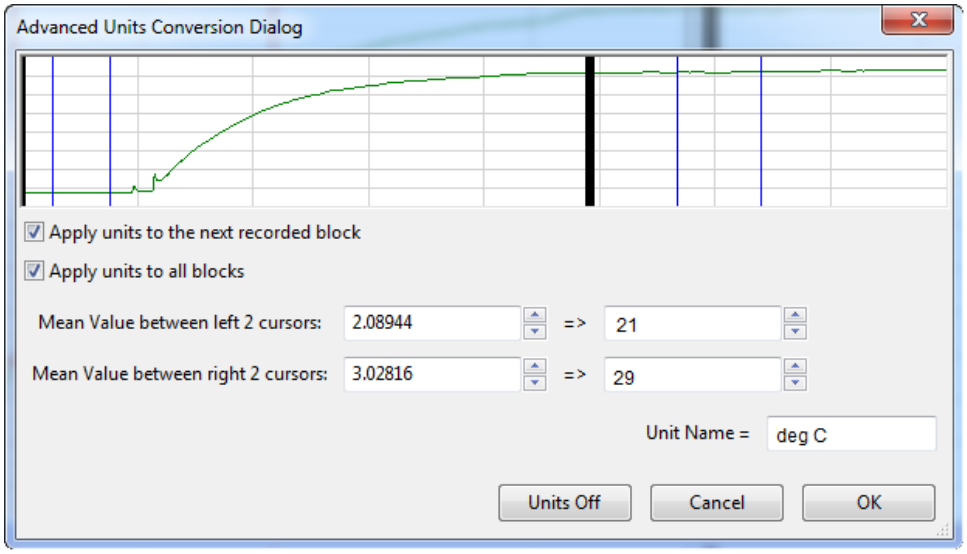
For some recordings, it may be more accurate to use the mean of a small range of data to set the calibration values, The **Advanced Units Conversion Dialog** makes this possible. To use the **Advanced Units Conversion Dialog** to make a 2 point calibration:

Choose **Advanced...** in the **Units** submenu.

Use the two cursors on the left to bracket an area of known average value, and the two on the right to bracket the second area of known average value. LabScribe will display the mean of the bracketed areas. In this way, it is possible to get representative values in recordings with some degree of amplitude fluctuation.

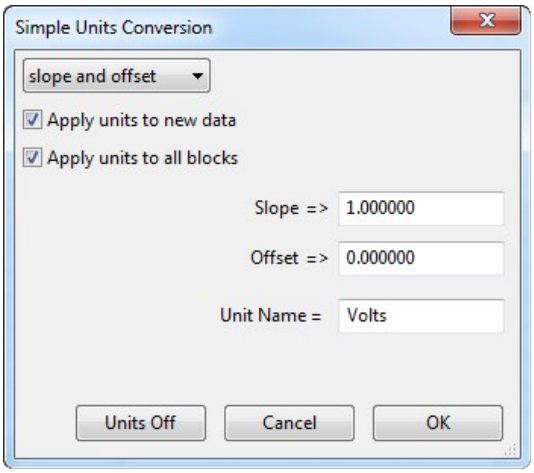
In the dialog, the mean voltage values between the two cursors on the left and the two cursors on the right are entered into the two text boxes on the left. Enter the corresponding values in real units into the two value boxes on the right.

Click OK to exit the dialog.



Slope and Offset

It is also possible to set the slope and offset directly in the **Simple Units Conversion** dialog, if those values are known. For example, if a pressure transducer produces 5mV (0.005V) per mmHg, the slope would be 0.005 and the units would be mmHg.

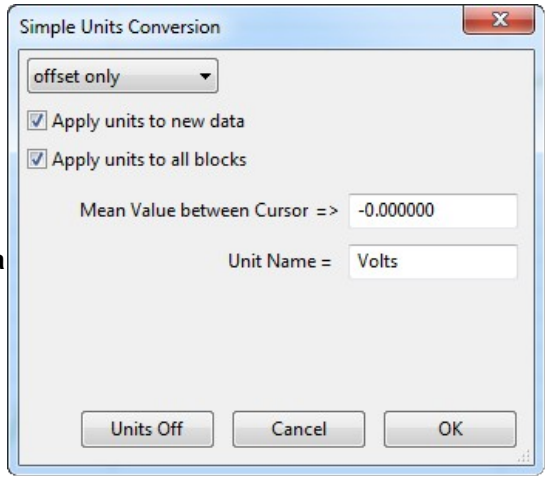


To set **slope and offset**:

- Right-click anywhere in the data channel, select **Units** from the **Channel Menu** or left-click on the **Value Display Area** of the **Channel Bar** to open the **Units** sub-menu.
- Select **Simple...**. to open the **Simple Units Conversion** dialog window.
- Select **slope and offset** from the drop-down menu of the **Simple Units Conversion** dialog.
- Enter the slope and unit name in the appropriate boxes.
- The slope must be expressed as volts/unit. Ideally, when a sensor puts out zero volts, the value of the converted units would also be zero. For many sensors this is true. However, there are many sensors that can have their offset changed by ambient conditions, such as changing barometric pressure. To correct for sensor offset, determine the value (in converted units) that *LabScribe* reports on the screen when the sensor should be reading zero. Enter this value in the **offset** area of the **Units Conversion** dialog window.
- The units are always applied to the selected block(s). To apply the units to all blocks, select the **Apply units to all blocks** checkbox. To apply units to new data which will be recorded, select the **Apply units to new data** checkbox.
- Click **OK** to exit the dialog.

Offset Only

Sometimes, it is necessary to keep the units conversion relationship and change the offset, like turning the offset control on an amplifier. For example, to set a particular region to zero:



- Set the two cursors around the desired region of data.
- Right-click anywhere in the data channel, select **Units** from the **Channel Menu** or left-click on the **Value Display Area** of the **Channel Bar** to open the **Units** sub-menu.
- Select **Simple...** from the **Units** submenu of the **Channel** menu.
- Choose **offset only** from the drop-down menu in the **Simple Units Conversion** dialog. The average value between the two cursors can now be set to the required offset value (zero, in this example).
- Click **OK** to exit the dialog.

Unit conversions can also be set from the **Channel** page of the **Preferences Dialog**. Each channel can be set with the conversion factors provided by the transducer manufacturer (refer to page 42 in **Chapter 4: Creating Your Own Settings and Preferences**).

At times, it may be desirable to turn off the **Units Conversion** and simply view the raw data in the default unit, which is volts. You can turn off the units for all blocks directly from the **Units** sub-menu or from the **Simple Units Conversion** dialog box.

The Meter

Large digital readouts of the data values recorded on each channel can be displayed on the left side in the **Main Window**.

Select the **Meter** function from the **View** menu or the **Meter** icon in the **Toolbar** to display these readouts.

Meter windows can be added by choosing Units from any Channel Menu, and selecting the Add Meter option

Choose the Channel that will be analyzed.

Various Calculations can be displayed in the meter: **V1, V2, V2-V1, Max, Min, Mean, Max-Min**.

There are 4 types of Meter that can be selected

Number:

BGYR color Bar : The value is displayed as a percentage of the displayed scale, in Blue (0-25%), Green (25%-50%), Yellow (50%-75%) and Red color(75%-100%).

Ch. Color Bar : The Value is shown as percentage of the displayed scale, In the color of the channel

Number with Limits : If the value displayed is outside the valid limits, the meter reverses the color, ie it will show the number in white over a channel color background, when the value being displayed is outside the valid limits. This can be used as a warning to make sure that the channel values does not exceed preset limits.

The Meter Edit dialog can be accessed by clicking on the Meter and clicking on **Edit...**. Choose the channel and parameter to be displayed, as well as the number of seconds to average while data are being recorded.

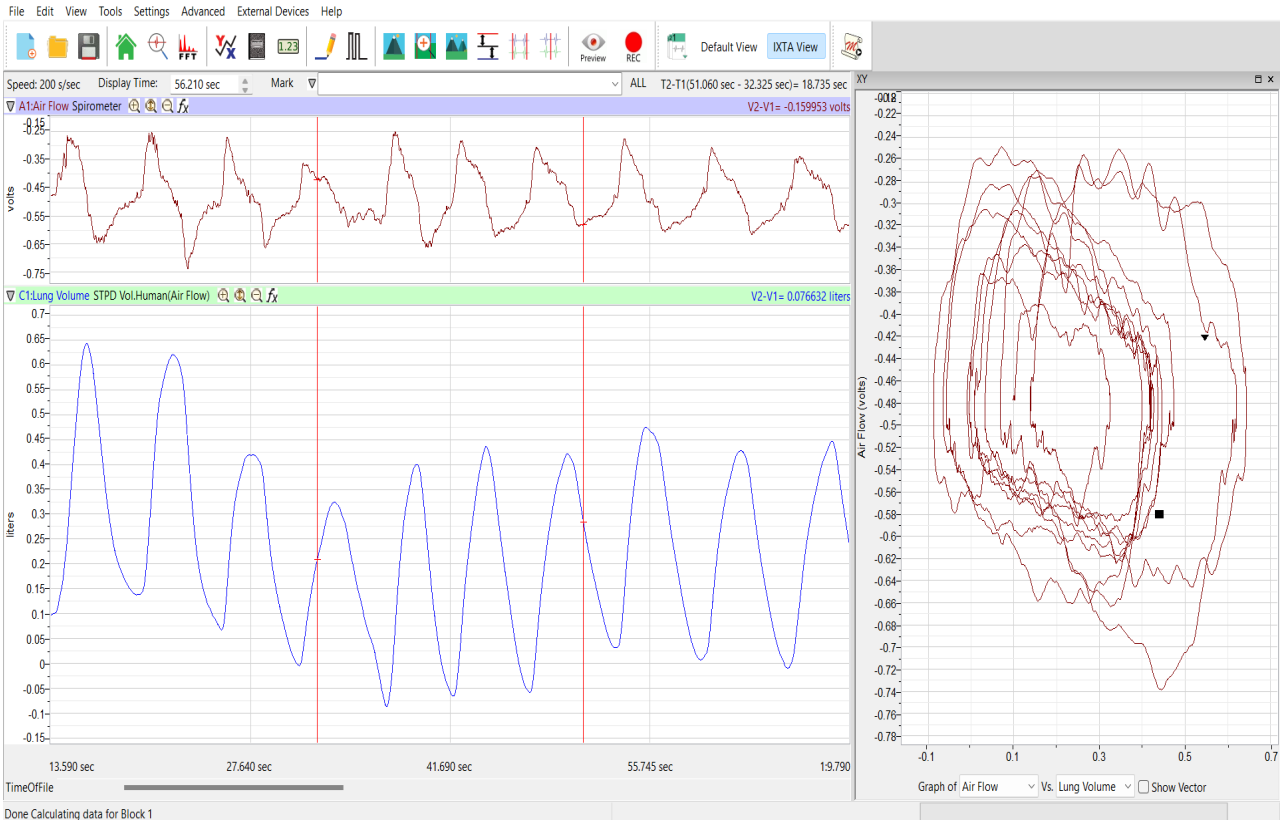
While data are being recorded, the most recent values are displayed.

Additional **Meter** windows can be added by choosing **Units** from any **Channel Menu**, and selecting the **Add Meter** option, as illustrated below.

The **Meter** display can be customized in different views. The channels to appear in the **Meter** display can be chosen. The font size and style, the color, and the channel order can be organized on the **Views** page of the **Preferences Dialog**, as discussed earlier in this chapter.

Online XY

In **Online XY** mode, the Y-values from one channel in the **Main Window** are plotted in real time against the Y-values from another **Main Window** channel. The resulting XY plot is dramatically different from a linear plot of data against time. Select the **OnlineXY** function from the **View** menu to display this plot. Select the Y-axis and the X-axis channel from the drop-down menu at the bottom of the plot window. The **Main Window** display time also applies to the online XY plot. The **Online XY** window can also be made part of the display by adding it on the **Views** page of the Preferences dialog. For a complete discussion of XY plots, refer to **XY Plot** in the **Redisplayed Data** section of **Chapter 7: Analysis**.



Other Display Windows

Data recording occurs only in the **Main Window**. However, once recording is complete, other windows can receive selected data from the **Main Window** for closer examination or display in another format, like an offline XY plot or an FFT analysis. There are several viewing options available in these other windows that are not available in the **Main Window**. The actual discussion of analytical functions found in these windows is deferred to the **Redisplayed Data** section of **Chapter 7: Analysis**.

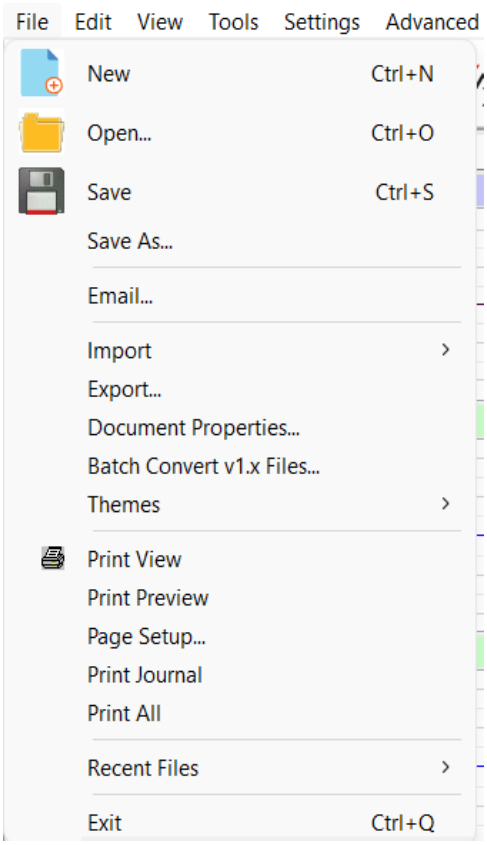
2: Menus

While many of LabScribe's features can be accessed in more than one way, the main menus and the dialogs they open provide a systematic way to access virtually every LabScribe feature.

The Menus

File

LabScribe supports all of the elements found in a standard **File** menu.



The File menu.

New: Opens a new file. Only one acquisition window may be open at a time. This function is also available from the **Toolbar**.

Open: Opens a previously recorded file. This function is also available from the **Toolbar**.

Save: Saves data to the active file. This function is also available from the **Toolbar**.

Save As: Saves data to a new file with a different name or format. It is possible to rename a data file, save the settings as a **Settings File**, generate a **Sequences Output**, or save the **Journal** as an html (*.html) or xml (*.xml) file.

Email...: Opens a dialog that allows the user to email the active file. This function requires an active Internet connection.

Import...: Opens a dialog that allows the user to set the parameters for importing text data files. This is a separately licensed feature of *LabScribe.*

Batch Import: Once a single text file is imported, a number of additional files can be imported with the same input parameters.

Export...: Allows the user to export the entire data file as text, or in a variety of formats appropriate to external analysis programs. These formats include MATLAB (*.mat), DADISP (*.dat), and Excel (*.xls). The current screen can be exported as a JPG (*.jpg) or Portable Network Graphics (*.png) file. The current screen can also be exported as a *LabScribe* data file. Files can also be exported as LabScribe (*.iwxdata) or in European Document Format (*.edf).

Document Properties...: Opens the **Document Properties** dialog that allows the user to annotate the file with notes, or to view the acquisition characteristics of the file, including the date and time of recording, the sampling speed, and the number of input channels.

Batch Convert v1.x Files...: Converts all v1.x files in a folder to v3.x files.

Print View: Prints the active window.

Print Preview: Previews the image to be printed.

Page Setup...: Opens a dialog box that allows the user to set up page formatting features specific to the printer being used.

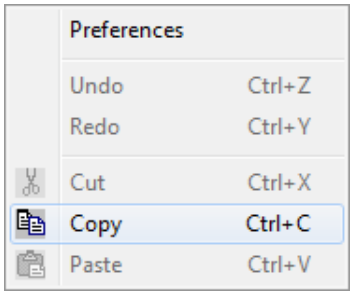
Print Journal: Prints the **Journal**.

Recent Files: Opens a submenu displaying the last ten files opened. Choosing one closes the current file and opens the selected data file.

Exit: Quits the program. On the Macintosh, use **Quit LabScribe** in the **LabScribe** menu.

Edit

LabScribe supports elements found in a standard **Edit** menu:



The Edit menu.

Undo: Un-does the last command (**Journal** only).

Redo: Re-does the last command (**Journal** only).

Cut: Cuts the selected information in the **Journal**.

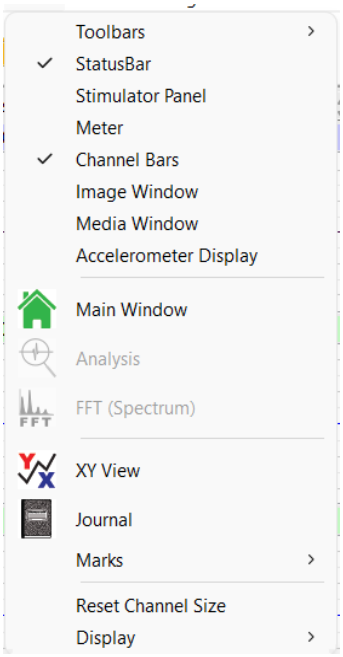
Copy: Copies the window in the foreground or the current selection in the **Journal** to the clipboard for pasting into another application.

Paste: Pastes the contents of the clipboard to the **Journal**.

Preferences: Opens the **Preferences Dialog**, a tabbed multi-pane dialog box that displays the **Channels**, **Stimulator**, **Sequences**, **Options** and **Events** configuration panels. The **Preferences Dialog** is accessed from the **LabScribe** menu on the Macintosh.

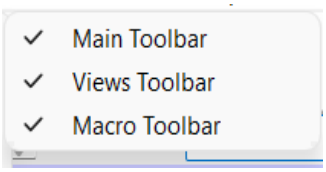
View

The **View** menu supports display elements specific to *LabScribe*.



The View menu.

Toolbars: Hides or displays the *LabScribe t*oolbars. The **Main Toolbar** is part of the default display.



The Toolbars submenu.

StatusBar: Hides or displays the **Status Bar**. The **Status Bar**, at the bottom of the **Main Window**, displays the progress status when files are being loaded or saved. The **Status Bar** is part of the default display.

Stimulator Control Panel: Hides or displays the **Stimulator Control Panel** directly beneath the **Toolbar**. The **Stimulator Control Panel** is hidden in the default display.

Meter: Hides or displays the M**eter** windows on the left side of the **Main Window**. In the default configuration, the **Meter** displays, in large type and in digital meter fashion, the amplitude values at the cursor (or the difference between the cursor values in **Two Cursor Mode**) from all channels. The **Meter** display configuration can be changed through the **Option**s drop-down menu in the **Meter** panel itself, or from the **Views** page of the **Preferences Dialog**. More detail can be found in **Chapter 1: The Display.**

Channel Bars: Displays or hides the **Channel Bars** at the top of each channel.

Media Window: Some sequences include the viewing of images. These images are displayed in the Media Window, which can be displayed or hidden with this menu item.

Main Window: Brings the **Main Window** to the foreground. This function is also available from the **Toolbar**.

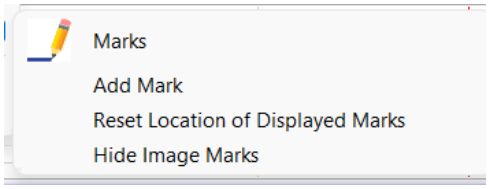
Analysis: Brings the **Analysis Window** to the foreground. This function is also available from the **Toolbar**.

XY View: Opens the **XY View**. This function is also available from the **Toolbar**.

FFT (Spectrum): Opens the **FFT Window**. This function is also available from the **Toolbar**.

Journal: Opens the **Journal** on the right side of the **Main**, **Analysis**, **XY**, and **FFT Windows**. This function is also available from the **Toolbar**.

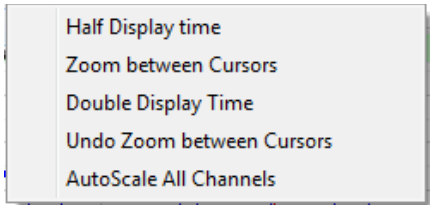
Marks: Opens a submenu with controls that open the **Marks Dialog**, add the mark in the **Marks** text box to the recording, and reset the marks on the current screen to their original positions in the **Text Display Area** at the base of the **Main Window**.



The Marks submenu.

Reset Channel Size: Returns all open channels to their default screen sizes.

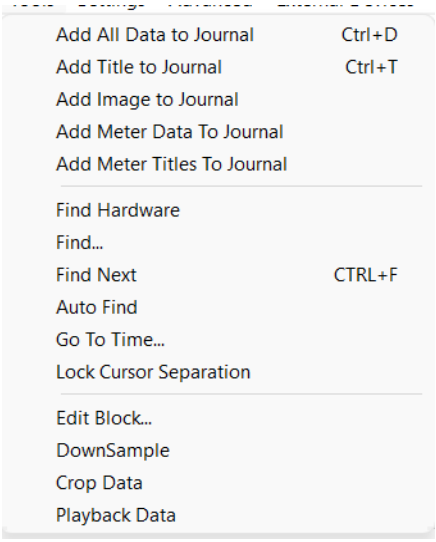
Display: Opens a submenu with controls for changing display time parameters. These parameters are discussed starting on page 35 of **Chapter 3: Acquisition**.



The Display submenu.

Tools

The **Tools** menu controls functions that can find and move specific data to the **Journal,** find specific events or regions in the recording, and edit the data file.



The Tools menu.

Add All Data to Journal: Sends data from the **Main** or **Analysis Windows** to the **Journal Table**.

Add Titles to Journal: Sends the titles of the channels in the **Main Window**, or the titles of the selected **Table Functions** from the **Analysis Window,** to the **Journal Table**.

Add Image to Journal: Sends an image of the current screen to the **Journal Editor**. Refer to the section beginning on page 248 of **Chapter 10: The Journal and Data Export** for a detailed account of this and the preceding two functions.

Add Meter Data to Journal: Sends the data displayed in the **Meter** windows to the **Journal Table**.

Add Meter Titles to Journal: Sends only the titles from the **Meter** windows to the **Journal Table**.

Find Hardware: Identifies the *iWorx* data acquisition device in use and initializes the computer's connection to it.

Find...: Calls a dialog box with controls that program *LabScribe's* cursors to find data that matches user-defined criteria in the **Main** or **Analysis Windows**.

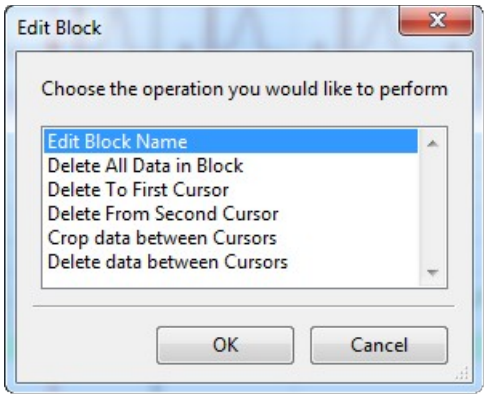
Find Next: Finds the next data point in the file which meets the criteria set in the **Find** box.

Auto Find: Automatically finds each successive data point in the file that meets the criteria set in the **Find** dialog box. Calculated values from the **Table Functions** selected in the **Analysis** window can be automatically added to the **Journal** for each matching data point. Refer to the **Find Functions** section beginning on page 112 of **Chapter 7: Analysis** for a complete discussion of all the **Find Functions**.

Go to Time...: Displays a dialog in which the user can specify a time in the file to be displayed.

Lock Cursor Separation: Locks the cursors at a fixed separation distance. Refer to **Locking Cursor Separation** on page 10 in the **Cursors** section of **Chapter 1: The Display** for a complete discussion.

Edit Block...: Opens a dialog box that offers a number of options to edit the current file. **Warning: These edits are permanent and cannot be undone!**



The Edit Block dialog.

The options in the **Edit Block** dialog are:

Edit Block Name: Allows the user to name or change the name of the data block.

Delete options: All the data in the block, the data in the block before **Cursor 1**, or the data in the block after **Cursor 2,** can be deleted. The data between the two cursors can also be deleted.

Crop: The data between the cursors can be cropped and saved as a data file.

DownSample: Used to down-sample the data to a sampling speed chosen by the user. This reduces the information in the file and should be used with caution. See the discussion on choosing a sampling speed beginning on page 41 of **Chapter 3: Acquisition**. It is important to be sure that the sampling rate chosen doesn't sample the data inadequately. **Warning: This cannot be undone!**

Crop Data: Crops the data between the cursors. This data section can be saved as a new file.

Settings

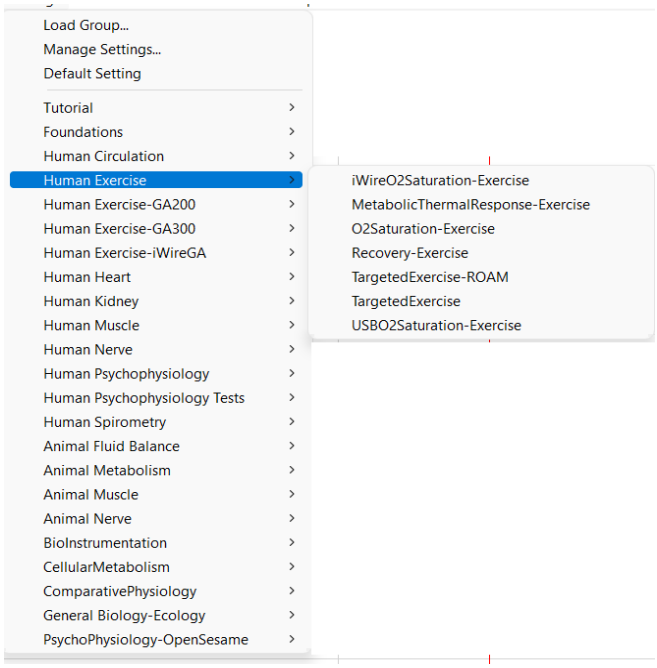
The **Settings** menu (illustrated below) allows the user to load, create, or edit files containing preset recording and analysis parameters. Selecting a file from the list of experiments beneath the line programs *LabScribe* to record data in a manner specified by the **settings file** associated with each experiment.

Load Group...: Loads a group of existing **settings files**. Each file that is part of the group contains the *LabScribe* recording and analysis parameters necessary to record a specific experiment or type of data. Refer to the section starting on page 34 in **Chapter 3: Acquisition** for detailed instructions.

Manage Settings...: Opens the **Settings Manager** dialog box. The controls in the dialog allow the user to edit existing **settings files** in a group, remove them from a group or to add new ones to a group. Refer to the section beginning on page 54 of **Chapter 4: Creating Your Own Preferences and Settings** for more details.

Default Setting: Restores the **Main Window** to its default view.

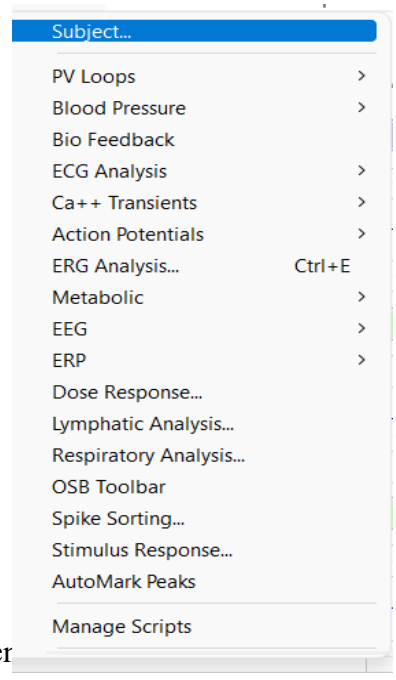
The menu items beneath the horizontal line refer to categories of experiments that have been loaded into *LabScribe*. Selecting any of them will open a sub-menu listing the experiments in that category.



The Settings menu.

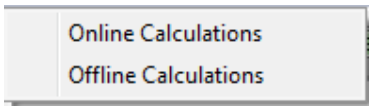
Advanced

The **Advanced** menu has options for performing advanced analyses specific to a physiological function or type of data. Through these analyses, *LabScribe* is able to locate specific data points of physiological interest and perform calculations pertaining to these data. Refer to **Chapter 8: Advanced Analysis** for a complete discussion of these functions.



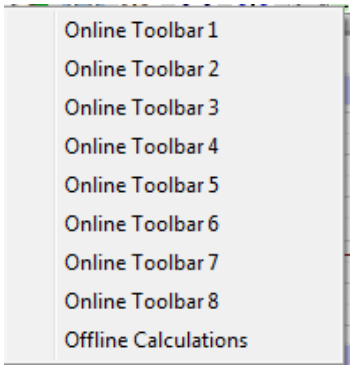
The Advanced menu

PV Loops: Displays a submenu that opens dialogs allowing the user to provide criteria by which *LabScribe* can locate and mark specific **Pressure Volume Loop** parameters, and perform both online and offline mathematical calculations on these parameters. Refer to the **PV Loops** section beginning on page 118 of **Chapter 8: Advanced Analysis** for complete instructions. **PV Loops** is a separately licensed analysis module.



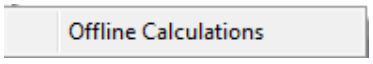
The PV Loops submenu.

Blood Pressure: Displays a submenu that opens dialogs allowing the user to provide criteria by which *LabScribe* can locate and mark specific **Blood Pressure** parameters, and perform both online and offline mathematical calculations on these parameters. Refer to the **Blood Pressure** section beginning on page 110 of **Chapter 8: Advanced Analysis Routines** for complete instructions. **Blood Pressure** is a separately licensed analysis module.



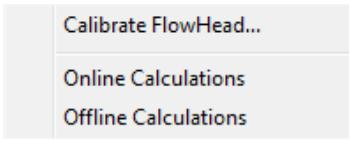
The Blood Pressure submenu.

ECG Analysis: Displays a submenu that opens dialogs allowing the user to provide criteria by which *LabScribe* can locate and mark specific **ECG** features, and perform offline mathematical calculations on these parameters. See the **ECG Analysis** section beginning on page 153 of **Chapter 8: Advanced Analysis** for details and complete instructions. **ECG Analysis** is a separately licensed analysis module.



The ECG Submenu.

ERG Analysis...: Opens a dialog that allows sophisticated analysis of electroretinograph recordings. See the **ERG Analysis** section beginning on page 173 of **Chapter 8: Advanced Analysis** for details and complete instructions. **ERG Analysis** is a separately licensed analysis module.



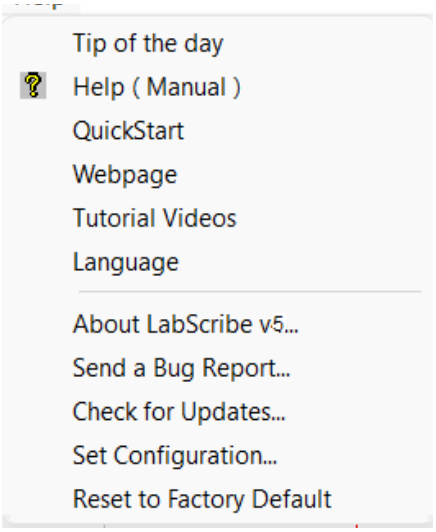
Metabolic: Displays a submenu that opens dialogs allowing the user to set up the criteria by which LabScribe can make both online and offline calculations of **Metabolic** functions. Refer to the **Metabolic** section beginning on page 198 of **Chapter 8: Advanced Analysis Routines** for more detailed information. **Metabolic** is a separately licensed analysis module.

AutoMark Peaks: Opens a dialog in which the user can set the criteria for *LabScribe* to automatically locate peaks in many types of recordings and calculate a number of peak characteristics. See the **AutoMark Peaks** section beginning on page 237 of **Chapter 8: Advanced Analysis Routines** for details and complete instructions.

Manage Scripts: Additional data analysis can be accomplished using external programs. Selecting **Manage Scripts** opens the **Scripting Setup Dialog** in which the user can set up shortcuts to export the relevant data, and then call an external script for further analysis. Scripting functions are described in more detail in the **Managing Scripts** section beginning on page 115 of **Chapter 7: Analysis**.

Help

The **Help** menu provides links to information about the *LabScribe* software and hardware.



The Help menu.

Tip of the Day: Displays a useful *LabScribe* tip.

Help (Manual): Opens the online version of the *LabScribe* software manual.

QuickStart: Opens the **QuickStart** guide.

Webpage: Takes the user to the iWorx home page. This function requires an open Internet connection.

Language: Allows the user to change the language *LabScribe* uses. Changing the language requires a restart to take effect.

About *LabScribe* v3**...**: Displays the version number and creation date of the copy of *LabScribe* in use, as well as information about the connected hardware.

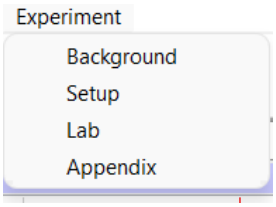
Send a Bug Report...: Sends a bug report to iWorx. This requires an active Internet connection.

Check for Updates...: Sends the user to the **User Area** login page at iworx.com. The current *LabScribe* software can be downloaded from the Software page of the **User Area**. This function requires an open Internet connection.

Reset to Factory Default: Resets all **Preferences** to the Factory Default condition.

Experiment

The **Experiment** menu displays several helper files associated with the experiment being performed. The **Setup** .pdf file is opened automatically when the experiment is chosen from the **Settings** menu. The other files can be opened by choosing them from the **Experiment** menu.



The Experiment menu.

3: Acquisition

Start Recording

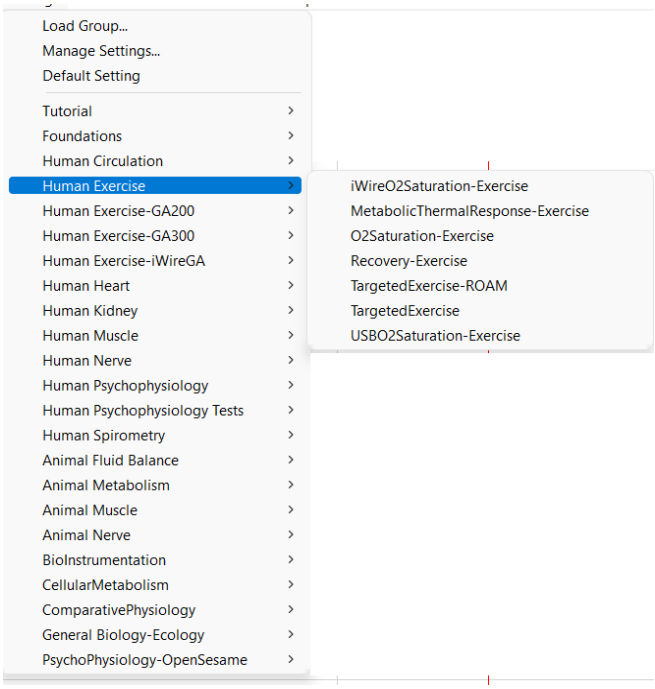
The most basic control in LabScribe is the one that starts and stops the recording. This control is found in the upper right hand corner of the Main Window. After ensuring that the source of your signal is properly connected to your data acquisition unit, click the Record button to begin recording.

While data are being recorded the Record button changes to Stop. Click Stop at any time to end data recording.

Settings

In addition to the hardware and software provided in its teaching kits, *iWorx* provides a variety of experiments in electronic lab manuals. To support these experiments, *iWorx* has created settings groups that contain links to settings files for each experiment in that group. Once a settings group is loaded, the settings files within the group can be called from a list in the Settings menu.

Calling a Settings File



The Settings menu.

To load a settings group and the settings files for the experiments:

Select Load Group from the Settings menu. This will open the LabScribe folder, which contains the Settings folder. From the Settings folder, choose the settings group file (settings group files will be of type *.iwxgrp) that you wish to load, and click Open. The Complete settings group loads automatically by default.

The settings files are organized into categories. Once a settings group is loaded, the experimental categories appear by name in the lower bracket of the Settings menu. To open a specific settings file, select the appropriate category to display the experiments in that category. Highlight the name of the file and click it. The settings file associated with that experiment will load into LabScribe and set the appropriate parameters for recording and displaying data.

Each settings file opened from the Settings menu is associated with helper files, which are .pdf documents of the laboratory exercise. Opening the exercise's settings file will also open the experiment's Setup file. Other helper files associated with the experiment can be opened by choosing them from the Experiment menu.

Main Window Display Considerations

Recorded data have two important dimensions: time and amplitude. Each of these has its own set of controls.

Managing the Display Time

The events recorded using LabScribe occur over very different time frames. For example recording the discharge curve of a 9-volt battery takes hours, while recording the QRS complex in a human electrocardiogram takes only a fraction of a second. LabScribe allows the recording of both very slow and very fast events while displaying the data in a format that is easily interpreted. To manage the time component of recorded data, a parameter called Display Time is used. Display Time is the amount of time represented by one full screen of data. When the program opens, the default Display Time is set to 10 seconds. Settings files for specific lab exercises may set a different Display Time. Display Time can be changed by the user by using the display controls in the Toolbar, or by manually entering a Display Time on the Channel page of the Preferences Dialog, which is launched by selecting Preferences in the Edit menu in Windows, or in the LabScribe menu on the Macintosh.

Using the Toolbar icons to control Display Time:

Clicking the Half Display Time icon (icon with the big mountain) in the Toolbar halves the screen time. If you clicked this icon once, a 10-second full-screen display would become a 5-second, full-screen display. This doubles the screen resolution, but cuts the amount of data seen on the screen in half. Using the Half Display Time tool expands the record as many times as requested, until there are only 10 data points on a screen of data. By the time this happens, the data will usually appear to "flatline" and events on this scale will not be recognizable. The Half Display Time command can also be accessed through the View menu's Display submenu.

Half Display Time

Zoom Between Cursors

Double Display Time

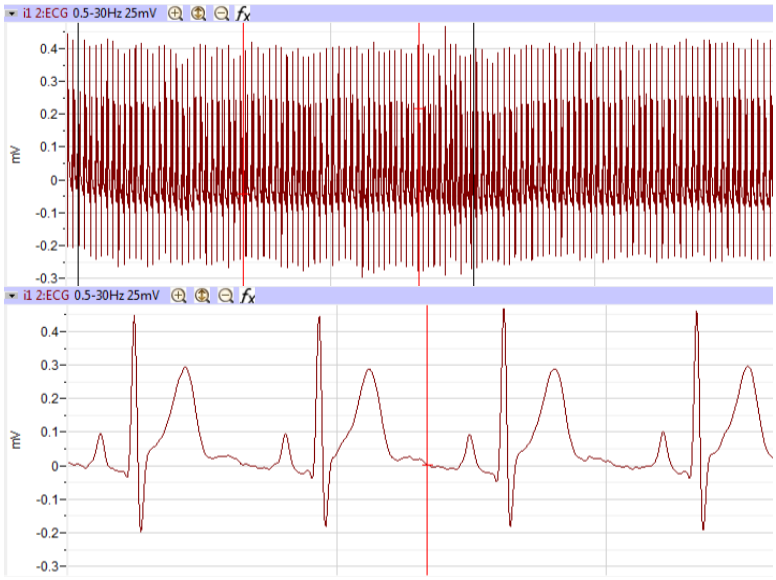
Display Time icons in the Main Window Toolbar.

Clicking the Double Display Time icon (icon with the two smaller mountain peaks) in the Toolbar doubles the screen time. In this case, a 10-second, full-screen display would become 20-seconds wide. This reduces the screen resolution by half, but doubles the amount of data that you see on the screen. The display time can be doubled as many times as requested until the limit of the maximum size of the data file or as many as 1,000,000 data points are displayed on one screen. By default, the maximum number of data points that may be displayed on the screen is 100,000. This can be changed on the Options page of the Preferences Dialog. The Double Display Time command can also be accessed through the View menu's Display submenu.

In Two Cursor Mode, clicking the Zoom Between Cursors icon fills the display with the data located between the cursors. You can undo the Zoom Between Cursors by choosing Undo Zoom Between Cursors in the Display submenu in the View menu.

There is a scrollbar at the bottom of the window that can be used to scroll through the data. Scrolling can also be achieved by holding down the CRTL key (COMMAND on the Macintosh) and clicking and dragging in the graph window.

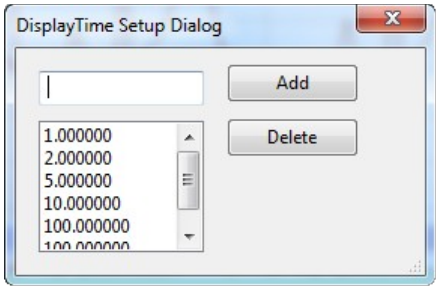
In this example, a human electrocardiogram is recorded with a 160-second screen time. Notice that the record is compressed and it is impossible to resolve detail in individual events. By clicking Half Display Time five times, the screen time is reduced from 160 seconds to about five seconds, making individual events clearly visible.



ECG viewed with a long Display Time (top) and a short Display Time (bottom).

Display Time Setup Dialog

Setting the display time to a specific value can be done on the Channel page of the Preferences Dialog. To switch between certain known display time values, using the Preferences Dialog can be cumbersome.



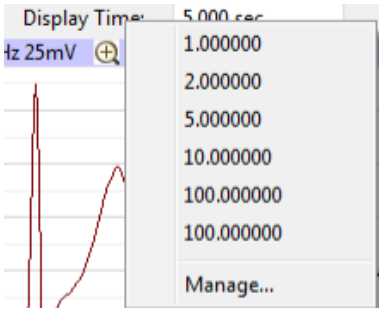
Specific display time values can be added to the Display Time menu directly beneath the Toolbar by using LabScribe's Display Time Setup Dialog.

To access the Display Time Setup Dialog:

Click on the Display Time label (just beneath the Toolbar) and choose Manage.... This brings up the Display Time Setup Dialog.

Enter the value of the desired display time (in seconds) in the text box, and click the Add button. This will add the desired display time to the list of display times. Once all the desired display times have been added, click OK to exit the dialog.

When you click on the Display Time label just below the Toolbar again, you will see the added values in the Display Time menu.



Display Time presets menu.

Choosing any of the preset display times will set the display time to the chosen value.

Managing Amplitude Display

The vertical display of the recorded signal is managed in a number of ways. In addition to the Toolbar icons, there is a Scale submenu available from the Channel Menu (accessed by clicking on the arrow on the left side of the Channel Bar or right-clicking anywhere in the data channel). Right-clicking on the values in the Y-Axis on the left hand side of each channel will also display the Scale submenu.

- Zoom In, AutoScale and Zoom Out can be controlled using the Toolbar icons or by using the commands in the Scale submenu. The other options in the Scale submenu are: Set Scale and Preferred Scale.
- Zoom Tools: The Zoom In, AutoScale and Zoom Out icons in each Channel Bar control the vertical display in that channel.

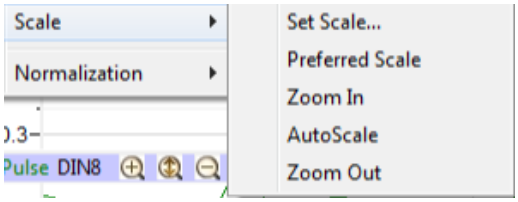
The Zoom Tools

- Clicking the Zoom In icon will increase the displayed amplitude of the trace.
- AutoScale locates the highest and lowest data points in the channel. It then adjusts the Y-scale range to include those points, optimizing the amplitude of the channel's data.
- Clicking the Zoom Out icon will reduce the displayed amplitude of the trace by a factor of two.

- Zoom In, AutoScale and Zoom Out can also be controlled using the commands in the Scale submenu found in the Channel menu.

Scroll Up/Down: When the Zoom tools are used, the data may drift above or below the center of the display area, or even move out of the display range. To adjust the position of the trace on a channel, click on the waveform and drag it to the desired position.

Set Scale: The range of the amplitude scale can be set manually by entering the lower and upper levels in the Set Scale dialog. The possible range will be limited by the iWorx data acquisition unit in use (±5 V or ±10 V).



The Scale submenu.

Preferred Scale: For any data, there is a range within which the Y values of the signal are most likely to occur. For example, if measuring room temperature, the user might select a range of 50oF to 100°F because it is unlikely that room temperature will be colder or warmer than these limits.

To set the range of the Preferred Scale, choose the Set Scale option from the Scale submenu and enter the upper and lower limits of Y-scale in the Set Scale dialog window that appears. The range will be limited by the hardware in use (±5 V or ±10 V).

To display the Preferred Scale you have specified, select the Preferred Scale option from the Scale submenu.

If an event outside the Preferred Scale occurs during the recording, the area of interest can be expanded using the Zoom or AutoScale tools. To return to the Preferred Scale, select the Preferred Scale option from the Scale submenu.

Signal Conditioning

Gain

There is a minimum voltage that the A/D Converter can display. The specific voltage depends on the iWorx data acquisition unit in use. If the signal being measured is smaller than this minimum voltage, additional gain can be applied to the signal before it is presented to the A/D Converter by using a bioamplifier.

For example, consider an ECG with a total peak to peak amplitude of only 2 mV. Because of its voltage limitations, the A/D Converter is not sensitive enough to record any meaningful changes to a signal this small. The signal is often smaller than the noise level, and it's not possible to distinguish the signal from the noise. If an amplifier is placed between the signal and the A/D Converter, the raw signal can be amplified by a selected gain. If the gain is 100 times (X100), the 2 mV ECG signal becomes a 200 mV

signal. Now, when the amplified signal is presented to the A/D Converter, it is 100 times bigger, and large enough for the A/D Converter to display it accurately and distinguish it from the noise.

Adding gain to the recording system improves the signal to noise ratio of the measuring system, but the A/D Converter is still limited to a total range of ± 5V or ±10V, depending on the A/D Converter in use. In the case where X100 gain is applied to a 0.2 V signal, the amplified signal becomes +20 V, which is outside the input limit of the A/D Converter and the signal goes out of range. If a gain of X10 is used on an amplifier with a total range of ±10 V, the effective input range of the A/D Converter drops to ±1 V (±10 V range and X10 gain). Any input signal larger than 1 V will be out of range. If a gain of X100 is applied to the input signal, the effective input range of the A/D Converter is restricted to ±0.1 V.

Bioamplifiers

The bioamplifier channels of the iWorx A/D converters or iWire devices apply gain to the input signals coming through them. The gain and filter modes of channels equipped with a bioamplifier are selected from the Mode/Function menu on the Channels page of the Preferences dialog window (accessed from the Edit menu in Windows or from the LabScribe menu on the Macintosh), or the Mode/Function button drop-down menu in the Channel Bar of the raw data channels with a bioamplifier input. The LabScribe settings files set the appropriate mode for each experiment that uses channels equipped with bioamplifiers.

DIN8 Inputs

The DIN8 inputs on iWorx A/D Converters can apply up to X1000 gain. This is accomplished through the placement of a gain programming resistor within the DIN8 connector of the transducer or cable that can be plugged into the DIN8 inputs of the iWorx units. Gain programming resistors are already present in iWorx transducers. Gain programming resistors can be installed on non-iWorx transducers by rewiring the connector. Consult the hardware documentation for the pin configurations and diagrams of the DIN8 connectors used with iWorx A/D Converters.

Offset

Offset is sometimes referred to as “positioning”. Some recorders, amplifiers, and transducers have a knob that positions the baseline of the recording on the screen. The positioning control permits the signal to be centered in the data window, making measurements more convenient and lowering the baseline to accommodate the display of a signal that has more gain applied to it. The availability of the AutoScale feature in the LabScribe software reduces the need for a positioning knob. In fact, the very low noise of the iWorx A/D Converters makes positioning controls unnecessary for many transducers as signals are automatically centered and expanded to fill the recording screen when the AutoScale button is clicked. Positioning of the waveform may be also be accomplished by clicking on the waveform and dragging it to the desired position within the channel. Some transducers still require a positioning control in order to position the trace within the data channel, and these iWorx transducers come equipped with an offset control.

Filters

Filters can be set to remove certain frequencies from signals. The goal of filtering is to remove noise from the recording while passing those frequencies that make up the signal of interest. There are two basic types of electronic filters: Low Pass and High Pass. When used in combination with each other, these filters can create either Band Pass or Band Reject (Notch) filters.

By definition, Low Pass filters pass only those frequencies below the set frequency. As an example, a large percentage of ECG signal information is contained in frequencies below 40 Hz. A significant noise source in such recordings is the 60 Hz line voltage (from 110 VAC power, or mains) used to power equipment and lights. A 50 Hz Low Pass filter allows all frequencies below 50 Hz (including most ECG information) to pass to the recorder, but excludes all frequencies above 50 Hz, including the 60 Hz noise from the mains. Applying the 50 Hz Low Pass filter creates a quieter, more readable ECG. In general, the application of a low pass filter “quiets” high frequency noise and improves the signal to noise ratio of the recording.

On the other hand, High Pass filters pass frequencies higher than the set frequency. These filters can remove low frequency interference, such as slow baseline drift or a standing offset voltage, so that the user sees a more stable baseline. The signals of interest (extracellularly recorded action potentials) in neuronal extracellular recordings are of a very high frequency, while there is little of biological interest in the lower frequencies, so High Pass filters are used to filter out both 60 Hz noise and slower oscillations that would otherwise cause the trace to drift in and out of the data channel.

The simultaneous use of High Pass and Low Pass filters can create a Band Pass filter. Several different analog band pass filters are available for the bioamplifiers on the iWorx A/D Converters. These Band Pass filters are enabled automatically when they are selected from the Mode/Function menu on the Channels page of the Preferences dialog window, or from the Mode/Function button drop-down menu in the Channel Bar of channels equipped with bioamplifiers. The appropriate filters are set by the settings files of experiments that require these bioamplifier filters.

High Pass, Low Pass and Band Pass filters can also be applied to each channel and displayed in a computed channel by using one of the Filter functions available from the add function button on the Channel Bar of each channel. These filters are not hardware filters; they are executed in software and work on all A/D Converters running LabScribe. Unlike hardware filters, software filters can be applied after the data are recorded. These filters also work in real time and can be applied to data during recording. More detailed descriptions of these digital filters can be found starting on page 86 in Chapter 5: Computed Channels.

Averaging

In addition to filtering, LabScribe can apply another quieting technique to data recorded at sampling rates lower than 200 samples per second. While fast events require fast sampling speeds, when slow events are recorded at fast sampling speeds, more information is collected than is needed to accurately display the signal. At sampling speeds of 100 samples per second or less, the LabScribe program operates on the “extra data” using a technique similar to the oversampling employed by CD players to reduce noise. The amount of oversampling that occurs is determined by the sample speed that you set. The end result is that small signals recorded at slow speed will appear less noisy than small signals recorded at high speed.

Outboard Conditioning

The built-in amplifiers and filters in iWorx A/D Converters should be adequate for most applications. In cases where additional or custom signal conditioning is required, outboard devices can be used to condition the signal before it is presented to the iWorx hardware. iWorx makes a full range of amplifiers for this purpose, but any amplifier with an analog output can be used. This allows other amplifiers, like those from Thornton or Grass, or special purpose devices, like those made by Warner Instruments, Axon Instruments, or World Precision Instruments, to be used with iWorx data acquisition units. Outputs from these and other devices can be connected to the un-amplified BNC inputs on the front panel of iWorx data acquisition systems. Outputs of external devices can also be connected to the DIN8 inputs with an adapter cable available from iWorx.

Chart Mode

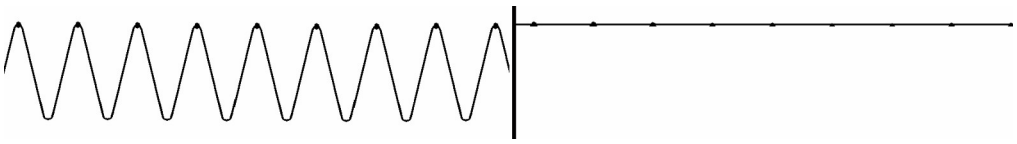
Once the signal source is connected to the iWorx unit and the signal conditioners are configured, data recording can begin. The most basic controls required are the ones that turn the recording on and off. LabScribe can start a recording manually, after a predetermined delay, or when triggered by a specific event or condition. A recording can be stopped manually or after a predetermined amount of time. Before recording begins, an appropriate sampling speed must be determined.

Selecting a Sampling Speed

Temporal resolution in digitally recorded data is determined by the sampling rate (sampling speed).

The iWorx A/D Converter takes voltage measurements at regular intervals. The voltage measurements (Y-axis values) and the times at which the voltages were recorded (X-axis values) are interpreted by the LabScribe software as a pair of (X,Y) coordinates. LabScribe plots these coordinates as data points. The software then connects the data points with a line to create the smooth, graphical appearance of an analog chart recording. Only the data points themselves are hard measurements. The connecting lines are “educated guesses” made by the software and will not accurately model the real data if the sampling speed, or the rate at which the data are sampled, is not fast enough for the data being recorded. To avoid creating recordings that may be inaccurate, the sampling interval needs to be short enough to insure that no important events occur between the sampled data points.

In the example below, a sine wave with a frequency of 100Hz has been sent to the A/D Converter. In the graph on the left, the data points recorded by an A/D Converter set to the same sampling speed as the frequency of the sine wave, are marked at the top of each cycle. Because the sine wave has the same frequency as the sampling rate, each recorded data point occurs at the same place in each cycle of the sine wave. The graph on the right shows that a straight line is the result when the data points are connected. To render a more accurate representation of the data, a faster sampling speed is required. How fast does the sampling speed need to be to record a reasonable representation of a real waveform? A general rule of thumb is to sample at a rate that is a minimum of five times faster than the fastest frequency of interest in the waveform.



On the left, a 100Hz sine wave appears as displayed on an analog recording device. On the right , the same sine wave appears as a line when recorded on an analog-digital recording device at 100Hz sampling rate, the same frequency as the wave.

To determine the optimal sampling frequency, find the shortest event in a sample recording. For example, the R wave has the shortest duration of any event in an ECG and should be used to determine the sampling speed needed to record an accurate representation of the ECG. Next, find the rise time (in seconds) of the R wave. The rise time is the time it takes the event of interest to go from its start to about 2/3 of its full amplitude. In the case of the R wave in an ECG, this value is about 20 milliseconds (0.020 seconds).

Substitute the value 0.02 for the rise time in the following equation to determine the bandwidth of the event (R wave):

0.159 / RiseTime = Bandwidth

(0.159 / 0.020) = 8

Multiply the bandwidth by five to determine the minimum sampling frequency needed, which in this example is 40 Hz. Higher sampling rates represent the data more accurately, but this accuracy comes at the expense of larger data files. The optimal sampling speed strikes a balance between the accurate portrayal of the data and the unwieldy size of the data file.

The default LabScribe sampling speed is 200 samples per second. This is adequate to execute many of the laboratory experiments presented in the online iWorx laboratory manuals. Some experiments utilize higher or lower sampling rates appropriate to the data being acquired.

Sampling speed can also be set experimentally. Start sampling the data at the fastest speed possible. Then, slowly reduce the sampling rate to a speed where data initially begins to degrade. Finally, set the sampling speed just above the rate that initially causes degradation.

Sampling rates are set from the Speed menu on the Channel page of the Preferences Dialog, accessed from the Edit menu in Windows or the LabScribe menu on the Macintosh.

The speeds displayed in the Speed menu are rates per second per channel. The maximum available sampling speed will vary depending on how many raw data channels are open.

SAMPLING SPEED EXERCISE

1) Using the Tutorial exercise as a guide, prepare to record some pulse transducer data.
2) Open the Channel page in the Preferences Dialog and set the sampling speed to 1,000 samples per second and the Display Time to 10 seconds. Record 10 seconds of data.

3) Next, set the sampling speed to 500 samples/second and record an additional 10 seconds of data.

4) Repeat this procedure for sampling speeds of 200, 100, 50, 20 and 10 samples/second.

5) Display a section of each recording block in the Main Window. Closely examine the recorded data as displayed in the Main Window. Notice that the signal becomes progressively more coarse as the sampling rates go down, until eventually the signal is unrecognizable.

Vertical Resolution

When making a measurement of length with a ruler, the accuracy of the measurement is determined by how many gradations are printed on the ruler. Clearly, a ruler with gradations every eighth of an inch allows more precise measurements than a ruler with a gradation every inch. The more lines or gradations there are per unit of measure, the more accurate the ruler.

If the A/D Converter is considered to be a ruler for voltage, then its resolution (its number of gradations) is determined by a parameter called “bit depth.”

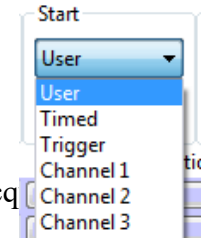
In an 8-bit word, or a byte, there are 256 (28) different possibilities for the value of the byte. A 9-bit word has twice that many possibilities (512), a 10-bit word has four times as many (1024) and so on. In a 16-bit A/D Converter, there are 65,536 different possibilities, while a system using a 24-bit A/D Converter provides 16,777,216 possibilities. The Digital Resolution of the A/D Converter is its voltage input range divided by the number of possible A/D Converter steps. This is the minimum amplitude measurement possible with the A/D Converter.

If the input range of a 16 bit A/D Converter is 10 V, dividing by 65,536 gives a minimum measurement of152 µV. Individual iWorx data acquisition units are capable of different Digital Resolutions.

It is not possible to make a measurement with more precision than the Digital Resolution unless the bit depth is increased or the input range is narrowed. Changing the bit depth requires a different A/D Converter to be placed in the unit. However, the input range can be narrowed easily by applying amplification (gain) to the signal before the signal is presented to the A/D Converter. If a X1000 gain is applied to the incoming signal by an amplifier, the minimum resolution of a 16-bit A/D Converter improves to152 nV.

Note: The actual resolution of the system depends on both the resolution of the analog input device and the digital resolution of the A/D Converter. It is important to consider the resolution of the system as a whole.

Starting Recording



The Start dialog.

The Start dialog on the Channel page of the Preferences Dialog (accessed from the Edit menu in Windows or the LabScribe menu on the Macintosh) shows the options for starting the acquisition process. Recording can be started manually (User), delayed for a specific amount of time after the Record button is clicked (Timed), triggered by a specific event from an external TTL device (Trigger), or triggered by an event or condition on one of the data channels.

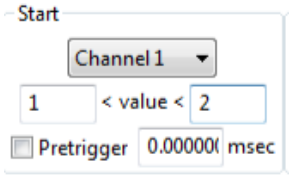
User: The simplest way to start the recording is to click the Record button in the upper right hand corner of the LabScribe Main Window. User is the default setting in LabScribe. Recording begins when the user presses the Record button, and will continue until one of the Stop conditions is met. Pretriggering is not possible in the User or Timed mode.

Timed: If desired, the recording of data can be delayed for a user-specified fixed duration by choosing Timed and entering the desired value in the Wait (sec) text box of the Start Dialog.

External Trigger: It may be necessary to synchronize the beginning of the recording with the beginning of an external event. LabScribe can be configured to start recording when the iWorx hardware detects a voltage pulse (+3 V to +5 V amplitude) through the BNC connector of the Trigger input. Many devices have Trigger or TTL outputs that are capable of starting the LabScribe recording software. These devices include stimulators, relays, pumps, valves, and cameras.

Triggered from Channel: An experiment may demand that data recording begin when the data meet certain criteria. For example, it may be necessary to record an animal's body temperature only if body temperature exceeds 100°F. LabScribe can be programmed to begin recording when the data on the temperature channel exceeds 100°F. Recording is triggered when data values enter the window between two threshold values.

To set triggering thresholds:



Options for Triggering from a data channel.

Open the Preferences Dialog (from the Edit menu in Windows or the LabScribe menu on the Macintosh) and click on the tab for the Channel page.

Pull down the Start menu and select the channel that contains the data to be used as a trigger.

Set the values that the data must meet before recording is triggered. In this example, LabScribe is programmed to look for a trigger from the data on Channel 1 when the amplitude of the data is above 1.5 V and below 2 V.

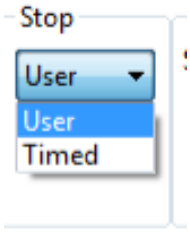
Pretriggering: When an external trigger or a trigger from a data channel is programmed, the data just before the trigger occurs may be important to record as well. For example, if the R wave is used to trigger the recording of an ECG, the P wave and other parts of the ECG that occur before the R wave can be recorded. The Pretrigger feature of the LabScribe software can be used to look back in time and display a small piece of data prior to the trigger.

To enable Pretriggering:

In either Trigger or Channel (1-4) mode, check the box next to Pretrigger in the Start area on the Channel page of the Preferences Dialog.

Enter the desired Pretrigger time in the Pretrigger text bo

Stopping Recording



The Stop dialog.

Once recording begins, the LabScribe programs offers two different ways to halt the recording: User or Timed. Each time recording starts and stops represents a data block, indicated on the display by a vertical line separating the blocks.

User: User is the default Stop mode for LabScribe and can be reset from the Stop box on the Channel page in the Preferences dialog. In User mode, the Stop button in the upper right hand corner of the LabScribe Main Window will stop the recording when clicked. The Record button changes to Stop after the Record button is clicked to begin the recording. The Stop button remains visible until it is clicked. Clicking the Stop button will change it back to Record.

Timed: When Timed is selected as the Stop mode, LabScribe will stop recording automatically after a predetermined time (in seconds) that has been entered into the text box.

Preview Mode

It is possible to preview or monitor data acquisition without saving the data to disk. This is accomplished by clicking on the Preview icon to the right of the Toolbar in the Main Window. When LabScribe is operating in Preview mode, a red “X” covers the icon and the acquisition screen is dimmed. Clicking the

icon again will allow the recorded data to be saved. It is important to remember to disable Preview when you want to save the data to disk. No data acquired in Preview mode can be saved.

Scope Mode

When to Use the Scope Mode

The first devices used to record data were electromechanical. These devices used a stylus or very fine pen that was moved by a sensitive motor. The frequency response of these machines was very low; the fastest events that they could record were on the order of tenths of a second. The need to record faster events was solved by the introduction of the oscilloscope. An oscilloscope is able to take a fast, brief “snapshot” of an event, but continuous chart-like recording is sacrificed.

To effectively use Scope mode in LabScribe, the length of the snapshot (display time) and the sampling rate need to be set to visualize the event with accuracy. Events that are best captured using Scope mode are brief and repetitive. Action potentials and other neurophysiological events are good examples of signals that are best recorded in Scope mode.

In addition to being able to capture a very brief event in time, a proper trigger is needed to begin the recording of the event at the moment it takes place. If the “snapshot” occurs too soon or too late, it may not show the event of interest. The acquisition of data at the right moment requires a proper trigger. In Scope mode either of the previously discussed triggering methods, external Trigger or Trigger from Channel, can be used to start the sweep.

Acquiring Data in the Scope Mode

Scope mode can be enabled from the Channel page in the Preferences Dialog, which is accessible in the Edit menu in Windows and the LabScribe menu on the Macintosh.

Data acquired in Scope mode can be viewed in either Chart or Scope format. Switching between formats is done by changing the acquisition mode in the Channel Page of the Preferences Dialog. When viewing Scope data in Chart format, each sweep is treated as a block of data. When viewed in Chart mode, sweeps are laid end to end, in the order that they were acquired, divided by block separation lines. Data can be continuously scrolled.

Data recorded in Chart mode can be viewed in Scope format. Each data block is treated as one sweep.

Existing text in the Marks Text box, will be automatically get added as a mark in the sweep, when recording is started in scopemode.

Setting Up the Software

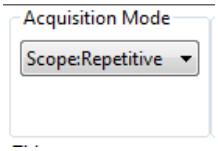
To program LabScribe to record in Scope mode:

Select Preferences from the Edit menu in Windows, or the LabScribe menu on the Macintosh.
Open the Channel page of the Preferences Dialog.
Select the appropriate Scope acquisition mode. The acquisition mode can be set to either Repetitive, Multiple or Averaged.
Set the Start mode that will begin the recording of the sweep. The available Start modes are the same as those in Chart mode:

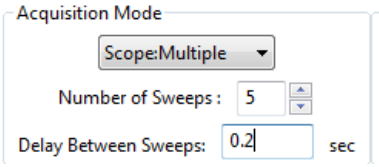
User: Recording starts when the user clicks Record.
Trigger: Recording starts with a signal from an external TTL source connected to the Trigger input of the A/D Converter. Because the Trigger input is being monitored for this signal, it is possible to see data occurring before the signal by setting the amount of time in the Pretrigger text box.

Channel 1, 2, 3, or 4: Recording starts when a predetermined data condition is met on the selected channel. The user enters the low and high threshold values in the appropriate boxes, and the Pretrigger time (if desired) in the Pretrigger text box.
Timed: Recording starts after an amount of time programmed by the user in the Wait (sec) box.

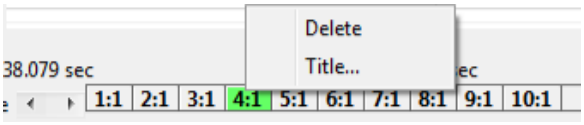
Repetitive Mode: When the Record button is clicked in Repetitive mode, each new sweep overwrites the previous sweep. While digital oscilloscopes can save a number of sweeps, analog oscilloscopes work in this way. When the Stop button is clicked, only the last trace is saved.



Multiple Sweep Mode: When the Record button is clicked in Multiple Sweep mode, LabScribe will acquire and save a predetermined number of sweeps. These sweeps will be grouped together, which helps in analyzing the data. The number of sweeps in a series can be set in the Number of Sweeps box on the Channel page of the Preferences Dialog. The beginning of each recorded sweep is determined by the Start mode conditions. A Delay Between Sweeps can also be programmed in the Multiple Sweep mode. If zero is selected as the Delay Between Sweeps, the next sweep in the series is taken as soon as the software is ready.



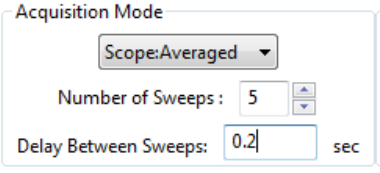
After recording, individual sweeps can be selected and viewed by clicking on the corresponding sweep number in the Sweep Selection Bar at the bottom of the screen. The RIGHT and LEFT arrow keys on the computer keyboard can be used to cycle through the sweeps on the Sweep Selection Bar. Right-clicking on a sweep number opens a drop-down menu allowing that sweep to be titled or deleted.



Sweep Selection Bar and drop-down menu.

In the Analysis window the groups of the sweeps can be analyzed together. The average of the multiple sweeps can viewed.

Averaged Mode: When the Record button is clicked in Averaged mode, LabScribe will record the user-specified Number of Sweeps, but will only save and display one sweep representing the average of all the individual recorded sweeps.



Sweep Length: When operating in Scope mode, LabScribe takes “snapshots” of data. Each “snapshot” is called a sweep and has a pre-determined length. The sweep length (or Stop Time) is set in the Stop mode box of the Channel page from the Preferences Dialog. By choosing Timed as the Stop Mode, the sweep length (in seconds) can be entered into the Stop mode edit box. Although used less frequently as a way to stop recording in Scope mode, each sweep can be ended manually by setting the Stop mode to User and clicking the Stop button when the sweep has acquired the desired data.

Sampling Rate: The optimal sampling frequency in Scope mode can be determined by the same procedure used in Chart mode. First, find the quickest event in the record. If the compound action potential is used as an example, the spike goes from baseline to about 80% of its full amplitude in about 0.00035 s. If you substitute 0.00035 s for the rise time in the following equation:

0.159 / RiseTime = Bandwidth

(0.159 / 0.00035) = 454

Multiply the bandwidth by five and the minimum sampling frequency is 2270 Hz. Doubling the sampling rate to 5 kHz ensures that the trace recorded is representative of the signal. If the entire event of interest is only 0.1 seconds long, a sweep at 5,000 samples per second uses only 500 data points. Since LabScribe can accommodate up to 1,000,000 points per screen while recording, there is substantial room available for longer individual sweeps or a faster sampling rate.

Saving Your Data

Every software manual has a section on the importance of backup and saving. LabScribe is no different.

SAVE YOUR DATA!

Consider that the data acquisition process imposes unique demands on the task of saving data. A word processor or spreadsheet document can be saved anytime that the user thinks about it. Most applications can also save data automatically, at regular intervals, and in the background.

In a data acquisition application, data are constantly being added, sometimes at remarkably high rates (200,000 data points/second at top speed). To save data, the recording would have to be stopped. In most recording applications, this is impractical.

Whenever it’s practical to do so, when recording is stopped, the user should instruct LabScribe to save the current data to disk. As a safeguard, LabScribe buffers the unsaved raw data to a file on the hard disk. In the event of an unexpected loss of power or computer crash, the data are preserved. When the LabScribe software is reopened after such an event, LabScribe will ask the user if they want to recover the data. If the answer is yes, the backup file is recovered and data are preserved. To permanently save the data, a new file should be created by using the Save As function before recording any new data.

4: Preferences and Settings

In addition to using LabScribe's pre-loaded preferences and settings, it is possible to modify or create your own Preferences and Settings.

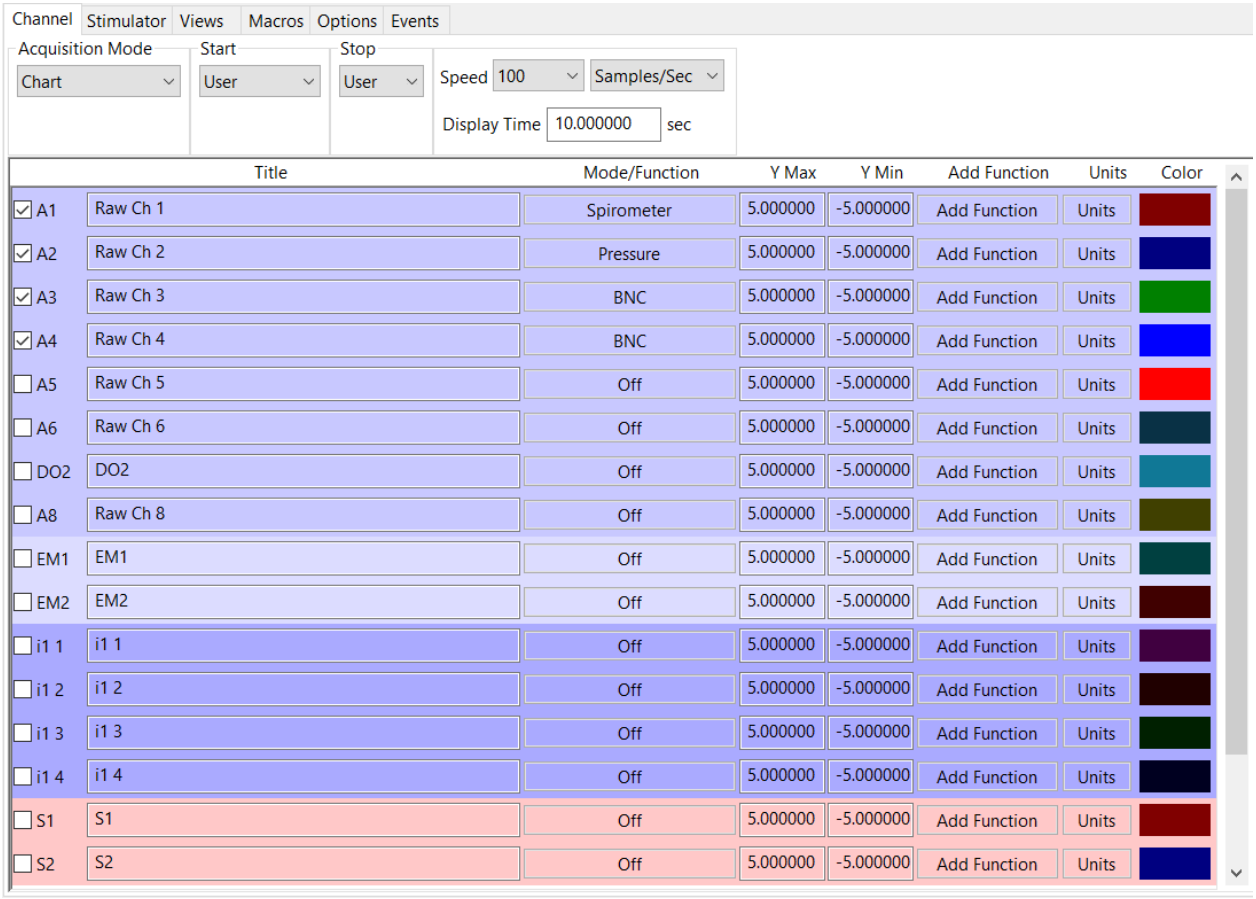
The Preferences Dialog

The Preferences Dialog can be accessed from the Edit menu in Windows and the LabScribe menu on the Macintosh. There are six tabbed pages in the Preferences Dialog. Details concerning the setup and use of many Preferences can be found in the relevant chapters of this manual.

When setting up Preferences and Settings for a new lab exercise, starting from the default values will make the process easier, as you will not be constrained by changes that have been made for other exercises. It is also possible to make the process easier by finding a similar experiment from among the LabScribe experiments, one that uses a similar system or technique, and use those settings as a starting point.

Channel Page

Many of the display parameters for each channel, as well as the recording parameters for data collection



channels, and the function of each computed channel, can be set on the Channel page of the Preferences Dialog.

Some of the Preferences set on the Channel page apply to all channels (refer to the discussion in Chapter 3: Acquisition):

Acquisition Mode: Sets the type of acquisition: Chart, or one of the three Scope modes.

Start: Sets the parameters that start the recording. The user can start the recording manually, recording can start a pre-determined amount of time after Record is clicked, or the start of recording can be triggered by an external event or by an event or condition on another channel.

Stop: Sets the parameters to stop recording. Recording can be stopped manually by the user or after a pre-determined amount of time after recording starts.

Speed: Sets the number of samples taken every second on each channel.

The Preferences that can be set for each individual channel include:

Title...: Edits the title of each channel to better identify the parameter being recorded (titles can also be edited in the individual Channel Menus of the Main Window).

Mode/Function: For raw data channels, clicking the Mode/Function button displays the input choices. These vary depending on the specific iWorx data acquisition unit. The filters applied to hardware channels with bioamplifiers can be selected, or the BNC or DIN8 input can be selected. On computed channels, clicking the Mode/Function button will display a list of the functions that can be

applied to that channel instead of the one currently applied. Despite changing the function, it will still be computed from the same channel as the previous choice unless configured otherwise. Refer to Chapter 5: Computed Channels for a discussion of the functions available and how to configure them.

Y Max, Y Min: Sets the maximum and minimum Y-axis values. These values can also be set in the Scale sub-menu of the Channel menu, or by right-clicking on the Y-axis. It is important to remember that each iWorx data acquisition unit is capable of recording a certain range of amplitude values, and not to set Y Max and Y Min outside these values.

add function: Adds a computed function to a channel. Add function opens an additional channel that will display the function computed from the data in the chosen channel. The add function control can also be found on the individual Channel Bars. Refer to Chapter 6: Computed Channels for a discussion of the functions available.

Units: Used to convert two raw data values in volts to the corresponding calculated values in units appropriate to the data being recorded. For more information refer to the Units Conversion discussion beginning on page 16 of Chapter 1: The Display.

Color...: Sets the color of the channel's trace. This can also be set from each individual Channel Menu.

Stimulator Page

Some iWorx data acquisition units contain a Digital to Analog converter that can function as a stimulator for use in experiments on excitable tissues. The stimulator(s) can be configured on the Stimulator page of the Preferences Dialog. There are potentially six stimulator protocols: Pulse, Train, Constant, Step, Ramp and Triangle. The appropriate parameter values for each of these modes can be preset and made part of a settings file. Refer to Chapter 5: The Stimulator for information on programming the stimulator.

Views Page

LabScribe can display various arrangements of the channels in the Main and Analysis Windows. Refer to page 15 of Chapter 1: The Display for information on configuring Views.

Sequences Page

The operation of the internal stimulator and, on iWorx data acquisition units with digital outputs, some external devices can be automated by building a sequence of events that is triggered by selecting the Sequence button on the Toolbar in the Main Window. Presentation of images and sounds can also be sequenced. Refer to the Sequences sections of Chapter 5: The Stimulator (starting on page 70) and Chapter 9: Digital Input and Output (starting on page 245) for information on building Sequences.

Options Page

Various aspects of the display are configured on the Options Page. Preferences configured here are saved and are applied to both the current and future files.

Options Page of the Preferences Dialog.

The Display options configured on the Options page include:

Channel Bar colors: The color of the raw data, computed channel, stimulator output and digital input Channel Bars can be chosen.
Grid characteristics: Sets the color of the grid lines in the channel windows, as well as the number of minor grid lines between y-axis numbers.
Graph parameters: It is possible to set the background color of the channel windows and the width of the trace line.
Cursor characteristics: The cursor color and width can be set, as can the cursor mouse click width.
Block separators: The width and color of the line separating recording blocks can be set.Mark characteristics: The mark line color and width can be changed.

The Main Window Functions box allows the user to select the functions that appear in the add function list accessed in the Main Window.

The following Data characteristics can be set on the Options page:

Data display precision: Sets the number of digits of precision displayed.
Data Separator: Set the type of data separator to be used for exporting data to the Journal.
Maximum display points: The maximum number of data points that can be displayed on a screen of data. The default value is 100,000 points. This can be increased on the Options page, but it should be noted that files with more data points, and a faster sampling speed, take up more of the computer's memory.

There are a few options associated with the use of the Advanced Analysis modules.

Advanced Analysis Button adds a module-specific moveable toolbar in the Main Window for one-button access to the module's offline calculations dialog.
Metabolic Analysis Type determines whether Mixing Chamber or Breath by Breath parameters are measured in the Metabolic advanced analysis module.
Clicking Experiment Server Port establishes a port connection with LabScribe in order to enable the sending of information from OpenSesame. This is used in conjunction with the OpenSesame experimental design software.

Events Page

As LabScribe acquires data, it is aware of the value of each data point as it happens. It is possible to instruct the software to watch for values above or below a specified level and have LabScribe advise the user when such conditions are met. In LabScribe, such an occurrence is called an Event. These Events can trigger output Sequences. Refer to Chapter 9: Digital Input and Output for a complete discussion of Sequences.

Controls for Events programming.

There are two types of events: Channel Events and Timed Events.

Channel Events: In the detection of Channel Events, one channel is monitored for Events that meet designated criteria. To set up LabScribe's detection of an Event:

In the Channel box, choose the channel to be monitored.
Choose the Type of Event detection:
No Triggering: The detection of the Event will not trigger the initiation of a sequence.
Positive Edge Triggered: The data have to pass from below the Low Threshold to above the High Threshold in order to be detected as an Event.
Negative Edge Trigger: The data have to pass from above the High Threshold to below the Low Threshold.
In Window: An Event is detected if the data values enter the window between the Low and High Thresholds and remain there.
Out of Window: An Event is detected if data previously contained within the Threshold window (between Low and High Thresholds) move outside the window.
The positions of the Low and High Thresholds are set depending on the type of data being recorded and the type of triggering that has been set. The thresholds can be chosen by entering data values in the Low and High Threshold boxes, or setting the values by moving the threshold lines in the graphical data sample.
Enable event detection by checking the checkbox.

Timed Events: Timed Events trigger a sequence after a designated amount of time has passed. To set the criteria for the detection of a Timed Event:

Choose Timed as the Type of Event and set the Time (in seconds) that should pass befor Events are detected, and after a previous Event if more than one is programmed.
Set the Count, or the number of events to be detected. Set the Count to zero for continuous Events occurring at the programmed Time interval.
Enable the event detection by checking the checkbox.

Event Priority

The Event Priority is set in relation to other Events. Sequences triggered by Events inherit their priority from the triggering Event. A higher priority Event can stop a lower priority Sequence, but a lower priority Event cannot stop a higher priority Sequence.

If a Sequence is manually triggered by the user, the trigger is considered a User Event with a priority of 50. Any Events with a higher priority than 50 will interrupt a user initiated Sequence, while Events with a lower priority than the User Event cannot interrupt a user initiated Sequence.

An Event can start in an enabled or disabled state. A disabled Event is ignored, but it can be enabled by other Events. The Enable Events and Disable Events boxes determine which Events enable or disable other Events. The Event being configured will enable Events highlighted in the Enable Events box, and will disable Events in the Disable Events box, regardless of relative priorities.

In the example shown on page 133 of Chapter 9: Digital Input and Output, the Pulse channel is being monitored for a positive threshold crossing from below 0.67804 to above 0.900062. The Event has a priority of 50 and is enabled to trigger the Sequence "Start Pump" when the triggering criteria are satisfied. This event will also enable “event3” and “event4”, while disabling “event2”.

The Settings Menu

LabScribe offers users several choices for recording and displaying data. When certain choices are used repeatedly, a template known as a settings file can be created to reduce the time required to program the recording software and the A/D Converter.

To understand how to create and use Settings, two terms need to be defined: settings group and settings file. A settings group is actually a simple text document that can contain links to individual settings files. Each settings file is a collection of settings for performing an experiment and is configured by using display controls and the options on the various pages of the Preferences Dialog. The settings contained in a file determine the number and titles of channels in the LabScribe windows, the sampling speed, the units conversions, the stimulator settings, and more.

LabScribe experiments use preconfigured settings files. Users can modify these settings or design their own settings groups and files. They can also associate their own settings files with documentation (experimental procedures, protocols, instructions, lab exercises) of their own design.

Creating a New Settings File

To create a settings file:

Configure LabScribe with the settings necessary to do the experiment. For example, go to the Channel page in the Preferences dialog window and select the number of channels needed, their titles and any functions that are needed to display or interpret the data. Stimulator settings, sequence outputs, a specific display arrangement, and even options like the colors of channel bars and traces can be set through the pages in the Preferences Dialog. Refer to the first part of this chapter for more detailed instructions.

Each experiment can have a a difficulty level and an aim associated with it. These can be attached to the settings file in the Document Settings dialog accessed from the File menu. The difficulty level for each setting is visible in the Difficulty column.

Saving a Settings File

Using the File menu:

- Click on the File menu and choose Save As. A Save File dialog will appear. In the Save as type drop-down box at the bottom of the dialog, choose Settings (*.iwxset). Using the file browser, choose a location on your computer where you want to save the settings file. We recommend that you create a “My Settings” folder in a location that you have write permissions to, such as the Documents folder in your home directory.
- Name the file and click Save.

Loading a Settings File into a Settings Group

If you have previously created a folder for your own settings (as described above), you can add your settings folder to the Available Settings library by clicking on the Add Folder to Library button and navigating to the desired folder location.

To add a settings file from the folder to the Current Settings Group, open the folder and select the settings file by clicking on it. Select the desired folder from the right pane, and click the right-facing arrow between the panes. You can add settings files from the list of Available Settings to any category or at the root level. Settings added to the root level are listed in the Current Settings Group below the designated categories.

Clicking Remove Folder from Library will remove a selected folder from the Available Settings.

Working with Settings Groups in the Settings Manager

To create a new settings group, click the New button in the Current Settings Group area. This will remove the current group and clear the Current Settings Group box. Click Save to name the group (it will be given a .iwxgrp suffix) and place the settings group file in the folder with your settings.

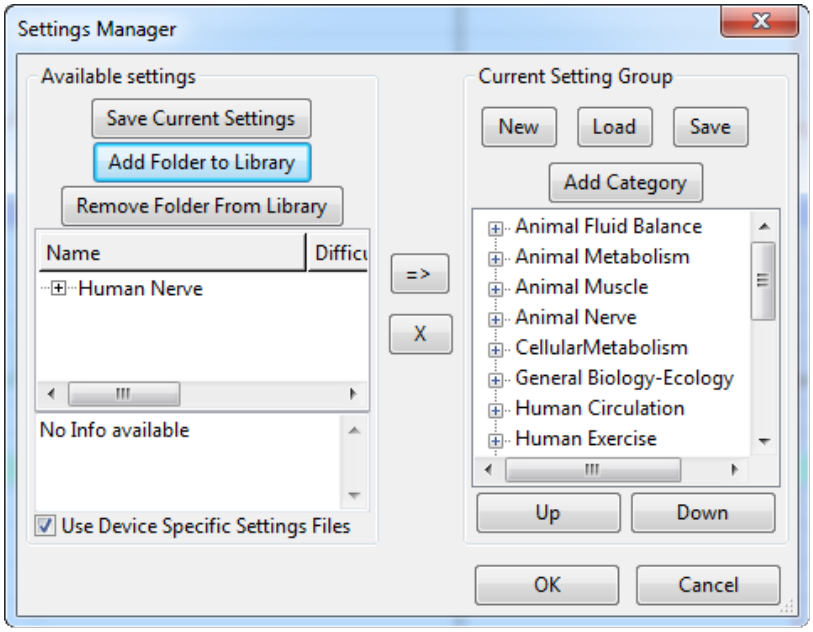
To load an existing group, click on the Load button in the Current Settings Group area. This will open a dialog where you can choose the settings group to load. Settings group files will have a .iwxgrp suffix. The settings files in the new settings group will now be displayed in the Current Settings Group window.

To create a new category in any settings group, click on the Add Category button and name the category.

The category order can be changed by selecting a category in the Current Settings Group and moving it up or down the list with the Up or Down buttons.

Clicking Save will allow the user to save the folders in the Current Settings Group pane as a settings group.

Category folders can be removed from the Current Settings Group by clicking on the X between the panes.



The Settings manager.

Helper Files

Helper files are documents with experimental instructions, diagrams and illustrations that can be linked to settings files and displayed on the computer screen when a settings file is selected. When a preconfigured iWorx settings group is loaded, a .pdf copy of each individual lab experiment is linked to the corresponding settings file in the settings group. When you select a settings file to do a particular experiment, a .pdf copy of the linked helper file (the experimental write-up) opens in Acrobat Reader. You now have a set of instructions, on the computer screen, to follow as you do the experiment. Alternatively, the .pdf file can be printed, edited in a .pdf editor, or uploaded to a content management system such as Blackboard.

Users can attach their helper files to their own or pre-existing settings files. Although iWorx Systems has chosen to attach .pdf documents to its setting files, any file (html, Microsoft Word, Open Office, etc.) can be linked to a settings file.

To associate helper files with any settings file:

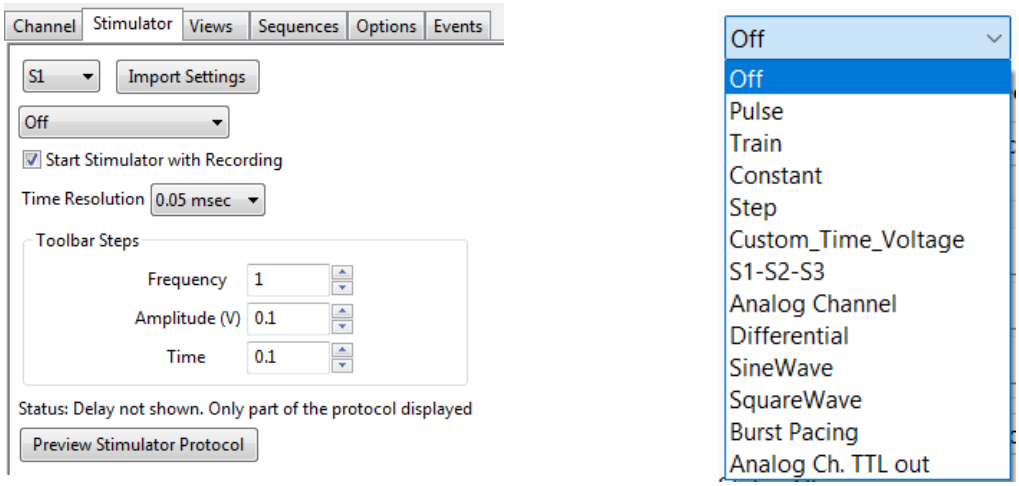
Place your helper files in the same folder as the settings file and give the helper file the same name as the settings file, but with the appropriate extension. For example, to associate a .pdf, an html and a .jpg file with the Tutorial.iwxset settings file, copy the .pdf, the html and the .jpg file to the same folder as the Tutorial.iwxset settings file. Name the .pdf file “Tutorial.pdf”, the html file ”Tutorial.html”, and the .jpg file ”Tutorial.jpg”. Now when the Tutorial settings file is chosen in LabScribe, the Tutorial.pdf, the Tutorial.html and the Tutorial.jpg files will be opened as well.

5: The Stimulator

Some iWorx data acquisition units contain stimulators capable of sending controlled current to the stimulating electrodes used in experiments involving excitable tissues like nerves and muscles. Both isolated low-voltage stimulators, suitable for animal nerve and muscle stimulation, and isolated high-voltage stimulators (HVS), designed to safely stimulate nerves and muscles in human subjects, are available. They do this through the use of internal Digital-to-Analog Converters (D/A Converters). The Stimulator page in the Preferences Dialog box controls the stimulator functions. It can be reached by selecting Preferences from the Edit menu in Windows or from the LabScribe menu on the Macintosh. Using controls described in this chapter, output protocols can be built that deliver current to the stimulating electrodes.

Stimulator Preferences

The Stimulator Preferences page sets up the parameters and protocols of the stimulator output. It also sets the parameters of the Stimulator Control Panel, which opens directly beneath the Toolbar in the Main Window when the Stimulator icon in the Toolbar is clicked. The Stimulator Control Panel can also be opened by selecting Stimulator in the View menu. The Stimulator Control Panel allows the user to change many of the Stimulator output parameters directly from the Main Window during recording.



The Stimulator Preferences panel

Some of the settings in the Stimulator Preferences are common to all stimulator output protocols:

iWorx Systems manufactures A/D Converters with different D/A Converter configurations. In units with single or multiple D/A Converters, each D/A Converter can be controlled independently. The Stimulator selection drop-down box (set in this example to Stim1) allows selection of the Stimulator to be configured.

For devices with multiple stimulators, an Import Settings button (not shown here) allows the user to copy settings from one stimulator to another.

Output modes can be selected using the Mode drop-down menu (set in this example to Off). The available modes are: Pulse, Train, Constant (voltage), Step, Triangle, Ramp, S1-S2-S3, Analog Output, Sinewave, Square wave, Burst Pacing, Buffer Analog Input Channel, TTL based on Analog Input Channel . Some modes are available only on some iWorx data acquisition units. The Bipolar checkbox (not shown here) allows the creation of bipolar pulses.

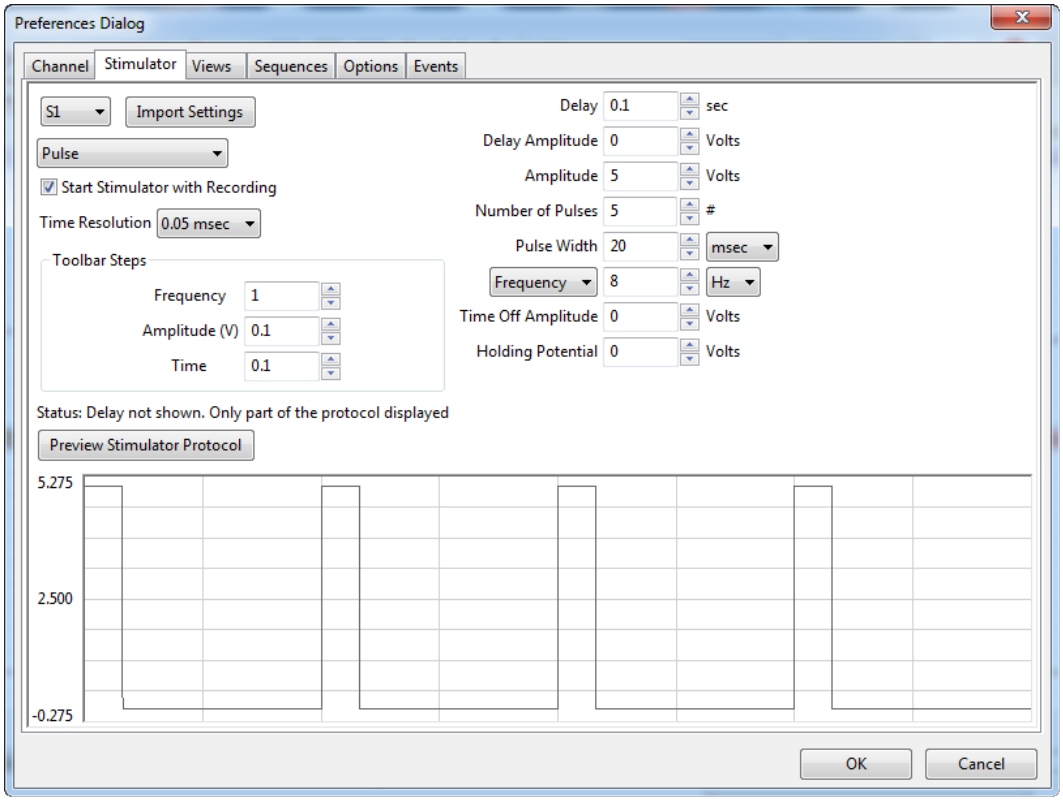
By checking the Start Stimulator with Recording checkbox, the stimulator can be set to fire when recording commences.

Time Resolution: The finer the Time Resolution, the shorter the maximum time duration for each parameter. For example, at a 0.04 msec Time Resolution the maximum Delay is 600 ms. At 0.4 ms this increases to six seconds, while at the 4 msec resolution the maximum Delay is 60 seconds. Individual iWorx data acquisition units are capable of different Time Resolutions. The software configures itself depending on the hardware selected and will limit the available range of values for each parameter accordingly.

Toolbar Steps: This selection determines the minimum step increments that the Stimulator Control Panel will use when the up/down buttons on the Control Panel are clicked. These are also the increments used by Sequences that program the stimulator output.

Pulse Protocols

Current pulses are delivered according to parameters set by the user in the boxes of the Stimulator Preferences page of the Preferences Dialog window.



The Stimulator Preferences panel of the Preferences Dialog, configured to set up Pulse protocols.

Building Output Protocols in Pulse Mode

By setting the Mode drop-down menu to Pulse, the relevant parameters for Pulse protocols are displayed in the dialog. In order to understand how the protocols are created, it is necessary to define the terms used on the Stimulator page of the Preferences Dialog:

Delay: This is the time between the clicking of the Record button to start recording and the first current pulse. This Delay is adjustable, and the maximum Delay varies with individual iWorx data acquisition units.

Amplitude: This is the height or voltage of the Pulse or wave being generated. The Amplitude programmed from the Preferences window will be the same for all Pulses leaving the stimulus output unless the Amplitude is changed manually from the Preferences window or the Stimulator Control Panel, or automatically from a programmed Sequence (described more completely later in the chapter).

Number of Pulses: The total number of pulses that will be sent from the stimulator output.

Note: In order to produce continuous pulses, the Number of Pulses must be set to zero.

Pulse Width: The pulse is the basic unit of an output protocol and it has two basic dimensions: Amplitude, as described above, and duration. The duration of the pulse is also called Pulse Width.

Pulse Frequency: This is the number of programmed pulses that are delivered in one second. The maximum frequency that can be set is dependent on the pulse duration. If the pulses are too long for the chosen frequency, they will overlap, and the voltage output will be continuous and not pulsed. The Pulse Width cannot be longer than the inverse of the frequency (also called the period). Pulse Frequency is chosen from the Frequency/Time Off submenu.

Time Off: This is the inter-pulse duration, the amount of time between two consecutive pulses. Pulse Frequency is 1/(Pulse Width + Time Off). Time Off is chosen from the Frequency/Time Off submenu.

Holding Potential: This is a voltage that can be programmed to shift the resting membrane voltage of an excitable tissue (like a neuron). It is known as a holding voltage because it can be used to hyperpolarize the membrane potential of an excitable tissue and hold it at a level hyperpolarized enough to prevent spiking. Individual iWorx data acquisition devices have different possible voltage output limitations, and the Holding Potential is limited to a value within this range.

To record and display stimulus pulses as in the examples that follow, the Stimulator channel should be turned on in the Channel page of the Preferences Dialog window.

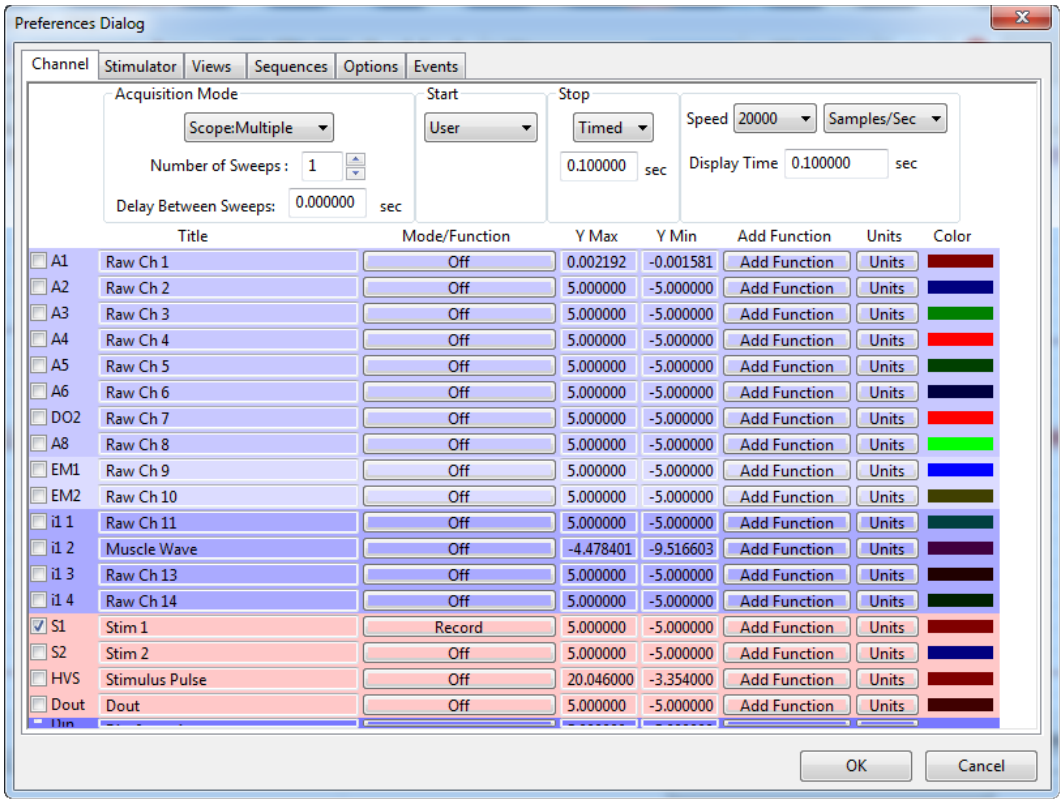
Note: While it is possible to record and display the stimulator voltage by routing the stimulator output to one of the hardware recording inputs, the Stimulator channel makes this unnecessary. Never connect both the positive (red) and the negative (black) banana outputs of a data acquisition unit to its own inputs, as this causes a short circuit that could damage the amplifier. These red and black outputs can be connected to other devices (nerve chambers, stimulating electrodes, and more), but not to its own inputs.

The following exercise will take you step by step through the construction of two different Pulse protocols.

PULSE MODE STIMULATOR EXERCISE

To construct and record some examples of stimulus pulses, select Preferences from the Edit menu. On the Channel page of the Preferences Dialog:

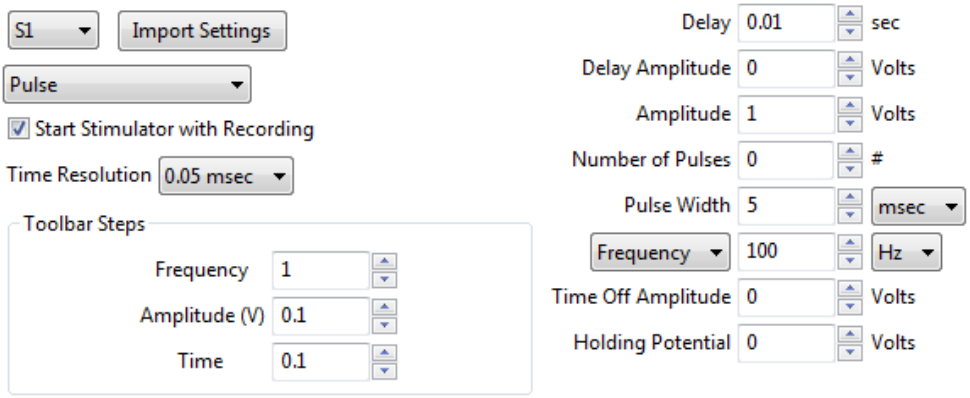
Set the sampling Speed to 10000 samples/sec, and the Display Time to 0.5 sec.
De-select the Raw Ch 1-4 by removing any checks in the checkboxes on the left.
Select the Stim1 channel, check its checkbox, and set it to Record the stimulator.



Channels page of the Preferences Dialog set for the pulse mode exercise.

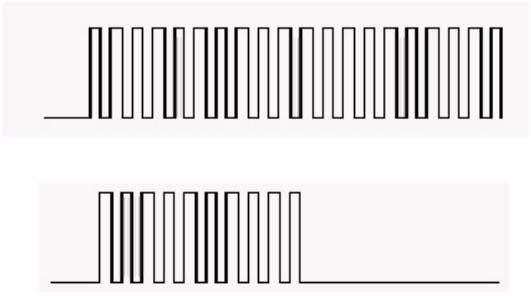
1. Open the Stimulator page of the Preferences Dialog and select Pulse from the mode box in the upper left corner of the page.

2. Enter the following values into the appropriate boxes on the Stimulator page:



These settings will create a protocol that delivers continuous square waves with 1V amplitude and 100Hz frequency.

1. Click the Record button. The D/A Converter will wait 100 milliseconds (the Delay value entered) and begin to deliver 5ms pulses at the rate of 100 pulses per second. Each pulse will be 1V high. These Pulse parameters can be adjusted in any way with one exception: the Pulse Width cannot be longer than the inverse of the frequency (or the period). In this example, the Pulse Width cannot be longer than the period of 10ms or the pulse will overlap the next pulse. The percentage of the period occupied by the Pulse Width is known as the duty cycle.
2. Next, use the same settings, with one exception, to produce a short burst of pulses. Set the Number of Pulses to a number other than zero. If the number 10 is entered in this box, the output from the D/A Converter would wait for 100 milliseconds after the Record signal, deliver pulses of the same amplitude and duration as before, but stop when 10 pulses have been delivered. A graphical representation of the two examples above is pictured below.

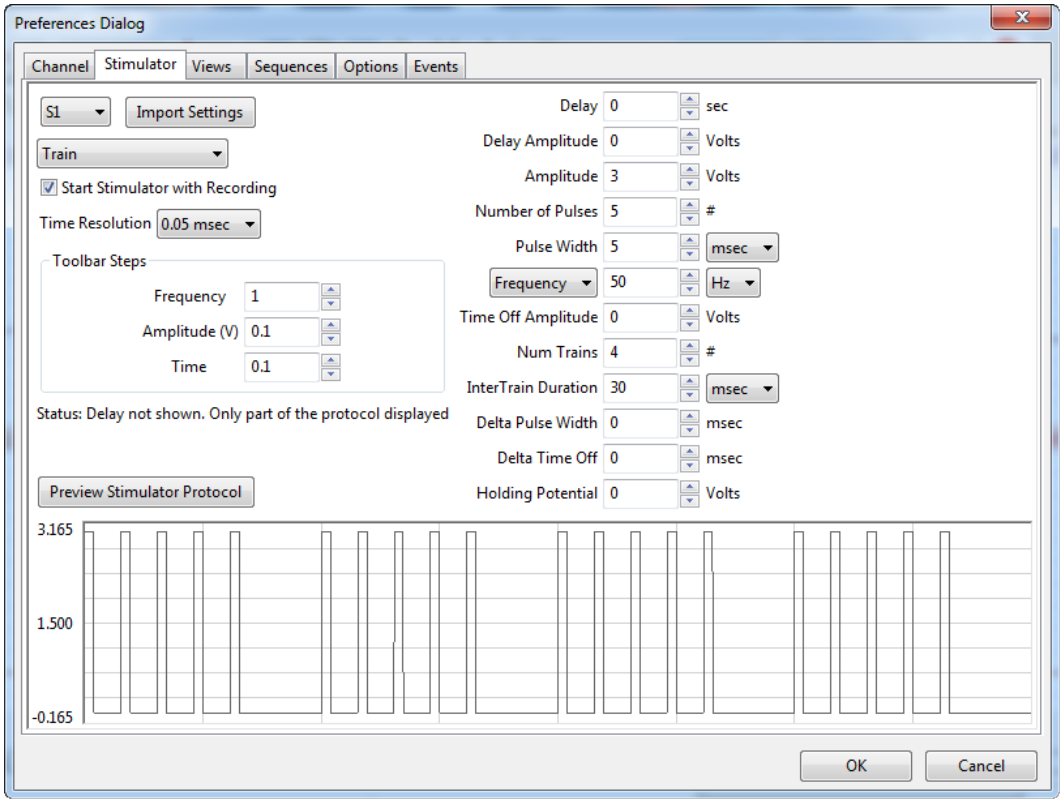


Continuous (top) and burst (bottom) of pulses that are the same amplitude, width, and frequency.

Trains of Pulses

A burst of pulses is more properly called a Train. Trains contain a specified Number of Pulses, which occur a specified number of times (Num Trains) at regular intervals (InterTrain Duration). The Train

mode is an extension of the Pulse mode so it is essential to be familiar with the Pulse mode to use the Train mode.



The parameter boxes on the Stimulator Preferences page for Train mode.

Building Output Protocols in Train Mode

In addition to the pulse parameters already described, configuring a pulse train requires that the following parameters also be set:

Num Trains: Number of Trains.

InterTrain Duration: The length of time between successive Trains or bursts.

TRAIN PROTOCOL STIMULATOR EXERCISE

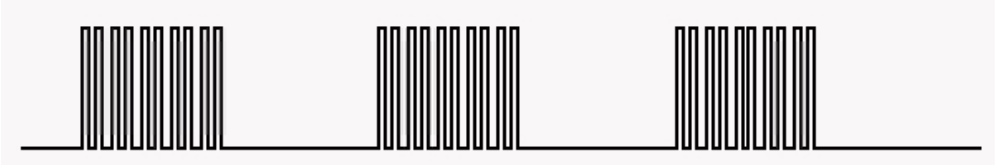
In many applications, more than one Train, or burst of pulses, must be delivered. Before the parameters of the Trains or bursts are specified, the dimensions of the pulses that will fill the bursts must be selected. After the pulse is designed, the frequency, duration, and number of trains can be programmed.

1. To construct and record examples of the Train mode, select Preferences from the Edit menu. On the Channel page of the Preferences Dialog:
   - Set the sampling Speed to 10000 samples/sec, and the Display Time to 5 sec.
   - De-select the Raw Ch 1-4 by removing any checks in the checkboxes on the left.
   - Select the Stim1 channel, check its checkbox, and set it to Record the stimulator.

2. Go to the Stimulator page of the Preferences Dialog and select Train from the Mode box in the upper left corner of the page.
3. Enter the following values into the appropriate boxes on the Stimulator page:
   - Delay: 100msec (an arbitrary value)
   - Amplitude: 1V
   - Number of Pulses: 10 (10 pulses at 100 Hz = 0.1 sec)
   - Pulse Width: 5ms
   - Pulse Frequency: 100 Hz
   - Number of Trains: 5
   - InterTrain Duration: 900ms

These settings will create a protocol that delivers a train of pulses every second. Each train will have 10 pulses with a frequency of 100 Hz. All pulses will have an amplitude of 1V and a Pulse Width of 5msec. Since a train occurs every second and is 100msec long, the time between trains, the InterTrain Duration, needs to be 900msec.

