DAQ Plot™ User Manual

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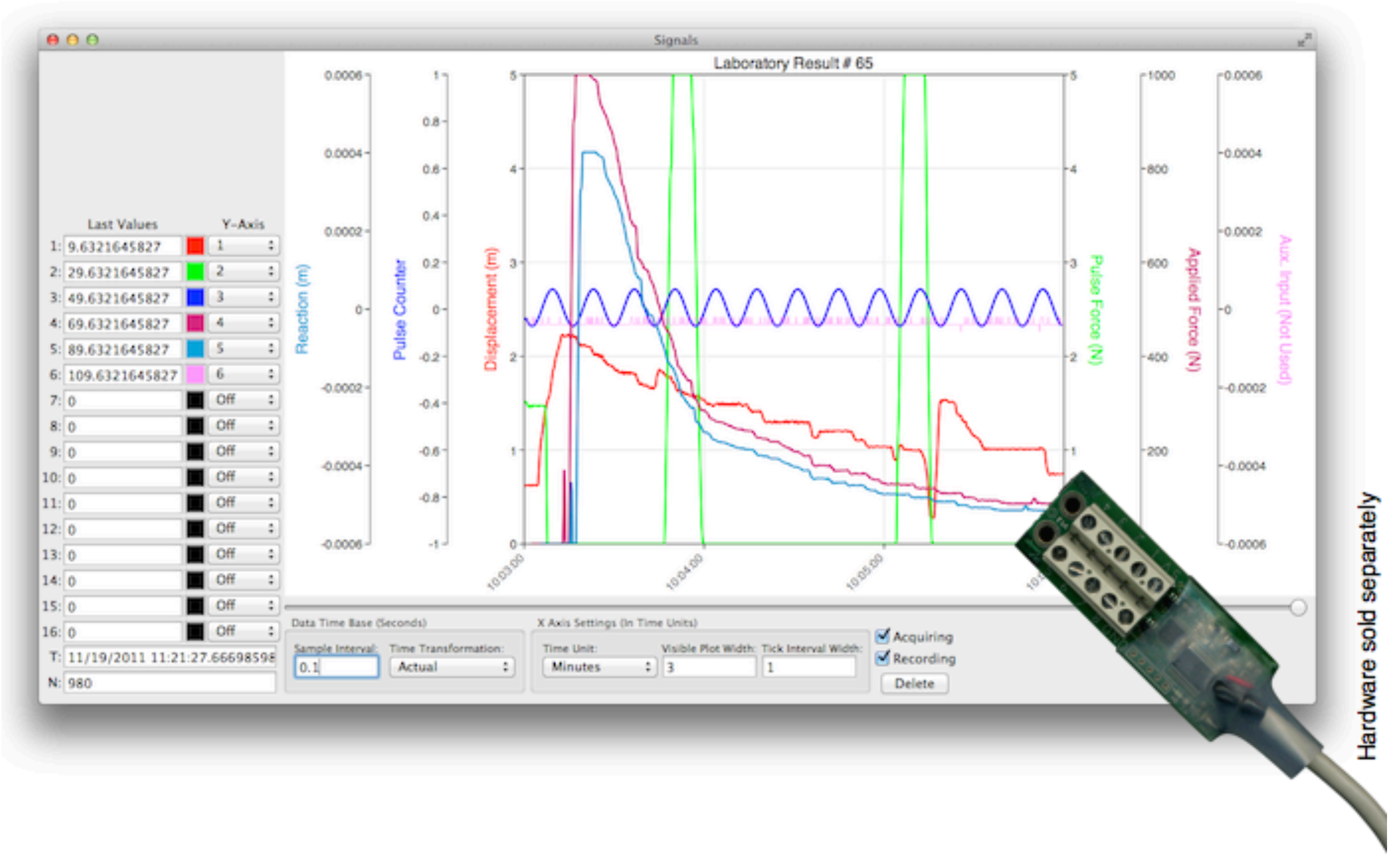
DAQ Plot is a simple to use strip chart application that plots electrical signals and controls devices in realtime. Its main interface looks like this:



Selecting the DAQ Plot ► Tools ► Turn Acquisition On menu item starts the process. But, first you need to attach a compatible analog to digital converter (DAQ Hardware) to your computer and configure it. For that see the tutorial First Project. If you do not currently have DAQ hardware then see the Simulation tutorial.