1. Click the Record button. The D/A Converter will wait 100 milliseconds (the Delay value entered) and begin to deliver ten 5ms pulses in a tenth of second. Each pulse will be 1V high. After 900 milliseconds, a second burst of ten pulses with the same parameters will occur. These bursts will appear in this manner until a total of 5 bursts have occurred.
2. If you only wanted the train or burst to repeat four times, the number 4 should be entered in the Num Trains box. The completed output protocol should look something like the figure below.



Burst of pulses separated by InterTrain Durations.

Constant Voltage Mode

Selecting the Constant (voltage) option on the Stimulator page of the Preferences dialog window disables the entry boxes for all stimulus parameters except Amplitude and Delay. When the Record button is clicked, the voltage set on the Stimulator page is delivered continuously to the low voltage output of the iWorx data acquisition unit. The voltage output terminates when the recording is stopped.

Step Mode

Step mode is used almost exclusively for voltage clamp protocols. In Step mode, the amplitude of the stimulator output can be increased or decreased in a step-wise manner.

The parameter boxes on the Stimulator page set for Step mode.

Building Output Protocols in Step Mode

In addition to the parameters already described, configuring a Step Protocol requires that the following parameters also be set:

Start Amplitude: The starting amplitude of the Steps.
Stop Amplitude: The ending amplitude of the Steps.
Number of Steps: The number of Steps in each “staircase”, or protocol.
Step Width: The duration of each individual Step.
Time Off (or InterStep Width): Time between individual Steps.
Repeat Count: The number of times the Step protocol will repeat.
Interprotocol Duration: The duration of time between the termination of one protocol (one “staircase”) and the initiation of the next.

The Amplitude of each individual Step in the protocol is determined by LabScribe with the starting and ending Amplitudes and the Number of Steps entered on the Stimulator page. The equation used to perform this calculation is:

(Start Amplitude - Stop Amplitude) / Number of Steps = Voltage Increment

If the user knows the voltage increment needed at each step, the equation can be transposed to solve for the Number of Steps required in the protocol and this value can be entered on the Stimulator page:

(Start Amplitude - Stop Amplitude) / Voltage Increment = Number of Steps

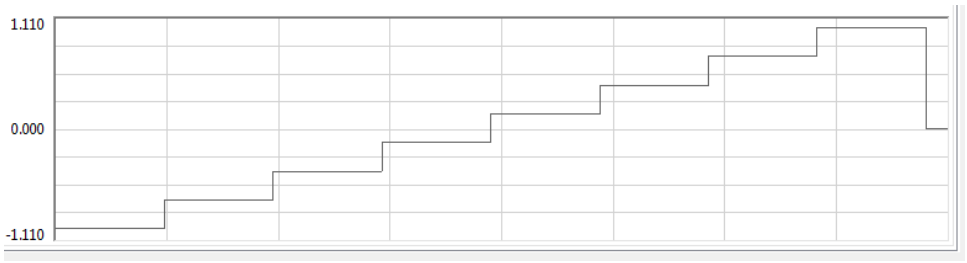
Likewise, if the user knows the previous amplitude and the voltage increment, the succeeding amplitude can be calculated:

Previous Amplitude + Voltage Increment = Succeeding Amplitude

With the starting, ending and incremental voltages set through Preferences, the voltage will change in a step-wise manner until the ending voltage is reached. The overall length of the protocol is determined by the Step Width and the time between steps, the Time Off.

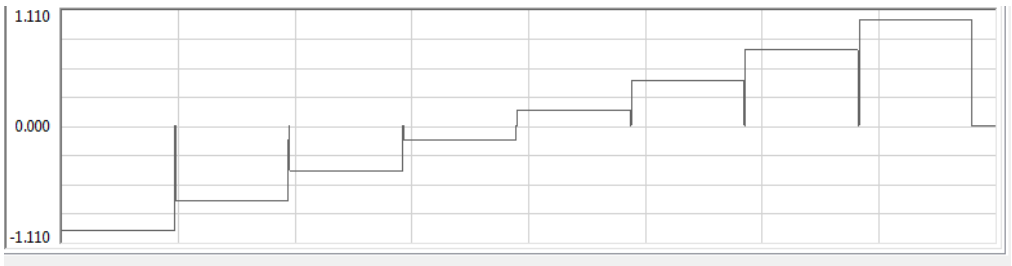
VOLTAGE STEP MODE STIMULATOR EXERCISE

1. To construct and record an example of pulses in Step mode, select Preferences from the Edit menu. On the Channel page of the Preferences Dialog:
2. Set the sampling Speed to 10000 samples/sec, and the Display Time to 2 sec.
3. De-select the Raw Ch 1-4 by removing any checks in the checkboxes on the left.
4. Select the Stim1 channel, check its checkbox, and set it to Record the stimulator.
5. Go to the Stimulator page of the Preferences dialog window and select Step from the Mode box in the upper left corner of the page.
6. Enter the following values into the appropriate boxes on the Stimulator page:
7. Delay: 0
8. Starting Amplitude: -1V
9. Ending Amplitude: 1V
10. Number of Steps: 8
11. Step Width: 100ms
12. Time Off: 0
13. Repeat Count: 1
14. Interprotocol duration: 0
15. Holding Potential: 0
16. These settings will create a waveform that starts at -1V and climbs to +1V in eight Steps. Each Step has a voltage increment of 0.25V and is 100ms wide.
17. Press the Record button. The resulting wave would be similar to the step-wise elevation of output amplitude seen in the figure below.



An example of a continuous step protocol.

1. To create a Step protocol where the voltage returns to a baseline value between Steps, alter the Time Off to a number greater than zero. The resulting wave would be similar to that seen in the figure below.



An example of a step protocol punctuated by returns to baseline between steps.

2. A Constant voltage protocol can be combined with the Step protocol to have the voltage return to a different baseline after the completion of the Step sequence. For example, setting the Holding Potential in the sample Step protocol to 500mV would cause the output Amplitude of the Stimulator to return to 500mV at the end of the Step sequence. Subsequent firings of the protocol would begin from the new baseline of 500mV, drop to the Start Amplitude in the example (-1V), step to the End Amplitude (+1V), and then return to the Holding Potential of 500mV.

Ramp Mode

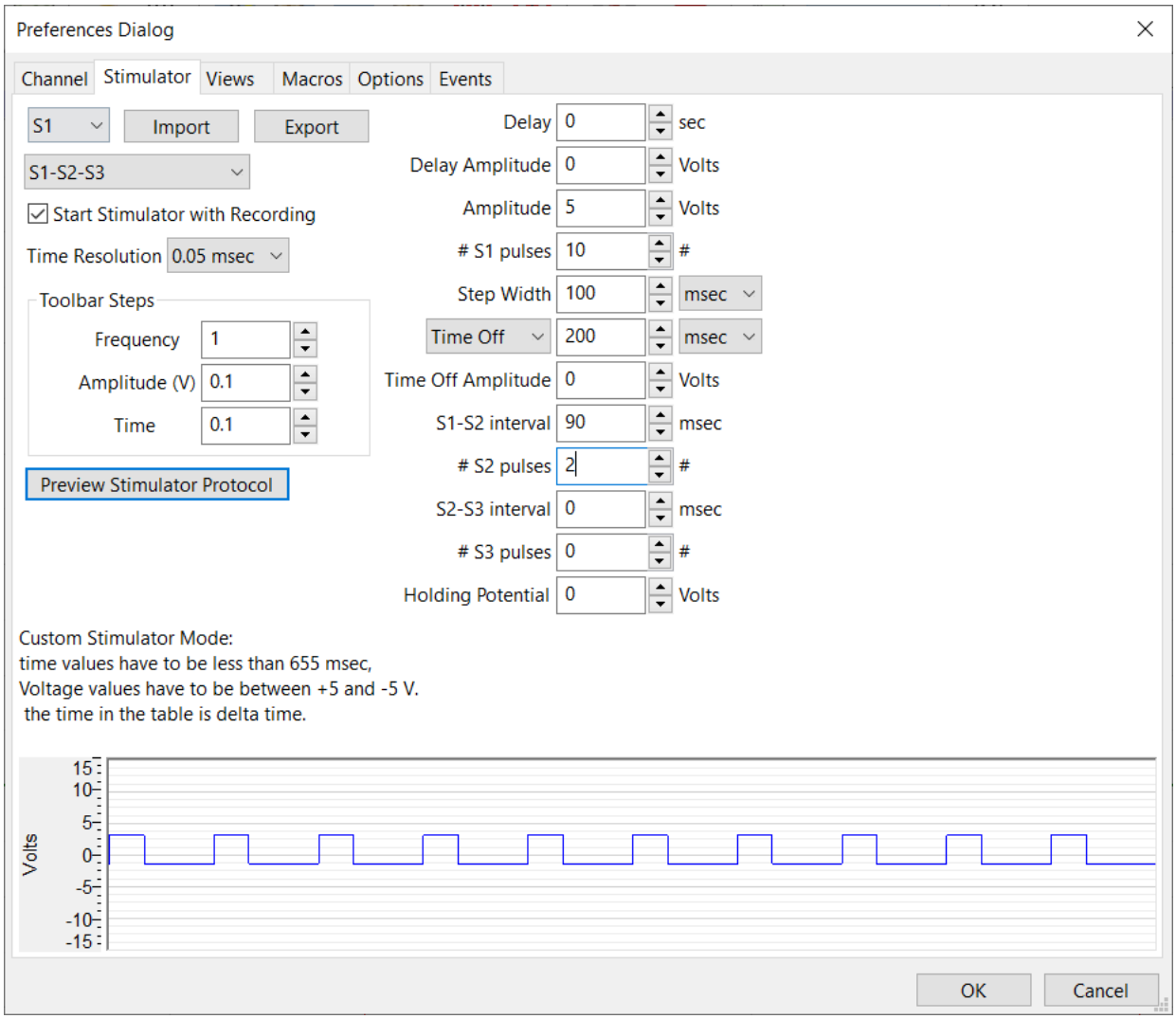
In Ramp mode, stimulator output increases or decreases periodically, as it does in Step mode, but the voltage change in Ramp mode is linear, as opposed to occurring in discrete steps. Ramp mode is only available in some iWorx data acquisition units.

In addition to the Pulse parameters already described, configuring a Ramp protocol requires that the following parameters also be set:

Triangle Mode

Triangle mode is similar to the Ramp mode, in that the voltage changes are linear. In Triangle mode, each protocol consists of an ascending and descending Ramp. Triangle mode is available only on some iWorx data acquisition units.

S1-S2-S3

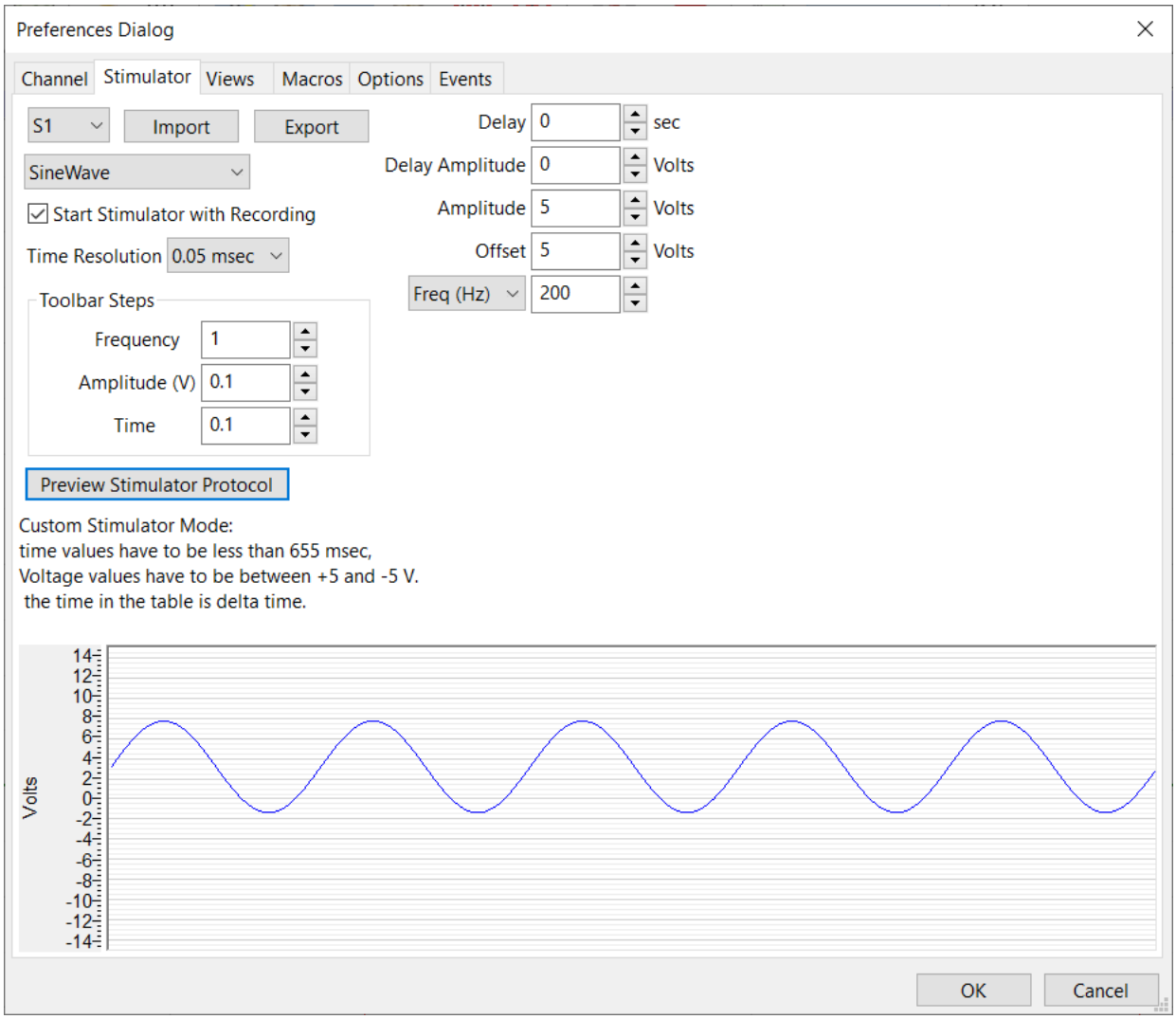


Analog Output

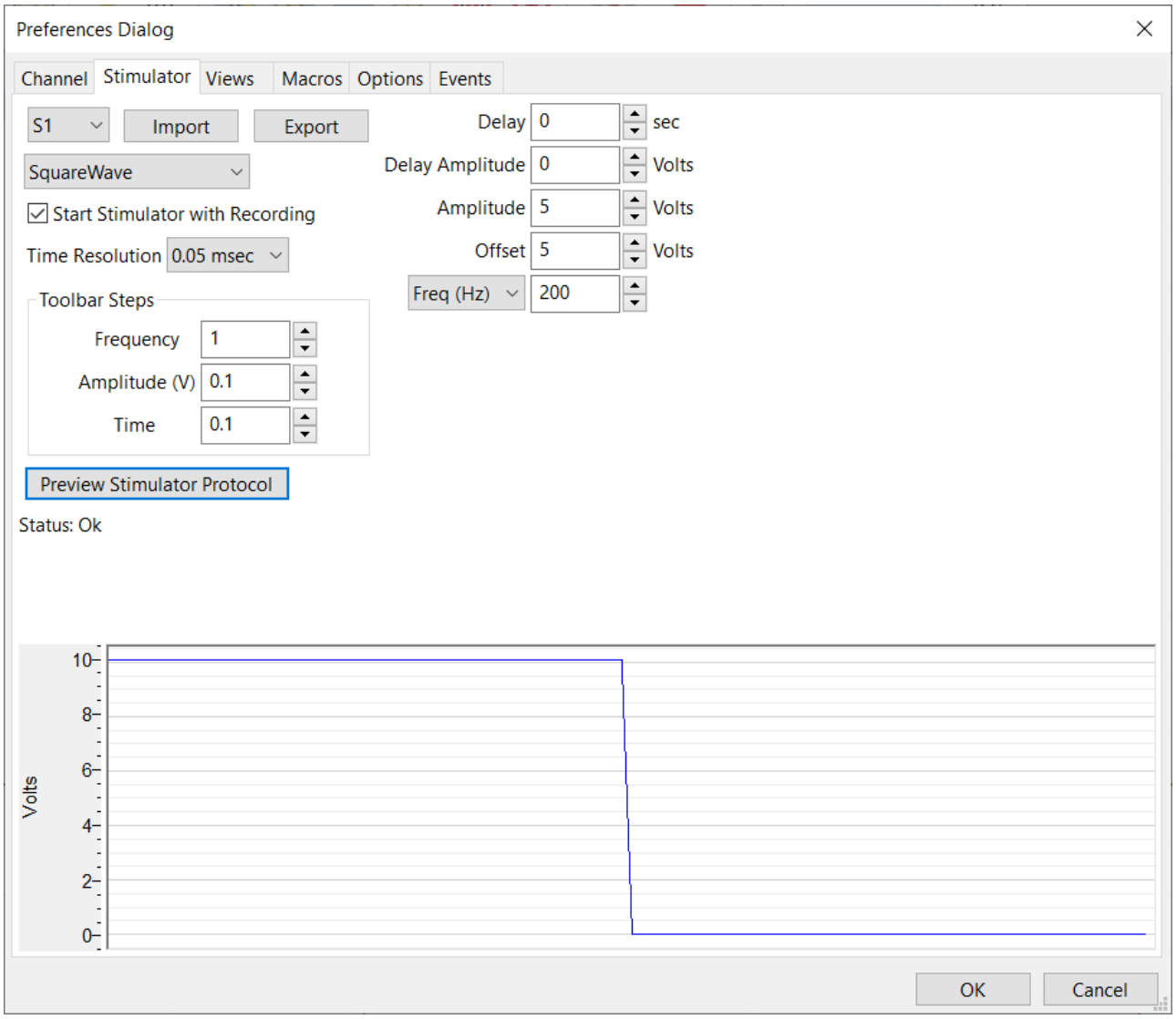
The Stimulator can be setup to output a signal that is being recorded on an input channel. For example, with the IX-TA-220, the heart sounds signal recorded on the A1 port can be output on the S1 stimulator and connected to a headphone using the A-BNC-HP, to enable a person to listen to the heart sounds.

Biopotential signals recorded from the iWire channels can also be output on the S1 and S2 stimulators of the IX-TA or the IX-RA.

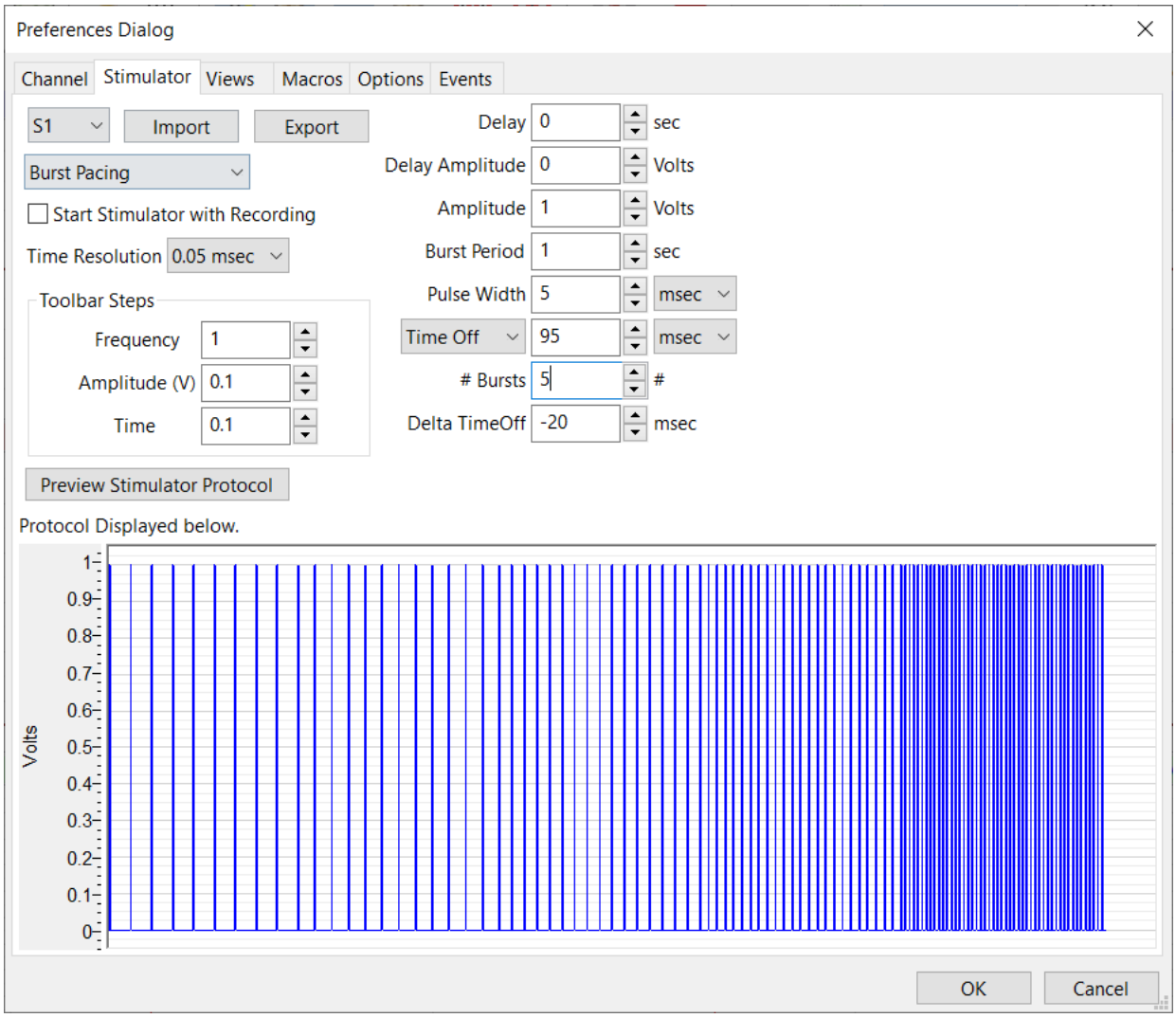
Sinewave


Preferences Dialog
Channel
Stimulator
Views
Macros
Options
Events
S1
Import
Export
SineWave
Start Stimulator with Recording
Time Resolution
0.05 msec
Toolbar Steps
Frequency
1
Amplitude (V)
0.1
Time
0.1
Preview Stimulator Protocol
Custom Stimulator Mode:
time values have to be less than 655 msec,
Voltage values have to be between +5 and -5 V.
the time in the table is delta time.
Delay
0
sec
Delay Amplitude
0
Volts
Amplitude
5
Volts
Offset
5
Volts
Freq (Hz)
200
Volts
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
OK
Cancel

Square wave

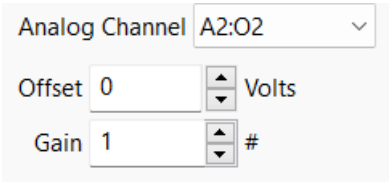

Preferences Dialog
Channel
Stimulator
Views
Macros
Options
Events
S1
Import
Export
SquareWave
Start Stimulator with Recording
Time Resolution
0.05 msec
Toolbar Steps
Frequency
1
Amplitude (V)
0.1
Time
0.1
Preview Stimulator Protocol
Status: Ok
Delay
0
sec
Delay Amplitude
0
Volts
Amplitude
5
Volts
Offset
5
Volts
Freq (Hz)
200
Volts
10
8
6
4
2
0
OK
Cancel

Burst Pacing



Note: The Stimulator Preferences dialog will draw whatever protocol you specify. Be sure to examine the output representation carefully before closing the dialog to confirm that this is in fact the output that you want.

Buffer Analog Input Channel



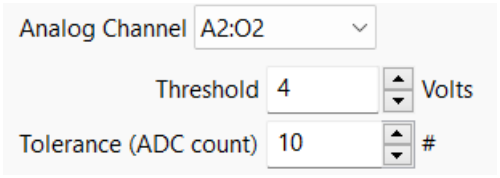
The data recorded on any analog channel can be output on some Stimulators, using the "**Analog Channel**" mode of the stimulator.

The value that is read by the ADC in the recorder is output on the stimulator. Some recorders allow the addition of an offset and gain to the signal before output.

The stimulator is a 16 bit recorder and it will convert a 16 bit value to an analog output depending on the output range of the stimulator, for eg. for the TA and RA recorders this is +/- 15V on the S1 and S2 stimulator.

Before using the gain and offset function, it is best to set the offset to 0 and the gain to 1 and see what output you get in Volts on the stimulator. Then apply an offset to the signal, see what you get and only then apply the gain.

TTL based on Analog Input Channel



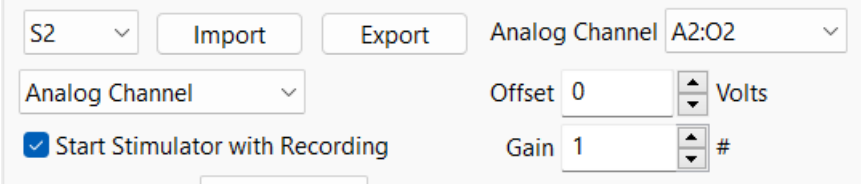
Before using the TTL output function, use the "**Analog Channel**" mode described above to see what the voltage output from the stimulator is without any gain and offset.

Then set the threshold depending on where you want the TTL output to trigger. The Tolerance is in ADC counts and is used to make sure that there is no misfirings due to noise in the record. Start with a tolerance of 10.

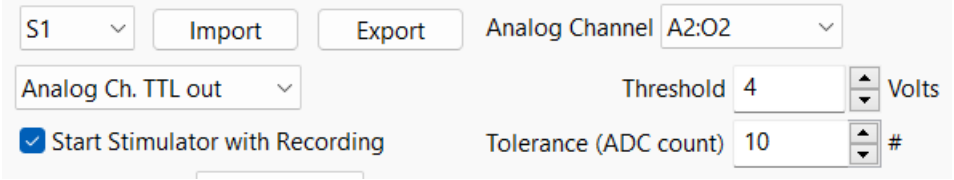
Example on using the Analog Channel and TTL output

The analog channel A2 is measuring the air pressure.

S2: is setup to output to analog channel with a gain of 1 and an offset of 0.



S1: is set to trigger



The pressure is measured in mmHg. When the pressure is output to the stimulator the output ranges from about 2.9 to 5V. We are setting the S1 stimulator to trigger at 4V

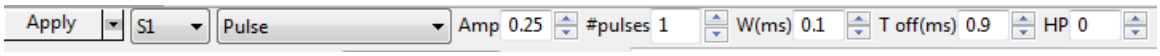
The Stimulator Control Panel

Clicking the Stimulator icon in the Toolbar, or selecting the Stimulator Panel item in the View menu will place a Stimulator Control Panel directly beneath the Toolbar in the Main Window.

The Stimulator Control Panel can be used to create a new protocol or change the parameters of a protocol that was created on the Stimulator Preferences page.

Each Stimulator mode has a unique Control Panel. The modes are described in the preceding section. The Stimulator Control Panel variations are illustrated and explained below.

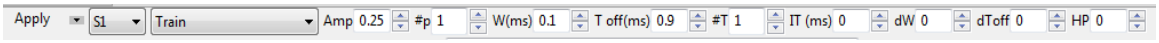
Pulse Mode Control Panel



The Stimulator Pulse Control Panel.

Amp: Amplitude of the stimulus pulse in Volts.
#pulses: Number of pulses (should be set to zero for continuous pulses).
Width(ms): Duration of the pulse in milliseconds (ms).
F(Hz): Frequency of stimulation in Hertz (Hz).
HP: Holding potential is the voltage that pulses start from and return to.
Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

Train Mode Control Panel



The Stimulator Train Control Panel.

Amp: Amplitude of the stimulus pulse in Volts.
#p: Number of pulses in each Train.
W(ms): Width of the pulse in milliseconds (ms).
F(Hz): Frequency of the pulses in each train in Hertz (Hz).
#R: Number of Trains (or Repeat Count).
IP Dur: InterTrain (or inter-protocol) duration.
HP: Holding potential is the voltage that pulses start from and return to.
Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

Step Control Panel

The Stimulator Step Control Panel.

A1: The Starting Amplitude of each protocol.
A2: The Stopping Amplitude of each protocol.
#steps: Number of Steps in each protocol.
W(ms): Width of each Step in milliseconds (ms).
F(Hz): Frequency of protocols in Hertz (Hz), OR
T Off (ms): Time between pulses
#R: Number of Step protocols (or Repeat Count).
IP Dur: Inter-protocol duration (time between “staircases”).
HP: Holding potential is the voltage that Steps start from and return to.
Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

Constant Voltage Mode Control Panel

The Stimulator Constant Voltage Control Panel.

Amplitude: Amplitude of the constant voltage.

Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

Ramp Mode Control Panel

Ramp mode is available only on some iWorx data acquisition units.

A1: The Starting Amplitude of each protocol.

A2: The Stopping Amplitude of each protocol.

Rise time: The time taken to go from the Starting Amplitude to the Stopping Amplitude.

Num Ramps: Number of Ramps.

IR: Time between Ramps (ms).

HP: Holding potential is the voltage that Ramps start from and return to.

Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

Triangle Mode Control Panel

Triangle mode is available only in some iWorx data acquisition units.

A1: The Starting Amplitude of each protocol.

A2: The Stopping Amplitude of each protocol.

Rise time: The time taken to go from the Start Amplitude to the Stop Amplitude.

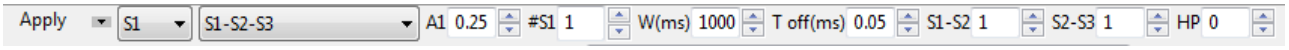
Triangles: Number of Triangles.

IR: Time between Triangles.

HP: Holding potential is the voltage that the Triangles start from and return to.

Apply: Applies any changes to the Stimulus protocol made to the Stimulator Control Panel. This button changes to Fire when recording starts. Clicking Fire while recording will send the stimulus defined by the parameters in the Control Panel. It is necessary to click on Apply when the parameters are changed. Otherwise, clicking on Fire will send an unchanged stimulus.

S1-S2-S3 Control Panel



Stimulus Protocols Built With the Macros

Experiments are often designed to record the response of a cell (or a tissue) to progressively larger or more frequent stimuli. In these cases, parameters of the stimulus are changed before each recording of

the cell's response to the next stimulus. The Macros Preferences, a tabbed page in the Preferences dialog window, can be used to automatically change parameters of the D/A Converter stimuli.

For example, excitable tissues like nerves and muscles are composed of multiple fibers, each with a different diameter, conduction velocity and threshold. Fibers with higher thresholds require a larger stimulus to evoke their action potentials. Increasing the amplitude of the stimulus sent to the excitable tissue will cause more fibers in the tissue to fire. This is known as recruitment and is measured as an increase in the amplitude of the tissue's compound action potential.

More information on using the macros refer to the **Macro** Chapter.

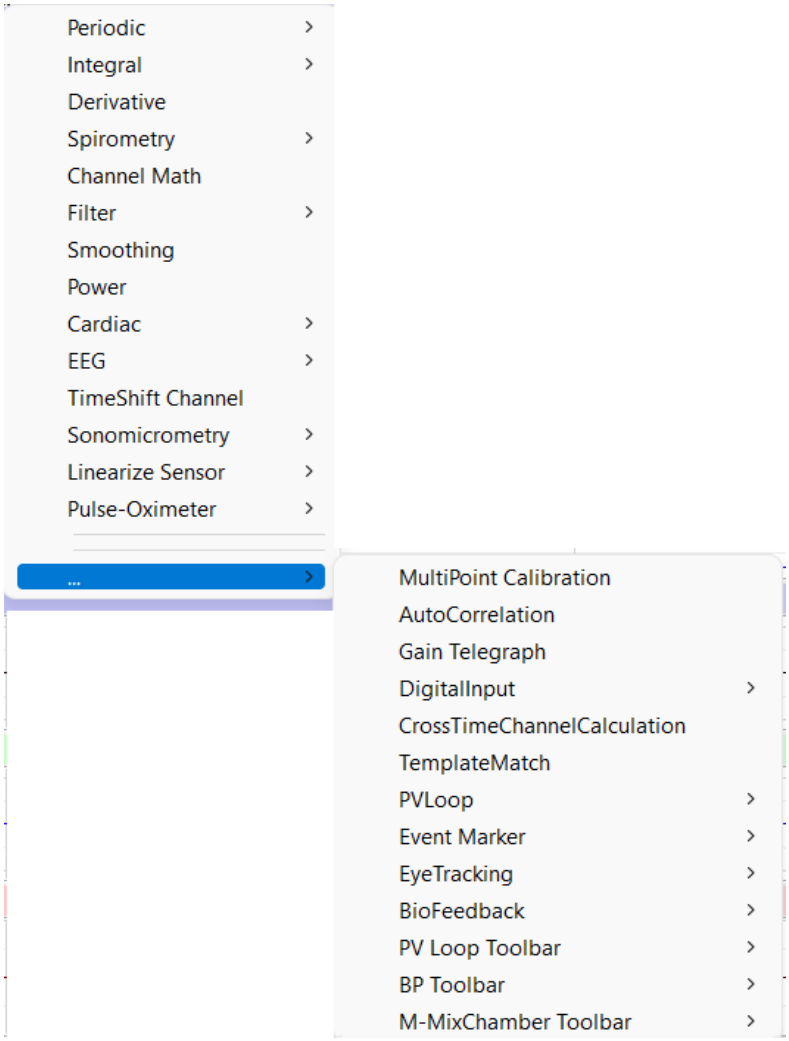
6: Computed Channels

LabScribe makes it possible to take all of the data in a channel and apply a transform, which converts the entire waveform described by the data points into a completely new wave that is displayed on a different channel.

Currently there are more than 50 computed functions included in LabScribe. These functions can only be accessed in the Main Window or from the Channel page of the Preferences Dialog. They are called by using the add function menu and most can be used online or offline. When used online, the functions can operate at the top acquisition rate of the program, 100,000 samples per second.

Adding a Computed Function Channel

In the add function menu, the transforms are organized into categories. The functions within a category have similar setup requirements and are usually located in a submenu. Many of these functions are included in the add function menu by default, but some more specialized functions need to be added to the add function menu by modifying the Main Window Functions box on the Options page of the Preferences Dialog, as illustrated and explained in Chapter 4: Creating Your Own Preferences and Settings.



To apply a function to a Raw Data or a Computed Data channel:

Click the add function button on that channel's Channel Bar, or on the Channel page of the Preferences Dialog, accessed through the Edit menu in Windows or from the LabScribe menu on the Macintosh. Choose the desired function category from the menu. Creation of a function channel through either method will add the channel to the list of channels on the Channel page of the Preferences Dialog.

If the function requires user specified parameters, a setup dialog will open. This setup dialog is also accessible by clicking on the computed channel's Mode/Function label after the Computed Function channel has been created. Setup Function is at the top of the menu.

The computed channel's function can also be changed by clicking on the Mode/Function button in the Channel Bar and choosing a new function from the add function list. The channel to which the function is applied remains the same, unless it is changed in the Setup Function dialog of the new function.

Whether computed functions are performed online (in real time) or offline (after recording has stopped), their setup is the same.

Note: Deleting the channel to which the function is applied will cause the function channel to have invalid data.

The Functions

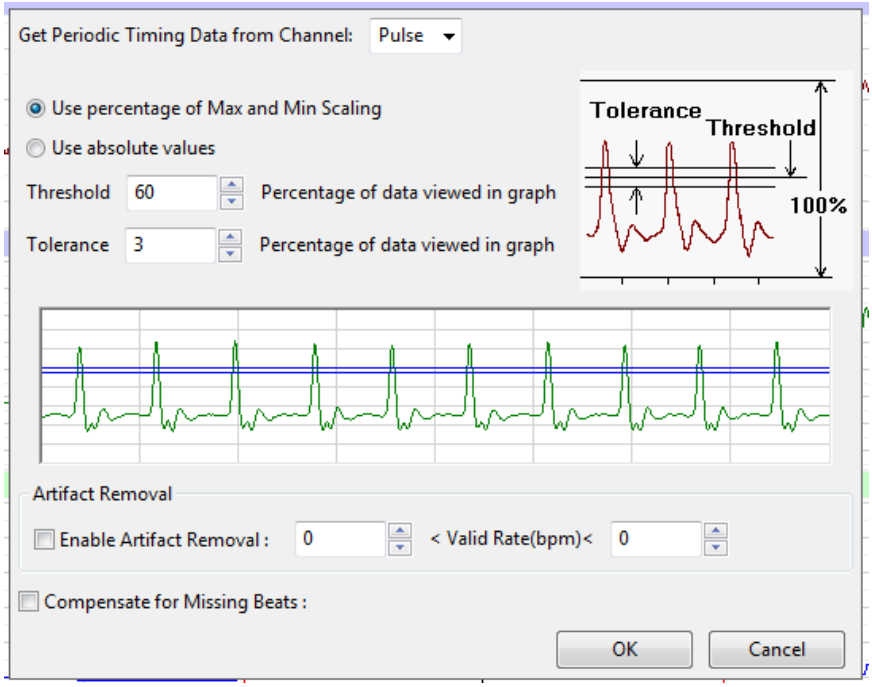
Periodic

Periodic functions operate on cyclic data to produce a graphical representation of how the functions vary with time. LabScribe calculates these parameters with each cycle of the signal and displays the calculation graphically in a new data channel.

The Periodic Setup Dialog

Choosing any of the Periodic functions opens the Periodic data setup dialog. To make Periodic calculations on each cycle, the software must have a way of defining a cycle of data, and the cyclic criteria are defined in this dialog. As data are collected online or processed offline, LabScribe begins the calculation by determining the maximum (Max) and minimum (Min) values in a given screen of data.

The program then finds the points on the recording where the trace repeatedly moves across a Threshold in a positive direction. The control for the Threshold level is set in the Periodic setup dialog. The Threshold level can be set at X% of the maximum value in any given screen of data or at an absolute value. By default, the Threshold is set to 60%, which is adequate for almost all biological signals. The Threshold value can be changed by entering a different number in its box, or by adjusting the horizontal threshold line in the dialog's data graph. LabScribe can now define the time between these points as a Period. If the recorded data are very stable, it is possible instead to enter an absolute Threshold value.



The Periodic Setup dialog.

Whether a relative or absolute Threshold criterion has been set, a second Periodic control known as Tolerance, or hysteresis, is also set in the Periodic setup dialog window. Tolerance is used to reduce false triggering due to noise in the signal. By default the tolerance is set to 3%. If the threshold is set at 60% then the signal has to cross from below 58.5% (60 - 3/2) to above 61.5% (60 + 3/2) for a Threshold crossing to be detected. The maximum value between two Threshold crossings is taken to be the peak, and adjacent peaks are used to calculate the periodic functions.

LabScribe makes it possible to remove the effects of artifacts from the cyclic data. By enabling Artifact Removal, and entering the minimum possible rate and the maximum possible rate for the type of data being recorded into the two edit boxes, the software will ignore areas of the trace where artifacts of some sort create artificially high or low rates. For example, if ECG data are being taken with wrist electrodes, there may be places in the trace where the subject moved their fingers and the movement artifact temporarily overwhelms the ECG data, creating an artificially high heart rate to be recorded. If Artifact Removal is enabled, and the minimum and maximum heart rates are set at 50 and 180, values less than and greater than heart rates are likely to be, even during exercise, any sections of the recording registering higher or lower than these values will be ignored, and this section of the recording won't display the artificially high heart rate.

It is also possible to Compensate for Missing Beats, beats that may be missed by the recording transducer.

PERIODIC FUNCTIONS SETUP EXERCISE

1. To see Threshold, Tolerance, and Artifact Removal in use, record some pulse data, following the procedure in the pulse monitor Tutorial exercise. Flex your fingers vigorously for four or five seconds at some point in the recording. Stop the recording and Autoscale the data in a section of the record that doesn't include the finger flexing.
2. Apply the Rate function to the pulse channel by clicking on add function in the Pulse Channel Bar and choosing Periodic from the Function menu. Choose Rate from the Periodic submenu to open the Periodic functions setup dialog.
3. The Rate function must be able to ignore the second small wave associated with each larger pulse wave; otherwise, it will report a rate that is twice what it should be. Look at the sample of data in the dialog window and adjust the Threshold and Tolerance such that the Threshold and Tolerance lines clear the smaller waves. Do not enable Artifact Removal, and click OK.
4. Enter Single Cursor Mode and move the cursor to various regions of the recording and read the rate in the Value Display area of the Rate Channel Bar. The rates should be accurate in most areas of the trace. Move the Cursor into the section where you flexed your fingers, and read the rate in this section. It will probably not be accurate because the movement artifact will prevent an accurate assessment of rate in this location.
5. Open the Periodic setup dialog again by clicking on the Mode/Function button on the Rate channel, opening the Functions menu. Choose Setup Function from the top of the list. This will open the setup dialog. Enable Artifact Removal and enter minimum and maximum rates of 50 and 150 respectively. Click OK.
6. Move the cursor so that it is in the section where you flexed your fingers. The rate here should now read the same as the rate to either side of the flexing, and is a much more accurate appraisal of your heart rate.
7. Open the Periodic setup dialog again by clicking on the Mode/Function button on the Rate channel, opening the Functions menu. Choose Setup Function from the top of the list, opening the setup dialog.
8. Adjust the Threshold and Tolerance so that the Threshold and Tolerance lines pass through both the larger and smaller waves. Click OK.
9. Move the cursor around the Rate channel again, checking the rate in the Value Display area of the Rate Channel Bar. The rate should now be indicating approximately twice the actual heart rate. You can see why it is necessary to adjust the Threshold so it is greater than the maximum peaks of the smaller waves. If you had been determining rate from an ECG, it would have been necessary to adjust the Threshold so that it cleared the P and T waves in the recording, and passed through just the QRS complex.

Using the Periodic Functions

All Periodic functions are selected in the same manner. To apply any of these functions to a channel:

- Select Periodic from the add function menu and a submenu appears. Select one of the functions in the submenu, opening the Periodic function setup dialog.
- Adjust and/or activate the parameters in the setup dialog as necessary, using the information in the previous section as a guide.
- Click Record in the Main Window to begin recording.
- AutoScale the raw data, then AutoScale the calculated channel
- Click Stop when you have recorded the desired data.
- The functions in the Periodic submenu are:

  Rate: LabScribe takes the Period in seconds and divides this value into 60. The result is a Rate, which is expressed in events per minute.

  Frequency: The program takes the Period in seconds and divides this value into 1. The result is a Frequency, which is expressed in Hz (cycles per second).

  Period: The program takes the Period for each cycle.

  CyclicMax: The program examines all of the data points in the current Period and finds the highest value.

  CyclicMin: The program examines all of the data points in the current Period and finds the lowest value.

  CyclicMean: The program examines all of the data points in the current Period and finds the average of all values.

  Max dV/dt: The program examines all of the derivatives in the current Period and finds the highest value. This will correspond to the steepest slope in the cycle.

  Min dV/dt: The program examines all of the derivatives in the current Period and finds the lowest value. This will correspond to the flattest area in the cycle.

  Mean dV/dt: The program examines all of the derivatives in the current Period and finds the average of all values.

  RMS: The program examines all of the data points in the current Period and finds the Root Mean Square value for all points.

  Max-Min: Cyclic Max - Cyclic Min.

  Count: Choosing Count opens a dialog in which the user can set a threshold over which events are counted and tallied from the beginning of the recording block.

  Delta P-P: Change in Period from the preceding cycle.

  OnTime:The Amount of time that the signal was above the threshold

  OffTime:The Amount of time that the signal was below the threshold

  DutyCycle: The Percentage of time at the signal was above the threshold with respect to the Complete cycle.

  Envelop: Calculates the Max-Min for each cycle and the smooths the Data, to create a envelop around the signal.

Integral

An integral is the area under a curve. The Integral function, as executed by LabScribe, calculates a continuous sum of all the data points on a given channel that satisfy certain criteria, and plots the running total. There are four types of Integrals:

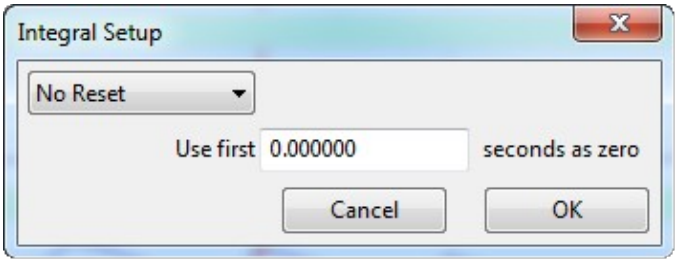
Standard: Includes all data points in the calculation.

Absolute: The Absolute Value of the Integral (Abs. Integral), as the name implies, makes all values of the integral positive and plots the running total. The Abs. Integral is used for analysis of cyclic data such as unit action potentials or EMG data.

Positive: Only the positive data points are included in the calculation.

Negative: Only the negative data points are included in the calculation.

Data points with values above zero make the Integral larger, those with values less than zero make the Integral smaller. To successfully complete the calculation of the Integral, the location of the zero-line needs to be established.



Integral Setup dialog.

Setting the baseline of the raw data channel to zero is important because this function defines the difference between positive and negative areas of the recording. If the baseline of the raw data record is in the positive range of amplitudes, then the Integral will have a positive slope, even though no signal is present. Conversely, if the baseline of the raw data is in the negative range, the Integral will have a negative slope.

Zero

To determine where the zero-line is located, LabScribe takes a value of zero volts as the zero-line. If real units, such as grams or mmHg are used, LabScribe will take the zero units value as zero.

LabScribe also has a Use First “N” seconds as zero option. The data values for the first “N” seconds collected are averaged and used by the program as zero. This feature is particularly useful when trying to integrate signals that are difficult to zero manually.

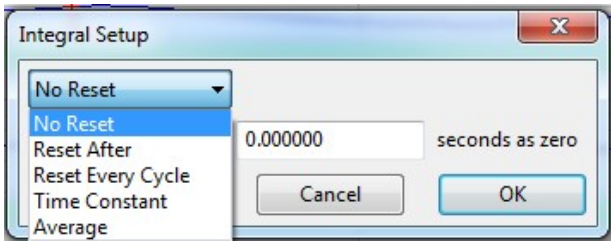
An example of the application of this feature is illustrated in the figure below. The output of a respiratory flow sensor is the value displayed on the upper channel; the lower channel is the integral of the upper channel, or the volume flowing through the sensor.

In this example, the setting of zero is critical because any offset of the raw data from zero will be taken as a flow and, subsequently, be interpreted as a volume. Two examples of the respiratory integral are shown. In each case the flow sensor has a small, but stable offset. In the first example, the integral shows constant increase in volume, even as the flow is constant.

In the second example, where the Use First “N” seconds as zero option is used, the initial flow is constant and is set to zero, so the initial volume is zero. When the flow increases to a level above the “effective” zero-line, then the volume will increase on the integral channel.

Integral with Zero.

The Reset control in the Integral Setup dialog window determines when the Integral or running count will reset itself to zero. This option allows the Integral to reset itself after a preset time.



Integral Setup dialog.

This is a useful option if the data being integrated contains artifacts that move the Integral artificially up or down. The Reset function keeps the Integral trace in the field of view. In the respiration example, if inhaled air is at 20ºC and exhaled air is closer to body temperature, then exhaled air has a larger volume. Since the subject exhales more than he or she inhales, the integral record will have a slow upward drift. Resetting the trace periodically will return it to zero.

Using the Integral Functions

All Integral functions are selected in the same manner. To apply any of these functions to a channel:

- Click on the add function button in the Channel Bar.
- Select Integral from the Function menu and a submenu appears. Select one of the functions in the submenu and configure the Integral Setup dialog.

Derivative

The Derivative function calculates the derivative (slope) around each point in the raw data, and then displays it on the calculated channel. On the channel where the derivative is displayed, the units are changed to the units of the raw data channel/second. Higher order derivatives can be calculated by applying a Derivative function to a Derivative channel.

Using the Derivative Function

To apply the Derivative function to a channel:

Click on the add function button in the Channel Bar.
Select Derivative from the Function menu.
Click Record in the Main Window to begin recording.

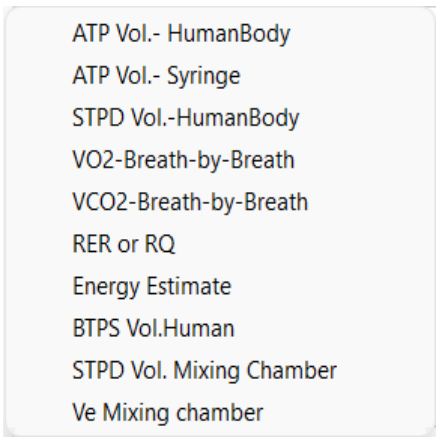
The Smoothing function has options for performing a smoothed derivative using Savitsky Golay smoothing function

Spirometry

The Spirometry volume functions use a specialized version of the integral function for use with iWorx spirometers. Spirometers, which measure respiratory volumes, are sensitive air flow sensors. LabScribe integrates the sequential flow values measured by the sensor as the subject breathes and displays the air flow volume. If a gas analyzer is used, VO2, VCO2, and the RER can also be calculated. The advanced LabScribe Metabolic module depends on the accurate recording of basic Spirometry functions.

The Spirometry functions are:

- ATP Vol.-Human Body: A measure of air flow from human respiration at ambient temperature and atmospheric air pressure.
- ATP Vol.-Syringe: An air volume measurement used in the calibration of the gas analyzer.



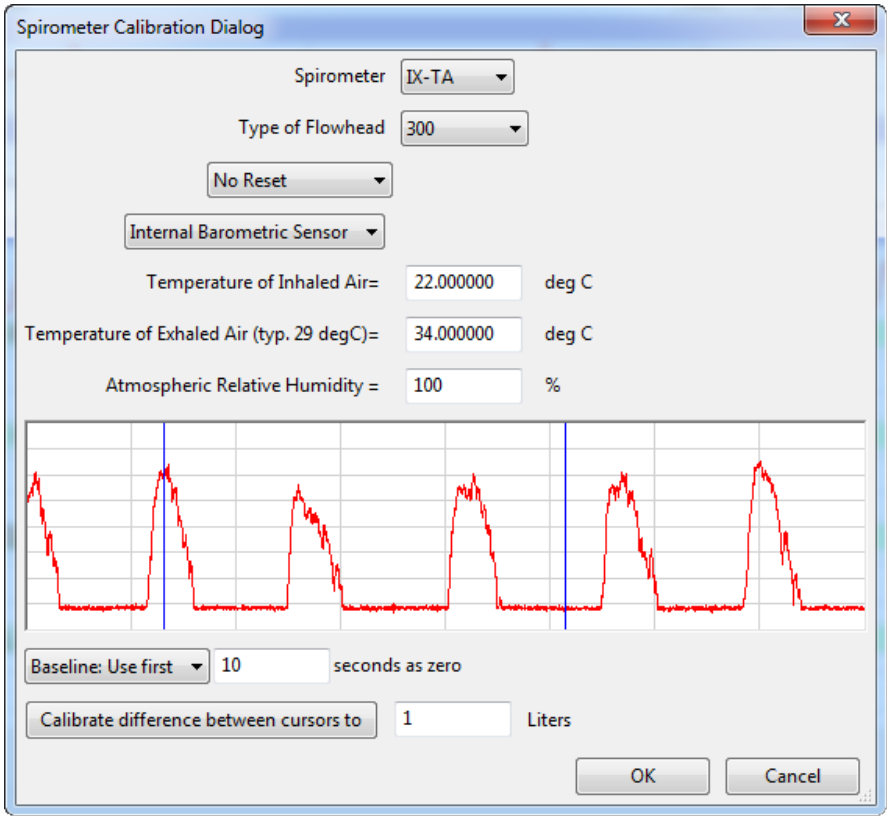
- STPD Vol.-Human Body: Respiratory air flow normalized to standard temperature.
- VO2-Breath-by-Breath: Online continuous calculation of the rate of oxygen consumption.
- VCO2-Breath-by-Breath: Online continuous calculation of the rate of carbon dioxide production.
- RER (Respiratory Exchange Ratio): VCO2/VO2.
- Energy Estimate: Mathematical estimate of energy expenditure based on rates of oxygen consumption and carbon dioxide production.
- BTPS Vol. Human: Respiratory air flow normalized to BTPS (Body Temperature and Pressure, Saturated)
- STPD Vol. Mixing Chamber: An air volume measurement used in the calibration of the gas analyzer.
- Ve Mixing chamber: A Ve measurement when using the mixing chamber.

Using the Spirometry Functions

To apply a Spirometry function to a channel, click on the add function button in the Channel Bar, or on the Channel page in the Preferences Dialog. Select Spirometry from the add function menu.

Each of the Spirometry functions requires configuration in the appropriate dialog window.

The calibration dialogs for the volume functions (ATP Vol.-Human Body, ATP Vol.-Syringe, and STPD Vol.-Human Body, BTPS Vol. Human, STPD Vol. Mixing Chamber) are quite similar.



The Spirometry Calibration Dialog.

To configure the Spirometry Calibration Dialogs:

Choose the type of spirometer and flowhead being used.

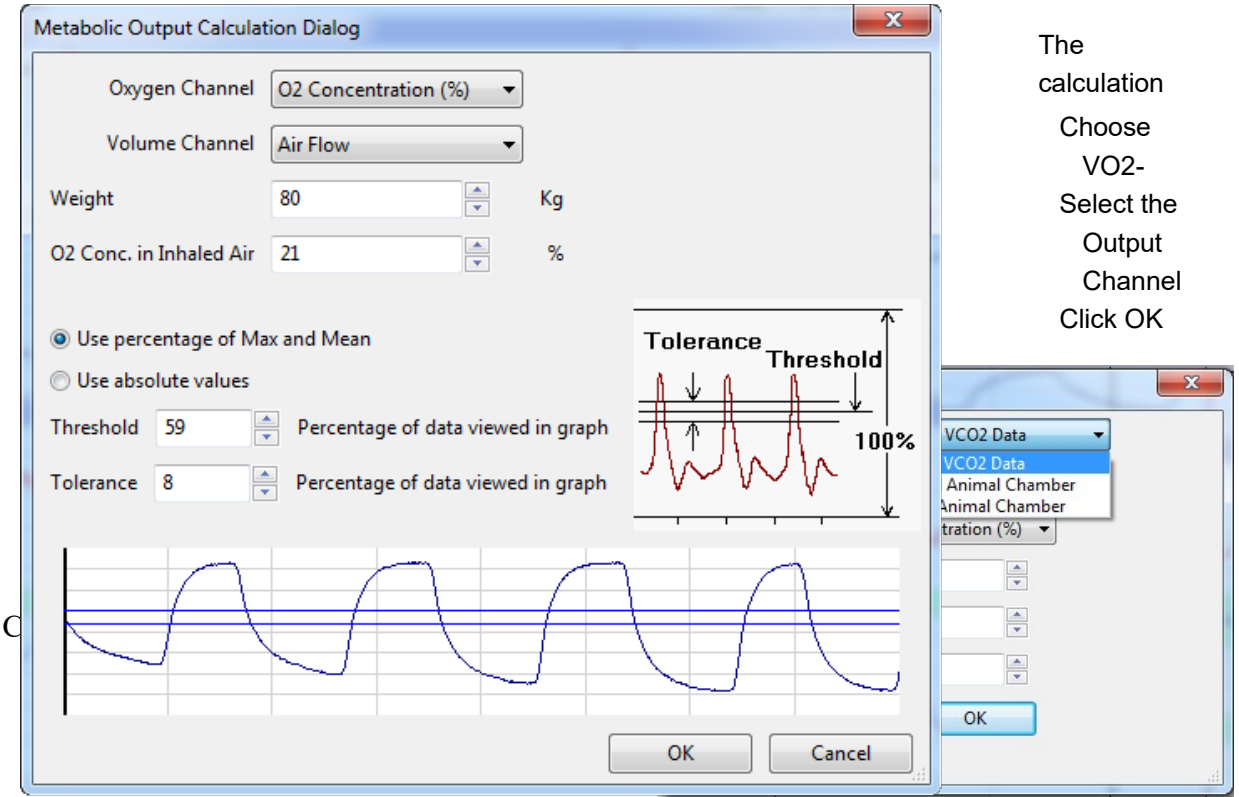
Each external iWorx spirometer has a calibration value on it. This value can be entered in the Spirometer Calibration text box.

If the specific Spirometry Calibration Dialog has entries for Atmospheric Pressure, Temperature of Inhaled Air, Temperature of Exhaled Air, Relative Humidity, and Water Vapor Pressure, enter these values in the appropriate text boxes.

If a calibration syringe is being used and the user has recorded data where a known volume of air was pushed through the spirometer, these data will be displayed in the graph window. Place the first cursor at Zero Volume and the second cursor at X Volume. Also enter this X value in the text box below the graph. Clicking the Calibrate Difference between Cursors button will calculate the required calibration value and place it in the Spirometer Calibration window.

To account for offset in the spirometer, choose a time at the beginning of the record when there is no flow through the spirometer and enter this value in the Use First “N” Seconds as Zero text box. LabScribe will take the first “N” (usually set to 10) seconds, average them together and use the result to set the zero-line of the Volume channel. This is necessary because the output of the air flow sensor is always offset and any offset causes the Volume channel (which is based on an integral function) to display a volume change even though no air is flowing through the sensor.

The Volume integral can also be programmed to reset after a certain time or with every cycle. During spirometry experiments, the volume trace drifts upward because the volume of exhaled air is larger than the volume of inhaled air. Cooler inhaled air at room temperature occupies less volume than warmer exhaled air. The Volume integral can drift up and out of view, as it reports correct values, unless a periodic reset is employed. Unless this drift is occurring, it is best not to reset the Volume calculation.



6: C

The calculation

Choose VO2-

Select the Output Channel

Click OK

Select RER from the Spirometry submenu, opening the RER Calculation Dialog.
Choose the source of the data: From VO2 and VCO2 Data, Closed Small Animal Chamber , or Open Small Animal Chamber. The RER is calculated from the changing percentages of oxygen and carbon dioxide in expired air. The setup menu also asks for the time intervals over which the values are averaged, and the flow rate through the mixing chamber, if appropriate.
Select the O2 and CO2 channels.
Choose the duration to average the values over.
If appropriate, enter the flow rate.
Delta time: Time taken for a 1% change in CO2 or O2 concentration. Set the cursors so that there is a 1% change between them in the relevant concentration, and use T2-T1 as Delta time.
Click OK.

MultiPoint Calibration

MultiPoint Calibration can be used to perform both linear and non-linear calibration of sensors, transducers, amplifiers and other equipment. It can also be used to check if an existing sensor's output is linear.

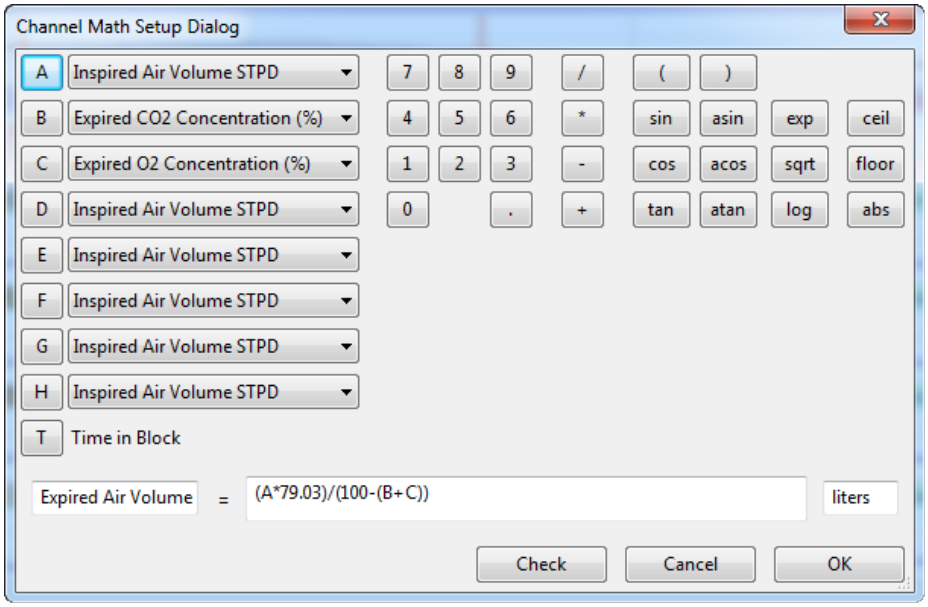
Using the MultiPoint Calibration Function

Place the cursors in the raw data graph, such that the Mean, Max, or Min value between the cursors, or the difference between the cursor values, is a calibrated value. The Current Value will be displayed in the text box following "between cursors".
Enter the Calibrated Value in the next text area. Set the units in the last text area.
Click the Convert button to add the Current Value and the Calibrated Value to the table. Repeat this procedure for all values that you want to calibrate.
Once the table has been populated, you can select the equation you want to fit to the raw data and then click on the Fit button. LabScribe will try to fit the selected equation to the values in the table. The fitted equation as well as the error is shown. If MultiPoint Calibration is being used to test the linearity of the sensor, the data from this window serves as confirmation.
Selecting OK will apply the fitted equation to the raw data to get a calibrated output.

Channel Math

The Channel Math function applies a user-defined function to points from up to four data channels and displays the output in a computed channel. One of four variables (A, B, C and D) can be associated with a user-selected data channel.

As an example, to divide Channel 1 by Channel 2, click the add function button on either the Channel 1 or Channel 2 Channel Bar. Select the Channel Math option to open the Channel Math Setup Dialog. Select A to be Channel 1, and B to be Channel 2. In the Channel edit box, name the computed channel A/B. Every Channel 1 data point is divided by the corresponding Channel 2 data point and the resulting waveform is displayed in the A/B computed channel.



A full range of trig and log functions, as well as the common mathematical operators, are available in the Channel Math dialog window. The Unit Name for the calculated value can be specified. There is also a Check Expression feature, which checks for errors like unclosed parentheses or division by zero. Since division by zero is a possible occurrence even in legitimate expressions, but it cannot be calculated by a computer, the program substitutes the last calculated value for the quotient if division by zero is attempted.

Using the Channel Math Function

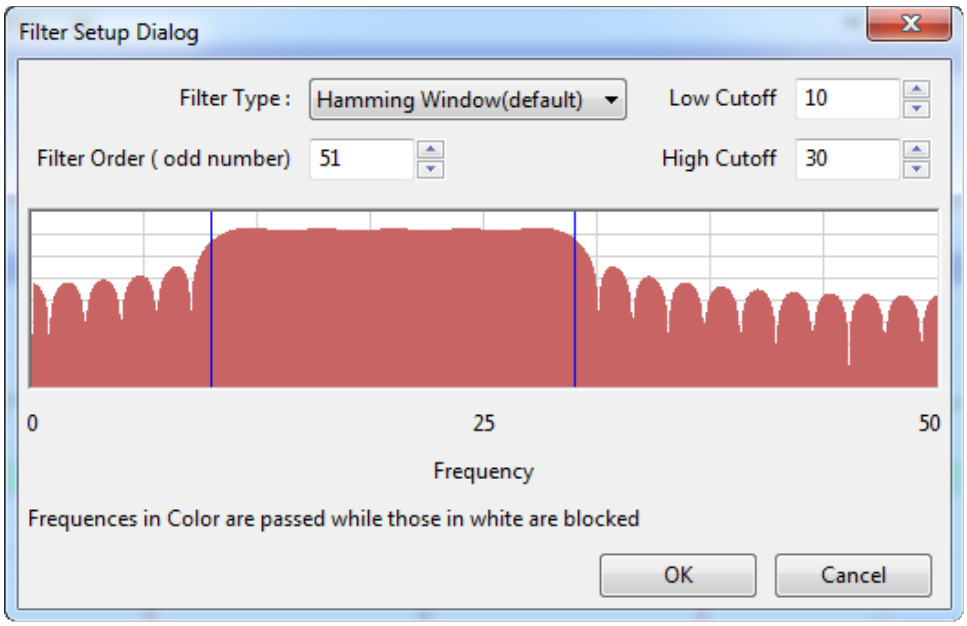
To apply the Channel Math function to a channel, click on the add function button in the Channel Bar.

Select Channel Math from the function list.
Select the channels corresponding to A, B, C and D.
Program the desired expression. Set the units if applicable, and click OK.

Filter

A digital filter can be applied to any channel in real time or to previously recorded data. LabScribe uses a FIR (Finite Impulse Response) filter. There are various windowing functions that can be used for setting up an FIR filter. The Hamming window (default) is appropriate for most applications. In addition to the Hamming function, LabScribe also provides Rectangular, Bartlett, Hanning, Blackman and Blackman-Harris windowing functions.

The Filter Order is the number of data points in the raw data required to calculate each point in the filtered data. The strength of the filter is determined by the filter order. The higher the order, the stronger the filter, and the longer LabScribe takes to calculate the function, which can slow down the display. Data points at the beginning and end of the filtered data (the first Filter Order/ 2 and the last Filter Order/2 data points) are invalid. For example, if the filter order is 51, then the first 25 and the last 25 data points in the filtered data are invalid.



The digital (software) Filter Setup Dialog.

The graphic interface in the Filter Setup Dialog is straightforward. The colored area corresponds to the frequencies that are passed or allowed, and the white area corresponds to the frequencies that are rejected. To remove high frequencies from the signal, click on the right boundary of the colored area and drag this boundary to the left. To remove low frequencies from the signal, click on the left boundary of the colored area and drag this boundary to the right. After clicking and dragging a boundary, it can be placed more accurately by entering the values in the Low Cutoff and High Cutoff fields. Boundaries can be placed in configurations that create High Pass, Low Pass, Band Pass (as illustrated in the figure above), or Notch filters.

Notice that the filter is subject to the Nyquist limitation of frequency. The maximum frequency in the Filter Setup Dialog is exactly half of the sampling speed.

By choosing Notch Filter from the Filter submenu, a 50 or 60 Hz notch filter can be specified, as well as whether or not the third harmonic should also be filtered.

Additional information about the digital filter functions can be found on page 40 of Chapter 3: Acquisition.

Using the Filter Functions

To apply a digital filter to a channel:

Click add function in the Channel Bar.
Choose Filter from the function list, opening either the FIR Filter Setup Dialog or the Notch Filter dialog.
Select a Filter Type from the drop-down menu.
Choose a Filter Order.
Adjust the boundaries of the colored area of the graph, or enter the desired values into the Low Cutoff and High Cutoff text boxes.
Click OK to add the Filter channel to the display.

Smoothing

All experimental data recordings include varying degrees of noise that can obscure important data. Hardware and software filters can increase the signal to noise ratio by removing certain frequencies from the data. In addition to the use of filters, LabScribe has the ability to smooth the data in order to reveal significant features of your data. Smoothing is used to remove noise that is uniform across all frequencies. LabScribe uses two different algorithms to smooth the data; the Moving Average function does wide smoothing, while the Savitzky-Golay function seeks to preserve shapes of peaks.

Moving Average

Applies a user specified number of points on either side of each data point to calculate the mean and replaces the datapoint with the calculated mean. For example, if you set the number of data points on either side to 1, then:

new data (N) = (data(N-1) + data(N) + data(N+1))/ 3

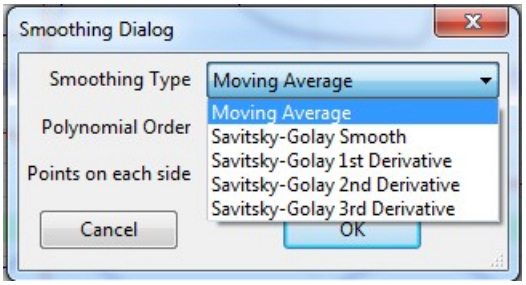
Savitsky-Golay

The Savitzky-Golay method essentially performs a local polynomial regression to determine the smoothed value for each data point. This method is superior to Moving Average because it tends to preserve features of the data such as peak height and width, which are often diminished by adjacent averaging. To use the Savitsky-Golay smoothing function, the order of the polynomial and the number of points on each side of the data need to be specified.

In addition to smoothing the data, LabScribe also provides the option to calculate the smoothed 1st, 2nd or 3rd derivative of the data.

Using the Smoothing Function:

To apply smoothing to a raw data or derivative channel:

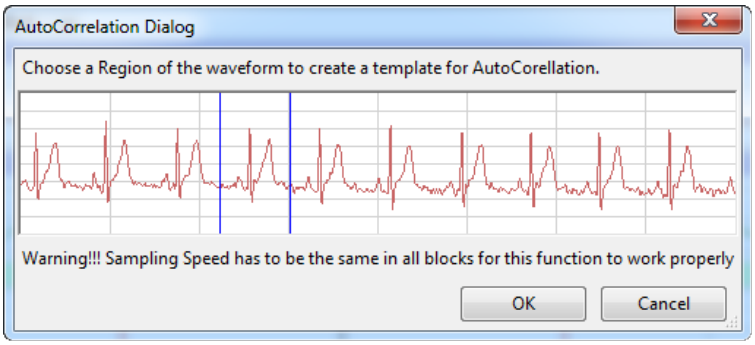


- Click add function in the Channel Bar.
- Choose Smoothing from the function list, opening the Smoothing Dialog.
- Choose one of the Smoothing functions from the drop-down menu.
- For the Moving Average function, enter into the text box the number of points that should be averaged on either side of each data point.
- For the Savitsky-Golay function or any of its derivatives, enter into the appropriate text boxes both the number of points on either side of each data point to which the polynomial regression should be applied, and the order of the polynomial regression.

AutoCorrelation

AutoCorrelation is a mathematical tool used frequently in signal processing for analyzing functions or series of values, such as time domain signals. Practically, it is a measure of how well a signal matches a time-shifted version of itself, as a function of the amount of time shift. More precisely, it is the cross-correlation of a signal with itself.

AutoCorrelation is useful for finding repeating patterns in a signal, such as determining the presence of a periodic signal which has been buried under noise, or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies.



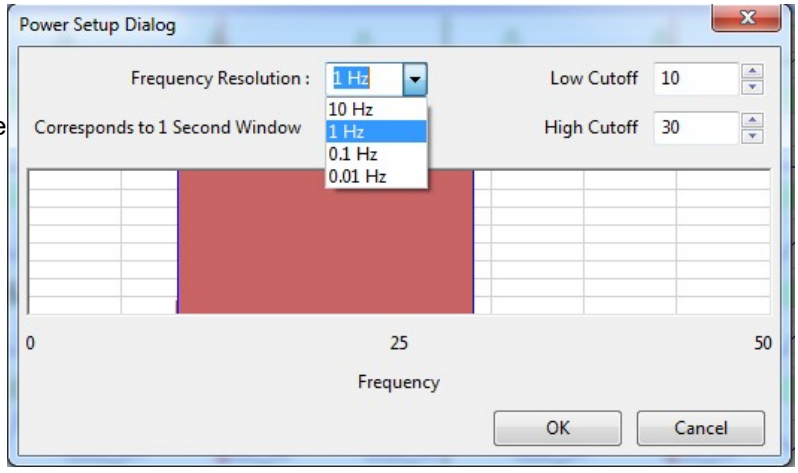
Using the Autocorrelation Function

To apply the AutoCorrelation function to a channel:

Click add function in the Channel Bar.
Choose AutoCorrelation from the function list, opening the AutoCorrelation Dialog.
Choose a region of the dialog waveform that you wish to check for AutoCorrelation and click OK.
A high degree of AutoCorrelation will be displayed as a very regular pattern in the AutoCorrelation computed channel.

Power

The Power function performs a Fast Fourier Transform (FFT) on data in the selected channel and returns the average Power (amplitude) in the frequency band selected.



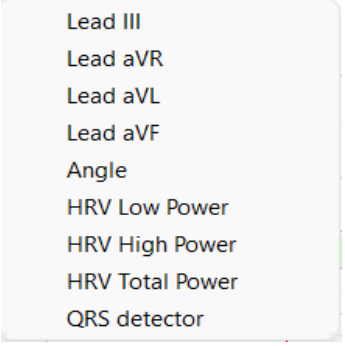
In LabScribe, this function works only off-line. The graphic interface in the Power Setup Dialog is similar to the one in the Filter Setup Dialog. The band of frequencies selected from the Power Setup Dialog are not filtered, but they are subjected to an FFT with an output known as a Power Number. In addition to specifying the range of frequencies transformed, the Frequency Resolution can be selected. The higher the frequency resolution is, the more data points are required to compute the FFT. Therefore, at slow sampling rates, higher frequency resolutions may require the processing of more data points from longer recording periods.

Using the Power Function: The Power function can only be applied offline. To apply the Power function to a previously recorded channel:

Click add function in the Channel Bar.
Choose Power from the function list, opening the Power Setup Dialog.
Choose a Frequency Resolution. Depending on the Frequency Resolution chosen, the Power function will be applied to data samples of different durations.
Choose a range of frequencies for which the Power function will determine the average Power (amplitude) frequency. This can be done by adjusting the position of the colored area of the graph, or entering the Low and High Cutoffs in the appropriate text boxes. Click OK.
The Power Number for each section of data will be graphed in the Power channel. The duration of the sections is determined by the Frequency Resolution.

Cardiac

The Cardiac functions are specifically used for the analysis of electrocardiograms (ECGs). Four of the Cardiac functions calculate Leads: III, aVR, aVL and aVF from the recordings of Lead I and Lead II. You can specify which channel corresponds to Lead I and Lead II in the Cardiac Setup dialog.



LabScribe can be programmed to do these calculations because all the points of view in a 6- lead ECG are in the same plane (frontal) of the body and each lead can be considered as a vector. So if any two of the limb leads are recorded, the other four leads can be calculated from them.

The Cardiac submenu also includes other functions. The cardiac Angle function calculates the vector of the cardiac depolarization that passes through the interventricular septum, and can indicate abnormalities in electrical conduction, or the actual anatomical orientation of the heart.

QRS Detector

The QRS detector displays a trace with only peaks representing the QRS complexes with amplitudes reflecting the amplitudes of the individual QRS complexes. The QRS detector uses the multiplication of backward differences (MOBD) algorithm

HRV Power

Three Power functions, which are special cases of the general Power function described previously, are also available. These three power functions are useful for heart rate variability (HRV) analysis. HRV Low Power (0.04-0.15 Hz), HRV High Power (0.18-0.4 Hz) and HRV Total Power are each calculated from a tachogram transformation of one of the ECG raw data channels, or from the QRS detector channel.

A 50 second window is selected, and the power spectrum is calculated. The power for the selected HRV band is calculated. This gives us oen data point. Now the 50 second window is moved forward by 10 seconds, and the power values is calculated again. Thus we get 1 power value every 10 seconds. The program moves through all the data for the channel and calculates the power, sliding the window 10 seconds at a time.

The ECG Analysis module in the Advanced menu can perform more extensive ECG analysis.

Using the Cardiac Functions

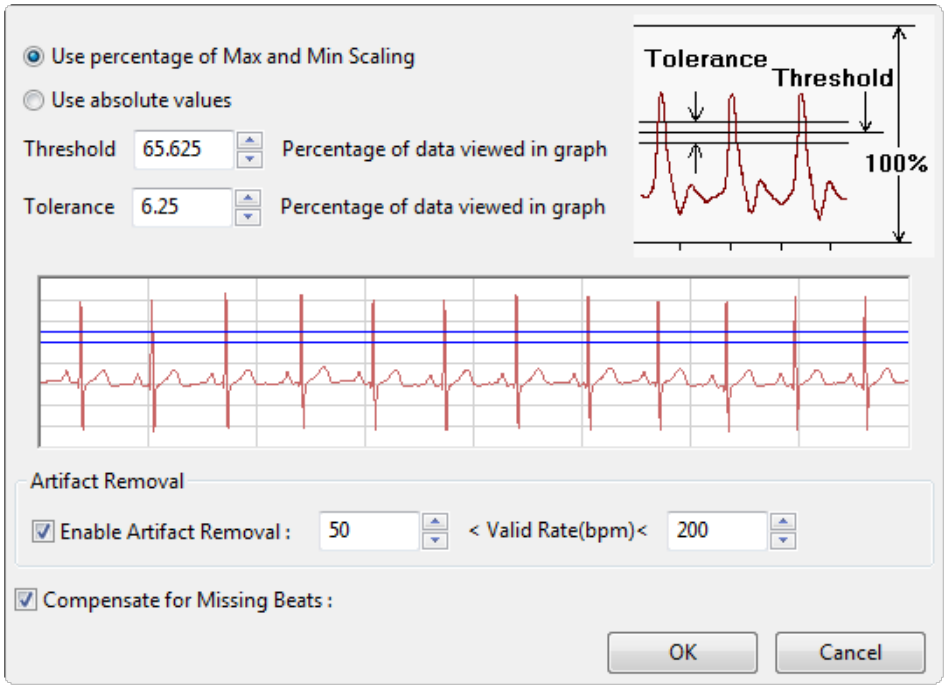
To apply the Cardiac function to a channel:

Click on the add function button in the Channel Bar.

Select Cardiac from the Function menu, which will display the Cardiac submenu.

Choosing Lead: III, aVL, aVF or aVR, or cardiac Angle, will open a dialog in which the channels corresponding to Lead I and Lead II can be chosen. Click OK to display the chosen lead or the cardiac Angle in the computed channel.

Choosing HRV Low Power, HRV High Power, or HRV Total Power will open a dialog in which the threshold lines should be adjusted to pass through just the QRS complexes. Artifact Removal is also possible from this dialog. Click OK to display the chosen function in the computed channel.



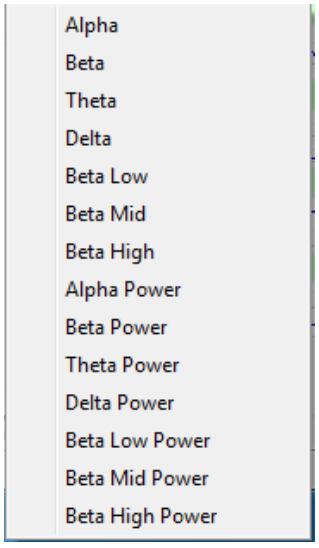
The HRV Power dialog.

Choosing QRS Detector will open a channel showing only the QRS complexes.

Many more ECG parameters can be determined by choosing ECG Analysis in the Advanced menu. Refer to the ECG Analysis section of the Advanced Analysis for a detailed discussion. ECG Analysis is a separately licensed LabScribe module.

EEG

In the EEG function submenu, a frequency band is chosen representing a component of the electroencephalograph (EEG): Alpha, Beta, Theta, Delta, Beta Low, Beta Mid or Beta High. For each selected band, LabScribe also calculates the average power represented in the band and displays the power value against time. Both the individual band and the band's Power functions can be displayed through the use of the EEG function. By displaying separate channels representing the bands, it is possible to see the effect that behavior has on the separate components of the EEG.



Using the EEG Functions

To apply the EEG function to a channel:

Click on the add function button in the Channel Bar.
Select EEG from the function list, opening the EEG submenu.

Choose one of the EEG bands or a Power function. Repeat for other bands you would like displayed. Refer to the EEG analysis chapter for more details.

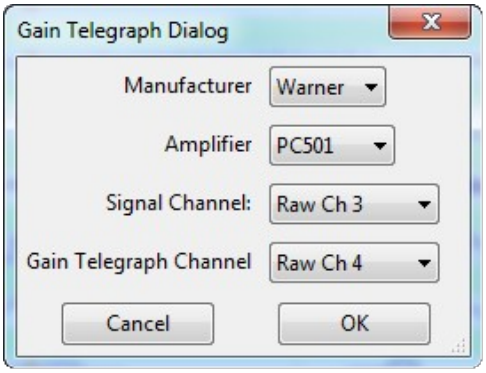
Gain Telegraph

The Gain Telegraph function is slightly different from the other functions. Some amplifiers have an additional output that sends a calibration signal to the data recording unit. This calibration signal relays information about the gain settings of the external amplifier. This information permits the recording program to re-calibrate the amplifier output in the correct units regardless of the gain set on the amplifier.

Using the Gain Telegraph Function

To configure the Gain Telegraph function:

Connect the analog output of the supported amplifier to any input channel. For this example, assume this is Channel 1. Next, connect the gain telegraph output of the amplifier to any input channel. For this example, assume this is Channel 2.



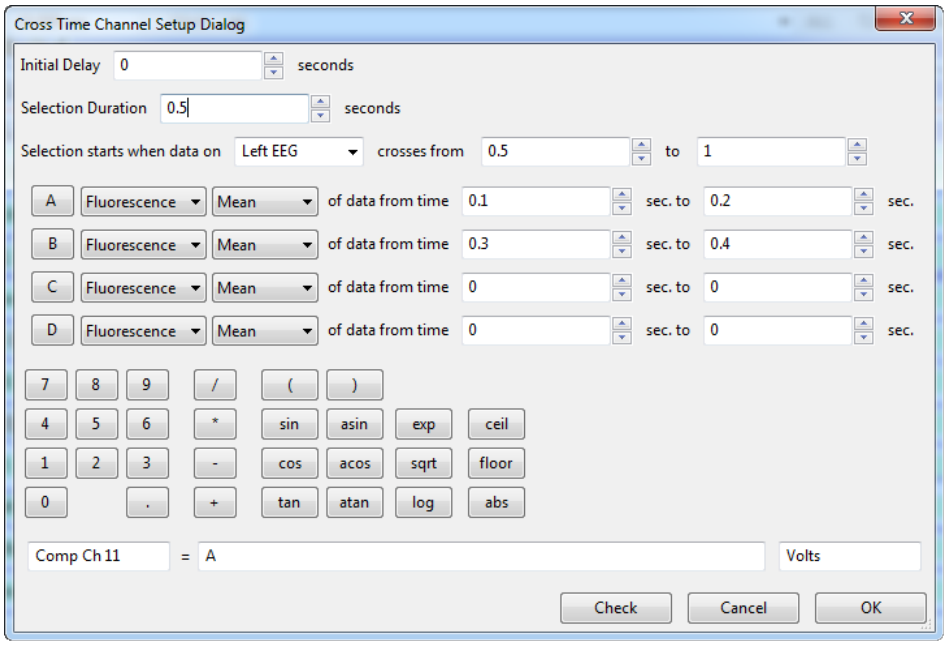
To apply the Gain Telegraph function to a channel, click on the add function button in the Channel Bar and select Gain Telegraph from the function list. Select the manufacturer of your amplifier, then select the amplifier you are using. Select the Signal Channel that the output from your amplifier is connected to (Channel 3 in this case), then select the Gain Telegraph Channel (Channel 4 in this case) and click OK.

Digital Input

Some iWorx data acquisition units have Digital Input connectors that allow external TTL devices to be monitored for state changes and have the changes indicated on the LabScribe recording. Because these functions are closely related to LabScribe's Digital Output functions, the details of configuring Digital Input computed channels are covered in Chapter 9: Digital Input and Output.

CrossTime Channel Calculation

CrossTime Channel Calculation can be used to demultiplex data from different sources that have been recorded on one channel. For example, in flourescence studies, the values of absorption as the filter wheel is changed from one filter to another may be recorded on one channel. It is then necessary to mathematically separate the absorption values corresponding to each filter value for further analysis.



Using CrossTime Channel Calculations

To use the CrossTime Channel Calculations function:

Click on add function in the Channel Bar of the raw data channel, and choose CrossTime Channel Calculation, This will open the Cross Time Channel Setup Dialog.

In the Initial Delay text box, enter the amount of time from the start of recording until the function is initiated.

In the Selection Duration text box, enter the duration of the protocol.

The selection can be set to start when the data on a selected channel crosses from one operator selected value to another.

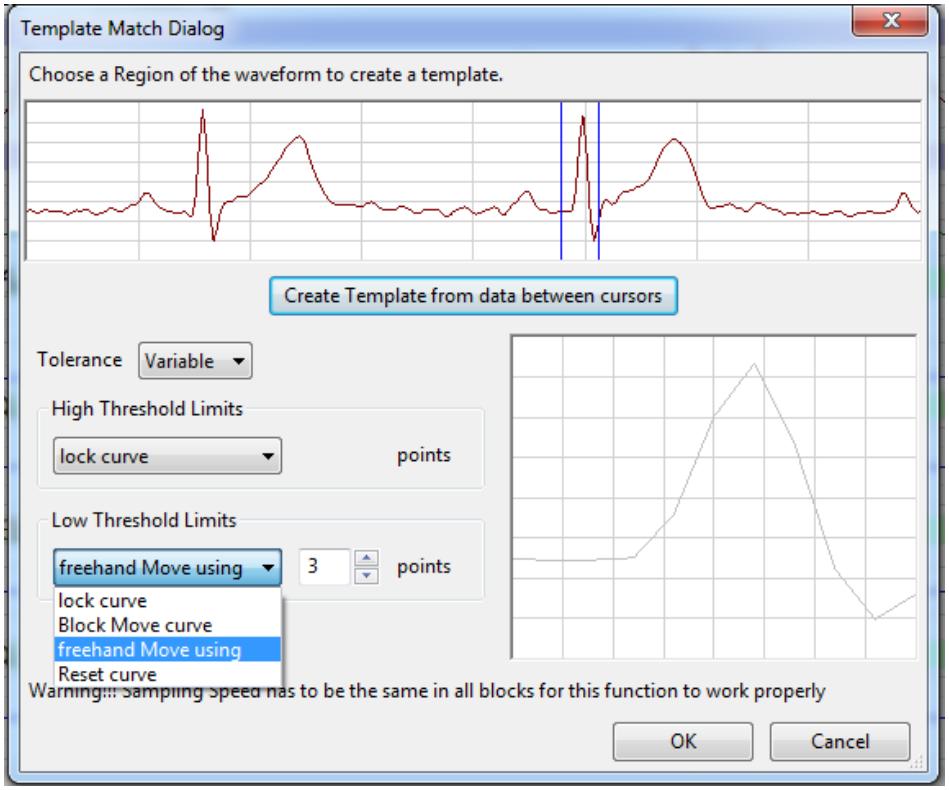
For each selection as defined above, variable A can be set up to equal the mean, maximum, minimum , time to maximum or time to minimum of the data during the selected time range on a selected channel. Variables B, C and D can be set up in similar fashion.

The title and units name of the computed channel can be set. The variables A, B, C, D and the calculator can be used to create an equation for the computed channel.

Template Match

Template Matching is a technique in digital signal processing for finding small parts of a signal which match a template. The idea of template matching is to create a model of a signal of interest (the

template, or kernel) and then to search over the recorded data for objects that match the template. One common use of this function is to sort extracellularly recorded action potentials by amplitude and width.



Using Template Matching

To create a template:

Select a region of interest using the two cursors. This will be a feature that you want LabScribe to search for matching waveforms throughout the recording.

Click Create Template from data between cursors to create a baseline for the template.

For each point in the template, you can set the acceptable tolerance. The tolerance can be fixed for all data points or the tolerance can vary for different parts of the waveform. In case of variable tolerance, the high and the low limits of the tolerance are set separately.

Each tolerance line can be moved up or down using Block Move Curve. It is also possible to move only certain segments of the curve using freehand Move using. When using the freehand move, it is necessary to specify the number of points each move will influence.

Once a template is created, the program will find segments of the data where each datapoint in the segment matches the template within the tolerance for each point.

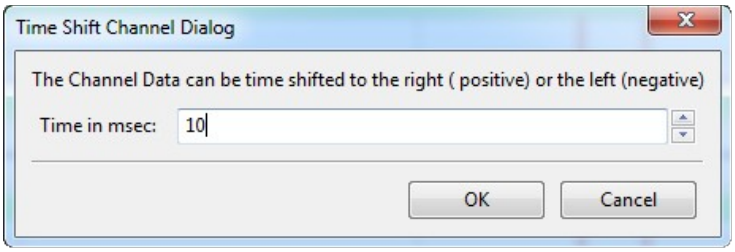
PVLoop

The PV Loop function is used to calibrate the contribution of parallel conductance and volume to ventricular volume estimates based on conductance catheter measurements. Details on integrating this

function into PV Loop analysis can be found in the PV Loops section of Chapter 8: Advanced Analysis Modules.

TimeShift Channel

Occasionally there is a known delay between two sensors and it makes sense to synchronize them. For example, there may be a latency between the O2 and CO2 sensors, and the air volume channel in metabolic recordings. The ability to time shift individual channels allows the user to compensate for these latencies.



Using Channel TimeShifting

To add a computed channel that is shifted to the right by a distance determined by the user:

Choose the channel you wish to shift, and click on add function in the Channel Bar.

In the Time Shift Channel Dialog, enter the desired time shift in milliseconds. Negative values will shift the channel to the left, and positive values will shift it to the right. The up and down arrows to the right of the edit box change the time shift by a millisecond with each mouse click.

Event Marker

The iWorx 4-channel Event Marker allows event markers of four different amplitudes to be placed on one raw data channel. The Event Marker function separates these markers and puts one, two, three, or all four on individual data channels. A Count function can be added as a computed channel for each of the individual event marker channels.

The Event Marker Submenu.

Using Event Markers

To use the Event Marker function:

In the Event Marker raw data Channel Bar, click on add function. Choose Event Marker from the list of functions.

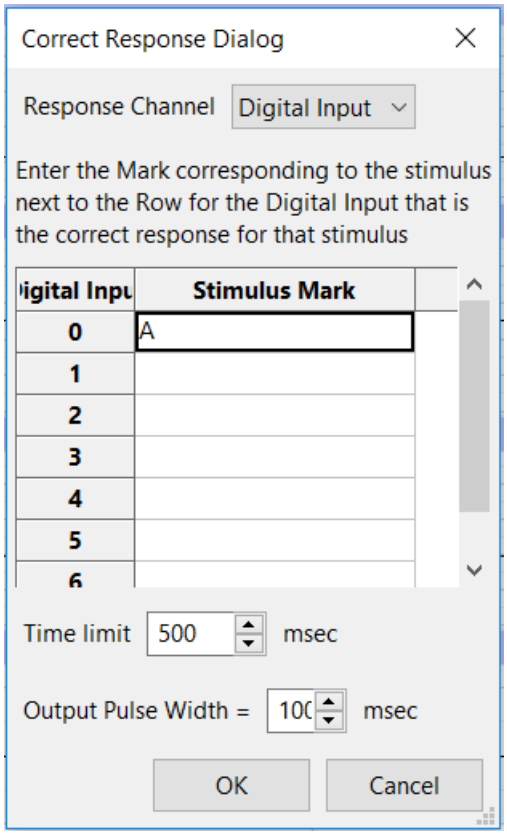
Select E1, E2, E3, or E4 from the Event Marker sub-menu to add one of the four sizes of markers to a computed channel. Repeat for as many of the other size markers as desired.

If you would like a count of markers from the beginning of the recording block, click add function on the appropriate computed channel. From the Periodic functions, choose Count. A dialog will open in

which you can set the correct threshold for the marker amplitude. A new computed channel will be added that will display the count for that size marker from the start of the recording block.

Correct Responses

When performing performing psychological test, some stimuli is presented to the subject and the subject is asked to respond by clicking on a button on the Response pad. The response pad connects to the digital inputs. The Correct Response function enables the researcher to assign which button press corresponds to a correct response for a particular stimuli. There is also a time limit within which the subject has to respond to the stimuli



Sonomicrometry

Sonomicrometry is a technique by which changes in length or volume of physiological tissue can be measured through the use of piezoelectric crystals that send sound waves through the tissue. Distance can be estimated by the amount of time it takes for these waves to reach another crystal. Two or three pair of crystals can be inserted in small animal epicardial tissue, measuring short axis and long axis distance measurements as the heart beats. Changes in ventricular volume can be estimated using the data from these measurements. The volume measurements can be used in the creation of Pressure Volume Loops.

Using the Sonomicrometry Functions:

Selecting the Sonomicrometry function opens a submenu with two choices:

Volume: Opens a dialog in which three sonometric axes can be specified. Volume changes based on changes in these sonometric axes are computed and displayed in a new computed channel.

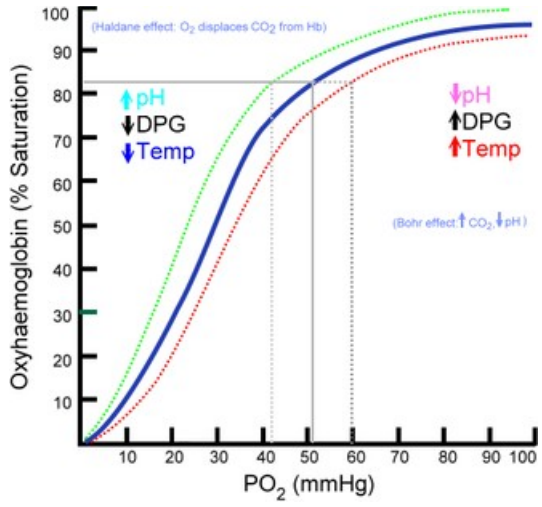
Remove Outliers: Data values outside the range of possible axis measurements (based on the known distances between the crystals) are removed.

Linearize Sensor

The Linearize Sensor function permits transducer-specific calibration of the iWorx TM-100 and TM-200 temperature sensors. The appropriate transducer is chosen from the Linearize Sensors submenu. In the dialog that opens, the cursors are placed at two known temperatures and those temperatures should be entered into the right-hand boxes. Upon clicking OK, a computed channel is added to the Main Window showing the calibrated temperatures for that transducer.

Pulse-Oximeter

The Pa02, is a measurement of the actual oxygen content in arterial blood. SpO2 is related to PaO2 in a complex way, as shown by the Oxyhemoglobin Dissociation Curve.



Eye Tracking

For setting up Eye Tracking to work with LabScribe refer to the External Devices Section.

7: Analysis

Built into LabScribe is a powerful array of data analysis tools. The variety of tools available span the range from the most frequently used straightforward operations to much more complex, specialized routines. LabScribe is a powerful analytical tool that can get to work on analysis immediately, or be customized to execute very specific, complex analysis routines.

Analysis in LabScribe is accomplished in several different ways. Waveform manipulations are discussed in Chapter 6: Computed Channels. In this chapter, the Analysis Window is introduced. In the Analysis Window, regions of data are characterized by mathematical calculations resulting in descriptive quantitative values.

Ways to redisplay the data, such as an XY View or a graphical FFT analysis, are discussed, as are LabScribe's sophisticated Find functions. Finally, Scripting options that incorporate other applications into the analysis of recorded data are outlined.

The Analysis Window

Functions specific to the Analysis Window take a group of data points selected by the user and reduce them into a single, mathematical value. These values can be saved to the Journal within LabScribe or exported to other programs.

Analysis Window Components

The Analysis window is used to display and perform calculations on selected regions of Chart data or Scope sweeps captured from the Main Window. The data in the Analysis Window are defined by the data displayed in the Main Window. The Analysis Window and its analysis functions are activated by clicking the Analysis icon on the LabScribe Toolbar or selecting Analysis from the View menu. Data from all channels within the selected area are displayed simultaneously in the Analysis window.

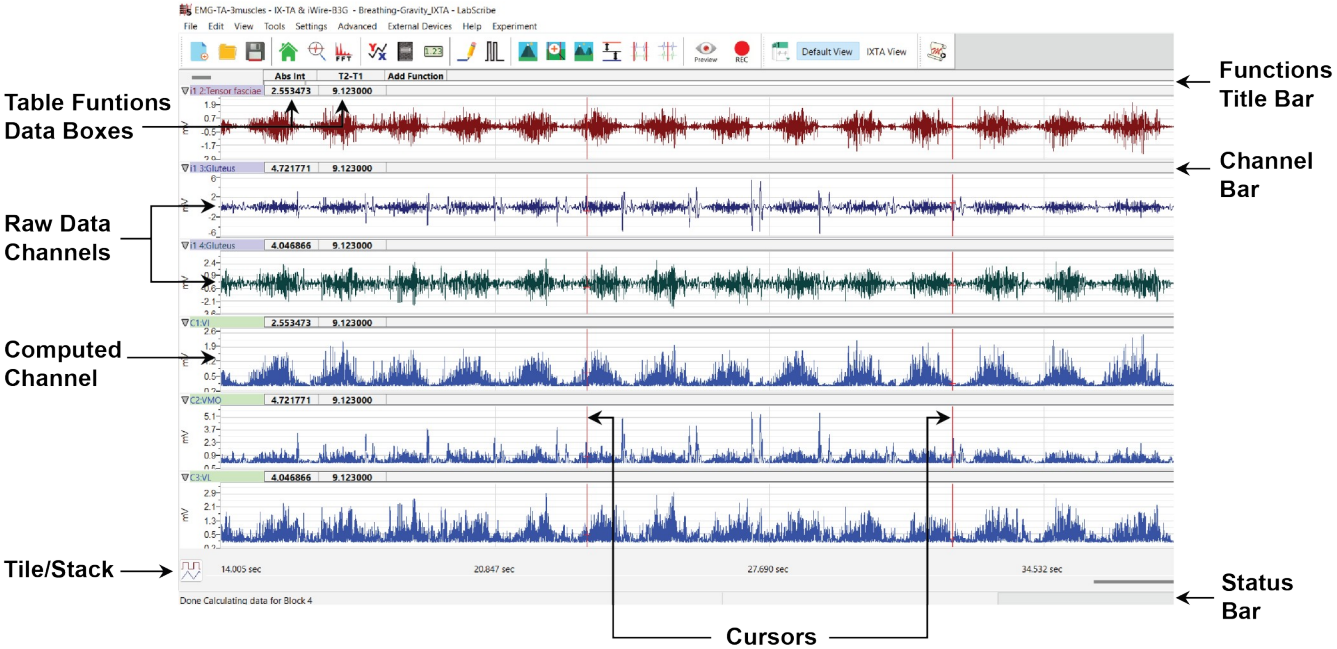
Many of the same tools in the Main Window are also available in the Analysis window. These include Display Time controls, Marks, and Two Cursor Mode (Single Cursor Mode is unavailable). The Toolbar icons have the same functions. Refer to Chapter 1: The Display for a complete description of these tools.

Scroll bars can be used to fine tune the area of data upon which the selected functions will operate in Chart mode. In Scope mode the sweeps of interest can be selected Individually or as part of a group.

Data in the Analysis window can be operated upon by the functions selected with the add function button just above the left hand side of the first channel. Functions are organized in four groups: General, Derivative, Integral (Area), and NIBP (Non-Invasive Blood Pressure).

By positioning the two cursors on the left and right edges of the data to be analyzed, LabScribe will immediately calculate and display the values for the selected parameters in the Table Function data boxes of each channel's Channel Bar.

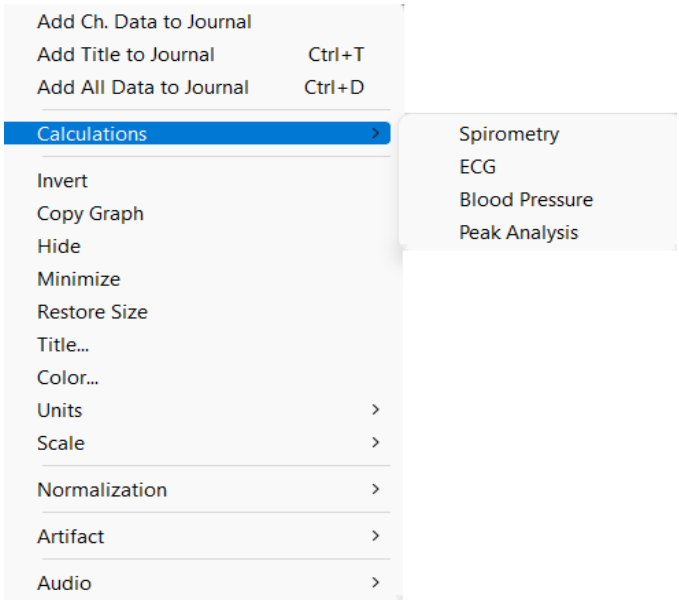
The primary features of the Analysis Window, including those that differ from the Main Window, are labeled in the figure below.



The Analysis Window.

Channel Menus in the Analysis Window

Clicking on the Channel Menu arrow on the left side of the Channel Bar or right-clicking in any channel of the Analysis Window opens the Channel Menu.



The Analysis Window Channel Menu.

The items in the lower section of the Analysis Window Channel Menu have the same functions as the similar items in the Main Window Channel Menu. Refer to page 7 in Chapter 1: The Display for a discussion of these menu items.

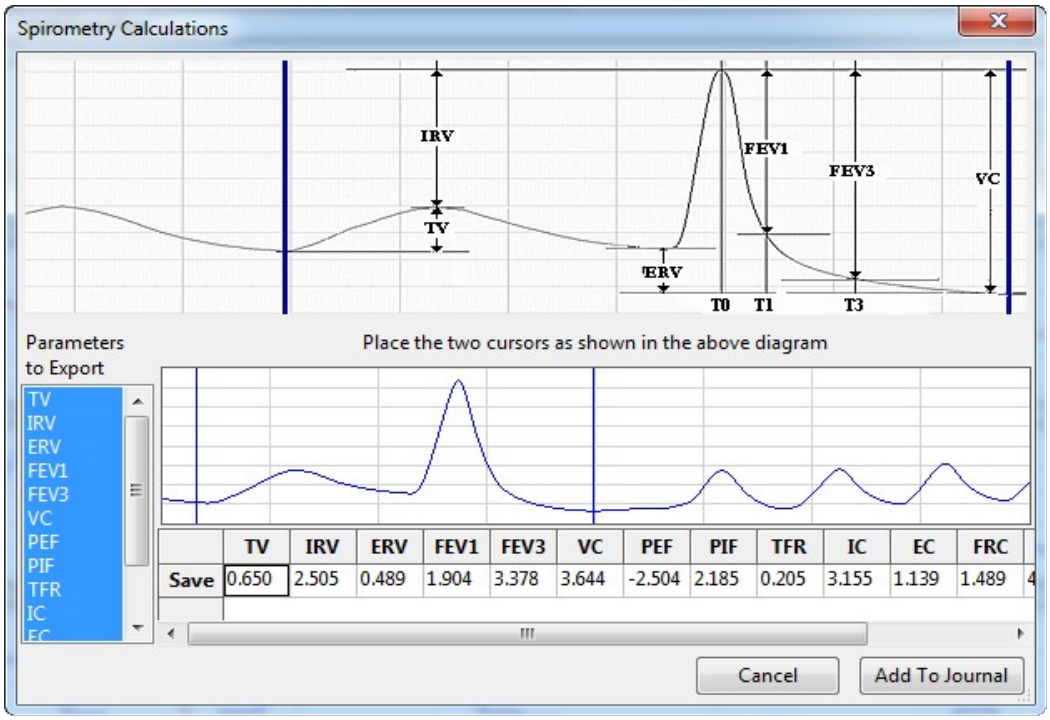
The first three menu items send the values in the Channel Bar Table Functions data boxes to the Journal for formatting and inclusion in reports:

- **Add Ch. Data to Journal**: Sends that channel's title and **Table Functions** data box values to the **Journal**.
- **Add All Data to Journal**: Sends the channel titles and the values from the **Table Functions** data boxes in the **Channel Bars** of all channels to the **Journal**.
- **Add Title to Journal**: Sends the **Title(s)** from the **Table Functions** data box title bar to the **Journal**.

Calculations: Spirometry, ECG, and Peak Analysis

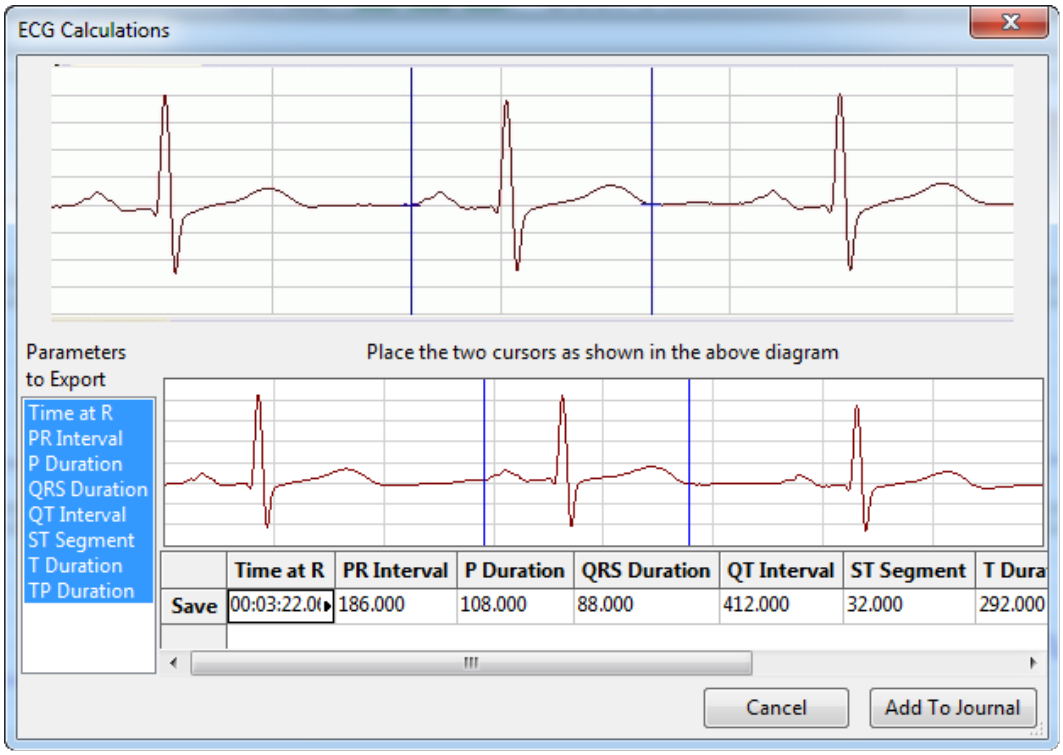
The choices in the Calculations submenu display calculated data values specific to individual functions:

- **Spirometry**: Opens a dialog that allows the user to choose and display calculations of **Spirometry** functions based on the raw data in a calibrated air flow channel. By placing the cursors in the data sample to the edges of one breath cycle as in the demonstration trace in the top part of the dialog, a number of spirometry parameters will be calculated automatically for that cycle of data. Clicking the **Save** button will add the data from that cycle and open up a new blank data row. The process can be repeated for other breaths in the recording. Clicking **Add to Journal** will add the data table to the **Journal**.



Spirometry Calculations.

- **ECG**: Opens a dialog that allows the user to choose and display calculations of ECG parameters based on the raw data in an **ECG** channel. By placing the cursors in the data sample to the edges of one heart beat cycle as in the demonstration trace in the top part of the dialog, a number of ECG parameters will be calculated automatically for that cycle of data. Clicking the **Save** button will add the data from that cycle and open up a new blank data row. The process can be repeated for other beat cycles in the recording. Clicking **Add to Journal** will add the data table to the **Journal**.

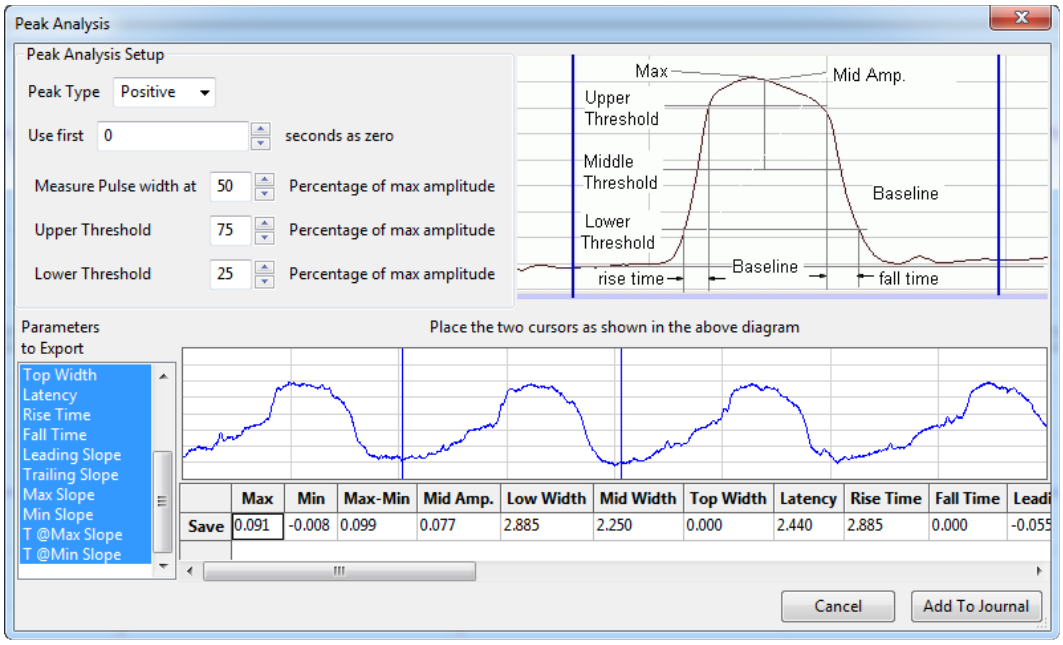


ECG Calculations.

- **Blood Pressure**: Opens a dialog that allows the user to choose and display calculations of blood pressure parameters based on the raw data in a **Blood Pressure** channel. By placing the cursors in the data sample to the edges of one heart beat cycle as in the demonstration trace in the top part of the dialog, a number of blood pressure parameters will be calculated automatically for that cycle of data. Clicking the **Save** button will add the data from that cycle and open up a new blank data row. The process can be repeated for other beat cycles in the recording. Clicking **Add to Journal** will add the data table to the **Journal**.

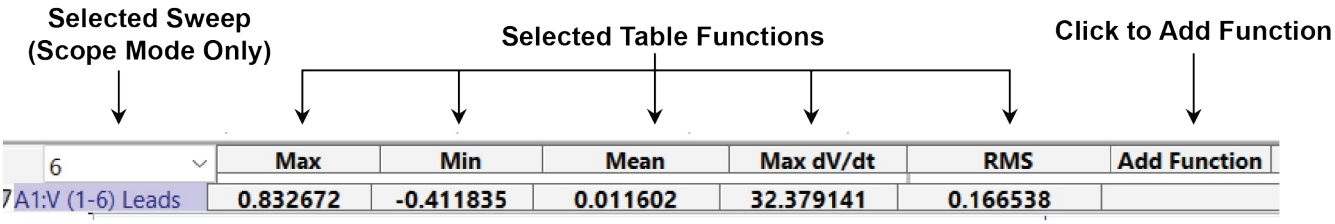
Blood Pressure Calculations.

- **Peak Analysis**: Opens a dialog that allows the user to choose and display calculations of peak parameters based on the raw data in a channel with peak data. By placing the cursors in the data sample to the edges of one peak as in the demonstration trace in the top part of the dialog, a number of peak parameters will be calculated automatically for that peak. Clicking the **Save** button will add the data from that peak and open up a new blank data row. The process can be repeated for other peaks in the recording. Clicking **Add to Journal** will add the data table to the **Journal**.



The Functions ("add function" categories): General, Derivative, Integral, and NIBP

The functions selected in the add function list determine the calculations performed on the data points between the two cursors in the Analysis window.



The Analysis Window Table Functions Title Bar.

The functions available in the **Analysis** window are divided into four categories: **General**, **Derivative**, **Integral, NIBP, Parameters**

General: The functions in the General category are:

- **Value1**: Amplitude at **Cursor 1**.
- **Value2**: Amplitude at **Cursor 2**.
- **Time1**: Time at **Cursor 1**.
- **Time2**: Time at Cursor 2.
- **V2-V1**: The amplitude at **Cursor 1** (the **Cursor** on the left) subtracted from the amplitude at **Cursor 2** (the **Cursor** on the right). This may be a negative number.
- **T2-T1**: **Time2-Time1**, the difference in time between the cursors.
- **Max**: Maximum amplitude between the cursors.
- **Min**: Minimum amplitude between the cursors.
- **Mean**: Mean or average amplitude between the cursors.
- **Max-Min**: Difference between the maximum and minimum amplitudes between the cursors.
- **Mark**: Text of any mark between the cursors.
- **Unit**: The units of the channel data.
- **RMS**: Root Mean Square of the amplitude values between the cursors.
- **StdDev**: Standard Deviation of the amplitude values between the cursors.
- **Events-# Zero Crossings**: Number of times the data cross zero (with a positive slope) in the region between the cursors.
- **Time @ Max**: Time at the Maximum Value
- **Time @ Min**: Time at Minimum Value
- **Max-V1**: Difference between Max and the Value at Cursor 1
- **Min-V1**: Difference between the Minimum and the Value at Cursor 1.
- **Tmax-T1**: Time difference between the Maximum and Cursor 1
- **Tmin-T1** : Time difference between the Minimum and Cursor 1.

Derivative: The functions in the Derivative category are:

- **dV1/dt**: Derivative at **Cursor 1**.
- **dV2/dt**: Derivative at **Cursor 2**.
- **Max dV/dt**: Largest dV/dt values (steepest slope) for all of the data points between the two cursors.
- **Min dV/dt**: Minimum (often negative with a steep slope; not necessarily a flatter region) dV/dt values for all of the data points between the two cursors.
- **Mean dV/dt**: Mean dV/dt for all of the data points between the two cursors. This is also the slope of the line of best fit for all the data points between the cursors.

Integral: All the integral and area functions are calculated as integrals. The functions in the Integral category are:

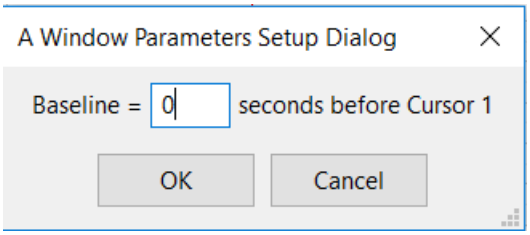
- **Area**: The **Area** function uses the line between **V1** and **V2** as the zero baseline, and then calculates the integral. The **Area** function gives more control over which segments of a waveform are included in the integral.
- **Abs. Area**: The absolute value of each data point is used to calculate the area as described above. **Areas** that would have been subtracted in the **Area** function, are instead added in the calculation of the **Absolute Area**.
- **Int**: For the **Integral** calculation, zero volts is used as the zero reference for the **Integral**. Values above zero add to the **Integral** and values below the zero-line subtract from the **Integral**.
- **Abs Int:** The **Absolute Integral** is very much like the Integral, except that the program takes the absolute value of the raw data before performing the **Integral** operation.
- **Area-Cursors**: The **Area-Cursors** function uses the baseline as set in the A-win Parameters described below, and then calculates the integral. The Area function gives more control over which segments of a waveform are included in the integral.
- **Abs. Area-Cursors**: The absolute value of each data point is used to calculate the area as described above. The Area-Cursors function uses the baseline as set in the A-win Parameters described below. Negative Areas, below the baseline that would have been subtracted in the Area function, are instead added in the calculation of the Absolute Area.

NIBP:

When using an iWorx non-invasive blood pressure transducer, it is possible to determine a subject's systolic and mean blood pressures from a pulse transducer recording. When the cursors are placed at the appropriate locations in the pulse transducer trace, the systolic and mean blood pressures are indicated in the NIBP channel data boxes, as is a calculated diastolic pressure.

Parameters:

For calculating the **Are**a-Cursors and AbsArea-Cursors the baseline is calculated as some number of seconds before the first cursor. This reduces the error in the baseline calculation due to noise at Cursor 1.



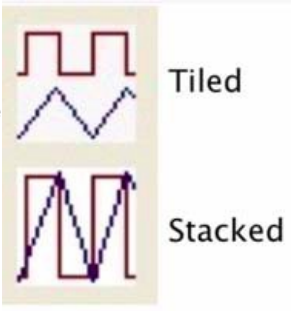
Adding Functions to the Analysis Window

To add a function to the data in the **Analysis Window**:

- Position the two cursors in the **Main Window** on either side of the section of data you wish to analyze.
- Click **AutoScale** in each of the **Main Window Channel Bars**.
- Click the **Analysis Window** icon in the **Toolbar**. The **Analysis Window** will now be displayed.
- Click the **add function** button in the **Table Functions Title Bar** just beneath the **Toolbar**.
- Select a function from one of the three function categories.
- That function will be applied to the data between the two cursors on all channels and be displayed in the **Table Functions** data boxes in each **Channel Bar** in the position vertically beneath the function title. While the chosen function will be calculated for all data channels, it may be more meaningful and relevant on some channels than others.
- Additional functions can be added in the same way. If there are more function boxes than space on the screen, the function boxes can be scrolled through using the scroll bar on the left end of the **Table Functions Title Bar**.
- The precision of the calculations performed is adjustable using the **Data Display Precision** value in the **Options** page of the **Preferences Dialog**.

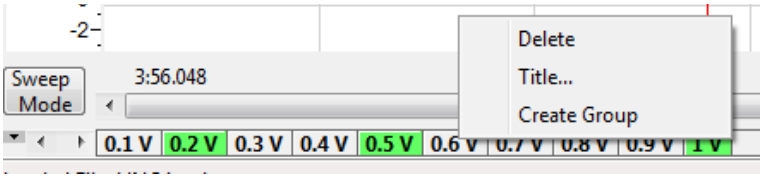
Tile or Stacked Display

By default, the channels selected for display are presented in **Tiled** mode. Each channel is displayed in its own area, as they are shown in the **Main** window. By clicking the **Tile/Stack** icon in the lower left hand corner of the **Analysis** window, each channel's waveforms are overlaid on the same set of axes.



Scope Mode Analysis Window Options

In Scope mode, you can view either a single sweep or multiple sweeps at the same time. Data functions can only be calculated on one sweep at a time.

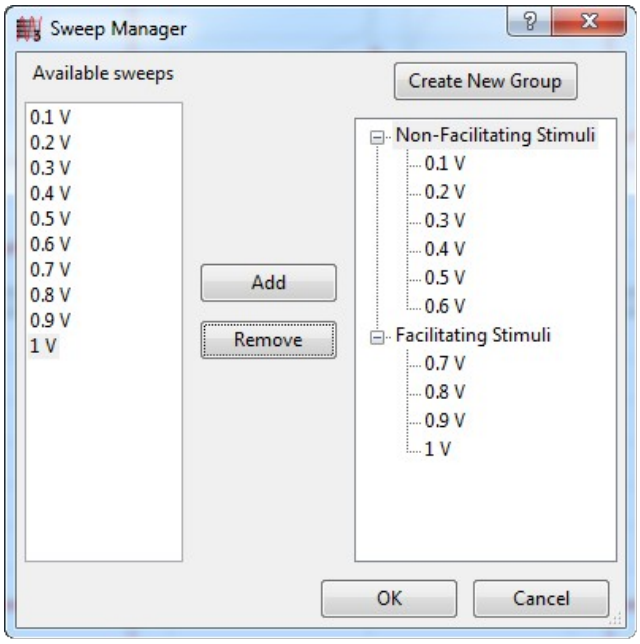


Sweep Selection bar in Sweep mode with multiple sweeps selected.

To view and calculate mathematical functions on Scope data:

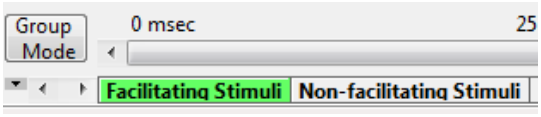
- The displayed sweeps can be chosen by clicking on the desired sweeps in the **Sweep Selection Bar** at the bottom of the **Analysis Window**.

- To choose multiple sweeps, click on each sweep while pressing CONTROL on the computer keyboard (COMMAND on the Macintosh). Multiple sweeps will be displayed superimposed on one another. Clicking a second time on any sweep will remove it from the display.
- When multiple sweeps are displayed simultaneously, the drop-down menu above **Channel 1** includes all the displayed sweeps, and options to include the average of the sweeps. The currently selected sweep is displayed in black, while the other sweeps are grey. The mathematical average of all displayed sweeps is in red and can be included with all the sweeps, by itself, or not included.
- As in the **Main Window**, individual sweeps can be titled (or re-titled) or deleted by right-clicking on that sweep in the **Sweep Selection Bar** and opening the drop-down menu.
- Data can be calculated from only one sweep at a time. The primary sweep, on which the functions operate, is selected in the drop-down box to the left of the **Table Functions Title Bar**. The primary sweep cannot be deselected from the **Sweep Selection Bar**.
- Functions are added in the same manner as in the **Chart** mode **Analysis Window**.
- Individual sweeps can be organized into groups by using the **Sweep Manager**. The **Sweep Manager** is available from the **Sweep** menu arrow to the left of the **Sweep Selection Bar**. To create a group, click on the **Create New Group** button and the **Edit Group Name** dialog will appear. Enter a name for the new group and click **OK**. The group is now listed in the group tree. To add a sweep to a group, select a sweep from the available sweeps list and drag it to the group, or click the **Add** button. To remove a sweep from a group, select the sweep and click the **Remove** button.



The Sweep Manager.

- To switch the display from **Sweep** mode to **Group** mode, click on the **Sweep/Group** mode button to the left of the scrollbar. This button changes from **Sweep** to **Group**. In **Group** mode, it's possible to display any of the named groups. Selecting the **Group** name will display just the sweeps in that **Group**.



The Sweep Selection Bar in Group mode.

Copy, Export, and Print Analysis Window Data

To copy the graphical data displayed in the Analysis Window, use the Copy command in the Edit menu. The image can be pasted into any program (including the Journal) that supports the clipboard. To copy an individual channel's trace, open the Channel Menu and choose Copy Graph.

The data in the Analysis window can be exported in Matlab (*.mat), DADiSP (*.dat), Excel (*.xls), Text (*.txt), LabScribe (*.iwxdata), or EDF (*.edf) formats. An image of the data can be exported in Portable Network Graphics (*.png) or JPEG (*.jpg) formats. To export the data viewed, use the Export command in the File menu. Select the format of the file from the list at the bottom of the Export File dialog.

To print the visible screen (excluding the Journal), choose Print View in the File menu.

XY Window

Data are recorded only into the Main Window. Main Window displays are linear or in series, meaning that Y-value parameters are recorded with respect to time.

Data recorded in a linear manner can be redisplayed in a format that is different than the standard Y-T plot. LabScribe supports XY and FFT plots. A host of measurements can be made from each type of redisplayed data window.

The XY View

In an XY plot, the Y-values from one channel in the Main Window are plotted against the Y values from another Main Window channel. The resulting XY plot is dramatically different from a linear plot of data against time. The XY View can be chosen by clicking on the XY View icon in the Toolbar or choosing XY View in the View menu.

XY View Components

The raw data channels to be plotted in the XY Graph are chosen from the menus beneath the XY Graph, as well as which of the channels will be the X axis and which will be the Y axis. The XY Graph is displayed on the left side of both the Main and Analysis Windows. Its size can be changed by clicking on and dragging the left border.

The XY View.

Selecting the Displayed Channels: To plot an **XY Graph**:

- Select the **X-axis** channel from the left drop-down box below the graph.

- Select the **Y-axis** channel from the right drop-down box below the graph.

Once the channels are selected, the **XY Graph** is displayed. All the data visible on the active screen in the X and Y axis traces will be included in the **XY Graph**. The locations of the left and right cursors are indicated in the **XY Graph** by two small cursors. To more finely tune the region of data to be included in the **XY Graph**, select **Two Cursor Mode** from the **Toolbar** and bracket the region of interest between the two cursors in the X-axis or the Y-axis channel. Next, select **Zoom Between Cursors** from the **Toolbar**.

FFT Window

FFT is short for Fast Fourier Transform, a mathematical operation that displays recorded data as the relative amplitudes of the frequency components that make up the recorded signal. **FFT** plots have **Frequency** on the X-axis and the **Power** (amplitude) contained in each frequency on the Y-axis. **FFT** analysis is used to determine the relative contributions of frequency components in a raw signal. For example, in EEG studies, Alpha waves are EEG signals with frequencies between 8 and 13 Hz. If an **FFT** is performed on an EEG recording that has a high number of Alpha waves, the **FFT** will show a spike or a higher amplitude (**Power**) at the frequencies in the Alpha band.

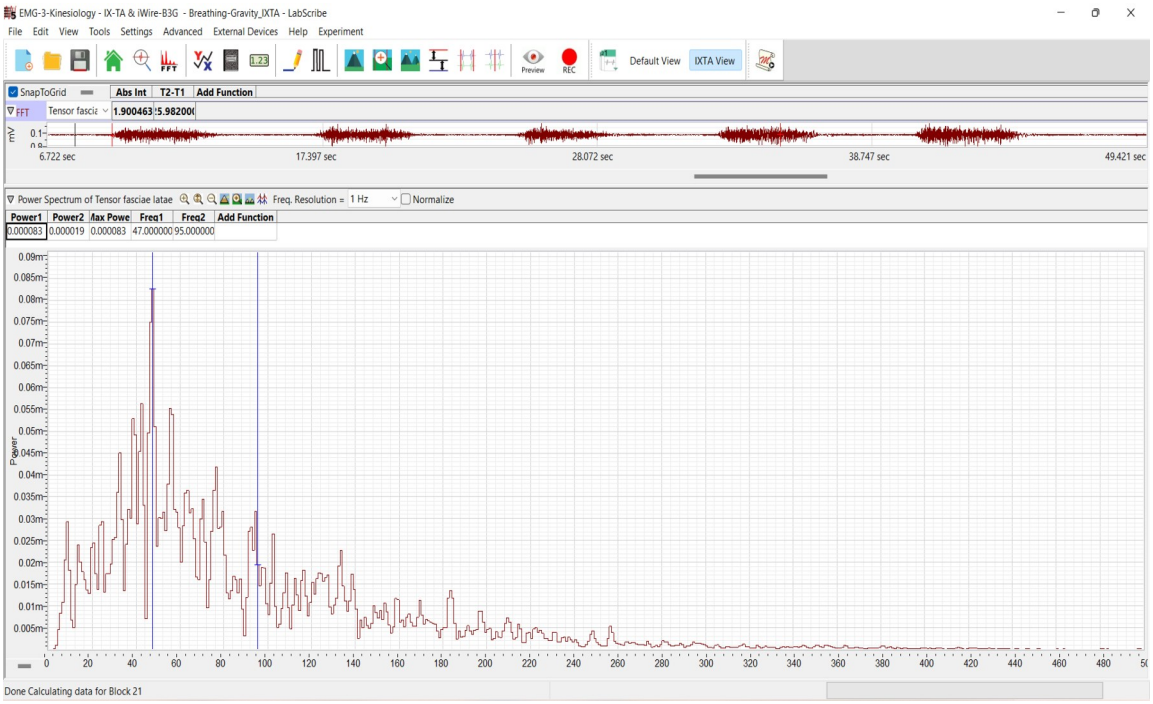
LabScribe can perform Fast Fourier Transforms on selected pieces of recorded data in the FFT window. The FFT window is opened from the View menu or by clicking the FFT icon on the Toolbar at the top of the Main Window. The selected data are moved to the Linear Display area in the FFT window where adjustments can be made which optimize the size of the FFT plot.

FFT Window Components

Located in the upper left of the data channel display area, the FFT channel selection drop-down box allows the user to select the data channel to be used in the FFT plot. The same functions available in the Analysis Window can be applied to the data from this channel by clicking on its add function button. The FFT plot is displayed in the lower pane. A different set of functions, appropriate to the FFT plot, can be accessed by clicking the add function button in this lower pane.

The FFT plot toolbar has display controls similar to the **Main Window**:

- **Half Display Time, Zoom between Cursors** and **Double Display Time** function as they do in the **Main Window**.
- The Y-axis can be scaled using the **Zoom In, AutoScale** and **Zoom Out** buttons.
- The **Frequency Resolution** drop-down box allows setting the **Frequency Resolution** of the **FFT** from 10Hz to 0.01Hz.
- Checking the **Normalize** checkbox adjusts the vertical scale of the **FFT Plot** to a zero to one scale. This standardized scale allows for direct comparisons with other **FFT Plots** that may have a different Y-axis range.



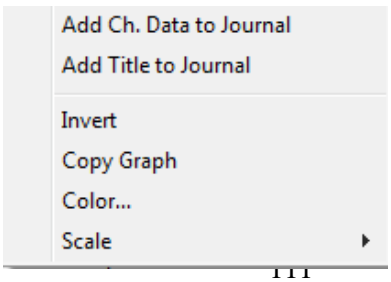
FFT Window.

To configure the **FFT View**:

- Select the data to be operated upon by the program. The **Display Time** controls are used to get the data of interest onto a single screen in the **Main Window**. The selected data are moved to the **FFT** window by clicking the **FFT** icon on the *LabScribe* toolbar or by selecting **FFT** from the **View** menu.
- Once the primary data set is moved to the **FFT** window, the two cursors on the linear graph of the data channel (above the actual **FFT** plot) can be used to fine-tune the data selection. Only the data between the cursors in the linear graph are actually used in the calculation. The data displayed on the linear graph and available for the transform can be changed using the **Display Time** icons on the **FFT** window or the scroll bar under the linear graph. If **Snap To Grid** is selected, *LabScribe* selects the end point for the data selection.
- The cursors also delineate the values for the selected **Table Functions** displayed above the linear data channel graph. The values and the titles can be copied to the **Journal** by using the functions in the **Channel Menu** for the data channel, as described below.

Channel Menu in the FFT View

Clicking the Channel Menu arrow at the left of the data channel opens the Channel Menu. It contains the following commands:



- **Add Ch Data to Journal**: Adds the channel title and **Table Functions** data to the **Journal**.
- **Add Title to Journal**: Adds the **Table Functions** titles to the **Journal**.
- **Invert**: Inverts the channel data.
- **Copy Graph**: Copies the channel graph to the clipboard. This can be then pasted into the **Journal** or an external application. *The Data Channel Menu.*
- **Color...**: Allows the user to choose the color of the trace for the channel.
- **Scale**: The items in the **Scale** submenu have the same functions as in the **Channel** menus of the **Main Window**. Refer to the discussion starting on page 38 in **Chapter 3: Acquisition** for details.

The functions available by clicking **add function** in the data Channel **Bar** are the same functions available in the **Analysis Window**.

The FFT Plot Menu

Clicking the arrow to the left of add function in the FFT Plot window opens the FFT Plot window menu with the following menu items:

- **Add All Data to Journal**: Adds the data from the **FFT Plot Table Functions** data boxes to the **Journal**.
- **Add Title to Journal**: Adds the **Table Functions** titles to the **Journal**.
- **Copy graph**: Copies the **FFT** plot to the clipboard. It can then be pasted into the **Journal** or an external application.

FFT Table Functions

The following functions are available in the FFT Plot window:

General

- **Power1**: Power at **Cursor 1**.
- **Power2**: Power at **Cursor 2**.
- **Freq1**: Frequency at **Cursor 1**.
- **Freq2**: Frequency at **Cursor 2**.
- **P2-P1**: Difference in power between the values at the two cursors.
- **F2-F1**: Difference in frequency between the values at the two cursors.
- **Max power**: Maximum power between the cursors.
- **Min power**: Minimum power between the cursors.
- **Mean power**: Mean power between the cursors.
- **MaxP-MinP**: The Maximum power value minus the Minimum power value.
- **Freq at Max power**: Frequency at Maximum power between the cursors.
- **Freq at Min power**: Frequency at Minimum power between the cursors.
- **Mean Frequency**: Mean frequency of the values between the cursors.
- **Median Fequency**: Median frequency of the values between the cursors.

- **Dispersion**:

Integral

- **Power between Cursors**: Summed power data values between the cursors.

Theoretical Considerations

To ensure problem-free operation of the **FFT** function, certain premises need to be considered.

- The mathematical underpinnings of digital sampling, which makes the *LabScribe* software work, begin with a foundation known as the Nyquist Sampling Theorem. Harry Nyquist showed that the sampling rate must be at least twice the highest frequency in the sample to reconstruct the original signal and capture its fundamental frequency. The converse of this rule is that the fastest frequency that can be reliably recorded is half of the sampling rate. If a recording was made at 1000 samples per second, the maximum frequency that could be recorded reliably would be 500Hz. If a recording was made at 100 samples per second, the maximum frequency that could be recorded reliably would be 50Hz. When an **FFT** is performed on data recorded with *LabScribe*, the program sets the X-axis to a scale from 0Hz (DC) to a frequency that is half of the sampling rate. A region of the scale can be expanded by using the cursors and the functions of the **Channel** menu, but frequencies greater than half the sampling rate cannot be viewed.
- To make an **FFT** work, the transform must operate on a *specific number of data points*. The number of data points used in the **FFT** is algorithm dependent. By default the **Snap to Grid** option is selected, which sets the second cursor to the location of the best selection of **FFT** data on the linear display section of the **FFT View**. If you make a different selection, *LabScribe* will fill in the remaining data points with zeros so the frequency content of the data that you did select will not be affected.
- As stated in the first rule that governs **FFT** functions, *LabScribe* sets the X-axis limits in the **FFT** window according to the sampling rate. Likewise, the number of data points used in the FFT calculation sets the resolution of the X-axis range. If more data points are used, the available **Frequency Resolution** will be greater. **Frequency Resolution** is set from the drop-down menu in the left hand margin of the **FFT** window. Resolution choices are limited to 100 Hz, 10 Hz, 1 Hz and 0.1 Hz. If the FFT cannot be displayed with the required frequency resolution, more data points need to be used to make the calculation.

Copy, Export, and Print FFT Windows

Use the **Copy** command in the **Edit** menu to copy the view of data displayed in the FFT View. This image can be pasted into any program (including the Journal) that supports the clipboard.

To export the data viewed, use the Export command in the File menu. Select the format of the exported file from the list at the bottom of the Export File window.

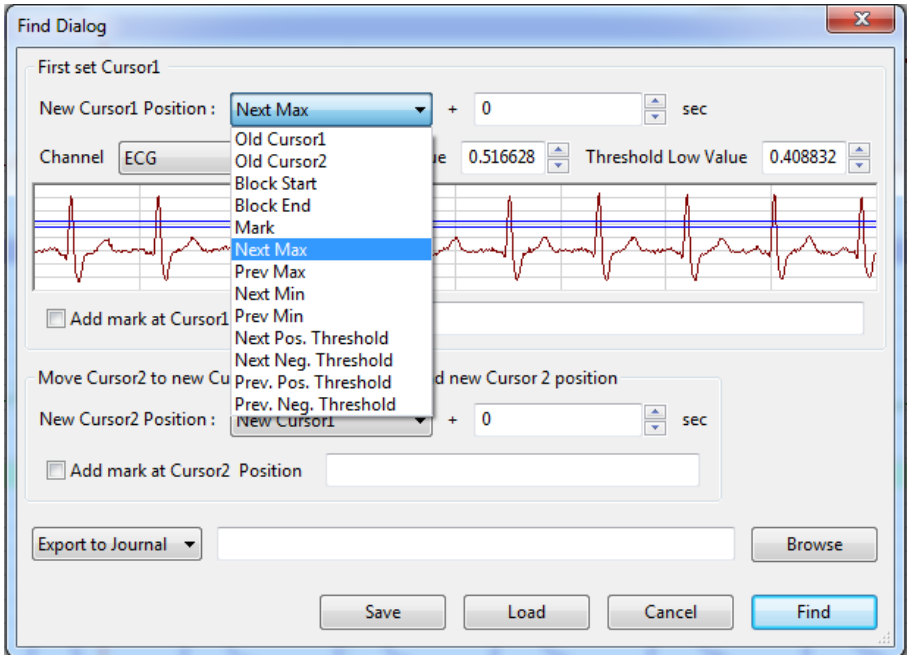
Choosing Print View will print the current window.

Find Functions

LabScribe can be used to identify Regions Of Interest (ROI) in recorded data. The identified data points or marks can be sent to either the Journal or the Marks window, where they can be used to build a report or to be exported. While identifying data does not constitute an analysis per se, the detection of specific data always precedes analysis. For example, to measure changes in Left Ventricular End Diastolic Pressure (LVEDP) over time, the LVEDP points need to be located in the blood pressure data and the corresponding values need to be recorded. The statistical manipulation of the recorded LVEDP values is classified as analysis, but the first critical step in the analysis is the extraction of the relevant data points or regions of interest from the raw data.

Find Dialog Window

The **Find** dialog window is accessed by selecting **Find** from the **Tools** menu. Data points of interest can be identified using commands from the **Find Dialog** window.



The Find Dialog.

In the Find Dialog, each cursor (in Two Cursor Mode) is programmed individually to move to a location with designated data criteria with the Find Next command in the Tools menu, or by its keyboard shortcut (CONTROL + F in Windows, or COMMAND + F on the Macintosh). To configure the Find Dialog:

- In the top part of the dialog, set the New **Cursor 1** position to the type of data point or **Mark** you want **Cursor 1** to locate.
- In the lower part of the dialog, set the New **Cursor 2** position to the type of data point or **Mark** you want **Cursor 2** to locate.
- Setting the New **Cursor 2** location to the New **Cursor 1** position enables the user to repeatedly find specific data points over and over, as the cursors will move as one to the positions designated for **Cursor 1**. Setting the New **Cursor 2** position at the next incidence of the type of data you are

looking for (which is not necessarily the same type of data point) will keep the two cursors separated, allowing you to determine both amplitude values and the distance between the two cursors.
- Indicate the channel you want to be used, and use the sample trace in the **Find Dialog** to specify the threshold window. For example, if the threshold lines are set above the P and T waves in an ECG, and **Next Max** is chosen for the desired New Cursor Position location, the cursors will move from R to R, as *LabScribe* will look for maximum values over the threshold lines.
- The cursors can be instructed to move a set number of seconds past (or before if a negative value is entered) the data criterion set.
- Once the criteria are set, choosing **Find Next**, or using its keyboard shortcut (CONTROL + F in WIndows, COMMAND + F on the Macintosh), will move the cursors to their next positions.

- Although the **Find** commands work in the **Main Window**, using them in the **Analysis Window** will report specified values to the **Table Functions** data boxes, allowing the values to be sent to the **Journal**.
- Once the **Find** routine is defined, it can be saved by clicking the **Save** button on the **Find Dialog** window. The named routine is saved in the **Auto Find** folder as an **.iwxfind** file.
- In the example in the figure, using this **Find** routine on the ECG trace will cause both cursors to move as one from R to R to R, allowing you to locate the position and determine the amplitude of each R. If the New **Cursor 2** were to be set instead at the next example of the type of data you were looking for, each time the **Find** command was called, the cursors would move individually and two R points would be located at each **Find** command, allowing the distance between Rs to be determined as well.

The locations that the cursors can be programmed to move to include:

- **Old Cursor 1** and **Old Cursor 2**: The positions from which the **Cursors** will be moving with each **Find Next** command.
- **New Cursor 1**: The position to which Cursor 1 moves with each **Find Next** command.
- **Block Start** and **Block End**: The cursors can be instructed to move to the start or the end of the current block of data.
- **Mark**: The cursors can be instructed to move to a specifed mark.
- **Next Max** or **Previous Max**: The cursors can be instructed to move to the Next Maximum value or the Previous Maximum value. These **Max** points will be over the threshold set in the sample data.
- **Next Min** or **Previous Min**: The cursors can be instructed to move to the Next or Previous Minimum values, as determined by the **Threshold** position.
- **Next** or **Previous Positive** or **Negative Threshold**: Instructs the cursors to move to the Next or Previous Threshold line the data cross in either a positive or negative direction.

The calculations to be performed on the selected data points or on the data between the points are chosen from the **Table Functions** list before the **Find** dialog window is opened.

FIND EXERCISE

As an example, the **Find** function could be used to determine the time (**T2-T1**) between two events. Occasionally, *R* waves in an ECG have significantly higher amplitudes than the other *R* waves in the same recording. The **Find** function could be used to measure the time between adjacent supranormal *R* waves. To find these durations:

1) Use the *LabScribe* ECG **Tutorial** to create an ECG recording.
2) **AutoScale** the ECG recording and transfer the data of interest from the ECG recording from the **Main Window** to the **Analysis Window**.
3) Select the calculations (**T1**, **T2**, **T2-T1**) to be performed on the data from the **Table Functions** list.
4) Pull down the **Tools** menu and select the **Find** function.
5) Program the cursor positions. To find the next supranormal *R* wave in the data, the **Cursor 1** position is set equal to **Next Max**. The New **Cursor 2** position is also set to **Next Max** and the data channel is selected.
6) Adjust the threshold amplitudes for both cursors, above which the **Find** function will **Find** the **Next Max**, so that only the supranormal R waves are above the threshold. Name and save the **Find** routine.
7) Click the **Find** button to place the cursors and to display the values for the selected **Table Functions** at the top of the **Analysis** window.
8) Copy values and their headings to the **Journal** via the **Add Title to Journal** and **Add Data to Journal** functions in the right-click menu of the **Analysis** window.
9) The **Find Next** command will shift both cursors one supranormal R wave to the right, allowing the next interval to be determined and recorded.

Auto Find Dialog Window

The Auto Find dialog window is similar to the Find window. It is also accessible from the Tools menu and works only from the Analysis Window. However, the Auto Find function can be programmed to find multiple data points with the same parameters within a data selection. The values at those points can be added to the Table Functions data boxes and the results of these analyses can be written to the Journal automatically.

The Auto Find function can find the same types of data points found with the Find function.

Like Find routines, Auto Find routines may be constructed from the various parameters available and saved in the Auto Find folder. For periodic functions, maximum values, and minimum values, LabScribe uses the threshold values set for periodic data on the add function menu in the Channel Bar. Just like other measurements of periodic data, the data must be scaled properly, which can be accomplished in most cases by clicking the AutoScale button in the Main Window.

AUTO FIND EXERCISE

As an example, the **Auto Find** routine can be used to place cursors on all the *R* waves in an ECG record and to measure the period (**T2-T1**) of each beat.

1) Manually place the cursors on the two successive *R* waves at the beginning of the record.

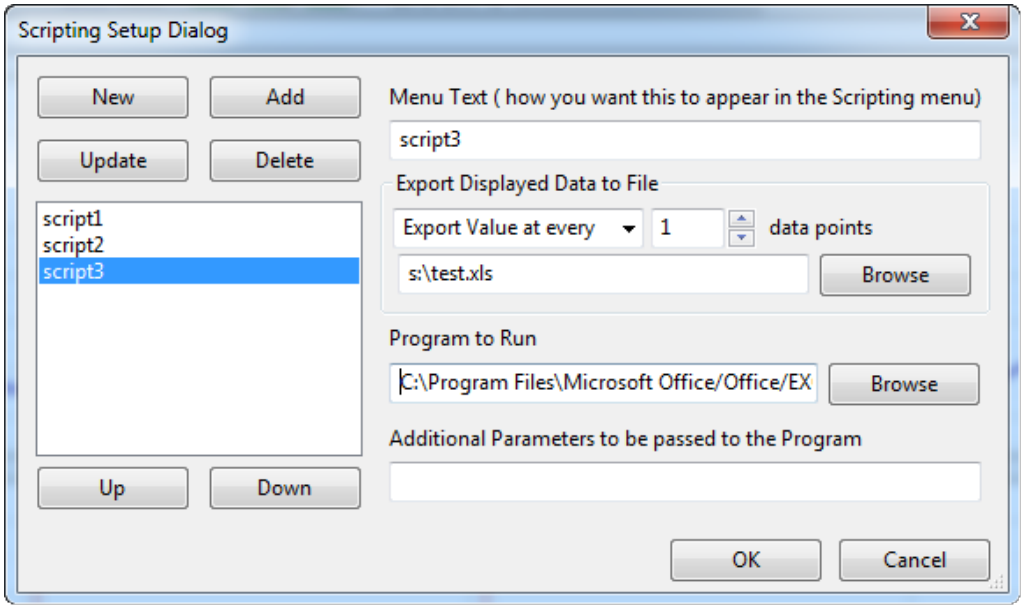
2) The next two data points that are needed for measuring the next period (**T2-T1**) are the first data point in the next period (the second *R* wave from the preceding period), and the next maximum value or *R* wave in succession (the second R wave in the next period).
3) Therefore, to make accurate measurements on the next period, the **Auto Find** window is programmed to set the **Cursor 1** position to be **Old Cursor 2** and the **Cursor 2** position to be the **Next Max**.
4) After the number of repetitions specified or the specified end of the **Auto Find** routine is reached, the **Auto Find** routine can be saved by clicking **Save** on the dialog window. The named **Auto Find** routines are saved as **.iwxfind** files and can be called by clicking on the **Load** button in the dialog window.

Other Analysis Tools

It is impossible to include all of the possible analyses and plotting capabilities required for biological research in a single program. We provide what we believe to be useful tools for completing the most common kinds of analyses. For circumstances where the built-in analysis tools fall short of the user's requirements, LabScribe has a Scripting function. Scripts can be written in any language, or they can be any program already installed on your computer. The Scripting Setup Dialog allows the user to manage the export of data being displayed on the screen, and to perform an operation on that data. LabScribe can be set up to provide easy access to these scripts in the Scripting Setup Dialog.

Managing Scripts

The Scripting Setup Dialog is launched by choosing Manage Scripts in the Advanced menu.



The Scripting Setup Dialog.

Choosing the Manage Scripts menu option launches the Scripting Setup Dialog. Using the Scripting Setup Dialog, you can create various scripting shortcuts that will then be available from the list of shortcuts in the Scripting Setup Dialog. Selecting the script from the menu and clicking OK will launch the associated script.

To set up a new scripting shortcut:

- Click the **New** button. Give the shortcut an appropriate name.
- You can export every "Nth" datapoint, or the **Mean** or **Maximum** of every "N" datapoints.
- Give the exported datafile a name, and choose the kind of file you want to export. We have chosen to export an Excel file in this example.
- Choose the program to launch (in this case, Microsoft Excel). Browse on your computer until you find the program file. The path of the chosen file will be shown next to the browse button.

- Specify any additional parameters you want applied to this program, such as the exported data file.

Note: *Exporting in Excel, text and DADiSP format creates multiple files (one for each block).*

- Set the working directory for the program if needed.
- Click the **Add** button to add this scripting shortcut to the menu. You can add many such shortcuts.
- You can change the order in which the shortcuts appear in the menu, using the keyboard UP and DOWN buttons.

8: Advanced Analysis

LabScribe includes modules designed to analyze data related to specific physiological processes. Separately licensed analysis modules include PV Loops (Pressure-Volume Loops), intravascular Blood Pressure, ECG data, ERG data, and Metabolic recordings. The Normalization module (accessed by right-clicking in a data channel and selecting Normalization) calibrates and standardizes the diameter of small vessels for experiments using wire myographs. AutoMark Peaks analyzes recordings with peak data. Except for the Normalization module, these Advanced Analysis routines can be accessed from the Advanced menu. Some of these analysis require a separate license. Contact iWorx for more information. Calculations specific to each analysis are computed from automarked data points and the results are displayed in the appropriate analysis windows.

8.1 PV Loop Analysis

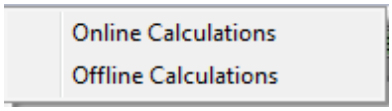
Ventricular pressure-volume loops are used to study many quantitative aspects of cardiac contractility. A single pressure-volume loop is a two-dimensional representation of the relationship of ventricular pressure to volume over time. The PV Loops Advanced Analysis Module integrates the variables and measurements necessary for the recording, analysis, and interpretation of ventricular pressure-volume loops. The PV Loops Advanced Analysis Module performs both baseline and occlusion analyses.

The PV Loops Advanced Analysis Module requires a separate license. The first time you select PV Loops, you will be asked for a username and a serial number. Contact iWorx Systems for more information.

This document includes a step by step tutorial for using most of the features of the PV Loops Advanced Analysis Module as well as a more detailed Reference section that covers the material in the tutorial, and adds additional context and detail. To use the step by step guide, you will need a recording with ventricular pressure and volume (or conductance) channels. This can be from any mammalian species. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

PV Loop Analysis: Step by Step

The PV Loops Advanced Analysis Module is accessed through the PV Loops submenu of the LabScribe Advanced menu. Both real-time Online Calculations and more sophisticated Offline Calculations are possible.



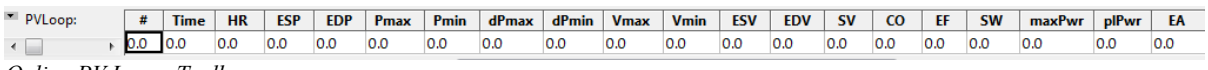
PV Loops submenu

PV Loop Online Calculations

It is possible to generate PV Loop calculations and graphs in real time.

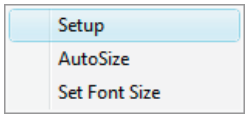
To use the Online Calculations:

1) Prepare the animal and configure the hardware and software to record ventricular pressure and volume measurements on two *LabScribe* channels. The volume measurement may be a conductance measurement or a calibrated or uncalibrated volume.
2) Record a sample and ascertain that the pressure and volume channels are recording data at the scale you desire. Stop recording while you configure the online analysis.
3) Choose **Online Calculations** from the **PV Loops** submenu to display the online **PV Loop Toolbar** above **Channel 1**.



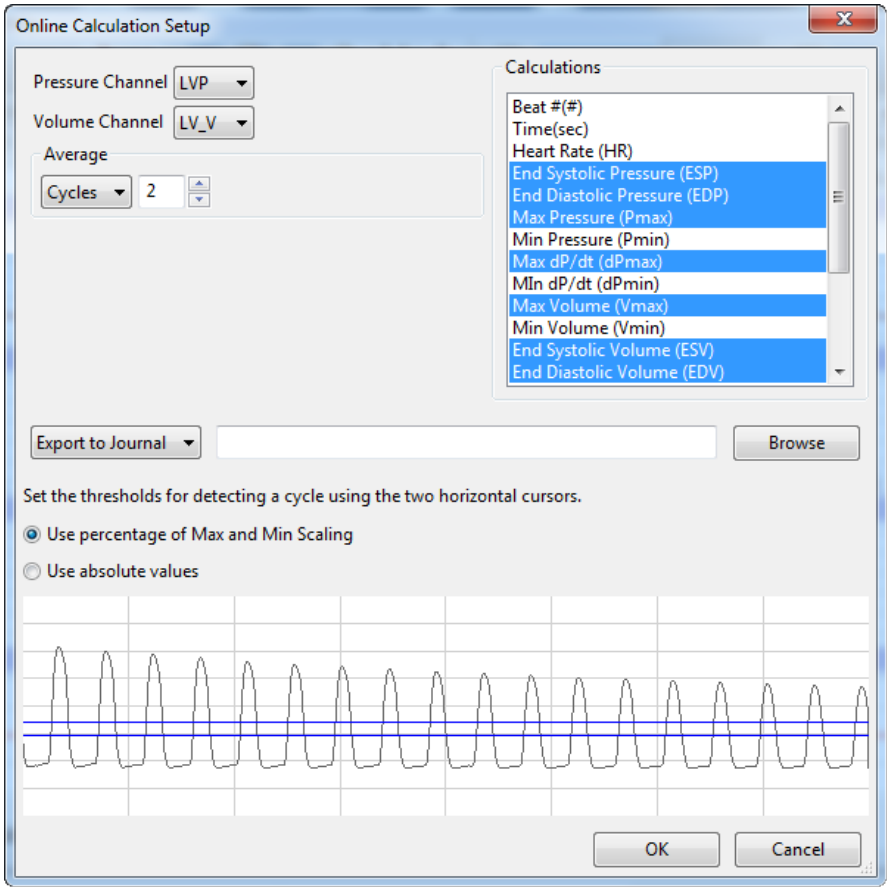
Online PV Loops Toolbar.

4) Click on the down arrow on the left side of the **PV Loop Toolbar** to display a menu with three choices: **Setup**, **AutoSize**, and **Set Font Size**.



PV Loop Online Setup menu.

5) Choose **Setup** to open the **Online Calculation Setup** dialog.

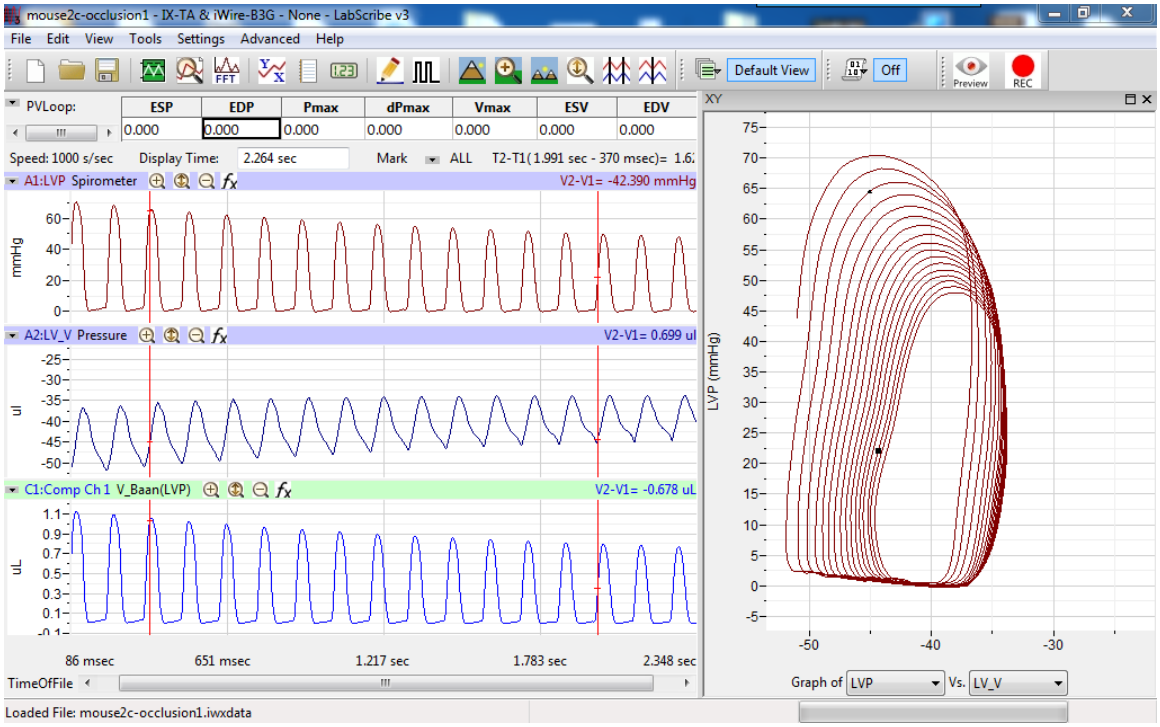


Online Calculation Setup dialog.

6) From the **Pressure Channel** and **Volume Channel** menus, choose the ventricular pressure and volume channels from your recording.
7) Once you select the **Pressure Channel**, a sample of the recording will be displayed at the bottom of the dialog. Set the thresholds for cycle detection by adjusting the Max and Min blue horizontal lines so that all cycles pass through both lines.
8) As you record data, cycles will be detected as either a percentage of the amplitude of the cycles based on where you placed the Max and Min lines, or as the absolute values of their set location. Choose which you prefer from the two choices above the sample recording.
9) From the **Calculations** menu, control-click on those variables you would like to record in the data boxes of the **PV Loop Toolbar**. To remove a variable after you have selected it,

control-click on that variable. Definitions of all variables can be found in the **PV Loops Analysis: Reference** section.

10) In order to compensate for variation from cycle to cycle, it is possible for *LabScribe* to average a user selected number of sequential cycles. Enter this number in the **Cycles to Average** text box. Start with a low number and adjust upward as necessary. Alternatively, **Time to Average** may be entered instead.
11) Click the **Export to File** menu item to send the data recorded in the **PV Loop Toolbar** as a .csv file to a location chosen in the dialog that opens. The other alternatives send the data to the *LabScribe* Journal (**Export to Journal**) or do not export the data at all (**No Export**).
12) Click **OK** to close the dialog.
13) Return to the **PV Loop Toolbar** menu (accessed by clicking the arrow) and choose **AutoSize**. The size of the data boxes and the titles will be adjusted to the number of variables you have chosen.
14) From the **PV Loop Toolbar** menu, choose **Set Font Size**. The font size of the data box values can be chosen from the dialog that opens.
15) Resume recording. The pressure and volume channels, and any computed channels, will be displayed on the left side of the **Main Window**, the changing variables will be displayed in the data boxes of the **PV Loop Toolbar.**
16) A real-time pressure-volume XY graph of the screen data can be displayed by clicking on the **XY Graph** icon in the **Toolbar**. The position in the **XY Graph** of the two vertical cursors in the recording are indicated by two moving markers. To change the proportion of the screen devoted to the graph, move the mouse cursor over the left border of the graph until you see a double-headed arrow. Click and drag to change the size of the graph.



The online PV Loop display, with the XY Graph option activated.

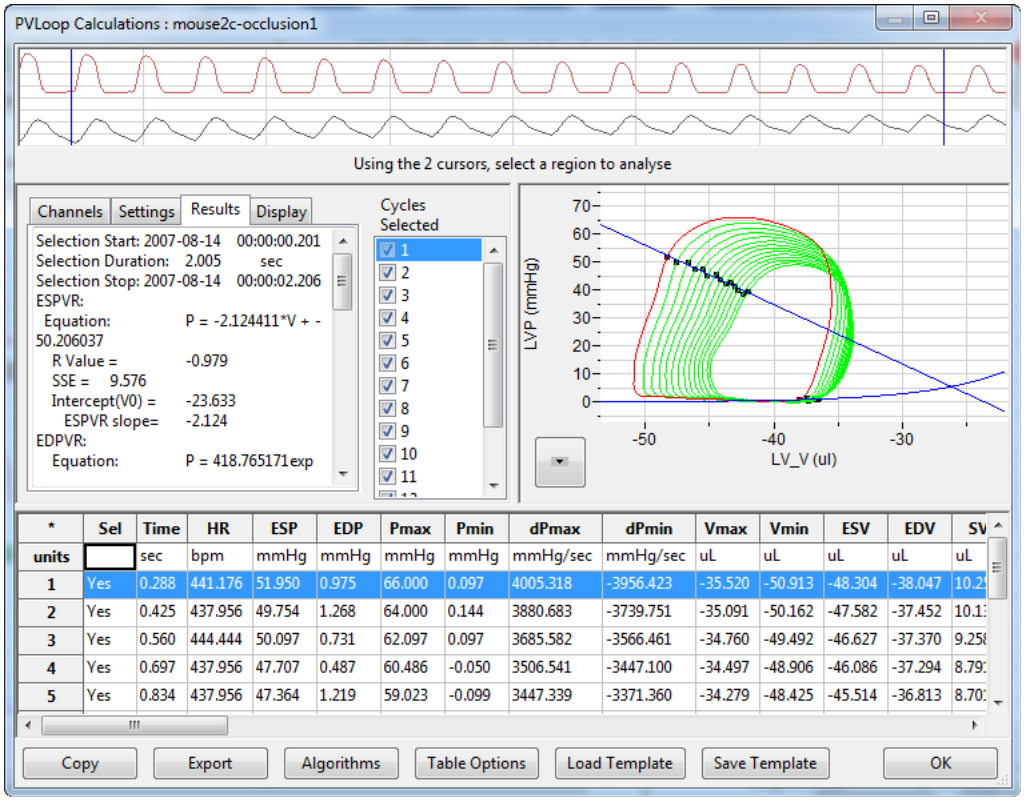
17) Save the recording for offline analysis.

PV Loop Offline Calculations:

The offline PV Loop Calculations dialog allows sophisticated offline analysis of previously recorded ventricular pressure-volume data.

To perform offline **PV Loop** analysis**:**

1) Open the recording from the online analysis or another file with previously recorded ventricular pressure and volume data.
2) Choose **Offline Calculations** from the **PV Loops** submenu to open the offline **PV Loop Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.



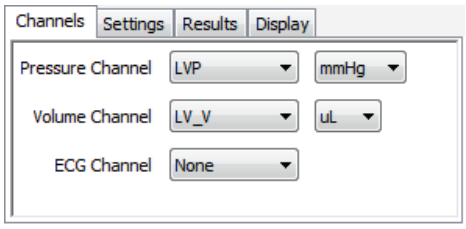
*	Sel	Time	HR	ESP	EDP	Pmax	Pmin	dPmax	dPmin	Vmax	Vmin	ESV	EDV	SV
units		sec	bpm	mmHg	mmHg	mmHg	mmHg	mmHg/sec	mmHg/sec	uL	uL	uL	uL	uL
1	Yes	0.288	441.176	51.950	0.975	66.000	0.097	4005.318	-3956.423	-35.520	-50.913	-48.304	-38.047	10.2
2	Yes	0.425	437.956	49.754	1.268	64.000	0.144	3880.683	-3739.751	-35.091	-50.162	-47.582	-37.452	10.1
3	Yes	0.560	444.444	50.097	0.731	62.097	0.097	3685.582	-3566.461	-34.760	-49.492	-46.627	-37.370	9.25
4	Yes	0.697	437.956	47.707	0.487	60.486	-0.050	3506.541	-3447.100	-34.497	-48.906	-46.086	-37.294	8.79
5	Yes	0.834	437.956	47.364	1.219	59.023	-0.099	3447.339	-3371.360	-34.279	-48.425	-45.514	-36.813	8.70

Offline PV Loop Calculations dialog.

3) Familiarize yourself with the offline **PV Loop Calculations** dialog, illustrated above.
   - Across the top of the dialog, in the channel display area, are samples from the pressure and volume channels of the recording.
   - The tabbed configuration dialogs are on the left below the recordings.
   - An XY graph window on the right displays the **PV Loops Graph**, or one of a selection of other XY graphs illustrating pressure-volume relationships.
   - Between the configuration dialogs and the XY graph window is the **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
   - The **Data Table** is located across the lower part of the dialog.

To configure the **Channels:**

1) Click on the **Channels** tab, opening the **Channels** configuration dialog.



PV Loops Channels configuration dialog.

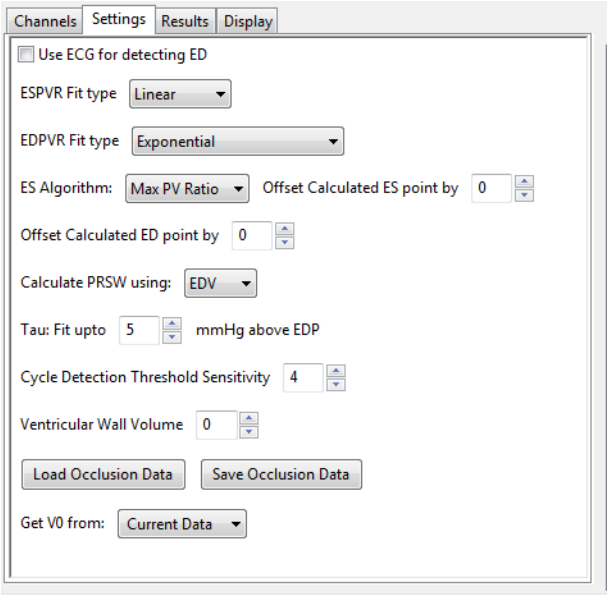
2) From the **Pressure Channel** menu, choose the channel with the ventricular pressure recording. Choose the pressure unit from the menu to the right.
3) From the **Volume Channel** menu, choose the channel with the ventricular volume recording. Choose the volume unit from the menu to the right.
4) Optionally, choose an ECG channel if there is one on the recording.

Once the pressure and volume channels are selected, the recordings of those channels will be displayed in the channel display area at the top of the dialog and the PV Loops Graph will be displayed in the XY graph window.

5) Select an area of the recording to be analyzed by moving the two vertical cursors in the channel display area to designate the section to be analyzed. Only those cycles will now be displayed in the **PV Loops Graph**, and the cycles will be listed by number in the **Cycles Selected** list to the left of the graph.

To configure the Settings**:**

1) Click on the **Settings** tab, opening the **PV Loops Settings** configuration dialog.



Starting at the top of the PV Loops Settings configuration dialog:

2) Check whether you wish to use an **ECG** recording for the detection of end-diastole (**ED**).

3) Choose **Linear** from the **ESPVR Fit type** menu. A linear fit is the default choice for the End Systolic Pressure-Volume Relationship (**ESPVR**) data, although an **Exponential** fit is an alternate choice.
4) Choose **Exponential** or **Exponential with Constant** from the **EDPVR Fit Type** menu.
5) Choose **Max PV Ratio** from the **ES Algorithm** menu. The maximum pressure-volume ratio (**Max PV Ratio**) will be used to compute end-systole (**ES**) in each cycle, and is the default value. Maximum pressure (**Max P**), and minimum or maximum derivatives of the pressure (**Min dP** or **Max dP**) are alternate choices.
6) End-systole will be offset from the selected value in Step 5 by a value selected in the **Offset Calculated ES point by** menu. This can be changed as desired.
7) Enter 0 into the **Offset Calculated ED point by** menu. This value can be changed as desired.
8) Specify end diastolic volume (**EDV**) as the value that should be used to calculate the preload recruitable stroke work, **PRSW**, a measure of contractility. The alternate choice is the maximum volume (**Vmax**).
9) Enter the number of mmHg above end diastolic pressure (**EDP**) that should be designated as the uppermost point to be used to create the best fit line from which **Tau** (the time constant of blood pressure decrease during diastole) is computed.
10) Enter 4 as the number of cycles that should be used to determine the **Cycle Detection Threshold Sensitivity**. By default, a threshold sensitivity of 4 is used to detect cycles. If each cycle is not being detected properly, the sensitivity can be adjusted.
11) The **Ventricular Wall Volume** can be compensated for by entering a value in the text box.
12) How to load and save occlusion data is described below.

To display and analyze the **PV Loops Graph:**

1) Familiarize yourself with the **PV Loops Graph**, which will be displayed in the XY graph area for all the cycles in the selection and is illustrated below.
   - By default, the highlighted cycle in the **Cycles Selected** window is shown in red, while all other selected cycles are displayed in green.
   - Cycles can be deselected (or selected) by clicking on the check box to the left of the cycle number in the **Cycles Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
   - The specific parameters shown in the graph are chosen from the **Display** configuration dialog.

The PV Loops Graph.

2) Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.

XY graph window menu.

3) Click **Copy Graph** to copy the current XY graph to the clipboard. It can then be pasted into the **Journal** or an external application.
4) Click **View PV Loops** to display the **PV Loops Graph** of the checked cycles in the **Cycles Selected** list to the left of the XY graph window.

A number of PV Loop relationships can be graphed from the items in this menu:

5) Click **View PRSW** to display the preload recruitable stroke work (**PRSW**) line, as defined in the **Settings**. By default, **PRSW**, a measure of contractility, is calculated by plotting stroke work (**SW**) on the Y-axis and end diastolic volume (**EDV**) on the X-axis. Maximum volume (**Vmax**) can be used as an alternative to **EDV** if desired.
6) Click **View Max dP vs. EDV** to display the XY graph of maximum dP/dt (**Max dP**) vs. end-diastolic volume (**EDV**).
7) Click **View PVA vs. EDV** to display the XY graph of the pressure-volume area (**PVA**) vs. end-diastolic volume (**EDV**).
8) Click **View PVA vs. ESP** to display the XY graph of the pressure-volume area (**PVA**) vs. end-systolic pressure (**ESP**).
9) Click **View E(t) vs. Time** to display time-varying elastance (**E(t)**) vs. **Time**.

Several display options are also available:

10) Click **Export Avg. Loop data** to export the data from the graphed average loop as a tab (*.txt) or comma (*.csv) separated text file.
11) Click **Export PV Loop data** to export the data from all the graphed loops as a tab (*.txt) or comma (*.csv) separated text file.
12) Click **View Markers** to display a graph of time (X-axis) vs. pressure and volume (Y-axis) with markers positioned at end-diastole (**ED**), maximum dP/dt (**Max dP**), end-diastole (**ES**), and minimum dP/dt (**Min dP**). The specific cycle displayed is determined by the position of the left cursor in the data recording at the top of the dialog.
13) Click **Export E(t) vs. Time data** to export the time-varying elastance (**E(t)**) vs. **Time** data as a tab (*.txt) or comma (*.csv) separated text file.
14) Click **Set X-axis Scale** or **Set Y-axis scale** to set the X-axis and Y-axis scales manually.
15) Click **AutoScale X-axis** or **AutoScale Y-axis** to optimize the display scale of the X-axis or Y-axis of the current XY graph.

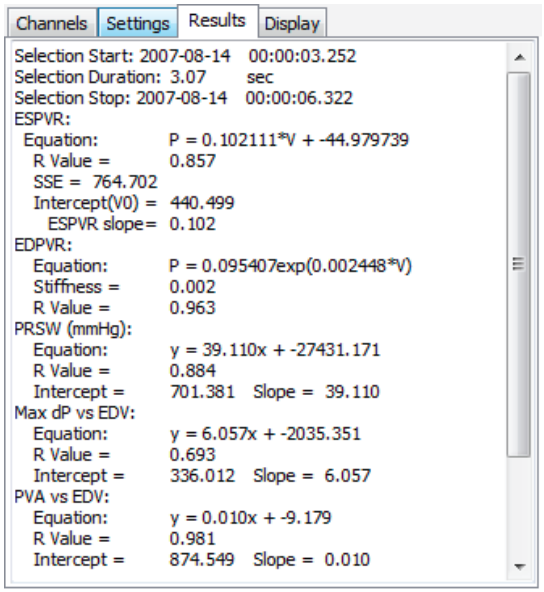
To Configure the **Display:**

1) Click on the **Display** tab to open the **PV Loops Display** configuration dialog.
2) In the top panel of the **Display** dialog, choose the parameters you would like displayed on the **PV Loops Graph**. Observe the **PV Loops Graph** to see the addition or subtraction of the parameters as they are clicked and unclicked.
3) In the bottom panel of the **Display** dialog, choose the color that you would like each listed parameter to appear in the **PV Loops Graph**.

PV Loops Display configuration dialog.

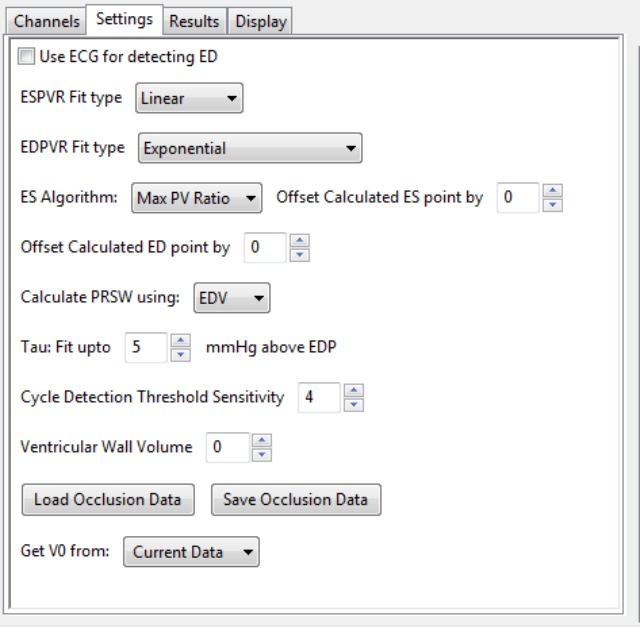
To Configure the **Results:**

1) Returning to the tabs across the top of the configuration dialogs, click on the **Results** tab to open the **PV Loops Results** configuration dialog. Here the mathematical equations defining the end systolic pressure-volume relationship (**ESPVR**), the end diastolic pressure-volume relationship (**EDPVR**), the preload recruitable stroke work (**PRSW**), maximum dPdT (**Max dP**) vs. end diastolic volume (**EDV**), pressure-volume area (**PVA**) vs. **EDV**, and **PVA** vs. end systolic volume (**ESP**) and the time-varying elastance (**Emax or E(t)**) are displayed, based on the data from the currently displayed **PV Loops Graph**. Additional text can be entered into this dialog.



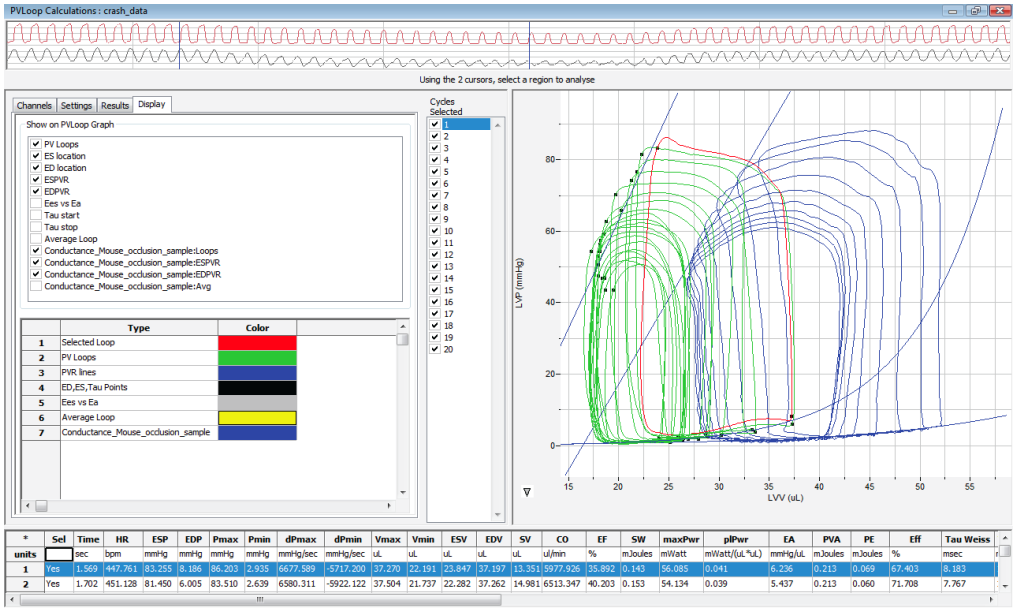
Save or Load Occlusion Data

Use the Save Occlusion Data and Load Occlusion Data buttons to save the data from the section of the trace where occlusion occurs or to load a previously saved occlusion. This allows the user to perform an occlusion and make direct comparisons to an occlusion under different conditions or from another subject. These options are accessed from the PV Loops Settings configuration dialog.



The PV Loops Settings configuration dialog.

1) To save occlusion data, choose **Save Occlusion Data** to open a dialog where you can specify the computer location to save the occlusion data as an iWorx occlusion data file (*.iwxocc).
2) To load previously saved occlusion data, choose **Load Occlusion Data** to open a dialog where you can choose a previously saved occlusion data settings file.
3) Once a previously saved occlusion data file is loaded, the tabbed **PV Loops Display** configuration dialog will add parameters from the loaded occlusion file that can be added to the current **PV Loops Graph**. From the **Display** dialog, choose the specific parameters to be displayed from the checklist, and select the display color of these parameters. An example is shown below.
4) Choose to **Get P0 & V0** (the zero-pressure end systolic volume) **from** from the **Current Data** or a previously saved occlusion data file. The ESPVR and the EDPVR equations are then calculated using these P0 and V0 values.



Offline PV Loop Calculations dialog with an occlusion comparison.

To Use the **Data Table:**

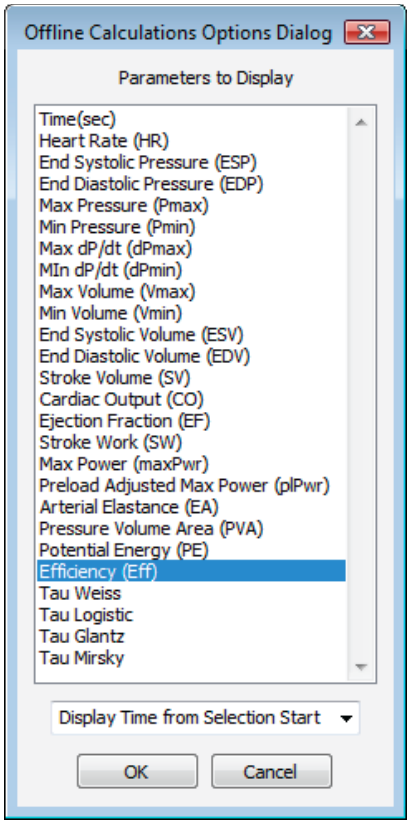
*	Sel	Time	HR	ESP	EDP	Pmax	Pmin	dPmax	dPmin	Vmax	Vmin	ESV	EDV	SV	CO	EF	SW	maxPwr	plPwr	EA
units		sec	bpm	mmHg	mmHg	mmHg	mmHg	mmHg/sec	mmHg/sec	uL	uL	uL	uL	uL	ul/min	%	mJoules	mWatt	mWatt/(uL*uL)	mmHg/uL
1	Yes	2.086	441.176	70.169	2.975	73.467	1.535	5806.989	-5881.777	31.337	19.153	19.673	30.230	10.556	4657.279	34.921	0.108	42.612	0.047	6.647
2	Yes	2.218	454.545	65.860	3.177	70.815	1.252	5521.278	-5802.478	29.510	19.552	20.256	28.663	8.407	3602.915	29.330	0.085	39.379	0.048	7.834
3	Yes	2.349	458.015	62.710	2.464	68.553	1.225	5293.833	-5401.578	29.234	17.767	18.753	28.913	10.160	5347.105	35.138	0.095	35.486	0.042	6.173
4	Yes	2.481	454.545	59.196	1.831	66.183	1.050	5035.133	-5219.100	28.718	17.802	18.494	27.942	9.448	4137.767	33.813	0.086	32.081	0.041	6.266
5	Yes	2.614	451.128	56.275	1.885	65.053	0.983	4946.811	-5139.844	27.066	17.017	18.156	26.945	8.789	3935.239	32.617	0.075	31.205	0.043	6.403
6	Yes	2.746	454.545	57.487	2.221	63.356	0.754	4709.045	-4879.511	26.639	17.443	18.184	26.197	8.013	3785.811	30.589	0.070	28.000	0.041	7.174
7	Yes	2.879	451.128	54.228	2.101	62.333	0.835	4622.289	-4816.667	27.105	17.174	18.106	26.384	8.278	3678.934	31.374	0.073	26.739	0.038	6.551
8	Yes	3.011	454.545	54.282	1.992	61.350	0.647	4432.289	-4562.433	26.667	16.542	17.251	26.455	9.204	4090.755	34.792	0.074	25.433	0.036	5.898
9	Yes	3.142	458.015	53.071	1.548	59.829	0.727	4252.755	-4421.811	26.590	17.065	17.962	26.332	8.370	3862.892	31.785	0.069	23.352	0.034	6.341
10	Yes	3.274	454.545	50.620	1.966	58.806	0.619	4139.034	-4379.900	26.206	17.109	17.939	26.039	8.100	3600.045	31.107	0.062	22.179	0.033	6.249
11																				
12	#		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
13	Mean		453.219	58.390	2.216	64.975	0.963	4875.946	-5050.510	27.907	17.662	18.478	27.410	8.932	4069.874	32.547	0.080	30.647	0.040	6.554
14	SD		4.567	5.848	0.489	4.558	0.287	520.454	508.255	1.608	0.919	0.840	1.370	0.840	521.027	1.929	0.013	6.477	0.005	0.534
15	Max		458.015	70.169	3.177	73.467	1.535	5806.989	-4379.900	31.337	19.552	20.256	30.230	10.556	5347.105	35.138	0.108	42.612	0.048	7.834
17	Min		441.176	50.620	1.548	58.806	0.619	4139.034	-5881.777	26.206	16.542	17.251	26.039	8.013	3600.045	29.330	0.062	22.179	0.033	5.898

PV Loops Data Table.

1) Familiarize yourself with the **Data Table**.
   - The **Data Table** spans the lower part of the **PV Loops Calculations** dialog and displays the calculated values for each of the cycles checked in the **Cycles Selected** list.
   - The top line indicates the **units** for each of the chosen parameters.
   - The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected cycles.
2) Click the asterisk at the upper left of the **Data Table** to display two options: **Autosize** and **Copy Selection**. **Autosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

There are six buttons beneath the **Data Table**: **Copy**, **Export**, **Algorithms**, **Table Options**, **Load Template**, and **Save Template**.

3) Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
4) Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
5) Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
6) Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **PV Loops Analysis: Reference** section.



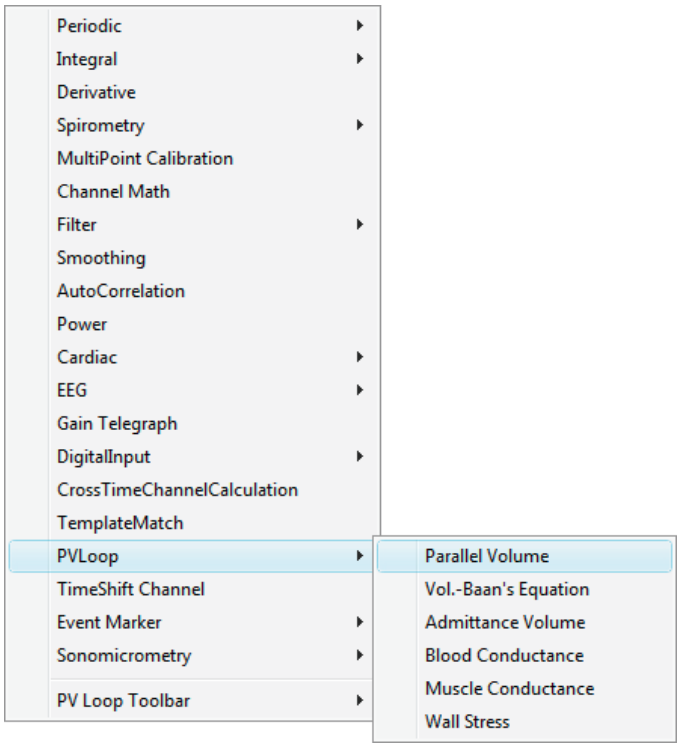
Complete list of Data Table parameters.

7) Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
8) Click **OK** to close the analysis.

Volume Calibration

Most sensors will need calibration of some type for ventricular volume measurements. While uncalibrated volumes or even raw conductance measurements will show contractility changes relatively well, calibration is necessary to obtain absolute volumes. For a more complete theoretical background, see the PV Loops Analysis: Reference section.

LabScribe offers a variety of algorithms for volume calibration, all accessed from the PV Loop submenu of the add function menu for the Main Window channel with the raw data.

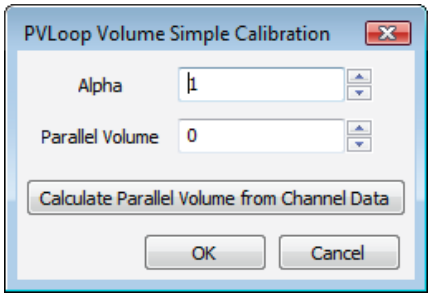


PV Loop Calibration options.

Conductance Volume

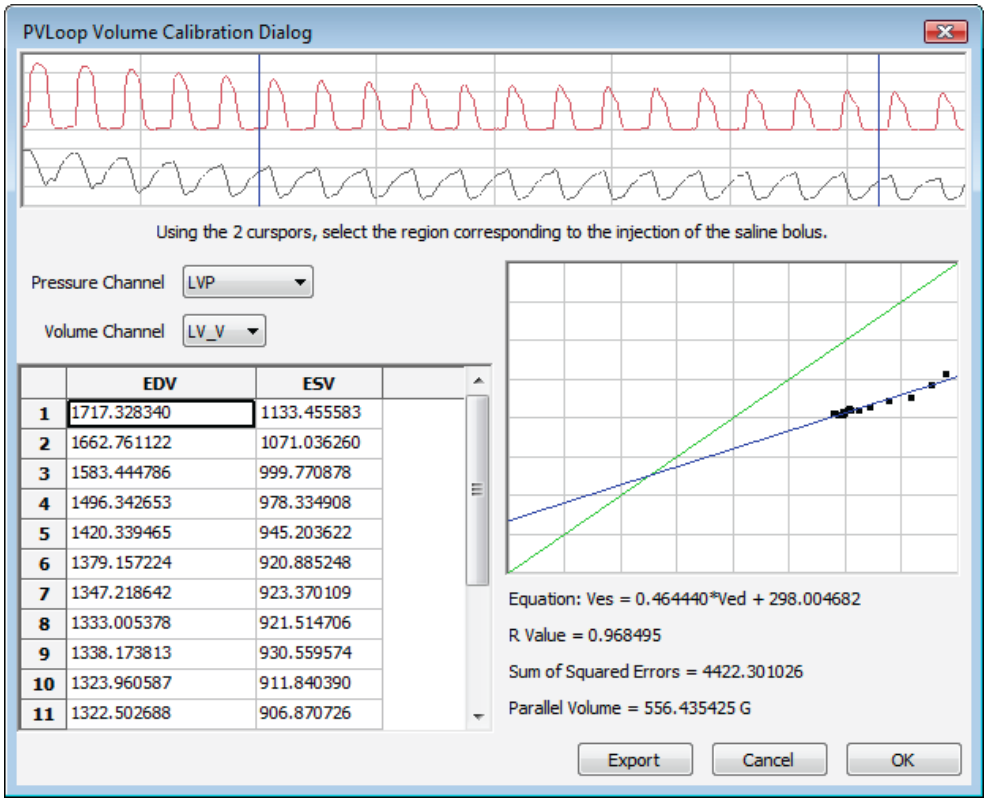
LabScribe offers two means of performing volume calibration based on the change in conductance due to the injection of a saline bolus. To use the Parallel Volume function to determine the parallel volume, it is necessary to use a calibrated total volume channel (one which includes the parallel volume). To use the Vol.-Baan's Equation function, it is possible to use a raw conductance channel. The resulting function channels will be volume calibrated and corrected for parallel conductance.

To use the Parallel Volume function:



1) Click on **add function** on the **Main WIndow** volume channel.
2) In the dialog that opens, select **PV Loops**, and then **Parallel Volume** from the submenu.

3) Enter the **Alpha** slope correction value, and click on **Calculate Parallel Volume from Channel Data**, opening the **PV Loop Volume Calibration** dialog.
4) In the **PV Loop Volume Calibration** dialog, choose the **Pressure** and calibrated **Volume** channel.
5) Using the cursors in the **Pressure** and **Volume** trace window at the top of the dialog, select the region corresponding to the saline bolus injection.

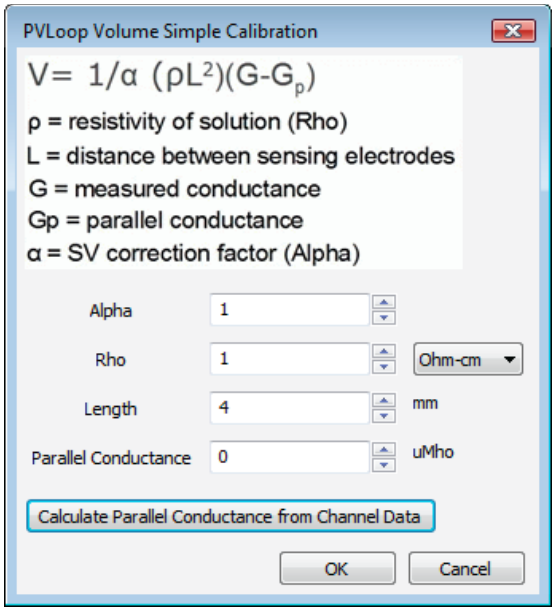


PV Loops Volume Calibration dialog: Parallel Volume from calibrated total volume channel.

6) In the end diastolic volume (**EDV**) vs. end systolic volume (**ESV**) XY graph, the line created by the shifting conductance values caused by the saline bolus will cross the identity line at the parallel volume. The equation of the data line, its goodness of fit, and the parallel volume are displayed below the XY graph window. Click **OK**.
7) The parallel volume will now be displayed in the **PV Loop Volume Simple Calibration** dialog. Click **OK** and a calibrated volume channel is added to the recording.

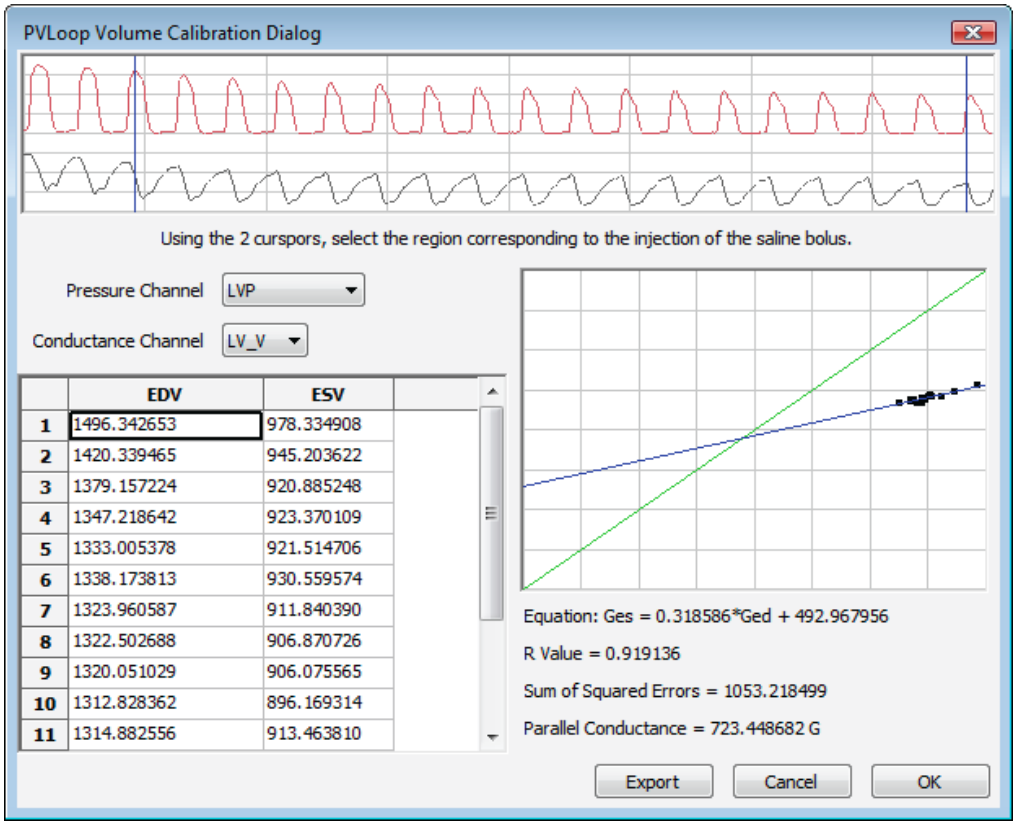
Baan's Equation: To use the Baan's Equation function:

1) Click on **add function** on a conductance (**Volume**) channel.
2) In the dialog that opens, select **PV Loops**, and then **Vol.-Baan's Equation** from the submenu, opening the **Baan's Equation** version of the **PV Loop Volume Simple Calibration** dialog.
3) Enter the **Alpha** slope correction factor, the resistivity of the blood (**Rho**), and the inter-electrode distance (**Length**).



PV Loop Simple Volume Calibration dialog: Baan's Equation.

4) Click on **Calculate Parallel Conductance from Channel Data**, opening the **PV Loop Volume Calibration Dialog**.



5) Choose the **Pressure** and conductance (**Volume**) channel.

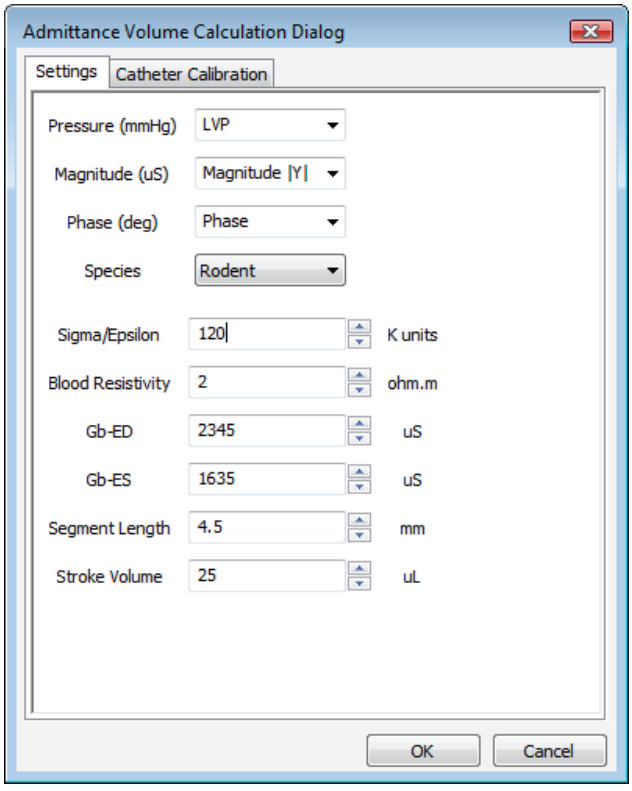
6) Using the cursors in the **Pressure** and **Volume** trace window at the top of the dialog, select the region corresponding to the saline bolus injection.
7) In the end diastolic volume (**EDV**) vs. end systolic volume (**ESV**) XY graph, the line created by the shifting conductance values caused by the saline bolus will cross the identity line at the parallel conductance. The equation of the data line, its goodness of fit, and the parallel conductance are displayed below the XY graph window. Click **OK**.
8) The parallel conductance will now be displayed in the **PVLoop Volume Simple Calibration** dialog. Click **OK** and a corrected volume channel is added to the recording.

Admittance Volume

Admittance sensors do not require the calculation of parallel volume or conductance. If you are using the ADVantage system, you will have entered the appropriate constants into the ADVantage interface, or used the ADVantage default values, and the calibrated volume, based on Wei's Equation, will be shown as a raw data channel in LabScribe. It may be necessary to recalculate this calibrated volume based on updated information that may cause a change in the constants. The PV Loops Advanced Analysis Module can compute the calibrated volume based on these updated constants and display the revised volume as a computed channel.

To calibrate ventricular volume based on revised constants:

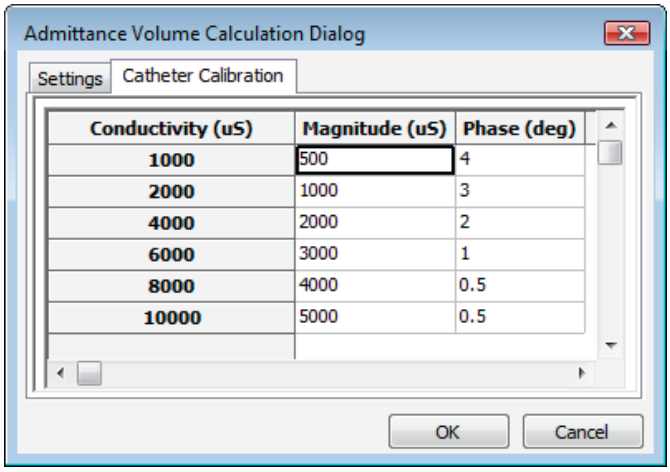
1) To add a channel showing the ventricular volume based on new constants, from the **PV Loops** submenu, choose **Admittance Volume**, displaying the **Admittance Volume Calculation** dialog.



2) In the dialog, enter the **Pressure**, **Magnitude**,

and **Phase** channels, the appropriate species, and any revised constants: the **Sigma/Epsilon** ratio, the **Blood Resistivity**, the blood conductance (**Gb**) values at end-diastole (**ED)** and end-systole (**ES**), the **Segment Length** between the sensing electrodes, and the **Stroke Volume**. Click **OK** to add a calibrated volume channel based on the entered constants.

3) It is also possible to calibrate the catheter as part of this procedure. In the **PV Loops Admittance Volume Calculation** dialog, click on the **Catheter Calibration** tab.
   - The correct **Magnitude** and **Phase** are calculated as the catheter is placed in each standard saline (as indicated by its **Conductivity**), and these are incorporated into the admittance volume calibration.



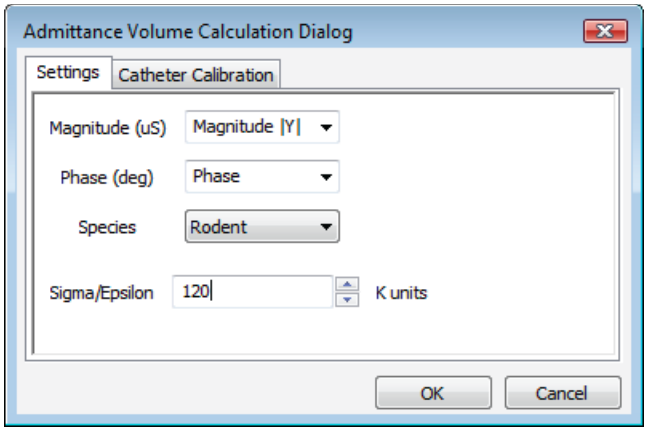
PV Loops Admittance Volume Calculation dialog: Catheter Calibration.

Muscle and Blood Conductance Calibration

Muscle and blood conductance can also be calibrated and determined based on revised constants.

To calibrate muscle and/or blood conductance:

1) Click on **add function** on a **Main Window** volume channel.
2) From the **PV Loops** submenu, choose **Muscle** or **Blood Conductance**, displaying the **Admittance Volume Calculation** dialog for **Muscle** or **Blood Conductance**.



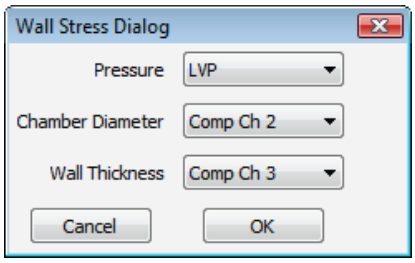
3) Choose the **Magnitude** and **Phase** channels and the appropriate species.
4) Enter a known or default **Sigma/Epsilon** value.
5) Click the **Catheter Conductance** tab and select corrected **Magnitude** and **Phase** values.
6) Click **OK**. A **Muscle** or **Blood Conductance** channel will be added with calibrated muscle or blood conductance values.

Wall Stress

It is possible to use stress-volume loops (instead of pressure-volume loops) to evaluate certain cardiomyopathies. To compute a Wall Stress channel, it is necessary to know the ventricular chamber diameter and the wall thickness. These channels, plus the pressure channel, can be used to calculate a Wall Stress channel that can be used to create and analyze wall stress-volume loops.

To calculate Wall Stress:

1) Choose **Wall Stress** from the **PV Loops** submenu, accessed by clicking **add function** on the volume channel.



PV Loops Wall Stress dialog.

2) In this dialog, choose the channels with the **Pressure**, **Chamber Diameter**, and **Wall Thickness** variables, and click **OK**. A computed **Wall Stress** channel will be added. This channel can be used instead of a pressure channel to compute and analyze stress-volume relationships.

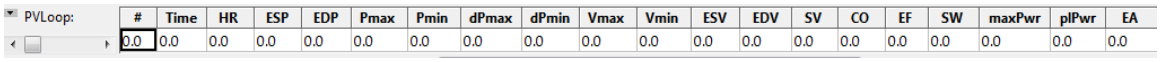
PV Loops Analysis: Reference

When PV Loops is chosen from the Advanced menu, a submenu opens, displaying two choices: Online Calculations and Offline Calculations.

Online Calculations:

LabScribe displays ventricular pressure and ventricular volume data in real time as individual waveforms as well as on a PV Loops XY graph. Beat-to-beat summary data from left ventricular pressure (LVP) and left ventricular volume (LVV) signals are displayed in real time and can be saved, during acquisition, to the online Journal. The summary data contained in the Journal can be saved, copied into a spreadsheet, or exported to an external application for further analysis.

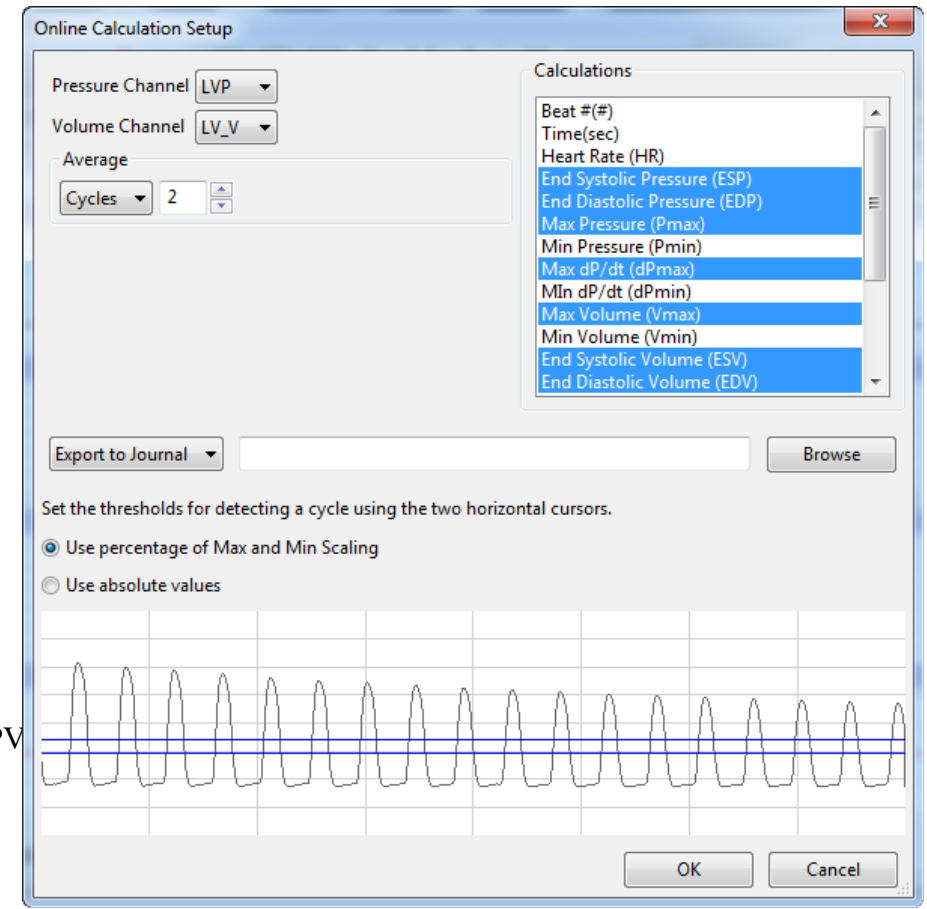
While recording data, it is possible to measure certain beat-by-beat parameters using **Online Calculations**. Choosing **Online Calculations** from the **PV Loops** submenu displays the **PV Loop Toolbar** above the uppermost channel.



The Online PV Loops Toolbar.

Online PV Loop calculations include:

- Sequential beat number (**#**): The sequential number of the particular cycle in the selection.
- Heart rate (**HR**): The heart rate during the cycle.
- End systolic pressure (**ESP**): The ventricular pressure at the end of systole.
- End diastolic pressure (**EDP**): The ventricular pressure at the end of diastole.
- Maximum pressure (**Pmax**): The maximum pressure generated during the cycle.
- Minimum pressure (**Pmin**): The minimum pressure generated during the cycle.
- Maximum dP/dt (**dPmax**): The maximum dP/dt during the cycle.
- Minimum dP/dt (**dPmin**): The minimum dP/dt during the cycle.
- Maximum volume (**Vmax**): The maximum ventricular volume during the cycle.
- Minimum volume (**Vmin**): The minimum ventricular volume during the cycle.
- End systolic volume (**ESV**): The ventricular volume at the end of systole.
- End diastolic volume (**EDV**): The ventricular volume at the end of diastole.
- Stroke volume (**SV**): The stroke volume based on the parameters of the cycle.
- Cardiac output (**CO**): The cardiac output based on the parameters of the cycle.
- Ejection fraction (**EF**): The ejection fraction based on the parameters of the cycle.
- Stroke work (**SW**): The stroke work based on the parameters of the cycle.
- Maximum Power (**maxPwr**): For each point in the cycle, power is calculated current value of the pressure multiplied by the current value of the smoothed derivative. **MaxPwr** is the maximum of the power averaged over the selected cycles.
- Preload Adjusted Max Power (**plPwr**): **maxPwr**/(**EDV** * **EDV**).



- A

Clicking on the

- **S**
- **A**
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The criteria for setting

The Online Calculation Setup dialog.

In this dialog, the Pressure and the Volume channels, the calculations to be performed online, and whether these calculations should be exported to the Journal, are specified.

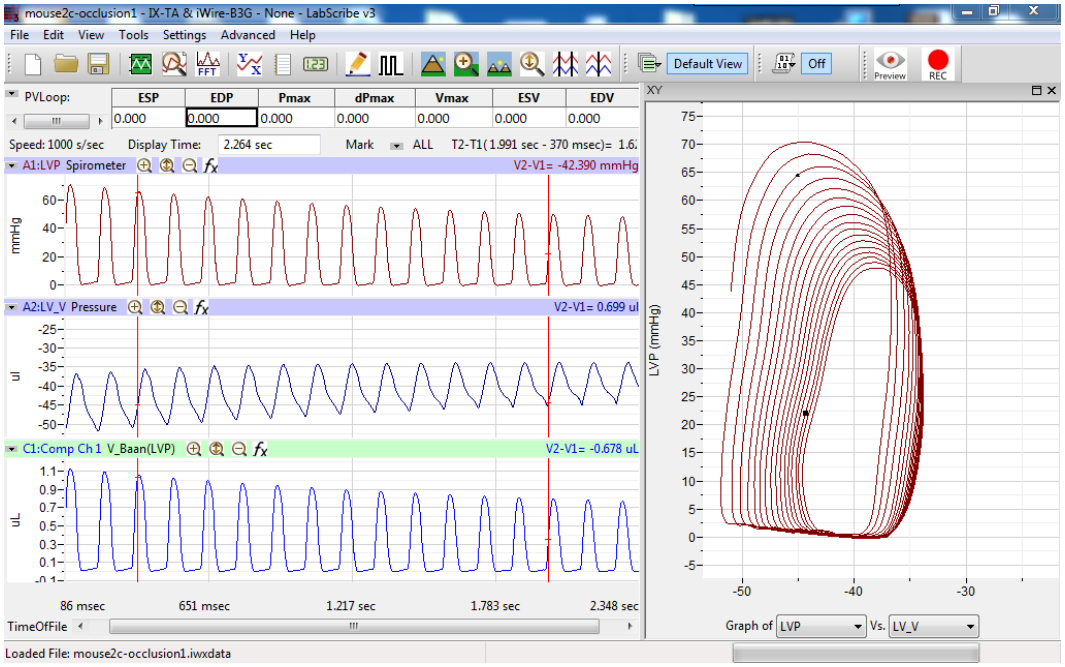
The Volume channel may be a recording from a conductance catheter, or a recording in which ventricular volume has been determined in some other way, for example, from Sonomicrometry measurements.

When the Pressure channel is selected, its graph will appear at the bottom of the dialog. The two horizontal threshold lines should be placed so that they are between each cycle's maximum and minimum. LabScribe uses the positive threshold crossing from below the lower threshold to above the upper threshold to determine the cycle.

In order to compensate for variation from cycle to cycle, it is possible for LabScribe to average a user-selected number of sequential cycles. This number should be entered in the Cycles to Average text box. Alternatively, data can be averaged over a specified Time.

Once the dialog is completed, and OK is clicked, the dialog will close and the selected calculations will be displayed in the data boxes of the PV Loops toolbar as data are recorded.

It is possible to generate a pressure-volume graph in real time by clicking on the XY Graph icon in the Toolbar and specifying the pressure and volume channels. The position in the loop of the left and right cursors are indicated by moving markers in the graph.



The online PV Loops dialog, with XY Graph activated.

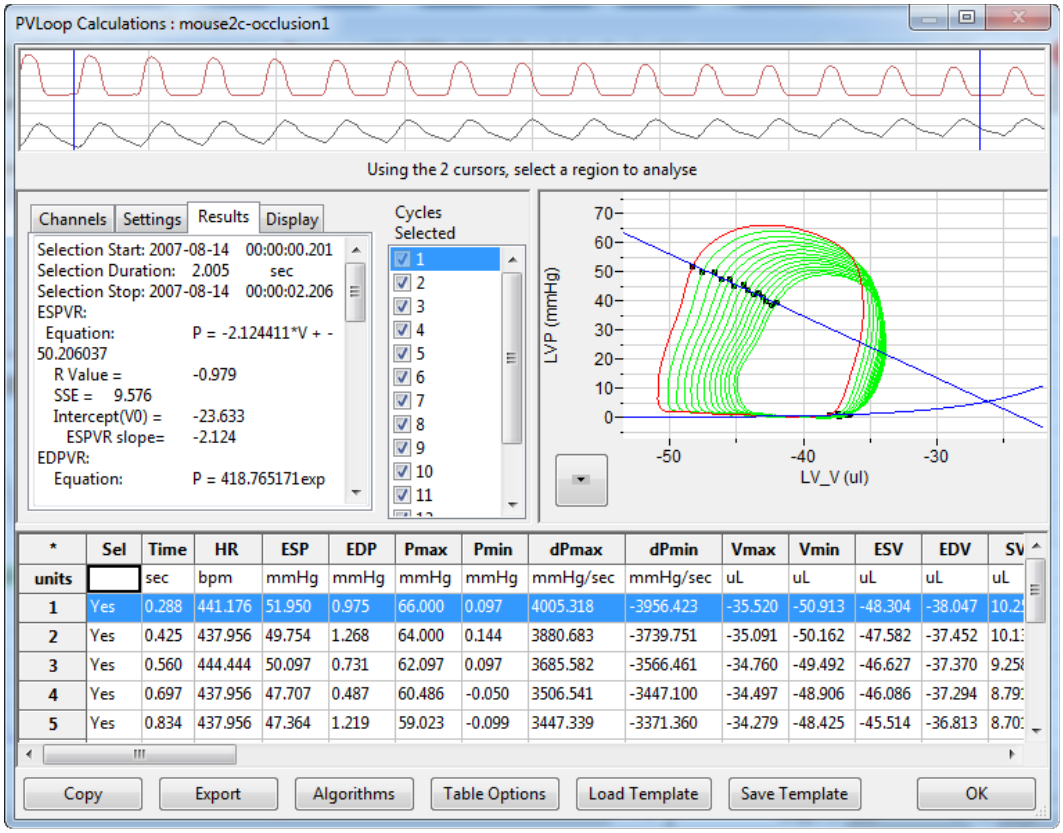
Offline Calculations

Offline, using previously recorded pressure and volume channels, LabScribe can calculate virtually every PV Loop derived parameter of cardiac function. XY graphs displaying relationships among the parameters can also be displayed. All calculations can be exported or copied to Excel or other spreadsheets for further analysis. The graphs can all be copied as images to include in presentations or manuscripts.

The Offline PV Loop Calculations Dialog: Choosing Offline Calculations from the PV Loops submenu opens the offline PV Loop Calculations dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.

The sections of the offline PV Loops Calculations dialog, each of which is described in more detail below:

- The raw pressure and volume channels are displayed across the top of the dialog in the channel display area.
- Tabbed configuration dialogs are on the left of the center part of the dialog.
- The XY graph window, in which the **PV Loops Graph** and pressure-volume relationships can be graphed, is on the right.
- Between the configuration dialogs and the graph area is the **Cycles Selected** list, in which the graphed cycles can be selected by checking the boxes to the left of each cycle number.
- The **Data Table** with each cycle's parameters extends across the lower part of the dialog.



*	Sel	Time	HR	ESP	EDP	Pmax	Pmin	dPmax	dPmin	Vmax	Vmin	ESV	EDV	SV
units		sec	bpm	mmHg	mmHg	mmHg	mmHg	mmHg/sec	mmHg/sec	uL	uL	uL	uL	uL
1	Yes	0.288	441.176	51.950	0.975	66.000	0.097	4005.318	-3956.423	-35.520	-50.913	-48.304	-38.047	10.2
2	Yes	0.425	437.956	49.754	1.268	64.000	0.144	3880.683	-3739.751	-35.091	-50.162	-47.582	-37.452	10.1
3	Yes	0.560	444.444	50.097	0.731	62.097	0.097	3685.582	-3566.461	-34.760	-49.492	-46.627	-37.370	9.25
4	Yes	0.697	437.956	47.707	0.487	60.486	-0.050	3506.541	-3447.100	-34.497	-48.906	-46.086	-37.294	8.79
5	Yes	0.834	437.956	47.364	1.219	59.023	-0.099	3447.339	-3371.360	-34.279	-48.425	-45.514	-36.813	8.70

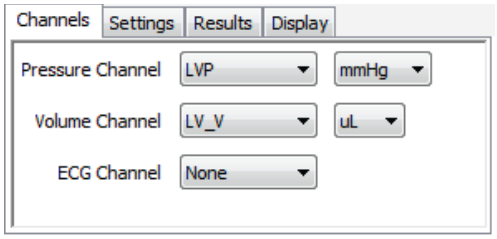
The offline PV Loop Calculations dialog.

The Channel Display Area: In the channel display area, the two vertical blue lines can be adjusted to designate a section of the recording for analysis.

The Configuration Dialogs

There are four tabbed dialogs used to configure the analysis: Channels, Settings, Results, and Display.

The Channels Configuration Dialog

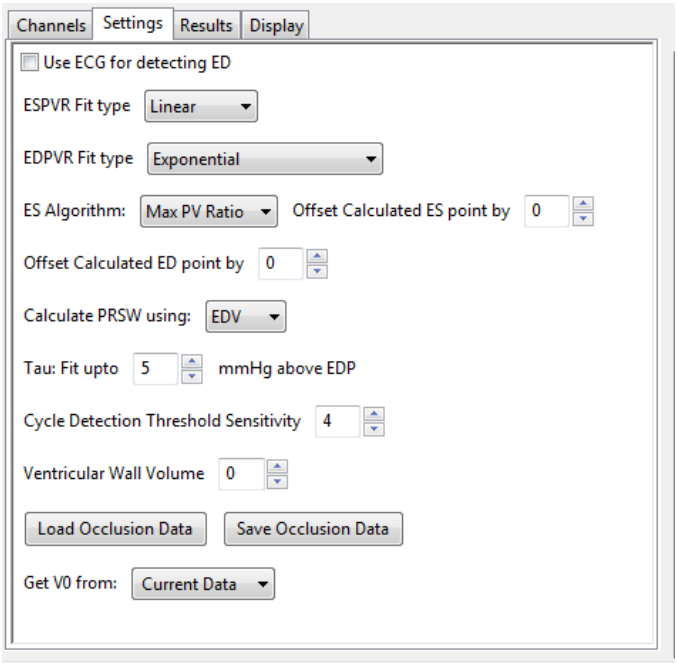


PV Loops Channels configuration dialog.

- The **Pressure Channel** and the **Volume Channel**, as well as the appropriate units, are chosen from the first two menus. Optionally, an **ECG** channel can also be chosen.
- The region of interest is defined by adjusting the two cursors in the channel display area at the top of the **PV Loop Calculations** dialog.

- Once the **Pressure** and **Volume** channels are designated, the **PV Loops Graph** will be displayed in the XY graph area for all the cycles in the selection between the cursors. The highlighted cycle in the **Cycles Selected** window is shown in red, while all other selected cycles are displayed in green. This makes it easy to identify individual cycles for inclusion or exclusion from the analysis. Cycles can be deselected (or selected) by clicking on the check box to the left of the cycle number. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.