DAQ Plot ► Overview

The following is a brief list and description of the overview sections:

Overview

Main Idea	Describes the main idea of DAQ Plot and when or why to use various components.
Major Components	Describes the major components of DAQ Plot, namely the Signals Window.
Multi Y Axes	Describes how and why to use multiple y axes.
Spectra	Describes the use of the frequency domain in DAQ Plot.
Export	Describes how to export data to other applications and systems.
Preference Style	Describes the UI styles of DAQ Plot.
Glossary	A list of terminology used in this manual.

DAQ Plot ▶ Overview ▶ Main Idea

DAQ Plot samples voltage signals and then processes them and displays them in various formats, namely on a strip chart (see Glossary). The following bullets gives pointers on where to go in this manual in order to read more and in the process touches upon the main ideas of DAQ Plot.

- Foremost, DAQ Plot is intended to be easy to use, at least at first. See the First Project tutorial to get started right away. Once you advance from straightforward data logging then there is a complex world of data synthesis and feedback control loops. DAQ Plot is designed to provide incremental complexity so that there can be a discovery process and an analysis process within the same application.
- The signal window shows strip chart output and is described in the section Major Components.
- To acquire a voltage signal you need to use compatible hardware as described in the Hardware sections.
- Naturally as soon as you acquire signals of higher frequency you shall want to perform vibration analysis and spectral analysis. For that see the Spectra section.
- The Derived preference section describes how to operate on signals to produce many things related to voltage signals such as energy, displacement, velocity, windowing and counting.
- DAQ Plot is not a programming system, neither is it a driver system. It is an application devoted to showing and working with voltages in an intuitive and high-quality format.
- The Simulation tutorial describes how to use a test signal, which does not require additional hardware, to work with DAQ Plot in order to further understand it.
- Once you have a nice graph in DAQ Plot then choose an Export technique to work with the data.