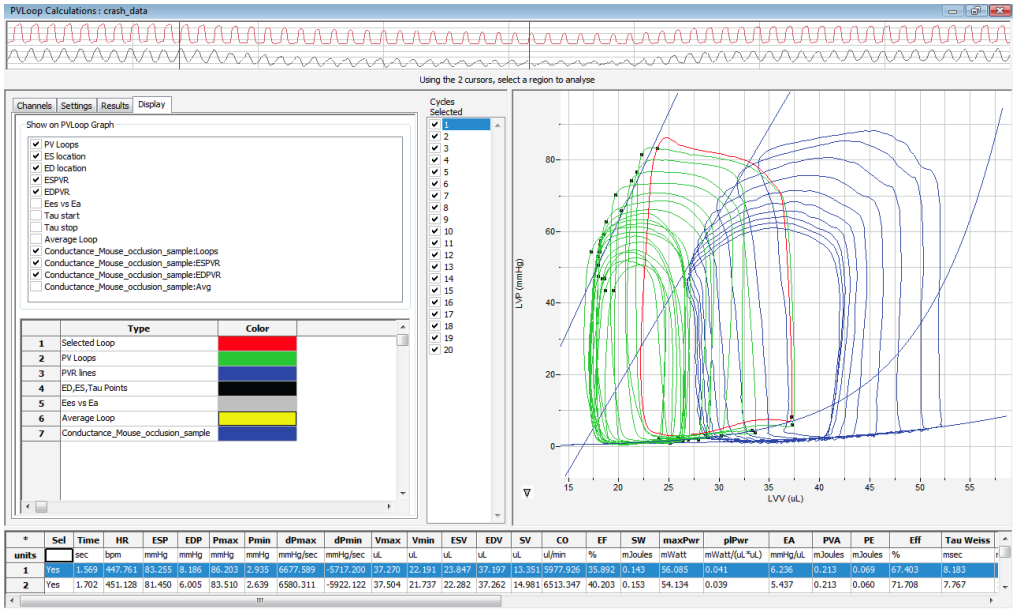
The Settings Configuration Dialog



PV Loops Settings dialog.

- Optionally, an **ECG** recording may be used for the detection of end-diastole (**ED**).
- A linear fit is the default choice for the end-systolic pressure-volume relationship (**ESPVR**) data, although an **Exponential** fit is an alternate choice.
- An **Exponential** or **Exponential with Constant** fit can be chosen from the **EDPVR Fit Type** menu.
- **Max PV Ratio** will be used to compute end-systole (**ES**) in each cycle, and is the default value. **Max P**, **Min dP**, and **Max dP** are alternate choices.
- The **Offset Calculated ES point by** menu indicates how far to offset **ES** from the calculated value. This can be changed as desired.
- The **Offset Calculated ED point by** menu indicates how far to offset **ED** from the calculated value. This value can be changed as desired.
- **EDV** or **Vmax** can be chosen to calculate the preload recruitable stroke work, **PRSW**.

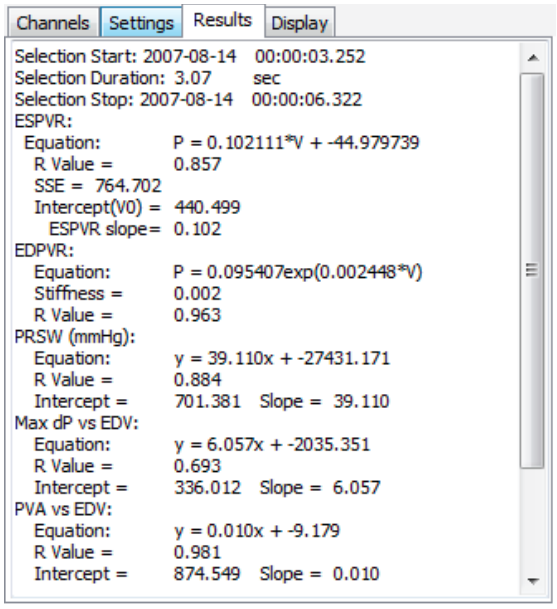
- The number of mmHg above end diastolic pressure (**EDP**) that should be designated as the uppermost point that should be used to create the best fit line from which **Tau** (the time constant of blood pressure decrease during diastole) is computed should be entered in the **Tau fit** box.
- The number of cycles that should be used to determine the **Cycle Detection Threshold Sensitivity** can be indicated. By default, a threshold sensitivity of 4 is used to detect cycles. If each cycle is not being detected properly, the sensitivity can be adjusted.
- The **Ventricular Wall Volume** can be compensated for by entering a value in the text box.
- The **Save Occlusion Data** and **Load Occlusion Data** buttons save the data from the section of the trace where occlusion occurs or load a previously saved occlusion. This allows the user to perform an occlusion and make direct comparisons to an occlusion under different conditions or from another subject. These options are accessed from the **PV Loops Settings** configuration dialog.
  - Choosing **Save Occlusion Data** opens a dialog where the user can specify the computer location to save the occlusion data as an iWorx occlusion data file (*.iwxocc).
  - Choosing **Load Occlusion Data** opens a dialog where the user can choose a previously saved occlusion data settings file.
  - Once a previously saved occlusion data file is loaded, the tabbed **Display** configuration dialog will add items from the loaded occlusion file that can be added to the current **PV Loops Graph**. From the **Display** dialog, the specific parameters to be displayed are chosen from the checklist, and the display color of these parameters is chosen. An example is shown below.



Offline PV Loop Calculations dialog with an occlusion comparison.

- The user can choose to **Get V0** (the zero-pressure end systolic volume) **from** from the **Current Data** or a previously saved occlusion data file.

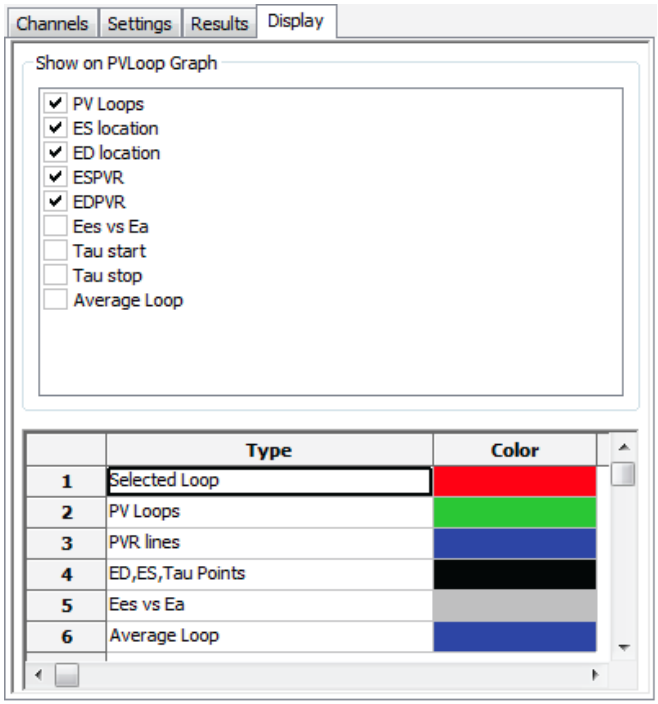
The Results Configuration Dialog



PV Loops Results configuration dialog.

- The mathematical equations defining **ESPVR**, **EDPVR**, **PRSW**, **Max dP** vs. **EDV**, **PVA** vs. **EDV**, and **PVA** vs. **ESP** and **Emax (E(t))** are displayed, based on the data from the currently displayed **PV Loops Graph**.
- Additional text can be entered into this dialog.

The Display Configuration Dialog



- The specific parameters shown in the graph are chosen from the top part of the **Display** configuration dialog.
- The colors of those parameters in the **PV Loops Graph** are chosen in the lower part of the **Display** configuration dialog.

The XY Graph Window

'The arrow to the lower left of the XY graph window can be clicked to open a menu with options for the displayed XY graph.

XY graph window menu.

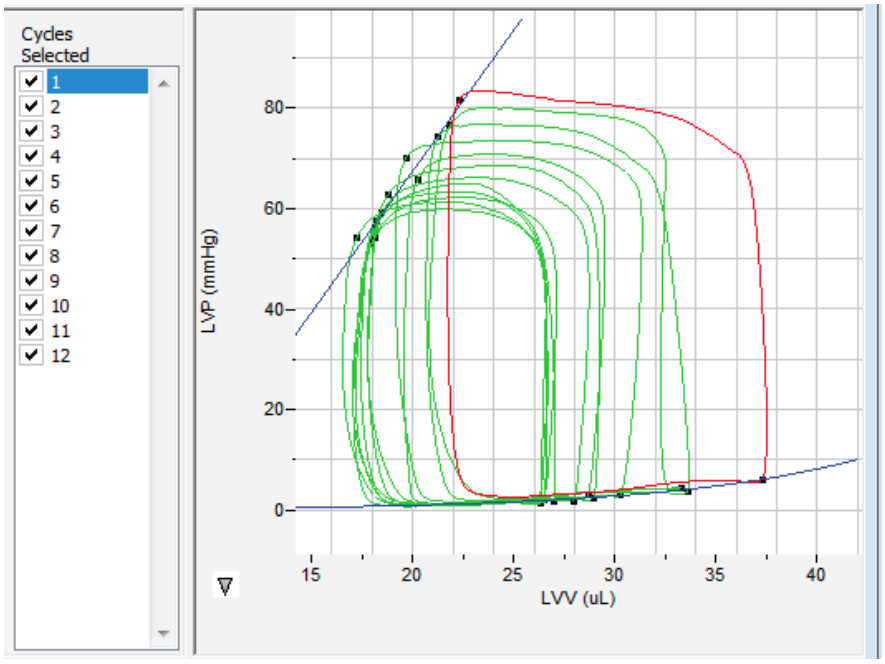
- **Copy Graph**: Copies the current XY graph to the clipboard. It can then be pasted into the **Journal** or an external application.
- **View PV Loops**: Displays the **PV Loops Graph** of the checked cycles in the **Cycles Selected** list to the left of the XY graph window.
- **View PRSW**: Displays the preload recruitable stroke work (**PRSW**) line, as defined in the **Settings**. By default, **PRSW** is calculated by plotting **SW** on the Y-axis and **EDV** on the X-axis. **Vmax** can be used as an alternative to **EDV** if desired.
- **View Max dp vs. EDV**: Displays the XY graph of maximum dP/dt (**Max dP**) vs. end diastolic volume (**EDV**).
- **View PVA vs. EDV**: Displays the XY graph of the pressure-volume area (**PVA**) vs. end diastolic volume (**EDV**).
- **View PVA vs. ESP**: Displays the XY graph of the pressure-volume area (**PVA**) vs. end systolic pressure (**ESP**).
- **View E(t) vs. Time**: Displays time-varying elastance (**E(t)**) vs. **Time**.
- **Export Avg. Loop data**: Exports the data from the graphed average loop as a tab (*.txt) or comma (*.csv) separated text file.
- **Export PV Loop data**: Exports the data from the all the graphed loops as a tab (*.txt) or comma (*.csv) separated text file.

- **View Markers**: Displays a graph of time (X-axis) vs. pressure and volume (Y-axis) with markers positioned at **ED**, **Max dP**, **ES**, and **Min dP**. The specific cycle displayed is determined by the position of the left cursor in the data recording at the top of the dialog.
- **Export E(t) vs. Time**: Exports the **E(t)** vs. **Time data** as a tab (*.txt) or comma (*.csv) separated text file.
- **Set X-axis Scale** or **Set Y-axis Scale**: Allows the user to set the X-axis and Y-axis scales manually.
- **AutoScale X-axis** or **AutoScale Y-axis**: Optimizes the display scale of the X-axis or Y-axis of the current XY graph.

The PV Loops Graph

The **PV Loops Graph** will be displayed in the XY graph area for all the cycles in the selection and is illustrated below.

- By default, the highlighted cycle in the **Cycles Selected** window is shown in red, while all other selected cycles are displayed in green.
- Cycles can be deselected (or selected) by clicking on the check box to the left of the cycle number in the **Cycles Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
- The specific parameters shown in the graph are chosen from the **Display** configuration dialog.



The PV Loops Graph.

The Data Table

The **Data Table** displays the calculated values for each of the selected cycles.

*	Sel	Time	HR	ESP	EDP	Pmax	Pmin	dPmax	dPmin	Vmax	Vmin	ESV	EDV	SV	CO	EF	SW	maxPwr	plPwr	EA
units		sec	bpm	mmHg	mmHg	mmHg	mmHg	mmHg/sec	mmHg/sec	uL	uL	uL	uL	uL	ul/min	%	mJoules	mWatt	mWatt/(uL*uL)	mmHg/uL
1	Yes	2.086	441.176	70.169	2.975	73.467	1.535	5806.989	-5881.777	31.337	19.153	19.673	30.230	10.556	4657.279	34.921	0.108	42.612	0.047	6.647
2	Yes	2.218	454.545	65.860	3.177	70.815	1.252	5521.278	-5802.478	29.510	19.552	20.256	28.663	8.407	3602.915	29.330	0.085	39.379	0.048	7.834
3	Yes	2.349	458.015	62.710	2.464	68.553	1.225	5293.833	-5401.578	29.234	17.767	18.753	28.913	10.160	5347.105	35.138	0.095	35.486	0.042	6.173
4	Yes	2.481	454.545	59.196	1.831	66.183	1.050	5035.133	-5219.100	28.718	17.802	18.494	27.942	9.448	4137.767	33.813	0.086	32.081	0.041	6.266
5	Yes	2.614	451.128	56.275	1.885	65.053	0.983	4946.811	-5139.844	27.066	17.017	18.156	26.945	8.789	3935.239	32.617	0.075	31.205	0.043	6.403
6	Yes	2.746	454.545	57.487	2.221	63.356	0.754	4709.045	-4879.511	26.639	17.443	18.184	26.197	8.013	3785.811	30.589	0.070	28.000	0.041	7.174
7	Yes	2.879	451.128	54.228	2.101	62.333	0.835	4622.289	-4816.667	27.105	17.174	18.106	26.384	8.278	3678.934	31.374	0.073	26.739	0.038	6.551
8	Yes	3.011	454.545	54.282	1.992	61.350	0.647	4432.289	-4562.433	26.667	16.542	17.251	26.455	9.204	4090.755	34.792	0.074	25.433	0.036	5.898
9	Yes	3.142	458.015	53.071	1.548	59.829	0.727	4252.755	-4421.811	26.590	17.065	17.962	26.332	8.370	3862.892	31.785	0.069	23.352	0.034	6.341
10	Yes	3.274	454.545	50.620	1.966	58.806	0.619	4139.034	-4379.900	26.206	17.109	17.939	26.039	8.100	3600.045	31.107	0.062	22.179	0.033	6.249
11																				
12	#		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
13	Mean		453.219	58.390	2.216	64.975	0.963	4875.946	-5050.510	27.907	17.662	18.478	27.410	8.932	4069.874	32.547	0.080	30.647	0.040	6.554
14	SD		4.567	5.848	0.489	4.558	0.287	520.454	508.255	1.608	0.919	0.840	1.370	0.840	521.027	1.929	0.013	6.477	0.005	0.534
15	Max		458.015	70.169	3.177	73.467	1.535	5806.989	-4379.900	31.337	19.552	20.256	30.230	10.556	5347.105	35.138	0.108	42.612	0.048	7.834
17	Min		441.176	50.620	1.548	58.806	0.619	4139.034	-5881.777	26.206	16.542	17.251	26.039	8.013	3600.045	29.330	0.062	22.179	0.033	5.898

PV Loops Data Table.

The top line indicates the units for each of the chosen parameters.

The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected cycles.

Clicking the asterisk at the upper left of the Data Table to display two options: Autosize and Copy Selection. Autosize will optimize the size of the Data Table boxes. Copy Selection copies any selected Data Table cells to the clipboard.

There are six buttons beneath the Data Table: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.

- **Copy:** Copies all the calculated data in the **Data Table** to the clipboard.
- **Export:** Exports the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** displays the mathematical definitions of the parameters included in the **Data Table**.
- **Table Options:** Opens the **Offline Calculations Options** dialog, which lists the functions from which the **Data Table** parameters can be chosen.

Complete list of Data Table parameters.

- **Load Template** or **Save Template:** Displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

Offline **Calculation Algorithms: The Offline PV Calculations displayed in the Data Table include:**

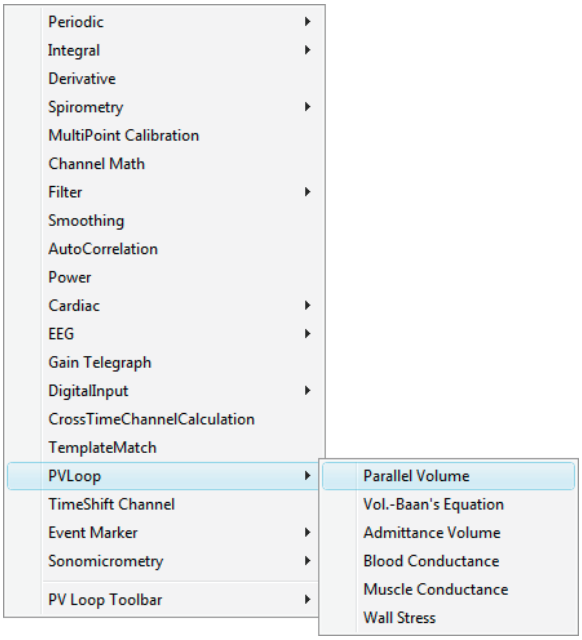
- Heart rate (**HR**): 60/average cycle period.
- End-systolic pressure (**ESP**): Ventricular pressure at end-systole.
- End-diastolic pressure (**EDP**): Ventricular pressure at end-diastole.
- Maximum pressure (**Pmax**): Average maximum value of pressure channel over selected cycles.
- Minimum pressure (**Pmin**)**:** Average minimum value of pressure channel over selected cycles.
- Maximum dP/dt (**dPmax**): Average maximum value of smoothed derivative over selected cycles.
- Minimum dP/dt (**dPmin**): Average minimum value of smoothed derivative over selected cycles.
- Maximum volume (**Vmax**): Average maximum value of volume channel over selected cycles.
- Minimum volume (**Vmin**): Average minimum value of volume channel over selected cycles.
- End systolic volume (**ESV**): Average value of volume channel at end-systole over selected cycles.
- End diastolic volume (**EDV**): Average value of volume channel at end-diastole over selected cycles.
- Stroke volume (**SV**): **EDV – ESV.**
- Cardiac output (**CO**): **SV** * **HR**.

- Ejection fraction (**EF**): **100***(**SV** / **EDV**).
- Stroke work (**SW**): Area within the PV Loop averaged over selected cardiac cycles.
- Maximum power (**maxPwr**): For each point in the cycle, power is calculated current value of the pressure multiplied by the current value of the smoothed derivative. **MaxPwr** is the maximum of the power averaged over the selected cycles.
- Preload adjusted maximum power (**plPwr**): **maxPwr**/(**EDV** * **EDV**).
- Arterial elastance (**Ea**): **ESP** / **SV**.
- Pressure-volume area (**PVA**): **PE** + **SW**.
- Potential energy (**PE**): (**ESP** * (**ESV** - **V0**))/2 - (**EDP** * (**EDV** - **V0**))/4, where **V0** is the zero-pressure end systolic volume.
- Efficiency (**Eff**): **SW** / **PVA**.
- Isovolumic relaxation time constant (**Tau**): Can be calculated a number of ways:
  - **Weiss**: P(t) = A(-t/**Tau**).
  - **Logistic**: P(t)= A(-t/**Tau**) + B.
  - **Glantz**: Regression of dP/dt vs. Pressure.
  - **Mirsky**: Time (in ms) required for left ventricular pressure to fall to 1/2 of its value at **ESP**.
- End systolic pressure-volume relationship (**ESPVR**):
  - Linear fit: Slope of line created by **ES** points of PV Loops during an occlusion.
  - Quadratic fit: sqrt(b2 -4 * a * c) where **ESP** = (a * **ESV** * **ESV**) + (b * **ESV** + c).
- Time-varying elastance (**E(t)**): **ED** points for all the loops are aligned and the maximum slope is calculated.

Calibration of Volume Data

Most sensors will need calibration of some type for ventricular volume measurements. While uncalibrated volumes or even raw conductance measurements will show contractility changes relatively well, calibration is necessary to obtain absolute volumes.

LabScribe offers a variety of algorithms for volume calibration, all accessed from the PV Loops submenu of the add function menu for the channel with the raw data.



Conductance Volume

Conductance catheters output raw conductance measurements that need to be converted to volumes, and it is necessary to correct for the conductance contributions (parallel conductance) of surrounding

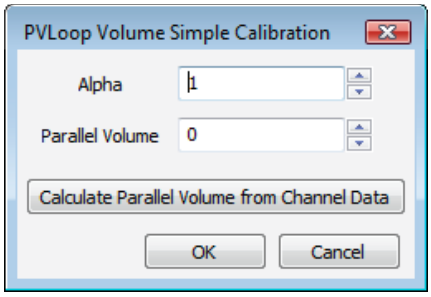
heart structures. It is possible to get calibrated volumes from conductance measurements through the use of Baan's equation, which uses variables including the distance between the electrodes, the resistivity of blood, and the conductance measurements to calculate calibrated volumes. A slope factor Alpha is also necessary to adjust for the physical shape of a heart and the nature of the electric field itself.

In the most common method of adjusting for the parallel conductance, a bolus of hypertonic saline is injected into the blood before it reaches the ventricle and the change in conductance as it passes through the ventricle is measured and used to determine the parallel conductance (or volume), as the parallel conductance won't change while the blood conductance will change as a result of the saline passing through the ventricle.

LabScribe offers two means of performing volume calibration based on the injection of a saline bolus. To use the Parallel Volume function to determine the parallel volume, it is necessary to use a calibrated total volume channel (including the parallel volume). To use the Vol.-Baan's Equation function, it is possible to use a raw conductance channel. The resulting function channels will be volume calibrated and corrected for parallel conductance.

Selecting the PV Loops submenu from the add functions list opens a dialog in which Parallel Volume or Vol.-Baan's Equation can be chosen. To use the Parallel Volume function to determine the parallel volume, it is necessary to use a calibrated volume channel. To use the Vol.-Baan's Equation function, it is possible to use a raw conductance channel. The resulting function channels will be volume calibrated and corrected for parallel conductance.

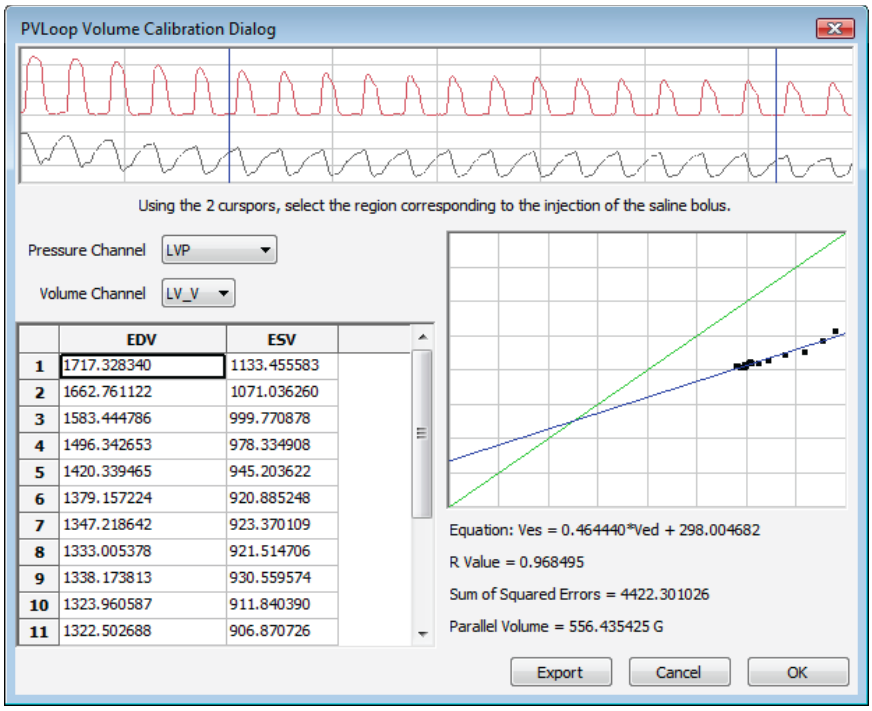
Using the Parallel Volume function:



PV Loop Volume Simple Calibration dialog.

- Clicking on **add function** on the volume channel displays a menu from which **PV Loops**, and then **Parallel Volume,** can be chosen. The **PV Loop Volume SImple Calibration** dialog will open.
- The **Alpha** slope correction value should be entered before clicking on **Calculate Parallel Volume from Channel Data**, which opens the **PV Loop Volume Calibration** dialog.

In the **PV Loop Volume Calibration Dialog**, the Pressure and calibrated **Volume** channel are chosen from the appropriate menus. The cursors in the **Pressure** and **Volume** trace window at the top of the dialog should be adjusted to select the region corresponding to the saline bolus injection.

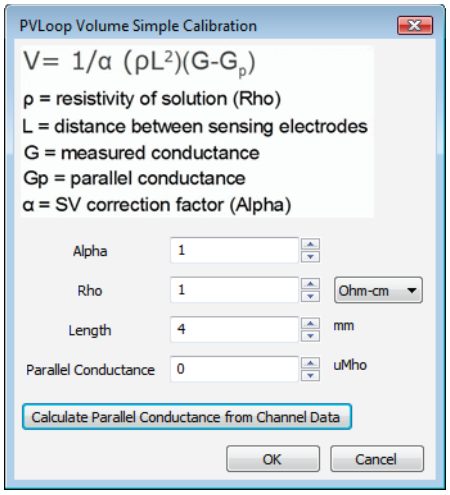


PV Loops Volume Calibration dialog: Parallel Volume from calibrated total volume channel.

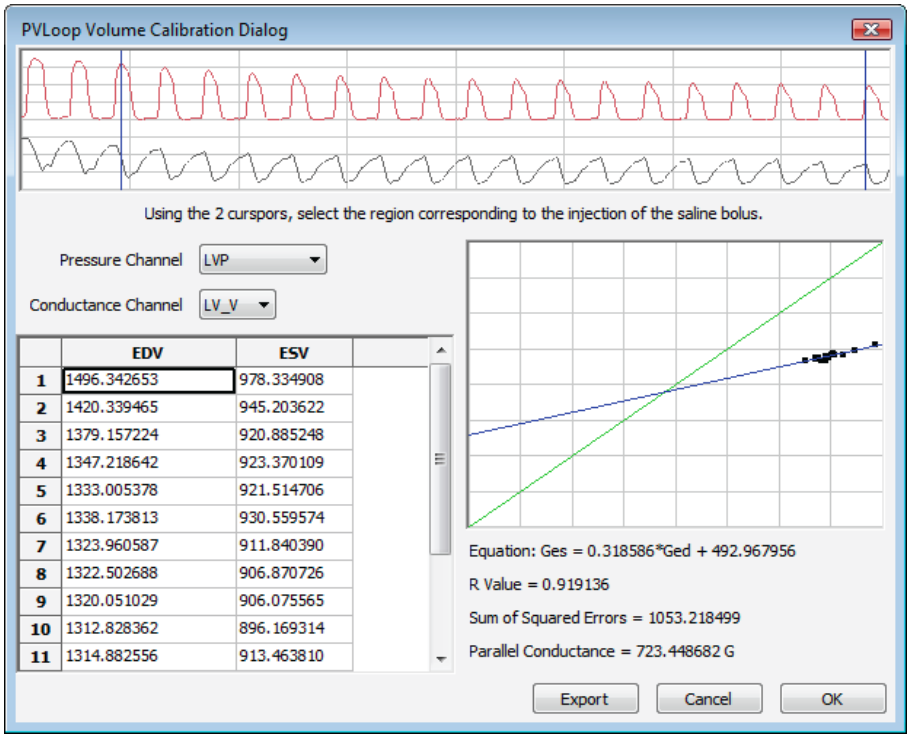
In the EDV vs. ESV XY graph, the line created by the shifting conductance values caused by the saline bolus will cross the identity line at the parallel volume. The equation of the data line, its goodness of fit, and the parallel volume are displayed below the XY graph window. Upon clicking OK, the parallel volume will now be displayed in the PVLoop Volume Simple Calibration dialog. Clicking OK in this dialog adds a corrected volume channel to the LabScribe Main WIndow.

Using the Baan's Equation function:

- Clicking on **add function** on a conductance (**Volume**) channel displays a menu from which **PV Loops**, and then **Vol.-Baan's Equation** should be chosen. The Baan's Equation version of the **PVLoop Volume Simple Calibration** dialog will open.



- In this dialog, the **Alpha** slope correction factor, the resistivity of the blood (**Rho**) and the inter-electrode distance (**Length**) should be entered.
- Clicking on **Calculate Parallel Conductance from Channel Data** will display the **PV Loop Volume Calibration** dialog.



PV Loops Volume Calibration dialog: Parallel Conductance for Baan's Equation

The appropriate Pressure and conductance (Volume) channels should be entered. Using the cursors in the Pressure and Volume trace window at the top of the dialog, the region corresponding to the saline bolus injection should be selected.

In the EDV vs. ESV XY graph, the line created by the shifting conductance values caused by the saline bolus will cross the identity line at the parallel conductance. The equation of the data line, its goodness of fit, and the parallel conductance are displayed below the XY graph window.

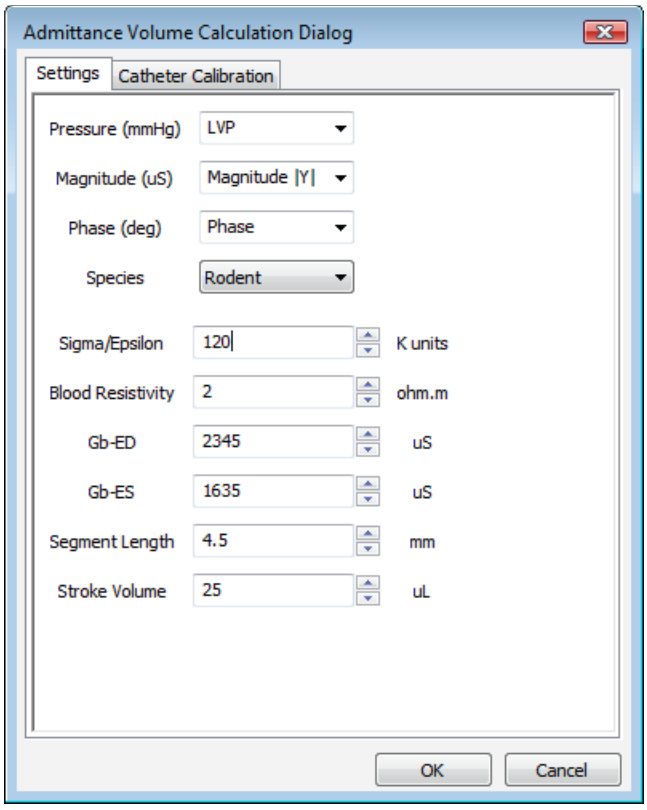
Upon clicking OK, the parallel conductance will now be displayed in the PVLoop Volume Simple Calibration dialog. Clicking OK in this dialog adds a calibrated volume channel to the LabScribe Main WIndow.

Admittance Volume

Admittance sensors do not require the calculation of parallel volume or conductance. If the ADVantage system is being used, the user will have entered the appropriate constants into the ADVantage interface, or used the ADVantage default values, and the calibrated volume, based on Wei's Equation, will be shown as a raw data channel in *LabScribe*, along with **Magnitude** and **Phase** channels. It may be necessary to recalculate this calibrated volume based on updated information that may cause a change in the constants. The **PVLoops** functions can compute the calibrated volume based on these updated constants and display the volume as a computed channel.

Calibration of the ventricular volume based on revised constants:

Choosing **Admittance Volume**, from the **PV Loops** submenu of the **add function** menu associated with the raw volume channel, displays the **Admittance Volume Calculation** dialog.



PV Loops Admittance Volume Calculation dialog.

- In this dialog, the **Pressure**, **Magnitude** and **Phase** channels, the appropriate species, the **Sigma/ Epsilon** ratio, the **Blood Resistivity**, the **GB** values at **ED** and **ES**, the **Segment Length** between the sensing electrodes, and the **Stroke Volume**, should be entered in the appropriate data boxes. Clicking **OK** adds a calibrated volume channel based on the entered constants.

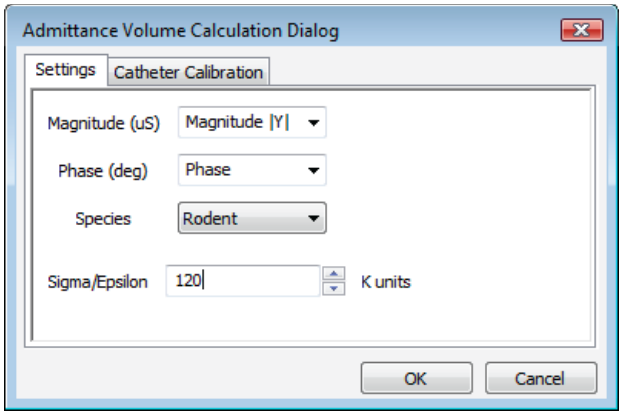
It is also possible to calibrate the catheter as part of this procedure. In the **PV** Loops **Admittance Volume Calculation** dialog, click on the **Catheter Calibration** tab.

- The correct **Magnitude** and **Phase** are calculated as the catheter is placed in each standard saline (as indicated by its **Conductivity**), and these are incorporated into the admittance volume calibration.

Muscle and Blood Conductance Calibration

Muscle and blood conductance can also be calibrated and determined based on revised constants.

From the PV Loops submenu of the add function menu of the volume channel, Muscle or Blood Conductance should be selected, displaying the Admittance Volume Calculation dialog for Muscle or Blood Conductance.



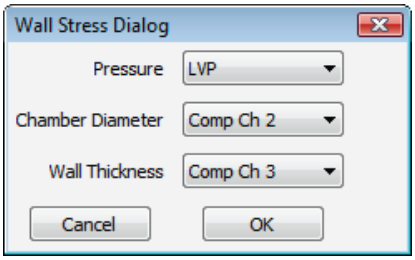
Muscle or Blood Conductance dialog.

- In this dialog, the **Magnitude** and **Phase** channels, the appropriate species, and a measured or default **Sigma/Epsilon** value should be entered.
- Clicking the **Catheter Conductance** tab and selecting the corrected **Magnitude** and **Phase** values, and then **OK**, will add a **Muscle** or **Blood Conductance** computed channel with the recalibrated muscle or blood conductance values.

Wall Stress

It is possible to use stress-volume loops (instead of pressure-volume loops) to evaluate certain cardiomyopathies. To compute a Wall Stress channel, it is necessary to know the ventricular chamber diameter and the wall thickness. The chamber diameter and the wall thickness can be calculated via ultrasound. The ultrasound system will calculate these values and output them as text values which can be imported into LabScribe as individual channels. These channels, plus the pressure channel, can be used to calculate a Wall Stress channel that can be used to create and analyze wall stress-volume loops.

To calculate Wall Stress:



- Choosing **Wall Stress** from the **PV Loops** submenu, accessed by clicking **add function** on the volume channel, opens the **Wall Stress** dialog.
- The **Pressure**, **Chamber Diameter**, and **Wall Thickness** channels are chosen from the three menus. Upon clicking **OK**, a computed **Wall Stress** channel will be added to the display. This channel can be used instead of a pressure channel to compute and analyze stress-volume relationships.

8.2 Blood Pressure Analysis

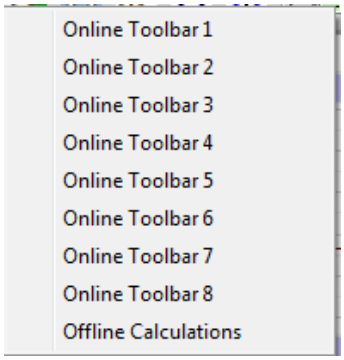
Arterial and ventricular blood pressure parameters are detected, and functions derived from those parameters are computed in LabScribe's Blood Pressure Advanced Analysis Module.

The Blood Pressure Advanced Analysis Module requires a separate license. The first time you select Blood Pressure, you will be asked for a username and a serial number. Contact iWorx Systems for more information.

This document includes a step by step tutorial for using most of the features of the Blood Pressure Advanced Analysis Module,as well as a more detailed Reference section that covers the material in the tutorial, and adds additional context and detail. To use the step by step guide, you will need a recording with at least one arterial or ventricular blood pressure channel. This can be from any mammalian species. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

Blood Pressure Analysis: Step by Step

When Blood Pressure is chosen from the Advanced menu, a submenu opens, displaying two options: Online Calculations (accessed by choosing from as many as eight Online Toolbars) and Offline Calculations.



Blood Pressure submenu.

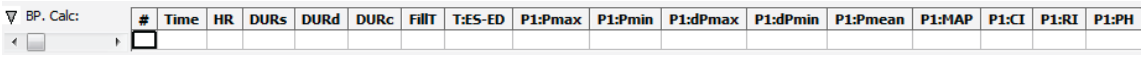
Online Blood Pressure Calculations

To use the Online Calculations:

You will need a recording of either arterial or ventricular blood pressure. Using the **Online Blood Pressure Calculations**, it is possible to generate Blood Pressure calculations and graphs in real time.

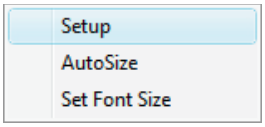
1) Prepare the animal and configure the hardware and software to record blood pressure on *LabScribe*.
2) Record a sample and ascertain that the pressure channel is recording data at the scale you desire. Stop recording as you configure the online analysis.

3) Choose one of the **Online Toolbar** choices from the **Blood Pressure** submenu to display that **Blood Pressure Toolbar** above **Channel 1**.
4) Multiple **Blood Pressure Toolbars** can be chosen sequentially, corresponding to as many as eight different blood pressure transducers.



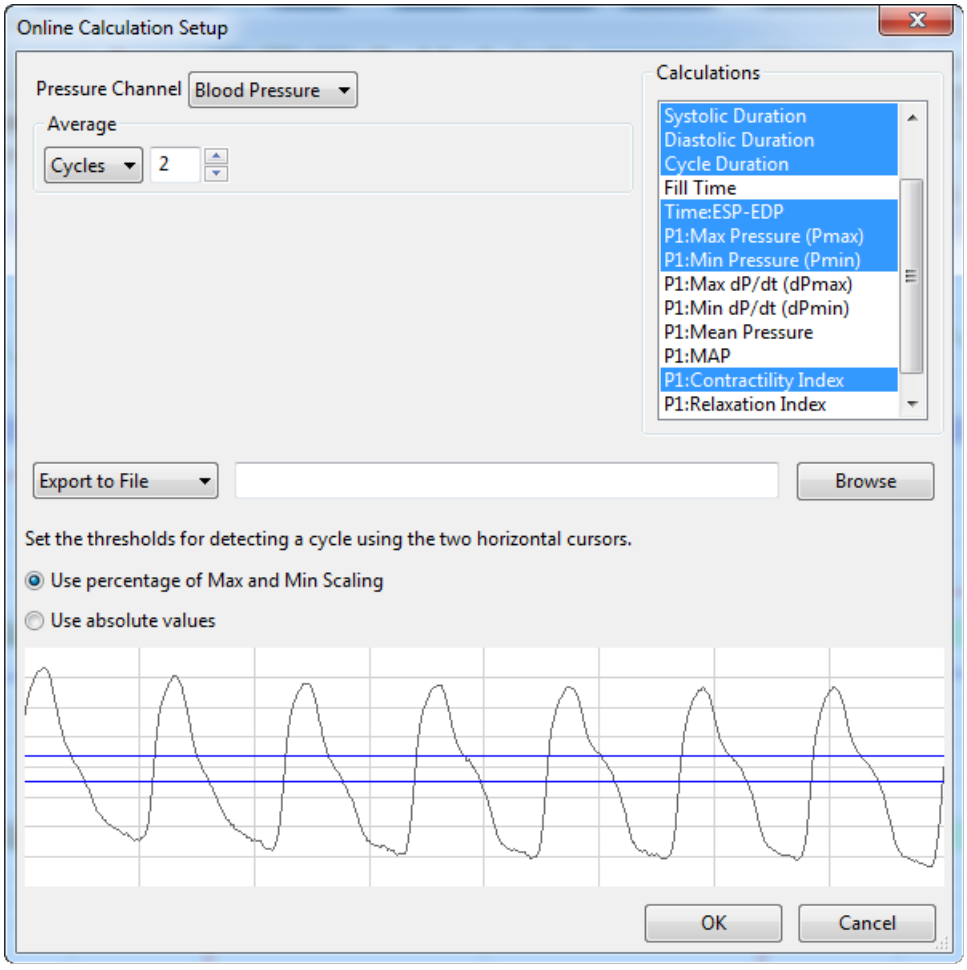
Online Blood Pressure Toolbar.

5) Click on the down arrow on the left side of each **Blood Pressure Toolbar** to display a submenu with three choices: **Setup**, **AutoSize**, and **Set Font Size**.



Blood Pressure Online Setup menu.

6) Choose **Setup** to open the **Online Calculation Setup** dialog.



Online Calculation Setup dialog.

7) From the **Pressure Channel** menu, choose the pressure channel from your recording.
8) Once you select the **Pressure Channel**, a sample of the recording will be displayed at the bottom of the dialog. Set the thresholds for cycle detection by adjusting the Max and Min blue horizontal lines so that all cycles pass through both lines.
9) As you record data, cycles will be detected as either a percentage of the amplitude of the cycles based on where you placed the Max and Min lines, or as the absolute values of their set location. Choose which you prefer from the two choices above the sample recording.
10) From the **Calculations** list, control-click on those variables you would like to record in the data boxes of the **Blood Pressure Toolbar**. To remove a variable after you have selected it, control-click on that variable. Definitions of all variables can be found in the **Blood Pressure Analysis: Reference** section.
11) In order to compensate for variation from cycle to cycle, it is possible for *LabScribe* to average a user selected number of sequential cycles. Enter this number in the **Cycles to Average** text box. Start with a low number and adjust upward as necessary. Alternatively, it is possible to average over a desired duration (**Time**).
12) Click the **Export to File** menu item to send the data recorded in the **Blood Pressure Toolbar** as a .csv file to a location chosen in the dialog that opens. The other alternatives send the data to the *LabScribe* **Journal** (**Export to Journa**l) or do not export the data at all (**No Export**).
13) Click **OK** to close the dialog.
14) Return to the **Blood Pressure Toolbar** menu (accessed by clicking the arrow) and choose **AutoSize**. The size of the data boxes and the titles will be adjusted to the number of variables you have chosen.
15) From the **Blood Pressure Toolbar** menu, choose **Set Font Size**. The font size of the data box values can be chosen from the dialog that opens.
16) Resume recording. The changing variables will be displayed in the data boxes of the toolbar.

8.2 Bl

Online Blood Pressure display.

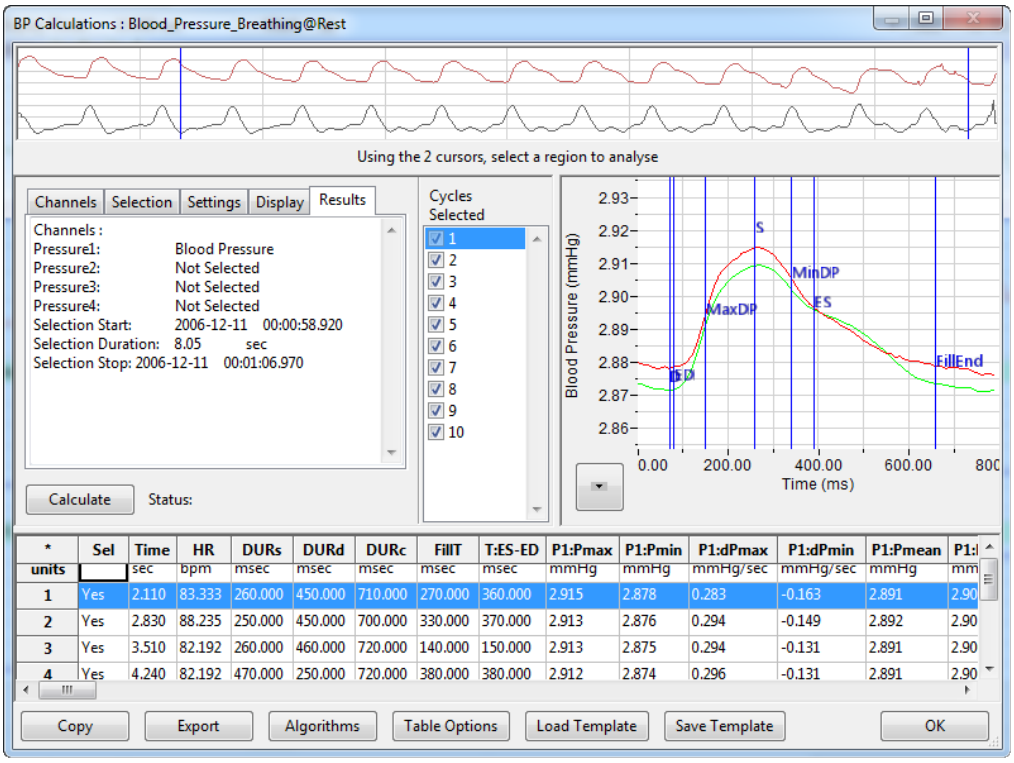
17) Save the recording for offline analysis.

Offline Blood Pressure Calculations

The offline **Blood Pressure Calculations** dialog allows sophisticated offline analysis of previously recorded blood pressure data.

To perform offline **Blood Pressure** analysis**:**

1) Open the recording from the online analysis or another file with previously recorded arterial or ventricular blood pressure data.
2) Choose **Offline Calculations** from the **Blood Pressure** submenu to open the offline **Blood Pressure Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.



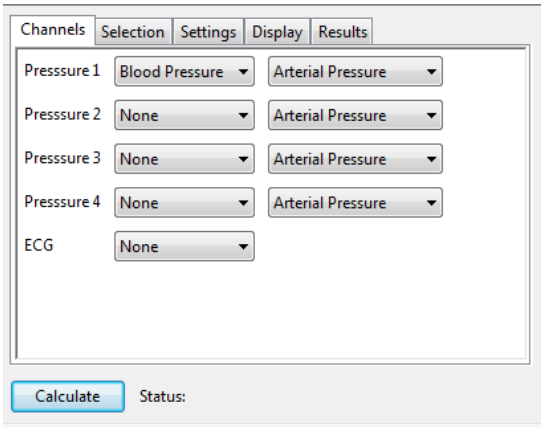
Blood Pressure Calculations dialog.

3) Familiarize yourself with the offline **Blood Pressure Calculations** dialog, pictured above.
   - Across the top of the dialog, in the channel display area, is the blood pressure channel from the recording and a computed derivative used to identify cycles and derivative functions.
   - The tabbed configuration dialogs are on the left below the recordings.
   - An XY graph window on the right displays the **Blood Pressure Graph**, showing the selected cycle and the average of all checked cycles from the **Cycles Selected** list.

- Between the configuration dialogs and the XY graph window is the **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
- The **Data Table** is located on the lower part of the dialog.

To configure the **Channels:**

1) Click on the **Channels** tab, opening the **Channels** configuration dialog.



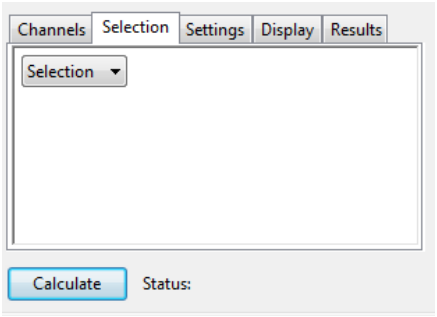
Blood Pressure Channels configuration dialog.

2) From the **Pressure 1** menu, choose a channel with the blood pressure recording. Choose whether the recording represents an **Arterial Pressure** or a **Ventricular Pressure** measurement from the menu to the right. If you would like to analyze additional blood pressure channels, choose them from the **Pressure 2**, **Pressure 3**, and **Pressure 4** menus.
3) Optionally, choose an **ECG** channel if there is one on the recording.

Once the pressure channel is selected, the recording of that channel will be displayed in the channel display area at the top of the dialog and the **Blood Pressure Graph** will be displayed in the XY graph window.

To configure the Selection**:**

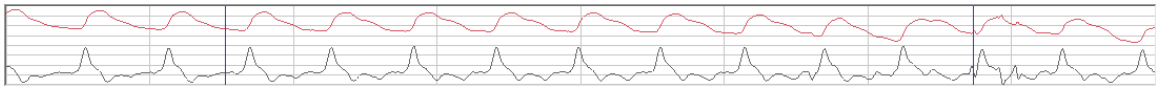
1) Click on the **Selection** tab, opening the **Selection** configuration dialog.



Blood Pressure Selection configuration menu.

2) From the **Selection** menu, choose to analyze either a selection or the entire recording.

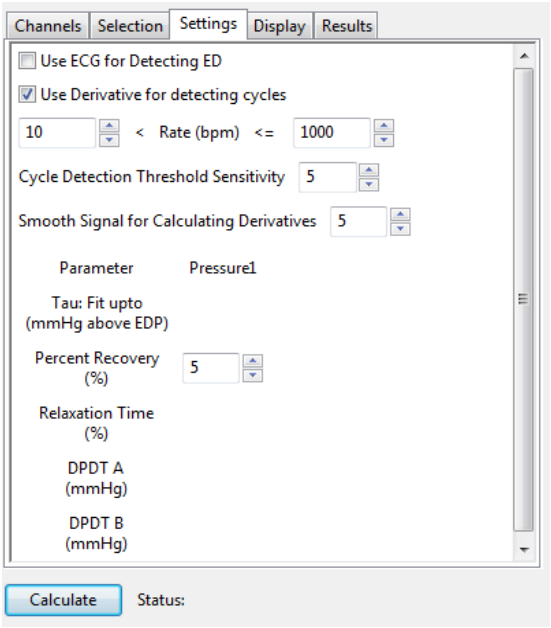
3) If you choose to analyze just a selection from your recording, select the area of the recording to be analyzed by moving the two vertical cursors in the channel display area at the top of the dialog to designate the section to be analyzed. Only those cycles will now be averaged in the **Blood Pressure Graph**, and the cycles will be listed by sequential number in the **Cycles Selected** list to the left of the graph.



Selection from the channel display area.

To configure the **Settings:**

1) Click on the **Settings** tab, opening the **Blood Pressure Settings** configuration dialog.



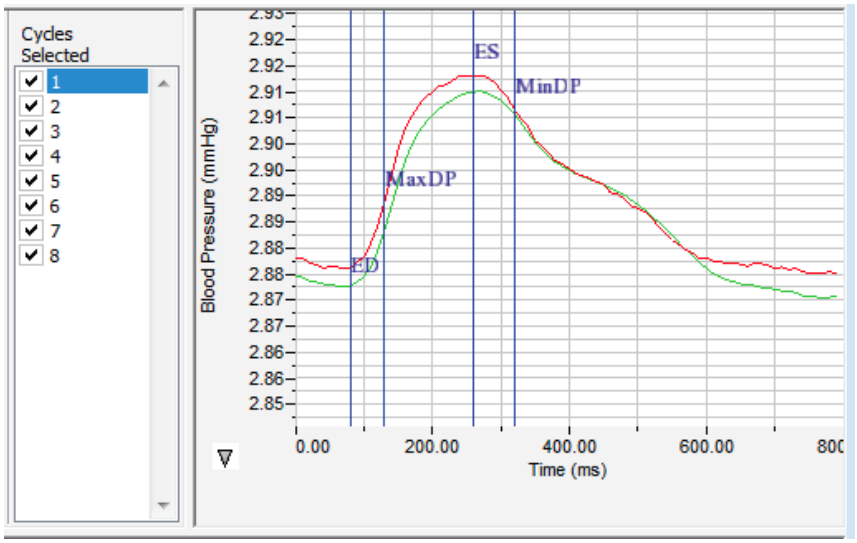
Starting at the top of the **Blood Pressure Settings** configuration dialog:

2) Check whether you wish to use an **ECG** recording for the detection of end-diastole (**ED**).
3) Check whether you would like to use the derivative of the data instead of the raw blood pressure data to detect cycles.
4) Enter a lower and upper permissible heart rate
5) Enter 5 as the number of cycles that should be used to determine the **Cycle Detection Threshold Sensitivity**. By default, a threshold sensitivity of 5 is used to detect cycles. If each cycle is not being detected properly, the sensitivity can be adjusted.
6) Enter a value to indicate the range over which data should be smoothed for calculating the Derivative. This can be used to reduce the high derivative values due to noise in the signal.
7) For each pressure being analyzed, enter the number of mmHg above end-diastolic pressure (**EDP**) that should be designated as the uppermost point that should be used to create the best fit line from which **Tau** (the time constant of blood pressure decrease during diastole) is computed.
8) For each pressure being analyzed, specify the percentage of the time it takes for the pressure to recover that should be displayed in the **Data Table**.

9) For each pressure being analyzed, specify the percentage of the **Relaxation Time** to be displayed in the **Data Table**. **Relaxation Time** is the time between the minimum dP/dt (**dPmin**) and the end of the cycle.
10) For each pressure being analyzed, specify up to two different specified blood pressures (**A** and **B**) at which the derivatives (**dPdT A** and **dPdT B**) should be determined and displayed in the **Data Table**.
11) Click the **Calculate** button above the **Data Table** to update all settings. Click **Calculate** whenever settings are updated.

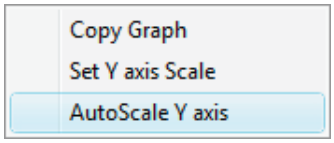
To display and analyze the Blood **Pressure Graph:**

1) Familiarize yourself with the **Blood Pressure Graph**, which will be displayed in the XY graph area for all the cycles in the selection and is illustrated below.
   - The highlighted cycle in the **Cycles Selected** window is shown in red, while the average of all the checked cycles is displayed in green.
   - Cycles can be deselected (or selected) by clicking on the check box to the left of the cycle number in the **Cycles Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
   - The specific parameters shown in the graph are chosen from the **Display** configuration dialog.



The Blood Pressure Graph.

2) Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.

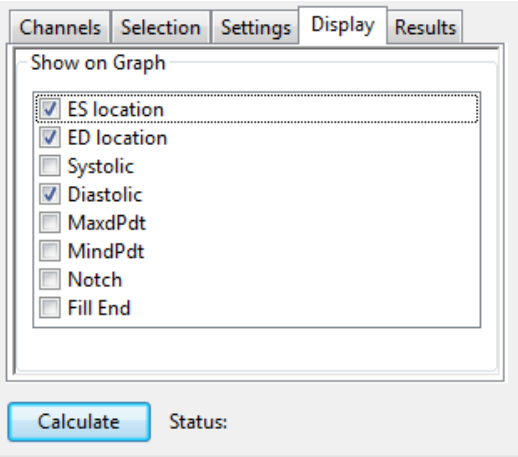


XY graph window menu.

3) Click **Copy Graph** to copy the **Blood Pressure Graph** to the clipboard. It can then be pasted into the **Journal** or an external application.
4) Click **Set Y-axis Scale** to set the Y-axis scale manually.
5) Click **AutoScale Y-axis** to optimize the display scale of the Y-axis.

To configure the **Display:**

1) Click on the **Display** tab to open the **Blood Pressure Display** configuration dialog.

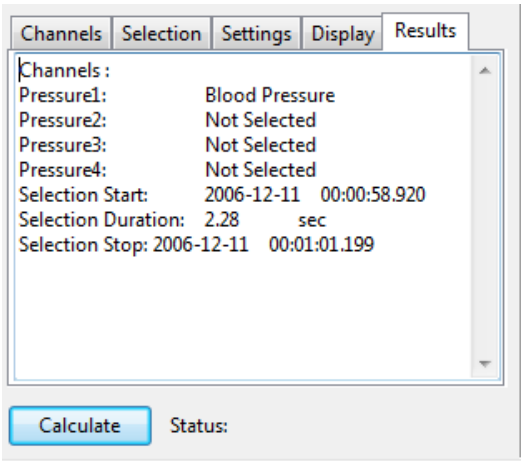


Blood Pressure Display configuration dialog.

2) Choose the parameters you would like displayed on the **Blood Pressure Graph**. Observe the **Blood Pressure Graph** to see the addition or subtraction of the parameters as they are clicked and un-clicked.

To configure the **Results:**

1) Click on the **Results** tab to open the **Blood Pressure Results** configuration dialog. Here information about the channel and the specific selection are displayed, based on the data from the currently displayed **Blood Pressure Graph**. Additional text can be entered into this dialog.



To use the **Data Table:**

*	Sel	Time	HR	DURs	DURd	DURc	FillT	T:ES-ED	P1:Pmax	P1:Pmin	P1:dPmax	P1:dPmin	P1:Pmean	P1:MAP	P1:CI	P1:RI	P1:PH	P1:ESP	P1:EDP	P1:ESP-EDP	P1:
units		sec	bpm	msec	msec	msec	msec	msec	mmHg	mmHg	mmHg/sec	mmHg/sec	mmHg	mmHg	#	#	mmHg	mmHg	mmHg	mmHg	mmH
1	Yes	2.740	82.192	230.000	490.000	720.000	490.000	510.000	2.913	2.875	0.457	-0.180	2.891	2.900	0.158	-0.062	0.038	2.913	2.875	0.038	2.87
2	Yes	3.470	82.192	230.000	490.000	720.000	490.000	510.000	2.912	2.874	0.474	-0.170	2.891	2.900	0.164	-0.059	0.038	2.912	2.875	0.038	2.87
3	Yes	4.200	84.507	230.000	490.000	720.000	480.000	510.000	2.912	2.874	0.459	-0.171	2.891	2.900	0.159	-0.059	0.038	2.912	2.874	0.038	2.87
4	Yes	4.910	82.192	230.000	470.000	700.000	420.000	510.000	2.912	2.874	0.470	-0.181	2.890	2.900	0.163	-0.062	0.039	2.912	2.874	0.038	2.87
5	No	5.640	84.507	240.000	500.000	740.000	380.000	530.000	2.910	2.872	0.457	-0.177	2.889	2.898	0.159	-0.061	0.038	2.910	2.873	0.037	2.87
6	Yes	6.350	83.333	220.000	470.000	690.000	470.000	500.000	2.908	2.870	0.462	-0.181	2.886	2.895	0.160	-0.062	0.039	2.908	2.870	0.038	2.87
7	Yes	7.070	88.235	230.000	460.000	690.000	300.000	490.000	2.902	2.865	0.436	-0.188	2.877	2.889	0.152	-0.065	0.037	2.902	2.865	0.036	2.86
8	Yes	7.750	92.308	470.000	210.000	680.000	-7980.0	450.000	2.899	2.855	0.494	-0.169	2.886	2.885	0.172	-0.059	0.044	2.899	2.856	0.044	2.85
10																					
11	#		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
12	Mean		84.994	262.857	440.000	702.857	-761.429	497.143	2.908	2.870	0.465	-0.177	2.888	2.895	0.161	-0.061	0.039	2.908	2.870	0.039	2.87
13	SD		3.597	84.636	94.567	15.779	2947.636	20.504	0.005	0.007	0.017	0.006	0.005	0.006	0.006	0.002	0.002	0.005	0.007	0.002	0.00
14	Max		92.308	470.000	490.000	720.000	490.000	510.000	2.913	2.875	0.494	-0.169	2.891	2.900	0.172	-0.059	0.044	2.913	2.875	0.044	2.87
15	Min		82.192	220.000	210.000	680.000	-7980.0	450.000	2.899	2.855	0.436	-0.188	2.877	2.885	0.152	-0.065	0.037	2.899	2.856	0.036	2.85

Blood Pressure Data Table.

1) Familiarize yourself with the **Data Table**.
   - The **Data Table** spans the lower part of the **Blood Pressure Calculations** dialog and displays the calculated values for each of the cycles checked in the **Cycles Selected** list.
   - The top line indicates the **units** for each of the chosen parameters.
   - The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected cycles.

There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.**

2) Click the asterisk at the upper left of the **Data Table** to display two options: **Autosize** and **Copy Selection**. **Autosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.
3) Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
4) Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
5) Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
6) Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **Blood Pressure Analysis: Reference** section. Marks indicating temperature and activity can also be added to the file, and those values can be chosen from the **Table Options** list and included in the **Data Table**.

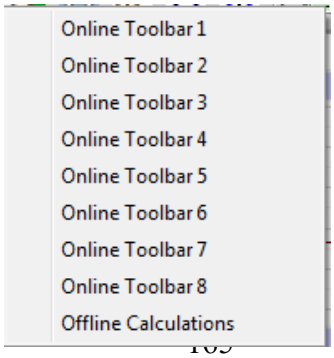
Complete list of Data Table parameters.

7) Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
8) Click **OK** to close the analysis.

Blood Pressure Analysis: Reference

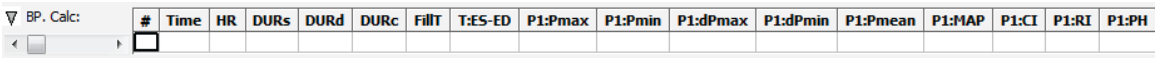
When Blood Pressure is chosen from the Advanced menu, a submenu opens, displaying two choices: Online Calculations (accessed by choosing from as many as eight Online Toolbars) and Offline Calculations.

Online Blood Pressure Calculations



While recording data, some beat-by-beat parameters can be calculated and displayed online using Online Calculations. Choosing one of the Online Toolbars from the Blood Pressure submenu opens a Blood Pressure Toolbar above the uppermost channel. The function titles and the corresponding data values are displayed in the toolbar's data boxes. Channel-specific parameters can be calculated for up to four different

blood pressure channels (P1,P2,P3,P4), or separate toolbars can be displayed for individual blood pressure data channels.



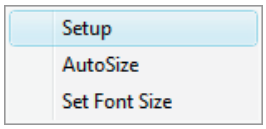
The Online Blood Pressure Toolbar.

The online parameters are:

- **Time**: Time (in seconds) from the start of the selection, or the time of day of the recording, depending upon which option is chosen.
- Heart Rate **(HR)**: 60/period of each cycle.
- Systolic Duration (**DURs**): Time between the start of the cycle and minimum dP/dt (**dPmin**)**.**
- Diastolic Duration (**DURd**): Time between minimum dP/dt (**dPmin**) and the end of the cycle.
- Cycle Duration (**DURc**): Time between any two analogous points in two cycles (often **ED**).
- Fill Time (**FillT**): Time from end-systole (**ES**) to where the pressure starts to fall to end-diastole (**ED**)
- pressure.
- Time from end-systole to end-diastole (**T:ES - ED**): Time from **ES** to next **ED**.
- Maximum Pressure (**Pmax**): Maximum value of the pressure channel for that cycle.
- Minimum Pressure (**Pmin**): Minimum value of the pressure channel for that cycle.
- Maximum dP/dt (**dPmax**): The smoothed derivative of the pressure channel is calculated, using 2 points on either side of any given point. **dPmax** is the steepest slope as pressure increases.
- Minimum dP/dt (**dPmin**): The smoothed derivative of the pressure channel is calculated, using 2 points on either side of any given point. **dPmin** is the steepest slope as pressure decreases.
- Mean Pressure (**Pmean**): Mean of all values in the cycle.
- Mean arterial pressure (**MAP**): 2/3 end systolic pressure (**ESP**) + 1/3 end diastolic pressure (**EDP**).
- Contractility Index (**CI**): (**dPmax**) / (**Pressure** at **dPmax**).
- Relaxation Index (**RI**): (**dPmin**) / (**Pressure** at **dPmin**).
- Pulse Height (**PH**): **Pmax - Pmin**.
- End Systolic Pressure (**ESP**): Value of the **Pressure** channel at end-systole (**ES**).
- End Diastolic Pressure (**EDP**): Value of the **Pressure** channel at end-diastole (**ED**).
- Developed Pressure (**ESP - EDP**)**: ESP - EDP**.
- Left Ventricular End Diastolic Pressure (**LVEDP**): Pressure at end-diastole (**ED**) in a left ventricular pressure channel.
- Tau Weiss (**Tau W**): P(t) = A(-t/**Tau**).
- Tau Logistic (**Tau L**): P(t)= A(-t/**Tau**) + B.
- Tau Glantz (**Tau G**): Regression of **dP/dt** vs. **Pressure**.
- Tau Mirsky (**Tau M**): Time required for **LV pressure** to fall to one-half of its value at **ESP**.
- Time to Peak (**TT Peak**): Time from the start of the cycle to **Pmax**.
- Ejection TIme (**ET**): Time between the start of the cycle and the dichrotic notch.
- Percent Recovery (**% rec**): Designated (by user) percentage of the time it takes for the pressure to recover.

- Tension Time Index (**TTI**): The average pressure during systole multiplied by systolic duration.
- Relaxation Time (**RT**): The time between **dPmin** and the time specified by the relaxation time value set by user.
- **dPdT A**: Rate of pressure change as a function of time at user designated point A.
- **dPdT B**: Rate of pressure change as a function of time at user designated point B.
- IsoVolumetric Time (**IVT**): Duration of the isovolumetric contraction period.

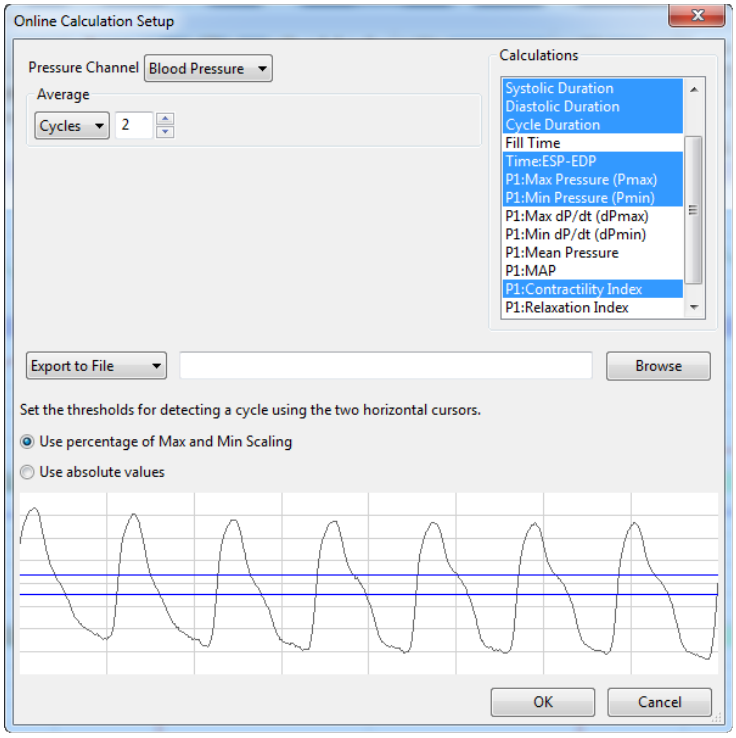
Clicking on the down arrow on the left side of the **Blood Pressure** Toolbar will display a submenu with three choices.



Blood Pressure Online Setup menu.

- **Setup**: Opens the **Online Blood Pressure Setup** dialog.
- **AutoSize**: Adjusts the size of the **Blood Pressure Toolbar** title and data boxes.
- **Set Font Size**: The user can change the size of the font in the **Blood Pressure** toolbar data boxes.

The criteria for setting up the **Blood Pressure** online calculations are entered into the **Online Calculation Setup** dialog.



The Online Blood Pressure Setup dialog is configured by choosing the pressure channel to be used, the calculations to be performed in real time, and whether these calculations should be exported to the Journal.

When the Pressure channel is selected, its graph will appear in the dialog. The threshold lines should be set so that they are between the cyclic minimum and maximum data values. LabScribe uses the positive threshold crossing from below the bottom cursor to above the top cursor to determine the cycle.

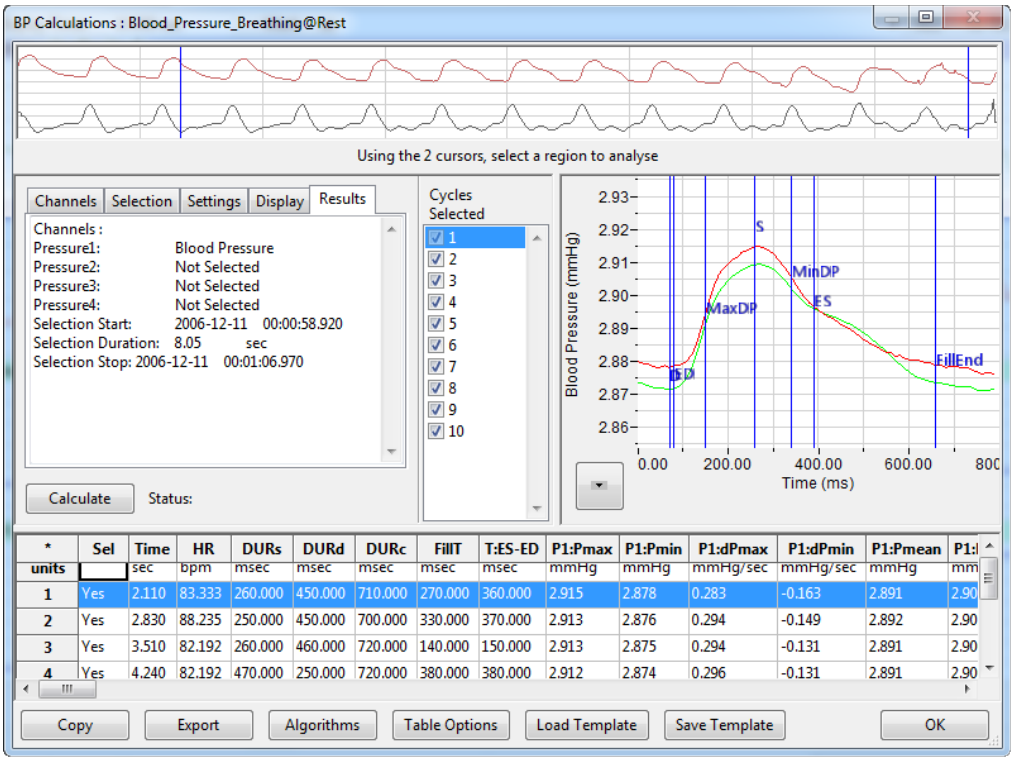
In order to compensate for variation from cycle to cycle, it is possible for LabScribe to average a user-selected number of sequential cycles. This number should be entered in the Cycles to Average text box. Alternatively, data can be averaged over a designated Time duration.

Clicking OK will close the dialog and the selected calculations will be displayed in the data boxes of the Blood Pressure Toolbar as data are recorded.

Offline Blood Pressure Calculations

In addition to the online Blood Pressure calculations, LabScribe can perform additional offline Blood Pressure calculations on previously recorded blood pressure traces, and display an XY graph of averaged Blood Pressure over time derived from user-selected cycles.

Choosing Offline Calculations from the Blood Pressure submenu opens the Blood Pressure Calculations Dialog. The panels of this dialog can all be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.



*	Sel	Time	HR	DURs	DURd	DURc	FillT	T:ES-ED	P1:Pmax	P1:Pmin	P1:dPmax	P1:dPmin	P1:Pmean	P1:
units		sec	bpm	msec	msec	msec	msec	msec	mmHg	mmHg	mmHg/sec	mmHg/sec	mmHg	mm
1	Yes	2.110	83.333	260.000	450.000	710.000	270.000	360.000	2.915	2.878	0.283	-0.163	2.891	2.90
2	Yes	2.830	88.235	250.000	450.000	700.000	330.000	370.000	2.913	2.876	0.294	-0.149	2.892	2.90
3	Yes	3.510	82.192	260.000	460.000	720.000	140.000	150.000	2.913	2.875	0.294	-0.131	2.891	2.90
4	Yes	4.240	82.192	470.000	250.000	720.000	380.000	380.000	2.912	2.874	0.296	-0.131	2.891	2.90

The Blood Pressure Calculations dialog.

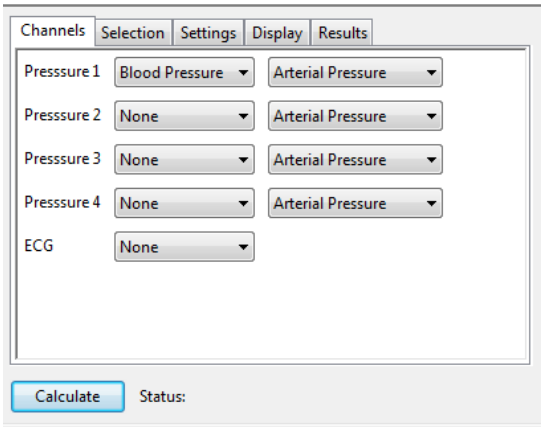
The sections of the offline **Blood Pressure Calculations** dialog, each of which is described in more detail below**:**

- Across the top of the dialog in the channel display area is the blood pressure channel from the recording and a computed derivative used to identify cycles and calculate derivative functions.
- The tabbed configuration dialogs are on the left below the recordings.
- An XY graph window on the right displays the **Blood Pressure Graph**, showing the selected cycle and the average of all checked cycles from the **Cycles Selected** list.
- Between the configuration dialogs and the XY graph window is the **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
- The **Data Table** is located on the lower part of the dialog.

The Channel Display Area**:** In the channel display area, the two vertical blue lines can be adjusted to designate a section of the recording for analysis.

The Configuration Dialogs: There are five tabbed configuration dialogs: Channels, Selection, Settings, Display, and Results.

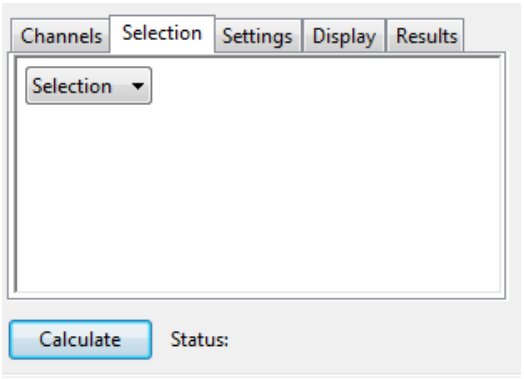
The Channels Configuration Dialog



Blood Pressure Channels configuration dialog.

- At least one blood pressure channel must be selected from the **Pressure 1** menu, and it is designated as an **Arterial Pressure** or a **Ventricular Pressure** measurement. If additional blood pressure channels are to be analyzed, they are chosen from the **Pressure 2**, **Pressure 3**, and **Pressure 4** menus.
- Optionally, an **ECG** channel may be chosen if there is one on the recording.
- Once the pressure channel is selected, the recording of that channel will be displayed in the channel display area at the top of the dialog and the **Blood Pressure Graph** will be displayed in the XY graph window.

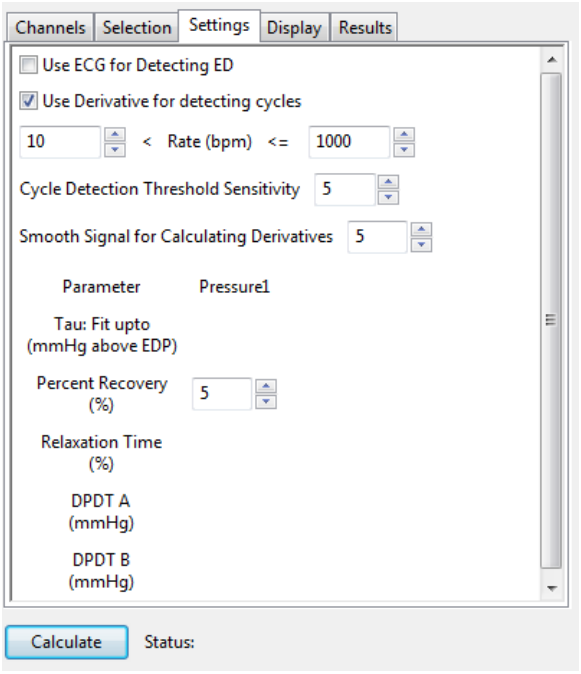
The Selection Configuration **Dialog**



Blood Pressure Selection configuration dialog.

- Whether to analyze a selection or the entire recording is chosen from the S**election** menu.
- If only a selection is chosen, the area of the recording to be analyzed is designated by adjusting the two vertical cursors in the channel display area at the top of the dialog.

The Settings Configuration Dialog

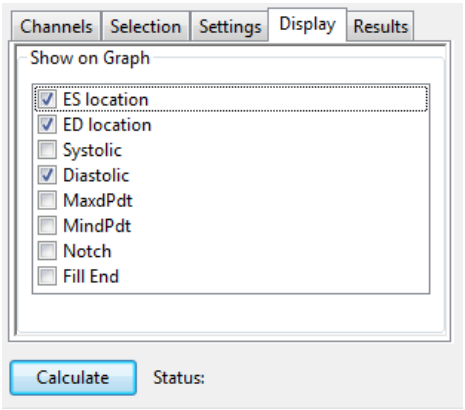


Blood Pressure Settings configuration dialog.

Starting at the top of the **Blood Pressure Settings** configuration dialog**:**

- An **ECG** recording can be used for the detection of end-diastole (**ED**).
- The derivative of the data instead of the raw blood pressure data can be used to detect cycles.
- The lower and upper rates of the permissible heart rate range should be entered.
- If each cycle is not being detected properly, the sensitivity can be adjusted changing the number of cycles that should be used to determine the **Cycle Detection Threshold Sensitivity**. By default, a threshold sensitivity of 5 is used to detect cycles.
- A range over which the data should be smoothed can be entered.
- **Tau Fit**: Allows the user to adjust the uppermost point that should be used to create the best fit line from which **Tau** (the time constant of blood pressure decrease during diastole) is computed (for each pressure being analyzed).
- **Percent Recovery:** Allows the user to specify a percentage of the time it takes for the pressure to recover. This value is displayed in the **Data Table** (for each pressure being analyzed).
- **Relaxation Time**: Allows the user to specify a percentage of the **Relaxation Time** to be displayed in the **Data Table**. **Relaxation Time** is the time between **dPmin** and the end of the cycle (for each pressure being analyzed).
- **dPdt A, dPdt B**: Allows the user to determine (for each pressure being analyzed) the derivative at up to two different specified blood pressures (**A** and **B**).

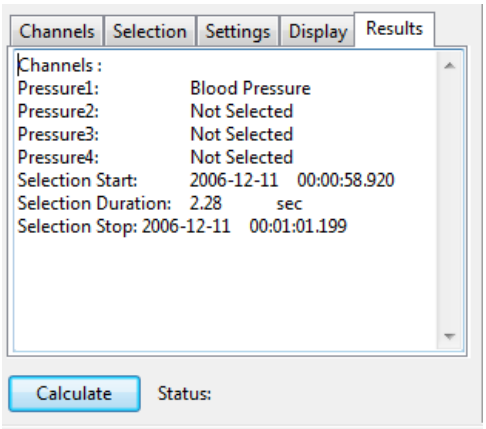
The Display Configuration Dialog



Blood Pressure Display configuration dialog.

- The parameters to be displayed on the **Blood Pressure Graph** are chosen in this dialog.

The Results Configuration Dialog



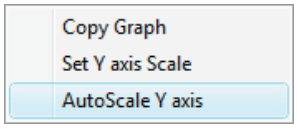
Blood Pressure Results configuration dialog.

- Information about the channel and the specific selection are displayed in this dialog based on the data from the currently displayed **Blood Pressure Graph**. Additional text can be entered into this dialog.

The **Blood Pressure Graph:** The XY graph plots blood pressure as a function of time. The currently selected cycle is displayed in red, and the average of all the cycles is displayed in green. Cycles can be deselected (or selected) by clicking on the check box to the left of the cycle number in the **Cycles Selected** box. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.

The Blood Pressure Graph.

The XY **Graph Menu:** Clicking on the arrow in the lower left corner of the XY graph pane opens a menu that offers options for scaling both the X-axis and Y-axis, as well as an option to copy the graph to the clipboard.



The XY Graph menu.

The menu items are:

- **Copy graph**: Copies the current XY graph to the clipboard. It can then be pasted into the journal or an external application.
- **Set Y-axis Scale**: Allows the user to set the Y-axis scale.
- **AutoScale Y-axis**: Optimizes the display scale of the Y-axis of the XY graph.
- The axes can also be re-scaled by left-clicking and dragging either of the axes.

The Data Table

The Data **Table** displays the chosen calculated values for each cycle.

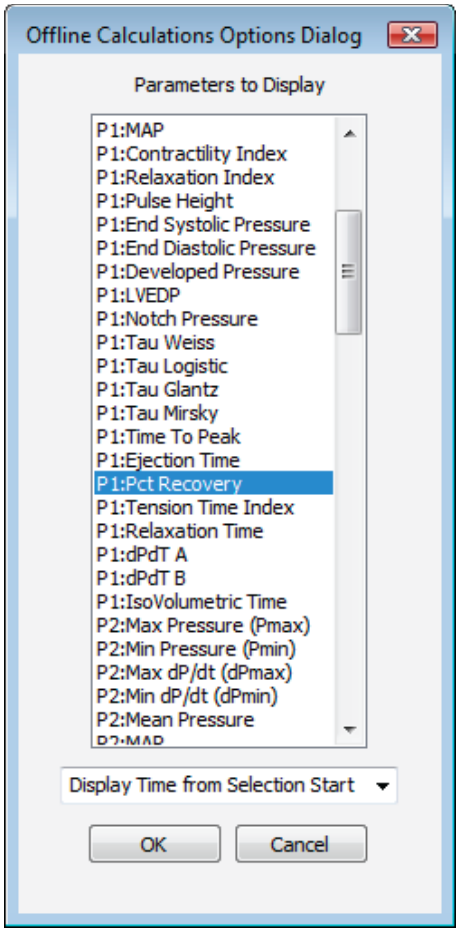
*	Sel	Time	HR	DURs	DURd	DURc	FillT	T:ES-ED	P1:Pmax	P1:Pmin	P1:dPmax	P1:dPmin	P1:Pmean	P1:MAP	P1:CI	P1:RI	P1:PH	P1:ES
units		sec	bpm	msec	msec	msec	msec	msec	mmHg	mmHg	mmHg/sec	mmHg/sec	mmHg	mmHg	#	#	mmHg	mmHg
1	Yes	2.740	82.192	230.000	490.000	720.000	490.000	510.000	2.913	2.875	0.457	-0.180	2.891	2.900	0.158	-0.062	0.038	2.913
2	Yes	3.470	82.192	230.000	490.000	720.000	490.000	510.000	2.912	2.874	0.474	-0.170	2.891	2.900	0.164	-0.059	0.038	2.912
3	Yes	4.200	84.507	230.000	490.000	720.000	480.000	510.000	2.912	2.874	0.459	-0.171	2.891	2.900	0.159	-0.059	0.038	2.912
4	Yes	4.910	82.192	230.000	470.000	700.000	420.000	510.000	2.912	2.874	0.470	-0.181	2.890	2.900	0.163	-0.062	0.039	2.912
5	No	5.640	84.507	240.000	500.000	740.000	380.000	530.000	2.910	2.872	0.457	-0.177	2.889	2.898	0.159	-0.061	0.038	2.910
6	Yes	6.350	83.333	220.000	470.000	690.000	470.000	500.000	2.908	2.870	0.462	-0.181	2.886	2.895	0.160	-0.062	0.039	2.908
7	Yes	7.070	88.235	230.000	460.000	690.000	300.000	490.000	2.902	2.865	0.436	-0.188	2.877	2.889	0.152	-0.065	0.037	2.902
8	Yes	7.750	92.308	470.000	210.000	680.000	-7980.0	450.000	2.899	2.855	0.494	-0.169	2.886	2.885	0.172	-0.059	0.044	2.899
10																		
11	#		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
12	Mean		84.994	262.857	440.000	702.857	-761.429	497.143	2.908	2.870	0.465	-0.177	2.888	2.895	0.161	-0.061	0.039	2.908
13	SD		3.597	84.636	94.567	15.779	2947.636	20.504	0.005	0.007	0.017	0.006	0.005	0.006	0.006	0.002	0.002	0.005
14	Max		92.308	470.000	490.000	720.000	490.000	510.000	2.913	2.875	0.494	-0.169	2.891	2.900	0.172	-0.059	0.044	2.913
15	Min		82.192	220.000	210.000	680.000	-7980.0	450.000	2.899	2.855	0.436	-0.188	2.877	2.885	0.152	-0.065	0.037	2.899

Clicking the asterisk at the upper left of the Data Table displays two options: Autosize and Copy Selection. Autosize will optimize the size of the Data Table boxes, and Copy Selection copies any selected Data Table cells to the clipboard.

The Data Table displays the chosen calculated values for each of the cycles checked in the Cycles Selected window, as well as the mean, standard deviation, and range of each of the chosen parameters averaged over all the selected cycles.

Clicking OK in the Offline Calculations Options Dialog saves the settings for future Blood Pressure analyses.

There are four buttons across the bottom of the Blood Pressure Calculations Dialog: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.



- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- *LabScribe* is able to calculate a large number of blood pressure calculations for each cycle. By clicking **Table Options** at the bottom of the **Blood Pressure Calculations Dialog**, the **Offline Calculations Options Dialog** opens, and calculations to be displayed in the dialog data table can be chosen from the list of all possible calculations. Marks indicating temperature and activity can also be added to the file, and those values can be chosen from the **Table Options** list and included in the **Data Table**.
- Clicking **Load Template** or **Save Template** displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

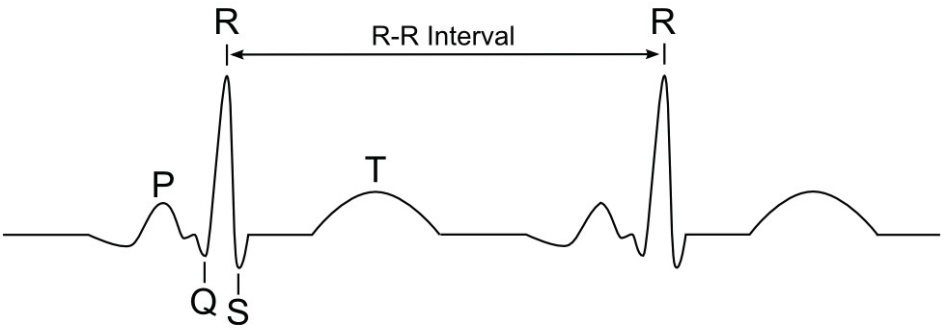
Offline **Calculations:**

- **Time**: Time (in seconds) from the start of the selection, or the time of day of the recording, depending upon which option is chosen.
- Heart Rate **(HR)**: 60/period of each cycle.
- Systolic Duration (**DURs**): Time between the start of the cycle and the minimum dP/dt (**dPmin**).
- Diastolic Duration (**DURd**): Time between the minimum dP/dt (**dPmin**) and the end of the cycle.
- Cycle Duration (**DURc**): Time between any two analogous points in two cycles (often **ED**).
- Fill Time (**FillT**): Time from end-systole (**ES**) to where the pressure starts to fall to end-diastole (**ED**).
- Time from end-systole to end-diastole (**T:ES - ED**): Time from **ES** to next **ED**..
- Maximum Pressure (**Pmax**): Maximum value of the pressure channel for that cycle.

- Minimum Pressure (**Pmin**): Minimum value of the pressure channel for that cycle.
- Maximum dP/dt (**dPmax**): The smoothed derivative of the pressure channel is calculated, using 2 points on either side of any given point. **dPmax** is the steepest slope as pressure increases.
- Minimum dP/dt (**dPmin**): The smoothed derivative of the pressure channel is calculated, using 2 points on either side of any given point. **dPmin** is the steepest slope as pressure decreases.
- Mean Pressure (**Pmean**): Mean of all values in the cycle.
- Mean arterial pressure (**MAP**): 2/3 end systolic pressure (**ESP**) + 1/3 end diastolic pressure (**EDP**).
- Contractility Index (**CI**): (**dPmax**) / (**Pressure** at **dPmax**).
- Relaxation Index (**RI**): (**dPmin**) / (**Pressure** at **dPmin**).
- Pulse Height (**PH**): **Pmax – Pmin**.
- End Systolic Pressure (**ESP**): Value of the **Pressure** channel at **ES**.
- End Diastolic Pressure (**EDP**): Value of the **Pressure** channel at **ED**.
- Developed Pressure (**ESP - EDP**)**: ESP - EDP**.
- Left Ventricular End Diastolic Pressure (**LVEDP**): Pressure at **ED** in a left ventricular pressure channel.
- Notch Pressure (**Notch**): Pressure at the dicrotic notch.
- Tau Weiss (**Tau W**): P(t) = a(-t/**Tau**).
- Tau Logistic (**Tau L**): P(t)= a(-t/**Tau**) + b.
- Tau Glantz (**Tau G**): Regression of **dP/dt** vs. **Pressure**.
- Tau Mirsky (**Tau M**): Time required for **LV pressure** to fall to one-half of its value at **ESP**.
- Time to Peak (**TT Peak**): Time from the start of the cycle to **Pmax**.
- Ejection TIme (**ET**): Time between the start of the cycle and the dichrotic notch.
- Percent Recovery (**% rec**): Designated (by user) percentage of the time it takes for the pressure to recover.
- Tension Time Index (**TTI**): The average pressure during systole multiplied by systolic duration.
- Relaxation Time (**RT**): The time between **dPmin** and the time specified by the relaxation time value set by user.
- **dPdT A**: Rate of pressure change as a function of time at user designated point A.
- **dPdT B**: Rate of pressure change as a function of time at user designated point B.
- IsoVolumetric Time (**IVT**): Duration of the isovolumetric contraction period.

8.3: ECG Analysis

An electrocardiogram is a representation of the electrical activity of the heart over time. The first wave indicates the depolarization of the atria, which appears in the ECG as the P wave. The P wave is followed by the QRS complex, which represents the depolarization of the ventricles. The repolarization of the ventricles appears as the T wave. After a brief fill period, the cycle starts again. The baseline from which the waves deviate is called the isoelectric line. By looking at the timing, and to a lesser extent the amplitude, of these events, various problems with the electrical conduction process can be diagnosed.



Electrocardiogram.

LabScribe offers a number of ways to analyze electrocardiograms. Many elements of the analysis can be done using features in the basic LabScribe software. More sophisticated analysis requires a license for the ECG Advanced Analysis Module.

This document includes a step by step tutorial for using most of the features of the ECG Advanced Analysis Module, as well as other ECG functions in LabScribe. It also includes a more detailed Reference section that covers the material in the tutorial, and adds additional context and detail. To use the step by step guide, you will need an ECG recording. This can be from any species, but in order to calculate the limb leads and the angle of the electrical axis of the heart, you will need a human ECG of limb Leads I and II. Basic instructions are included for recording a two lead human ECG.

ECG Analysis: Step by Step

Recording a Human ECG

You will need to record an electrocardiogram in order to complete this step by step guide. This ECG can be from any mammalian species, but in order to complete the sections on the calculation of limb leads and the angle of the electrical axis of the heart, it is necessary to record a human ECG of limb Leads I and II.

To record a human ECG to use with this tutorial:

1) Place two disposable ECG electrodes on the underside of the right wrist (one above the other), one on the underside of the left wrist and one on the back of each leg just above each ankle.
2) Using a five-conductor ECG cable, attach wires 1+ to the electrode on the left wrist, 1- and 2- to the right wrist, 2+ to the left ankle, and the ground wire to the right ankle.
3) Plug the cable into the iWorx A/D unit.
4) Choose the ECG Settings file you wish to record with. One possibility is to open the **Six-Lead ECG** settings file in the **Human Heart** category. For the purposes of this Step by Step guide, delete all channels except for Leads I and II from this settings file.
5) While sitting down, relax your muscles and support your hands on a non-metallic surface.
6) Click **Record** and make sure that your electrocardiogram is being recorded on both the **Lead I** and **Lead II** channels. **AutoScale** each channel, and use the **Zoom In** or **Zoom Out** function to display an appropriate time scale.
7) After two minutes, click **Stop**.
8) **Save** the file as “Tutorial ECG”.

Basic Cardiac Functions: Step by Step

Limb Lead Calculations

On a human ECG, you can calculate Lead III, as well as the augmented limb Leads aVL, aVR, and aVF, from the Lead I and Lead II recordings. If you are analyzing the ECG of another species, you can skip to the Heart Rate Variability section below.

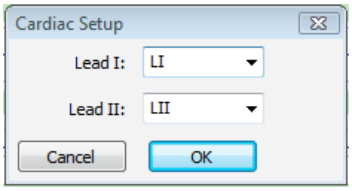
Background: Lead I is a bipolar human limb lead, with the electrodes on the right (-) and left (+) arms. Lead 2 is another limb lead, with the electrodes on the right arm (-) and left foot (+). Lead III is the lead going from the left arm (-) to the left foot (+). There are three unipolar augmented limb leads which go from one of the three electrode locations to an average of the other two. Lead aVR is the augmented lead from the right arm (+) to the left arm and left foot (-), Lead aVL is the augmented lead from the left arm (+) to the combined right arm and left foot (-), and Lead aVF is the augmented lead from the left foot to the combined right and left arms (-).

To calculate and display the four remaining limb leads:

1) Click **add function** in the **Lead I Channel Bar**. Scroll down to **Cardiac** in the list of functions and select **Lead III** from the available options.

The Cardiac submenu.

2) In the **Cardiac Setup** dialog, specify the two channels that correspond to Leads I and II. In the example in the figure below, they have been named LI and LII.



Cardiac Setup dialog.

3) Click **OK**, and a computed channel will be added displaying Lead III.
4) Repeat Steps 1-3 for the three augmented leads. You will now see six channels on the screen displaying all six limb leads.
5) Delete the four computed channels before continuing.

Angle of the Electrical Axis of the Heart

If you have recordings from Leads I and II, you can also calculate the Angle of the electrical axis of the heart.

Background: *The electrical axis of the heart is the mean direction of the cardiac action potential. The deflection of this axis in relation to the horizontal axis of the heart is the Angle of the electrical axis. The Angle can be calculated from the leads that make up Einthoven's Triangle, the three bipolar limb leads. A normal angle ranges from +90 to -30 degrees. Deviations from this range can indicate a number of*

morphological and electrical cardiac conditions. Left axis deviation ranges from -30 to -90 degrees. Right axis deviation ranges from +90 to +180 degrees.

To calculate the electrical **Angle** in *LabScribe*:

1) Choose **Angle** from the list of cardiac functions, and in the dialog that opens specify the two channels that correspond to Leads I and II.
2) Click **OK**, and the beat by beat **Angle** of the electrical axis will be displayed in the computed channel.
3) Delete this channel before continuing.

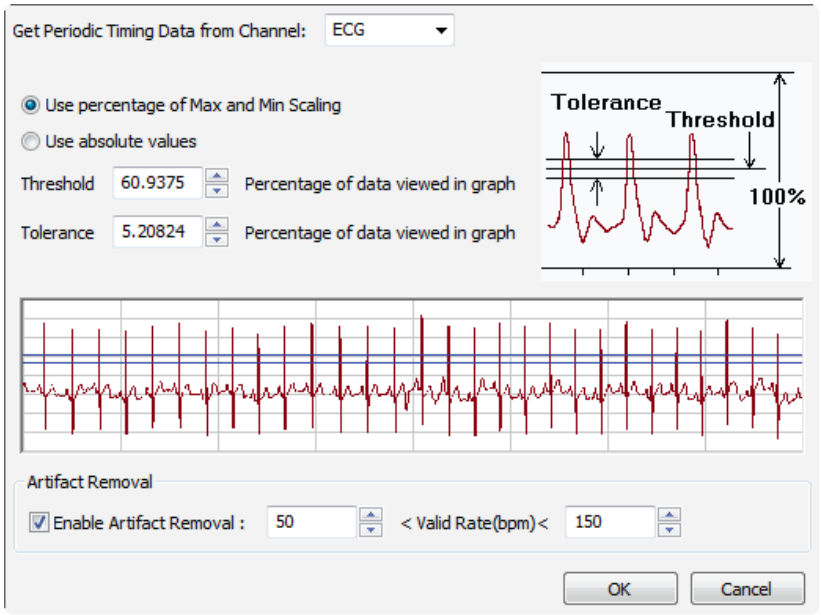
Heart Rate and Heart Rate Variability

Heart rate variability can be calculated using the Cardiac functions. Although it is not necessary, it is useful to calculate heart rate before looking at heart rate variability.

Heart Rate

To determine heart rate:

1) Click **add function** above a channel with a recorded ECG. From the **Periodic** submenu, choose the **Rate** function, opening the **Periodic** dialog.



Periodic dialog. Threshold is the amplitude value that will trigger detection of a beat. Tolerance determines the permissible range in amplitude for detection of a beat. Both are computed either as a percentage of the total amplitude of the data in the ECG or from absolute amplitude data values.

2) Each of the beats on the ECG needs to be detected. There are two ways of configuring this analysis, each using **Threshold** and **Tolerance** values to detect the beats.
   - To **Use percentage of Max and Min Scaling**, enter the **Threshold** and **Tolerance** values directly into the data boxes, or visually determine the value by positioning the two

blue horizontal lines on the sample portion of the ECG recording that appears at the bottom of the dialog so that all R waves pass through both lines. If the **Threshold** and **Tolerance** lines are not immediately obvious, check at the very bottom of the ECG window in the dialog. The horizontal scale of this sample can be changed by changing the time scale of the ECG recording itself.

- To **Use absolute values**, enter the absolute **Threshold** and **Tolerance** amplitudes that should trigger detection of a beat directly into the data boxes. These values can be determined from the original ECG.

3) In the **Artifact Removal** data boxes, enter the minimum and maximum heart rates that are likely to be encountered in the data. Cycles occurring at a slower or faster rate than these, and therefore most likely representing noise or artifacts, will be eliminated from the analysis.
4) Click **OK**, and a new channel will be added, displaying the beat by beat heart rate.
5) To find the average rate over a selected section of the recording, switch to the **Analysis Window**.
6) In the functions bar above **Channel 1**, click on **add function** and choose the **Mean** function in the **General** submenu.
7) Place the left cursor at the start of the chosen section, and the right cursor at the end. In the **Mean** data box above the **Rate** channel, the average rate over the selection will be displayed.

Heart Rate Variability

Heart rate variability is a measure of the amount of cyclic fluctuation there is from the average beat length (RR). These fluctuations often occur over time in a regular pattern. It's possible to use Power functions to determine how much of the variability is due to fast cycling (HRV High Power) and how much is due to slower cycling (HRV Low Power). HRV Total Power is a measure of the overall variance.

To determine **HRV Total Power:**

1) Click on **add function** above the ECG data channel.
2) Select **HRV Total Power** from the **Cardiac** functions. This will once again open the **Periodic** dialog, already seen when you were determining the heart rate.
3) Configure the **Periodic** dialog as instructed in the **Rate** section above. Click **OK**.
4) The **HRV Total Power** function, computed over time, will be displayed in the added function channel. Notice the HRV increases in areas where the rate undergoes more change, and decreases in areas where the rate remains constant.

Human ECG recording with computed channels showing Rate and HRV Total Power functions.

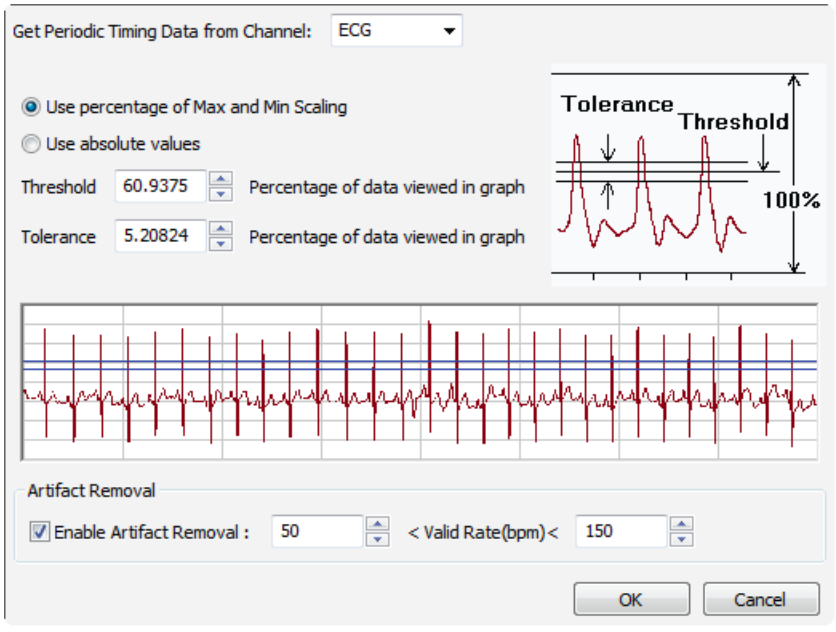
5) To compute and display **HRV Low Power** or **HRV High Power**, follow Steps 1-5 for the desired function.
6) Delete the **HRV** and **Rate** channels before continuing.

QRS Detection

The QRS Detector can be used to mark R waves on a computed channel by placing corresponding peaks at the location of each R wave.

To use the **QRS Detector:**

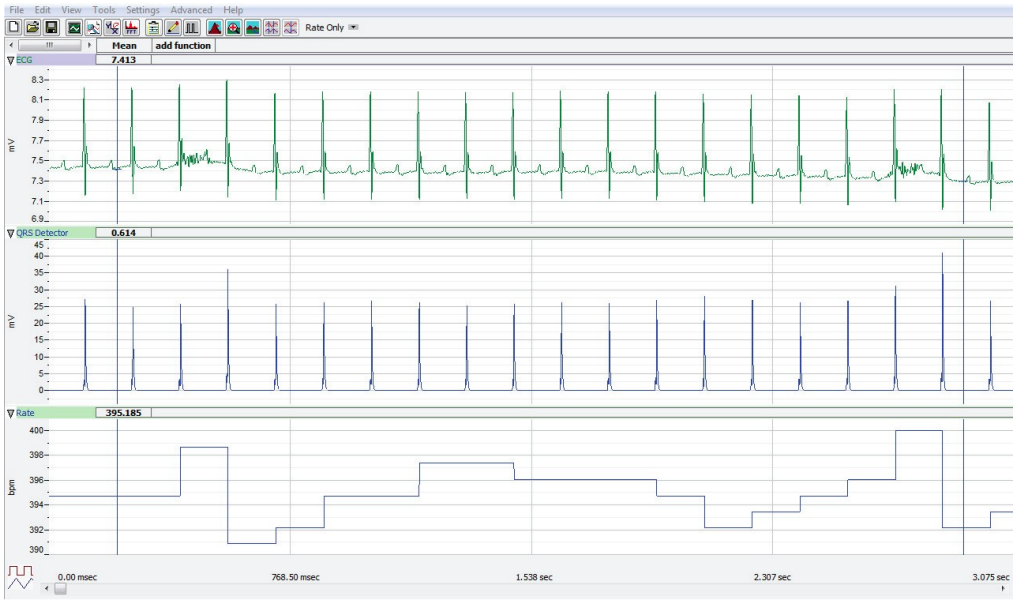
1) Click on **add function** above a channel with an ECG recording.
2) Select **QRS Detector** from the **Cardiac** functions.
3) The **QRS Detector** computed channel will be added, showing spikes at the location of each R wave. The amplitudes of the spikes correlate with the amplitudes of the actual waves.
4) The **QRS Detector** channel can be used to determine the heart rate. Click **add function** above the **QRS Detector** channel. From the **Periodic** submenu, choose the **Rate** function to open the **Periodic** dialog.



QRS Detection Periodic dialog.

5) In the **Periodic** dialog, each of the detected QRS peaks needs to be detected. There are two ways of configuring this analysis, each using **Threshold** and **Tolerance** values to detect the beats.
   - To **Use percentage of Max and Min Scaling**, enter the **Threshold** and **Tolerance** values directly into the data boxes, or visually determine the value by positioning the two blue horizontal lines on the sample portion of the ECG recording that appears at the bottom of the dialog so that all R waves pass through both lines. If the **Threshold** and **Tolerance** lines are not immediately obvious, check at the very bottom of the ECG window in the dialog. The horizontal scale of this sample can be changed by changing the time scale of the ECG recording itself.

   - To **Use absolute values**, enter the absolute **Threshold** and **Tolerance** amplitudes that should trigger detection of a beat directly into the data boxes. These values can be determined from the original ECG.
6) In the **Artifact Removal** data boxes, enter the minimum and maximum heart rates that are likely to be encountered in the data. Events occurring at a slower or faster rate than these, and therefore most likely representing noise or artifacts, will be eliminated from the analysis.
7) Click **OK**, and a new channel will be added, displaying the beat by beat heart rate.
8) To find the average rate over a selected section of the recording, switch to the **Analysis Window**.
9) In the functions bar above **Channel 1**, click on **add function** and choose the **Mean** function in the **General** submenu.
10) Place the left cursor at the start of the chosen section, and the right cursor at the end. In the **Mean** data box above the **Rate** channel, the average rate over the selection will be displayed.



Mouse ECG recording Analysis Window showing QRS Detector and Rate computed channels.

11) Delete the **QRS Detector** and **Rate** channels before continuing.

ECG Advanced Analysis Module: Step by Step

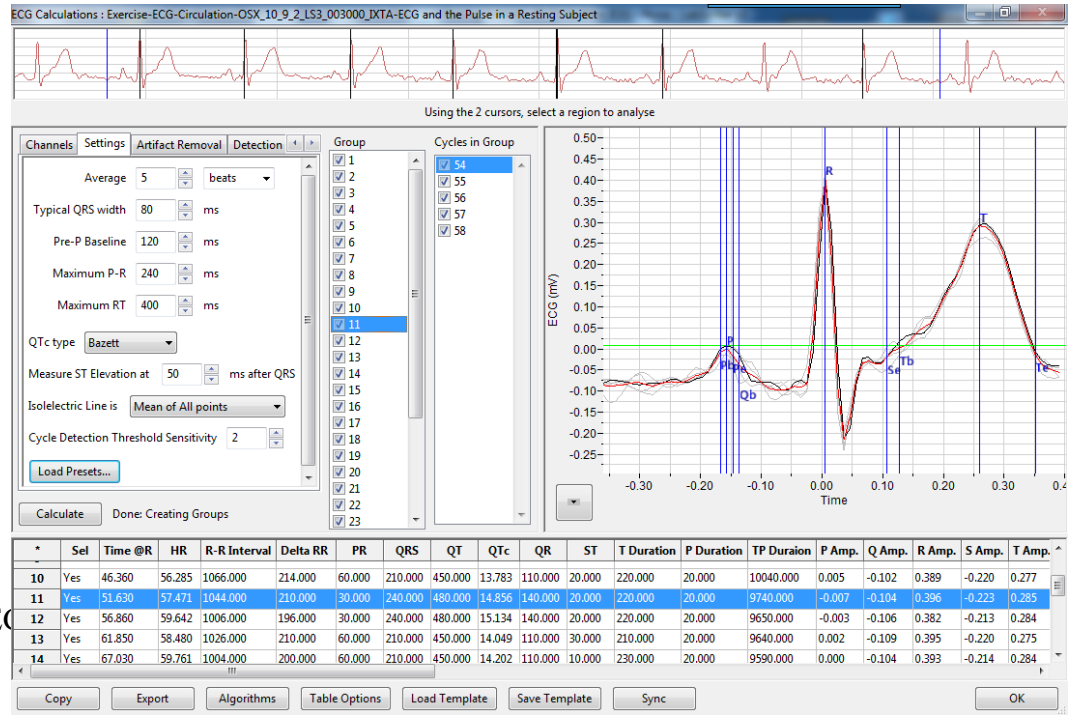
Offline Calculations

More sophisticated analysis can be done on a previously recorded electrocardiogram using the Offline Calculations function of the ECG Advanced Analysis Module. This analysis is performed using the offline ECG Calculations dialog, so you should first become familiar with this dialog.

The Offline ECG Calculations Dialog

To display the ECG Calculations dialog and familiarize yourself with its features:

1) If it is not already open, open the “Tutorial ECG” file you recorded at the start of this guide, or another ECG recording.
2) Select **Offline Calculations** from the **ECG Analysis** submenu of the **Advanced** menu. This will open the offline **ECG Calculations** dialog.
3) Familiarize yourself with the offline **ECG Calculations** dialog, pictured above.
   - Across the top of the dialog, in the channel display area, you will see a sample of the raw data channel to be analyzed. By default **Channel 1** is displayed. How much of the ECG appears there can be set by using *LabScribe*’s **Zoom In** and **Zoom Out** features on the original recording.
   - On the left of the middle row are the tabbed dialogs used to configure the analysis.
   - At the right is the XY graph window in which the **ECG Graph** or the **Artifact Graph** can be displayed.
   - Between the configuration dialogs and the graph are the editable lists of the **Groups** and **Cycles in Group** to be analyzed and displayed.
   - Across the lower part of the dialog is the **Data Table** with the calculated average values for each of the analyzed groups of beats.



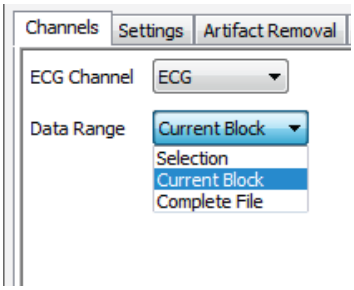
8.3: EC

Offline ECG Calculations dialog.

To configure the analysis, the tabbed configuration panels at the left side of the middle row of the dialog are used.

To configure Channels**:**

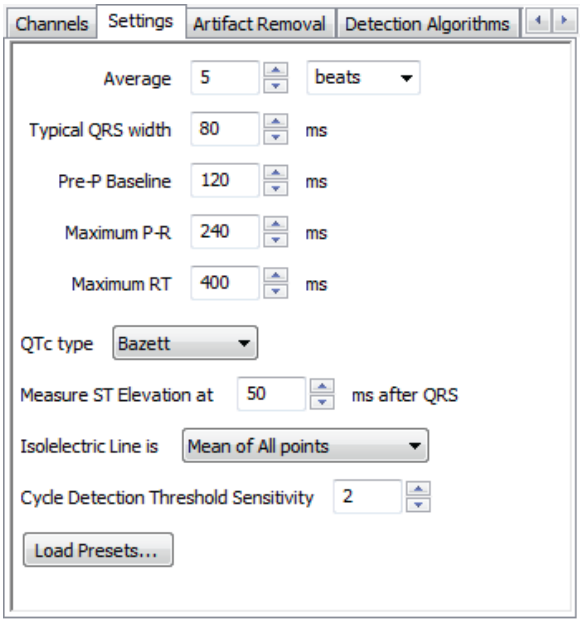
1) Click the leftmost tab of the configuration dialogs, the one labeled **Channels**.
2) From the **ECG Channel** menu, choose an ECG channel. This could be the human Lead I channel or the ECG you recorded from another species. This is the channel on which the analysis will be performed.



3) From the **Data Range** menu, choose **Complete File** to analyze the entire electrocardiogram file. You could instead choose **Selection**, which will analyze a sample of the data between the two vertical cursors in the data sample in the channel display area at the top of the dialog, or **Current Block**, which will analyze all the data in the current recording block.

To configure the **Settings:**

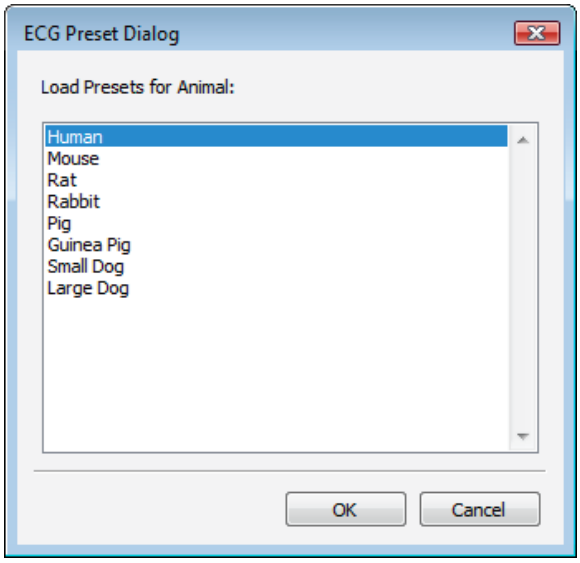
1) Click the **Settings** tab, which is the second tab from the left in the configuration dialogs. The **ECG Settings** configuration dialog will open.



ECG Settings configuration dialog.

2) In the **Average** box, enter **5**, and choose **beats** from the menu to the right. Averaging over a certain number of beats (or seconds) is done to compensate for small cycle by cycle fluctuations, or to average the beats within a specific experimental condition.
3) From the **QTc type** menu, choose **Bazett**. There are a number of options for calculating QTc type, the QT Interval normalized for heart rate. The default calculation is the Bazett formula, but the Fredericia, Framingham, and Hodge formulae are also available options.
4) From the **Isoelectric Line is** menu, choose **Mean of All points**. Alternatively, the isoelectric line can be averaged from only the pre-P points or the absolute zero line.

5) From the **Cycle Detection Threshold Sensitivity** menu, choose **2**. It is important that the cycle detection is set to the correct sensitivity. Adjusting the **Cycle Detection Threshold Sensitivity** number to higher numbers will lower the threshold at which a cycle is detected. Start at a low value; you will be able to adjust this later if you discover that cycles are being missed in the analysis.
6) Click the **Load Presets** button and choose the species from which your ECG was recorded. The remaining data boxes (**Typical QRS width**, **Pre-P Baseline duration**, **Maximum P>R duration**, **Maximum RT duration**, and the **Measure ST Elevation at** value) will be completed using typical values for the designated species. These default values can also be changed manually. *I*t is necessary to choose the correct species from the **ECG Preset Dialog** in order to appropriately display an ECG cycle in the **ECG Graph**.



ECG Preset Dialog.

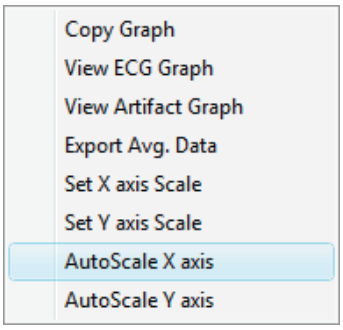
7) Click the **Calculate** button just above the **Data Table** to start the analysis. The **ECG Graph** will appear in the graph window at the right, and the **Data Table** will be populated with values.

Important: *After any configuration settings are changed, click* ***Calculate*** *again, to trigger the revised analysis.*

Once the Channels and **Settings** configuration dialogs are completed, it is possible to display the **ECG Graph** and start the analysis.

To display the **ECG Graph:**

1) Choose **View ECG Graph** from the menu at the lower left of the graph window. The **ECG Graph** will be displayed in the XY Graph window, showing the group of cycles specified in the **Groups** and **Cycles in Group** lists to its left.
2) Use the menu indicated by the arrow at the lower left of the graph to **AutoScale** the **X-axis** and the **Y-axis**. The X and Y axes can also be set manually by using the menu items or clicking and dragging the axis numbers themselves.



3) Make sure a complete cycle is visible in the **ECG Graph**. If a complete cycle doesn't appear (from before the P Wave to after the T Wave), go back to the **Settings** configuration dialog, open the **Load Presets** menu, and click on the species from which your ECG was recorded. Click **Calculate** above the **Data Table** and the complete cycle should appear on the **ECG Graph**.
4) Look at the **ECG Graph** and familiarize yourself with its features.
   - Several ECG parameters are automatically indicated by the vertical blue Marks on the graph. Their locations are determined by the algorithms in the configuration dialogs.
   - The graph displays the checked cycles in one selected group from the **Groups** list to the left of the graph. They are superimposed on each other and the cycle mathematically averaged from all of them is highlighted in red. The parameters and calculations from this averaged cycle appear in the **Data Table**. The individual cycles are in grey and the currently selected cycle (from the **Cycles in Group** list) is in black. The number of cycles in a group has been determined in the **Settings** configuration dialog as the **Average**.
5) Change the group of cycles displayed by selecting a different group in the **Group** list. The groups are listed in order of their appearance in the ECG.
6) Select a different cycle in the **Cycles in Group** list. Notice that the cycle displayed in black changes with your selection.
7) Uncheck one of the cycles. Notice that one of the cycles is deleted from the graph. The red averaged cycle will also change to reflect the new mathematical average. Add the cycle back again by checking its check box.

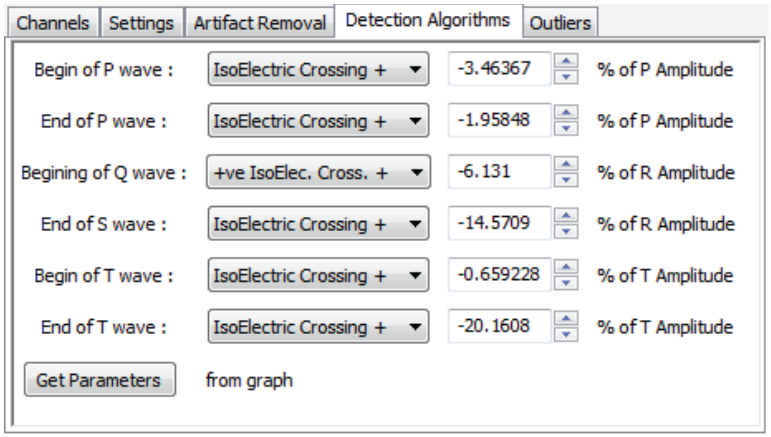
Configure Detection Algorithms

The detection criteria for the parameters displayed on the **ECG Graph** are determined in the **Detection Algorithms** configuration dialog. Default values for the chosen species are entered into the data boxes automatically, and these values can be changed manually.

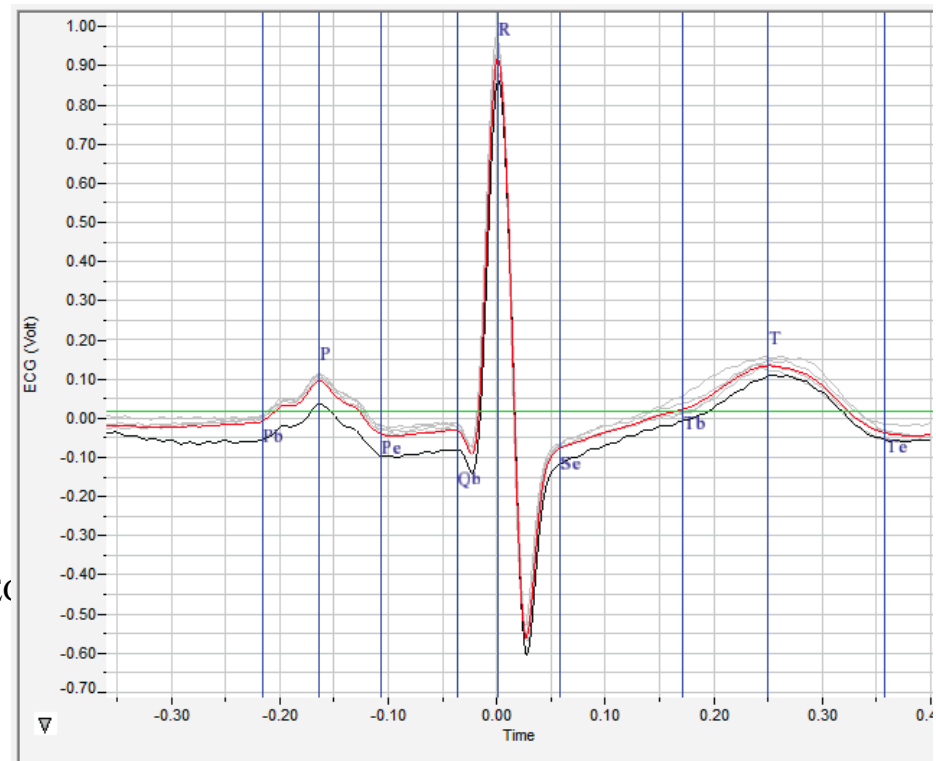
The parameters marked are the **Beginning (Pb)** and **End (Pe) of the P Wave**, the peak of the **P Wave (P)**, the **Beginning of the Q Wave (Qb)**, the peak of the **R Wave (R)**, the **End of the S Wave (Se)**, and the **Beginning (Tb) and End (Te) of the T Wave**.

To configure the **Detection Algorithms** dialog:

1) Click on the **Detection Algorithms** tab to open the **Detection Algorithms** configuration dialog.



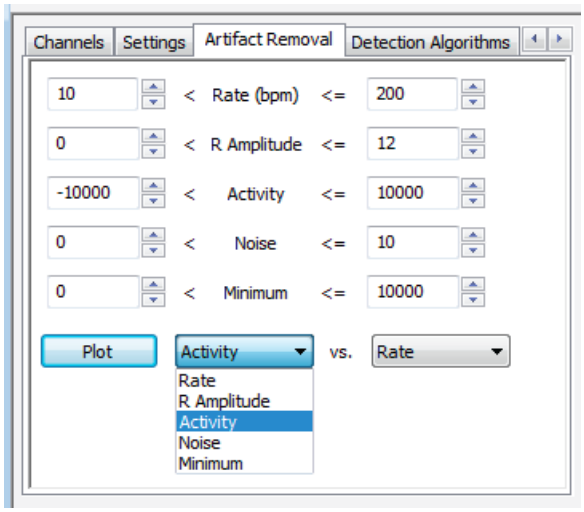
2) Examine the **ECG Graph**. Determine if the default locations are correct. Any incorrect locations can be remedied in the **ECG Graph** itself by clicking and dragging the vertical blue



Any noise or artifacts from the

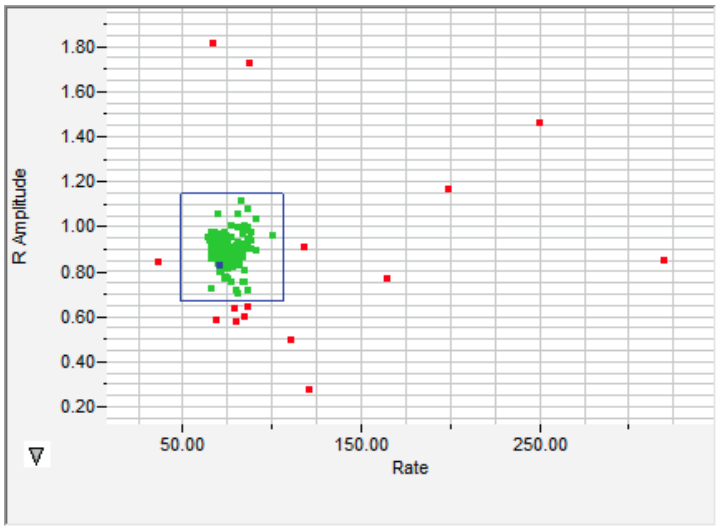
To use the **Artifact Removal** configuration dialog and the **Artifact Graph** for artifact detection and elimination:

1) Click the **Artifact Removal** tab to open the **Artifact Removal** configuration dialog. Initial default values are automatically entered into the data boxes.



Artifact Removal configuration dialog.

2) Choose **Artifact Graph** from the XY Graph menu at the lower left of the graph window.

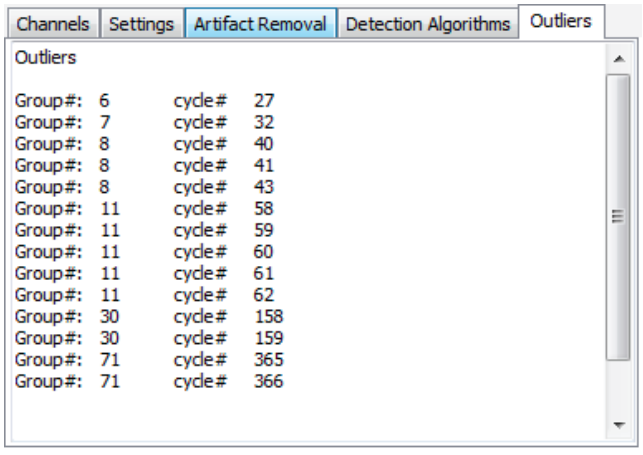


Artifact Graph

3) Use the menu at the lower left to **Autoscale** the **X-axis** and the **Y-axis**.
4) In the **Artifact Removal** dialog, choose **Rate** and **R Amplitude** from the two menus next to the **Plot** button. Click **Plot**.
5) Look at the **Artifact Graph**. Each dot represents one cycle from the data. The green dots are those currently included in the analysis. The red dots are those that have already been

removed by the default **Artifact Removal** settings. The currently selected cycle from the **Cycles in Group** list is highlighted in blue.

6) Select another cycle from the **Cycles in Group** list, and notice that the blue dot changes.
7) Click on any dot in the graph, and notice that it becomes blue, and the selected group and cycle indicated in the two lists change.
8) Notice that the dots are clustered in one area of the graph. The most representative ECG cycles will be clustered in one area of the graph, and will probably be surrounded by a number of outlying values that represent cycles characterized by values of one graphed variable or the other that are well outside the typical values.
9) Look at the **Rate** axis and see if there are any dots outside the cluster. Click on one of these dots; this represents a cycle that has been determined to be much shorter or longer than typical. Choose **View ECG Graph** (in the menu to the lower left of the graph) to display the group of cycles to which that cycle belongs. The selected cycle will be in black and may differ from the other cycles in the graph.
10) Look at the **R Amplitude** axis and repeat Step 9.
11) In the **Artifact Graph**, resize the blue box around the cluster of cycles and all cycles represented by dots outside the box will be removed from the analysis and will turn red after you click **Calculate** to update the analysis. Adjusting the size of the blue box will adjust the values in the data boxes of the **Artifact Removal** configuration dialog that determine the **Artifact Removal** criteria for the two graphed variables.
12) Repeat the process for other variables in the **Artifact Removal** dialog by plotting those variables and repeating the process. In this way outlying values can be excluded for any or all of the variables. Any **Outliers** will be removed from all calculations.
13) Click on the **Outliers** tab (to the right of **Detection Algorithms**) to see a list of all **Outliers**, described by **Group** and **Cycle** number.



Outliers dialog.

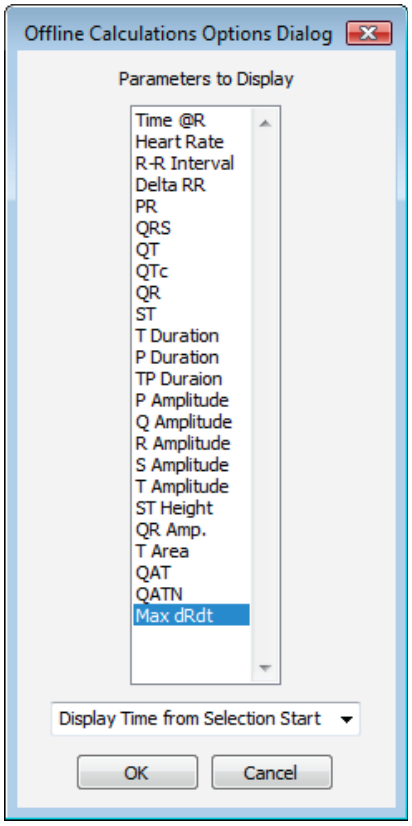
Data Table

All the data for each averaged group will be included in the **Data Table**. Each row of the **Data Table** contains the averaged ECG parameters for one of the checked cycle groups in the **Groups** list.

The Data Table.

To use the **Data Table** and export values to the **Journal:**

1) Click **Table Options** at the bottom of the dialog to see a list of all the ECG parameters that can be displayed in the **Data Table**. These parameters and calculations are all defined in the **ECG Advanced Analysis Module: Reference** section.

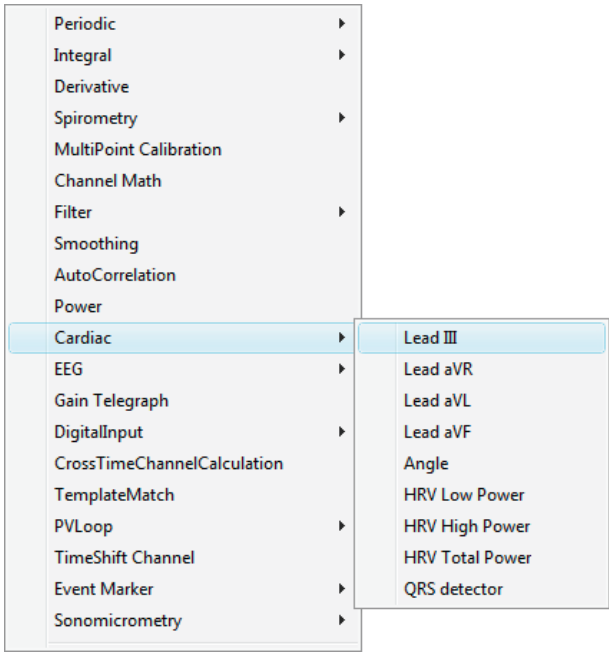


2) Choose the options you wish to include in the analysis and display in the **Data Table**. Choose whether you wish to display the **Time from the Start of the Selection** or the **Time of Day** of the recording. Click **OK**.
3) Click the asterisk in the upper left corner of the **Data Table**. The **Autosize** option adjusts the size of the cells for optimal display. The **Copy Selection** option will copy any selected cells to the clipboard.
4) Click **Algorithms** to see the definitions of the parameters and calculations.
5) To copy all the calculated data in the **Data Table** to the clipboard, click the **Copy** button, or click the **Export** button to export the data. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
6) To load the analysis configuration for the current analysis, click **Save Template** to name and save the settings. Clicking **Load Template** when the module is reopened will display the list of previously saved templates.

ECG Analysis: Reference

Basic Cardiac Functions: Reference

LabScribe's **Cardiac** functions can be accessed by clicking **add function** on the channel of an ECG recording and selecting one of the **Cardiac** functions.



The Cardiac submenu.

The limb lead **Cardiac** functions are specifically used for the analysis of human electrocardiograms (ECGs). Four of the **Cardiac** functions calculate limb **Leads: III, aVR, aVL** and **aVF** from recordings of **Lead I** and **Lead II**. The channels corresponding to **Lead I** and **Lead II** should be chosen in the **Cardiac Setup** dialog.

LabScribe can be programmed to do these calculations because all the points of view in a 6- lead ECG are in the same plane (frontal) of the body and each lead can be considered as a vector. So if any two of the limb leads are recorded, the other four leads can be calculated from them.

The **Cardiac** submenu also includes other functions. The cardiac **Angle** function is also specific to human cardiograms and calculates the vector of the cardiac depolarization that passes through the interventricular septum, and can indicate abnormalities in electrical conduction, or the actual anatomical orientation of the heart.

Three **Power** functions, which are special cases of the general **Power** function and can be used in the analysis of any species, are also available. These three power functions are useful for heart rate variability (**HRV**) analysis. **HRV Low Power** (0.04-0.15 Hz), which shows low frequency cyclic fluctuations in heart rate, **HRV High Power** (0.18-0.4 Hz), which shows high frequency cyclic fluctuations in heart rate, and **HRV Total Power** are each calculated from a tachogram transformation of one of the ECG raw data channels, or from the **QRS detector** channel.

The **QRS detector** displays a trace of peaks representing the QRS complexes with amplitudes reflecting the amplitudes of the individual QRS complexes. Heart rate can be determined from this function and

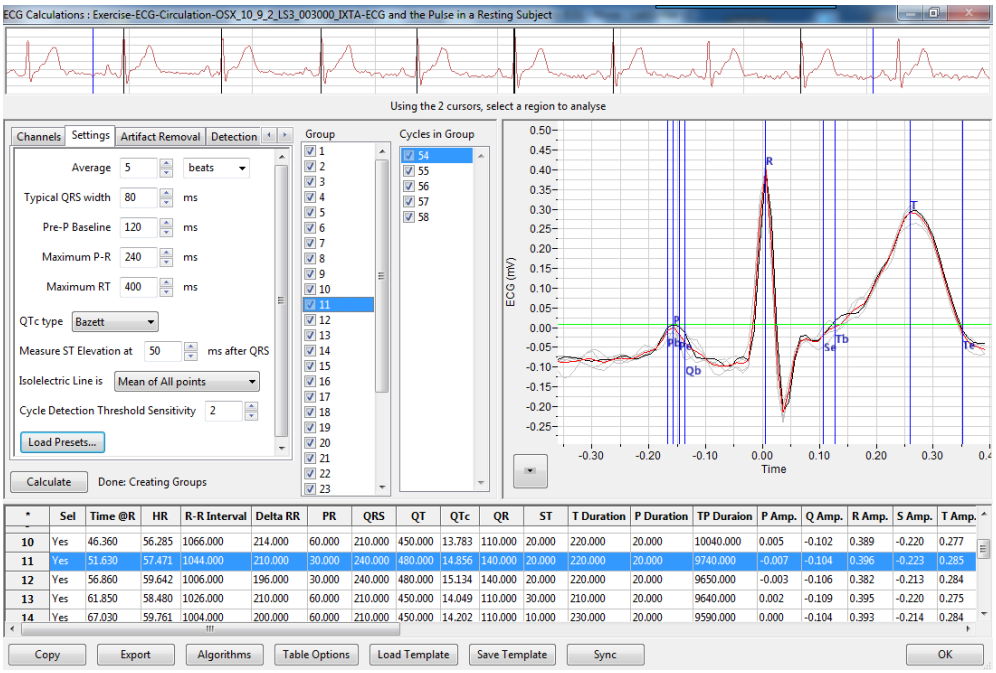
the relative amplitudes of the R waves can be compared.

ECG Advanced Analysis Module: Reference

Offline Calculations

Sophisticated ECG analysis can be accomplished by selecting **Offline Calculations** from the **ECG Analysis** submenu and opening the offline **ECG Calculations Dialog**. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.

The Offline ECG Calculations Dialog



Offline ECG Calculations dialog.

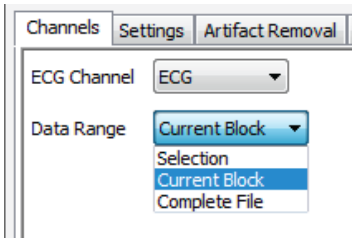
Across the top of the dialog, in the channel display area, is the raw data channel to be analyzed. On the left of the middle row are the windows used to configure the analysis. At the right is a window in which the **ECG Graph** and **Artifact Removal** graphs can be displayed. Between them is an editable list of the cycles to be analyzed and displayed. Across the lower part of the dialog is a **Data Table** with the calculated average parameter values for each of the analyzed groups of beats.

The Channel Display Area: In the channel display area, the two vertical blue lines can be adjusted to designate a section of the recording for analysis.

The Configuration Dialogs

There are five tabbed dialogs used to configure the analysis: **Channels, Settings, Artifact Removal, Detection Algorithms,** and **Outliers.**

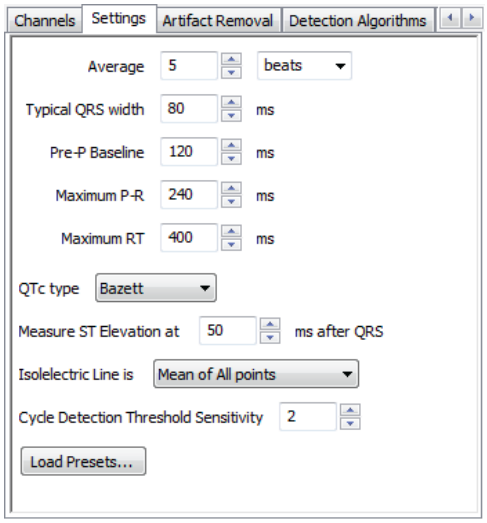
The Channels Configuration Dialog



Channels configuration dialog.

- The ECG channel you wish to analyze from the data file can be selected from the **ECG Channel** menu.
- It is possible to select whether you want to analyze the complete file, the current block or the selection between the cursors on the data sample in the channel display area at the top of the dialog from the **Data Range** menu.

The Settings Configuration Dialog



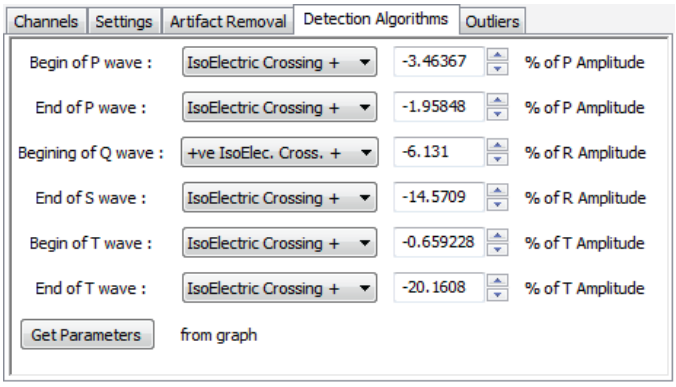
Settings configuration dialog.

- In order to compensate for variation from cycle to cycle, or to compare different experimental conditions, it is possible for *LabScribe* to average a user-selected number of sequential cycles. This number should be entered in the **Average** text box.
- The number of cycles that should be used to determine the **Cycle Detection Threshold Sensitivity** should be entered in the **Cycle Detection Threshold Sensitivity** data box. If each cycle is not being detected properly, the sensitivity can be adjusted. As the numbers increase, the threshold for beat detection is lowered and more cycles are detected.
- The desired type of QTc analysis and how you would like the isoelectric line to be calculated are chosen from the **QTc type** and **Isoelectric Line is** menus.

- Clicking **Load Presets...** will open the **ECG Preset Dialog**, from which the species from which the analyzed ECG has been recorded can be chosen.

- The remaining data boxes will be loaded with values appropriate to the ECG of the selected species.
- Changes to the default values can also be entered manually into the appropriate boxes of the **Settings** dialog.

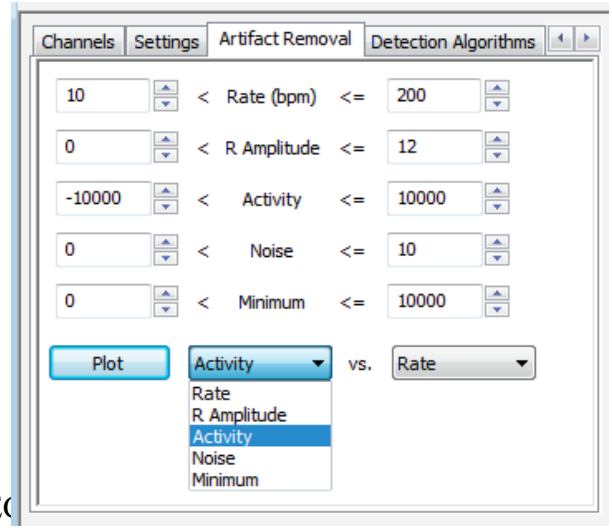
The Detection Algorithms Configuration Dialog



Detection Algorithms configuration dialog.

- The default algorithms used to place markers at specific locations in the ECG are displayed.
- The positions of the markers can be set manually by adjusting the markers in the **ECG Graph** and clicking **Get Parameters from graph**. The revised parameters will be used in the analysis of other ECG groups to be analyzed.

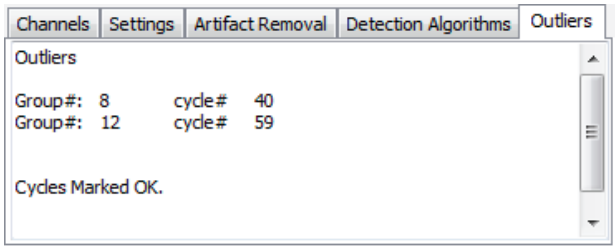
The Artifact Removal Configuration Dialog



Artifact Removal configuration dialog.

- *LabScribe* can remove cycles that are likely to be misinterpreted due to artifacts or noise in the recording. Individual cycles that fall outside expected values for **Rate**, **R Amplitude**, **Activity, Noise**, and **Minimum** will not be displayed or included in the averaged values. **Activity** (for example, from movement artifacts) and **Noise** are both measures of fluctuation from a continuous trace.
- Default values are automatically entered in the **Artifact Removal** dialog.
- These values can be changed by entering new values in the text boxes manually, or by clicking on the **Plot** button to display the **Artifact Graph** in the graph area to the right of the dialog (see the Artifact Graph section below for details). The parameters that are graphed are those entered in the two **Plot** menus of the **Artifact Removal** dialog.

The Outliers Configuration Panel



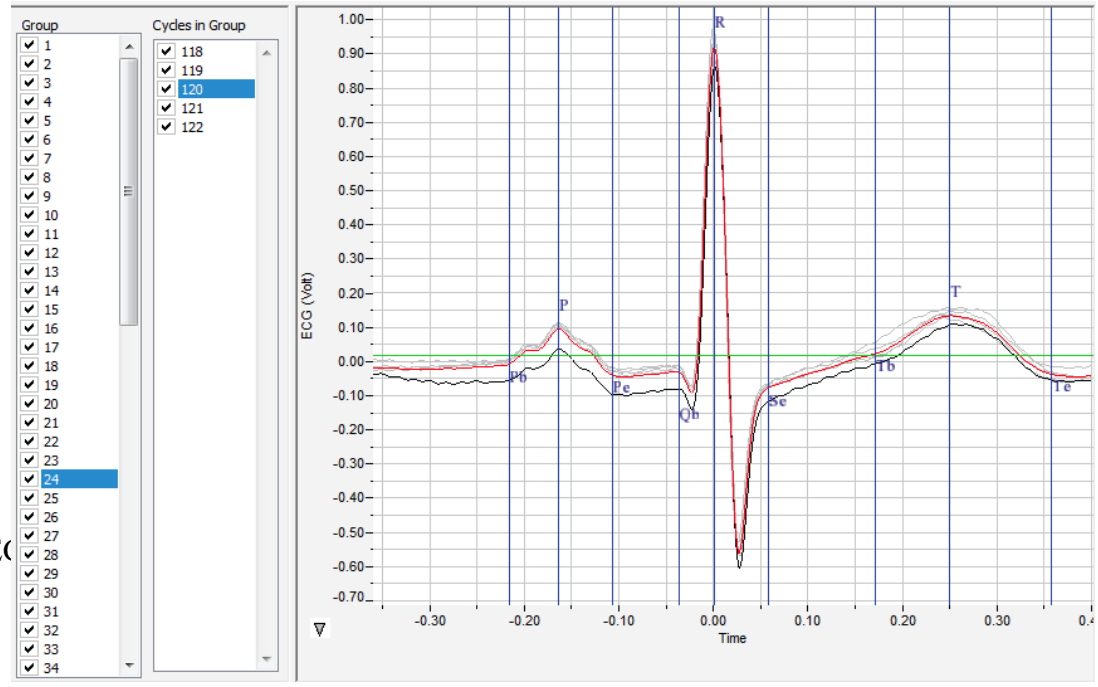
Outliers configuration dialog.

- The specific outlying cycles determined by the **Artifact Removal** process are listed.

The ECG Graph

Once the **Settings** configuration dialog is completed, clicking **Calculate** just above the **Data Table** will display the **ECG Graph** in the XY graph window.

8.3: EC

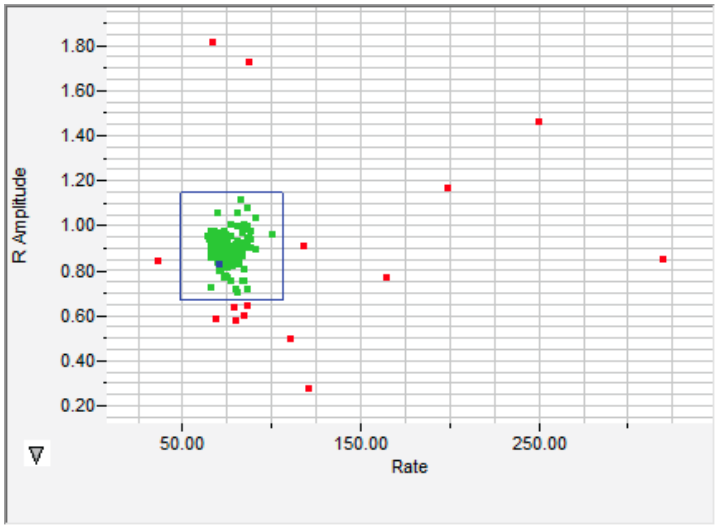


A group of cycles is displayed at a time. The number of cycles displayed is determined by the number entered in the **Average** box of the **Settings** dialog. The group being displayed is indicated in the **Group** window, and the individual cycles in that group are indicated in the **Cycles in Group** window. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual groups or cycles. In the graph, the currently selected cycle is in black, and the average of the group is in red. Any others are in grey. The calculated values displayed in the **Data Table** are the averages of each group.

The parameters marked are the **Beginning (Pb) and End (Pe) of the P Wave**, the peak of the **P Wave (P)**, the **Beginning of the Q Wave (Qb)**, the peak of the **R Wave (R)**, the **End of the S Wave (Se)**, and the **Beginning (Tb) and End (Te) of the T Wave**. Their locations are set by the default values for the species chosen in the **ECG Preset** dialog. Incorrect locations can be remedied by manually moving the vertical blue Marks to the correct location and clicking on **Get Parameters from graph** in the **Detection Algorithms** dialog.

The Artifact Graph

The **Artifact Graph** is accessed in the menu at the lower left of the XY Graph window. In the **Artifact Graph**, each dot represents one cycle from the data. The green dots are those currently included in the analysis. The red dots are those that have already been removed by the default **Artifact Removal** settings. The currently selected cycle from the **Cycles in Group** list is highlighted in blue.



Artifact Graph.

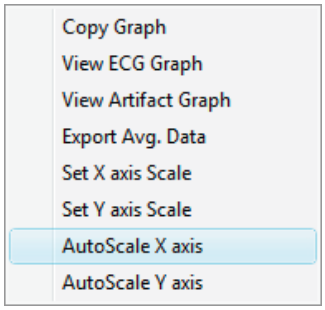
The blue box in the **Artifact Graph** can be resized to exclude cycles represented by outlying data points.

Clicking **Calculate** after adjusting the size of the box will update the analysis and the newly excluded data points will be red. The values in the data boxes of the **Artifact Removal** configuration dialog wll

also be adjusted.

The XY Graph Menu

Clicking the arrow to the lower left of the XY graph window displays the XY graph menu.



XY Graph menu.

XY Graph menu options:

- **Copy graph**: Copies the current XY graph to the clipboard. It can then be pasted into the **Journal** or an external application.
- **View ECG Graph**: Displays the beats determined by the checked **Group** and **Cycles in Group**. The group's signal-averaged ECG is also displayed in red.
- **View Artifact Graph**: Displays the graph configured in the **Artifact Removal** tabbed dialog.
- **Export Avg. Data**: Exports the data points representing the averaged ECG as a tab (*.txt) or comma (*.csv) separated text file.
- **Set X-axis Scale**, **Set Y-axis scale**: Allows the user to set the X-axis and Y-axis scales. The axes can also be rescaled by clicking and dragging the X-axis or Y-axis numbers.
- **AutoScale X-axis**, **AutoScale Y-axis**: Optimizes display scale of the X-axis or Y-axis of the XY graph.

The Data Table

All the data for each averaged group is included in the **Data Table**. Each row of the **Data Table** contains the averaged ECG parameters for one of the checked cycle groups in the **Groups** list.

*	Sel	Time @R	HR	R-R Interval	Delta RR	PR	QRS	QT	QTc	QR	ST	T Duration	P Duration	TP Duraion	P
1	Yes	0.870	35.864	836.500	276.000	110.000	206.000	430.000	14.867	102.000	56.000	168.000	82.000	1092.900	0.
2	Yes	5.002	37.764	794.400	156.800	108.000	206.000	440.000	15.611	102.000	40.000	194.000	72.000	1002.000	0.
3	Yes	8.998	40.021	749.600	142.400	102.000	206.000	420.000	15.340	102.000	10.000	204.000	76.000	954.800	0.
4	Yes	12.658	40.584	739.200	149.600	114.000	206.000	430.000	15.816	102.000	50.000	174.000	84.000	932.400	0.
5	Yes	16.372	42.301	709.200	139.600	86.000	208.000	440.000	16.522	102.000	76.000	156.000	42.000	856.800	0.
6	Yes	19.872	42.397	707.600	144.800	120.000	208.000	420.000	15.789	102.000	14.000	198.000	94.000	880.400	0.
7	Yes	23.456	42.931	698.800	132.400	52.000	230.000	516.000	19.520	156.000	56.000	230.000	12.000	815.300	0.
8	Yes	26.872	43.956	682.500	171.500	70.000	200.000	446.000	17.072	136.000	2.000	244.000	36.000	800.900	0.
9	Yes	30.308	44.883	668.400	186.000	210.000	134.000	368.000	14.234	30.000	178.000	56.000	120.000	928.400	0.
10	Yes	33.912	36.946	812.000	172.000	112.000	206.000	446.000	15.652	102.000	80.000	160.000	90.000	1121.600	0.
11	Yes	38.050	34.981	857.600	172.000	102.000	206.000	454.000	15.503	102.000	52.000	196.000	76.000	843.100	0.
12	Yes	42.368	51.948	577.500	100.667	118.000	278.000	430.000	17.893	122.000	120.000	32.000	120.000	1080.300	0.
13	Yes	46.634	29.331	1022.800	180.000	108.000	208.000	428.000	13.383	104.000	64.000	156.000	86.000	1356.800	0.
14	Yes	50.960	34.642	866.000	173.600	106.000	206.000	434.000	14.748	102.000	60.000	168.000	78.000	1176.400	0.

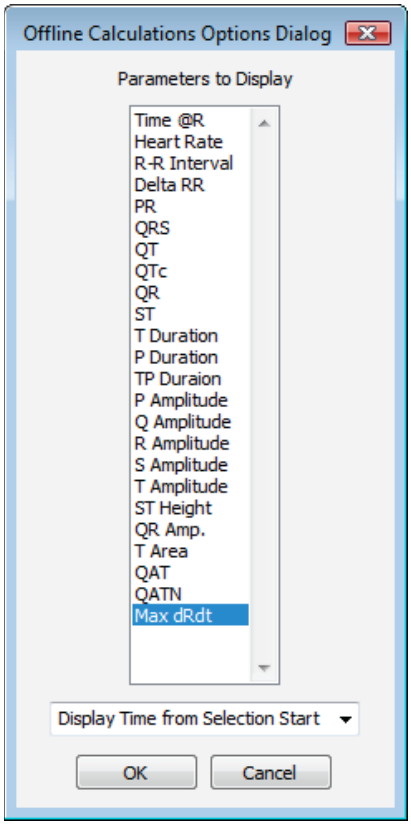
Copy | Export | Algorithms | Table Options | Load Template | Save Template | OK | Cancel

Data Table.

Clicking the asterisk at the upper left of the **Data Table** displays the **Autosize** or **Copy Selection** options. Clicking **Autosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** will copy any selected cells from the **Data Table** to the clipboard.

There are six buttons beneath the Data Table: **Copy, Export, Algorithms,Table Options, Load Template,** and **Save Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image
- *LabScribe* is able to calculate a large number of ECG calculations for each group of cycles. By clicking **Table Options** at the bottom of the offline **ECG Calculations Dialog**, the **Offline Calculations Options Dialog** opens and calculations to be displayed in the **Data Table** can be chosen from the list of all possible calculations. The **Display Time** to be used (**from Selection Start** or **Time of Day** of recording) is also chosen here.



Data Table parameter options.

- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- Clicking **Save Template** allows you to name and save a template for future analysis. **Load Template** allows a choice from previously saved templates.

- Clicking **OK** saves the current configuration. The next time the offline **ECG Calculations** dialog is opened, it opens with these settings.

Offline Calculation Algorithms**: The offline calculations (averaged over the cycles in the group unless indicated otherwise) include:**

- **Time @ R**: The time at the peak of the averaged R wave.
- **Heart Rate**: 60/period of each cycle averaged over the cycles in the group.
- **R-R Interval**: Average of the R-R intervals (peak to peak) of the cycles in the group.
- **Delta RR**: Change of the current R-R interval from the R-R interval of the preceding group.
- **PR**: Time from the beginning of the P wave to the peak of the R wave.
- **QRS**: Time from the beginning of the Q wave to the end of the S wave.
- **QT**: Time from the beginning of the Q wave to the end of the T wave.
- **QTc**: Rate-corrected **QT Interval (QTc** = **QT Interval**/square root of preceding **R-R interval).**
- **QR**: Time from the beginning of the Q wave to the peak of the R wave.
- **ST**: Time from the end of the S wave to the start of the T wave.
- **P Duration**: Time from the beginning to the end of the P waves.
- **T Duration**: Time from the beginning to the end of the T wave.
- **TP Duration**: Time from the beginning of the T wave to the end of the P wave.
- **P Amplitude**: Amplitude of the P wave (from the baseline).
- **Q Amplitude**: Amplitude of the Q wave (from the baseline).
- **R Amplitude**: Amplitude of the R wave (from the baseline).
- **S Amplitude**: Amplitude of the S wave (from the baseline).
- **T Amplitude**: Amplitude of the T wave (from the baseline).
- **ST Height**: The height of the point at the beginning of the ST segment (from the baseline).
- **QR Amplitude**: Lowest point of the Q wave to the peak of the R wave.
- **T Area**: Area between the T wave and the baseline from the start to the end of the T wave.
- **QAT** (Q alpha T): The time from the Q wave to the peak of the T wave.
- **QATN** (Q alpha T normalized): Time between the Q wave and the lowest point between the end of the S wave and the end of the T wave.
- **Max dRdt**: Maximum derivative between Qbegin and R.

8.4: Metabolic

Metabolic parameters are detected, and functions derived from those parameters are computed in *LabScribe's* **Metabolic Advanced Analysis Module**.

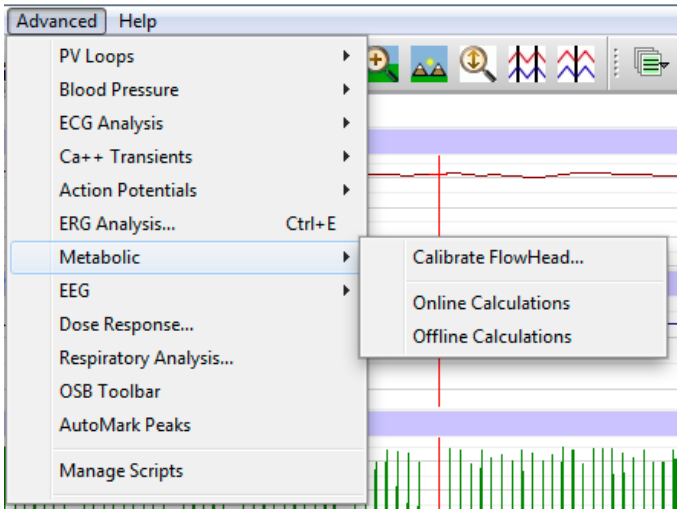
The **Metabolic Advanced Analysis Module** can both analyze online data as they are being collected, and perform offline analysis of previously recorded data files.

This document includes a **Step by Step** tutorial for using most of the features of the **Metabolic Advanced Analysis Module**, as well as a more detailed **Reference** section that covers the material in the tutorial, and adds additional context and detail. To use the **Step by Step** guide, you will need a recording with metabolic data. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

For users not familiar with how to use iWorx hardware and software to generate a file with metabolic data, a checklist for setting up the metabolic cart, and configuring *LabScribe* to record metabolic data, follows the **Step by Step** and **Reference** sections of this document. Detailed hardware and software instructions are also included in the individual **Human Exercise** lab exercises that utilize iWorx gas analyzers. There are also instructional videos available at iworx.com illustrating the process.

Metabolic Analysis: Step by Step

The **Metabolic Analysis Module** automatically opens as part of any of the Metabolic Labs using one of the gas analyzer systems or metabolic carts. Or **Metabolic** can be chosen from the **Advanced** menu, a submenu opens, displaying three options: **Calibrate flow head**, **Online Calculations**, and **Offline Calculations**.



Metabolic submenu

Complete instructions for using the **optional** flow head calibration routine <**Calibrate flow head**> dialog can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200, Human**

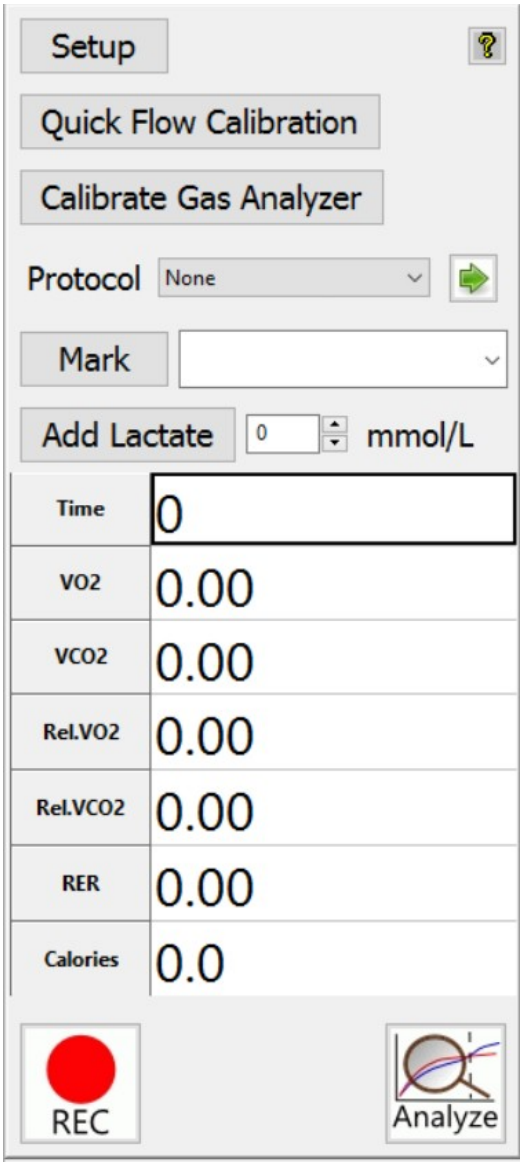
Exercise-GA300, and **Human Exercise-iWireGA** folders of the complete *LabScribe* installer. This flow head calibration only needs to be completed if using the IX-214 or IX-228 data acquisition systems.

The **Online Calculations** and **Offline Calculations** options provide analysis of metabolic experiments that use a mixing chamber such as the experiments in the **Human Exercise-GA200, Human Exercise-GA300,** and **Human Exercise-iWireGA** folders of the complete *LabScribe* installer.

Online Calculations

To use the **Online Calculations:**

To perform real-time analysis of mixing chamber metabolic data, *LabScribe* needs to be configured as in the experiments in the **Human Exercise-GA200, Human Exercise-GA300** and **Human Exercise-iWireGA** folders. The procedure for setting up the iWorx hardware and software is also summarized after the **Reference** section of this manual. Using the **Online Calculations**, it is possible to generate metabolic calculations in real time.



1) Configure the hardware and *LabScribe* software to record mixing chamber metabolic data.
2) Record a sample, autoscaling all channels. Stop recording as you configure the online analysis.
3) Choose **Online Calculations** from the **Metabolic** submenu to display the **Metabolic Toolbar** if it does not open automatically.
   - NOTE – if using the latest version of the *LabScribe software*, the module will open automatically.

Setup

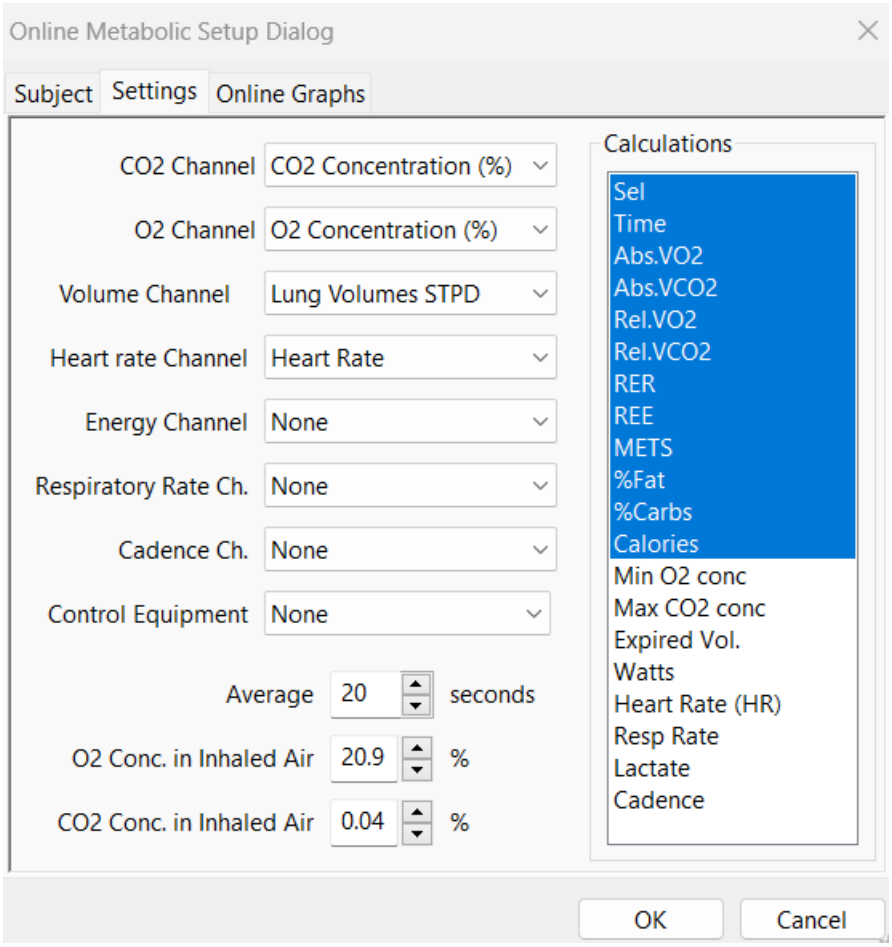
Choose **Setup** to open the **Online Calculation Setup** dialog.

Subject Information:

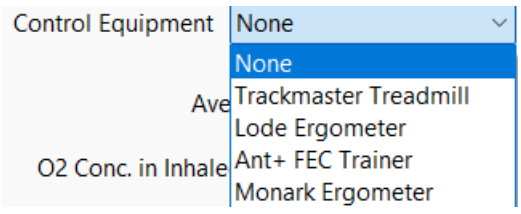
Enter the Subject information or load a saved Subject file.

Height and weight can be change from kg cm and kg to in and lbs.

NOTE – this should be set up automatically.

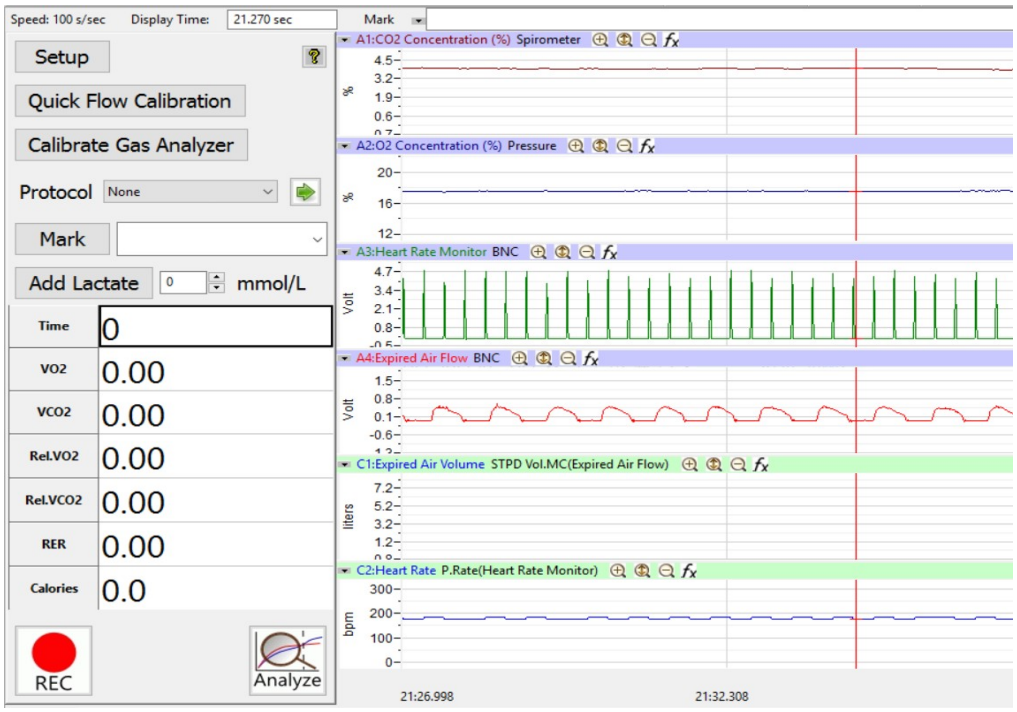


1. From the **CO2 Channel** menu, choose the % CO_2 channel from your recording.
2. From the **O2 Channel** menu, choose the % O_2 channel from your recording.
3. From the **Volume Channel** menu, choose the volume channel from your recording.
4. Choose the Heart Rate, Energy, Respiratory Rate or Cadence Channel if present.
5. Choose the equipment that you want to control, if any.



6. In order to compensate for variation from breath to breath, it is possible for *LabScribe* to average the data over a segment of time. In the text box to the right of **Average**, indicate the segment duration you would like to average for analysis. The ACSM recommends an averaging time of twenty (20) seconds.
7. In the text box to the right of **O2 Conc. in Inhaled Air**, indicate the oxygen concentration of inhaled air, usually 20.9%.

8. In the text box to the right of **CO2 Conc. in Inhaled Air**, indicate the carbon dioxide concentration of inhaled air, usually 0.04%.
9. From the **Calculations** list, control-click on those variables you would like to record in the data boxes of the **Metabolic Toolbar**. To remove a variable after you have selected it, control-click on that variable. Definitions of all variables can be found in the **Metabolic Analysis: Reference** section.
10. Click **OK** to close the dialog.



nline Metabolic main window display.

Flow Calibration

Click on the **Quick Flow Calibration** button to start the flow calibration. Follow the onscreen prompts.

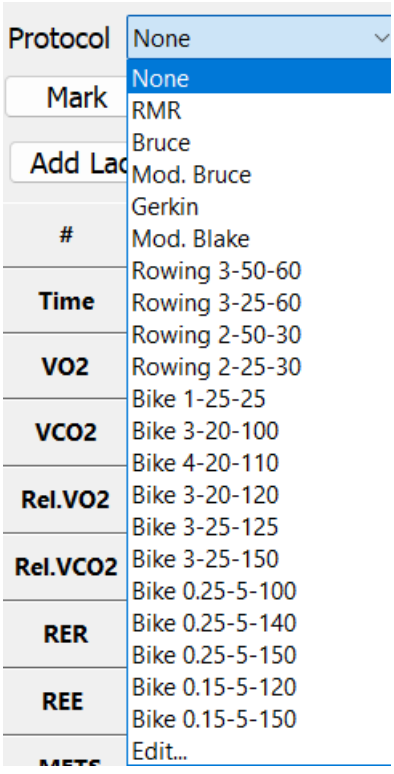
Calibrate Gas Analyzer

Click on the **Calibrate Gas Analyzer** button to start the gas calibration. Follow the onscreen prompts.

Protocols:

Labscribe comes with preset protocols for performing some common Metabolic tests, such as RMR, Bruce, Modified Bruce, Gerkin, Modified Blake, Rowing, Biking etc... These protocols can be customized by choosing the edit option.

To Run a protocol, choose the protocol from the drop-down list and then click the Green arrow. The Program will start recording data and run the selected protocol.



Marks:

During recording marks can be placed in the record, When protocol is run, the stages of the protocol are automatically marked. Various marks can be preset.

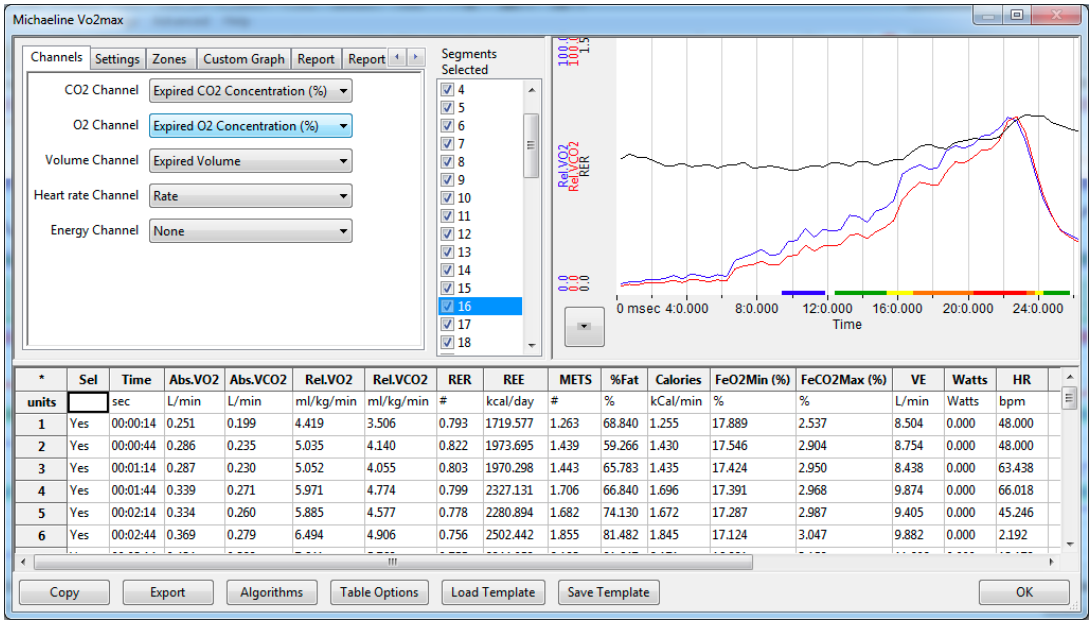
If measuring Lactate values, they can be entered in the record by clicking on the **Add Lactate** button.

After recording is completed

The offline **Metabolic Calculations** dialog allows sophisticated offline analysis of previously recorded metabolic data.

To perform offline analysis:

- Open the recording from the online analysis or another file with previously recorded metabolic data by clicking the **Analysis** button. Or, choose **Offline Calculations** from the **Metabolic** submenu to open the **Offline Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.
- Familiarize yourself with the **Offline Calculations** dialog, pictured below.
- The tabbed configuration dialogs are on the upper left portion of the dialog.
- An XY graph window on the right displays the **Metabolic Graph**, showing metabolic data from the selected segments in the **Segments Selected** list.
- Between the configuration dialogs and the XY graph window is the **Segments Selected** list, an editable list of the segments that can be displayed and analyzed.
- The **Data Table** is located on the lower part of the dialog.

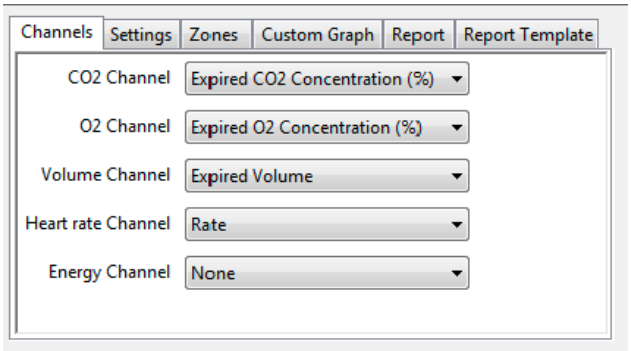


*	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR
units		sec	L/min	L/min	ml/kg/min	ml/kg/min	#	kcal/day	#	%	kCal/min	%	%	L/min	Watts	bpm
1	Yes	00:00:14	0.251	0.199	4.419	3.506	0.793	1719.577	1.263	68.840	1.255	17.889	2.537	8.504	0.000	48.000
2	Yes	00:00:44	0.286	0.235	5.035	4.140	0.822	1973.695	1.439	59.266	1.430	17.546	2.904	8.754	0.000	48.000
3	Yes	00:01:14	0.287	0.230	5.052	4.055	0.803	1970.298	1.443	65.783	1.435	17.424	2.950	8.438	0.000	63.438
4	Yes	00:01:44	0.339	0.271	5.971	4.774	0.799	2327.131	1.706	66.840	1.696	17.391	2.968	9.874	0.000	66.018
5	Yes	00:02:14	0.334	0.260	5.885	4.577	0.778	2280.894	1.682	74.130	1.672	17.287	2.987	9.405	0.000	45.246
6	Yes	00:02:44	0.369	0.279	6.494	4.906	0.756	2502.442	1.855	81.482	1.845	17.124	3.047	9.882	0.000	2.192

The Offline Calculations Dialog

To configure the **Channels:**

Click on the **Channels** tab, opening the **Channels** configuration dialog.

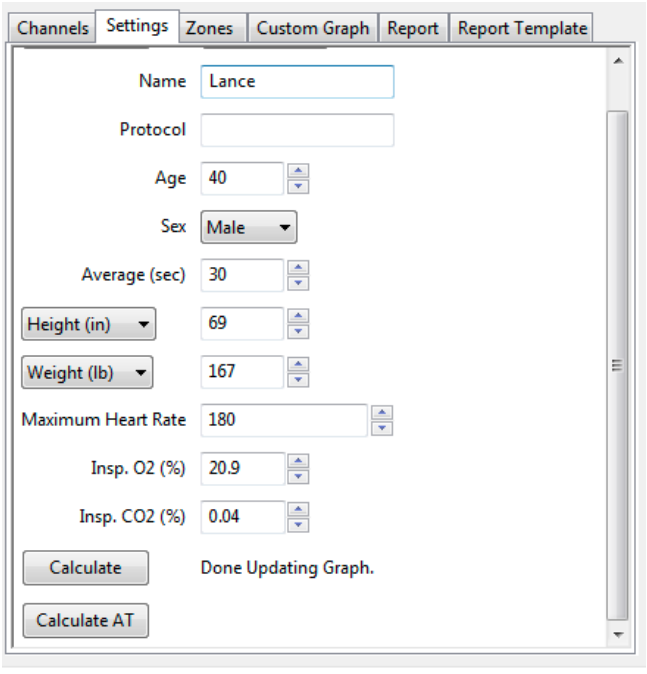


The Channels configuration dialog.

- From the CO2 Channel menu, choose the % CO2 channel from your recording.
- From the O2 Channel menu, choose the % O2 channel from your recording.
- From the Volume Channel menu, choose the breath volume channel from your recording.
- From the Heart rate Channel menu, choose the calculated heart rate channel from your recording.
- Optionally, choose an Energy Channel if there is one on the recording, typically a power output from an ergometer.

To configure the **Settings:**

Click on the **Settings** tab, opening the **Settings** configuration dialog. Most of the information will be filled in automatically.



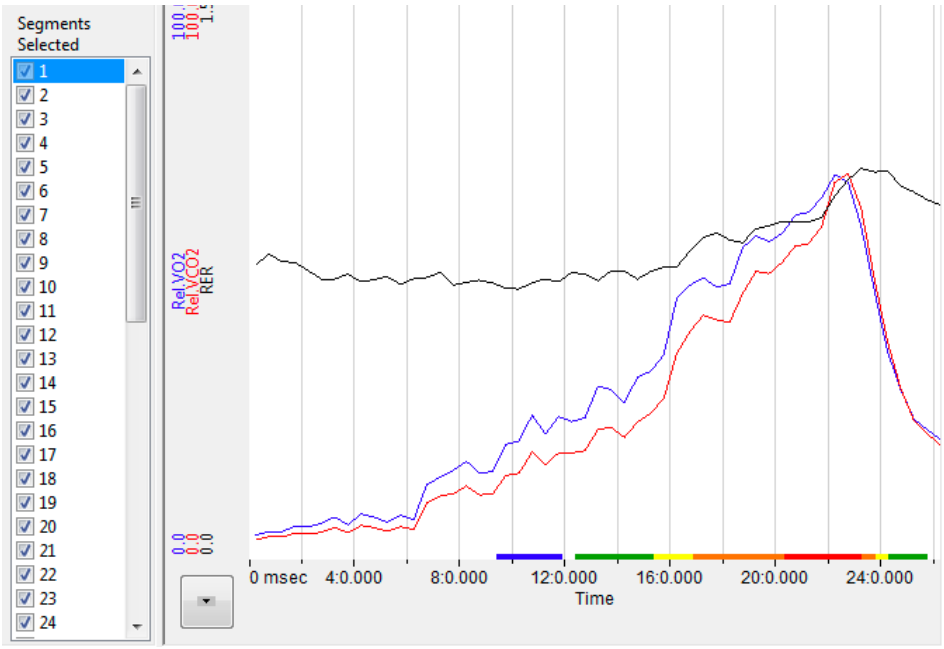
The Settings configuration dialog.

- Enter the subject's name, protocol being used, age and gender in the **Name, Protocol, Age** and **Sex** text boxes.

- Select the amount of time to average per segment in the **Average (sec)** text box.
- Enter the subject's height (cm or in) and weight (kg or lbs) in the **Height** and **Weight** text boxes.
- Enter the maximum heart rate your subject may attain in the **Maximum Heart Rate** text box. This is typically calculated as: 220 - the subject's age.
- Enter the concentrations of oxygen (usually 20.9%) and carbon dioxide (usually 0.04%) in inhaled air in the **Insp. O2 (%)** and **Insp. CO2 (%)** text boxes.
- The subject's profile can be saved for future experiments by clicking the **Save Subject** button at the top of the dialog. This profile can later be retrieved and entered by clicking the **Load Subject** button.
- By clicking **Calculate**, the **Metabolic Graph** will appear in the XY graph window, and the **Data Table** will be populated with the metabolic parameters. Click **Calculate** whenever settings are updated.
- The subject's anaerobic threshold (**AT**) is calculated automatically, and is shown in the **VCO2 vs VO2** XY graph. This value can be recalculated manually as described in the **Metabolic Graph** section below. Click **Calculate AT** to display the recalculated anaerobic threshold.

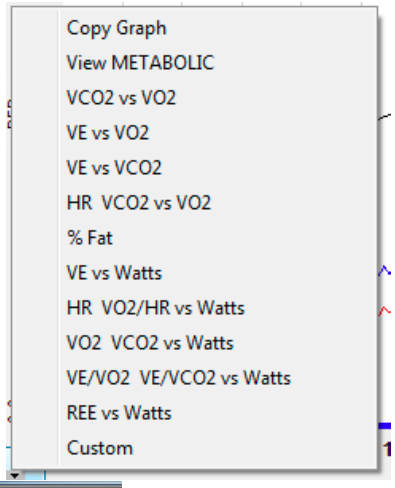
To display and analyze the **Metabolic Graph:**

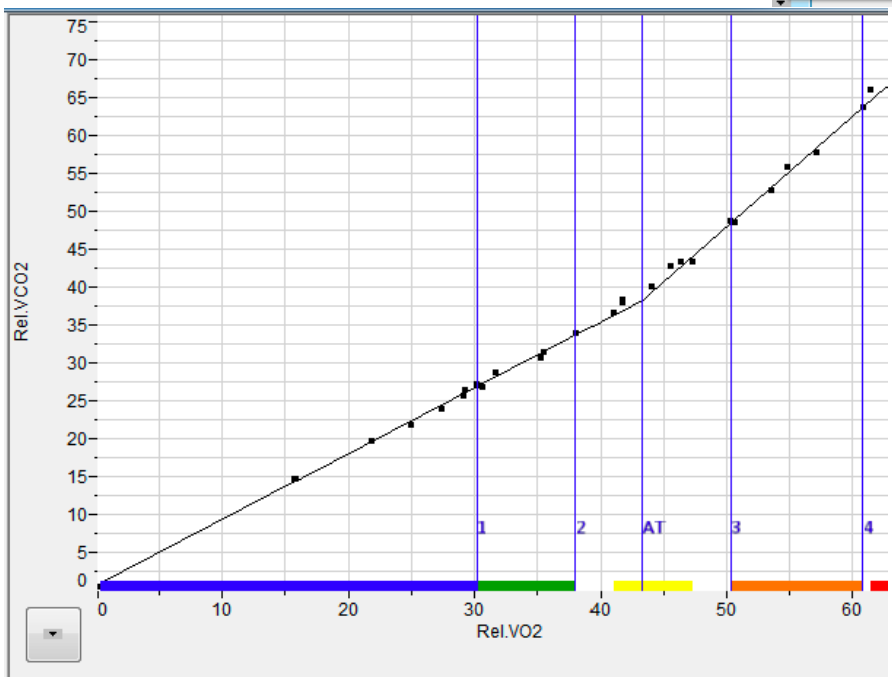
- Familiarize yourself with the **Metabolic Graph**, which will be displayed in the XY graph area for all the segments in the selection and is illustrated below.
  - By default, the graph displayed is of **VCO2**, **VO2**, and **RER** over time.
  - Segments can be deselected (or selected) by clicking on the check box to the left of the segment number in the **Segments Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
  - The specific parameters shown in the graph can be customized in the **Custom Graph** dialog.



The Metabolic Graph.

- Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.
- Click **Copy Graph** to copy the current **Metabolic Graph** to the clipboard. It can then be pasted into the **Journal** or an external application.
- **View Metabolic** displays the default graph.
- **VCO_2 vs VO_2** displays VCO_2 as a function of VO_2.
  - The subject's anaerobic threshold (**AT**) is calculated automatically and is indicated on this graph, as well as the intervals over which the slopes before and after the aerobic/anaerobic break were determined. These intervals (indicated by the markers labeled 1 - 2 and 3 - 4) can be adjusted by moving the markers on the graph. Click **Calculate AT** in the **Settings** dialog to recalculate the anaerobic threshold based on the revised intervals.





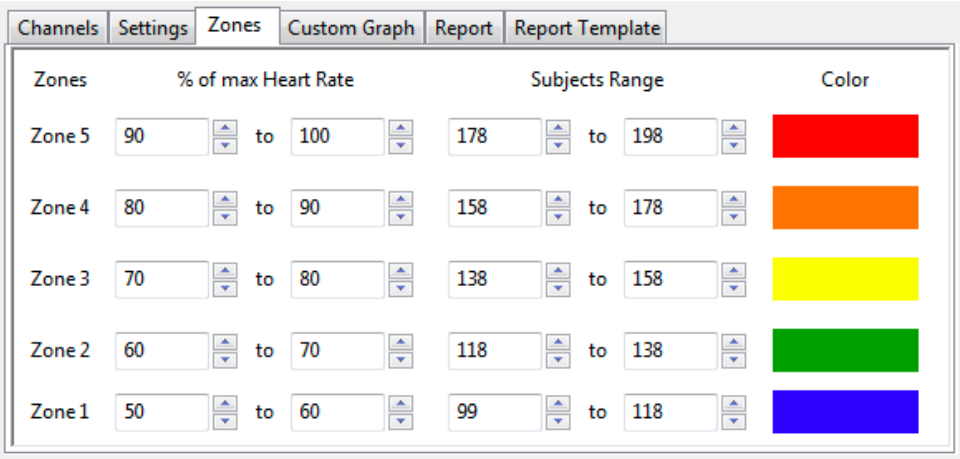
VCO_2 vs VO_2 XY graph with Anaerobic Threshold (AT) indicated.

- **VE vs VO_2** displays the minute ventilation as a function of VO_2.
- **VE vs VCO_2** displays the minute ventilation as a function of VCO_2.
- **HR VCO_2 vs VO_2** displays the Heart Rate and VCO_2 as a function of VO_2.
- **% Fat** displays the calories from fat as a % of total calories burned over time.
- **VE vs Watts** displays the minute ventilation as a function of Watts (requires an Energy channel).
- **HR VO_2/HR vs Watts** displays the Heart Rate and VO_2/HR as a function of Watts (requires an Energy channel).
- **VO_2 VCO_2 vs Watts** displays VO_2 and VCO_2 as a function of Watts (requires an Energy channel).

- **VE/VO_2 VE/VCO_2 vs Watts** displays VE/VO_2 and VE/VCO_2 as a function of Watts (requires an Energy channel).
- **REE vs Watts** displays REE as a function of Watts (requires an Energy channel).
- **Custom** displays a custom graph as configured in the **Custom Graph** dialog.

To configure **Heart Rate Zones:**

Click on the **Zones** tab to open the **Zones** configuration dialog.



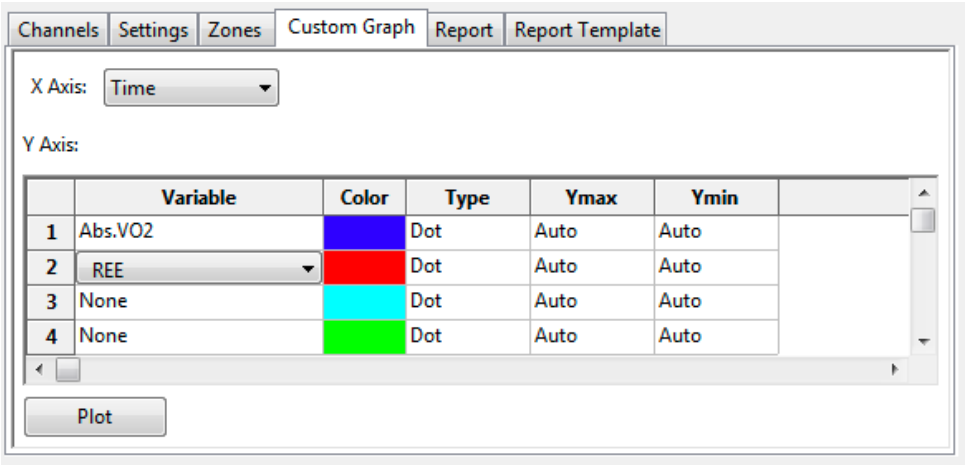
The Zones configuration dialog.

Different heart rate zones are displayed in different colors on the X-axis of the default graph and the **VO_2 vs VCO_2** XY graph. The default zones are automatically calculated based on the subject's maximum heart rate and will typically not need to be changed. If, however, you would like to change the zones from the default settings, it is possible to change heart rate zones by changing the values in this dialog.

To configure the **Custom Graph:**

Click on the **Custom Graph** tab to open the **Custom Graph** dialog.

- Choose the variable you would like displayed on the X-axis by choosing one of the variables in the menu next to **X-axis**.
- Choose the variable(s) you would like displayed on the Y-axis by choosing them from the menus in the boxes of the left column next to **Y-axis.**
- Choose the desired color for each Y variable, whether you would like the data displayed as dots or a line, and the Y-axis scale for each chosen variable.
- Click **Plot** to display your custom graph. Choosing **Custom** from the XY graph menu will display the most recently configured custom graph.

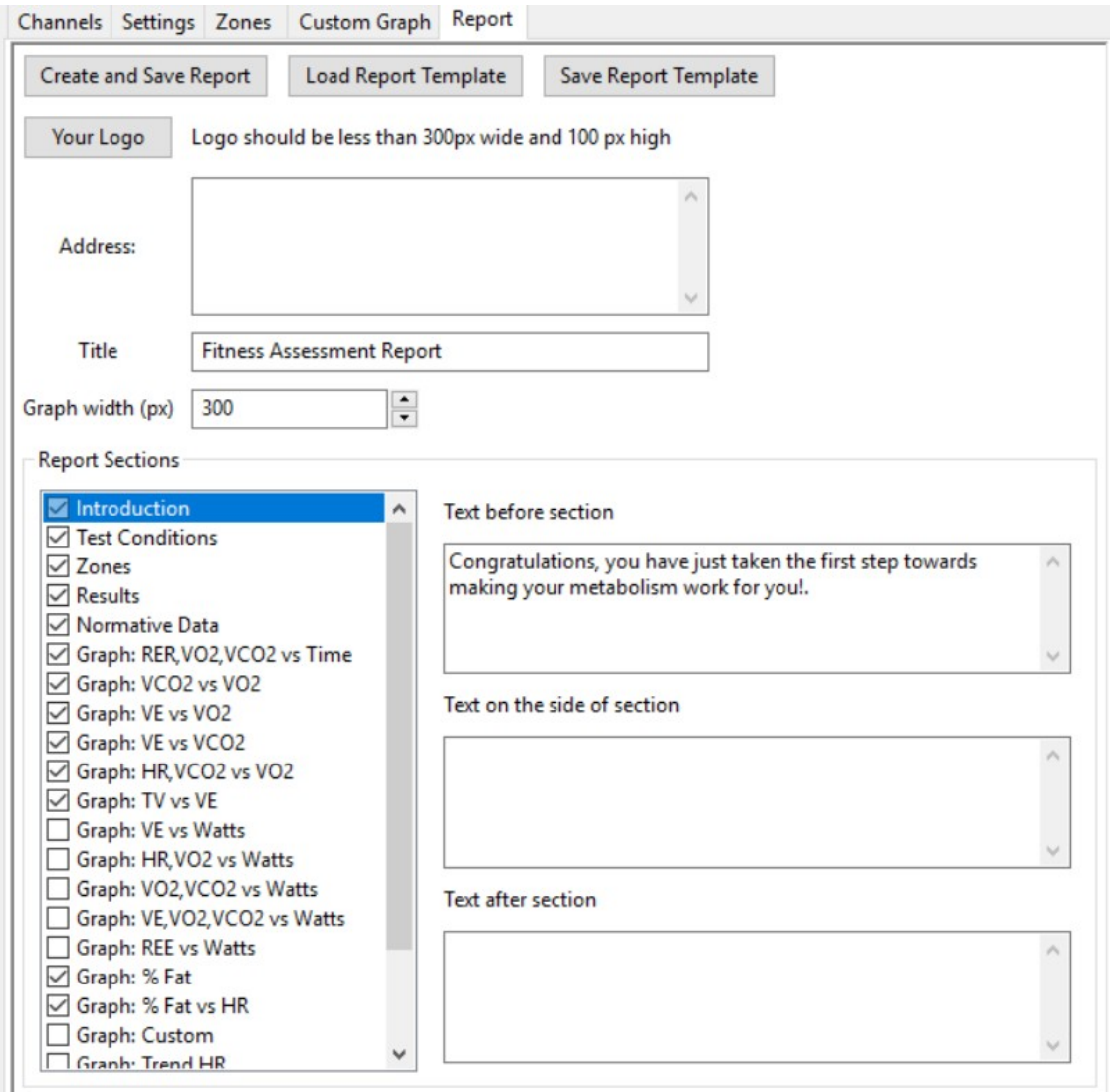


To configure the **Report:**

Click on the **Report** tab to open the **Metabolic Report** configuration dialog.

- By clicking **Create and Save Report**, a dated report is generated. This report includes subject information, the metabolic data in table form, and the current set of XY graphs.
- Reports can be customized with a logo, address, title and specific data you want included.

8.



Results Summary

Results

Calculation	2012-05-22	2013-01-30	2013-06-13	Units
Maximum Heartrate	187	183	177	beats per min
Heartrate at Threshold	139	143	132	beats per min
Heartrate at aerobic base	111	118	110	beats per min
VO2 max	63.2	65.8	65.7	ml/kg/min
VO2 at Threshold	36.0	44.4	43.3	ml/kg/min
VO2 at aerobic base	19.1	20.4	30.7	ml/kg/min
VCO2 max	77.8	75.9	75.9	ml/kg/min
VCO2 at Threshold	32.0	39.2	38.3	ml/kg/min
VCO2 at aerobic base	19.1	20.5	26.8	ml/kg/min

To use the **Data Table:**

*	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR
47	Yes	00:23:14	3.400	3.581	59.846	63.028	1.053	24832.720	17.099	0.000	17.002	17.273	3.818	101.033	0.000	185.818
48	Yes	00:23:44	2.748	2.868	48.368	50.481	1.044	20024.412	13.819	0.000	13.741	17.225	3.841	80.427	0.000	179.068
49	Yes	00:24:14	2.121	2.222	37.338	39.111	1.047	15472.123	10.668	0.000	10.607	17.389	3.681	65.042	0.000	164.471
50	Yes	00:24:44	1.737	1.746	30.567	30.724	1.005	12537.678	8.733	0.000	8.684	17.221	3.734	50.370	0.000	147.507
51	Yes	00:25:14	1.435	1.421	25.258	25.006	0.990	10322.146	7.217	3.327	7.176	17.315	3.597	42.577	0.000	135.545
52	Yes	00:25:44	1.326	1.285	23.335	22.611	0.969	9487.320	6.667	10.344	6.629	17.332	3.520	39.345	0.000	125.386
53	Yes	00:26:14	1.228	1.173	21.611	20.643	0.955	8756.923	6.175	14.924	6.139	17.378	3.436	36.807	0.000	120.682
55																
56	#		44	44	44	44	44	44	44	44	44	44	44	44	44	44
57	Mean		1.975	1.729	34.756	30.437	0.841	13808.813	9.930	54.380	9.874	16.446	3.872	47.004	0.000	132.031
58	SD		1.056	1.055	18.586	18.568	0.102	7592.239	5.310	31.703	5.280	0.606	0.387	28.146	0.000	36.145
59	Max		3.928	3.940	69.130	69.336	1.053	28183.000	19.751	90.441	19.639	17.389	4.349	112.202	0.000	187.547
60	Min		0.382	0.291	6.723	5.121	0.729	2594.836	1.921	0.000	1.910	15.544	2.865	10.571	0.000	68.868

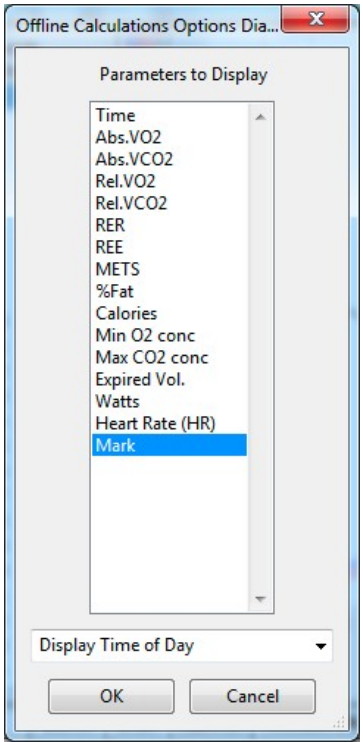
Metabolic Data Table.

Familiarize yourself with the **Data Table**.

- The **Data Table** spans the lower part of the **Metabolic Calculations** dialog and displays the calculated values for each of the segments in the **Segments Selected** list.
- The top line indicates the **units** for each of the chosen parameters.
- The colors in the left-hand column correspond to the Heart Rate zones configured in the **Zones** dialog.
- The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected segments.

Click the asterisk at the upper left of the **Data Table** to display two options: **AutoSize** and **Copy Selection**.

- **AutoSize** will optimize the size of the **Data Table** boxes.
- **Copy Selection** copies any selected **Data Table** cells to the clipboard.



There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template,** and **Save Template.**

1. Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
2. Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.

3. Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
4. Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **Metabolic Analysis: Reference** section.
5. Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
6. Click **OK** to close the analysis.

Metabolic Analysis: Reference

OPTIONAL Calibrate flow head

In order to use the mixing chamber calculations, the flow head must be calibrated. In the lab exercises, a Long Flow Head Calibration (.ixwfcd) file has already been loaded for you and does not need to be replaced.

If you choose to do your own flow head calibrate, detailed instructions for flow head calibration can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200** and **Human Exercise-GA300** folders of the complete *LabScribe* installer. Part of that procedure requires that the **Calibrate flow head** dialog be displayed and completed. A calibration file is generated that can be used in future experiments, which will then require only an abbreviated spirometer calibration process.

Online Metabolic Calculations Definitions

While recording data, many metabolic parameters can be calculated and displayed online using **Online Calculations**. Choosing **Online Calculations** from the **Metabolic** submenu opens the **Metabolic Toolbar** as shown on page 2 of this manual.

The online parameters are:

Time: Time (in seconds) from the start of the recording.
Absolute VO_2 (**Abs. VO_2**): Volume of oxygen consumed in liters per minute**.**
Absolute VCO_2 (**Abs. VCO_2**): Volume of carbon dioxide produced in liters per minute.
Relative VO_2 (**Rel. VO_2**): Volume of oxygen consumed in milliliters per minute per kilogram of body weight.
Relative VCO_2 (**Rel. VCO_2**): Volume of carbon dioxide produced in milliliters per minute per kilogram of body weight.
Respiratory Exchange Ratio (**RER**): VCO_2/VO_2.
Resting Energy Expenditure (**REE**): 5.46 VO_2 + 1.75 VCO_2 (in kcal/24 hr).
Metabolic Equivalents (**METS**): Units of energy expenditure; 3.5 ml VO_2/kg body weight.
% Fat (**%Fat**): Estimate of energy expenditure that comes from fat as a percentage of total calories expended.
Calories (**Calories**): The total number of calories expended.
Minimum oxygen concentration (**FeO_2Min %**): Minimum percentage of oxygen in expired air.
Maximum CO_2 concentration (**$FeCO_2$Max %**): Maximum percentage of carbon dioxide in expired air.
Expired volume (**VE**): Expired air volume per minute at BTPS.
Watts (**Watts**): Measure of power produced during exercise, or rate of energy use.
Heart Rate **(HR)**: 60/period of each cycle.

Mark (**Mark**): Phase of protocol as indicated by associated mark.

8.5: ERG Analysis

An electroretinogram (ERG) is a recording of the electrical responses of the cells of the retina to a light stimulus. ERG parameters are detected, and functions derived from those parameters are computed in *LabScribe*'s **ERG Advanced Analysis Module**.

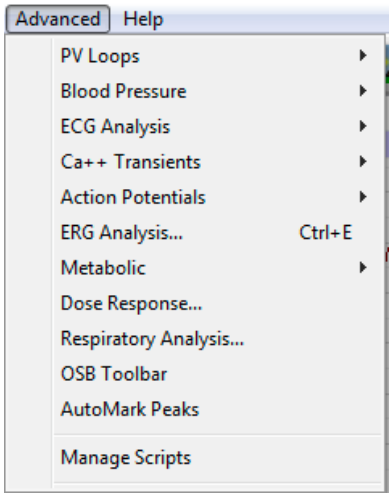
The **ERG Advanced Analysis Module** requires a separate license. The first time you select **Blood Pressure**, you will be asked for a username and a serial number. Contact iWorx Systems for more information.

This document includes a step by step tutorial for using most of the features of the **ERG Advanced Analysis Module**, as well as a more detailed **Reference** section that covers the material in the tutorial, and adds additional context and detail. To use the step by step guide, you will need an ERG recording that has been recorded in *LabScribe*'s sweep mode, with each sweep triggered by the light stimulus. The ERG can be from any mammalian species.This file can then be saved and used in the offline analysis tutorial.

ERG Analysis: Step by Step

ERG data are recorded in *LabScribe* in Scope mode, with the stimulus triggering each sweep. To use the ERG Advanced Analysis Module, open an ERG data file.

When **ERG Analysis** is chosen from the **Advanced** menu, the **Offline Calculations**.dialog opens.



Advanced menu.

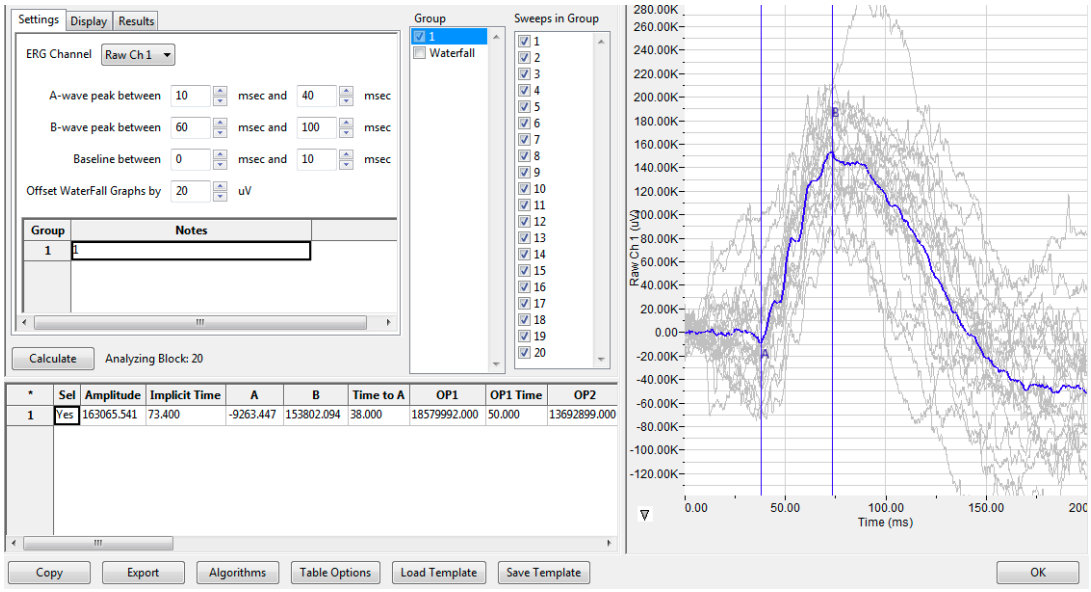
Offline ERG Calculations

The offline **ERG Calculations** dialog allows sophisticated offline analysis of previously recorded ERG data.

To perform offline ERG analysis**:**

- Open a previously recorded ERG data file.
- Choose **ERG Analysis** from the **Advanced** menu to open the offline **ERG Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a

double-headed arrow appears, and dragging the boundaries to resize the panels.



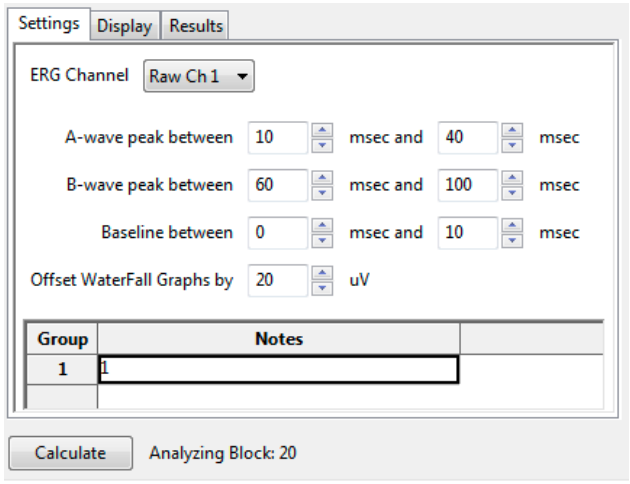
ERG Calculations dialog.

Familiarize yourself with the offline **ERG Calculations** dialog, pictured above.

- The tabbed configuration dialogs are on the left side of the dialog.
- An XY graph window on the right displays the **ERG Graph**, showing the selected cycle and the average of all checked cycles from the **Cycles Selected** list.
- Between the configuration dialogs and the XY graph window are the **Group** and **Sweeps in Group** lists, editable lists of the groups and sweeps that can be displayed and analyzed.
- The **Data Table** is located on the lower left part of the dialog.

To configure the **Settings:**

Click on the **Settings** tab, opening the **Settings** configuration dialog.



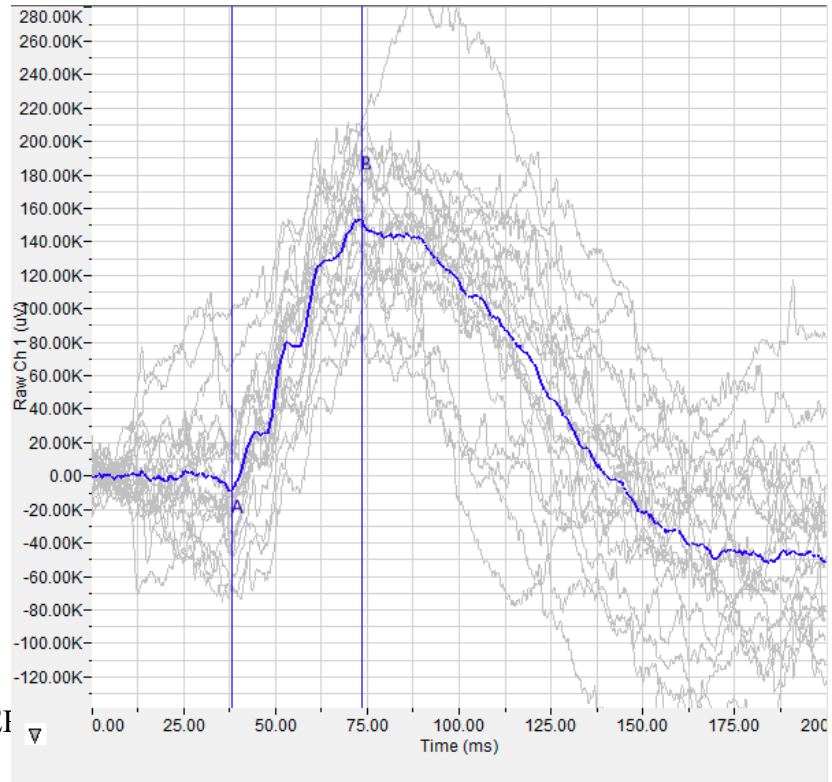
ERG Settings configuration dialog.

1) From the **ERG Channel** menu, choose the channel with the ERG recording.
2) Specify the intervals during which the A and B waves can be expected to be found, and enter the start and end times in the appropriate fields.
3) Specify the interval to be used as a baseline by entering the start and end times in the appropriate fields.
4) In a Waterfall graph of all the group averages, the group averages can be offset from each other. Enter the desired offset value in the **Offset Waterfall Graphs** field.
5) Distinguishing characteristics of the individual groups can be entered as notes in the table at the bottom of the **Settings** window.
6) Click the **Calculate** button above the **Data Table** to update all settings. Click **Calculate** whenever settings are updated.

To display and analyze the ERG Graph:

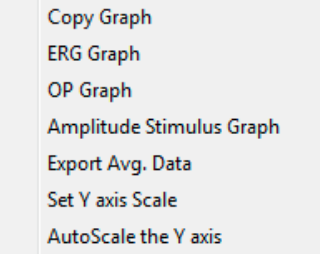
Familiarize yourself with the ERG Graph, which will be displayed in the XY graph area and is illustrated below.

- The average of the selected sweeps is shown in black, while the individual sweeps are displayed in grey.
- Sweeps can be deselected (or selected) by clicking on the check box to the left of the sweep number in the **Sweeps in Group** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual sweeps. If a particular sweep is selected from the Sweeps list, that sweep is highlighted in black in the graph.
- The specific parameters shown in the graph are chosen from the **Display** configuration dialog.



The ERG Graph.

- Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.

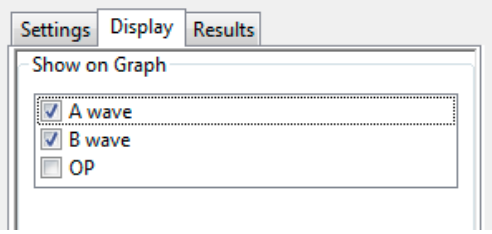


XY graph window menu.

- Click **Copy Graph** to copy the **ERG Graph** to the computer clipboard. It can then be pasted into the **Journal** or an external application.
- Click **ERG Graph** to display either the selected sweeps from one group, or a Waterfall graph of the averages of multiple groups. The graph that is displayed can be chosen from the options in the **Group** list.
- Click **OP Graph** to display the oscillatory potentials that occur in the depolarization that occurs between the a-wave and b-wave.
- Click **Amplitude Stimulus** to display a graph of the amplitude stimulus properties.
- Click **Export Average Data** to export the average data of a group of sweeps as a text file that can be named and placed in a chosen location.
- Click **Set Y-axis Scale** to set the Y-axis scale manually.
- Click **AutoScale Y-axis** to optimize the display scale of the Y-axis.

To configure the **Display:**

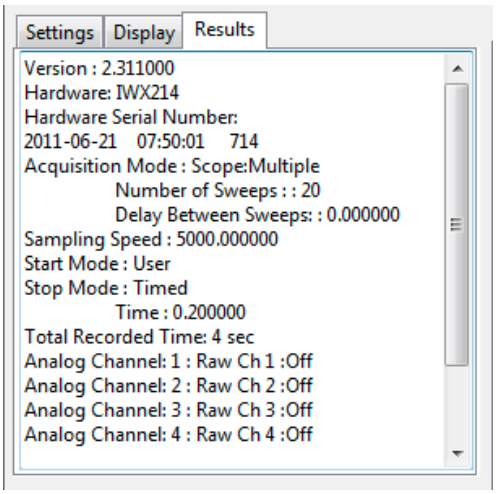
1) Click on the **Display** tab to open the **ERG Display** configuration dialog.
   Choose the parameters you would like displayed on the **ERG** or **OP Graph**. Observe the graph to see the addition or subtraction of the parameters as they are clicked and unclicked. The available options include the trough of the a-wave, the peak of the b-wave (on the ERG Graph), and the individual oscillatory potentials occurring between the a-wave and the b-wave (on the OP graph).



ERG Display configuration dialog.

To configure the **Results:**

1) Click on the **Results** tab to open the **ERG Results** configuration dialog. Here information about the original data file is displayed. Additional text can be entered into this dialog.



ERG Results configuration dialog.

To use the **Data Table:**

*	Sel	Amplitude	Implicit Time	A	B	Time to A	OP1	OP1 Time	OP2	OP2 Time	Notes
1	Yes	163065.541	73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600	1
2											
3	#		1	1	1	1	1	1	1	1	
4	Mean		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600	
5	SD		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
6	Max		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600	0.000
7	Min		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600	0.000

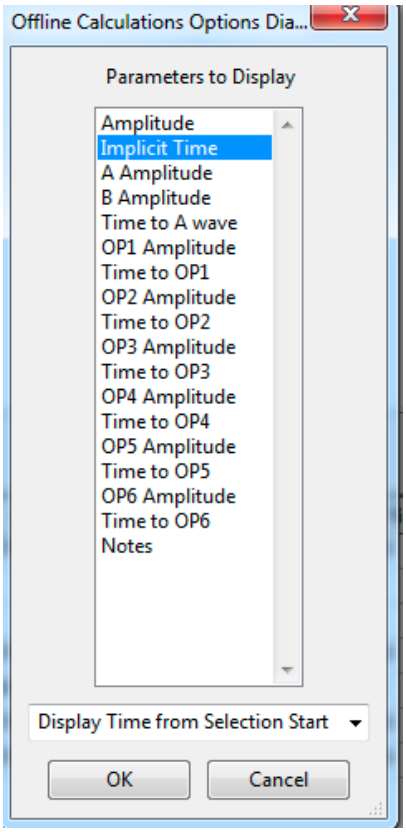
ERG Data Table.

1) Familiarize yourself with the **Data Table**.
   - The **Data Table** spans the lower left part of the **ERG Calculations** dialog and displays the average calculated values for the chosen parameters in each of the groups checked in the **Group** list.
   - The parameters displayed are chosen from the list of available parameters chosen from the list displayed by clicking the **Table Options** button at the bottom of the dialog.
2) Click the asterisk at the upper left of the **Data Table** to display two options: **Autosize** and **Copy Selection**. **Autosize** will optimize the size of the **Data Table** columns, and **Copy Selection** copies any selected **Data Table** cells to the clipboard. The width of the individual columns can also be adjusted manually.

There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template,** and **Save Template:**

3) Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
4) Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
5) Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.

6) Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **ERG Analysis: Reference** section.



Complete list of Data Table parameters.

7) Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
8) Click **OK** to close the analysis.

ERG Analysis: Reference

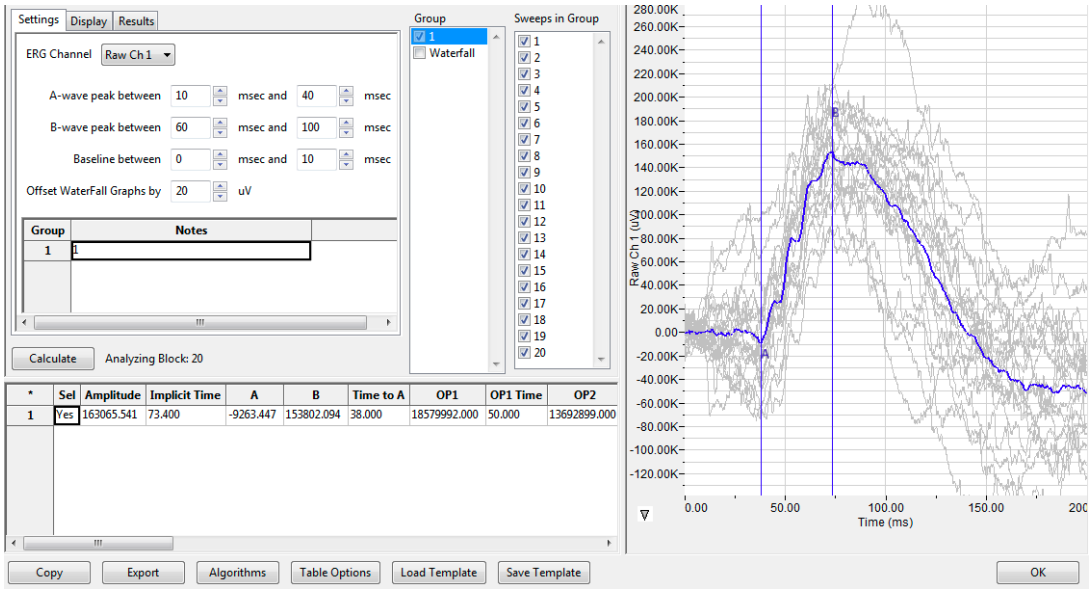
When **ERG Analysis** is chosen from the **Advanced** menu while an ERG data file is displayed in the Main window, the **ERG Calculations** dialog opens.

Offline ERG Calculations

LabScribe can perform offline **ERG** calculations on previously recorded ERG traces, and display a number of XY graphs based on the ERG data.

Choosing **ERG Analysis** from the **Advanced** menu opens the **ERG Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.

The ERG Calculations dialog.



The sections of the offline **ERG Calculations** dialog, each of which is described in more detail below:

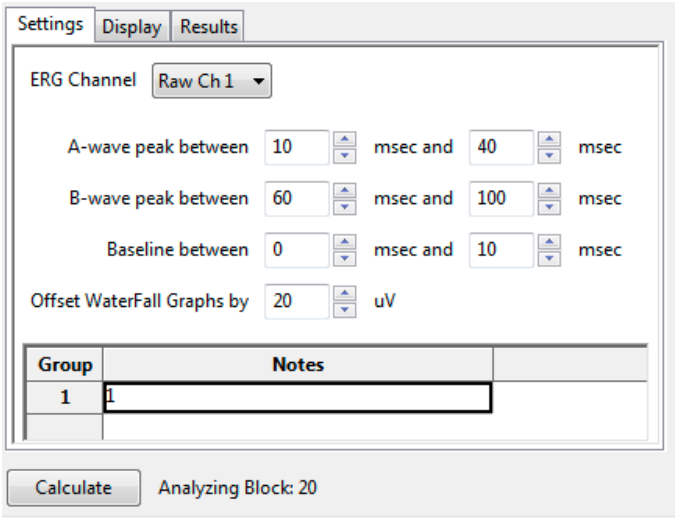
- The tabbed configuration windows are on the left side of the upper part of the dialog.
- An XY graph window on the right displays XY graphs based on the ERG data.
- Between the configuration dialogs and the XY graph window are the **Group** list, an editable list of the groups that can be displayed and analyzed, and the **Sweeps in Group** list, and editable list of the sweeps to be displayed from a single group.
- The **Data Table** is located on the lower part of the dialog.