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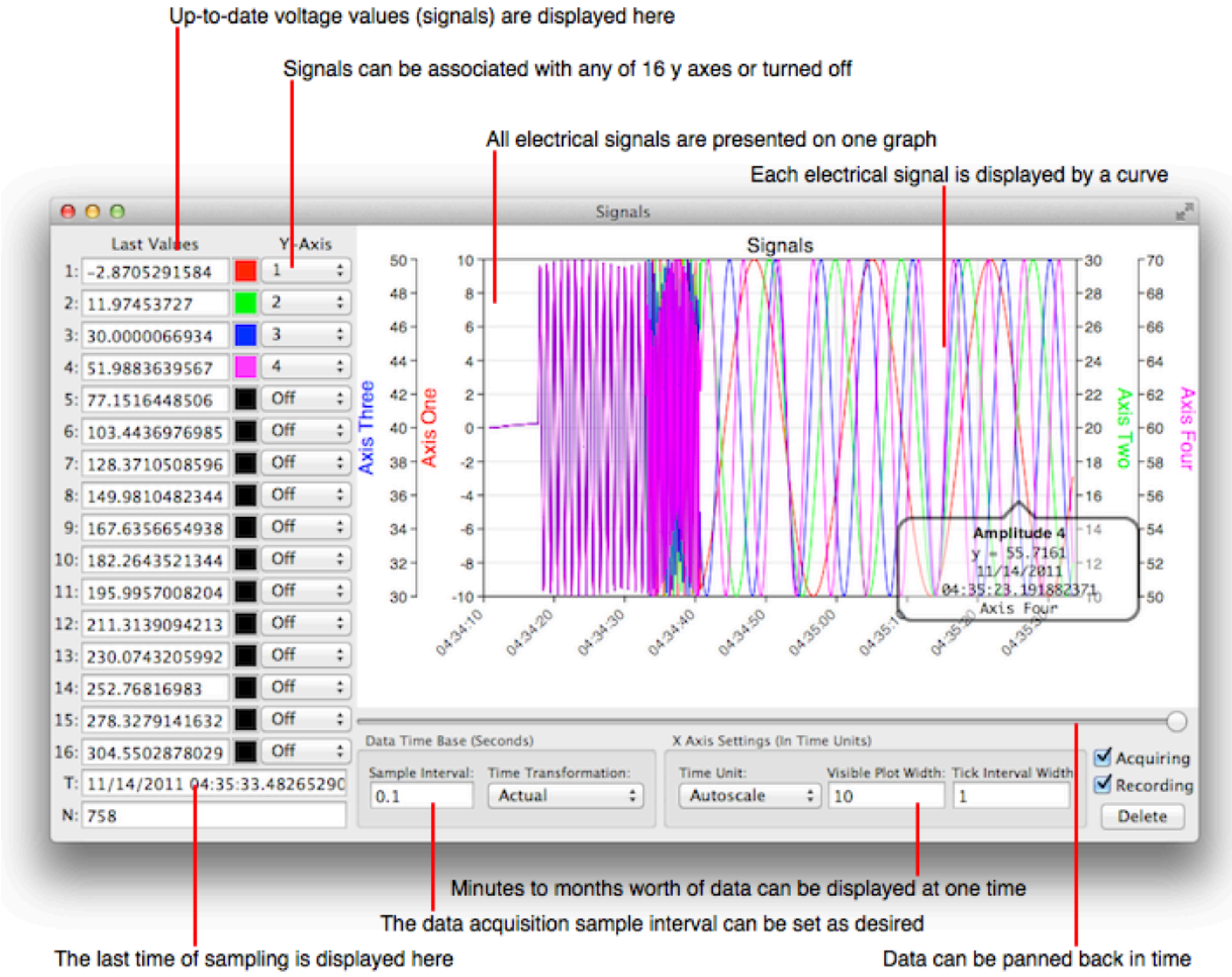
DAQ Plot ► Overview ► Major Components

When you launch DAQ Plot it first shows a signal viewer (a.k.a. a strip chart) as shown in the following diagram. That viewer shows up to sixteen separate signals acquired through various sources, namely Hardware. Signals are displayed as as curve of amplitude vs time and also a numeric value of the last value acquired. The signal viewer also includes controls that are defined below.

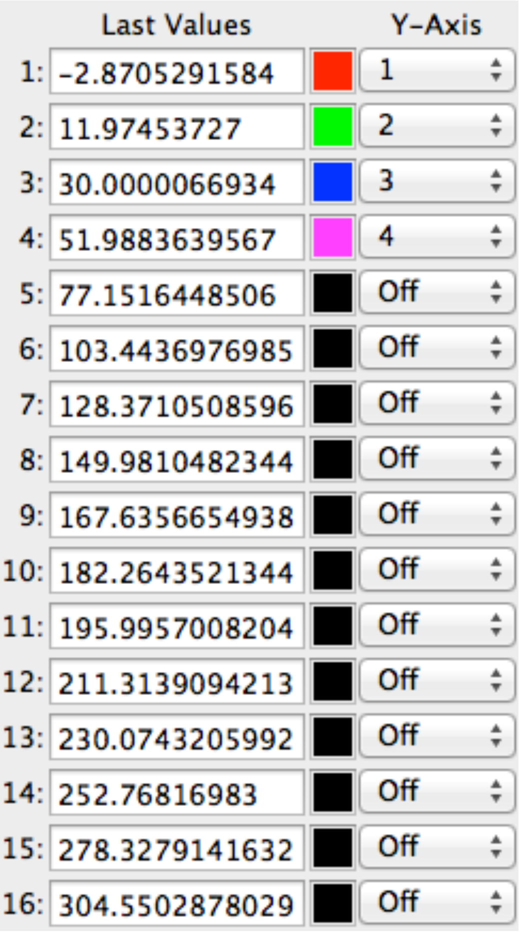


Other controls appear in the Preferences panes.