The Configuration Windows

There are three tabbed configuration dialogs: **Settings, Display, and Results.**

The Settings Configuration Dialog

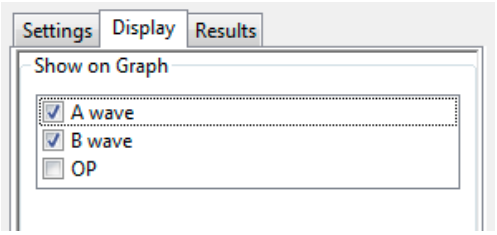
Starting at the top of the **ERG Settings** configuration dialog:



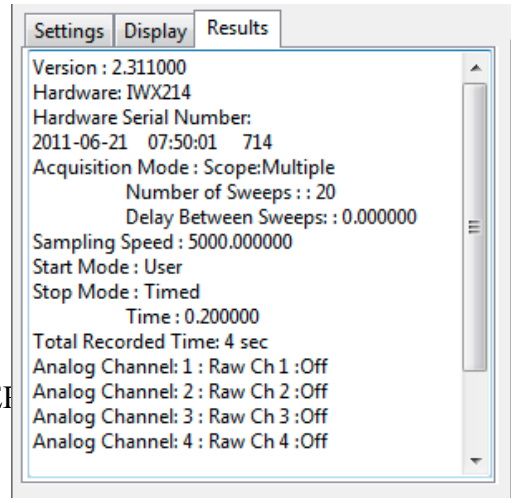
- The channel with the ERG raw data is specified.
- The time interval during which the a-wave trough can be expected to be found is specified.
- The time interval during which the b-wave peak can be expected to be found is specified.
- The amount of time before the ERG to be used as a baseline is specified.
- In a Waterfall graph of all the group averages, the group averages can be offset from each other. The desired offset value is entered in the **Offset Waterfall Graphs** field.
- Distinguishing characteristics of the individual groups can be entered as notes in the table at the bottom of the **Settings** window.

The Display Configuration Dialog

- The parameters to be displayed on the **XY Graph** are chosen in this window.The options include the trough of the a-wave, the peak of the b-wave, and the individual oscillatory potentials occurring between the a-wave and the b-wave.



The Results Configuration Dialog

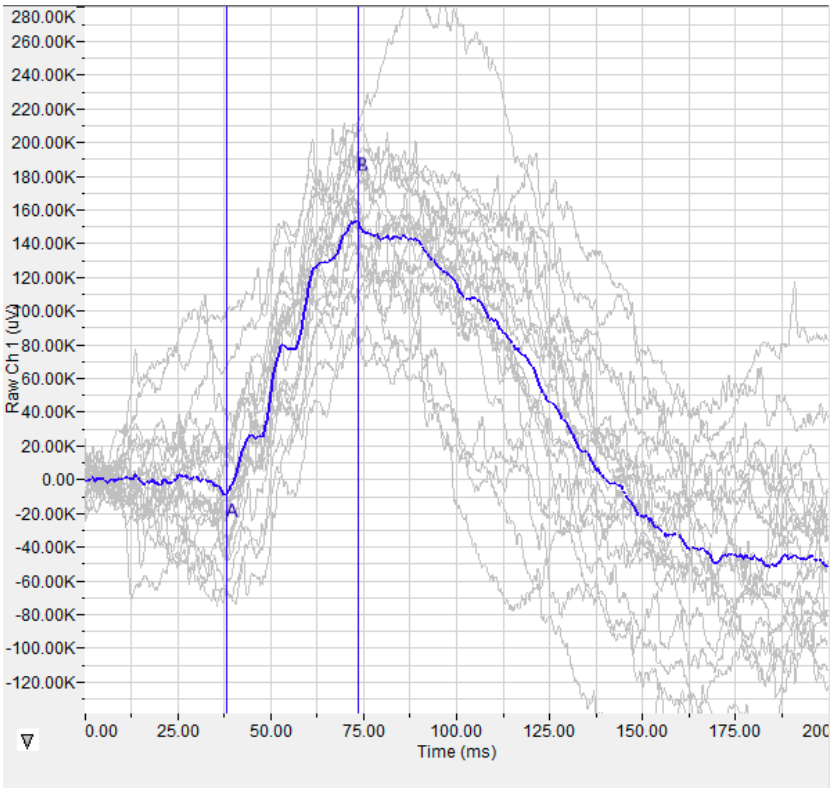


ERG Results configuration dialog.

- Information about the original ERG data file is displayed. Additional text can be entered into this dialog.

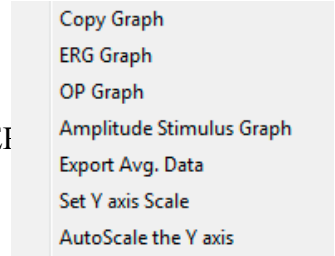
The XY Graph

The XY graph displays one of a number of graphs based on the ERG data. The specific graph displayed is chosen from the XY Graph menu found to the lower left of the graph.



The ERG Graph.

The XY Graph Menu: Clicking on the arrow in the lower left corner of the XY graph pane opens a menu that offers options for choosing the graph to be displayed and for scaling both the X-axis and Y-axis. There are also options to copy the graph to the clipboard and export the data as a text file.



The XY Graph menu.

The menu items are:

- **Copy graph**: Copies the current XY graph to the clipboard. It can then be pasted into the journal or an external application.
- **ERG Graph:** Displays either a graph of the individual sweeps and average of a specific group or a waterfall graph of the averages of a number of groups. The group to be displayed is chosen from the **Group** list and the sweeps to be displayed are chosen from the **Sweeps in Group** list. The choice of a waterfall graph is made in the **Group** list. The average of the selected sweeps is shown in blue, while the individual sweeps are displayed in grey. Sweeps can be deselected (or selected) by clicking on the check box to the left of the sweep number in the **Sweeps in Group** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual sweeps. If a particular sweep is selected from the Sweeps list, that sweep is highlighted in black in the graph.
- **OP Graph:** Displays a graph of the oscillatory potentials occurring during the depolarization between the a-wave and b-wave.
- **Amplitude Stimulus Graph**: Displays the stimulus amplitude changes.
- **Export Avg Data**: Exports the averaged data from a group to a text file.
- **Set Y-axis Scale**: Allows the user to set the Y-axis scale.
- **AutoScale Y-axis**: Optimizes the display scale of the Y-axis of the XY graph.
- The axes can also be re-scaled by left-clicking and dragging either of the axes.

The Data Table

The **Data Table** displays the chosen calculated values for each cycle.

*	Sel	Amplitude	Implicit Time	A	B	Time to A	OP1	OP1 Time	OP2	OP2 Tin
1	Yes	163065.541	73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600
2										
3	#		1	1	1	1	1	1	1	1
4	Mean		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600
5	SD		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	Max		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600
7	Min		73.400	-9263.447	153802.094	38.000	18579992.000	50.000	13692899.000	58.600

The ERG Data Table.

Clicking the asterisk at the upper left of the **Data Table** displays two options: **Autosize** and **Copy Selection**. A**utosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

The **Data Table** displays the average calculated values for the chosen parameters in each of the groups checked in the **Group** list. The last few rows of the data table include column statistics for each of the parameters.

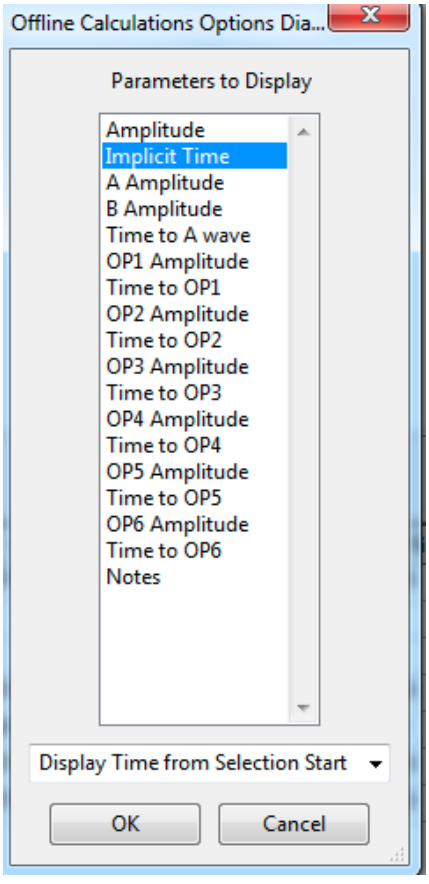
There are six buttons across the bottom of the **ERG Calculations Dialog: Copy, Export, Algorithms, Table Options, Save Template,** and **Load Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.

- *LabScribe* is able to calculate a large number of ERG calculations for each cycle. By clicking **Table Options** at the bottom of the **ERG Calculations Dialog**, the **Offline Calculations Options Dialog** opens, and calculations to be displayed in the **Data Table** can be chosen from the list of all possible calculations.
- Clicking **Load Template** or **Save Template** displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

Offline Calculations:

- **Amplitude**: Change in amplitude from trough of a-wave to peak of b-wave.
- **Implicit Time**: Time from stimulus onset to peak of b-wave.
- **A Amplitude**: Amplitude at trough of a-wave.
- **B Amplitude**: Amplitude at peak of b-wave.
- **Time to A-wave**: Time from stimulus onset to peak of a-wave.
- **OP1 Amplitude**: Amplitude of Oscillatory Potential 1.
- **Time to OP1**: Time from stimulus onset to peak of Oscillatory Potential 1.
- **OP2 Amplitude**: Amplitude of Oscillatory Potential 2.
- **Time to OP2**: Time from stimulus onset to peak of Oscillatory Potential 2.
- **OP3 Amplitude**: Amplitude of Oscillatory Potential 3.
- **Time to OP3**: Time from stimulus onset to peak of Oscillatory Potential 3.
- **OP4 Amplitude**: Amplitude of Oscillatory Potential 4.
- **Time to OP4**:Time from stimulus onset to peak of Oscillatory Potential 4.
- **OP5 Amplitude**: Amplitude of Oscillatory Potential 5.
- **Time to OP5**: Time from stimulus onset to peak of Oscillatory Potential 5.

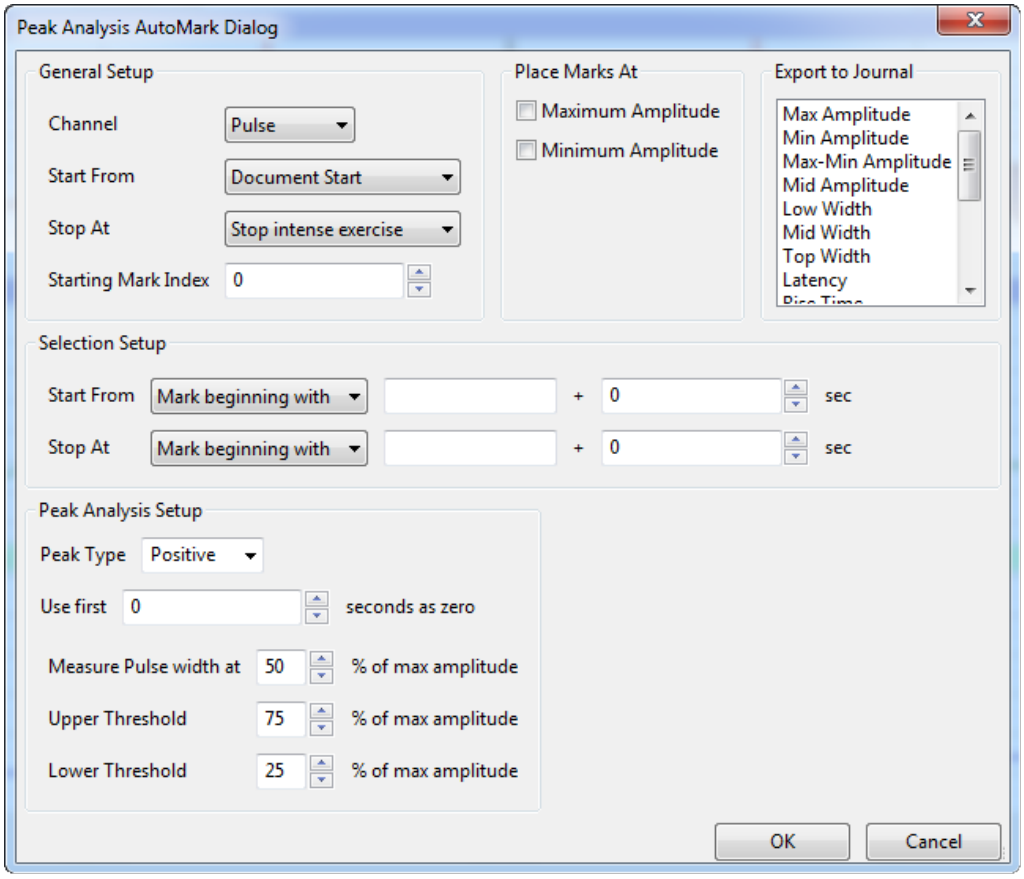


- **OP6 Amplitude**: Amplitude of Oscillatory Potential 6.
- **Time to OP6:** Time from stimulus onset to peak of Oscillatory Potential 6.
- **Notes**: Any notes entered into the Notes field in the Settings window.

8.6 Peaks Analysis

AutoMark Peaks

The regular occurrence of peaks is a common feature of many types of data files. The **AutoMark Peaks Advanced** function can locate and analyze the peaks in a *LabScribe* recording.



The Peak Analysis AutoMark Dialog.

Peak Analysis AutoMarks:

The **Peak Analysis AutoMark Dialog** can be opened by selecting **AutoMark Peaks** from the **Advanced** menu. The options for configuring the dialog follow.

General Setup:

- **Channel**: Channel with peaks data.
- **Start From**: Location in the data file to start the analysis. The start of the document or an existing mark can be used to set the start location.
- **Stop At**: Location in the data file to end the analysis. The end of the document or an existing mark can be used to set the stop location.

- **Starting Mark Index**: Marks placed in the record have a number which corresponds to the cycle number. The default cycle number starts at zero, but the starting cycle number can be changed here.
- When the data channel is selected, it will appear in the graph. Set the threshold using the two horizontal cursors, such that the positive threshold crossing from below the lower threshold to above the upper threshold can be used to determine the cycle.

Place Marks At:

Choose the points of interest the program should mark in the record. This can be used to verify that the program has detected the correct points of interest.

Export to Journal:

Choose the calculated values you want exported to the journal for each peak.

Selection Setup:

The start and the stop of the selection is set in this drop-down menu. To define a time location one can choose a mark identified by its starting text, the block start, or positive or negative crossing of the data. A time offset can be added to this location if desired.

Peak Analysis Setup:

- **Peak type**: The software will look for positive or negative peaks.
- **Use first "N" seconds as zero**: Used to set the offset, or the baseline.
- **Measure Pulse width at**: A percentage of the amplitude can be set as the location at which peak width is measured.
- **Upper and Lower Thresholds**: Upper and lower detection thresholds can be set in the edit boxes.

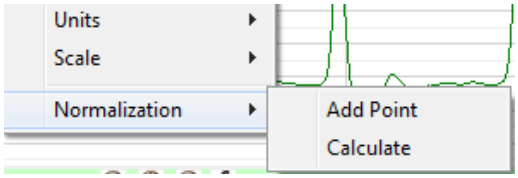
The calculated peak functions that can be exported to the **Journal**:

- **Max**: Maximum amplitude.
- **Min**: Minimum amplitude.
- **Max-Min**: Maximum amplitude - Minimum amplitude.
- **Mid Amp.**: Amplitude at the midpoint of the middle threshold.
- **Low Width**: Width of the peak as measures at the lower threshold.
- **Mid Width**: Width of the peak as measures at the middle threshold.
- **Top Width**: Width of the peak as measures at the upper threshold.
- **Latency**: Time from when the peak leaves the baseline to the peak.
- **Rise Time**: Time for the signal to travel from the lower threshold to the upper threshold.
- **Fall Time**: Time for the signal to travel from the upper threshold to the lower threshold.
- **Leading Slope**: Average slope of the signal as it travels from the lower threshold to the upper threshold.
- **Trailing Slope**: Average slope of the signal as it travels from the upper threshold to the lower threshold.

- **Max Slope**: Maximum slope.
- **Min Slope**: Minimum slope.
- **T at Max Slope**: Time at maximum slope.
- **T at Min Slope**: Time at minimum slope.

8.7 Myograph Normalization

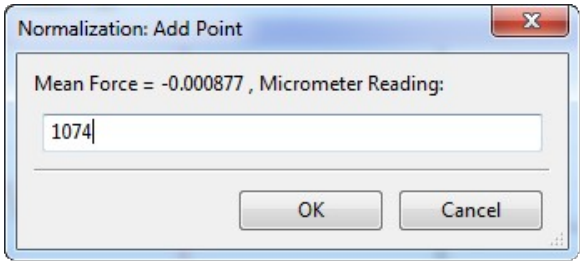
Normalization is a separately licensed module designed specifically to calibrate small vessel size for the use of wire myographs in vessel contractility experiments. In order to make comparisons between different vessels and experimental conditions, an internal circumference that exerts a **Target Pressure** needs to be determined to make comparisons meaningful. The relaxed vessel wall is stretched to a number of micrometer settings for a specific size myograph. The vessel wall force in response to each stretch is recorded by using the **Add Point** command. After a curve is generated from these forces, the **Calculate** command is used to determine the internal circumference at a **Target Pressure**, usually 13.3kPa. The normalized internal circumference is usually determined to be 90% of this value.



The Normalization submenu.

The **Normalization** module is accessed by right-clicking in the appropriate wire myograph channel display area. **Normalization** will be at the bottom of the menu.

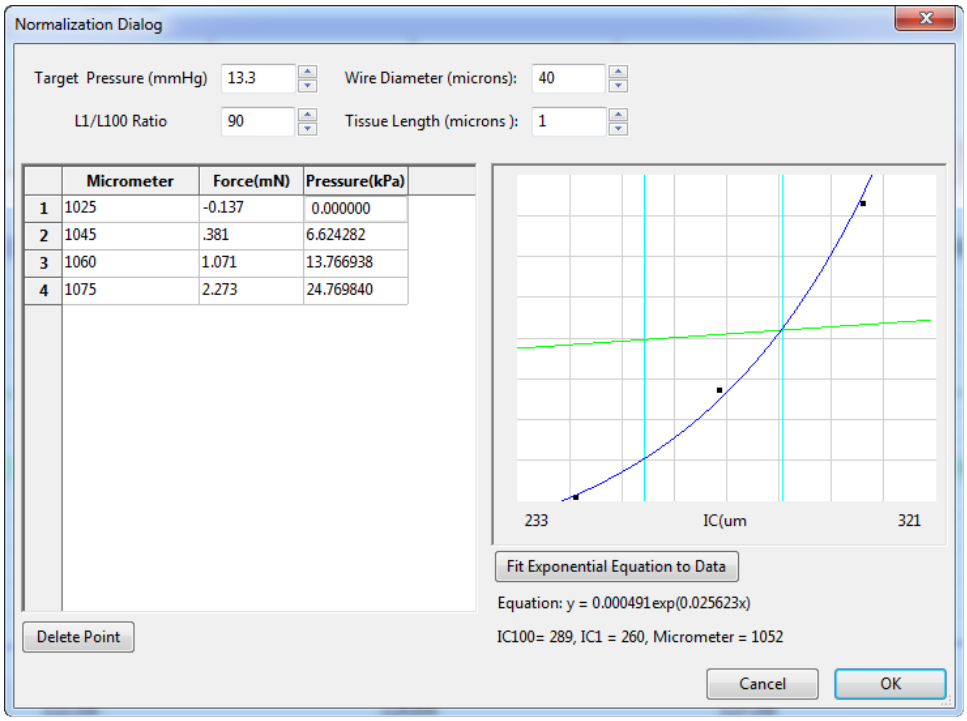
To use the **Normalization** module:



The Normalization: Add Point dialog.

- Calibrate the myograph(s) to be used in the experiment, according to procedures outlined in the myograph documentation.
- With the wires positioned and exerting no stretch, click **Record**.
- If the wires have been properly calibrated, the pressure should be zero. Click **Stop**.
- In **Two Cursor Mode**, position the cursors on either side of a representative section of the trace and select **Add Point** from the **Normalization** menu. The mean value between the cursors will be recorded in the **Normalization Dialog**.
- Increase the micrometer setting to stretch the vessel wall minimally. Click **Record**.
- After the pressure has stabilized, click **Stop**.
- Position the cursors on either side of a stabilized section of the trace and select **Add Point** from the **Normalization** menu.

- Repeat this procedure for a number of micrometer settings. Once enough points have been recorded, select **Calculate** from the **Normalization** menu, opening the **Normalization Dialog**. The micrometer setting, the force registered by the wires, and the vessel wall pressure are displayed for each data point recorded.
- In the **Normalization Dialog**, enter the **Target Pressure**, the **Wire Diameter**, the **IC Ratio**, and the **Vessel Length.**
- Click **Fit Exponential Equation to Data**. A graph is generated and the **Internal Circumference** at the **Target Pressure**, the normalized **IC**, and the correct micrometer setting for that normalized internal circumference are displayed.
- Outlying data points can be deleted by selecting the point and clicking **Delete Point.**



The Normalization Dialog.

8.8 Dose Response

The Dose Response relationship describes the change in the effect on an organism or tissue caused by differing levels of exposure to a chemical stressor after a certain exposure time.

Dose Response parameters are calculated and then a dose-response curve is calculated in *LabScribe's* **Dose Response Advanced Analysis Module**.

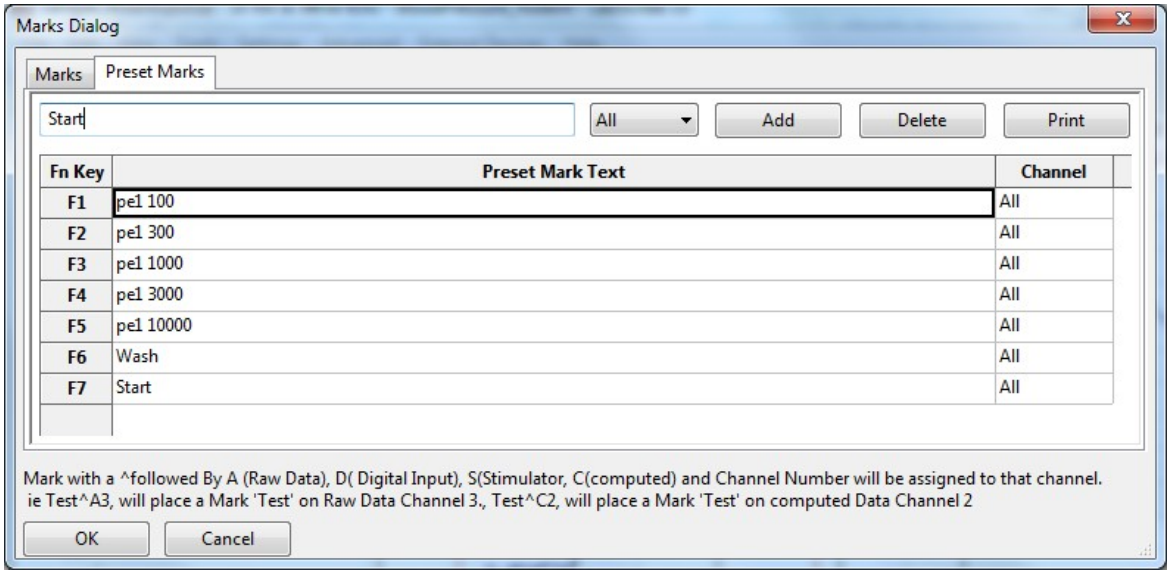
The **Dose Response Advanced Analysis Module** requires a separate license. The first time you select **Dose Response**, you will be asked for a username and a serial number. Contact iWorx Systems for more information.

This document includes a step by step tutorial for using most of the features of the **Dose Response Advanced Analysis Module**. To use the step by step guide, you will need a recording with at least one Dose Response channel. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

Dose Response Measurement

To make it easier later to analyze the data it is beneficial to follow the following procedure when recording the data.

1) Make a table of the drug concentrations that you are going to be using. In our example we are going to apply 100, 300, 1000, 3000, and 10000 units of the drug pe1.
2) Setup preset marks to make it easier to mark the data during recording. The preset marks are present in the Marks window, which you can access from the Toolbar or the View Menu. It is best to start the mark with the drug name.



Marks dialog with preset marks entered.

3) While recording data, make sure that the marks are placed in the record when the drug is given.

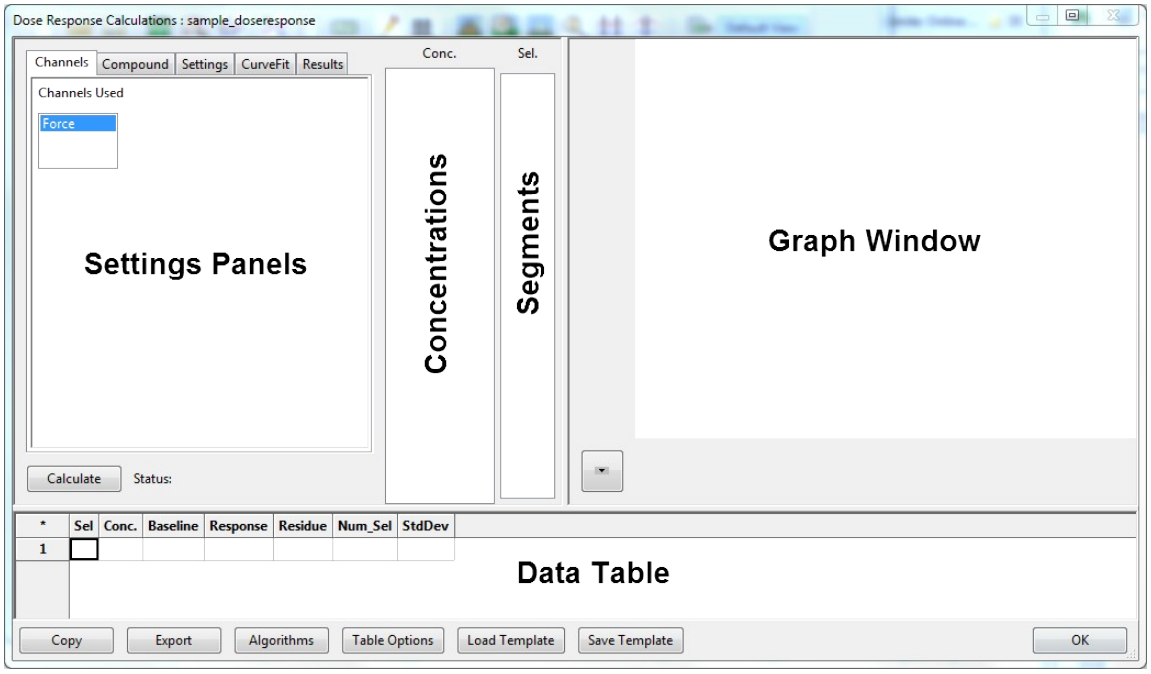
Dose Response Analysis: Step by Step

The **Dose Response Calculations** dialog allows sophisticated offline analysis of previously recorded Dose Response data.

The Offline Dose Response Calculations Dialog

To display the **Dose Response Calculations** dialog and familiarize yourself with its features:

1) Open the Dose Response data file.
2) Choose **Dose Response** from the **Advanced** menu to open the offline **Dose Response Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.



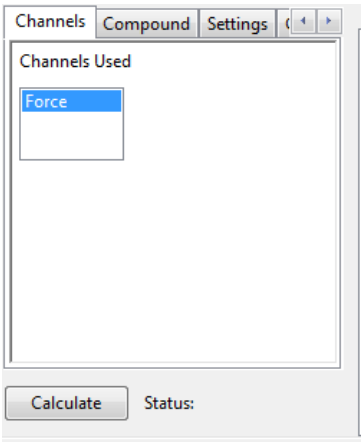
Dose Response Calculations dialog.

3) Familiarize yourself with the **Dose Response Calculations** dialog, pictured above.
   - The tabbed **Settings** panels are on the left.
   - The **Concentrations** list, will show the Drug concentrations used.
   - The **Segments** list shows the list of segments for a particular concentration
   - An XY graph window on the right displays the **Dose Response Graph**,
   - Between the configuration dialogs and the XY graph window is the **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
   - The **Data Table** is located on the lower part of the dialog.

-

To configure the Dose Response Channels:

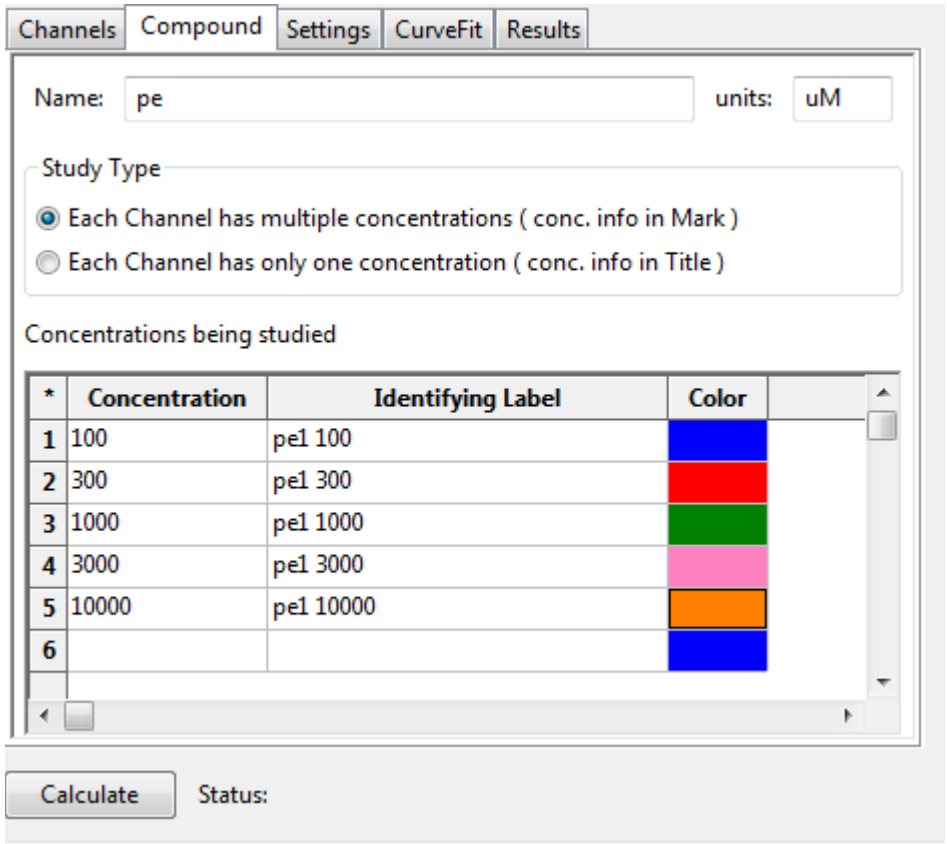
1) Click on the **Channels** tab, opening the **Channels** configuration dialog.
2) Select the channels that have the Dose Response data.



Dose Response Channels configuration panel.

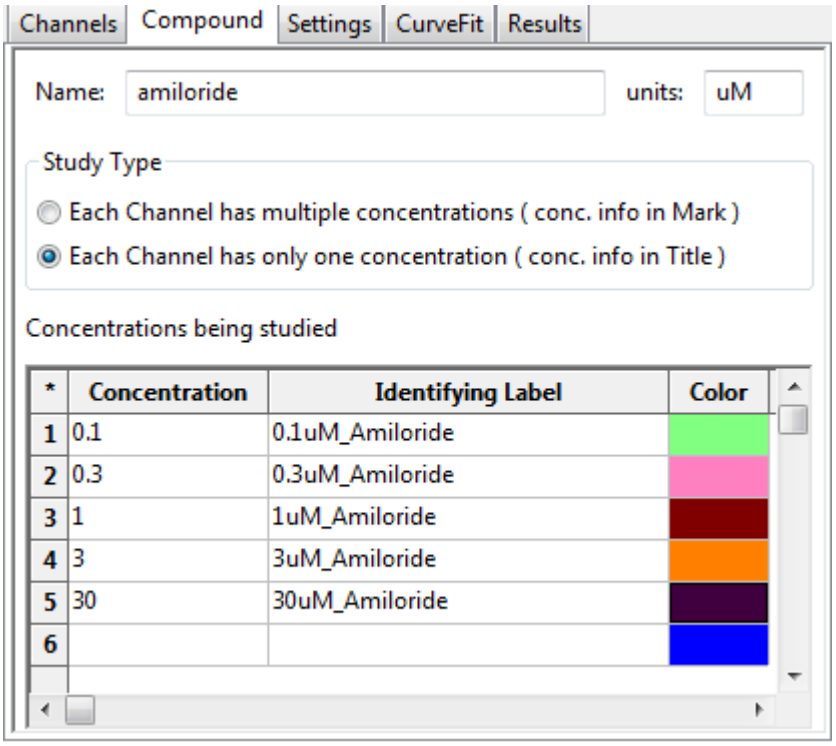
To configure the Dose Response Compound:

1) Click on the **Compound** tab, opening the **Compound** configuration dialog.



Dose Response Compound configuration dialog. Concentration information indicated in marks.

- Enter the name of the drug or compound (as an example, “pe”).
- Enter the name of the units.
- Select the type of Study. Indicate whether each channel has multiple concentrations, which are labeled using marks, or if each channel has only one concentration and the concentration information is in the title. Figures show each option.
- In the table of concentrations being studies, click on the empty Identifying Label cell to see a list of Marks or Titles in the data file. Choose the Mark you want to associate with the concentration and enter the concentration.
- Choose a color for the concentration. The software will create a new row below. Enter the next concentration until all the concentrations are entered.

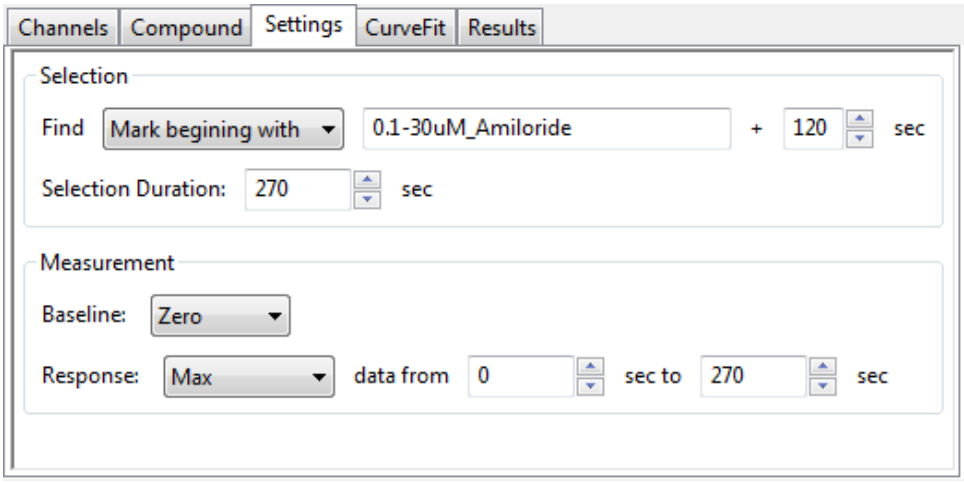


Dose Response Compound configuration dialog. Concentration information comes from channel titles.

To configure the Dose Response Settings:

1) Define the selection that will be used to calculate the response. The selection is identified using marks in the data file. In the example illustrated below, LabScribe finds the mark “0.1-30uM_Amiloride”, and indicates the selection should start 120 seconds after the mark. If the marks contain the dose information, it is important that the mark begins with the drug name followed by the concentration, allowing LabScribe to find all the drug delivery marks easily.
2) Indicate the desired **Selection Duration** in seconds.
3) The Baseline that will be used to calculate the response can be set to zero. It can also be set to the Max, Min, Max-Min, or Mean of a selected region of the data.

4) Response is calculated as the Maximum, Minimum, Max-Min, Mean of the selected region of the data. The period of data used to calculate the response is set in the illustrated example as from 0 seconds in the selection to 270 seconds.



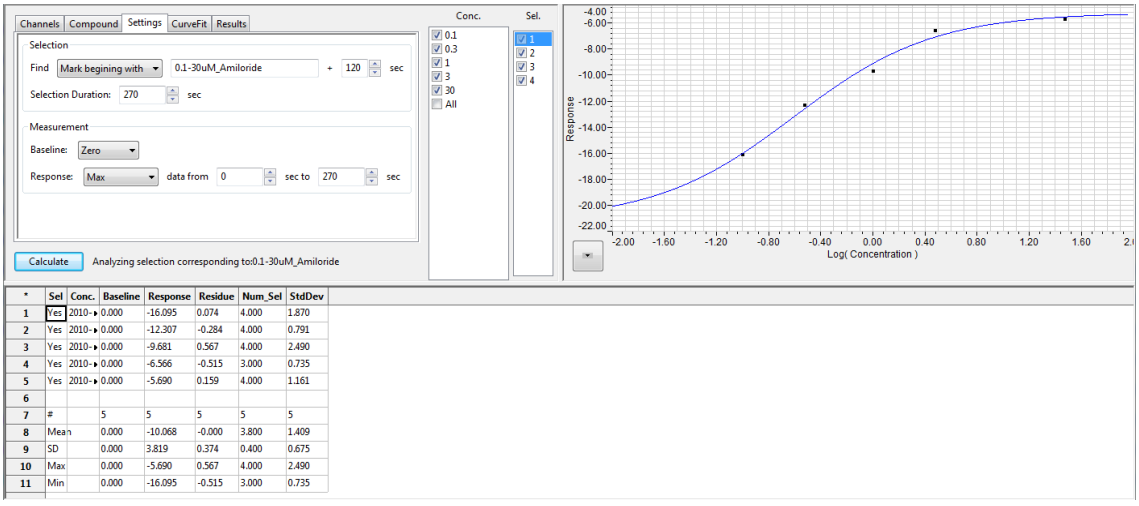
Dose Response Settings configuration dialog.

5) Click the **Calculate** button just above the **Data Table** to start the analysis.

***Important:** After any configuration settings are changed, click **Calculate** to trigger the revised analysis.*

The software will find all the segments of data that have the dose response measurements. These segments will be sorted, averaged and listed under the **Conc.** list. In the illustrated example below, the concentrations 0.1, 0.3, 1, 3, and 30 are listed. The program will also calculate the **Response** for each concentration and draw the **Schild Plot** in the XY Graph window. The calculated values are displayed in the **Data Table.**

Click on any of the concentration values in the **Conc** list shows the data segments corresponding to that concentration. Clicking on **All** shows all the data segments.



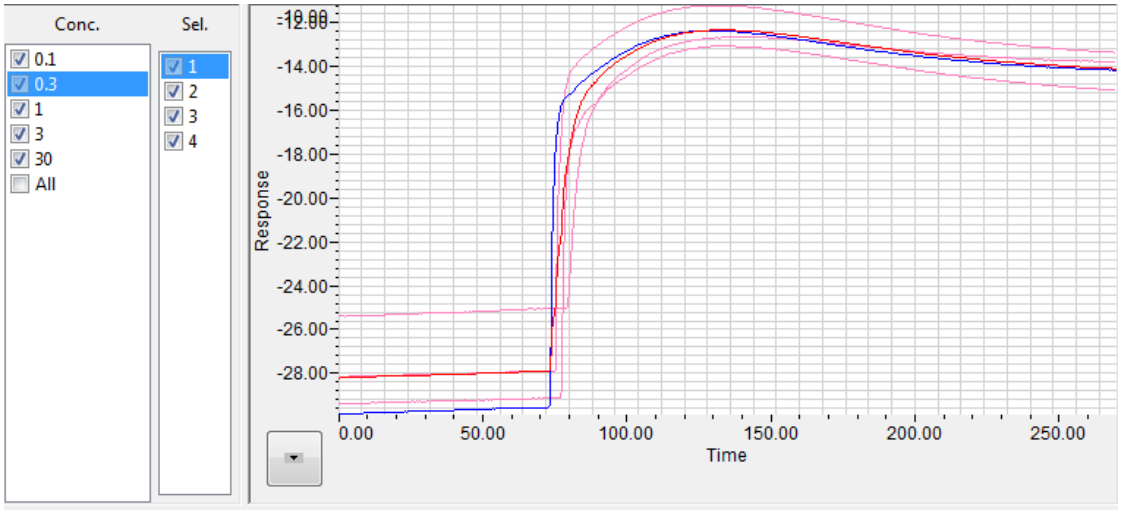
*	Sel	Conc.	Baseline	Response	Residue	Num_Sel	StdDev
1	Yes	2010-▸	0.000	-16.095	0.074	4.000	1.870
2	Yes	2010-▸	0.000	-12.307	-0.284	4.000	0.791
3	Yes	2010-▸	0.000	-9.681	0.567	4.000	2.490
4	Yes	2010-▸	0.000	-6.566	-0.515	3.000	0.735
5	Yes	2010-▸	0.000	-5.690	0.159	4.000	1.161
6							
7	#		5	5	5	5	5
8	Mean		0.000	-10.068	-0.000	3.800	1.409
9	SD		0.000	3.819	0.374	0.400	0.675
10	Max		0.000	-5.690	0.567	4.000	2.490
11	Min		0.000	-16.095	-0.515	3.000	0.735

Dose Response Calculations dialog with Schild Plot displayed.

Click the button below the graph to display the XY Graph menu.

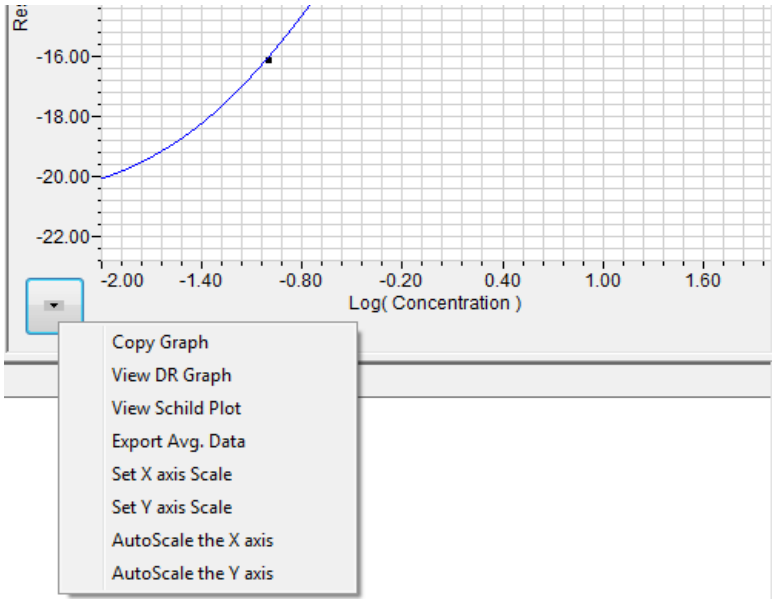
From this menu, one can:

1) **Copy Graph**: Copies the current Graph to the clipboard.
2) **View the DR Graph**: Displays the segments for one or all concentrations.



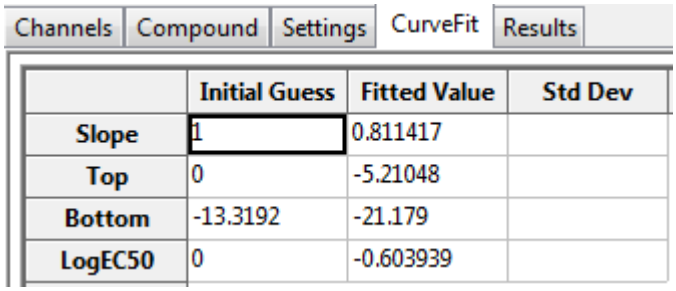
DR Graph

3) **View the Schild Plot**: Displays the Schild Plot.
4) The next 4 options are used to set the X and Y axes. The X and Y axes can also be set by right-clicking on the axis and using the axis submenu.



XY Graph menu.

To display the parameters used to generate the Schild plot, click the CurveFit tab.



Dose Response Curve Fit panel.

Data Table

The **Data Table** spans the lower part of the **Dose Response Calculations** dialog and displays the calculated values for each of the segments

The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected cycles.

There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.**

1) Click the asterisk at the upper left of the **Data Table** to display two options: **Autosize** and **Copy Selection**. **Autosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.
2) Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
3) Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.237
4) Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
5) Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **Dose Response Analysis: Reference** section. Marks indicating temperature and activity can also be added to the file, and those values can be chosen from the **Table Options** list and included in the **Data Table**.
6) Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
7) Click **OK** to close the analysis.

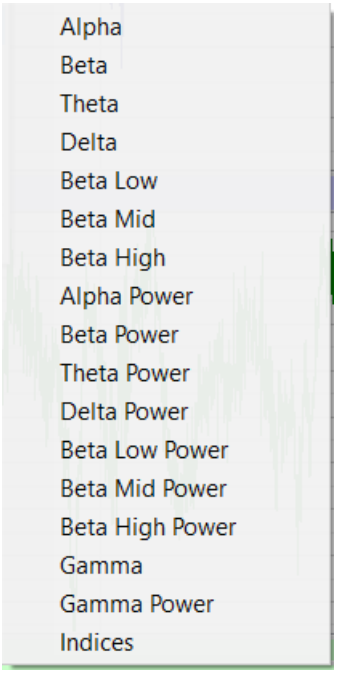
8.9: EEG Analysis

The **EEG Advanced Analysis Module** is used to analyze electroencephalograms. Using the module, it is possible to analyze conventional and custom EEG montages. It is possible to measure the frequency and amplitude of Alpha, Beta, Theta, and Delta wave forms from chosen segments of a multi-electrode EEG.

This document includes a step by step tutorial for using most of the features of the **EEG Advanced Analysis Module.** To use the step by step guide, you will need a previously recorded electroencephalogram to analyze.

EEG Analysis in Main Window

In the EEG function submenu, a frequency band is chosen representing a component of the electroencephalograph (EEG): Alpha, Beta, Theta, Delta, Beta Low, Beta Mid or Beta High. For each selected band, LabScribe also calculates the average power represented in the band and displays the power value against time. Both the individual band and the band's Power functions can be displayed through the use of the EEG function. By displaying separate channels representing the bands, it is possible to see the effect that behavior has on the separate components of the EEG.



Using the EEG Functions

To apply the EEG function to a channel:

Click on the add function button in the Channel Bar.

Select EEG from the function list to open the EEG submenu.

Choose one of the EEG bands or a Power function. Repeat for other bands you would like displayed.

EEG Indices

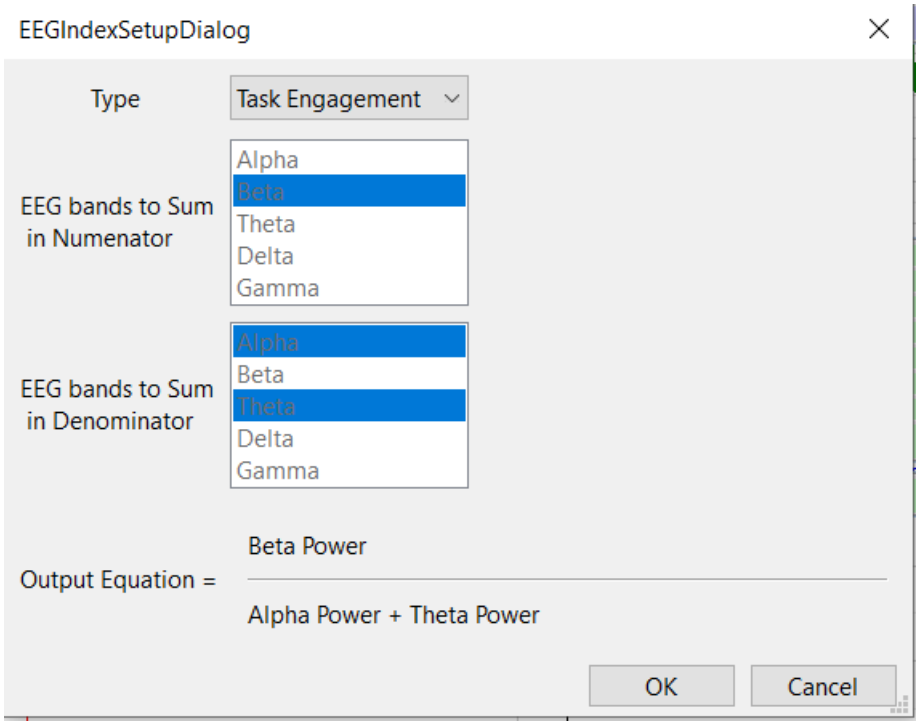
In literature, various indices are used for classifying EEG signals.

Various indices can be calculated from EEG power bands, For example, the task engagement index given by Equation (1) from Pope, Bogart, and Bartolome:

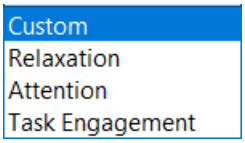
TEI = beta power / (alpha power + theta power)

The EEG indices calculation allows the user to pick the bands that get summed in the numerator and the bands that get summed in the denominator and then calculate the ratio. Thus various indices can be calculated from EEG bands.

Choosing the Indices option brings up a EEG Index setup Dialog.



Select the index you want to measure:



- Custom
- Relaxation
- Attention
- Task Engagement

The Custom option allows the user to select the bands that get summed in the numerator and the denominator. Other options such as the Relaxation, Attention or Task Engagement index, are predefined.

The output equation shows the calculation for the chosen index.

EEG Analysis Window

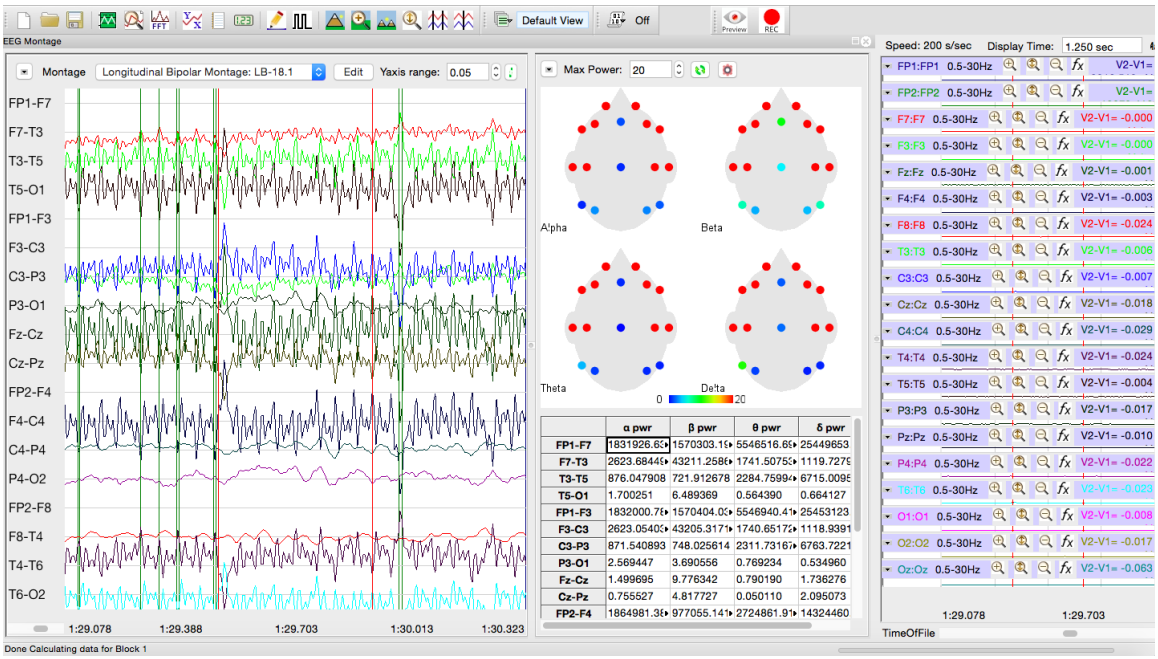
The EEG Analysis is performed using the **EEG Montage** dialog, so you should first become familiar with this dialog.

The EEG Montage Dialog

To display the EEG Montage dialog and familiarize yourself with its features:

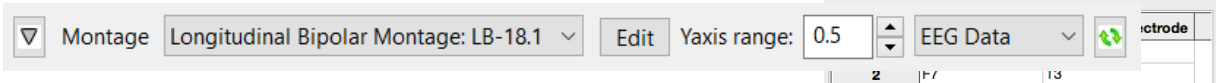
1. Open a file with EEG data.
2. Select **EEG** from the **Advanced** menu. Choose **View Montages** to open the **EEG Montage** dialog.
3. Familiarize yourself with the **EEG Montage** dialog, pictured below.The EEG Montage dialog consists of two parts, one of which displays the data from the chosen montage segment and the other displays a graphical analysis of the wave form frequency and amplitude.

- On the left is the montage configuration panel, showing the chosen segments from a specific montage.
- On the right is the data analysis configuration panel, showing the relative frequency and amplitude of Alpha, Beta, Delta, and Theta wave forms, as both pictorial and table format.
- The sizes of the two panels can be adjusted by dragging the edges of the panels.
- A part of the raw data from the Main window can also be included on the screen at the same time as the **EEG Montage** dialog by choosing the desired view. Clicking the icon to the left of the X at the upper right of the dialog will shift the size of the dialog from a view showing only the dialog to a view including a portion of the Main screen data. The X will close the **EEG Montage** dialog.



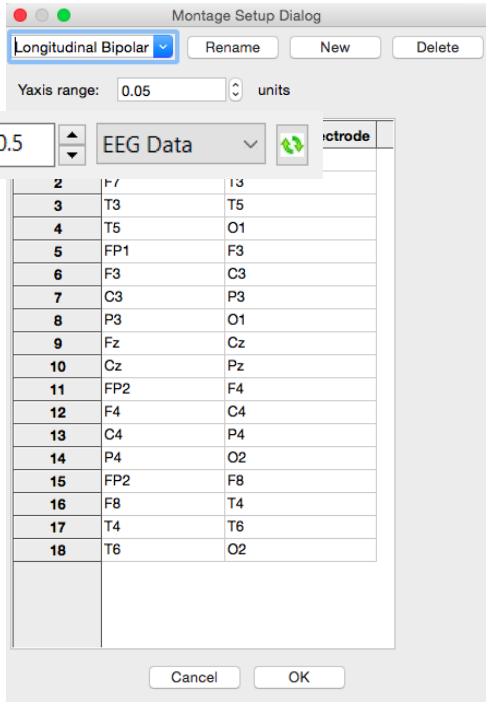
EEG Montage dialog.

To configure the analysis, start with the montage selector and graph on the left. Use the toolbar across the top to configure



Montage configuration toolbar.

1. Click on the arrow at the left of the montage configuration toolbar to copy the graph to the clipboard.
2. The desired montage can be chosen from from a list of preconfigured montages shown in the montage menu.
3. Click on the Edit button to open the Montage Setup dialog. In this dialog, a custom montage can be constructed from



the available electrode pairings. Existing montages can be renamed, a new montage can be created, and montages can be deleted. The default y-axis scale can also be set here.

4. Indicate the desired Y-axis scale by indicating it in the Y-axis range text box. Adjust the graph to this range by clicking the recalculation icon to the right of the axis range selector.
5. In order to display the new configuration, it is necessary to click the recalculation icon to the right of the Y-axis range selector each time the configuration is changed.
6. Set the amount of time to be displayed by adjusting the Display Time icons in the main toolbar.

Display Time icons.

Choose the specific segment to be displayed by scrolling through the Main window data to the desired location. Once the segment is chosen, click the recalculation icon to the right of the Y-axis range selector to display this segment in the montage panel.

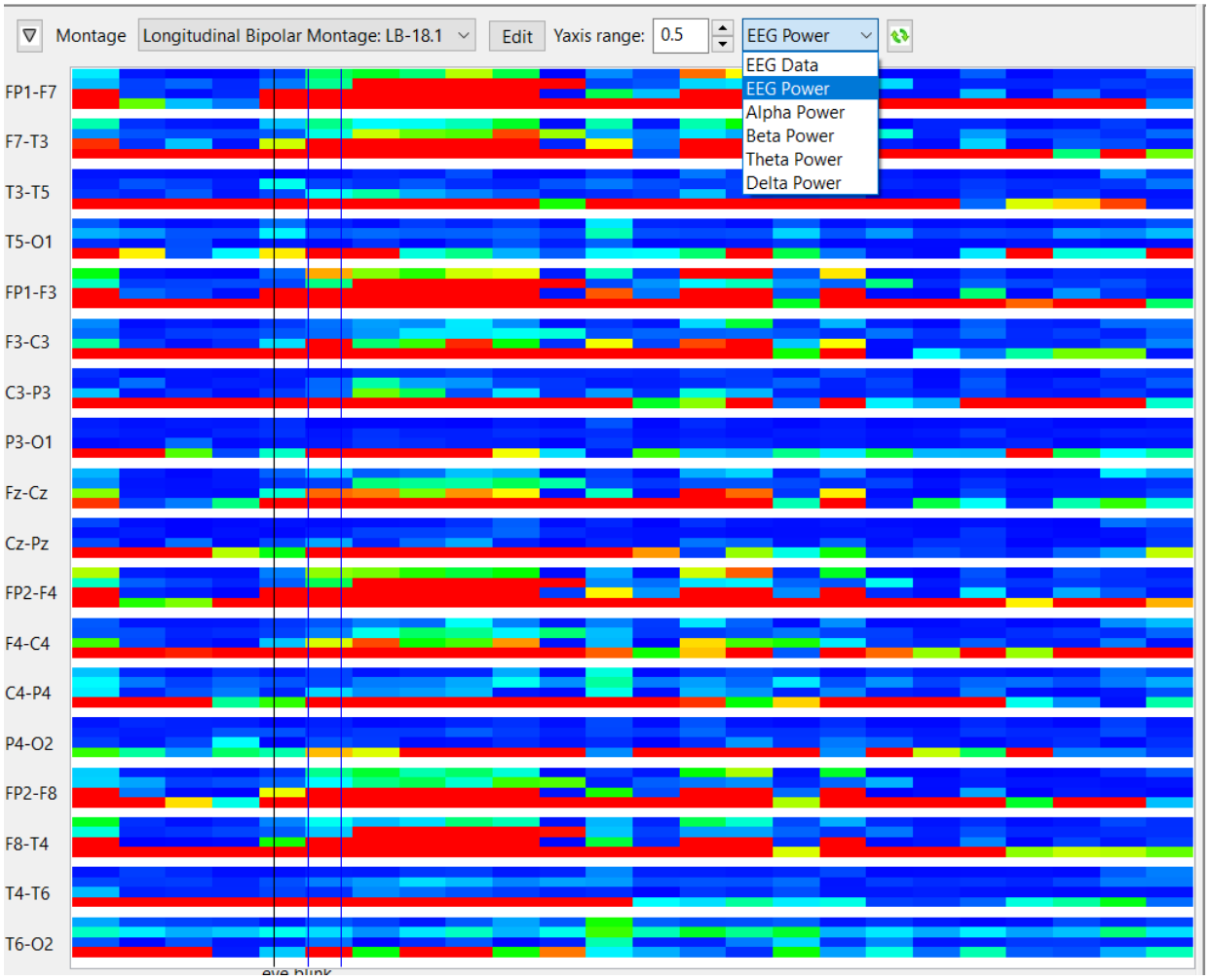
Display Power

There are a few options to display the EEG power bands (Alpha, Beta, Theta and Delta).

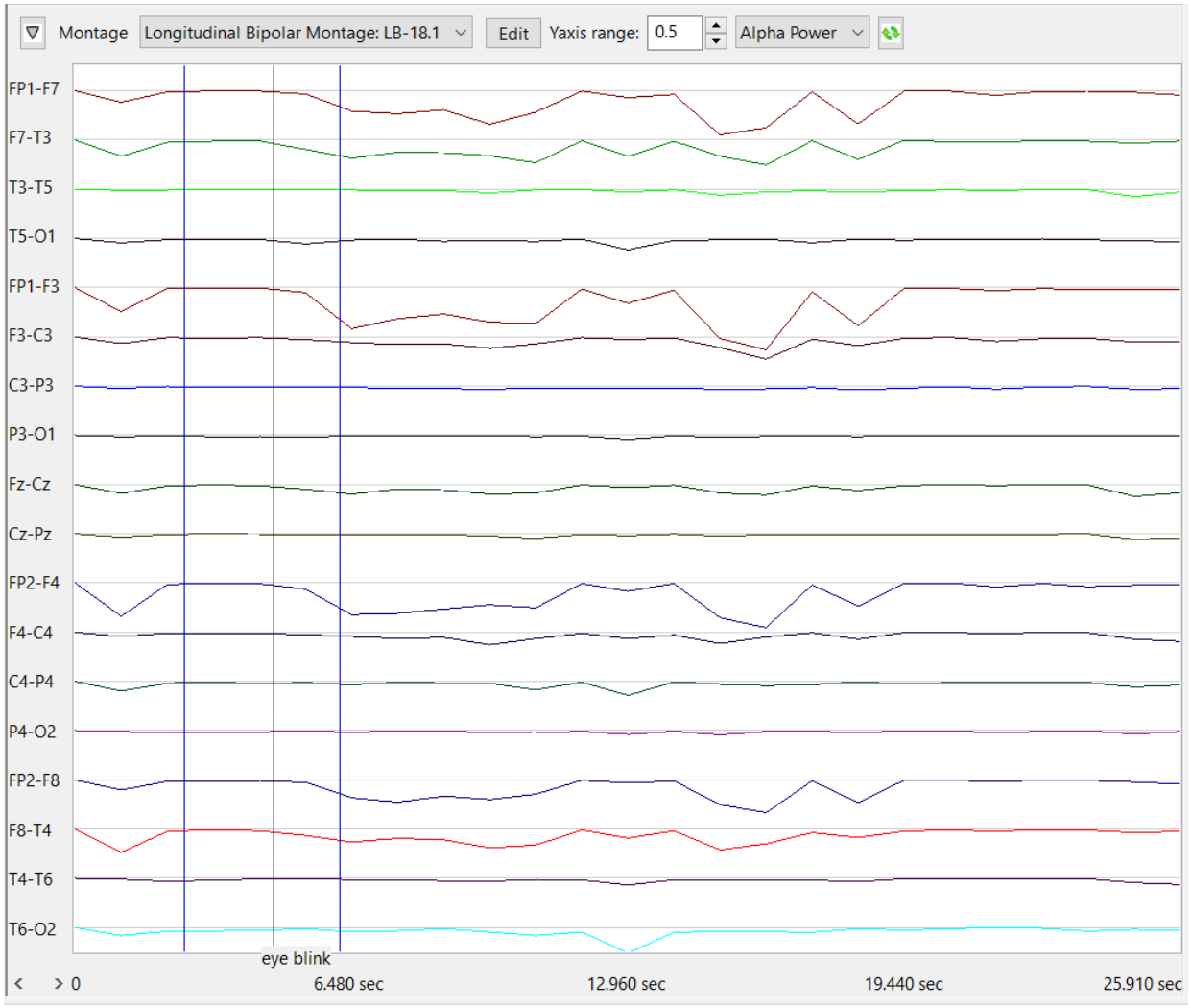
To see a big picture display of all the power bands, choose **EEG Power**.

For each Montage channel, there are 4 vertical bands displayed, the first band corresponds to Alpha Power, the second to Beta Power, the third to Theta Power and the fourth to Delta Power.

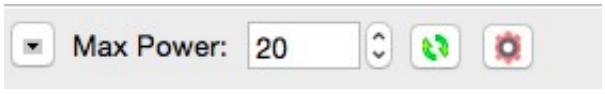
The data displayed can be refreshed by clicking on the refresh icon.



The Alpha, Beta, Theta and Delta power can also be displayed.



The right-hand panel analyzes the data from the chosen montage in the montage configuration panel. Use the toolbar at the top to configure the analysis.



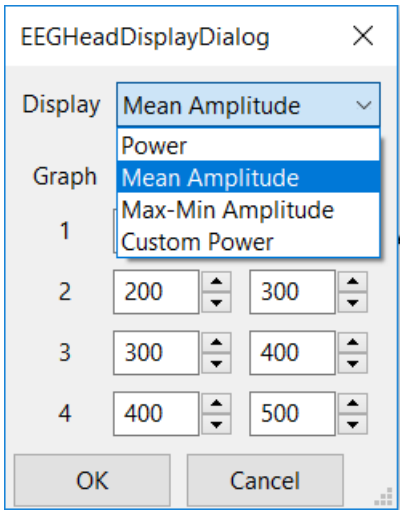
Data analysis configuration toolbar.

1) The arrow at the left of the data analysis configuration toolbar offers the choice to copy the head graph or the data table to the clipboard, export the table data to a spreadsheet, or a selection from the data table to the Journal.
2) Choose the Maximum power to be calculated in the Max Power text box.
3) Click the green recalculation icon each time you desire to recalculate the power and amplitude data based on changes in the montage configuration panel or in the data analysis parameters.

4) Click the red gear icon to the right to display the **EEG Head Display Dialog**. In this dialog, you can choose whether the data table displays the relative powers of the Alpha, Beta, Delta, and Theta wave forms, or the wave form amplitudes (Mean or Max-Min) over chosen time durations in the selection.

The Head Display

The head display can be used to display the following:



1. Power: This is the default display showing the power in the alpha, beta, theta and delta bands.
2. Mean Amplitude: Show the mean amplitude between 4 regions.
3. Max-Min Amplitude: Shows the Max-Min amplitude between 4 regions.
4. Custom Power: This can be used to display other power bands such as Gamma, or High and Low Beta or any other custom band. The high and low frequency for each band can also be selected.
5. The head display indicates the frequency of the Alpha, Beta, Delta, and Theta waveforms or the wave amplitude (depending on which has been chosen) by electrode location.
6. The data table indicates the frequency or the amplitude by electrode location.

8.10: ERP Analysis

An ERP (Event Related Potential) occurs in response to a specific stimulus. This stimulus may be a sensory, cognitive, or motor event. The ERP is the time-locked average of an EEG over many trials involving the same event. The repetition reduces the EEG's inherent signal to noise ratio, so the specific potential related to the event is displayed. The **ERP Advanced Analysis Module** allows sophisticated ERP analysis.

This document includes a step by step tutorial for using most of the features of the **ERP Advanced Analysis Module.** To use the step by step guide, you will need an ERP recording.

ERP Analysis: Step by Step

Recording a Human ERP Data File

You will need to record an electroencephalogram designed to elicit an ERP in order to complete this step by step guide. The ERP Advanced Analysis Module allows the comparison of the ERPs due to different stimuli.

ERP Advanced Analysis Module: Step by Step

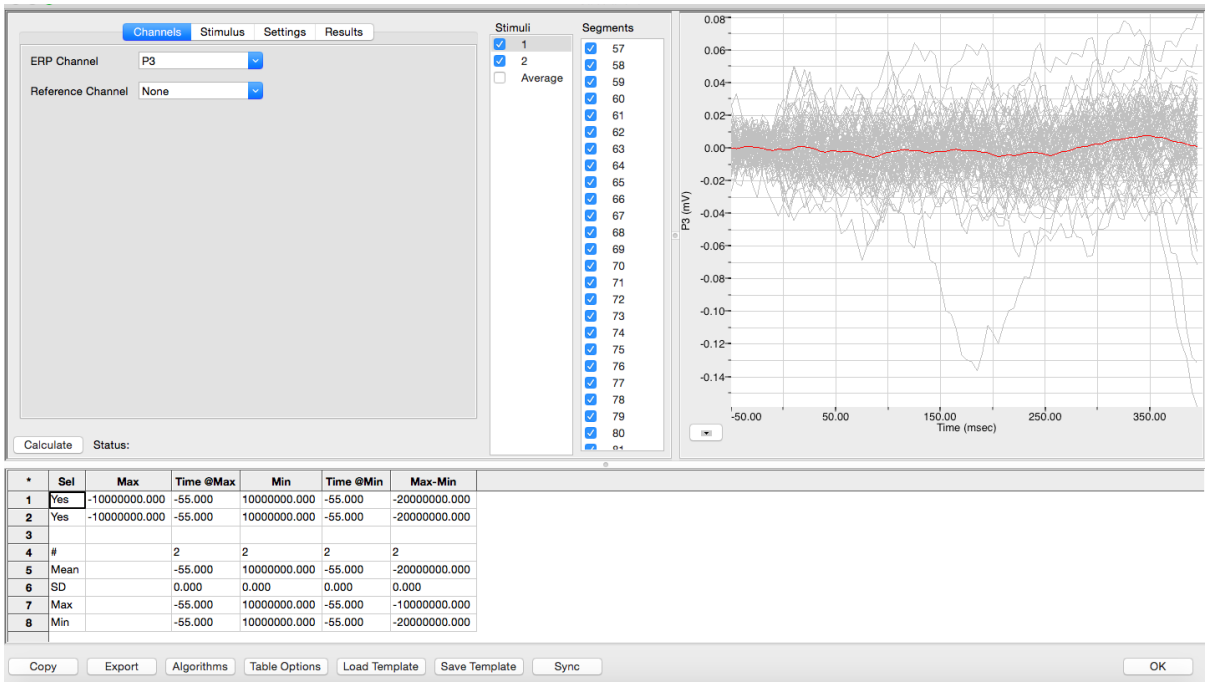
Offline Calculations

The ERP analysis is performed using the **ERP Calculations** dialog, so you should first become familiar with this dialog.

The ERP Calculations Dialog

To display the **ERP Calculations** dialog and familiarize yourself with its features:

1) Open a file with ERP data.
2) Select **ERP** from the **Advanced** menu. Choose **ERP Calculations**, opening the **ERP Calculations** dialog.
3) Familiarize yourself with the **ERP Calculations** dialog, pictured below.
   - On the left are the tabbed dialogs used to configure the analysis.
   - At the right is the XY graph window in which the **ERP Graph** can be displayed.
   - Between the configuration dialogs and the graph are the editable lists of the **Stimuli** and **Segments** to be analyzed and displayed.
   - Across the lower part of the dialog is the **Data Table**, summarizing the calculated average ERP responses for each of the stimuli.



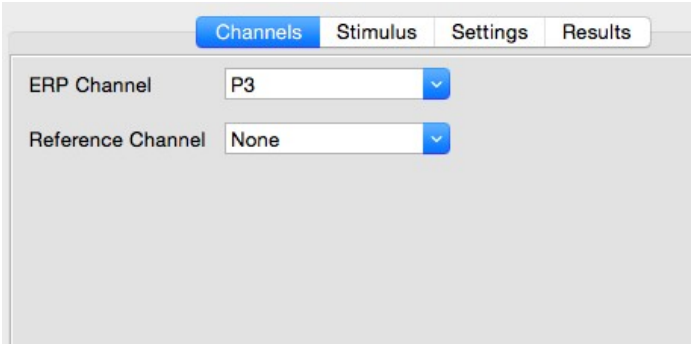
*	Sel	Max	Time @Max	Min	Time @Min	Max-Min
1	Yes	-10000000.000	-55.000	10000000.000	-55.000	-20000000.000
2	Yes	-10000000.000	-55.000	10000000.000	-55.000	-20000000.000
3						
4	#		2	2	2	2
5	Mean		-55.000	10000000.000	-55.000	-20000000.000
6	SD		0.000	0.000	0.000	0.000
7	Max		-55.000	10000000.000	-55.000	-10000000.000
8	Min		-55.000	10000000.000	-55.000	-20000000.000

ERP Calculations dialog.

To configure the analysis, the tabbed configuration panels at the left side of the dialog are used.

To configure Channels:

1) Click the leftmost tab of the configuration dialogs, the one labeled **Channels**.
2) From the **ERP Channel** menu, choose the desired EEG electrode from the menu. This is the channel on which the analysis will be performed.
3) From the **Reference Channel** menu, choose the specific electrode to which the ERP channel is to be compared.
4) These choices may be changed at any point during the analysis.

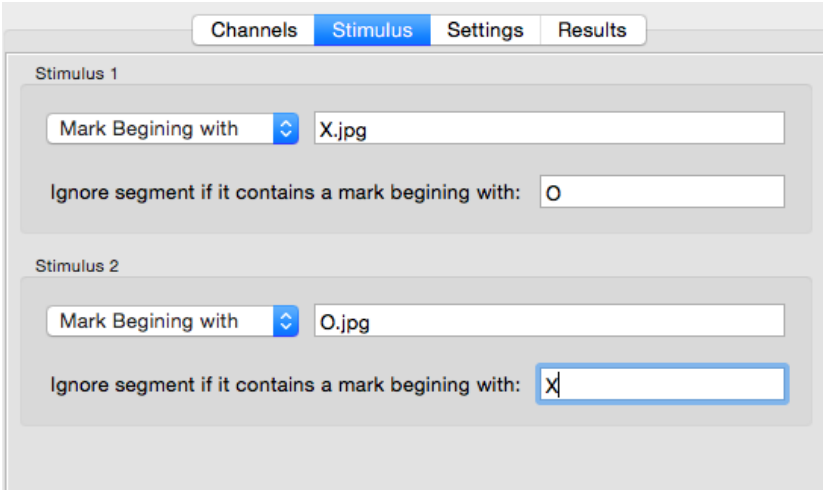


ERP Channels configuration dialog.

Most ERP experiments compare the ERPs in response to two different stimuli.

To configure the **Stimulus:**

1) Click the **Stimulus** tab, which is the second tab from the left in the configuration dialogs. The **ERP Stimulus** configuration dialog will open.

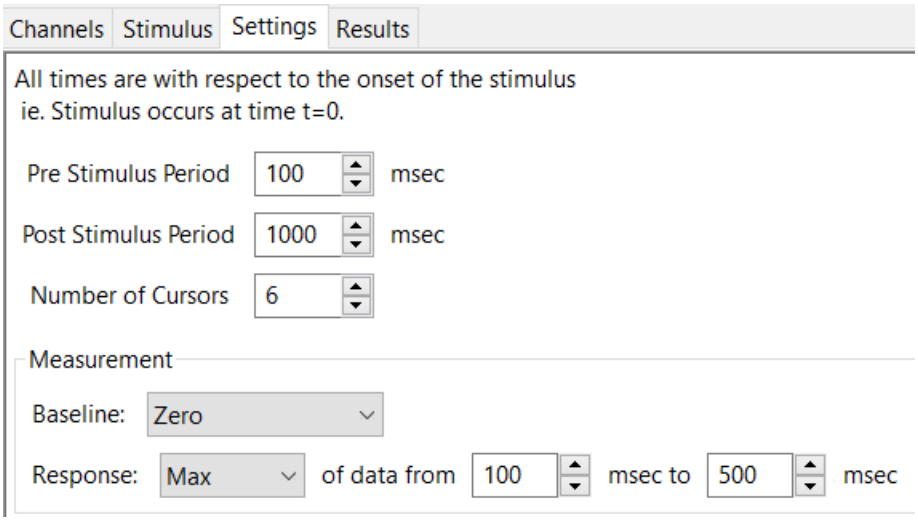


ERP Stimulus configuration dialog.

2) To designate **Stimulus 1**, indicate the mark on the data file that corresponds to that stimulus by choosing either **Mark Beginning with** or **Exact** and entering the relevant text. Alternatively, **Block Start** may be chosen.
3) To designate **Stimulus 2**, indicate the mark that corresponds to that stimulus by choosing either **Mark Beginning with** or **Exact** and entering the relevant text. Alternatively, **Block Start** may be chosen.
4) For both stimuli, segments that contain an incorrect response can be ignored by specifying responses that should be ignored.

To configure the Settings:

1) Click the **Settings** tab, which is the third tab from the left in the configuration dialogs. The **ERP Settings** configuration dialog will open.
2) Both the pre-stimulus and post-stimulus duration to be displayed in the ERP graph can be chosen by entering the desired durations in the appropriate boxes.
3) Choose the desired baseline value by selecting either **Zero**, **Pre-stimulus Mean**, or **Mean** from the **Baseline** menu.
4) Specific ERP components are characterized by the time at which they occur. Choose the time to be analyzed by entering the start and end values in the **Response** text boxes. **Max**, **Min**, **Max-Min**, and **Mean** values within this time window are determined and displayed in the **Data Table**.
5) To exclude segments that fall outside appropriate values, and represent artifacts, enter the allowable segment values into the text boxes in the **Artifact Removal** section.



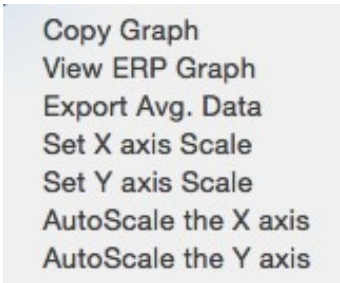
ERP Settings configuration dialog.

6) Once the **Channels**, **Stimulus**, and **Settings** dialogs have been configured, click the **Calculate** button just above the **Data Table** to start the analysis. The **ERP Graph** will appear in the graph window at the right, and the **Data Table** will be populated with values.

***Important:** After any configuration settings are changed, click **Calculate** again, to trigger the revised analysis.*

To display the ERP Graph:

1) Choose **View ERP Graph** from the menu at the lower left of the graph window. The **ERP Graph** will be displayed in the XY Graph window, showing the segments specified in the **Stimuli** and **Segments** lists to its left.
2) There are options to **AutoScale** the **X-axis** and the **Y-axis**. The X and Y axes can also be set manually by using the menu items or clicking and dragging the axis numbers themselves.
3) Copy the graph to the clipboard by choosing **Copy Graph**. The mathematical data from the averages can be exported to a spreadsheet by choosing **Export Avg. Data**.



XY Graph menu.

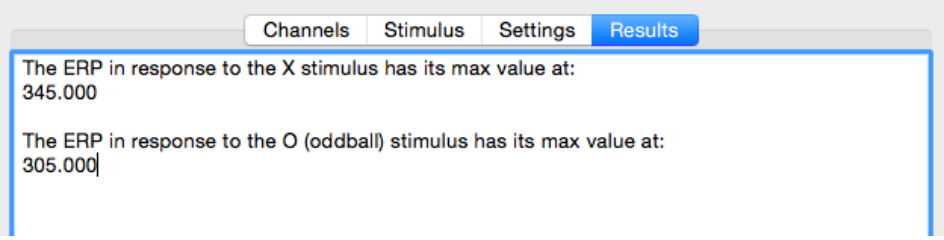
4) Look at the **ERP Graph** and familiarize yourself with its features.

- The graph displays the checked segments representing responses to one of the two stimuli. They are superimposed on each other and the segment mathematically averaged from all of them is highlighted in red. The individual cycles are in grey and the currently selected segment (from the **Segments** list) is in black.

5) Change the responses displayed by selecting a different stimulus in the **Stimuli** list.
6) Select a different segment in the **Segments** list. Notice that the segment displayed in black changes with your selection.
7) Uncheck one of the cycles. Notice that one of the cycles is deleted from the graph. The red averaged cycle will also change to reflect the new mathematical average. Add the cycle back again by checking its check box.
8) To see just the averages, select **Average** from the **Stimuli** list. Highlight one or the other average in black by selecting **Stim 1** or **Stim 2** from the **Stimuli** list.
9) To see the difference between the Stim1 and Stim 2 response, select **Difference** from the **Stimuli** list

To configure the Results:

1) Click the **Results** tab, which is the fourth tab from the left in the configuration dialogs. The **ERP Results** configuration dialog will open.
2) In this dialog, you may enter text, and copy items from the clipboard.



ERP Results configuration dialog.

Data Table

The top two horizontal rows in the data table summarize and compare the averaged ERP values (choosing from **Max**, **Time at Max**, **Min**, **Time at Min**, and **Max-Min**) resulting from each of the two stimuli. The averages displayed are those occurring within the time window specified in the **Settings** dialog.

*	Sel	Max	Time @Max	Min	Time @Min	Max-Min	C1 val	C1 time	C2 val	C2 time	C3 val	C3 time	C4 val	C4 time	C5 val	C5 time	C6 val	C6 time
1	Yes	-3.474	122.000	-3.489	472.000	0.015	-3.470	-28.000	-3.474	162.000	-3.486	312.000	-3.487	450.000	-3.490	592.000	-3.470	724.000
2	Yes	-3.490	104.000	-3.526	326.000	0.036	-3.517	-28.000	-3.510	162.000	-3.522	312.000	-3.523	450.000	-3.509	592.000	-3.518	724.000
3																		
4	#		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	Mean		113.000	-3.508	399.000	0.026	-3.494	-28.000	-3.492	162.000	-3.504	312.000	-3.505	450.000	-3.499	592.000	-3.494	724.000
6	SD		9.000	0.019	73.000	0.011	0.023	0.000	0.018	0.000	0.018	0.000	0.018	0.000	0.009	0.000	0.024	0.000
7	Max		122.000	-3.489	472.000	0.036	-3.470	-28.000	-3.474	162.000	-3.486	312.000	-3.487	450.000	-3.490	592.000	-3.470	724.000
8	Min		104.000	-3.526	326.000	0.015	-3.517	-28.000	-3.510	162.000	-3.522	312.000	-3.523	450.000	-3.509	592.000	-3.518	724.000

The Data Table.

To use the Data Table and export values:

1) Click **Table Options** at the bottom of the dialog to see a list of all the ERP parameters that can be displayed in the **Data Table**. These parameters and calculations are all defined in the **ERP Advanced Analysis Module: Reference** section.
2) Choose the options you wish to include in the analysis and display in the **Data Table**. Choose whether you wish to display the **Time from the Start of the Selection** or the **Time of Day** of the recording. Click **OK**.

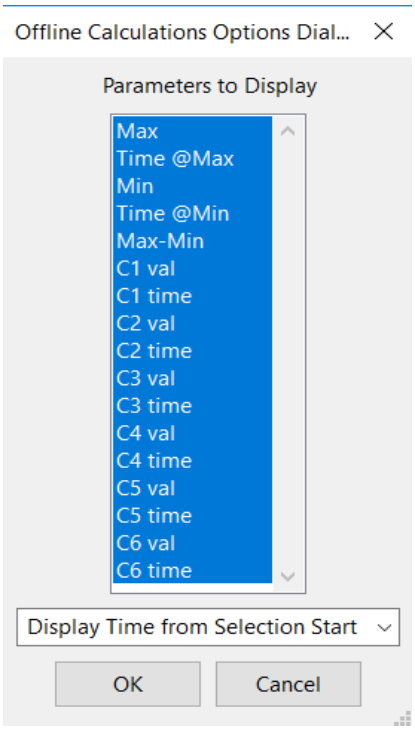


Table Options dialog.

3) Click the asterisk in the upper left corner of the **Data Table**. The **Autosize** option adjusts the size of the cells for optimal display. The **Copy Selection** option will copy any selected cells to the clipboard.
4) Click **Algorithms** to see the definitions of the parameters and calculations.
5) To copy all the calculated data in the **Data Table** to the clipboard, click the **Copy** button, or click the **Export** button to export the data. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
6) To load the analysis configuration for the current analysis, click **Save Template** to name and save the settings. Clicking **Load Template** when the module is reopened will display the list of previously saved templates.

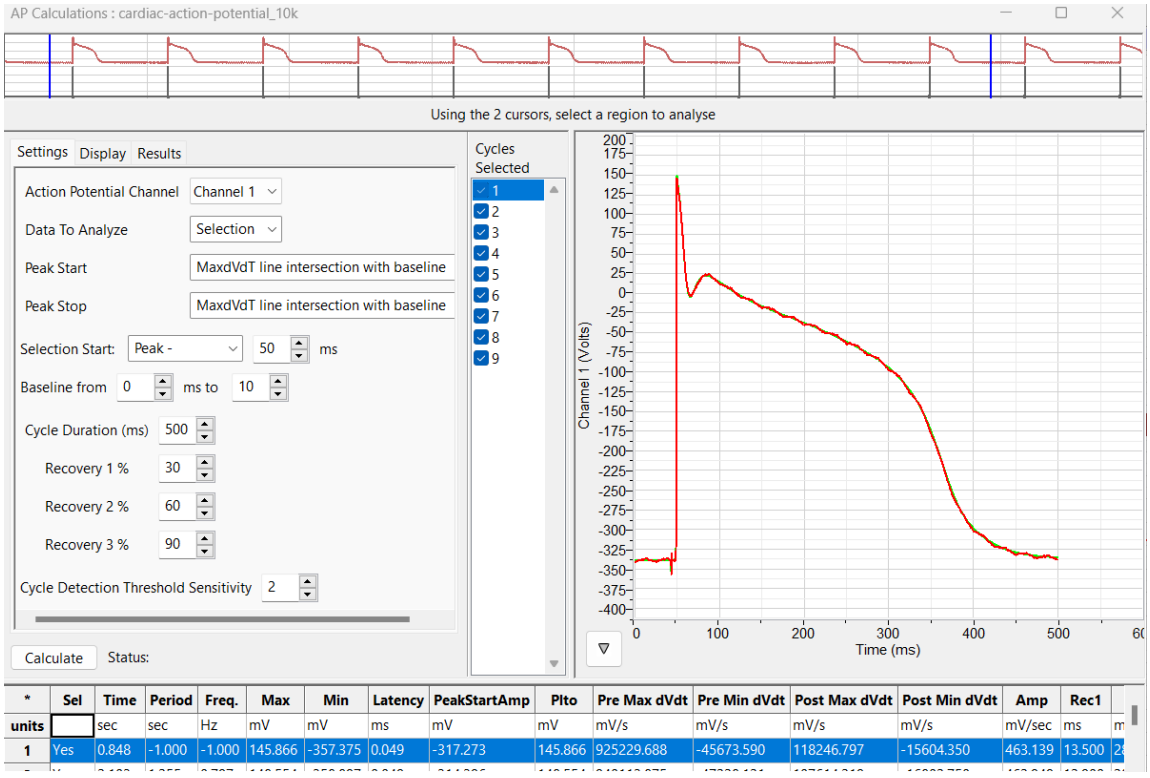
8.11: Action Potentials

The **Action Potentials Advanced Analysis Module** calculates physiologically relevant parameters from previously recorded intracellular cardiac action potential data.

This document includes a step by step tutorial for using the features of the *LabScribe* **Action Potentials Advanced Analysis Module**. To use the step by step guide, you will need a recording of intracellularly recorded Action Potentials from any species.

Action Potentials Analysis: Step by Step

Sophisticated analysis can be done on a previously recorded cardiac action potentials data file using the **Action Potentials Advanced Analysis Module**.



*	Sel	Time	Period	Freq.	Max	Min	Latency	PeakStartAmp	PIto	Pre Max dVdt	Pre Min dVdt	Post Max dVdt	Post Min dVdt	Amp	Rec1
units		sec	sec	Hz	mV	mV	ms	mV	mV	mV/s	mV/s	mV/s	mV/s	mV/sec	ms
1	Yes	0.848	-1.000	-1.000	145.866	-357.375	0.049	-317.273	145.866	925229.688	-45673.590	118246.797	-15604.350	463.139	13.500

The Action Potentials Calculations Dialog

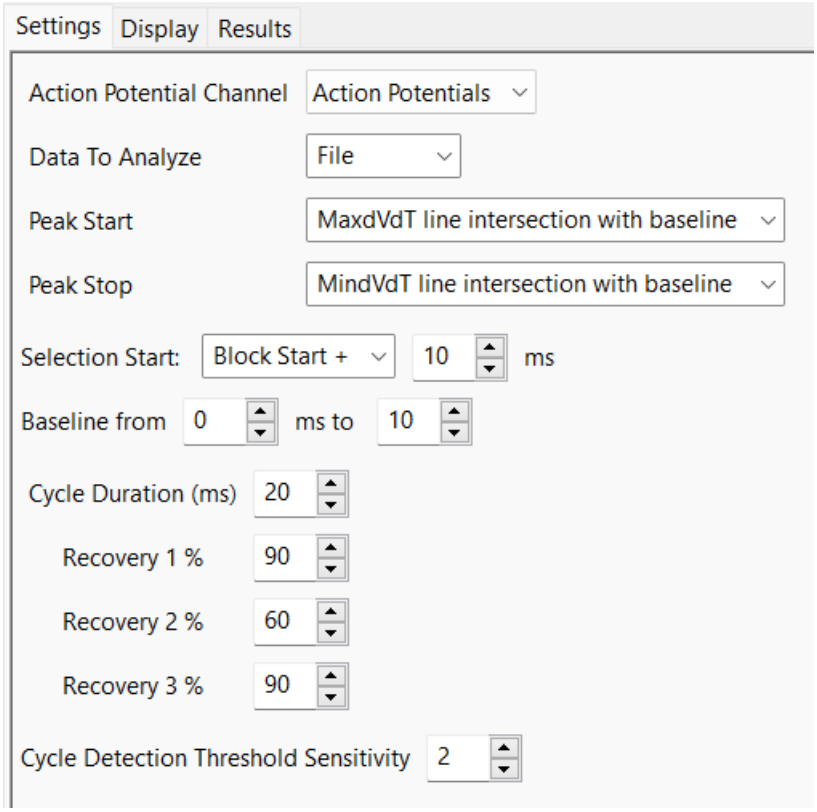
To display the **Action Potentials Calculations** dialog and familiarize yourself with its features:

1) If it is not already open, open a cardiac action potential recording.
2) Select the **Action Potentials** submenu of the **Advanced** menu. This will open the offline **Action Potentials Calculations** dialog.
3) Familiarize yourself with the offline **Action Potentials Calculations** dialog, pictured below.
   - Across the top of the dialog, in the channel display area, you will see a sample of the raw data channel to be analyzed, including the selection between the two cursors. By default **Channel 1** is displayed.

- On the left of the middle row are the tabbed dialogs used to configure the analysis.
- At the right is the XY graph window in which the **Action Potentials Graph** is displayed.
- Between the configuration dialogs and the graph are the editable lists of the **Cycles** to be analyzed and displayed.
- Across the lower part of the dialog is the **Data Table** with the calculated average values for each of the analyzed groups of beats.

To configure the analysis, the tabbed configuration panels at the left side of the middle row of the dialog are used.

Settings:



1) From the **Action Potential Channel** dropdown, choose the desired channel. This is the channel on which the analysis will be performed.
2) From the **Data to Analyze** menu, choose whether you want to analyze the entire file, a block of data, or a selection of data defined by the two cursors.
3) Detect the start of the peak. You can choose:
   1. **derivative zero** : The max derivative before the peak is detected, and the program walks back until the derivative is zero.
   2. **MaxdVdT line intersection with baseline** : A line is drawn tangential to the max derivative and the point where this line intersects the baseline is selected.

3. **MindVdT line intersection with baseline** : A line is drawn tangential to the minimum derivative and the point where this line intersects the baseline is selected.

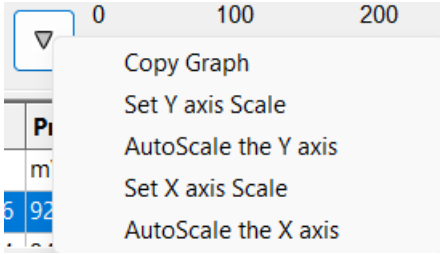
4) Detect the stop of the peak. You can choose:
   1. **derivative zero** : The min derivative after the peak is detected, and the program walks forward until the derivative is zero.
   2. **MaxdVdT line intersection with baseline** : A line is drawn tangential to the max derivative after the peak and the point where this line intersects the baseline is selected.
   3. **MindVdT line intersection with baseline** : A line is drawn tangential to the minimum derivative after the peak and the point where this line intersects the baseline is selected.
   4. **Start Value :** The program tries to detect the pooint at which the peak comes down to the start value or as close to it as possible.
5) The start of the selection(or cycle) for each peak, can be the block start plus an offset value, or the peak location minus a value
6) The baseline can be calculated for each cycle.
7) The cycle duration is the duration of the selection.
8) From the **Recovery 1%, Recovery 2%, and Recovery 3%** menus, choose the % recovery you would like indicated on the graph and entered onto the **Data Table** for each of these points.
9) From the **Cycle Detection Threshold Sensitivity** menu, choose **2**. It is important that the cycle detection is set to the correct sensitivity. Adjusting the **Cycle Detection Threshold Sensitivity** number to higher numbers will lower the threshold at which a cycle is detected. Start at a low value; you will be able to adjust this later if you discover that cycles are being missed in the analysis.
10) Click the **Calculate** button just above the **Data Table** to start the analysis. The **Action Potentials Graph** will appear in the graph window at the right, and the **Data Table** will be populated with values.

Important: *After any configuration settings are changed, click* ***Calculate****, to trigger the revised analysis.*

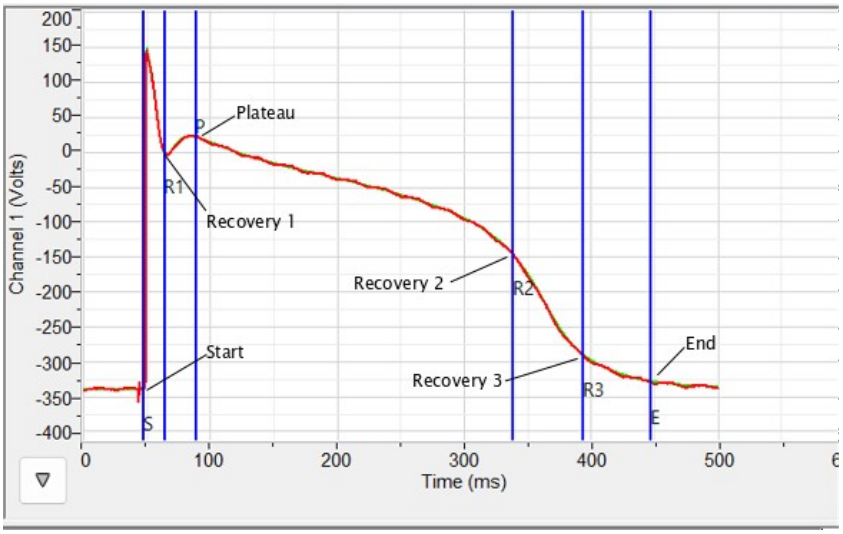
Once the **Settings** configuration dialogs are completed, it is possible to view the **Action Potentials Graph** and start the analysis.

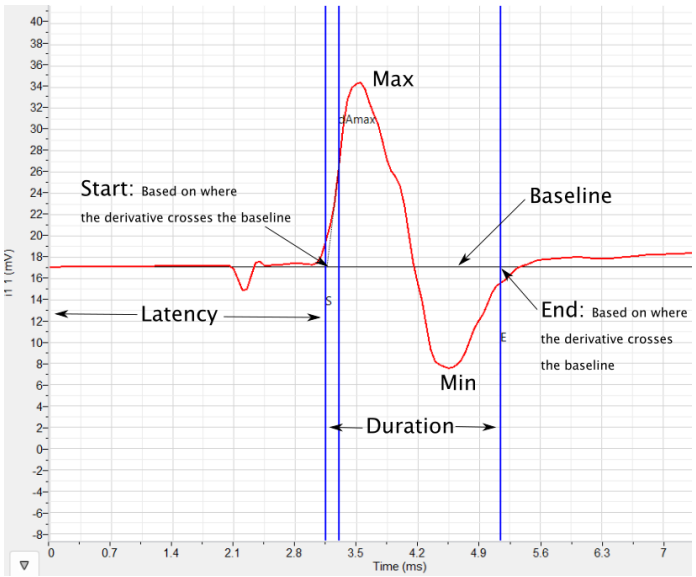
To display the **Action Potentials Graph:**

1) The Action Potentials Graph should be automatically displayed in the XY Graph window, showing the selected cycle from the group of cycles specified in the **Cycles in Group** list to its left.
2) Use the menu indicated by the arrow at the lower left of the graph to **Copy Graph** to the clipboard, **Set the X,Y axis scale**, or **AutoScale the X,Y axis**. .



3) Look at the **Action Potentials Graph** and familiarize yourself with its features.
   - Action Potentials parameters are indicated by the vertical blue Marks on the graph. The parameters that are shown are determined by the **Display** configuration dialog.
   - The specific cycle shown in the graph corresponds to the checked cycle in the **Cycles Selected** list to the left of the graph. The parameters and calculations from this cycle appear in the **Data Table**.
4) Change the cycle displayed by selecting a different cycle in the **Cycles Slected** list. The cycles are listed in order of their appearance in the data file.
5) The current Graph is shown in Red. The average graph is shown in Green, and the baseline if show in Black. You can choose to hide the average or the baseline using the display Tab.

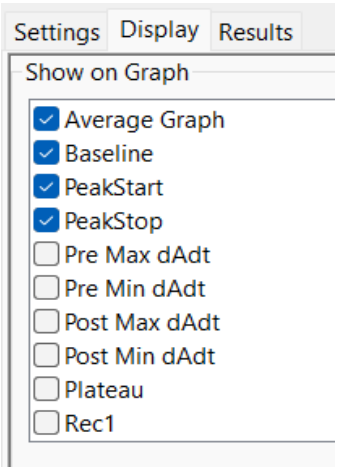




Display:

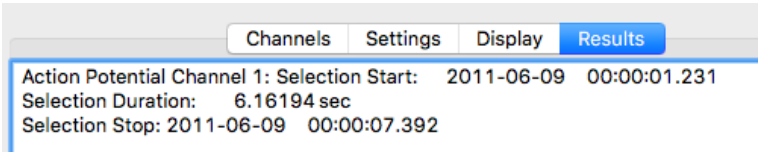
To configure the **Display** dialog:

1) Click on the **Display** tab to open the **Display** configuration dialog.
2) From the **Show on Graph** menu, choose if you want to show the average graph or the baseline, as well as which parameters you would like indicated on the **Action Potentials Graph** Choose from the **Peak Start**, **Peak Stop** the **Maximum** and **Minimum** derivatives, and the three **Recovery** points specified in the **Settings** dialog. These parameters are defined in the Algorithms section below.



Results.:

The **Results** dialog includes basic information about the selection being analyzed, and can be edited by the user.



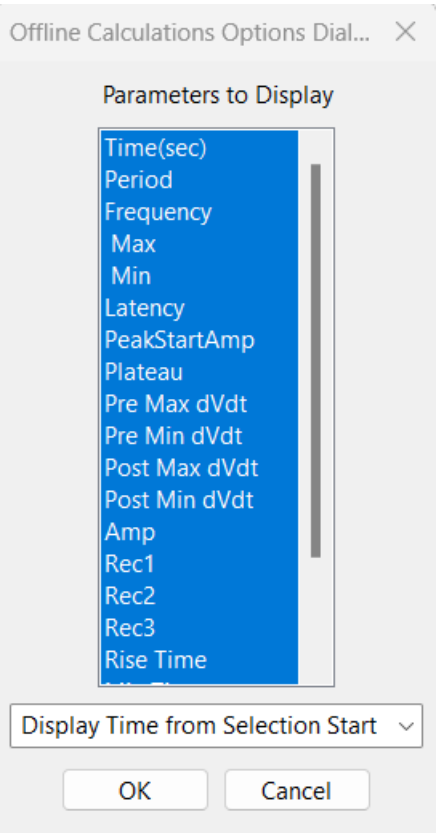
1) Click on the **Results** tab to open the **Results** configuration dialog.
2) The **Results** dialog includes basic information about the selection being analyzed. To edit the information included, add more text or paste the contents of the clipboard into the dialog.

Data Table

All the data for each cycle, as well as the averaged values for all the cycles, is included in the **Data Table.**

*	Sel	Time	Period	Freq.	Max	Min	Latency	PeakStartAmp	Plto	Pre Max dVdt	Pre Min dVdt	Post Max dVdt	Post Min dVdt	Amp	Rec1	
units		sec	sec	Hz	mV	mV	ms	mV	mV	mV/s	mV/s	mV/s	mV/s	mV/sec	ms	n
1	Yes	0.848	1.000	1.000	145.866	-357.375	0.048	-340.485	23.600	925229.688	-45673.590	118246.797	-15604.350	364.085	16.200	2
2	Yes	2.103	1.255	0.797	148.554	-358.897	0.047	-340.256	24.646	940113.875	-47228.121	107614.219	-16802.750	364.902	16.200	2
3	Yes	3.359	1.255	0.797	149.665	-356.233	0.047	-338.179	22.513	943408.875	-49647.824	101894.672	-16223.433	360.693	15.900	2
4	Yes	4.614	1.255	0.797	149.356	-354.341	0.048	-336.649	21.499	942946.250	-48810.523	99822.359	-18390.787	358.148	14.500	2
5	Yes	5.870	1.255	0.797	147.261	-357.672	0.048	-339.200	23.199	944247.500	-54415.555	93714.250	-15462.569	362.399	15.300	2
6	Yes	7.125	1.255	0.797	148.148	-359.965	0.048	-341.200	24.228	946925.562	-48537.527	84135.711	-16897.561	365.428	15.600	2
7	Yes	8.380	1.255	0.797	150.935	-359.627	0.048	-338.381	23.600	939768.812	-43761.902	75343.297	-16188.400	361.981	15.000	2
8	Yes	9.636	1.255	0.797	150.293	-356.382	0.048	-337.057	21.335	928194.688	-46376.578	64920.984	-17287.891	358.392	14.800	2
9	Yes	10.891	1.255	0.797	147.959	-354.041	0.048	-339.094	23.213	924787.250	-50504.352	118947.305	-16271.192	362.306	15.400	2
10	Yes	12.146	1.255	0.797	147.257	-356.969	0.048	-339.200	25.501	944231.188	-53003.031	100279.672	-16161.969	364.701	15.400	2
12																
13	#		10	10	10	10	10	10	10	10	10	10	10	10	10	1
14	Mean		1.030	0.617	148.529	-357.150	0.048	-338.970	23.333	937985.369	-48795.900	96491.927	-16529.090	362.304	15.430	2
15	SD		0.677	0.539	1.472	1.909	0.001	1.381	1.242	8078.631	3104.723	16613.948	815.828	2.464	0.539	1
16	Max		1.255	0.797	150.935	-354.041	0.048	-336.649	25.501	946925.562	-43761.902	118947.305	-15462.569	365.428	16.200	2
17	Min		-1.000	-1.000	145.866	-359.965	0.047	-341.200	21.335	924787.250	-54415.555	64920.984	-18390.787	358.148	14.500	2

Copy Export Algorithms Table Options Load Template Save Template



To use the **Data Table** and export values to the **Journal:**

1) Click **Table Options** at the bottom of the dialog to see a list of all the cardiac action potential parameters that can be displayed in the **Data Table**. These parameters and calculations are all defined in the **Algorithms** dialog, and are summarized below.

2) Choose the options you wish to include in the analysis and display in the **Data Table**. Choose whether you wish to display the **Time from the Start of the Selection** or the **Time of Day** of the recording. Click **OK**.
3) Click the asterisk in the upper left corner of the **Data Table**. The **Autosize** option adjusts the size of the cells for optimal display. The **Copy Selection** option will copy any selected cells to the clipboard.
4) Click **Algorithms** to see the definitions of the parameters and calculations. The definitions are also included below.
5) To copy all the calculated data in the **Data Table** to the clipboard, click the **Copy** button, or click the **Export** button to export the data. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
6) To load the analysis configuration for the current analysis, click **Save Template** to name and save the settings. Clicking **Load Template** when the module is reopened will display the list of previously saved templates.
7) Click **OK to** save the current configuration. The next time the offline **Action Potentials Calculations** dialog is opened, it opens with these settings.

Offline Calculation Algorithms: The offline calculations include:

- **Period**: The time from the start of one action potential to the start of the next.
- **Rate**: Rate, measured in Hz.
- **Maximum**: Maximum amplitude voltage for the selected action potential.
- **Minimum**: Minimum amplitude voltage for the selected action potential.
- **Peak Start Amplitude**: Voltage before the initial upswing of the action potential.
- **Latency** : Time from start of the cycle to the Peak Start
- **Pre Max dAdt**: Maximum derivative of action potential before the peak.
- **Pre Min dAdt**: Minimum derivative of action potential before the peak.
- **Post Max dAdt**: Maximum derivative of action potential after the peak.
- **Post Min dAdt**: Minimum derivative of action potential after the peak.
- **Plto**: Plateau voltage of action potential.
- **Amplitude**: Plto - PeakStartAmplitude**.**
- **Recovery 1**: The time, in milliseconds, from PeakStart to the point where the signal drops below the level corresponding to the % Recovery 1 level.
- **Recovery 2**: The time, in milliseconds, from PeakStart to the point where the signal drops below the level corresponding to the % Recovery 1 level.
- **Recovery 3**: The time, in milliseconds, from PeakStart to the point where the signal drops below the level corresponding to the % Recovery 1 level..
- **Rise Time**: Time from PeakStart to Maximum.
- **Minimum Time**: Time from PeakStart to Minimum.
- **Peak Stop**: Time where the peak ends.
- **Cycle Duration**: Time from PeakStart to PeakStop

Other Examples

8.12: Respiration Analysis

The **Respiration Analysis Module** calculates physiologically relevant parameters from previously recorded respiration pressure and volume data.

This document includes a step by step tutorial for using the features of the *LabScribe* **Respiration Analysis Module**. To use the step by step guide, you will need a recording of recorded Respiration from any species.

Respiration Analysis: Step by Step

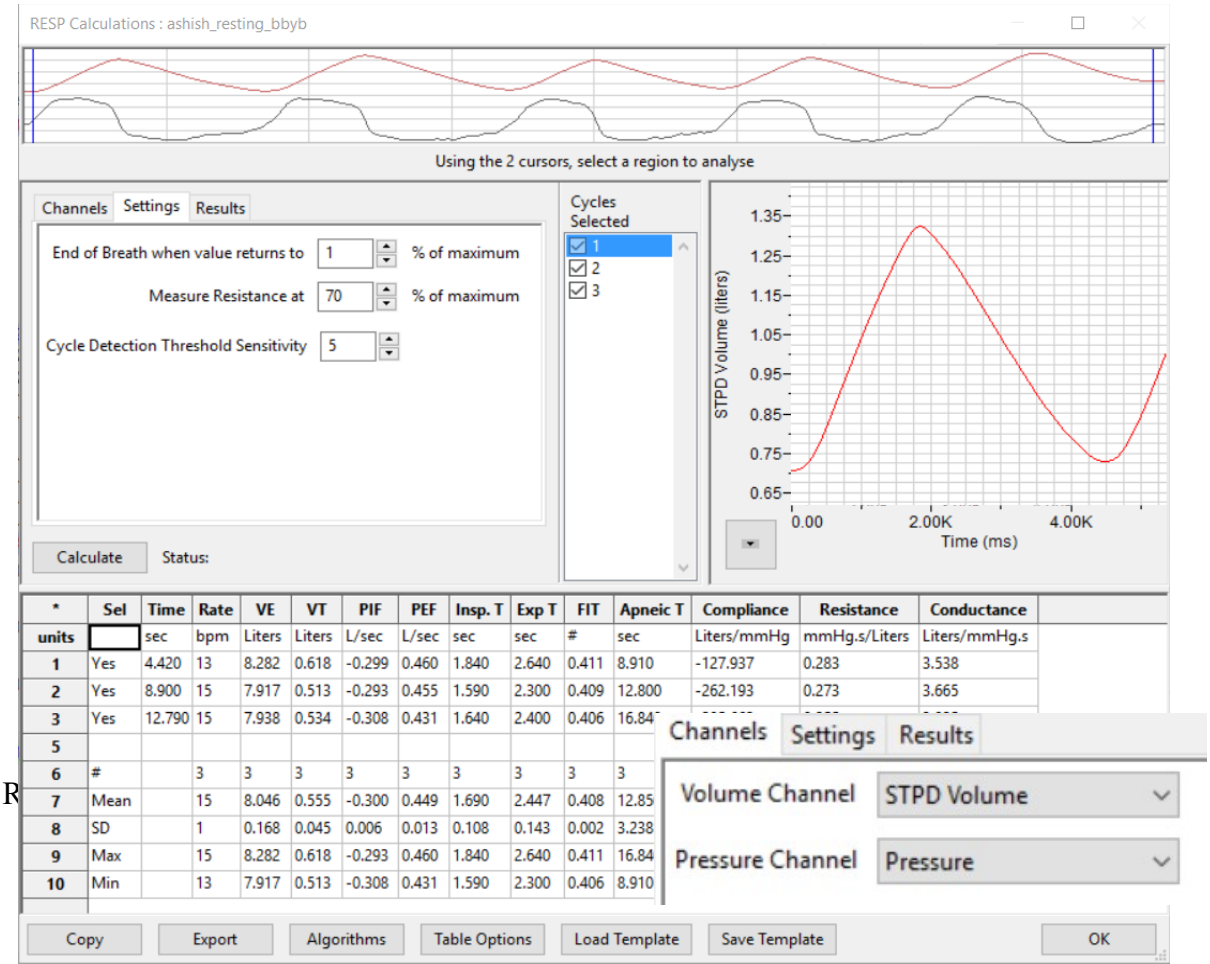
Offline Calculations

Sophisticated analysis can be done on a previously recorded Respiration data file using the **Offline Calculations** function of the **Respiration Advanced Analysis Module**. This analysis is performed using the offline **Respiration Calculations** dialog, so you should first become familiar with this dialog.

The Offline Respiration Calculations Dialog

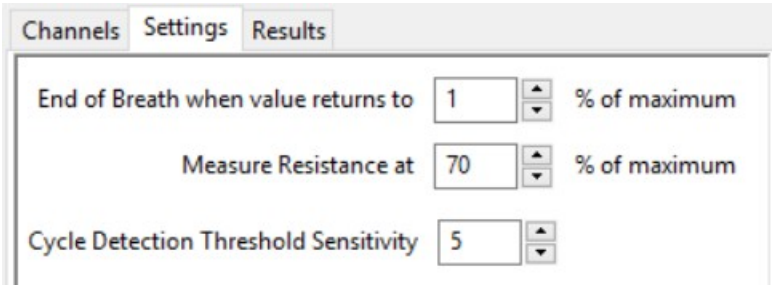
To display the **Respiration Calculations** dialog and familiarize yourself with its features:

1) If it is not already open, open a respiration recording.
2) Select **Respiration Analysis** from the **Advanced** menu. This will open the offline **Respiration Calculations** dialog.
3) Familiarize yourself with the offline **Respiration Calculations** dialog, pictured below.



1) Click the leftmost tab of the configuration dialogs, the one labeled **Channels**.
2) Choose the Volume and the Pressure Channel.

To configure the **Settings:**



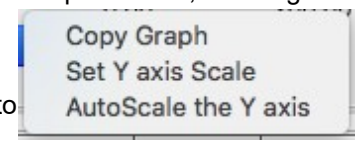
1) Click the **Settings** tab, which is the second tab from the left in the configuration dialogs. The **Respiration Settings** configuration dialog will open.
2) Choose when the end of the breath should be determined.
3) Choose the point at which the Resistance should be calculated.
4) From the **Cycle Detection Threshold Sensitivity** menu, choose **2**. It is important that the cycle detection is set to the correct sensitivity. Adjusting the **Cycle Detection Threshold Sensitivity** number to higher numbers will lower the threshold at which a cycle is detected. Start at a low value; you will be able to adjust this later if you discover that cycles are being missed in the analysis.
5) Click the **Calculate** button just above the **Data Table** to start the analysis. The **Respiration Graph** will appear in the graph window at the right, and the **Data Table** will be populated with values.

Important: *After any configuration settings are changed, click* ***Calculate****, to trigger the revised analysis.*

Once the **Channels** and **Settings** configuration dialogs are completed, it is possible to view the **Respiration Graph** and start the analysis.

To display the **Respiration Graph:**

1) The Respiration Graph should be automatically displayed in the XY Graph window, showing the selected cycle from the group of cycles specified in the **Cycles in Group** list to its left.
2) Use the menu indicated by the arrow at the lower left of the graph to **Copy Graph** to the clipboard, **Set the Y axis scale**, or **AutoScale the Y axis**. .

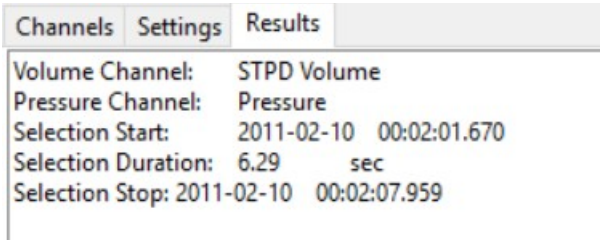


3) Look at the **Respiration Graph** and familiarize yourself with its features.
   - Respiration parameters are indicated by the vertical blue Marks on the graph. The parameters that are shown are determined by the **Display** configuration dialog.
   - The specific cycle shown in the graph corresponds to the checked cycle in the **Cycles Selected** list to the left of the graph. The parameters and calculations from this cycle appear in the **Data Table**.

4) Change the cycle displayed by selecting a different cycle in the **Cycles Slected** list. The cycles are listed in order of their appearance in the data file.

The **Results** dialog includes basic information about the selection being analyzed,

1) Click on the **Results** tab to open the **Results** configuration dialog.
2) The **Results** dialog includes basic information about the selection being analyzed.

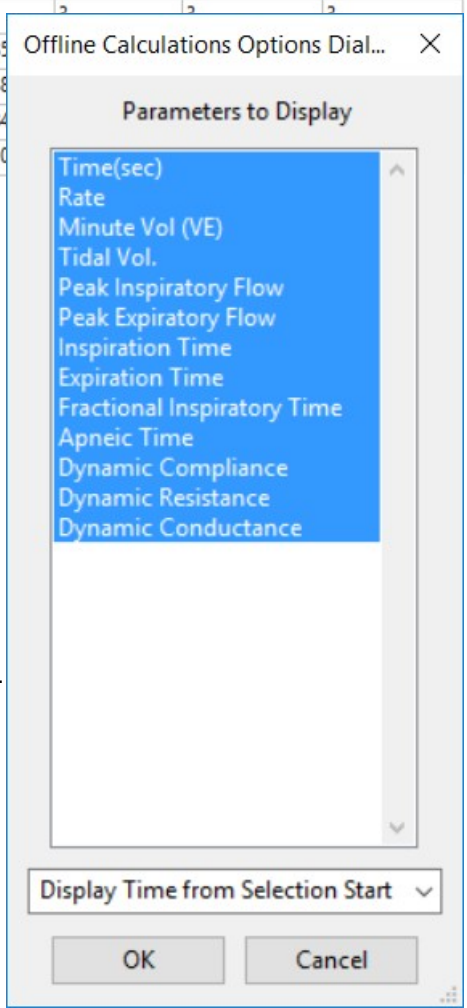


Data Table

All the data for each cycle, as well as the averaged values for all the cycles, is included in the **Data Table.**

*	Sel	Time	Rate	VE	VT	PIF	PEF	Insp. T	Exp T	FIT	Apneic T	Compliance	Resistance	Conductance
units		sec	bpm	Liters	Liters	L/sec	L/sec	sec	sec	#	sec	Liters/mmHg	mmHg.s/Liters	Liters/mmHg.s
1	Yes	4.420	13	8.282	0.618	-0.299	0.460	1.840	2.640	0.411	8.910	-127.937	0.283	3.538
2	Yes	8.900	15	7.917	0.513	-0.293	0.455	1.590	2.300	0.409	12.800	-262.193	0.273	3.665
3	Yes	12.790	15	7.938	0.534	-0.308	0.431	1.640	2.400	0.406	16.840	-295.662	0.255	3.925
5														
6	#		3	3	3	3	3	3	3	3	3			
7	Mean		15	8.046	0.555	-0.300	0.449	1.690	2.447	0.408	12.85			
8	SD		1	0.168	0.045	0.006	0.013	0.108	0.143	0.002	3.238			
9	Max		15	8.282	0.618	-0.293	0.460	1.840	2.640	0.411	16.84			
10	Min		13	7.917	0.513	-0.308	0.431	1.590	2.300	0.406	8.910			

The Respiration Data Table.



To use the **Data Table** and export values to the **Journal:**

1) Click **Table Options** at the bottom of the dialog to see a list of all the cardiac action potential parameters that can be displayed in the **Data Table**. These parameters and calculations are all defined in the **Algorithms** dialog, and are summarized below.
2) Choose the options you wish to include in the analysis and display in the **Data Table**. Choose whether you wish to display the **Time from the Start of the Selection** or the **Time of Day** of the recording. Click **OK**.
3) Click the asterisk in the upper left corner of the **Data Table**. The **Autosize** option adjusts the size of the cells for optimal display. The **Copy Selection** option will copy any selected cells to the clipboard.

4) Click **Algorithms** to see the definitions of the parameters and calculations. The definitions are also included below.
5) To copy all the calculated data in the **Data Table** to the clipboard, click the **Copy** button, or click the **Export** button to export the data. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
6) To load the analysis configuration for the current analysis, click **Save Template** to name and save the settings. Clicking **Load Template** when the module is reopened will display the list of previously saved templates.
7) Click **OK to** save the current configuration. The next time the offline **Respiration Calculations** dialog is opened, it opens with these settings.

Offline Calculation Algorithms: The offline calculations include:

- **Rate** : Respiration Rate (bpm)
- **VE**: Minute Vol. (VE) is calculated as VT*Rate
- **VT:** Tidal Vol. Volume of air displaced between normal inspiration and expiration
- **PIF**: Peak Inspiratory Flow.
- **PEF**: Peak Expiratory Flow
- **Insp. T:** Inspiration Time
- **Exp. T**: Expiration Time
- **FIT**: Fractional Inspiratory Time, it is calculated as
  Inspiration Time/(Inspiration Time + Expiration Time)
- **Apneic T**: Apneic Time. Time from end of breath to start of next breath
- **Compliance**: Dynamic Compliance
  deltaV/deltaP) at zero flow pt
- **Resistance**: Dynamic Resistance
  (deltaP/deltaF) at isovolume pts
- **Conductance**: Dynamic Conductance
  (deltaF/deltaP) at isovolume pts

8.13 Stimulus Response

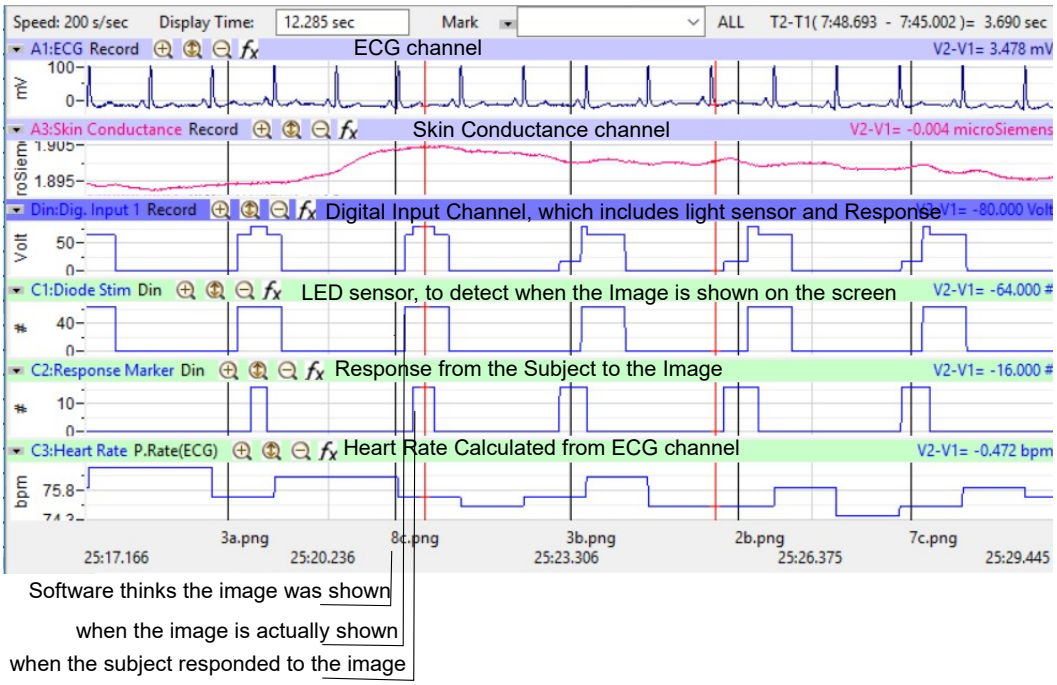
The **Stimulus Response Analysis Module** is an advanced analysis module that allows users to automatically calculate data such as: Mean, Maximum, Minimum, Time to Maximum, Time to Minimum, Response Time, and the Correct Response.

This document includes a step by step tutorial for using the features of the LabScribe **Stimulus Response Analysis Module**. To use the step by step guide, you will need a recording of stimulus and response data file.

Stimulus Response Analysis: Step by Step

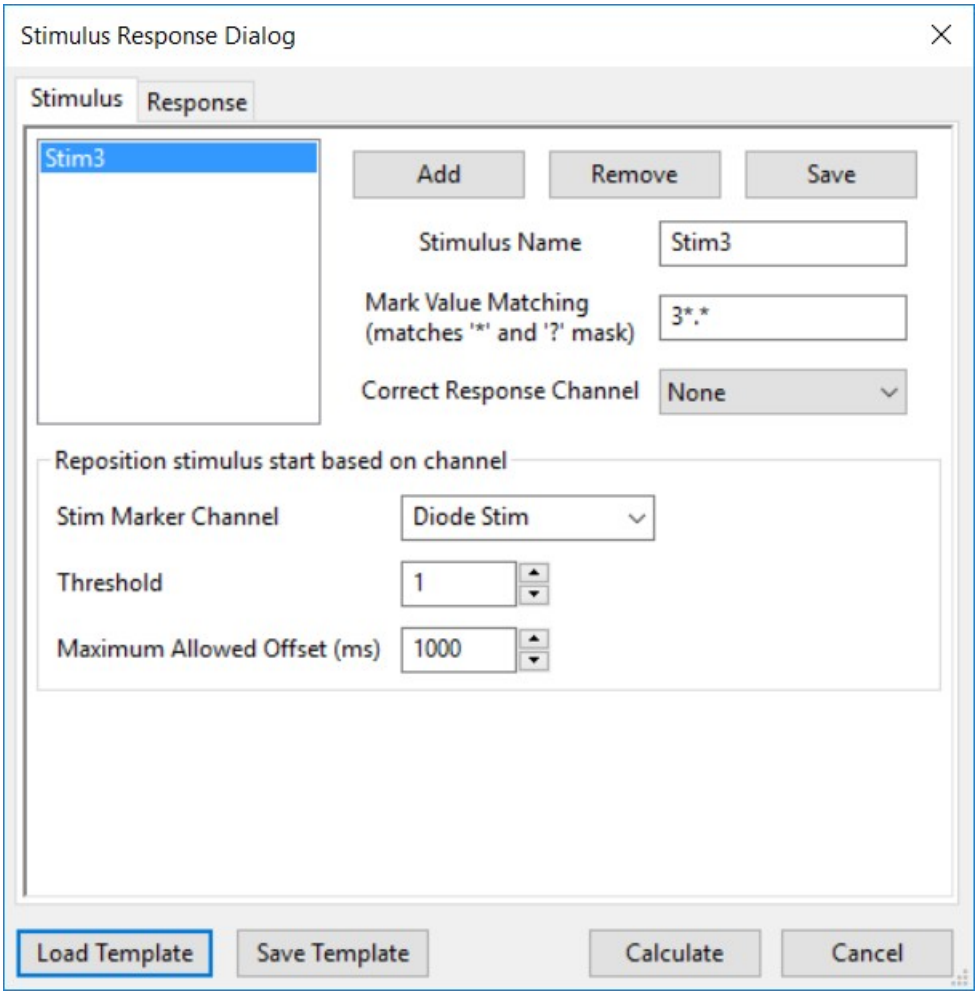
Sophisticated analysis can be done on a previously recorded data file using the **Stimulus Response Analysis Module**.

A screenshot from a stimulus response file is shown below.



ECG, skin conductance, a light sensor and the user response are recorded in this file. As you can see, there is a time difference between when the software tells the computer to show an image and when the image is actually displayed. The Stimulus Response analysis module can take this into account.

The Stimulus Response Analysis dialog can be launched from the Advanced menu in LabScribe. When the dialog is launched the first time, it will ask for the User Name and License for the Stimulus Response Analysis module. Please contact iWorx Systems for more information.



The Stimulus Response Dialog has 2 tabs:

Stimulus:

This tab is used to define the different stimuli in the file. To add a Stimulus click on the **Add** button. A sample stimulus will be added, For each Stimulus you can define the following:

- **Stimulus Name**. This makes it easy to identify the stimulus.
- **Mark Value Matching**: Regular Expression and Wildcard capabilities are available for defining a pattern to match Marks in the record. For example: N*.jpg will find all marks that begin with the letter N and end in .jpg. This can be useful in finding specific marks in the record. If you want to find any mark, just use *.

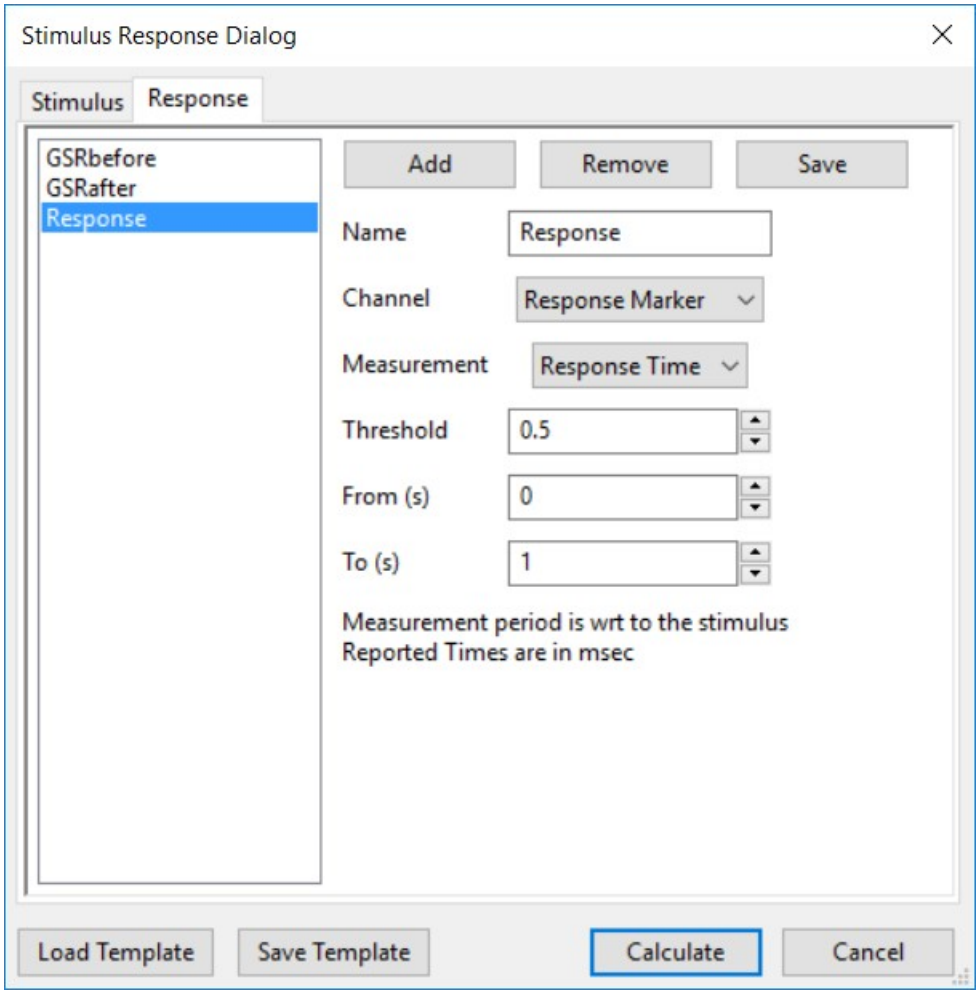
- **Correct Response Channel**: If there is a channel that corresponds to the correct response for this stimulus enter it here.

Click the Save Button to save this stimulus. Multiple stimuli can be added, so you can measure more than one parameter. To delete a stimulus, select the stimulus from the list on the left and click the delete button.

If a light sensor is being used to determine the exact time when an image is shown, the **Stim Marker Channel** can be set with the LED sensor channel. Specify the threshold for the light sensor channel, which can be used to determine the time at which the image is shown. To allow for cases when there is a problem, specify the maximum amount of time, after the stimulus is presented, that the program will look for the light sensor, using the **Maximum Allowed Offset** setting.

Response:

Similar to the stimulus tab, multiple Responses can be added in the Response tab.



Click the Add button to add a response measurement.

Specify the following for each measurement:

- **Name**: This will be the column heading in the exported csv file.
- **Channel**: The channel to make the measurement from.
- **Measurement**: The type of measurement that we want to perform on the channel. Some options are Mean, Maximum, Minimum, Time to Maximum, Time to Minimum, Response Time, Correct Response. Correct Response looks at the channel specified for each stimulus, in the Stimulus lab.
- **Threshold**: Used for determining the Response Time.
- **From (s)**: The time in seconds with respect to the stimulus presentation, that the selection starts.
- **To (s)**: The time in seconds with respect to the stimulus presentation, that the selection ends. For measurements before the stimulus presentation, negative numbers can be used. For eg to measure the baseline from 5 seconds before the stimulus to the stimulus presentation, set the following:
  - **Measurement**: Mean
  - **From (s)**: -5
  - **To (s)**: 0

The stimulus and response parameters and settings can be saved to a template file, by clicking on the **Save Template** button. A previously saved template can be loaded with the **Load Template** button.

Click **Calculate**.

The File save dialog box will open up.

- Choose the folder where you want to save the stimulus response analysis data.
- Choose the subjects name as a filename, to make it easier to analyse the data later.

The module will analyze the data file and export an individual file for each stimulus that was defined in the stimulus tab. If the file name chosen was "*John"* and 2 stimuli were defined with the names *Stim1* and *Stim2*, then there will be 2 files created "*John_Stim1.csv"* and "*John_Stim2.csv".*

An example of the exported file is shown below.

	A	B	C	D	E	F	G
1	Time	Mark	Stim Index	Stim Offset	GSRbefore	GSRafter	Response
2	2017-01-13 11:11:39.322	3c.png	218701	28	0.371448	0.371535	340
3	2017-01-13 11:11:50.027	3b.png	220842	25	0.371805	0.371524	305
4	2017-01-13 11:12:04.967	3a.png	223830	27	0.371386	0.37089	370
5	2017-01-13 11:12:19.937	3b.png	226824	454	0.370621	0.370504	540
6	2017-01-13 11:12:24.237	3a.png	227684	27	0.370531	0.37057	280
7	2017-01-13 11:12:28.542	3c.png	228545	31	0.370525	0.370465	250

8.14 Lymphatic Contractions

The **Lymphatic Contractions Analysis Module** is an advanced analysis module that allows users to automatically calculate parameters from Lymphatic contraction data.

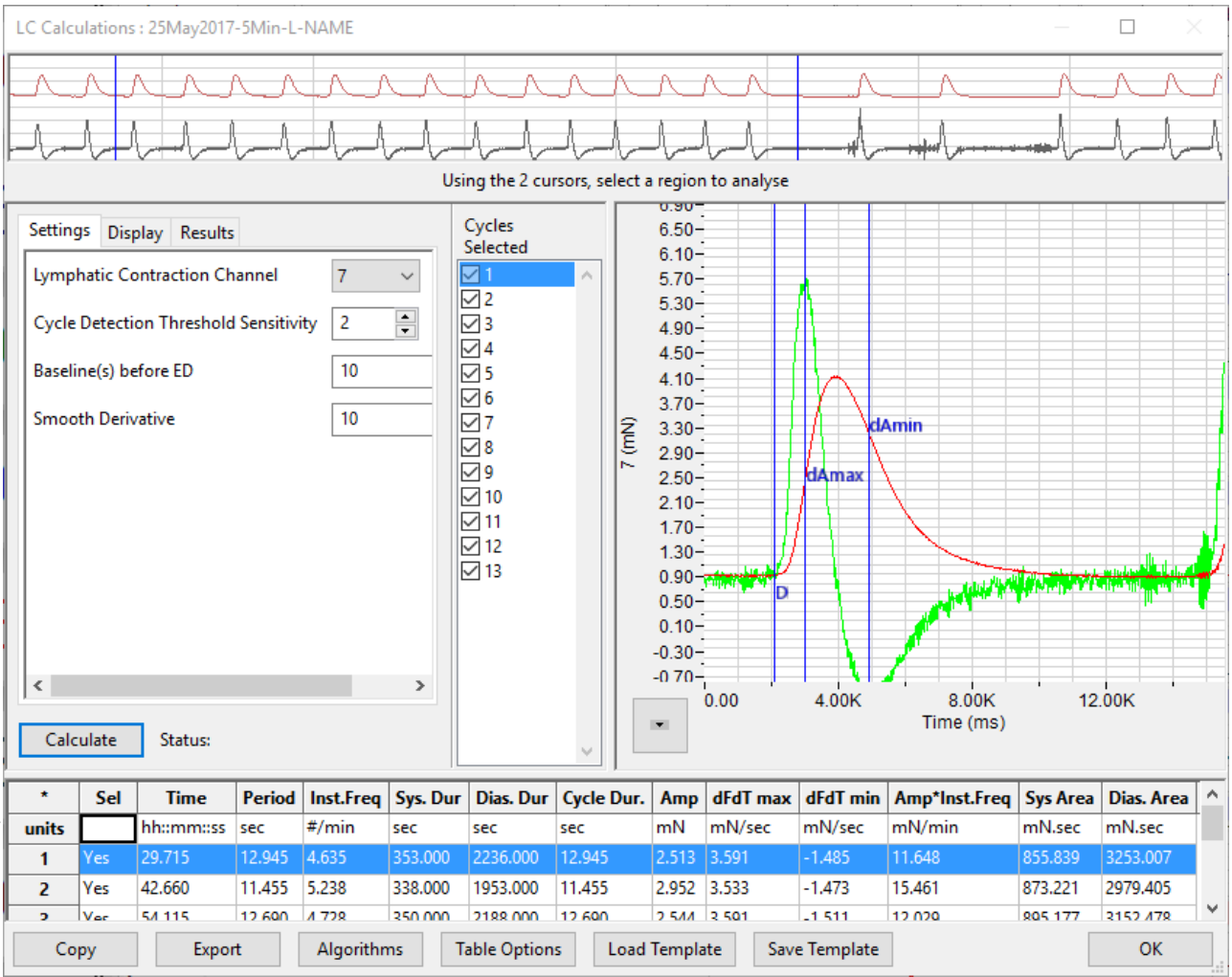
This document includes a step by step tutorial for using the features of the LabScribe **Lymphatic Contractions Analysis Module**. To use the step by step guide, you will need a recording of stimulus and response data file.

Lymphatic Contractions Analysis: Step by Step

Sophisticated analysis can be done on a previously recorded data file using the **Lymphatic Contractions Analysis Module**.

The Lymphatic Contractions Analysis dialog can be launched from the Advanced menu in LabScribe. When the dialog is launched the first time, it will ask for the User Name and License for the Lymphatic Contractions Analysis module. Please contact iWorx Systems for more information.

1. Familiarize yourself with the offline **Lymphatic Contractions Analysis** dialog, pictured below.
2. Across the top of the dialog, in the channel display area, is the lymphatic contraction channel

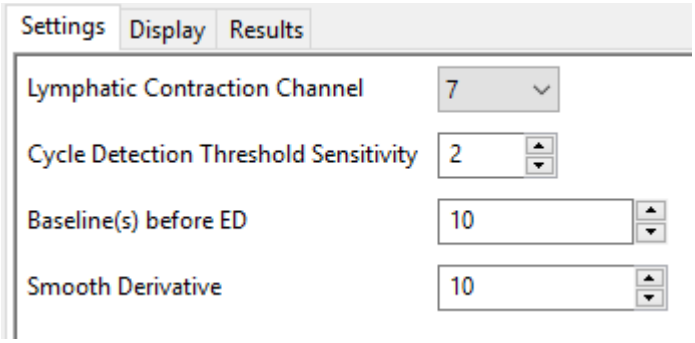


8.

*	Sel	Time	Period	Inst.Freq	Sys. Dur	Dias. Dur	Cycle Dur.	Amp	dFdT max	dFdT min	Amp*Inst.Freq	Sys Area	Dias. Area
units		hh::mm::ss	sec	#/min	sec	sec	sec	mN	mN/sec	mN/sec	mN/min	mN.sec	mN.sec
1	Yes	29.715	12.945	4.635	353.000	2236.000	12.945	2.513	3.591	-1.485	11.648	855.839	3253.007
2	Yes	42.660	11.455	5.238	338.000	1953.000	11.455	2.952	3.533	-1.473	15.461	873.221	2979.405
3	Yes	54.115	12.690	4.728	350.000	2188.000	12.690	2.544	3.591	-1.511	12.029	895.177	3152.478

Setup:

Click on the **Settings** tab:



- Choose the Lymphatic Contractions Channel.
- Cycle Detection Threshold Sensitivity, determines how sensitive the program is to detecting a cycle, Typically a value of 2 should work. If the program is missing some cycles, increase the value of the sensitivity.
- Set the number of seconds before ED, that you want to calculate the baseline from.
- Set how many data points should be used for smoothing the derivative. This helps reduce the noise on the derivative.

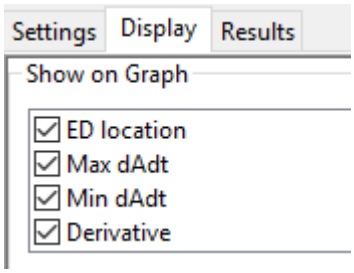
Select the area of the recording to be analyzed by moving the two vertical cursors in the channel display area at the top of the dialog to designate the section to be analyzed.

Click the **Calculate** button above the **Data Table** to update all settings. Click **Calculate** whenever settings are updated.

The Program will detect all the cycles in the selection. The list of detected cycles will be displayed in the Cycles Selected listbox. The graph of the current selected cycle will be displayed in the Graph window.

To show the ED, max and min derivative and the derivative graph, choose the Display Tab.

Check the items to show on the graph.



The values for all the cycles are calculated and displayed in the Data Table.

The Data Table

The **Data Table** displays the chosen calculated values for each cycle.

*	Sel	Time	Period	Inst.Freq	Sys. Dur	Dias. Dur	Cycle Dur.	Amp	dFdT max	dFdT min	Amp*Inst.Freq	Sys Area	Dias. Area
units		hh::mm::ss	sec	#/min	sec	sec	sec	mN	mN/sec	mN/sec	mN/min	mN.sec	mN.sec
1	Yes	29.715	12.945	4.635	353.000	2236.000	12.945	2.513	3.591	-1.485	11.648	855.839	3253.007
2	Yes	42.660	11.455	5.238	338.000	1953.000	11.455	2.952	3.533	-1.473	15.461	873.221	2979.405
3	Yes	54.115	12.690	4.728	350.000	2188.000	12.690	2.544	3.591	-1.511	12.029	895.177	3152.478
4	Yes	66.805	11.850	5.063	382.000	1988.000	11.850	2.868	3.365	-1.484	14.520	896.500	3001.600
5	Yes	78.655	11.800	5.085	365.000	1995.000	11.800	2.588	3.535	-1.439	13.161	906.208	2977.816
6	Yes	90.455	11.620	5.164	395.000	1929.000	11.620	2.558	3.425	-1.425	13.209	869.521	2983.804

Copy | Export | Algorithms | Table Options | Load Template | Save Template

Clicking the asterisk at the upper left of the **Data Table** displays two options: **Autosize** and **Copy Selection**. A**utosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

The **Data Table** displays the chosen calculated values for each of the cycles checked in the **Cycles Selected** window, as well as the mean, standard deviation, and range of each of the chosen parameters averaged over all the selected cycles.

Clicking **OK** in the **Offline Calculations Options Dialog** saves the settings for future analyses.

There are four buttons across the bottom of the Dialog**: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- *LabScribe* is able to calculate a large number of lymphatic contraction calculations for each cycle. By clicking **Table Options** at the bottom of the **Lymphatic Contractions Calculations Dialog**, the **Offline Calculations Options Dialog** opens, and calculations to be displayed in the dialog data table can be chosen from the list of all possible calculations. Marks indicating temperature and activity can also be added to the file, and those values can be chosen from the **Table Options** list and included in the **Data Table**.
- Clicking **Load Template** or **Save Template** displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

Calculations:

- **Time**: Time (in seconds) from the start of the selection, or the time of day of the recording, depending upon which option is chosen.
- **Period:** Time interval between contractions
- **Inst Frequency:** Instantaneous contractions per min, calculated from the period of each cycle
- **Amplitude**: Amplitude of the Contraction (Maximum o the cycle - baseline)
- **Baseline Period** : Time Duration before the systolic start to calculate baseline
- **EDV:** Voltage before the upstroke during the cardiac cycle, where the derivative crosses zero.
- **DFmax** : The smoothed derivative of the channel is calculated, using 2 points on either side.
- **DFmin** : The smoothed derivative of the channel is calculated, using 2 points on either side.
- **AmpInstFreq:** Amp*InstantenousFreq
- **Amp*AvgFreq:** Amp*Average Freq
- **Sys. Area:** Area under the curve from systolic start to Max, with respect to the baseline
- **Diast. Area:** Area under the curve from Max to diastolic end, with respect to the baseline
- **Sys. Dur:** The time, seconds, from Systolic Start to Max.
- **Dias. Dur:** The time, seconds, Max to Systolic Start of next cycle

- **Cycle Dur:** Systolic Duration + Diastolic Duration.

8.15: Spike Sorting

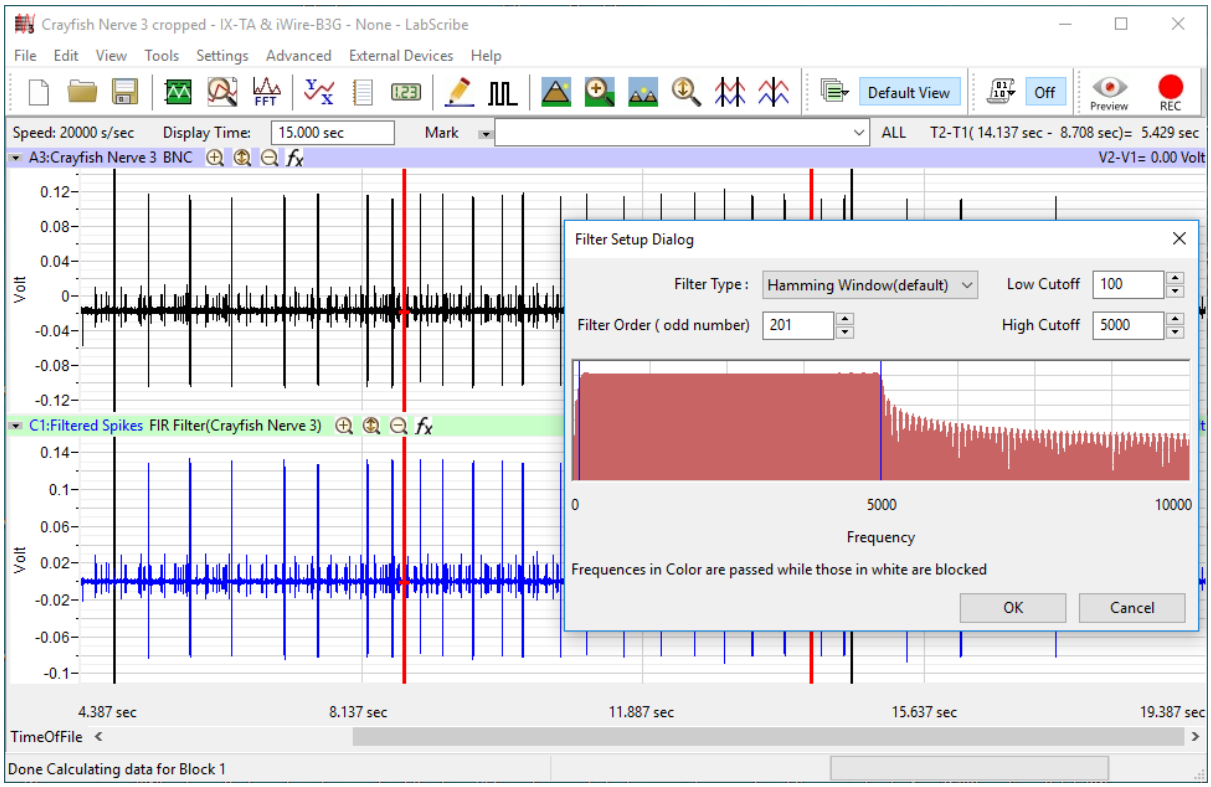
The **Spike Sorting Analysis Module** is an advanced analysis module that allows users to automatically calculate parameters from Nerve spike data.

This document includes a step by step tutorial for using the features of the LabScribe **Spike Sorting Analysis Module**. To use the step by step guide, you will need a recording of stimulus and response data file.

Spike Sorting Analysis: Step by Step

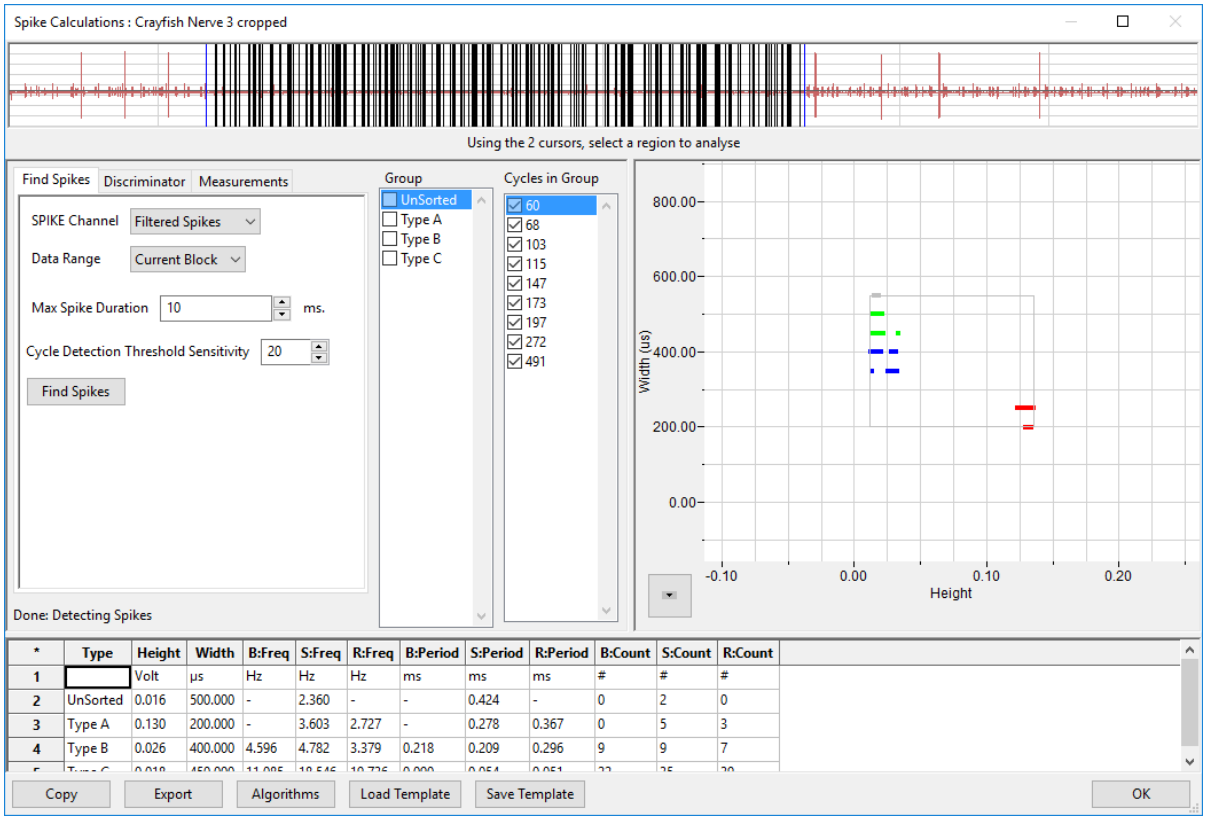
Sophisticated analysis can be done on a previously recorded data file using the **Spike Sorting Analysis Module**.

Before analyzing the spikes, it is best to filter the spike data to remove any baseline and reduce noise. This can be done in LabScribe by creating a filter channel. To reduce baseline and 60Hz mains noise, choose a Low Cutoff of 100 Hz.



The Spike Sorting Analysis dialog can be launched from the Advanced menu in LabScribe.

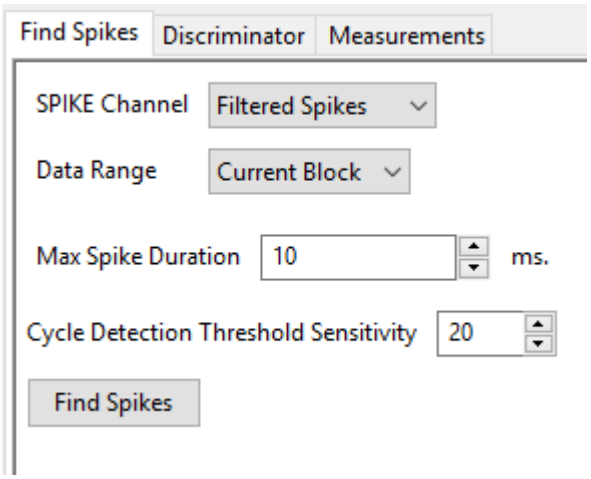
When the dialog is launched the first time, it will ask for the User Name and License for the Spike Sorting Analysis module. Please contact iWorx Systems for more information.



*	Type	Height	Width	B:Freq	S:Freq	R:Freq	B:Period	S:Period	R:Period	B:Count	S:Count	R:Count
1		Volt	µs	Hz	Hz	Hz	ms	ms	ms	#	#	#
2	UnSorted	0.016	500.000	-	2.360	-	-	0.424	-	0	2	0
3	Type A	0.130	200.000	-	3.603	2.727	-	0.278	0.367	0	5	3
4	Type B	0.026	400.000	4.596	4.782	3.379	0.218	0.209	0.296	9	9	7

1. Familiarize yourself with the offline **Spike Sorting Analysis** dialog, pictured above.
2. Across the top of the dialog, in the channel display area, is the spike data channel from the recording.
3. The tabbed configuration dialogs are on the left below the recordings.
4. An XY graph window on the right displays the **Spike Graph, Sorting Graph or Histograms**
5. Between the configuration dialogs and the XY graph window is the **Groups** and **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
6. The **Data Table** is located on the lower part of the dialog.

Find Spikes:



Click on the **Find Spikes** tab:

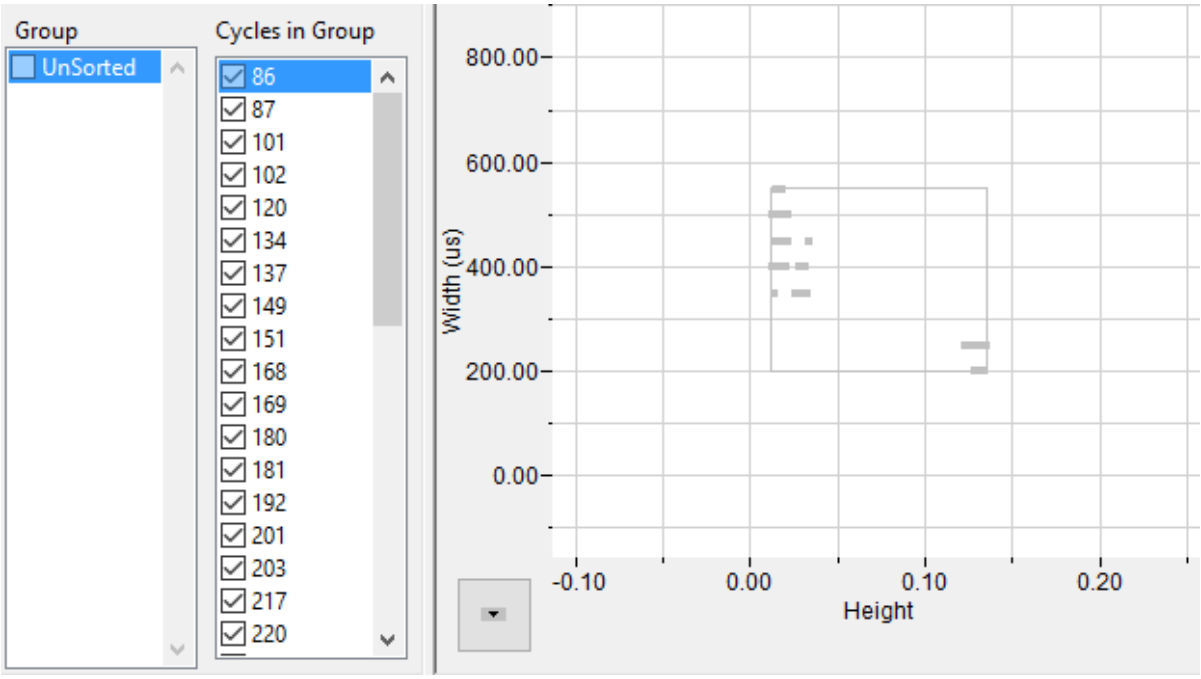
- Choose the Spike Sorting Channel.
- Set the Data Range to analyze:
  - Selection,
  - Current block
  - Complete File
- Max Spike Duration, sets the width of the spikes

- Cycle Detection Threshold Sensitivity, determines how sensitive the program is to detecting a cycle, Typically a value of 20 should work. If the program is missing some cycles, increase the value of the sensitivity.

Select a representative area of the recording by moving the two vertical cursors in the channel display area at the top of the dialog, For a selection is the complete data set that will be analyzed

Click on the Find Spikes button: The detected spikes within the representative area will be displayed as black lines in the Channel area. The Complete list of cycles found will be listed in the Cycles Selected list box, under the unselected group.

The Spike graph will display the unsorted spikes in a sorting graph, each spike is displayed as a point, corresponding to its width and height.



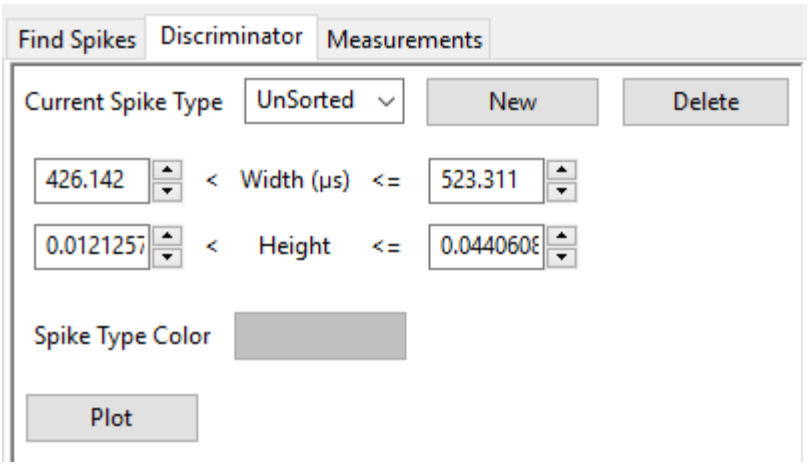
Discriminator:

Click on the **Discriminator** tab:

The unsorted spikes are shown in the Spike Graph on the right.

Click on **New**.

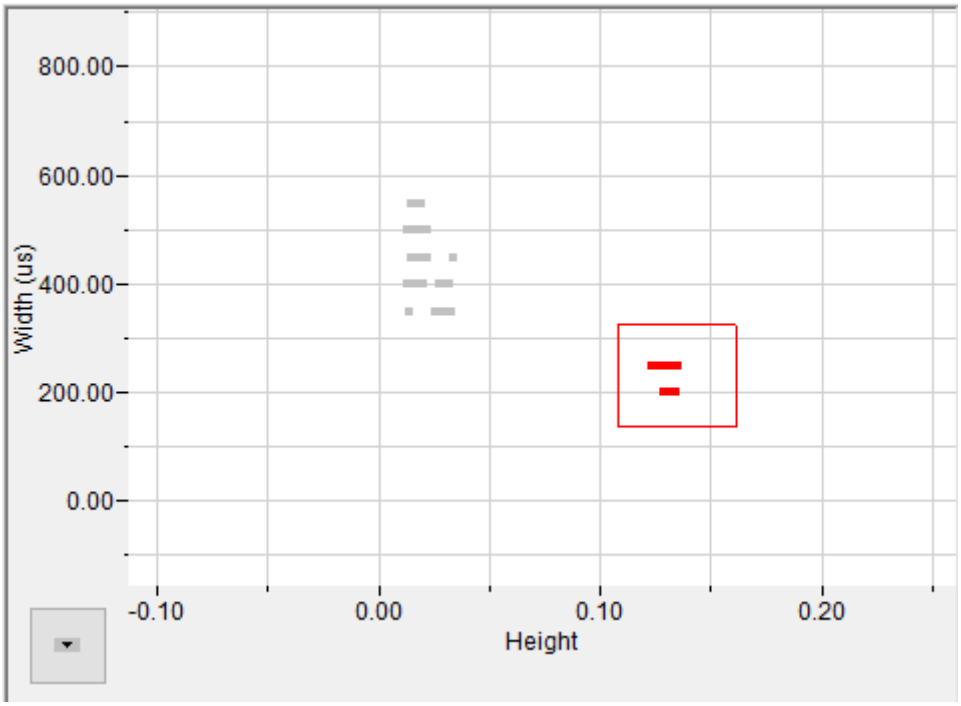
A new Spike Type **Type A** will be created, The Width and the height for the Type A spikes can be set either using



the number boxes or by clicking and dragging the square in the spike graph. The color of the spike type can be changed as well.

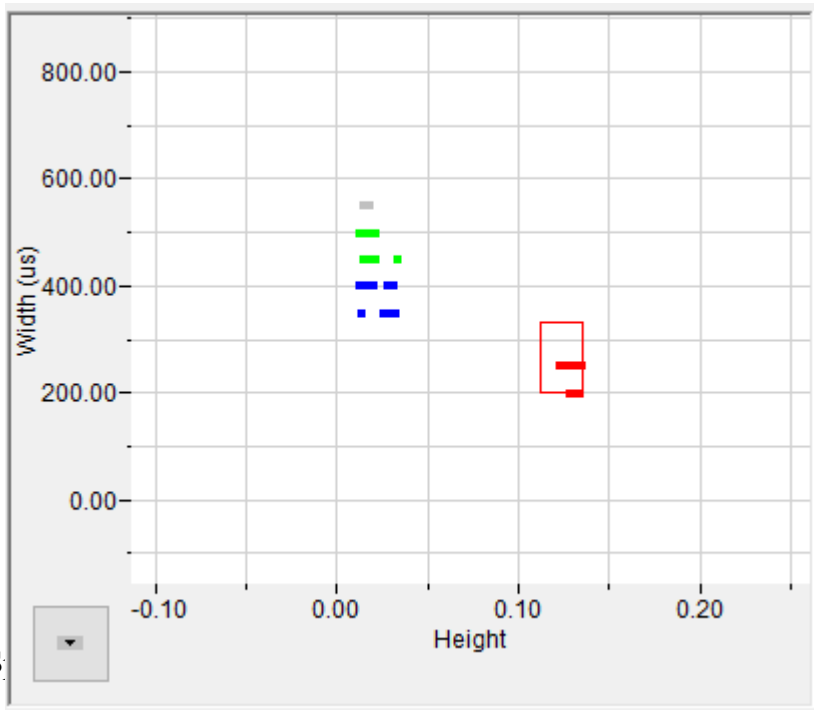
Click **Save.**

Click on the **Plot** button to change the right handside graph to the discriminator graph.

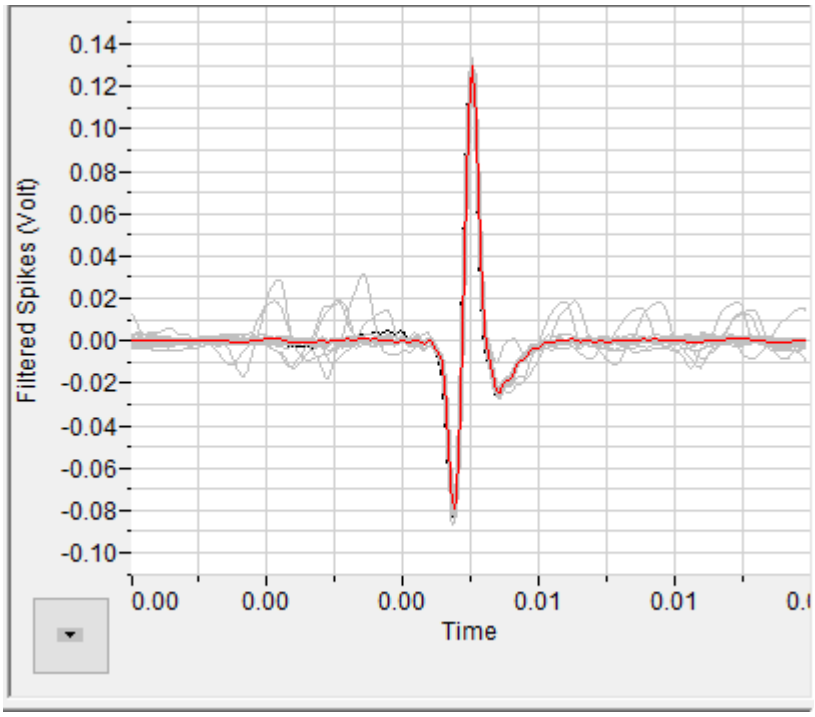


The selected spikes will be Marked in the color of the spike type.

Create other Spike Types as needed. The graph below shows Spike Types A,B,C created

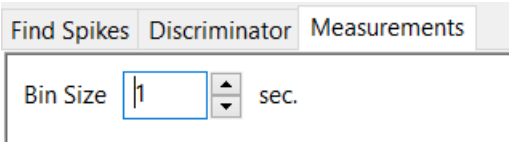


In the Groups list box, click on a group to see the spikes in that group and the average spike.

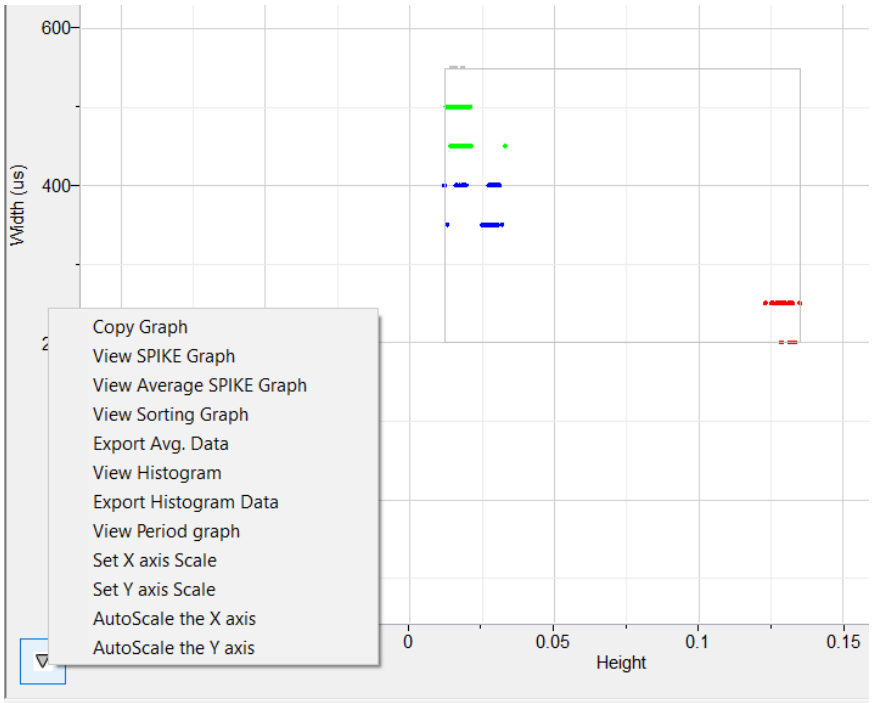


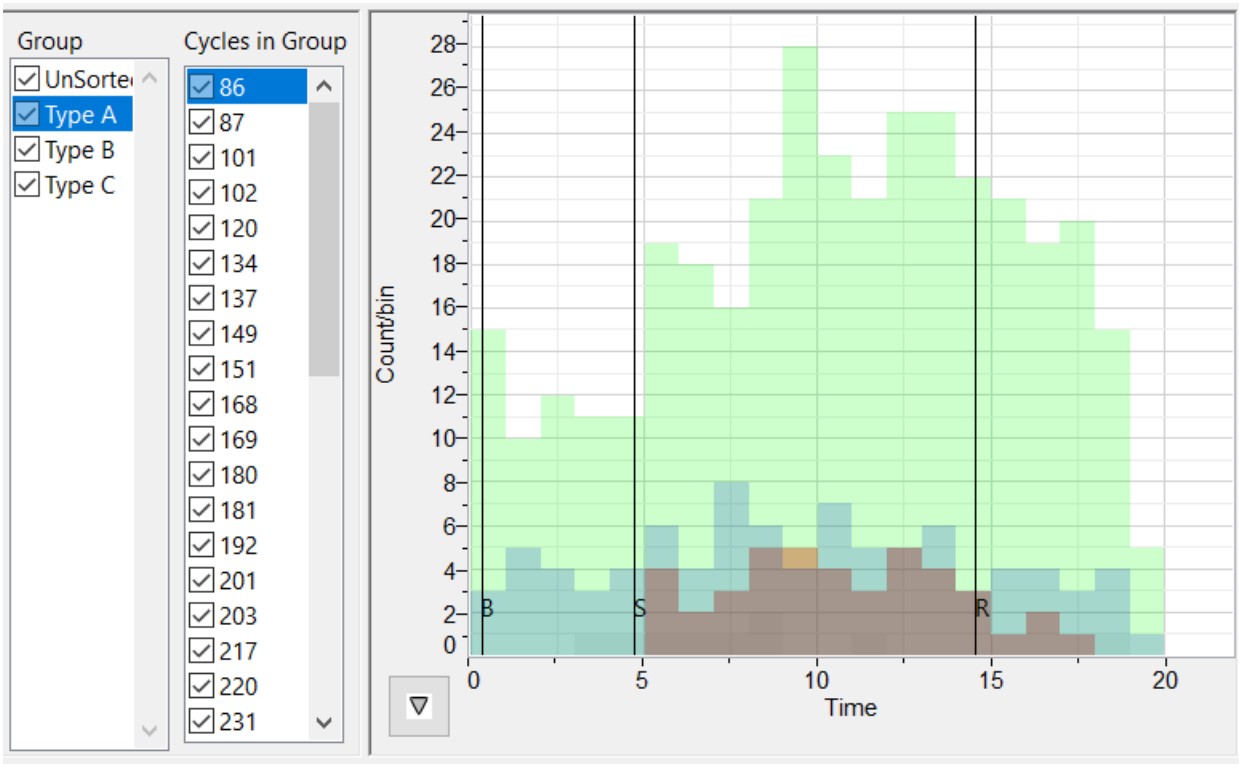
Histogram

Set the Bin size for the histogram:



Choose View Histogram from the Graph Menu.

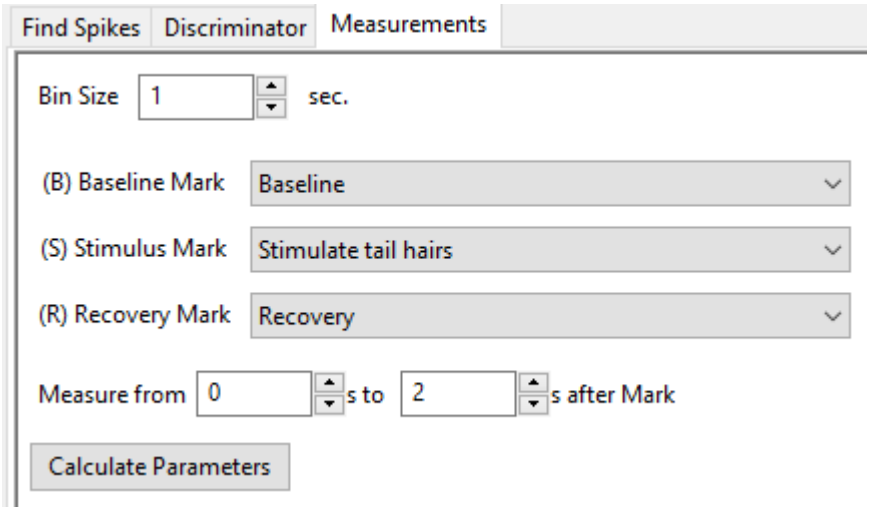




In the Histogram View, you can choose the groups to be displayed by checking the Group checkbox. Clicking on a group in the group list box, selects and highlights the group in the histogram.

The Histogram data can be exported using the Export Histogram data option under the graph menu.

Measurements:



Set the Bin Size for the histograms. The Histogram displays the number of spikes in a bin vs time.

The Data set can be marked for 3 regions, Baseline, Stimulus and Recovery. Choose the marks in the record corresponding to the 3 regions. Marking the data into these regions helps in the analysis, since typically we want to see the difference from baseline when a stimulus occurs and then we want to see how fast the recovery takes place.

One can also set the time period from the beginning of each region to be analyzed.

Data Table:

The values for all the cycles are calculated and displayed in the Data Table.

The **Data Table** displays the chosen calculated values for each cycle.

Done: Detecting Spikes

*	Type	Height	Width	B:Freq	S:Freq	R:Freq	B:Period	S:Period	R:Period	B:Count	S:Count	R:Count
1		mV	µs	Hz	Hz	Hz	ms	ms	ms	#	#	#
2	UnSorted	20.695	300.000	18.424	18.424	18.424	0.054	0.054	0.054	19	19	19
3	Type A	31.933	450.000	51.713	51.713	51.713	0.019	0.019	0.019	5	5	5
4	Type B	174.958	200.000	-	-	-	-	-	-	0	0	0

Copy Export Algorithms Load Template Save Template

Clicking the asterisk at the upper left of the **Data Table** displays two options: **Autosize** and **Copy Selection**. A**utosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

The **Data Table** displays the chosen calculated values for each of the cycles checked in the **Cycles Selected** window, as well as the mean, standard deviation, and range of each of the chosen parameters averaged over all the selected cycles.

Clicking **OK** in the **Offline Calculations Options Dialog** saves the settings for future analyses.

There are four buttons across the bottom of the Dialog**: Copy, Export, Algorithms, Load Template, and Save Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- Clicking **Load Template** or **Save Template** displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

Calculations:

- **Type** Type of the Spike
- **Height** Average Height of the spikes
- **Width** Average Width of the spikes
- **B:Freq** Mean Frequency of the spikes during the Baseline period
- **S:Freq** Mean Frequency of the spikes during the Stimulus period
- **R:Freq** Mean Frequency of the spikes during the Response period
- **B:Period** Mean Period between the spikes during the Baseline period
- **SPeriod** Mean Period between the spikes during the Stimulus period
- **RPeriod** Mean Period between the spikes during the Response period
- **B:Count** Mean :Count of the spikes during the Baseline period
- **S:Count** Mean :Count of the spikes during the Stimulus period
- **R:Count** Mean :Count of the spikes during the Response period

8.16 Calcium Transients

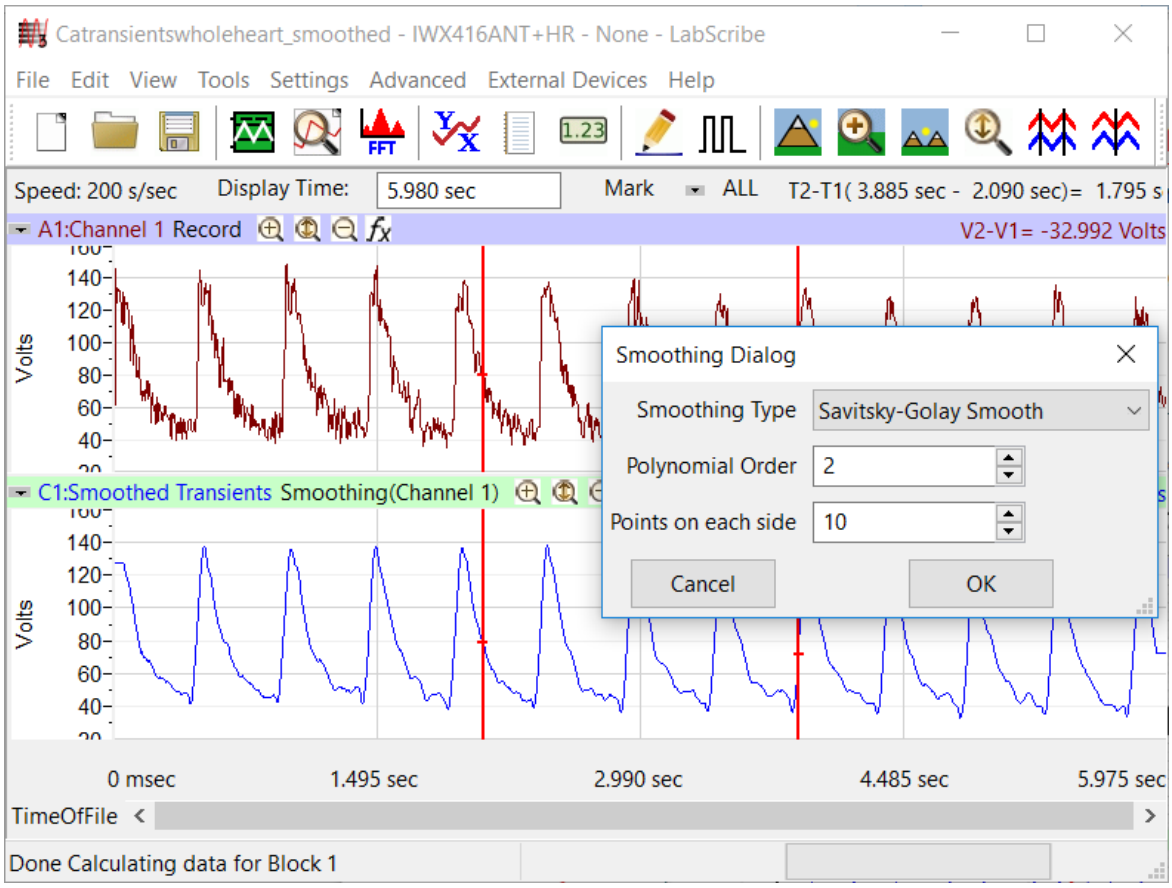
The **Calcium Transients Analysis Module** is an advanced analysis module that allows users to automatically calculate parameters from Nerve spike data.

This document includes a step by step tutorial for using the features of the LabScribe **Calcium Transients Analysis Module**.

Calcium Transients Analysis: Step by Step

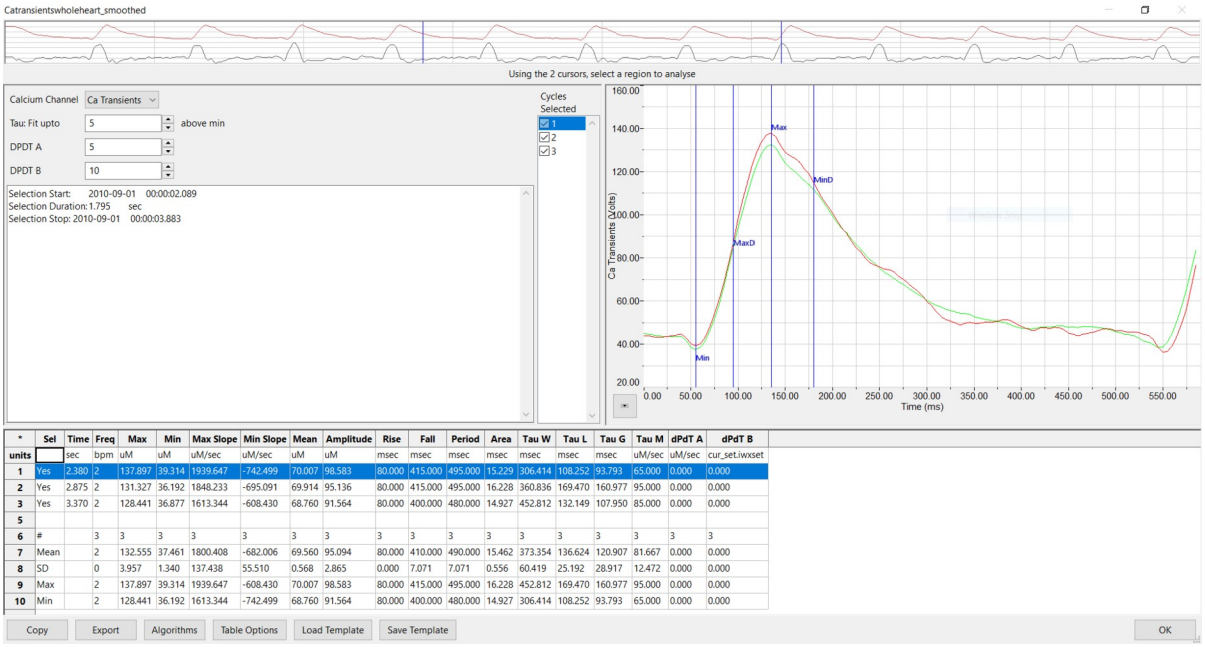
Sophisticated analysis can be done on a previously recorded data file using the **Calcium Transients Analysis Module**.

Before analyzing the transients, it is best to smooth the data to reduce noise. This can be done in LabScribe by creating a Smoothing channel, using the Savitsky-Golay Smooth function, which preserves the amplitudes of the peaks.



The Calcium Transients Analysis dialog can be launched from the Advanced menu in LabScribe.

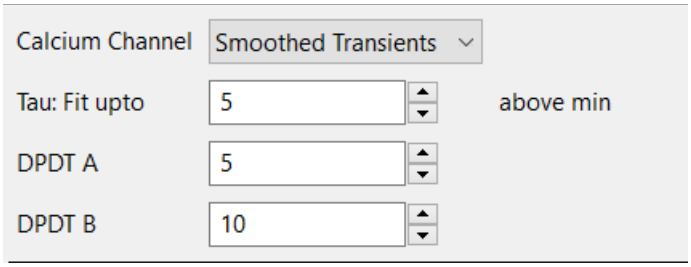
When the dialog is launched the first time, it will ask for the User Name and License for the Calcium Transients Analysis module. Please contact iWorx Systems for more information.



*	Sel	Time	Freq	Max	Min	Max Slope	Min Slope	Mean	Amplitude	Rise	Fall	Period	Area	Tau W	Tau L	Tau G	Tau M	dPdT A	dPdT B
units		sec	bpm	uM	uM	uM/sec	uM/sec	uM	uM	msec	msec	msec	msec	msec	msec	msec	uM/sec	uM/sec	cur_set.iwxset
1	Yes	2.380	2	137.897	39.314	1939.647	-742.499	70.007	98.583	80.000	415.000	495.000	15.229	306.414	108.252	93.793	65.000	0.000	0.000
2	Yes	2.875	2	131.327	36.192	1848.233	-695.091	69.914	95.136	80.000	415.000	495.000	16.228	360.836	169.470	160.977	95.000	0.000	0.000
3	Yes	3.370	2	128.441	36.877	1613.344	-608.430	68.760	91.564	80.000	400.000	480.000	14.927	452.812	132.149	107.950	85.000	0.000	0.000
5																			
6	#		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	Mean		2	132.555	37.461	1800.408	-682.006	69.560	95.094	80.000	410.000	490.000	15.462	373.354	136.624	120.907	81.667	0.000	0.000
8	SD		0	3.957	1.340	137.438	55.510	0.568	2.865	0.000	7.071	7.071	0.556	60.419	25.192	28.917	12.472	0.000	0.000
9	Max		2	137.897	39.314	1939.647	-608.430	70.007	98.583	80.000	415.000	495.000	16.228	452.812	169.470	160.977	95.000	0.000	0.000
10	Min		2	128.441	36.192	1613.344	-742.499	68.760	91.564	80.000	400.000	480.000	14.927	306.414	108.252	93.793	65.000	0.000	0.000

1. Familiarize yourself with the offline **Calcium Transients Analysis** dialog, pictured above.
2. Across the top of the dialog, in the channel display area, is the calcium data channel from the recording.
3. The tabbed configuration dialogs are on the left below the recordings.
4. An XY graph window on the right displays the **Current Calcium Transient.**
5. Between the configuration dialogs and the XY graph window is the **Cycles Selected** list, an editable list of the cycles that can be displayed and analyzed.
6. The **Data Table** is located on the lower part of the dialog.

Setup:



1. Choose the Calcium Channel
2. Choose the point upto which the program should try to fit the data for calculating Tau
3. Choose the points at which the derivative should be calculated.

Usage:

Moving the cursors changes the selection used for calculating the parameters. As you move the cursors you will see that the number of Calcium transient cycles change. The cycles detected are displayed in the cycles selected listbox. Individual cycles can be selected and deselected from this list box. Clicking on a cycles in the listbox selects the cycle.

The Graph on the right will show the current cycle. The various points of interest will be marked on the graph.

Data Table:

The values for all the cycles are calculated and displayed in the Data Table.

The Data Table

The **Data Table** displays the chosen calculated values for each cycle.

*	Sel	Time	Freq	Max	Min	Max Slope	Min Slope	Mean	Amplitude	Rise	Fall	Period	Area	Tau W	Tau L	Tau G	Tau M	dPdT A	dPdT B
units		sec	bpm	uM	uM	uM/sec	uM/sec	uM	uM	msec	msec	msec	msec	msec	msec	msec	uM/sec	uM/sec	cur_set.iwxset
1	Yes	1.895	2	136.297	38.113	1671.381	-796.636	71.805	98.184	80.000	405.000	485.000	15.632	343.180	121.297	105.720	85.000	0.000	0.000
2	Yes	2.380	2	137.897	39.314	1939.647	-742.499	70.007	98.583	80.000	415.000	495.000	15.229	306.414	108.252	93.793	65.000	0.000	0.000
3	Yes	2.875	2	131.327	36.192	1848.233	-695.091	69.914	95.136	80.000	415.000	495.000	16.228	360.836	169.470	160.977	95.000	0.000	0.000
4	Yes	3.370	2	128.441	36.877	1613.344	-608.430	68.760	91.564	80.000	400.000	480.000	14.927	452.812	132.149	107.950	85.000	0.000	0.000
5																			
6	#		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7	Mean		2	133.491	37.624	1768.151	-710.664	70.121	95.867	80.000	408.750	488.750	15.504	365.811	132.792	117.110	82.500	0.000	0.000
9	SD		0	3.791	1.194	131.485	69.100	1.089	2.819	0.000	6.495	6.495	0.487	53.931	22.804	25.892	10.897	0.000	0.000
10	Max		2	137.897	39.314	1939.647	-608.430	71.805	98.583	80.000	415.000	495.000	16.228	452.812	169.470	160.977	95.000	0.000	0.000
11	Min		2	128.441	36.192	1613.344	-796.636	68.760	91.564	80.000	400.000	480.000	14.927	306.414	108.252	93.793	65.000	0.000	0.000

Clicking the asterisk at the upper left of the **Data Table** displays two options: **Autosize** and **Copy Selection**. A**utosize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

The **Data Table** displays the chosen calculated values for each of the cycles checked in the **Cycles Selected** window, as well as the mean, standard deviation, and range of each of the chosen parameters averaged over all the selected cycles.

Clicking **OK** in the **Offline Calculations Options Dialog** saves the settings for future analyses.

There are four buttons across the bottom of the Dialog**: Copy, Export, Algorithms, Table Options, Load Template, and Save Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- *LabScribe* is able to calculate a large number of lymphatic contraction calculations for each cycle. By clicking **Table Options** at the bottom of the **Calcium Transients Calculations**

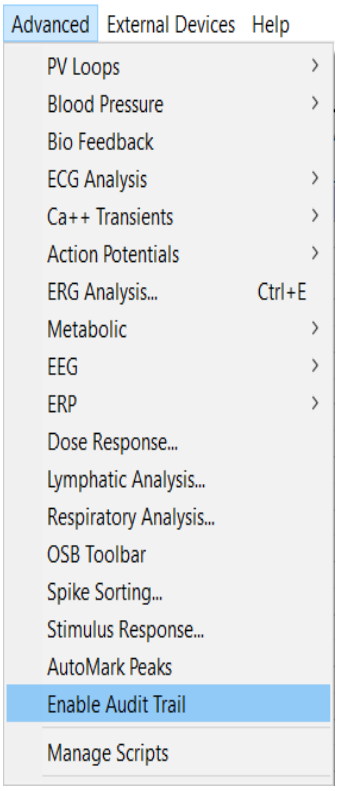
Dialog, the **Offline Calculations Options Dialog** opens, and calculations to be displayed in the dialog data table can be chosen from the list of all possible calculations. Marks indicating temperature and activity can also be added to the file, and those values can be chosen from the **Table Options** list and included in the **Data Table**.

- Clicking **Load Template** or **Save Template** displays a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.

Calculations:

- **Time**: Time (in seconds) from the start of the selection, or the time of day of the recording, depending upon which option is chosen.
- **Freq: Rate :** 60/period of each cycle.
- **Max**: Maximum value of the Calcium Transients channel
- **Min** : Minimum value of the Calcium Transients channel
- **Max Slope: dCAmax** : Maximum of the smoothed derivative of the Calcium channel which is calculated, using 2 points on either side.
- **Min Slope dCAmin** : Minimum of the smoothed derivative of the Calcium channel which is calculated, using 2 points on either side.
- **Mean** : Mean of all values in the cycle
- **Amplitude:** Pulse Height : Max-Min of the cycle.
- **Rise** : Rise Time: Time from min to max in msec.
- **Fall** : Fall Time : Time from max to min in msec.
- **Period**: Cycle Duration : Time between adjacent minimums
- **Area**: Area under the curve.
- **Tau W** : Tau Weiss : P(t) = Aexp(-t/Tau)
- **Tau L** : Tau Logistic : P(t)= Aexp(-t/Tau) + B
- **Tau G** : Tau Glantz : Regression of dCa/dt Vs Pressure
- **Tau M**: Tau Mirsky : time required for signal to fall to one-half of its value at ESP
- **dPdT A,B** : value of derivative at levels set by user.

8.17 Audit Trail

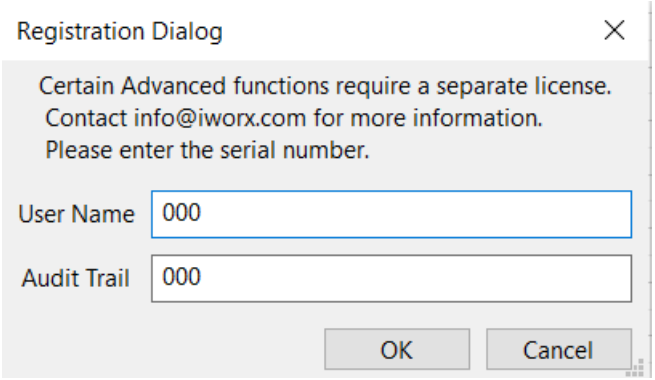


To help with GLP and GMP proceedures, LabScribe has various features built-in.

LabScribe records the raw data from the recorder. All functions in LabScribe are designed to operate on this raw data, but the raw data is not changed. If you create a filter function, Labscribe will create a separate channel showing the filtered data, the original data is not changed. Even with units, the raw data is always available and if the units can be turned off to get back to the raw data.

The Audit Trail module keeps track of user interactions in a data file and logs the interactions in an readonly log. The name of the user is taken from the computer account, so the user does not have to log into Labscribe.

To enable the Audit Trail module, Choose Enable Audit Trail from the Advanced menu. This has to be only done once on a computer. The program pop-up a registration dialog



Please enter the username and Audit Trail license provided by iWorx.

Once the Audit Trail module is enabled on the computer, LabScribe will start logging user interactions with the data.

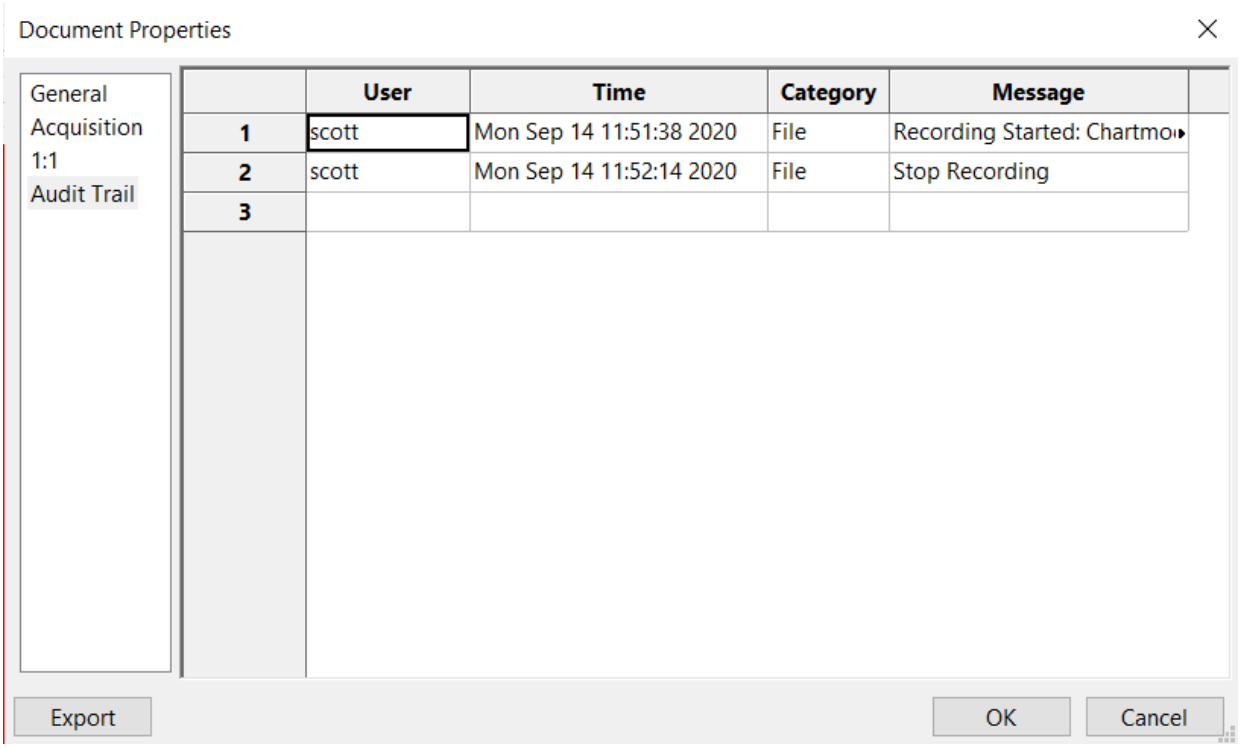
Categories

The following categories of data is logged:

- **File**: For File level operations, such as starting and stopping recording
- **Mark**: when marks are added or modified

The audit trail can be viewed under File→Document Properties

In addition to the user interaction, Labscribe also keeps track of the properties of each block of data collected.



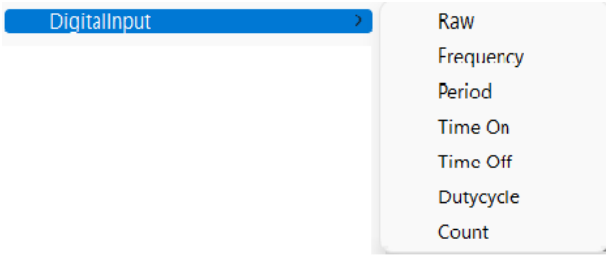
Export

The Audit trail data can be exported out by clicking on the Export button.

9 Digital Input and Output

Some *iWorx* data acquisition units are equipped with **Digital Input** and **Output** connectors. A dedicated **Trigger** input allows external devices with a TTL output to trigger *LabScribe* recording when the device turns on or off. Other **Digital Input** connectors allow external TTL devices to be monitored for changes and have the changes indicated on the *LabScribe* recording. iWorx units with **Digital Output** connectors can send information to external devices with a TTL input, instructing the devices to turn on or off, based on programmed criteria. **Macros** can be used to control the digital outputs.

Digital Input



The Digital Input menu.

The **Digital Input** function may have to be added to the list of computed functions available through the **add function** command by adding it to the active function list on the **Options** page of the **Preferences Dialog**. Once added to the list, it can be accessed on the **Channel** page of the **Preferences Dialog**, or through the **add function** command in the **Channel Bar** of each channel in the **Main Window**.

For instructions on using the **add function** command in either of these locations, refer to page 74 in **Chapter 6: Computed Functions**. Unlike other computed functions, **Digital Input** is not usually associated with a certain raw data channel. The **Digital Input** channel can be added directly from the **Channel** page of the **Preferences Dialog**, by activating a computed channel and selecting **Digital Input** from the **add function** list.

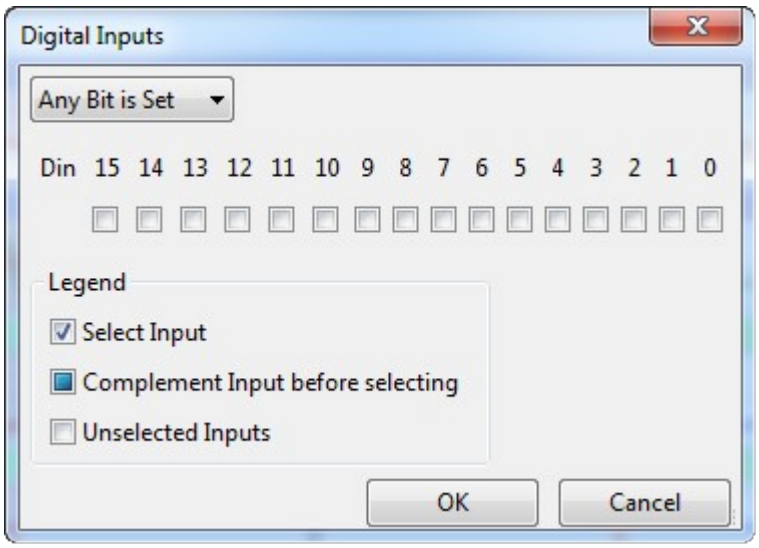
Selecting any of the **Digital Input** sub-menu functions will open the **Digital Inputs** dialog. The hardware channels that are to be monitored for TTL changes can be specified in this dialog. The **Digital Input** function treats the data received on a selected hardware channel as a binary number, on or off, which indicates a change in the state of external devices connected through a TTL Output. These changes are indicated on the added **Computed Channel**.

The changes that can be monitored are:

- **Raw**: The digital value at any given time, as a 32 bit word, is displayed (16 lines, each either on or off).
- **Frequency**: The program takes the **period** of the **Digital Input** data in seconds and divides this value into 1. The result is a **frequency**, which is expressed in Hz or cycles per second.
- **Period**: The program takes the **period** for each cycle.

- **Time On**: The time that the selected channels receive high TTL signals from the external device.
- **Time Off**: The time that the selected channels receive low TTL signals from the external device.
- **Duty Cycle**: The percent of a cycle during which the device is turned on, determined by the equation: **100 *** (**Time On**/**Period)**.
- **Count**: Cumulative number of events since the last reset.

The options on the **Digital Inputs** setup dialog are:



The Digital Inputs dialog.

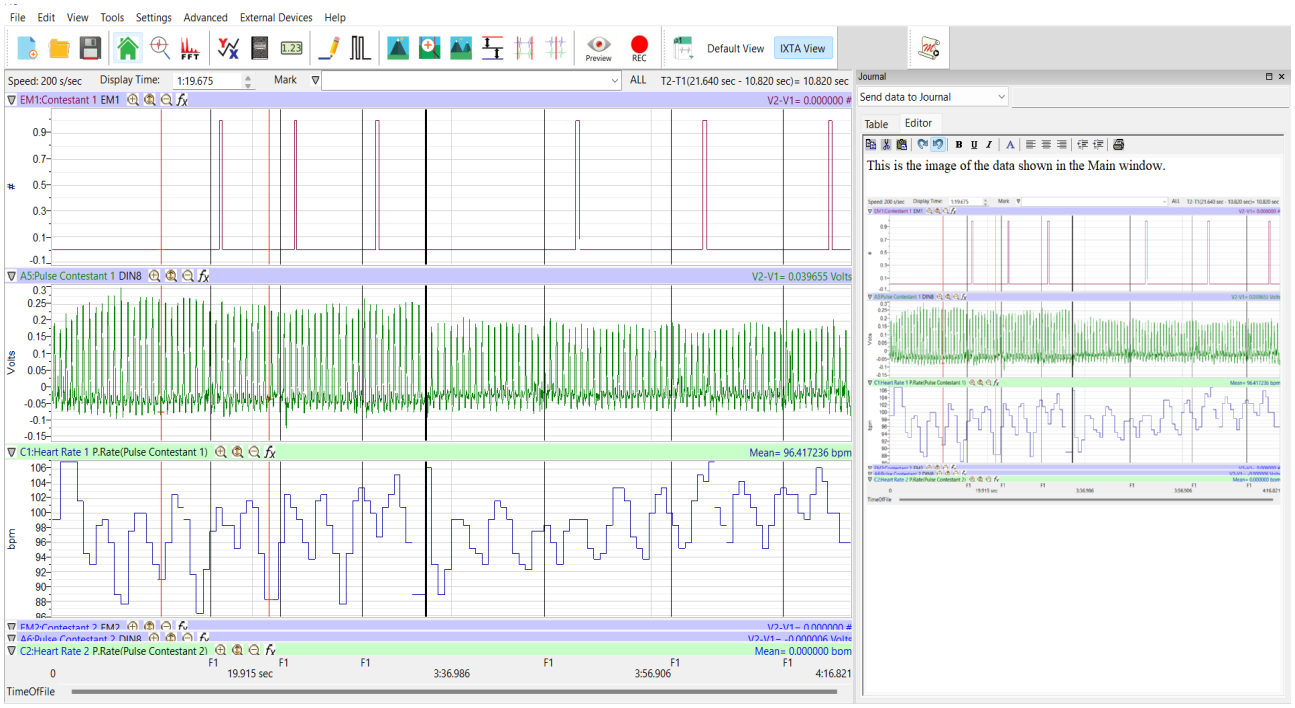
- **Channel checkboxes**: The channels of interest can be selected using the checkboxes in the **Digital Inputs** dialog. If you desire to complement the input (change the input data from a 1 to a zero or a zero to a 1) before it is selected then click on the checkbox again, which will place a solid square in the checkbox, as shown in the legend.
- **Reset After N sec**: This option is only available for the **Count** function, which is used to reset the event **Count** after a user-determined number of seconds.
- **Any Bit is Set/ All Bits are set**: If **Any Bit is Set**, an event is detected if any channel receives a high TTL signal. If **All Bits are Set**, an event will be detected only if all channels receive a high TTL signal.

Digital Output

iWorx data acquisition units with digital output capabilities are able to control external TTL devices like pumps, heaters, cameras, and relays. Each external device receives a digital signal that instructs the device to change its status from one condition to another. For example, a pump may be turned on or off. The internal stimulators in iWorx data acquisition units can also be controlled with digital instructions. Refer to the **Stimulator** chapter for instructions and an example of building an output sequence that controls the stimulator operation.

10 Journal & Data Export

The **Journal** is very similar to a text editor. Text can be entered and edited in the **Journal** area and images of the traces and graphs from the raw data and computed channels can be copied to the **Journal**. In addition to images, data values from the **Main** and **Analysis Windows** can be added to the **Journal**. The **Journal** can be printed, and its contents can be copied and pasted into other applications.



Analysis Window with Journal including both text and graphics.

The **Journal** is not visible in *LabScribe*'s default **View**. Clicking on the **Journal** icon in the **Toolbar,** or selecting **Journal** in the **View** menu, opens the **Journa**l on the right side of the **Main**, **Analysis**, **XY Tools**, and **FFT Windows**. There are two tabs at the top of the Journal display area: **Table** and **Editor**. Data are sent from the **Main** or **Analysis Window** to the **Journal Table**. The tabular entries can then be copied and pasted into the **Editor**. The **Journal Editor** toolbar runs across the top of the **Journal Editor**.

The Journal Editor Toolbar

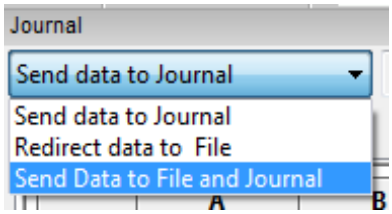
The Journal Editor Toolbar.

The **Journal Editor Toolbar** functions are:

- **Copy:** Copies selected text and images from the **Journal** to the clipboard.
- **Cut:** Cuts selected text and images from the **Journal** and copies it to the clipboard.
- **Paste**: Pastes the clipboard contents into the **Journal**.
- **Redo:** After an **Undo**, this command restores the **Journal** to its pre-**Undo** state.
- **Undo**: Undoes the most recent **Journal** operation.
- **Bold:** Makes the selected **Journal** text bold.
- **Underline**: Underlines the selected **Journal** text.
- **Italic:** Italicizes the selected **Journal** text.
- **Font:** Opens a dialog in which the user can choose a font, font style, font size, and font color, and apply them to the selected text.
- **Align Left:** Aligns selected text or graphics to the left border of the **Journal**.
- **Align Center:** Centers selected text or graphics on the **Journal** page.
- **Align Right:** Aligns selected text or graphics to the right border of the **Journal**.
- **Indents Less:** Moves selected indented text or graphics to the left.
- **Indents More:** Indents selected text or graphics.
- **Print:** Opens the Journal (Editor) as a text file that can then be printed.

Adding Text, Images, and Data to the Journal

Beneath the **Journal** toolbar is a drop-down menu that allows the user to instruct *LabScribe* where to send data from the **Main** and **Analysis Windows**.



Journal submenu.

Choosing **Send Data to Journal** instructs *LabScribe* to send data values from the **Main** or **Analysis Windows** to the **Journal Table**. Choosing **Redirect data to File** opens a dialog from which the user can instruct *LabScribe* to send data values from the **Main** or **Analysis Windows** to a tab (*.txt) or comma (*.csv) separated text file chosen and named by the user. Choosing **Send Data to File and Journal** opens the same dialog and sends data to both the **Journal Table** and the chosen file. The specific data values that are sent depends on whether the data are being sent from the **Main** or **Analysis Window**.

From the Main Window:

- Choosing **Add All Data to Journal** from the **Tools** menu sends the titles of each channel and each channel's data values to the specified location(s). In **Single Cursor** mode, the amplitude

values at the **Cursor** from all channels are sent. In **Two Cursor Mode**, the difference in amplitude values between the two cursors (**Cursor 2** - **Cursor 1**) from all channels are sent.

- Choosing **Add Title to Journal** from the **Tools** menu sends the titles of all channels to the specified location(s).

From the Analysis Window:

- Choosing **Add All Data to Journal** from the **Tools** menu or from any of the **Channel Menus**
- (accessed by clicking on the arrow on the left side of any of the **Channel Bars** or right-clicking in any of the channels) sends the channel titles and the values from the **Table Functions** data boxes in the **Channel Bars** of all channels to the specified location(s).
- Choosing **Add Title to Journal** from the **Tools** menu or from any of the **Channel Menus** sends the **Title(s)** from the **Table Functions** data box title bar to the specified location(s).
- Choosing **Add Ch. Data to Journal** from a channel menu sends that channel's title and **Table Functions** data box values to the specified location(s).
- These three **Journal** commands can also be displayed by clicking on any of the **Table Functions** data boxes in a **Channel Bar**.

Images of the raw data and computed channels can also be added to the **Journal**:

- Choosing **Add Image to the Journal** from the **Tools** menu sends an image of all the raw data and computed channels on the visible screen to the **Journal Editor** from either the **Main** or **Analysis Window**.
- Choosing **Copy Graph** from any of the **Channel Menus** will send an image of that channel to the clipboard. The image can then be pasted into the **Journal Editor** or an external application.

Printing and Saving the Journal

The **Journal** can be printed by using the **Print Journal** command in the **File** menu or the Print icon in the **Journal Editor Toolbar**.

The **Journal** can be saved as a web page (in *.html format) or as an XML file (in *.xml format) by selecting **Save as...** in the **File** menu and choosing a format from the **Save as type:** drop-down menu in the **Save as...** dialog.

By moving images and calculated values to the **Journal** and adding typed comments from the keyboard, an entire lab report can be created without ever leaving *LabScribe*.

Cutting, Copying, and Pasting

LabScribe supports cutting and copying:

- Choosing **Copy** in the **Edit** menu will copy an image of all raw data and computed channels to the clipboard. This image can then be pasted into the **Journal** (by using the **Paste** icon in the

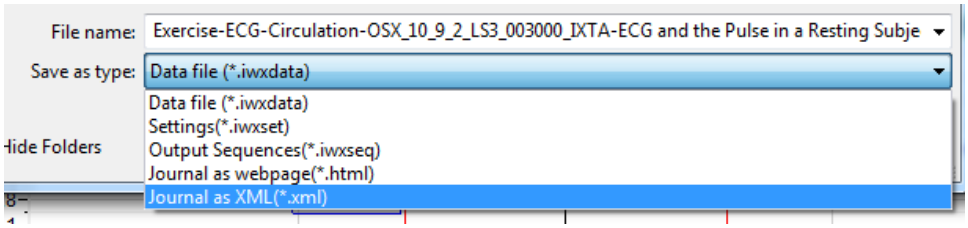
Journal's toolbar) or into an external application.

- In *LabScribe*, pasting is supported only in the **Journal**. To paste the copied image into the **Journal**, first **Copy** data from either the **Main** or **Analysis** windows. Open the **Journal** and click the **Paste** icon in the **Journal's** toolbar. Text and images from other sources can also be pasted into the **Journal**. Data can be copied from the **Journal Table** and pasted into the **Journal Editor**.

Saving and Saving As

Once recorded, *LabScribe* can save data in its own binary format using the **Save** or **Save As** command found in the **File** menu. Selecting **Save As...** will open a dialog allowing the user to create a copy of the file with a new name. *LabScribe* can save several types of documents:

- An iWorx data file (*.iwxdata format).
- An iWorx **Settings File** (*.iwxset format).
- A macro (*.iwxmacro).
- The **Journal** as a web page (*.html format) or XML file (*.xml format).



Save as... file type options in the Save as... dialog.

Printing

The **Print View** command in the **File** menu will print the raw and computed data channels exactly as they appear on the current screen. The **Print Preview** command previews the image to be printed.

The **Print Journal** command will preview the **Journal** pages as they will appear in print. A **Print...** command will appear over this preview which opens a dialog from which the user can choose the pages of the **Journal** to be printed.

It is important that you display the *LabScribe* windows exactly as you want them to appear on the printed page before issuing a **Print** command.

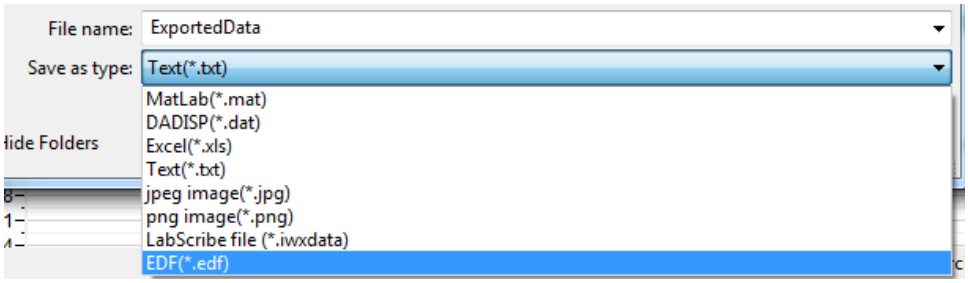
Exporting Data

Data can be exported from *LabScribe* as either data values or pictures from any window. To export data, select **Export** from the **File** menu and choose the file's format, location and name in the dialog window.

Exporting Images

The active display can be exported as a JPEG (*.jpeg format) or a Portable Network Graphics (*.png) image. Portable Network Graphics is a high resolution format for images. Only the raw data and

computed channels will be included in the image. If the **Journal** is open, it will not be part of the image.



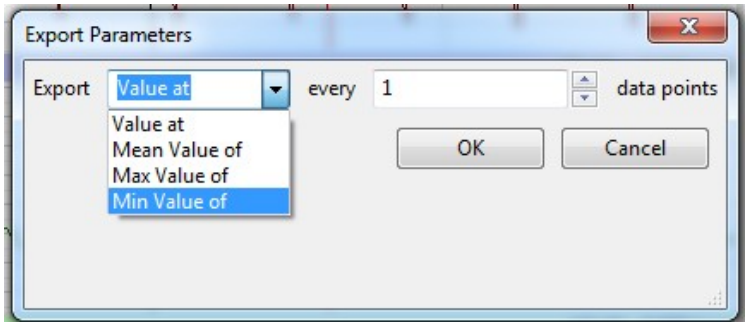
Export file format options.

Exporting Numerical Data

The numerical data points that make up the recorded data can be exported in MATLAB (*.mat format), DADiSP (*.dat format), Text (*.txt format) or Excel (*.xls format). The data can also be exported as a LabScribe data file (*.iwxdata) or as a European Data Format file (*.edf).

If data are exported from the **Main Window**, the complete data file is exported. If data are exported from the **Analysis Window**, then only the data displayed in the visible window are exported.

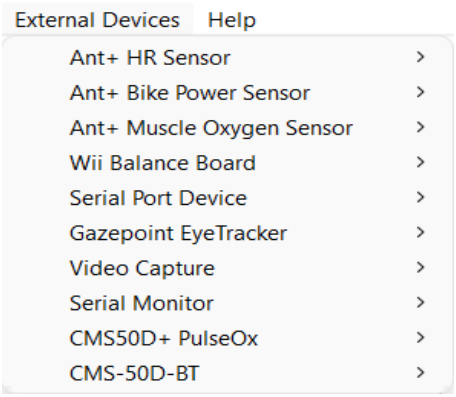
Choosing any of these **Export** formats will open an **Export Parameters** dialog in which the user can choose whether to export every data point, a sampling of data points, the averages of a chosen number of data points, or the maximum or minimum values of a chosen number of data points.



The Export Parameters dialog.

11 External Devices

LabScribe can record data from the following External Devices:



- **Ant+ Heart Rate Sensor**
- **Ant+ Bike Power Sensor**
- **Ant+ Muscle Oxygen Sensor**
- **Wii Balance Board**
- **GazePoint Eye Tracker**
- **Video & Screen Capture**
- **Serial Monitor**
- **Serial Port Device**
- **CMS50D+ PulseOx**
- **CMS-50D-BT (pulseox sensor)**

The data from these devices is recorded at the same time as data from the iWorx Recorder, allowing the comparison of physiological parameters recorded with iWorx Recorders and these external devices.

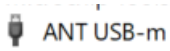
These devices may not be available on all operating systems.

Setup for these devices is through the External Devices menu on the Menu Bar. A separate license is required for using these devices. The license code is entered in the setup dialog for each device.

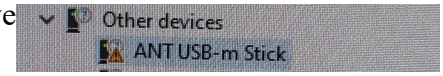
Ant+ Sensors

Ant+ sensors require an ant+ USB dongle. The dynastream ANT+ usb dongle has been tested to work. The drivers for the ANT+USB dongle may need to be installed. The drivers can be downloaded from : https://iworx.com/users/ant_usb2_drivers.zip

Troubleshooting:

Check that the device manager shows the USB ANT+ device: 

- If there is an exclamation mark next to it, the drivers have not been installed properly.



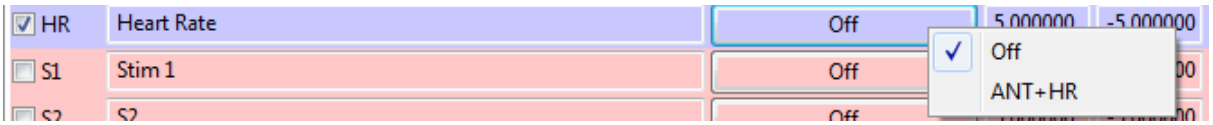
Ant+ Heart Rate Sensor

The Ant+ Heart Rate Sensor enables LabScribe to record heart rate information from an ANT+ heart rate sensor. An ANT+ USB adapter is required. Plug the ANT+ USB dongle into the computer. Follow the directions from the ANT+ USB adapter to install it on the computer.

Launch LabScribe and choose External Devices → Ant+ HR Sensor → Setup menu.

- Enter the license number for the ANT+ Heart Rate module that is provided.
- Choose the ANT+ port.
- Enable the ANT+ sensor.

Under Edit → Preferences, you will see an additional channel in the channel list



Place a check mark in the HR channel to enable it, name it “Heart Rate” and choose ANT+HR from the mode drop down menu.

The Heart Rate channel will now show up in the main window.

Ant+ Bike Power Sensor

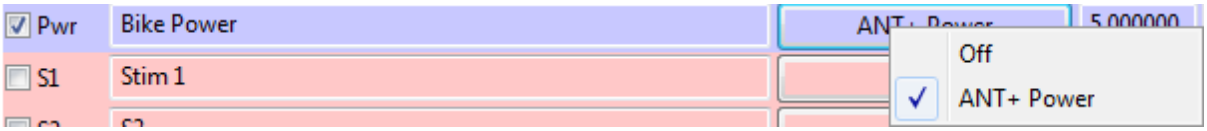
The Ant+ Bike Power Sensor enables LabScribe to record Bike Power information from an ANT+ bike power sensor. An ANT+ USB adapter is required.

Plug the ANT+ USB dongle into the computer. Follow the directions from the ANT+ USB adapter to install it on the computer.

Launch LabScribe choose External Devices → Ant+ Bike Power Sensor → Setup menu.

- Enter the license number for the ANT+ Bike Power module that is provided.
- Choose the ANT+ port.
- Enable the ANT+ sensor.

Under Edit → Preferences, now you will see an additional channel in the channel list



Place a check mark in the Pwr channel to enable it, name it “Bike Power” and choose ANT+Power from the mode drop down menu.

The Bike Power channel will now show up in the main window.

Ant+ Muscle Oxygen Sensor

The Ant+ Muscle Oxygen Sensor enables LabScribe to record Muscle Oxygen information from an ANT+ Muscle Oxygen sensor. An ANT+ USB adapter is required.

Plug the ANT+ USB dongle into the computer. Follow the directions from the ANT+ USB adapter to install it on the computer.

Launch LabScribe choose External Devices → Ant+ Muscle Oxygen Sensor → Setup menu.

- Enter the license number for the ANT+ Muscle Oxygen module that is provided.
- Choose the ANT+ port.
- Enable the ANT+ sensor.

Under Edit → Preferences, now you will see an additional channel in the channel list

Place a check mark in the SmO2 and/or the THg channels to enable them, name the channels and choose ANT+ SmO2 and/or ANT+ Thg from the mode drop down menu.

The Muscle Oxygen channel(s) will now show up in the main window.

Wii Balance Board

The Wii Balance Board enables LabScribe to record balance activity from the Wii Board. This is available on Windows and OSX operating systems. A Bluetooth adapter is required.

Follow the directions for enabling Bluetooth on your computer.

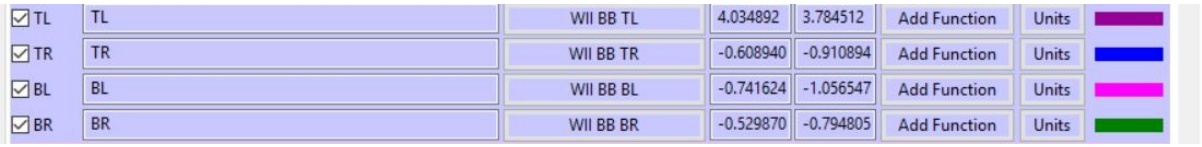
Enabling Bluetooth:

1. Open the Bluetooth Manager for your computer.
2. Add the Wii Balance Board as a device. Directions can be found online for your model of computer.
3. Once the Wii Board has been added as a Bluetooth device:
   - Open the Bluetooth Manager
   - Double-click on the Wii Board (Nintendo RVL-WBC-01)
     - A message should appear about syncing the Wii Board to the computer
     - Press and hold the “sync” button on the underside of the Wii Board. You may need to remove the battery cover
     - The Wii Board power light will flash
     - Click OK
     - The Bluetooth “connect” symbol will appear on your Bluetooth menu

Launch LabScribe choose External Devices → Wii Balance Board → Setup menu.