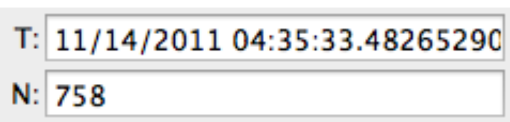
The following details each control on the main window.

Amplitude Display

These settings control the display of amplitudes (see Glossary for a definition of amplitude). Each column is described from left to right. Each amplitude is given an index from 1-16. The last value shows that amplitude's last value collected. The color well shows and helps change the color of the associated curve. The Y-Axis pop up button defines which y-axis is associated with the amplitude index and is used to select a number from 1 to 16, or Off is the amplitude is not to be displayed.

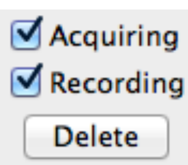


Current Seconds And Index



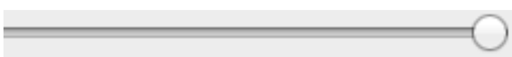
Shows the value of the last sample time and its sample index.

Recording States



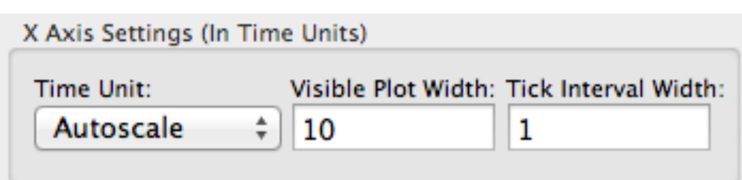
Turn on the Acquiring switch to acquire data. Turn on the Recording switch to record that data. Click the delete button to delete previously recorded data.

Scroll Bar



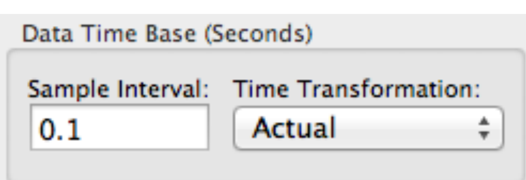
The scroll bar defines the number of ticks scrolled back in time. This does not have a valid affect when the x-axis is autoscaled.

Graph Tick Settings



The tick settings define the number of tick intervals displayed on the graph, the date-unit length of each tick interval and the tick unit type.

Time Base



The time base defines the time-discretization of the signal. The Sample Interval defines how many times per second values are sampled, or more appropriately, the seconds between sampling. The Time Transformation button controls whether the gaps, which happen when recording is off, are displayed or if those gaps are not displayed thus forming a contiguously on display (hence the name).