- Enter the license code for the Wii Balance Board module that is provided.
- Enable the Wii Board.

Under Edit → Preferences, now you will see an additional channels in the channel list



Place a check mark in the TL, TR, BL and BR channels to enable them, name them “TL,” “TR,” “BL,” and “BR,” and choose WII BB TL (etc) from the mode drop down menu.

The Wii Board channels will now show up in the main window.

Troubleshooting:

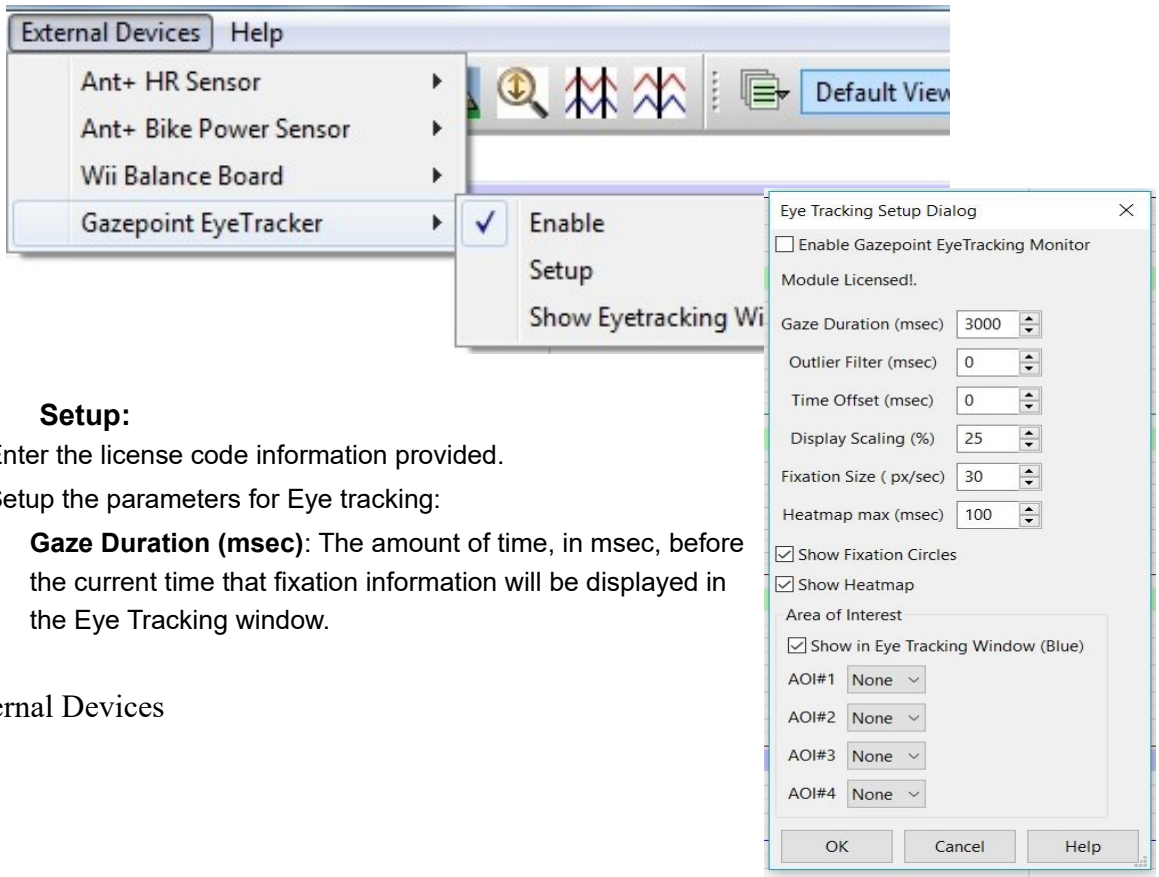
Windows 10 will sometimes ask for a passcode to connect to the Wii Balance board. To bypass that.

- Right Click on the Bluetooth icon on the task bar.
- Choose Join a Personal Area Network.
- Add Device
- It should find the nintendo wii board.
- when it asks for pass code, just click next.

GazePoint Eye Tracker

GazePoint Eye Tracker module allows LabScribe to acquire eye tracking data from a GazePoint Eye Tracker and integrate it with physiological data acquired with an iWorx Recorder. This is available on Windows operating systems only. Please refer to the GazePoint computer specs https://www.iworx.com/customer-area/tech-center/ for minimum computer requirements.

You can access the GazePoint Eye Tracker setup from the External Devices menu.



Setup:

Enter the license code information provided.

Setup the parameters for Eye tracking:

- **Gaze Duration (msec)**: The amount of time, in msec, before the current time that fixation information will be displayed in the Eye Tracking window.

- **Outlier Filter (msec)**: The amount of time, in msec, that the eye has to be fixated at a single spot. If the fixation duration is less than the Outlier Filter value, then the fixation will not be displayed in the Eye Tracking window.
- **Time Offset (msec)**: This can be used to take care of any time offset between the eye tracking data and LabScribe data.
- **Display Scaling (%)**: The Eye Tracker tracks the complete screen. We want to analyze LabScribe data as well as eye tracking data. Display scaling allows for the eye tracking window to show a scaled version of the screen.
- **Fixation Size**: The "fixation" data is shown as a circle whose radius is proportional to the fixation duration. The circle size is the radius of the circle in pixels corresponding to a 1 second fixation duration.

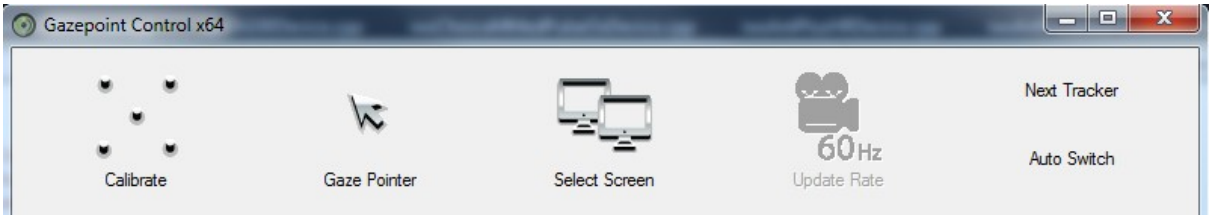
Setup the Area of Interest (AOI)

- Set up the Area of Interest (AOI) if there is a specific location on the image you wish the subject to focus on. Note that some experiments will just want to see where the subject is focusing rather than knowing when the subject focuses on the "designated" area.
  - **Choose AOI#**, click the drop down to have the AOI shown as a circle or rectangle
  - Open the image that the subjects will be looking at in an image editing program such as Paint, Photoshop, Lightroom
  - Hover over the AOI, note the X and Y pixel coordinates – and enter these in the boxes to the right of AOI#
- When you choose to "Show the EyeTracking Window" - the image the subject is looking at will be shown on one monitor with the AOI in blue. The actual image the subject will be looking at on the second monitor will not show the AOI.

To acquire eye tracking data, the GazePoint module has to be enabled in LabScribe and the GazePoint application has to be running.

GazePoint Control Software

Calibration of the Eye Tracker is handled by the GazePoint software.

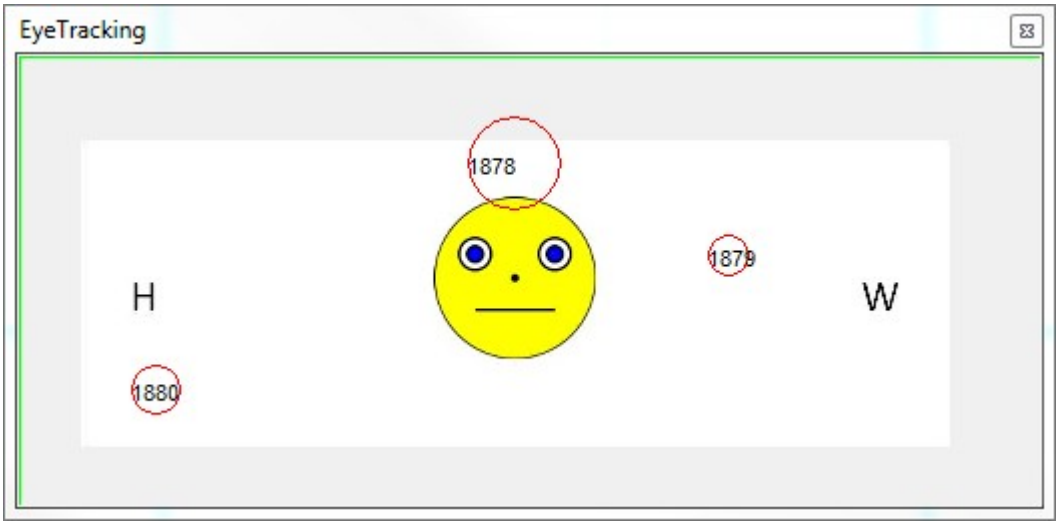


Choose the screen that the subject will be using. Then calibrate the Eye Tracker.

Refer to the GazePoint manual for more instructions to calibrate the system.

The image window in LabScribe can be moved over to a second monitor if using multiple monitors.

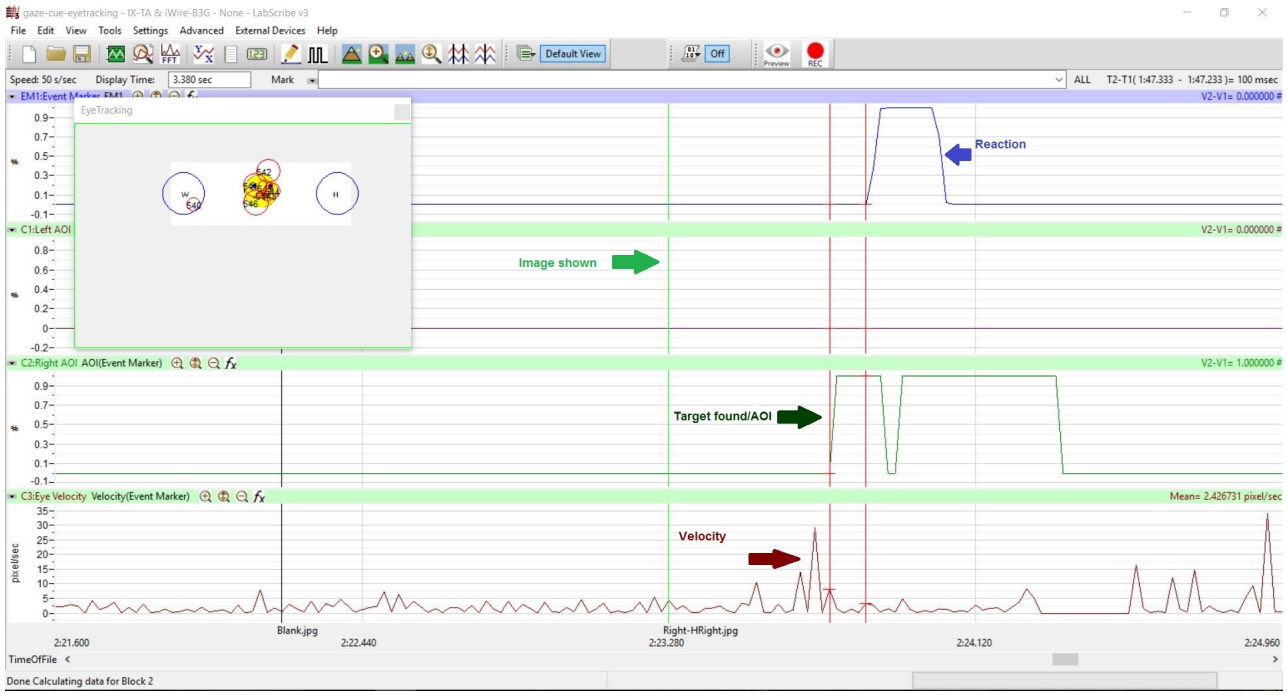
Enable the Eye Tracking window by choosing External Devices → GazePoint Eye Tracker → Show Eye Tracking Window.



During recording the Eye Tracking window will show the images that is displayed in the image window of LabScribe as well as the current fixation of the eye at that time.

Once recording is stopped, the Eye Tracking window will show the image displayed at the time corresponding to the midpoint of the data displayed on the Main window. This point is shown by a green line on the main window.

The fixation data for the time set by the Gaze Duration is displayed in the Eye Tracking window.



Channel Functions:

LabScribe has additional Eye tracking channel functions available from the Add Function button on the Channel bar.

Click on the ***fx*** button on the Channel bar and choose **Eye Tracking.** The following Eye tracking functions are available

1) **Velocity**:This creates a Channel, that displays the velocity in pixels per second of the **Best Eye Point of Gaze.**

2) **Area of Interest (AOI)** : The AOI's are defined in the Eye trackign setup window. The Channel function, looks at the AOI region, that has been selected.

1. When the gaze is in the AOI: channel data is 1.
2. If the gaze is outside the AOI then the channel data is 0.

There is an option to only look for the AOI if a particular Image is being displayed. A text to match the images names can be provided here. LabScribe will only calculate if the gaze is in the AOI, if an image that contain the match text is being displayed.

To acquire eye tracking data, the GazePoint module has to be enabled in LabScribe and the Gazepoint application has to be running.

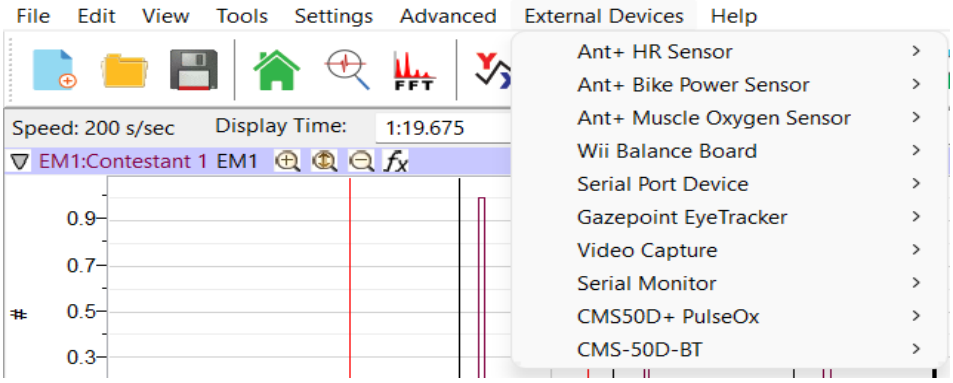
Typical Use:

- Connect the iWorx Hardware to the computer, turn it on and Start Labscribe.
- Load the appropriate settings file.
- Start the Gazepoitn Control Software. Choose the monitor if using multiple monitors.
- Make sure the subject is at the correct distance and Calibrate the Gazepoint Eye Tracker.
- Open the Eye Tracking Setup dialog in LabScribe, by choosing External Devices -> Gazepoint EyeTracker -> Setup
- Use the Experiment Builder in LabScribe, to create a sequence of images to be displayed
- If using multiple monitors, open the Image window and drag it to the second monitor.
- Open the Eye Tracking Display window, so we can monitor the gaze data in real time.
- Connect the physiological sensor to the Subject.
- Start Recording.
- If Gazepoint can detect the eyes of the subject, you should start seeing the Fixation circle in the Eye Tracking window.
- Run the Experiment.
- Stop Recording
- Analyze the Data.

Video and Screen Capture

The Video and Screen Capture module allows LabScribe to actively record a screen capture or video, both with or without audio, during data acquisition. This module can be used with the built-in camera on the computer or an external video camera.

You can access the Video and Screen Capture setup from the External Devices menu.



To **ENABLE** this module:

- Click External Devices → Video Capture
- Click Enable

Setup:

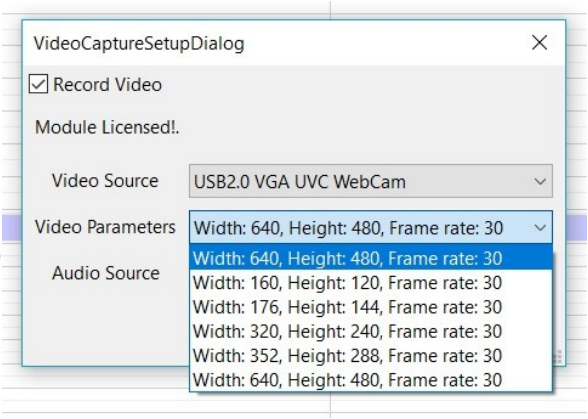
Enter the license information provided.

Setup the parameters for Video or Screen Capture:

- **Record Video:** Check this box.
- **Video Source:** Choose Screen Capture or video capture.
- **Video Parameters:**

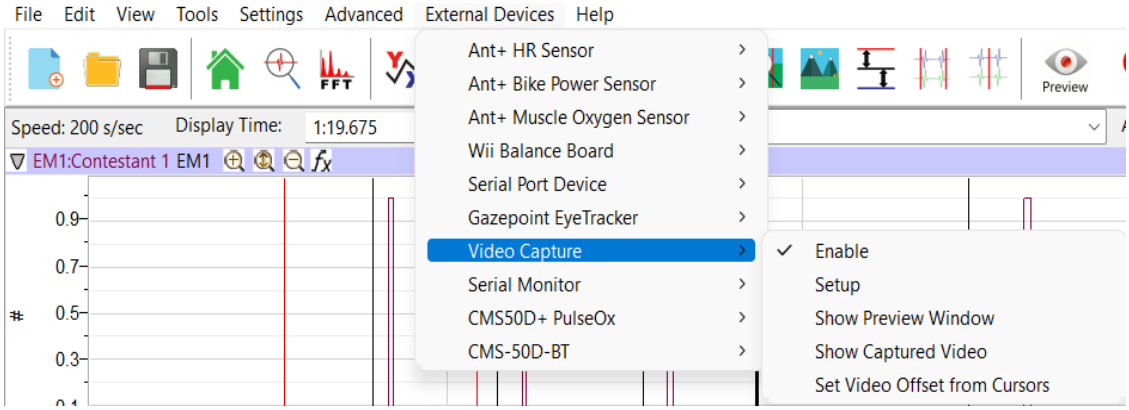
  For Screen Capture, this will be your screen resolution.

  For Video Capture, this will usually be the first choice on the list. It is based on the type of camera and frame rate of capture.
- **Audio Source:** Choose the audio source. It can be a built-in or external microphone.



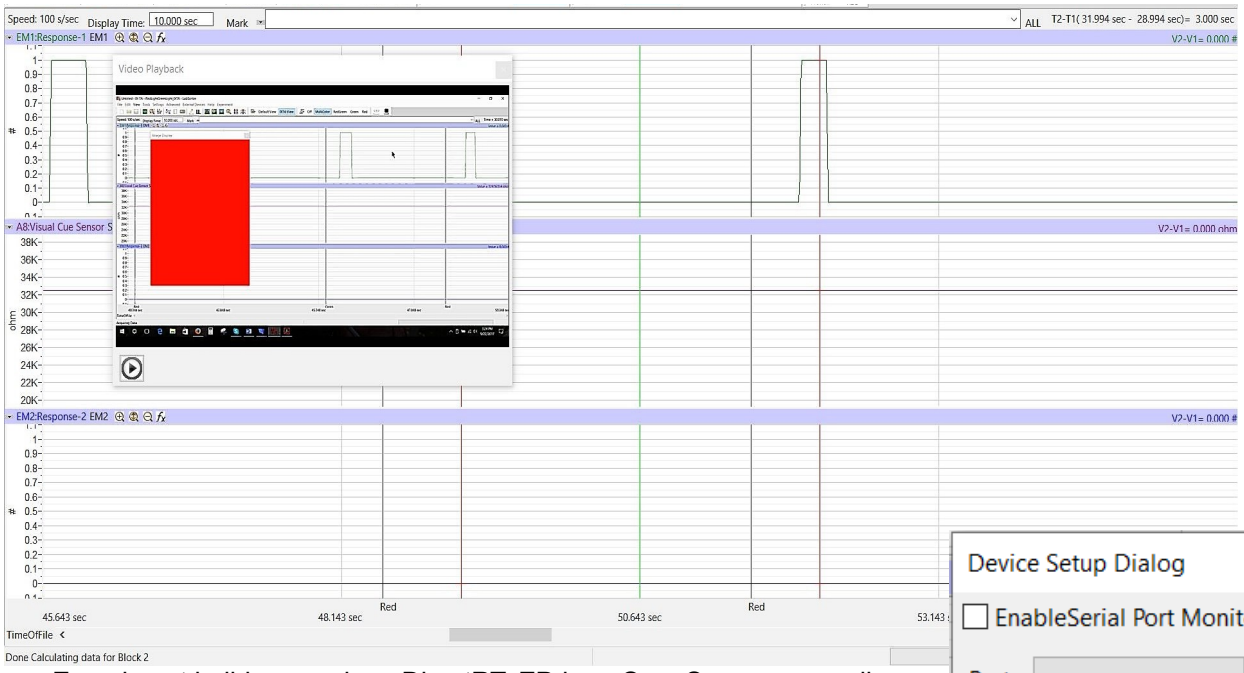
Data Acquisition:

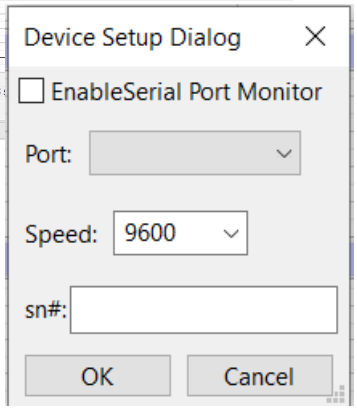
- **Show Preview Window (Recommended):** It is recommended that you show the preview window while actively collecting data so that you can see what is being captured in real time.
- **Data Collection:** Choose the lab you wish to do from the Settings menu. Record data normally. Click Stop and Save your data when recording is completed.



Data Analysis:

- Click External Devices → Video Capture → Show Captured Video
- Scroll to the beginning of your recording.
- Click the “play” button. This will begin playing the screen capture or video that was recorded during data collection and move the recorded data on screen in conjunction with the capture.





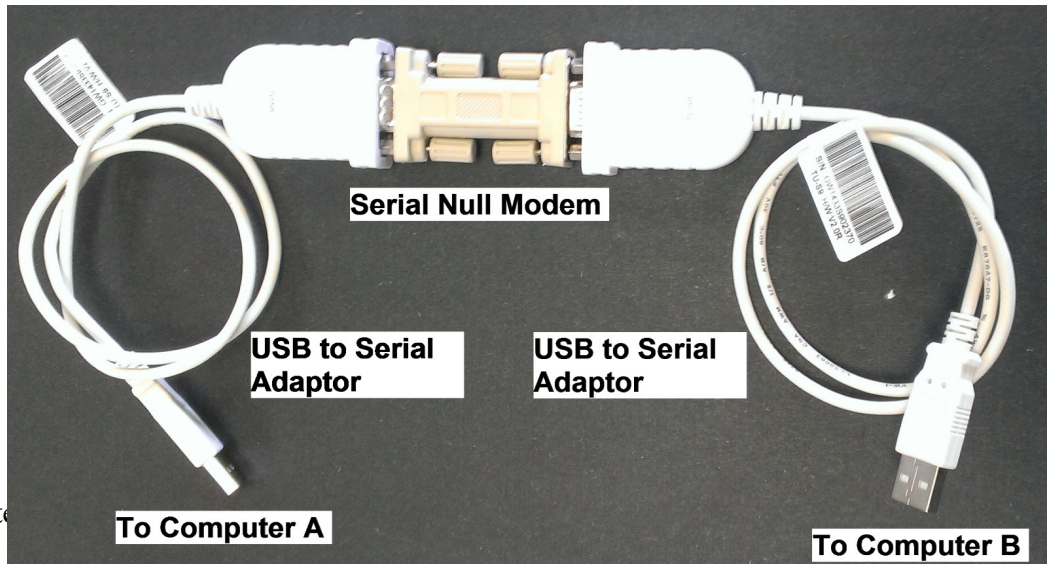
Serial Monitor

Experiment builders, such as DirectRT, EPrime, OpenSesame as well as other softwares have the ability to send a message on the serial port. LS-SERIAL-MON serial monitor enables LabScribe to listen on the serial port and place marks in LabScribe with the text received on the serial port. This can be used to communicate to Labscribe when a particular image or video is played by the experiment builder.

- Choose the serial port.
- Choose the serial port speed.
- Enable the Serial Port monitor
- Place the cursor on the green line shown on your recording screen. This line represents the actual time at which the stimulus occurred.
- Place the other cursor on the Mark, then click External Devices → Video Capture → Set Video Offset From Cursors. This will allow you to remove the offset timing between when the video captured the stimulus and when the mark was made on the screen.
- You can then analyze your data as you would normally.

Connecting 2 computers:

- If both the computers have existing serial ports, the serial ports can be connected together using a Null-Modem adapter/Cable or a Serial crossover cable.
- If one or more computers do not have a serial port, you can add a serial port to the computer using a USB to serial adapter.



When any serial input is received on the serial port during recording, Labscribe will place a mark in the record with the text received from the serial port.

If a single byte is received then the mark will show the `SP:Byte:0x` followed by the value of the byte in hex.

Serial Port Device

Various devices such as electronic scales have a serial port output. The Serial Port Device module is designed to simplify collecting data from these devices.

Setup

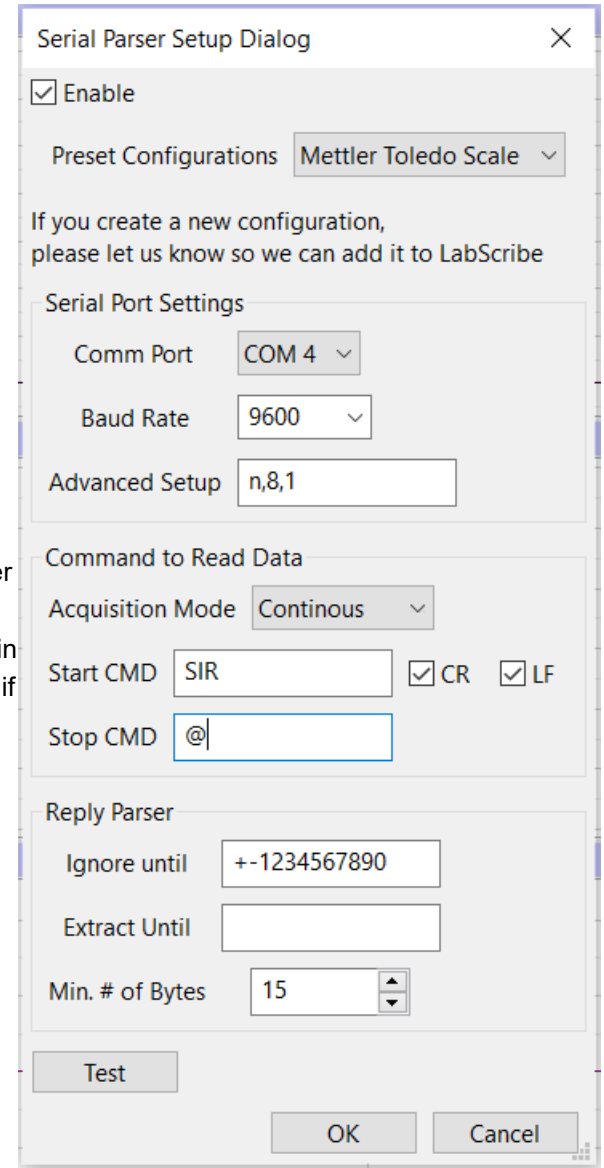
Choose External Devices → Serial Port Device → Setup menu.

Enter the license number for the Serial Port Device module that is provided.

The Serial Port Device Parser has some preset configurations that can be used to setup the device.

If you are using one of the preset configurations, then you only need to select the Comm Port.

If you are using a device that is not among the preset configurations then you will have to setup all the parameters.



The serial port parameters are as follows:

- **Comm Port**: the port that the serial device is connected to
- **Baud Rate**: the speed of the comm port
- **Advanced setup**: typically most serial ports use no parity, 8bit data with 1 stop bit, this is represented as n,8,1.

Serial Devices operate in 2 modes, continuous or single value

Single Value

In Single Value mode, the computer sends an Ascii command to read the value. For Example for a Mettler Toledo scale, one needs to send an ‘S’ followed by ‘CR’ and ‘LF’. So for a Mettler Toledo scale, enter ‘S’ in the text area and select the CR and LF check boxes, if you want faster output, use ‘SI’ instead of ‘S’.

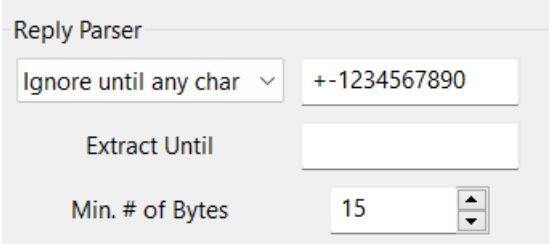
In this mode the start command is send to the device every time a packet is received from the device, to trigger the next data value.

Continuous mode

In Continuous mode, we still need to send the device a command to start the recording. For Example for a Mettler Toledo scale, for continous mode one needs to send an 'SIR' followed by 'CR' and 'LF'. In this mode we also need to have a stop command to tell the device to stop transmitting data. For the Mettler Toledo Scale that is '@'.

When the device receives the command from the computer it replies back with a string containing the value. In continuous mode, the device continually sends the updated values.

Reply Parser



The Reply Parser reads the reply string and reads the value in the string.

Ignore until any char: value tells the parser to ignore all characters in the string until it finds one of these characters. For the Mettler Toledo scale, we tell the Parser to ignore all characters until +-1234567890, ie: until it finds a number in the string.

Find String: The string is located in the reply, and the start position is set after this string.

Extract Until value is used to find the end of the number. In the case of the Mettler Toledo scale, this value is ' ' or a space. The parser will read the number until it reaches a space.

The Min. # of Bytes is used to make sure that the parser waits until it has received enough bytes of data.

Click **Test** to test the communication. It may take 5-10 seconds. A dialog box will popup showing the reply string and the parsed value.

Click on the Enable checkbox to enable the Serial Device Parser.

Under Edit → Preferences, now you will see an additional SP channel in the channel list

CMS50D+ PulseOx or CMS-50D-BT

The CMS50D+ or CMS-50D-BT PulseOx enables LabScribe to record Oxygen saturation and a Heart Rate signal from the pulse-oximeter.

Plug the CMS50D+ or CMS-50D-BT PulseOx into the computer.

Launch LabScribe choose External Devices → CMS50D+ PulseOx or CMS-50D-BT→ Setup menu.

- Enter the license number that is provided.
- Choose the port if not automatically recognized.
- Enable the sensor.

Under Edit → Preferences, now you will see 2 additional channels one for the Oxygen saturation (SpO2) and one for the pulse signal (HR) in the channel list

Put a check mark in the boxes to enable the channels that you want to record.

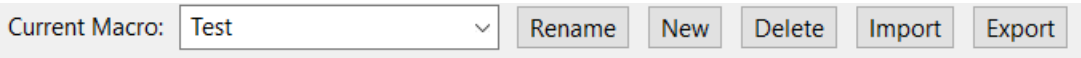
12 Macros

Multiple actions in LabScribe can be automated using Macros.

Macros are accessed from the Macro button on the toolbar or from the Preferences menu.

Creating a Macro

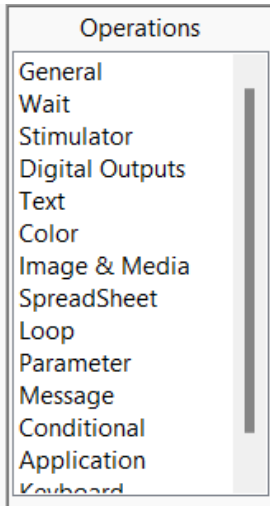
Open the Macro window. By selecting the Macro menu command.



Create a new macro by clicking on the New button. To edit a macro select the macro from the dropdown list. Macros can also be exported to and imported from other LabScribe files.

Macro Operations

The following operations are available.



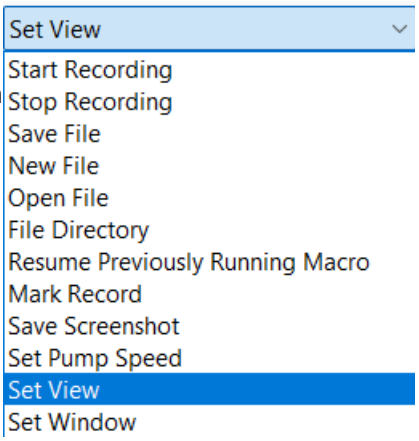
- General
- Wait
- Stimulator
- Digital Outputs
- Display Text
- Display Color
- Display Image and other Media
- Use a Spreadsheet to customize and “program” displayed text, color, or images
- Loop
- Parameter
- Message
- Conditional
- Application
- Keyboard

Select the macro command, and click on the **Add Operation to Macro** button, to add the selected macro command to the current macro.

Once a command has been modified, click on the save button to save the changes made to the macro command. If you want to place a mark in LabScribe when the macro command is executed, select the **Add Mark to Record** checkbox, and optionally enter the mark you which to place. If the mark text is blank , the program will place a descriptive mark depending on the macro command.

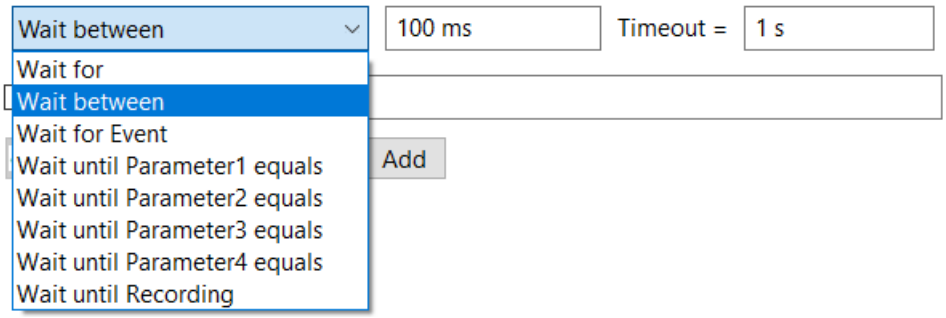
General

- **Start Recording**: Start recording data using the current settings.
- **Stop Recording**: Stop recording data.
- **Save File**: Save the file. The file name can be specified and if multiple files are to be saved in the macro, the filename can be incremented or a date or a parameter value can be appended to the file name. The parameter value is set using the Variable macro command.
- **New File**: Start a new file.
- **Open File**: Open a file.
- **File Directory**: Used to set the default folder that the program will use to load and save files. The files saved with the Save Filename operation are saved in this directory.



- **Resume Previously Running Macro** : If a macro is interrupted and paused by another macro, the state of the paused macro is saved. The new macro then can resume the previous macro using the **Resume Previously Running Macro** command. For example if we want the stimulator to fire when the user click on a button. We can create a macro that fires the stimulator and then calls **Resume Previously Running Macro** command so that any macro which was running will continue.
- **Mark Record**: Place a mark in the record.
- **Save Screenshot**: Save the screen to a file.
- **Set Pump Speed**: Set the pump speed for a recorder that has a gas analyzer
- **Set View** : Set the current View
- **Set Window** : Change the window. The options are Main, Analysis, FFT, XY View.

Wait



The wait command is used to pause the execution of the macro for a certain amount of time.

The Time can be specified in the HH:MM:SS.msec format. It can also be specified as “ms” or “s”

As seen in the example above the wait time is set between 100 msec and 1 sec. This allows you to choose any wait period.

- **Wait for**: Choose the amount of time you want to wait for.
- **Wait between**: Used to get a random wait time between 2 time values.

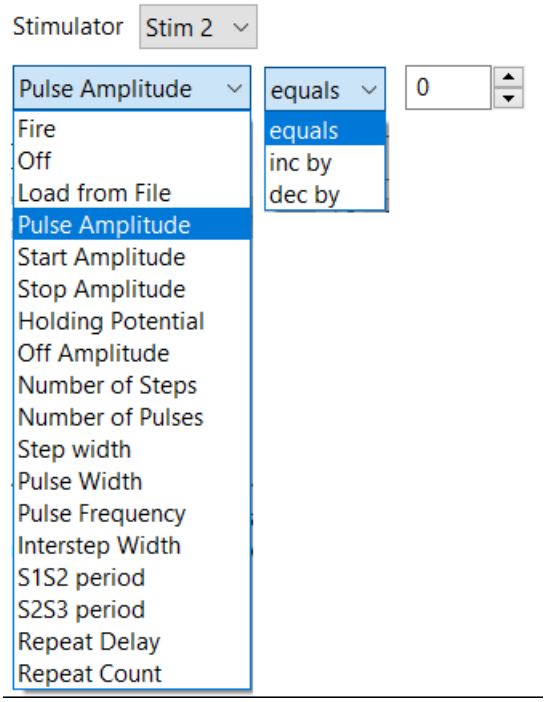
- **Wait for Event**: Wait until an preset event happens, you can choose the number of the event. The event is define in the Events page of the preferences dialog.
- **Wait until Parameter1 equals**: Wait until the parameter1 equals a certain value.
- **Wait until Parameter2 equals**: Wait until the parameter1 equals a certain value.
- **Wait until Parameter3 equals**: Wait until the parameter1 equals a certain value.
- **Wait until Parameter4 equals**: Wait until the parameter1 equals a certain value.
- **Wait until Recording**: The macro is paused until recording begins. This is use when converting old sequences into new macros. Sequences in Labscribe only ran when data was being recorded.

Stimulator

The Stimulator parameters can be controlled from the macro, as well as firing and stopping a stimulator.

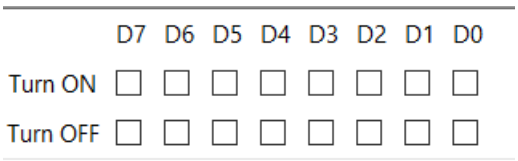
Choose the stimulator. Then choose the stimulator parameter you want to change. A complete stimulator setting can be loaded from a file. The stimulator setup file can be exported from the stimulation tab, under the Preferences dialog.

The stimulator parameter selected to be modilfied can be set to a value or incremented by or decremented by a value.



Digital Outputs

The digital outputs can be turned on and off using macros. Each digital i/o line can be controlled independently. Choose the digital outputs that you want to turn on first, then the digital outputs that will be turned off.



Display Text

This is used as part of the Experiment builder. LabScribe can be programmed to display a text to the user.

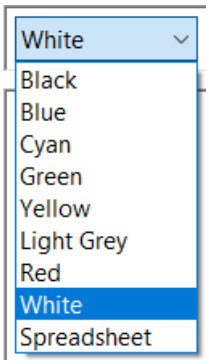
In the custom mode the Text to be displayed, the font , font size, color, angle of the text, and the background color is set using the dialog.

The spreadsheet can be used to ease the task of displaying multiple text. The Spreadsheet needs to be setup with the following columns.

- Column 1 is the Text to be displayed : eg. *Text to be displayed*
- Column 2 is the Font size : eg. *12*
- Column 3 is the font weight: can be *normal*, *bold, italic, bold italic*
- Column 4 is the angle of the text in degrees: eg. *45*
- Column 5 is the color of Text to be displayed : eg. *black, blue, cyan, green, yellow, light grey, red, white* ...
- Column 6 is the background color : eg. *black, blue, cyan, green, yellow, light grey, red, white* ...

Display Color

This is used part of the Experiment builder. LabScribe can be programmed to display a window with a solid color.



The colors available are **Black, Blue, Cyan, Green, Yellow, Light Grey, Red, White,**

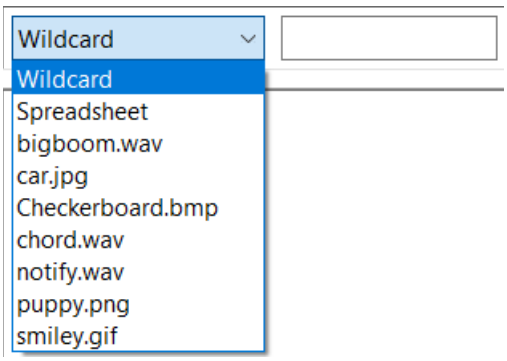
The spreadsheet can be used to specify the color as well. When using the spreadsheet, the column containing the color information needs to be specified as well.

Display Image and other Media

LabScribe can display images and other media.

First import the images or media into LabScribe using the Import Media button. The Delete Media button can be used delete any files imported.

The imported media will now be available under the Image and Media command setup.



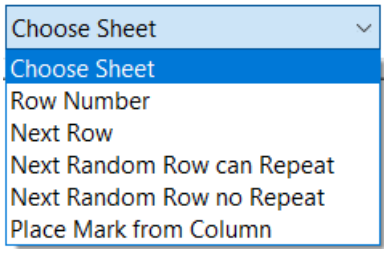
- **Wildcard** : Use a wildcard to select images or media to be displayed.
  - '?' Matches any single character.
  - '*' Matches any sequence of characters (including the empty sequence).
- **Spreadsheet** : Choose the column in the sheet that has the image or media to be displayed.
- **Imagename** : The names of the imported files are listed in the dropdown. Choose a filename to display that image or media.

Spreadsheet

Spreadsheet can be used to automate selection of images , videos, text colors etc.

Import a spreadsheet using the **Import Sheet** button

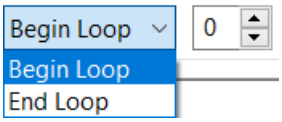
An imported sheet can be deleted using the **Delete Sheet** button.



The spreadsheet macro command setup:

- **Choose Sheet** : Choose the current sheet.
- **Row Number** : Set the row number to a value
- **Next Row**: Choose the next row.
- **Next Random Row can Repeat**: Choose a random row, the row numbers can repeat.
- **Next Random Row no Repeat**: Choose a random row, the row numbers cannot repeat.
- **Place Mark from column**.: Place a mark from the text in the selected column.

Loop



Macro commands can be repeated using a loop.

Macro commands between Begin Loop and End Loop are repeated.

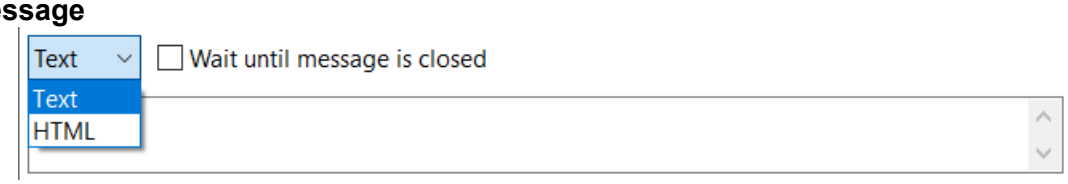
Choose Begin Loop and set the number of times the macro commands should be repeated.

Parameter

There are 4 parameters that can be used by the Macros. These parameters can be used by other macro commands, such as Save File, where the parameter value is appended to the file name.

The Parameter can be set to a value, incremented or decremented.

Message



Display a Text or HTML message. Check the Wait until message is closed to pause the macro until the message dialog is closed.

Conditional

There are 4 parameters that can be used by the Macros. You can use these parameters as part of a conditional statement to choose if the macro performs certain operations.

For eg lets say we want to fire a stimulator when a person presses the event marker 5 times. We can setup an event to increment Parameter1 everytime the event marker is pressed.

Then we can use a conditional operation in a macro such as:

```
If:Parameter1 = 5
  Fire Stim
  Parameter1 = 0
End If
```

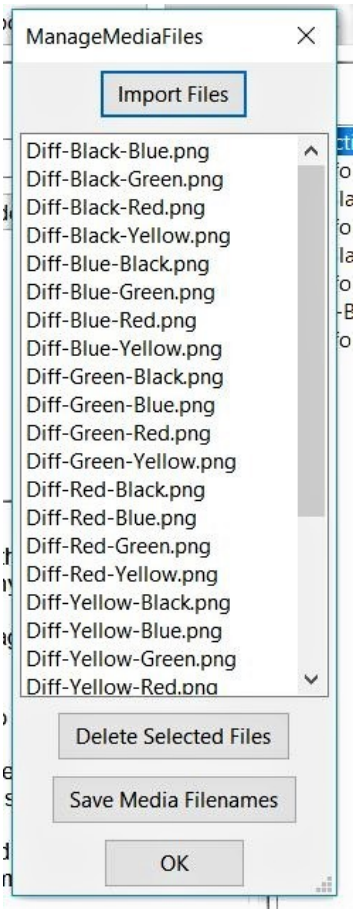
This will fire the stimulator if the Parameter 1 is 5

Experiment Builder using Macros

General Directions:

- These examples are also listed under the Experiment builder lab in the complete settings and in the macro-examples.iwxdata file in the macro folder.
- To start building your macro, click the arrow next to MACROS on the toolbar.

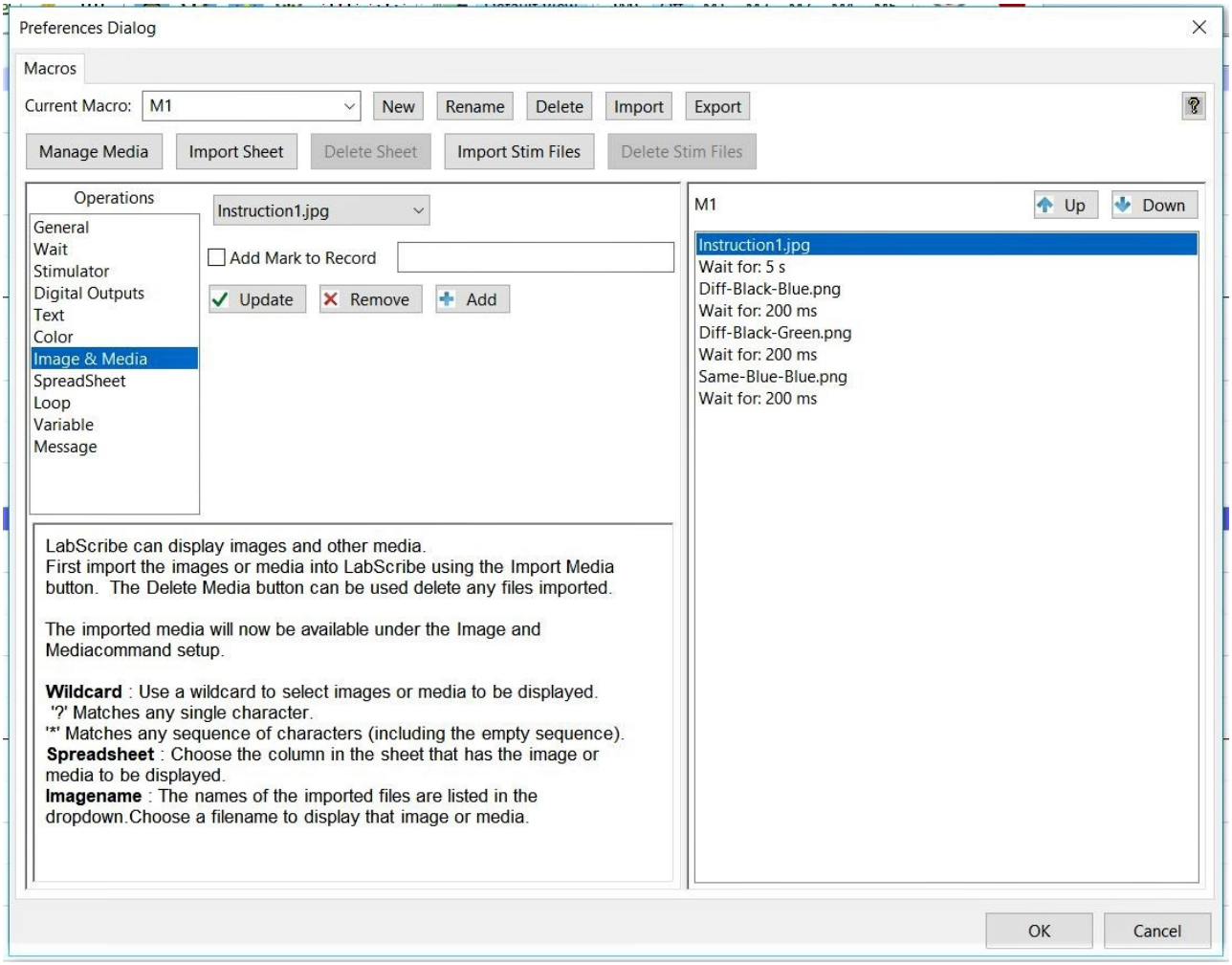
- In the new window that opens, import your media by clicking the Manage Media button and then Import Files. This will import your media files into LabScribe. You can import images, sounds, videos, and other types of files.



- Click New to create and new macro and name it.
- Follow the specific directions for each Exercise to learn how to design your own.

Macro 1

1. Click the down arrow to the right of the word MACRO.
2. Make sure M1 is selected as the current Macro so you can see the directions.
3. In this macro, instructions will be displayed at the beginning for 5 sec. Followed by 3 images 200msec apart.



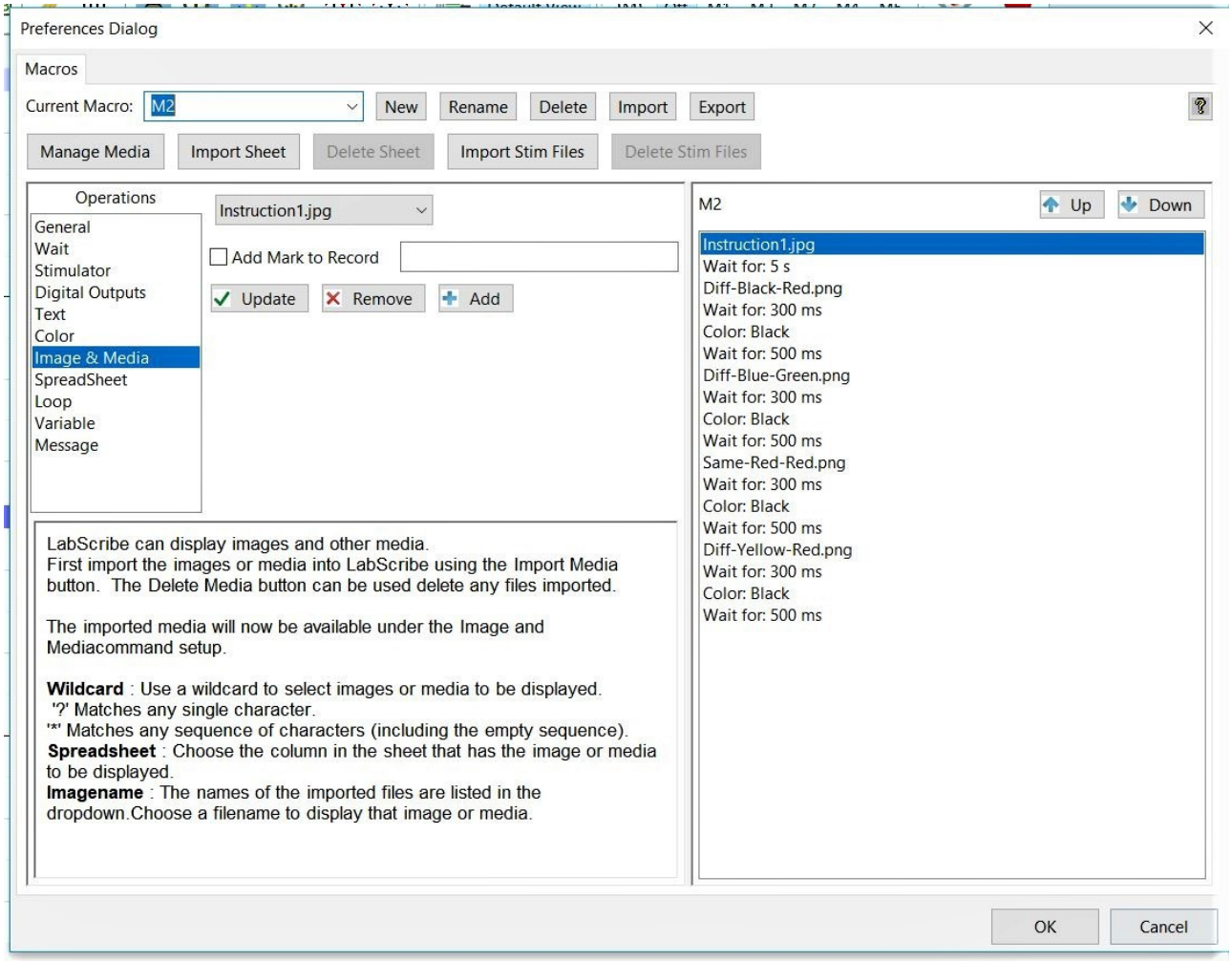
1. The macro was built by:
   - Clicking Image and Media – this will bring up the list of images imported
   - Highlight Instructions and then click Add
   - Click Wait and change the time to 5 seconds and Add
   - Click Image and Media
   - Highlight the image you want to add and then click Add
   - Click Wait, adjust the wait time and Add
   - Repeat until completed
   - Click OK
2. Click M1 on the Macro toolbar to run the example macro.

Macro 2

1. Click the down arrow to the right of the word MACRO.
2. Make sure M2 is selected as the current Macro so you can see the directions.
3. In this macro, we will display instructions at the beginning for 5 sec. Followed by 4 images Each image is displayed for 300ms, followed by a black screen for 500msec.
4. The macro was built by:
   - Clicking Image and Media – this will bring up the list of images imported
   - Highlight Instructions and then click Add
   - Click Wait and change the time to 5 seconds and Add
   - Click Image and Media
   - Highlight the image you want to add and then click Add
   - Click Wait, adjust the wait time and Add
   - Click Color, Black, Add
   - Click Wait, adjust the wait time and Add

- Repeat until completed
- Click OK

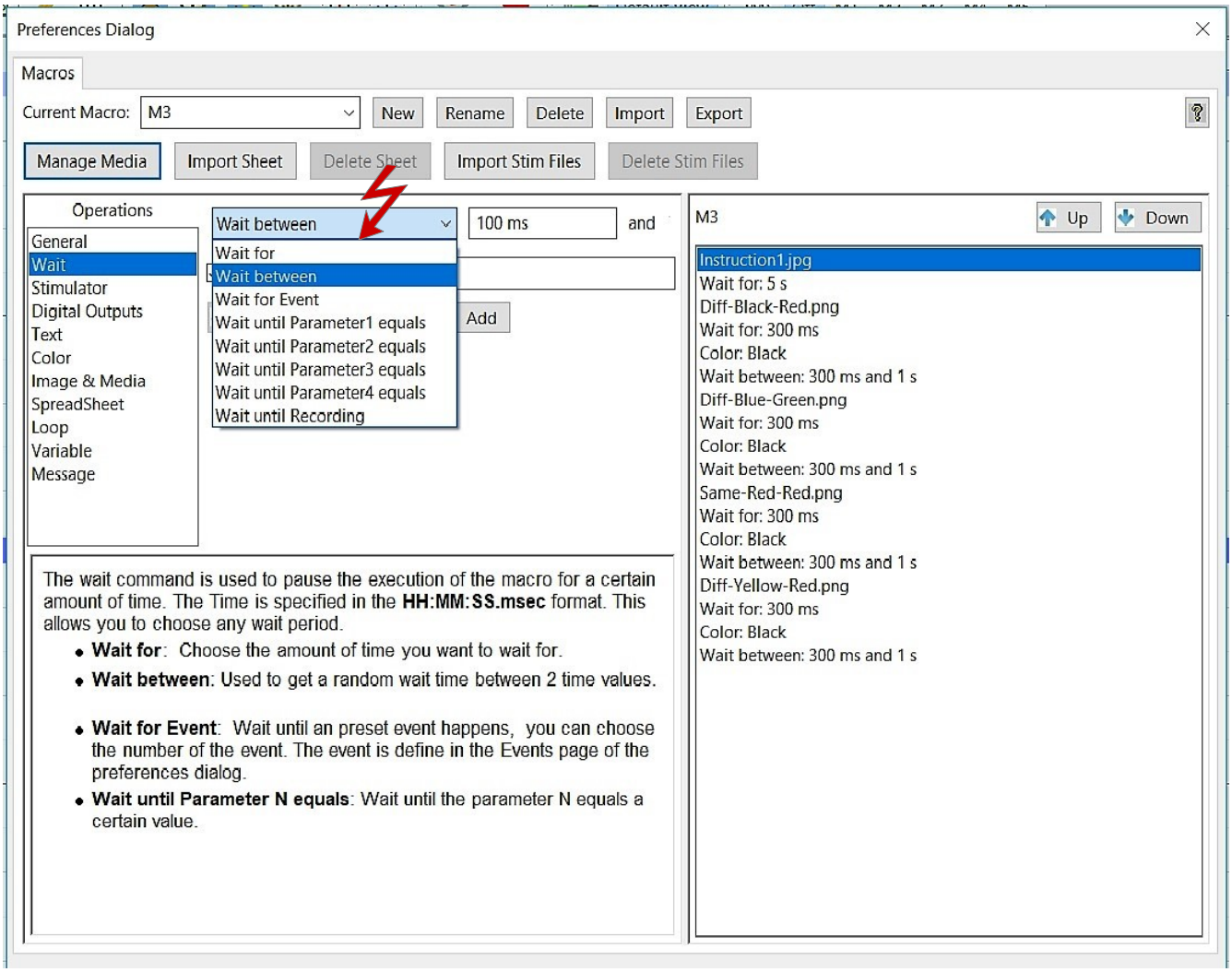
5. Click M2 on the Macro toolbar to run the example macro.



Macro 3

1. Click the down arrow to the right of the word MACRO.
2. Make sure M3 is selected as the current Macro so you can see the directions.

3. In this macro, we will display instructions at the beginning for 5 sec. Followed by 4 images Each image is displayed for 300ms, followed by a black screen for between 300msec and 1 second.
4. The macro was built by:
   - Clicking Image and Media – this will bring up the list of images imported
   - Highlight Instructions and then click Add
   - Click Wait and change the time to 5 seconds and Add
   - Click Image and Media
   - Highlight the image you want to add and then click Add
   - Click Wait, adjust the wait time and Add
   - Click Color, Black, Add
   - Click Wait, change Wait For to Wait between, adjust the wait time and Add
   - Repeat until completed
   - Click OK
5. Click M3 on the Macro toolbar to run the example macro.



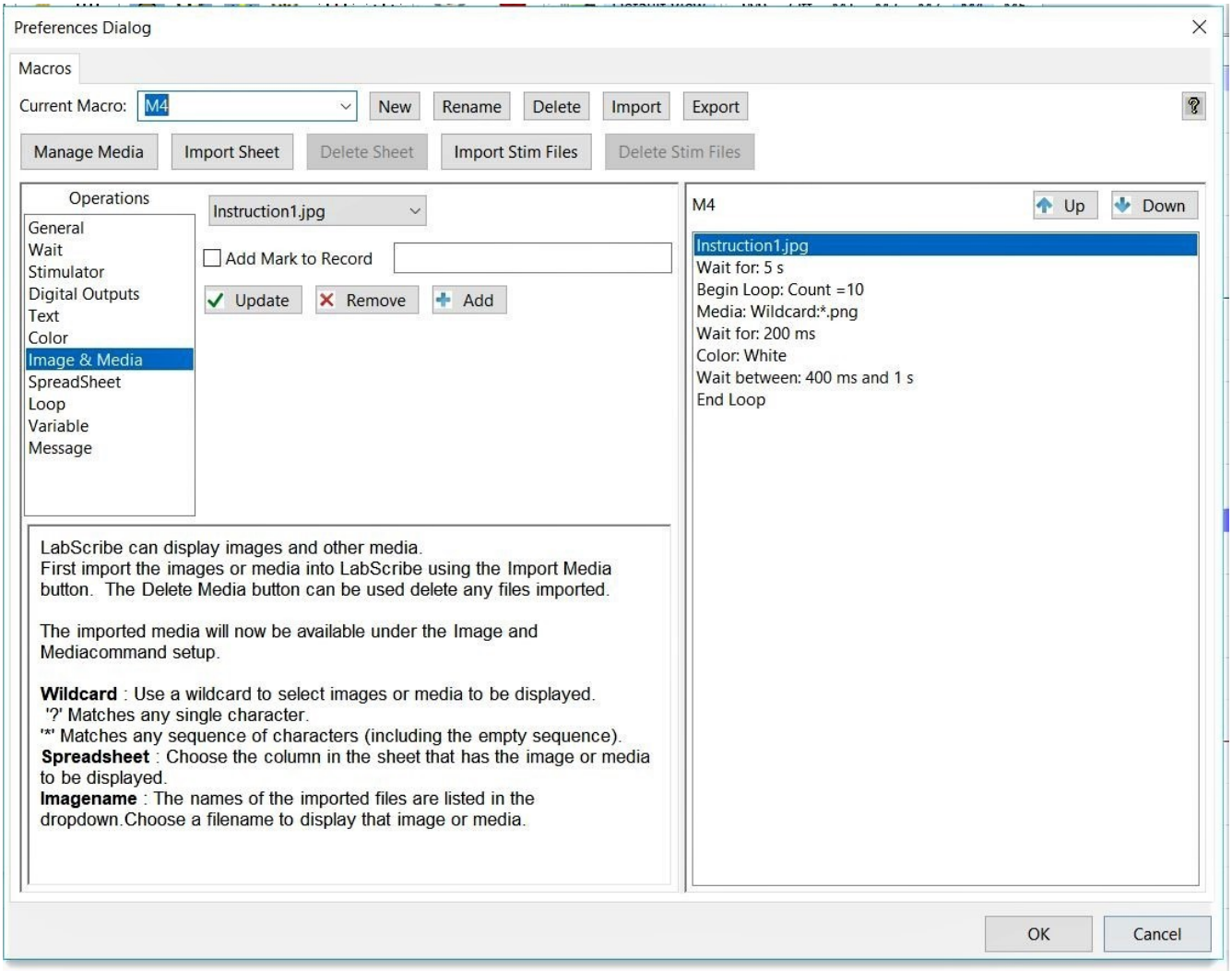
Macro 4

1. Click the down arrow to the right of the word MACRO.
2. Make sure M4 is selected as the current Macro so you can see the directions.

3. In this macro, we will display instructions at the beginning for 5 sec. Then in a Loop that is repeated 10 times, a random image is displayed. The wildcard "*.png" selects all png images to be displayed. the image is displayed for 200msec, then a White color is displayed between 400ms to 1 sec.
4. The macro was built by:
   - Clicking Image and Media – this will bring up the list of images imported
   - Highlight Instructions and then click Add

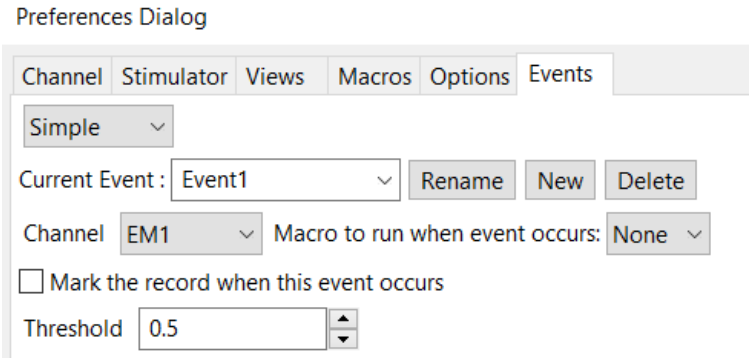
- Click Wait and change the time to 5 seconds and Add
- Begin Loop and change “0” to the number of times you would like the macro repeated.
  - You will Begin Loop and End Loop
- Click Image and Media, choose Wildcard, click Add
- Click Wait, adjust the wait time and Add
- Click Color, White, Add
- Click Wait, adjust the wait time and Add
- Move End Loop to the end of the Macro
- Click OK

5. Click M4 on the Macro toolbar to run the example macro.



Macro 5

1. Click the down arrow to the right of the word MACRO.
2. Make sure M5 is selected as the current Macro so you can see the directions.
3. In this macro, we will wait for an event to occur before showing the next image. We need to setup an event first.
   - Go to Edit → Preferences → Channels (LabScribe → Preferences on a Mac)
   - Enable the EM1 channel. We will be looking for the subject to press the Event marker.
   - In the Events Tab:
   - Create a new Event called Event1
   - Set the Channel to EM1
   - Set the Threshold to 0.5

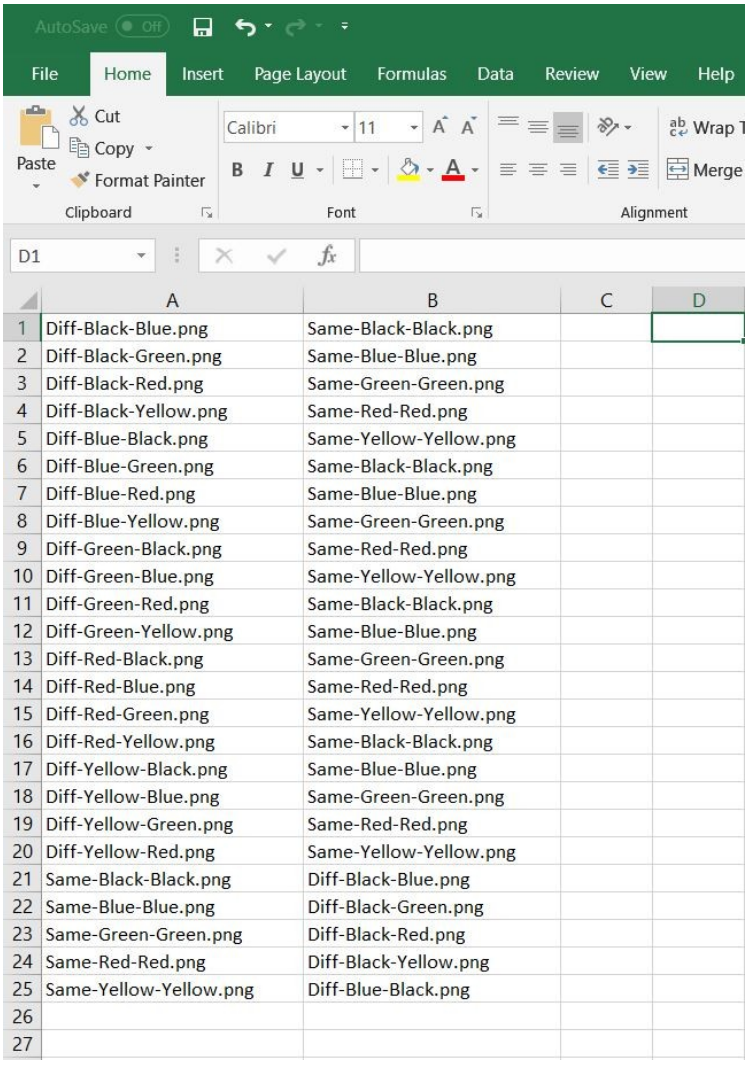


4. We will display instructions at the beginning for 5 sec. Then a Loop that is repeated 10 times, a random image is displayed. The wildcard "*.png" selects all png images to be displayed. The image is displayed until the subject presses the Event Marker plugged into the EM1 channel or 1 second, which ever happens first. Then a White color is displayed between 400ms to 1 sec.
5. Click M5 on the Macro toolbar to run the example macro.

Macro 6

1. Click the down arrow to the right of the word MACRO.
2. Make sure M6 is selected as the current Macro so you can see the directions.

3. We will use a spreadsheet to choose the images displayed. The macro-example.csv file was created and then imported using the Import Sheet button.
4. In this macro, we will select the sheet to be used, and set the row number to 1. We will display instructions at the beginning for 5 sec. Then in a Loop that is repeated 10 times, display an image, whose name is in column 1 of the spreadsheet, go to the next row of the spreadsheet display the image for 200msec. Then a White color is displayed between 400ms to 1 sec.
5. Click M6 on the Macro toolbar to run the example macro.



	A	B	C	D
1	Diff-Black-Blue.png	Same-Black-Black.png		
2	Diff-Black-Green.png	Same-Blue-Blue.png		
3	Diff-Black-Red.png	Same-Green-Green.png		
4	Diff-Black-Yellow.png	Same-Red-Red.png		
5	Diff-Blue-Black.png	Same-Yellow-Yellow.png		
6	Diff-Blue-Green.png	Same-Black-Black.png		
7	Diff-Blue-Red.png	Same-Blue-Blue.png		
8	Diff-Blue-Yellow.png	Same-Green-Green.png		
9	Diff-Green-Black.png	Same-Red-Red.png		
10	Diff-Green-Blue.png	Same-Yellow-Yellow.png		
11	Diff-Green-Red.png	Same-Black-Black.png		
12	Diff-Green-Yellow.png	Same-Blue-Blue.png		
13	Diff-Red-Black.png	Same-Green-Green.png		
14	Diff-Red-Blue.png	Same-Red-Red.png		
15	Diff-Red-Green.png	Same-Yellow-Yellow.png		
16	Diff-Red-Yellow.png	Same-Black-Black.png		
17	Diff-Yellow-Black.png	Same-Blue-Blue.png		
18	Diff-Yellow-Blue.png	Same-Green-Green.png		
19	Diff-Yellow-Green.png	Same-Red-Red.png		
20	Diff-Yellow-Red.png	Same-Yellow-Yellow.png		
21	Same-Black-Black.png	Diff-Black-Blue.png		
22	Same-Blue-Blue.png	Diff-Black-Green.png		
23	Same-Green-Green.png	Diff-Black-Red.png		
24	Same-Red-Red.png	Diff-Black-Yellow.png		
25	Same-Yellow-Yellow.png	Diff-Blue-Black.png		
26				
27				

Macro 7

1. Click the down arrow to the right of the word MACRO.
2. Make sure M7 is selected as the current Macro so you can see the directions.
3. We will use a spreadsheet to choose the images displayed. The macro-example.csv file was created and then imported using the Import Sheet button.
4. In this macro, we will select the sheet to be used, and set the row number to 1. We will display instructions at the beginning for 5 sec. Then in a Loop that is repeated 10 times, Display an image, whose name is in column 1 of the spreadsheet. Go to the next random row of the spreadsheet, without repeating a previously selected row. The image is displayed for 200msec, then a White color is displayed between 400ms to 1 sec.
5. Click M7 on the Macro toolbar to run the example macro.

Macro 8

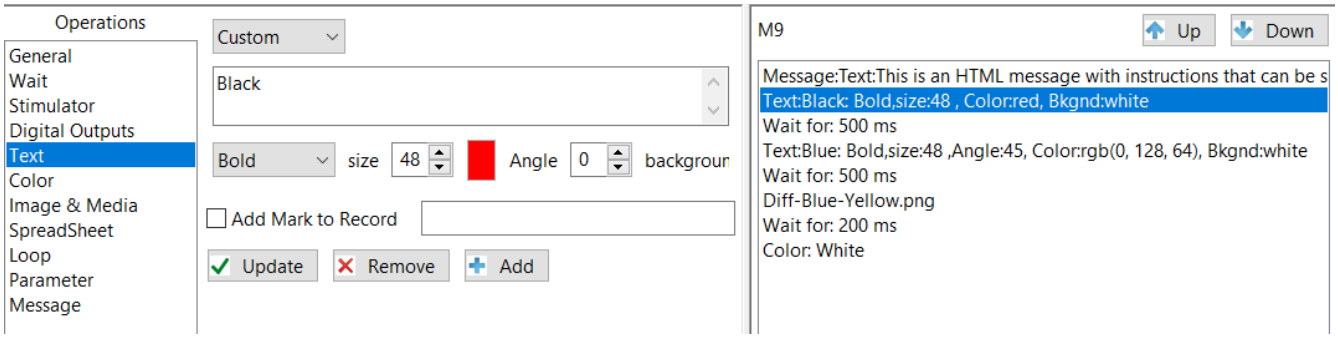
1. Click the down arrow to the right of the word MACRO.
2. Make sure M8 is selected as the current Macro so you can see the directions.
3. We will use a spreadsheet to choose the images displayed. The macro-example.csv file was created and then imported using the Import Sheet button.
4. In this macro, we will select the sheet to be used, and set the row number to 1. We will display instructions at the beginning for 5 sec. Then in a Loop that is repeated 10 times, display an image, whose name is in column 1 of the spreadsheet. Go to the next random row of the spreadsheet, without repeating a previously selected row. The image is displayed for 200msec. Display an image, whose name is in column 2 of the spreadsheet, the image is displayed for 300msec, then a White color is displayed between 400ms to 1 sec.
5. Click M8 on the Macro toolbar to run the example macro.

Macro 9

1. Click the down arrow to the right of the word MACRO.
2. Make sure M9 is selected as the current Macro so you can see the directions.
3. We will use a spreadsheet to choose the images displayed. The macro-example.csv file was created and then imported using the Import Sheet button. We will use the

Html Message and Text Operations

4. In this macro, we will display an HTML message that is shown until the subject clicks on the Next button. We will display the word Black in bold, red color for 500msec. Then we will display the word “Blue” in color RGB (0,128,64) at an angle of 45 deg for 500msec. This will be followed by an image for 200msec. We will end with the color white.
5. Click M9 on the Macro toolbar to run the example macro.

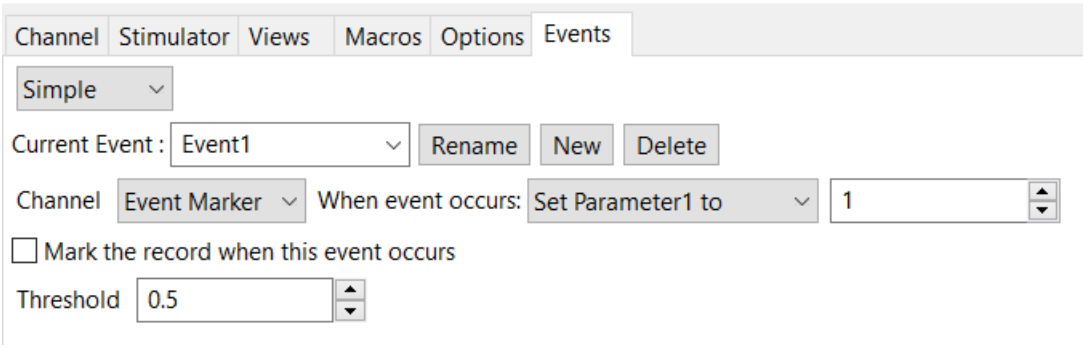


Macro 10

Conditional Statements and Events

1. Click the down arrow to the right of the word MACRO.
2. Make sure M10 is selected as the current Macro so you can see the directions.
3. In this macro, We will be showing an image, and if the person does not respond within 500msec the color Black will be displayed. Instead of displaying the color Black, we could perform other operations such as firing the stimulator. We need to setup an event first.
   - Go to Edit → Preferences → Channels (LabScribe → Preferences on a Mac)
   - Enable the EM1 channel. We will be looking for the subject to press the Event marker.
   - In the Events Tab:
   - Create a new Event called Event1
   - Set the Channel to EM1
   - Set the Threshold to 0.5
   - When the event occurs we want Parameter1 to be set to 1.

Preferences Dialog



4. In this macro,
    1. We will display the instruction first.
    2. Then in a loop display the Green color for 200 ms followed by the White color. We also set Parameter1 to 0.
    3. If the user presses the event marker, the value of Parameter1 will change to 1
    4. At 500 msec after green color is displayed, we check if the user has pressed the event marker. If the user has not pressed the event marker the value of Paramet1 is still 0, and the color Black will be displayed for 200 msec. If the user has pressed the event marker then the color Black will not be displayed.

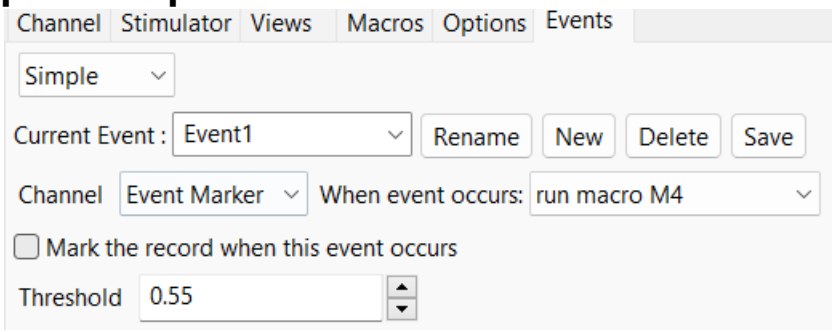
13 Events

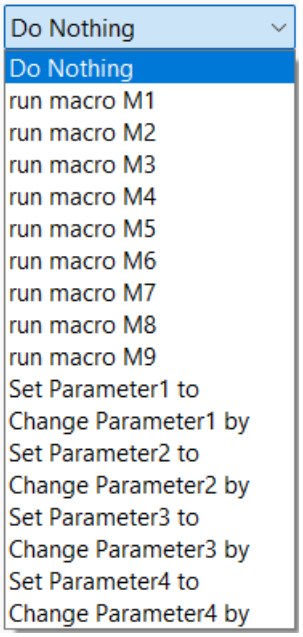
As LabScribe acquires data, it is aware of the value of each data point as it happens. It is possible to instruct the software to watch for values above or below a specified level and have LabScribe advise the user when such conditions are met. In LabScribe, such an occurrence is called an Event. These Events can trigger Macros. Refer to Chapter 12: Macros for a complete discussion of macros.

Events Setup

There are 2 options for setting up the Events, Simple and Advanced.

Simple Setup





Choose the current Event that you want to modify or create a new Event.

Choose the Channel that the event will be monitoring.

Choose what happens when the event is trigerred.

- We can run a Macro, that has already been defined. Refer to the Macros Chapter for more information on setting up a macro.
- Set one of the 4 macro parameters
- Change the value of one of the 4 macro parameters.

You can also place a mark in the record when this event occurs.

Choose the threshold, the Data on the selected channel has to cross from below the threshold value to above the threshold value for the event to be triggered.

Advanced Setup

There are two types of events: Channel Events and Timed Events.

Channel Events:

In the detection of Channel Events, one channel is monitored for Events that meet designated criteria. To set up LabScribe's detection of an Event:

In the Channel box, choose the channel to be monitored.

Choose the Type of Event detection:

No Triggering: The detection of the Event will not trigger the initiation of a Macro.

Positive Edge Triggered: The data have to pass from below the Low Threshold to above the High Threshold in order to be detected as an Event.

Negative Edge Trigger: The data have to pass from above the High Threshold to below the Low Threshold.

In Window: An Event is detected if the data values enter the window between the Low and High Thresholds and remain there.

Out of Window: An Event is detected if data previously contained within the Threshold window (between Low and High Thresholds) move outside the window.

The positions of the Low and High Thresholds are set depending on the type of data being recorded and the type of triggering that has been set. The thresholds can be chosen by entering data values in the Low and High Threshold boxes, or setting the values by moving the threshold lines in the graphical data sample.

Enable event detection by checking the checkbox.

Timed Events: Timed Events trigger a Macro after a designated amount of time has passed. To set the criteria for the detection of a Timed Event:

Choose Timed as the Type of Event and set the Time (in seconds) that should pass befor Events are detected, and after a previous Event if more than one is programmed.

Set the Count, or the number of events to be detected. Set the Count to zero for continuous Events occurring at the programmed Time interval.

Enable the event detection by checking the checkbox.

Event Priority

The Event Priority is set in relation to other Events. Macros triggered by Events inherit their priority from the triggering Event. A higher priority Event can stop a lower priority Macro, but a lower priority Event cannot stop a higher priority Macro.

If a Macro is manually triggered by the user, the trigger is considered a User Event with a priority of 50. Any Events with a higher priority than 50 will interrupt a user initiated Macro, while Events with a lower priority than the User Event cannot interrupt a user initiated Macro.

An Event can start in an enabled or disabled state. A disabled Event is ignored, but it can be enabled by other Events. The Enable Events and Disable Events boxes determine which Events enable or disable other Events. The Event being configured will enable Events highlighted in the Enable Events box, and will disable Events in the Disable Events box, regardless of relative priorities.

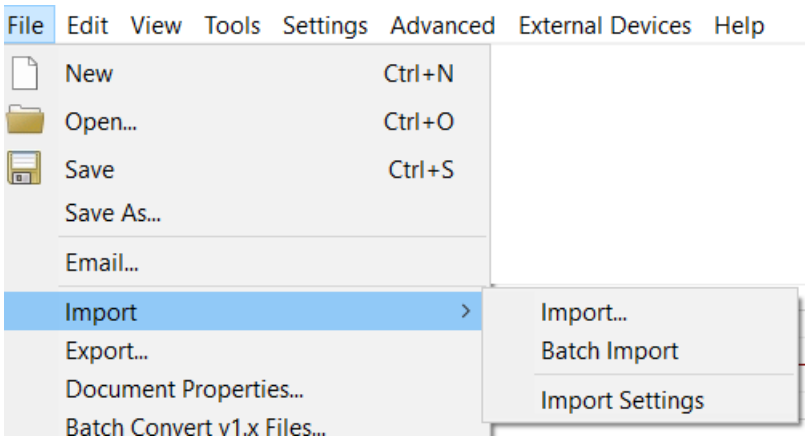
14 Importing Data

LabScribe records data from iWorx recorders. All data acquisition systems do not have access to the powerful analysis features in LabScribe. The optional Import module allows users of other systems to use the analysis features of LabScribe while recording the data with a different system. This also enables users who are switching to an iWorx System to analyze their old data with LabScribe. ASCII text files and edf files can be imported using the Import Module.

The Import Module requires a separate license. The first time you select the Import functions, you will be asked for a user name and a serial number. Contact iWorx Systems for more information.

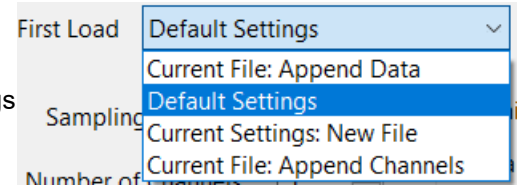
The Import functions are available under the File Menu.

Choosing the Import menu will open the Import Dialog Box



LabScribe can import text or edf files. EDF files have settings information embedded in the file so no further setup is required.

Text Import Dialog Setup

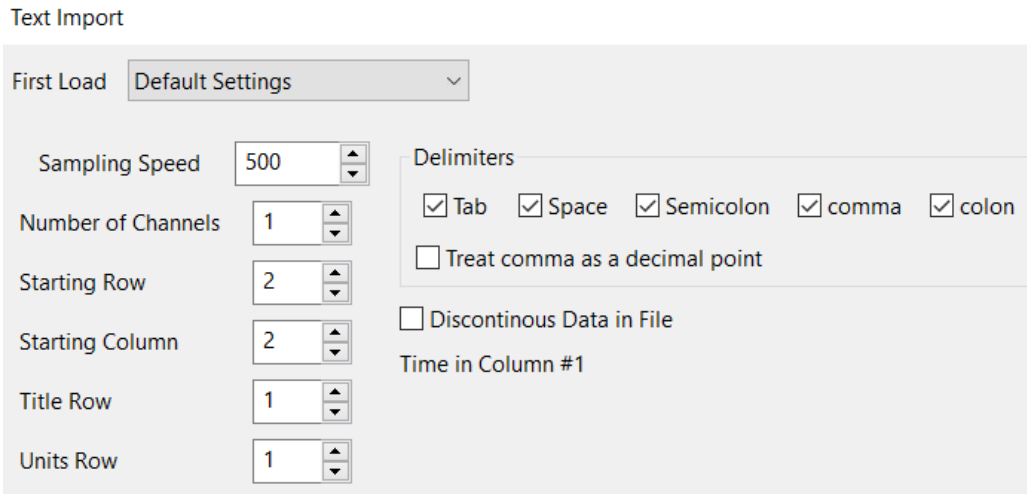


LabScribe data files consist of the data in the channels as well as settings about what to do with the data, such as any computed channels, etc...

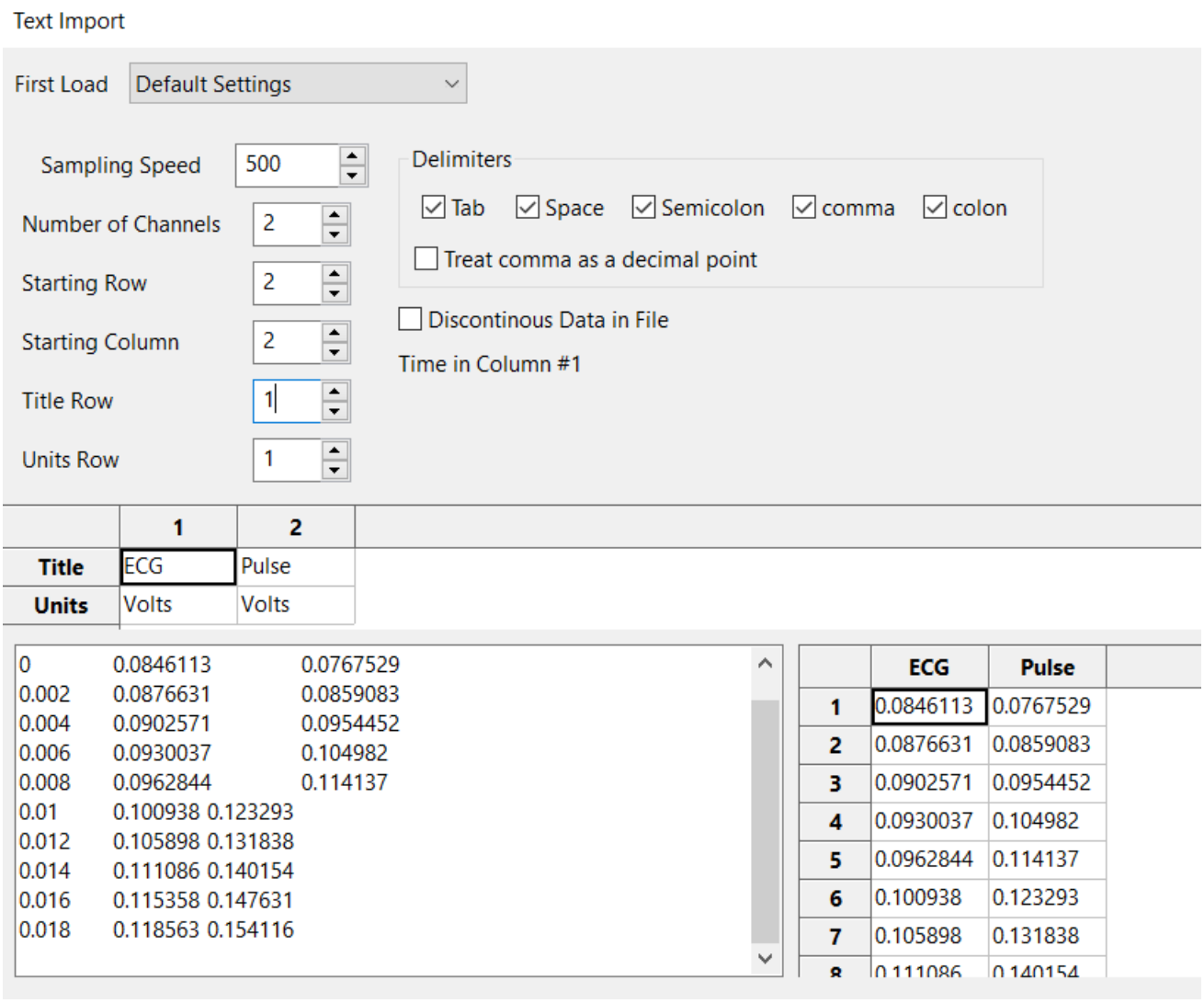
The options are:

- **Current File: Append Data**: The current File has data and the imported data is appended to this at the end of the file
- **Default settings**: Start with Default Settings. This is the option to pick unless one of the other options is a better fit.
- **Current Settings: New File**: Use the current setting and create a new File for the imported data.

- **Current File: Append Channels**: Append Channels to the current data file. This assumes that the data in the file to import has the same length as the existing data in the file.



- **Sampling Speed**: The sampling speed used to record the data. The sampling speed can be any value. LabScribe data files require the sampling speed to be in 1, 2, or 5 increments, LabScribe will automatically up sample the data, for example: if the sampling speed was 256, LabScribe will up sample the data to 500 samples per second.
- **Number of Channels**: The number of channels to import.
- **Starting Row**: The row index at which the data starts. This is useful to ignore any text heading that may be in the file to be imported.
- **Starting Column**: Starting column for channel 1 data, If time is in column 1, set this to a value of 2 to ignore the time column
- **Title Row**: If the channel titles are in the file, set the row which contains the channel titles.
- **Units row**: If the channel units are in the file, set the row which contains the channel units.
- **Delimiters**: Set the delimiter(s) for the data file.
- **Discontinuous Data in File**: If the data is in the file is discontinuous, and column 1 contains the time information, select this checkbox. LabScribe will create multiple blocks (sections) of data to import the discontinuous data.



When you have set your parameters, click OK to import the data.

15 Accessibility

Customizing Labscribe for Individuals with Vision Impairments

Keyboard Shortcuts

The following keyboard shortcuts are available:

File→New : Ctrl + N

File→Open : Ctrl + O

File→Save : Ctrl + S

File→Exit : Ctrl + Q

Edit→Undo : Ctrl + Z

Edit→Redo : Ctrl + Y

Edit→Cut : Ctrl + X

Edit→Copy : Ctrl + C

Edit→Paste : Ctrl + V

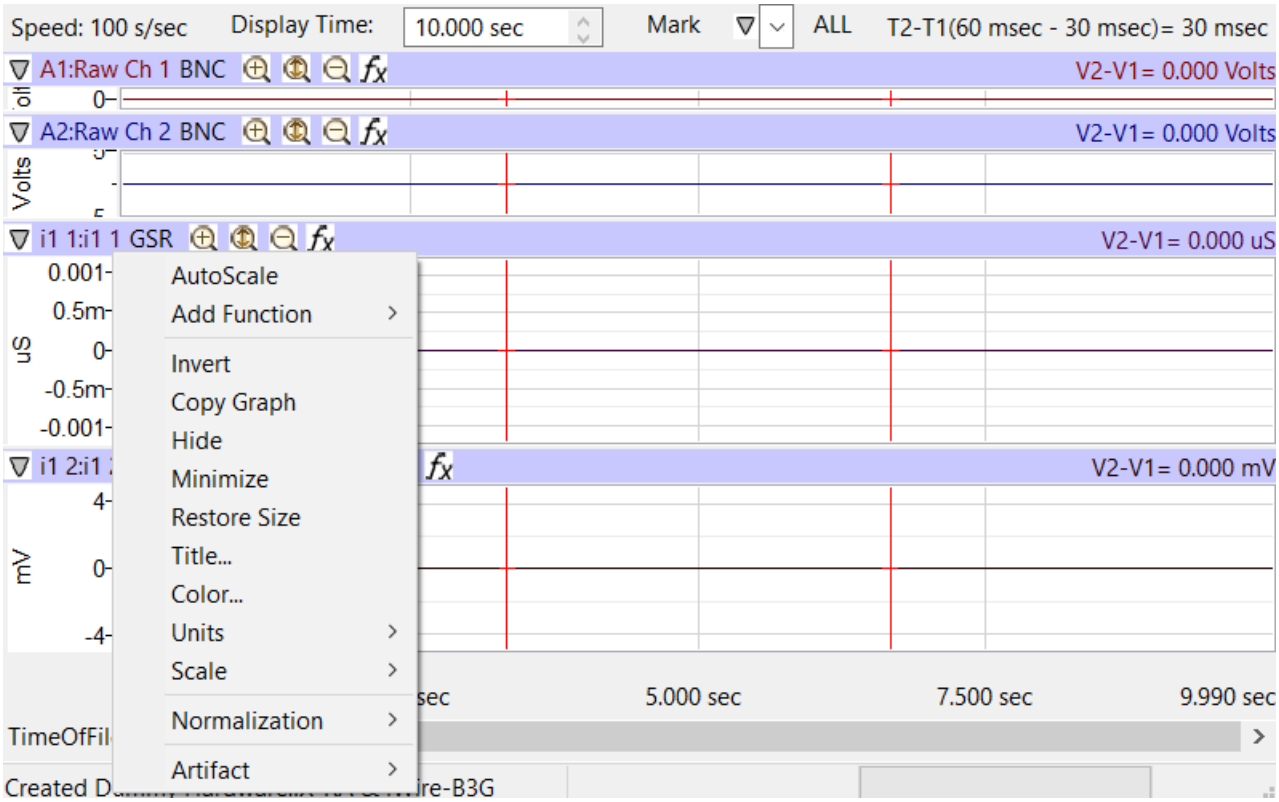
Tools→Find Next : Ctrl + F

Record : Ctrl + R

Add All Data to Journal : Ctrl + D

Add Title to Journal : Ctrl +T

To Show the Channel menu, Press Ctrl+*n*, where *n* is the number of the graph displayed on the screen. To show the channel menu for channel i1, which is displayed in graph 3 on the screen, press CTRL+3 The Channel menu includes Autoscale as well as Add Function options.



The user can create custom Macros to automate tasks.

Operating System

Windows OS has various options for individuals with vision impairments. Most of those settings can be used with LabScribe. Some common accessibility features include:

- Making Items on Screen appear bigger with Magnifier
- Make the Text Size Larger.

Options in LabScribe

Under Edit→Preferences in LabScribe, various display options for the program can be set.

Colors:

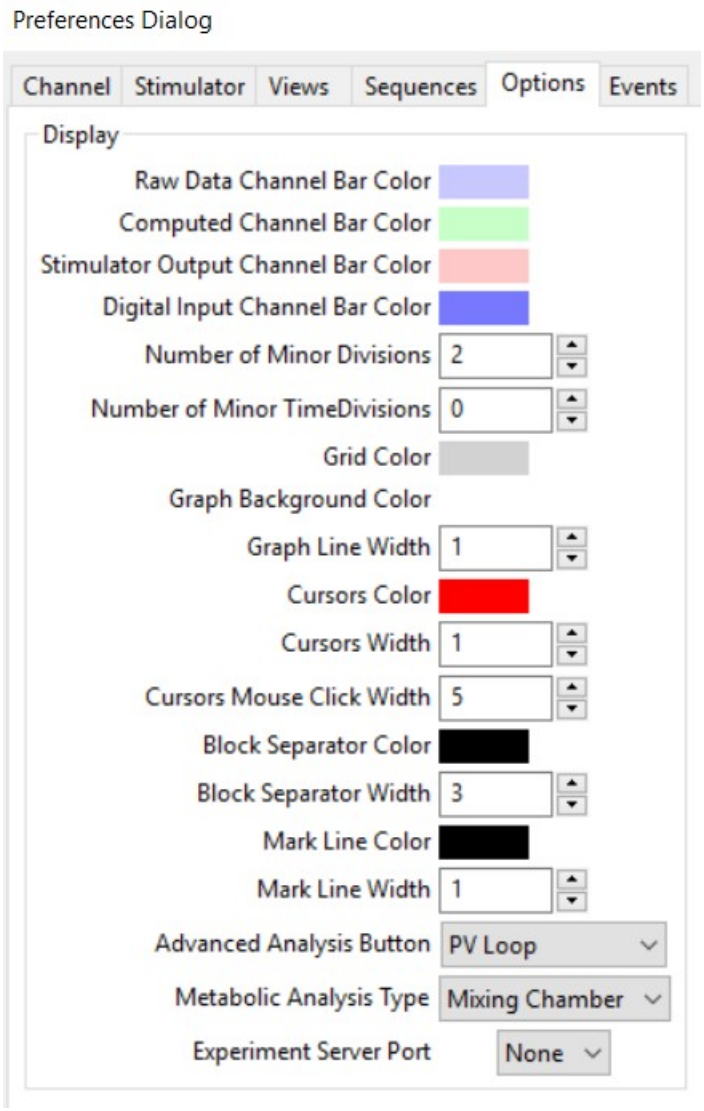
the colors used for channels and graphs can be set. For example to use a high contrast mode, you can set the graph background color to black and the graph line color to white. Colors for individual channels are selected from the channel menu in the Main window.

Thickness:

The thickness of the graph lines and the cursors, the marks line and block lines can be set as well.

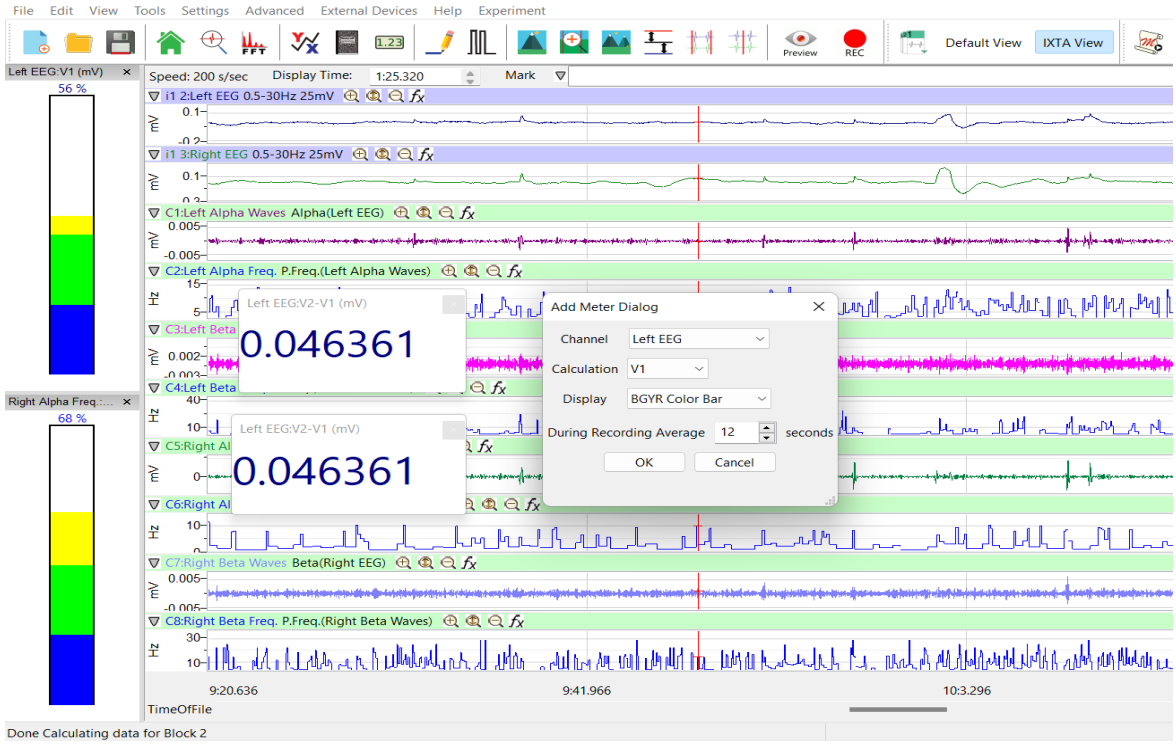
Cursor Sensitivity:

The sensitivity of the cursor can be set using the Cursor Mouse Click Width setting. This allows the user to click near the cursor and still select the cursor.



Meters

Various meters can be created in LabScribe to display the recorded value as well as some calculations in a larger font.



Manuals

iWorx Lab Manuals are provided as pdf and are available as open document format. These documents can be used with a screen reader and other assistive technologies.

16 Syncing Multiple Devices

There are various methods to synchronize data collection with iWorx recorders and other data recorders.

Ganging multiple iWorx Recorders

Up to 4 iWorx recorders can be ganged together to increase the number of channels.

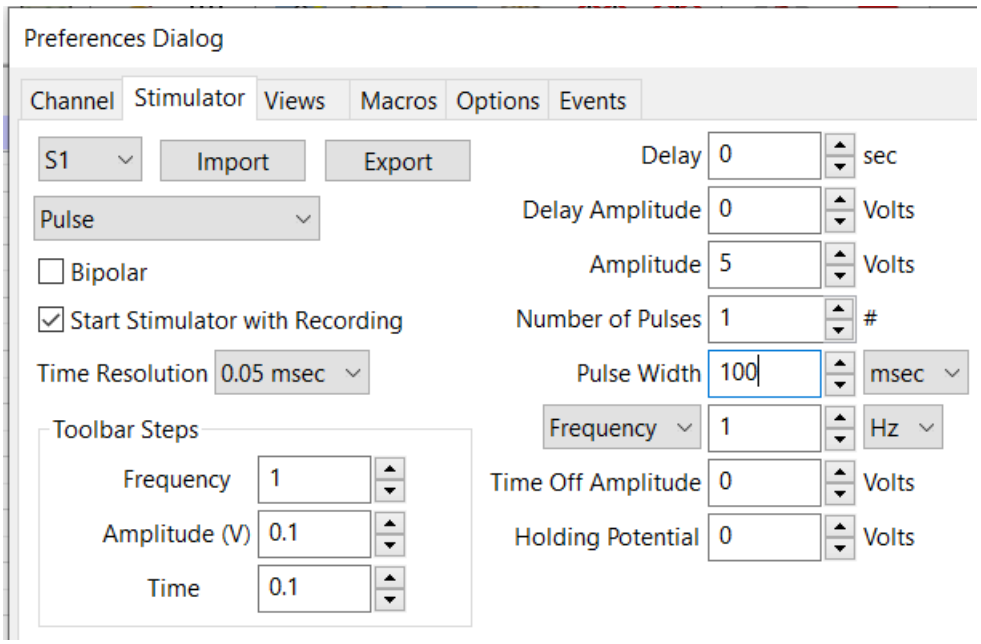
When multiple iWorx recorders are connected to the computer, LabScribe will detect them and gang them together. The order of the devices can be changed in LabScribe. When devices are ganged this was the sampling clock for each device can be slightly different causing synchronization issues between the channels recorded from multiple devices. To overcome this problem, the some iWorx Recorders, such as the IX-TA-220, IX-TR and the IX-RA-834 have the ability to sync multiple devices.

The IX-TA-220, IX-TR and the IX-RA-834 have a sync in and a sync out port on the back of the units, Connect the Sync out from the first device (Master) to the sync in on the second device, Then the sync out from the second device to the sync in on the third device, and so on.

The IX-BIOx series and the IX-EEG device have a sync in port, and they can be the last device. For example to Gang an IX-TA-220 with an IX-BIO4, use the C-BNC-J6 cable to connect the SYNC out port of the IX-TA to the SYNC in port of the IX-BIO4.

Trigger from iWorx Recorder to the Other Device

iWorx recorders with a stimulator or Digital Outputs (such as the IX-TA-220, IX-TR, IX-RA-834, IX-408, IX-416 etc...) can be set up to output a TTL pulse.



To Setup the Stimulator open the preferences dialog in LabScribe. This will be under Edit (PC) or LabScribe (Mac).

Choose the Stimulator tab, and set up the stimulator to output a pulse, 5V, 100ms one time.

Select ‘Start Stimulator with Recording” to fire the stimulator and send the TTL pulse when the recording starts.

In the other device setup the device to trigger on receiving the TTL Pulse.

Trigger from Other Devices to iWorx Recorder

Any analog or digital input channel of an iWorx Recorder can be used to record a pulse from an external device.

Connect the Trigger output from your device to an input channel on the iWorx Recorder using an appropriate cable.

For example if the trigger output of your device has a BNC connector, then:

Connect to an iWorx Recorder with a BNC input use the C-BNC cable

1) For the IX-TA-220 or the IX-TR: connect to channel A3 or A4

2) For the IX-RA-834: connect to A1, A2, A3 or A4

3) For the IX-4xx series connect to any channel

To connect to an iWorx Biopotential Recorder without a BNC input but with 1.5mm safety inputs, you will need the C-BNC-P2-TTL cable.

Connect to any of biopotential channels, the ground of the BNC cable (Yellow) should be connected to the negative input of the biopotential channel. The Blue connector from the BNC cable should be connected to the positive input of the biopotential channel.

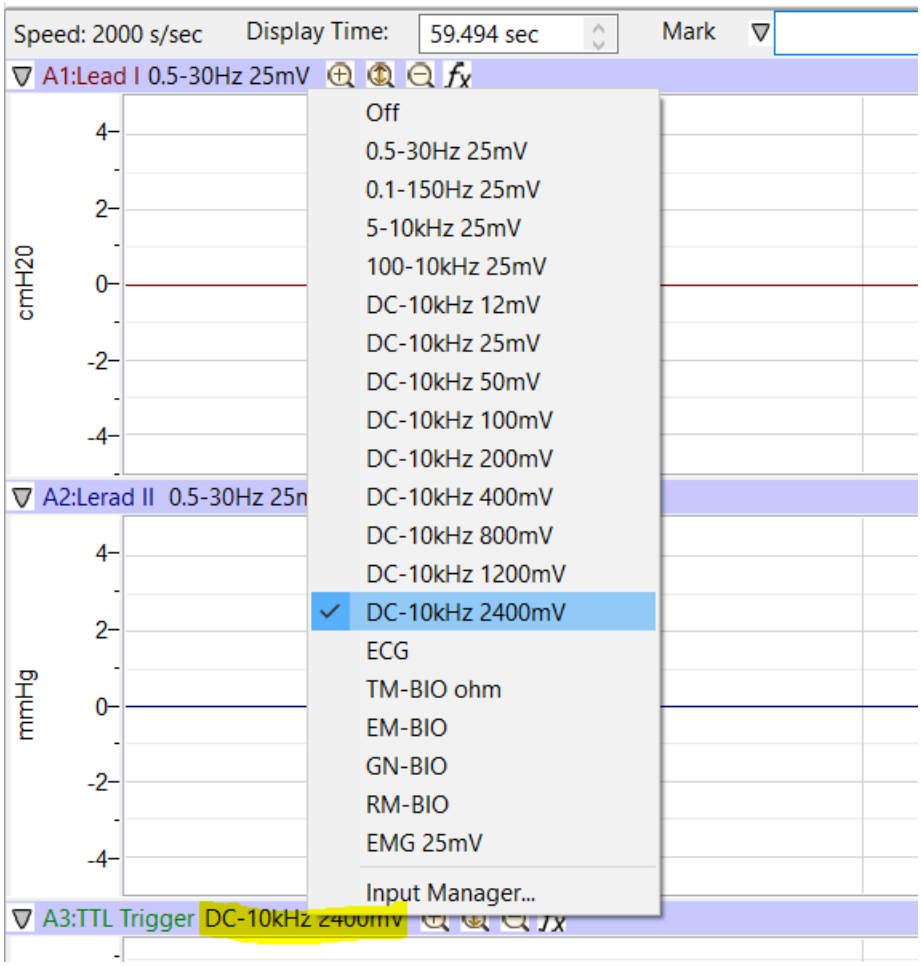
Figure 1: TTL into Channel 3 of the IX-BIO4

Figure 2: TTL into Channel 4 of the IX-BIO4

To setup the IX-BIOx for recording the TTL.

Make sure that the sampling speed is fast enough to record the trigger pulse, for example: if the width of the trigger pulse is 1msec, you need to be sampling at least 2k samples/sec.

Setup the input mode of the TTL input channel to DC-10kHz 2400mV


Speed: 2000 s/sec
Display Time:
59.494 sec
Mark
A1:Lead I 0.5-30Hz 25mV
cmH20
4
2
0
-2
-4
A2:Lerad II 0.5-30Hz 25m
mmHg
4
2
0
-2
-4
A3:TTL Trigger
Off
0.5-30Hz 25mV
0.1-150Hz 25mV
5-10kHz 25mV
100-10kHz 25mV
DC-10kHz 12mV
DC-10kHz 25mV
DC-10kHz 50mV
DC-10kHz 100mV
DC-10kHz 200mV
DC-10kHz 400mV
DC-10kHz 800mV
DC-10kHz 1200mV
DC-10kHz 2400mV
ECG
TM-BIO ohm
EM-BIO
GN-BIO
RM-BIO
EMG 25mV
Input Manager...