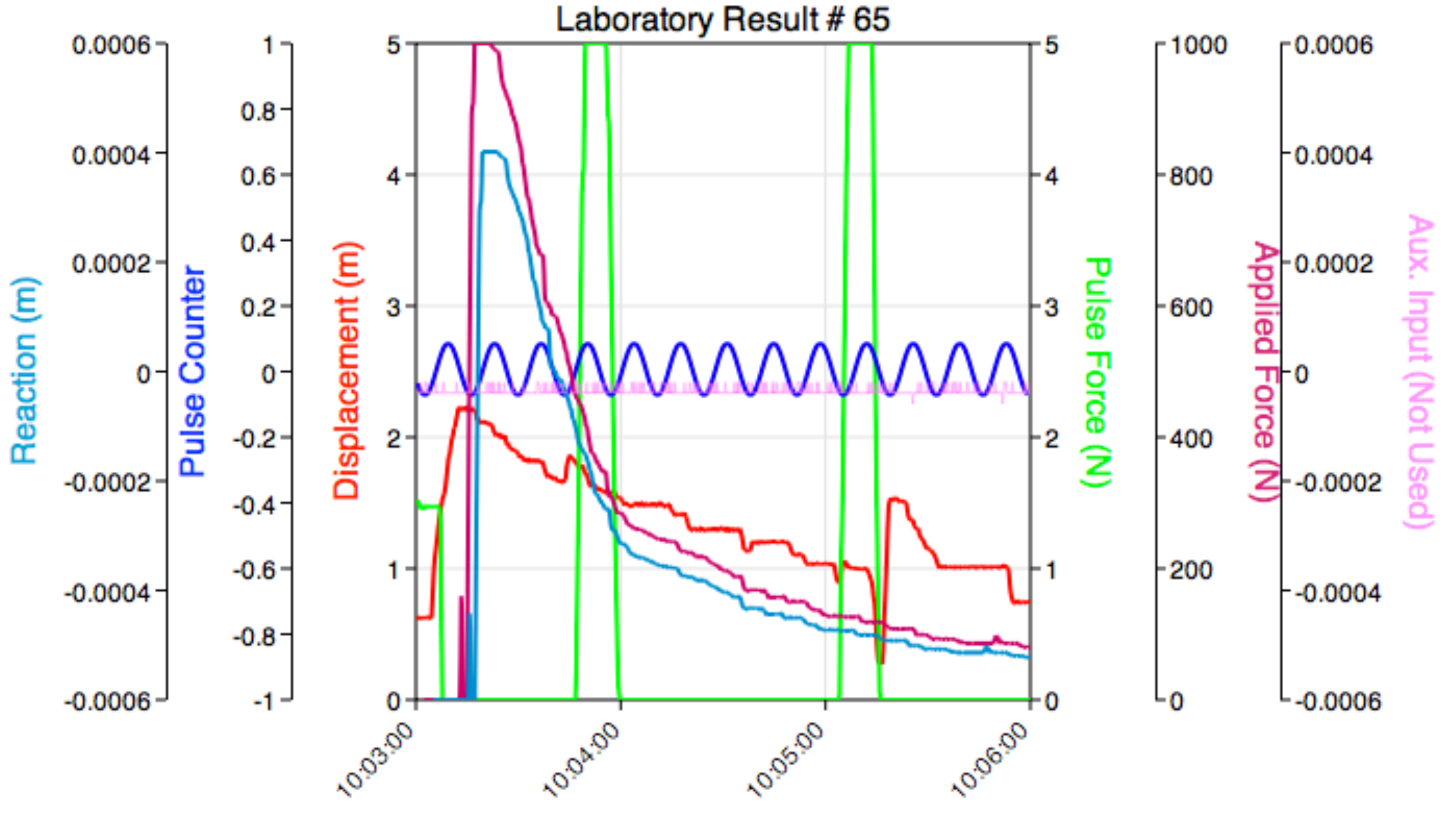
If a device is in segment-mode (such as for hardware clocking) then the Sample Interval represents the speed at which the user interface is updated and not the sampling time of the actual data.

When you first use DAQ Plot, you should configure it with the minimal amount of amplitudes. You do that by these steps:

- First configure your Hardware device. During configuration, turn off all channels that will not be use. You do that by unselecting the switch next to each channel settings (make sure to click Apply after your changes). Typically hardware collects signals (voltages) from a group of screw terminals, say one through eight. It collects those voltages one at a time by multiplexing a single analog to digital converter, thus the collection is serialized and as such each signal you collect delays the collection of the next signal.
- You can also combine hardware via the Meta preferences. The Meta device multiplexes the channels of hardware into one contiguous sequence of channels.
- Once you are collecting data from your hardware then use the Derived preferences to synthesize the data into other groups of data. This may result in a decrease or increase of number of amplitudes.
- Use the Data preferences to remap voltage units to physical units.
- Most likely, you are simply using one piece of hardware and all you need to do is connect voltage signals to the connectors and start plotting, but the above shows how there can be more complex situations that result in the collection of many signals.
- On the main window (and spectra window) turn off all unused amplitudes by setting the y-axis index to Off.

The result of the above is probably a bunch of no-ops. That is: You simply want to plot a voltage. However, it may be that your amplitudes represent different units such as force, displacement, logic states, intensity of light or other things. In that case, the y-values may have very different scales and it doesn't make sense to plot all the curves on one y-axis. For that situation, there is the multi-y-axes representation. Use the Y-Axis pop up buttons on the main interface to associate the amplitude index (curve index) with the y-axis index. y-axis indices are numbered from in to out in sequence, that is: 1 is the left axis, 2 is the right axis, 3 is the 2nd left axis, 4 is the 2nd right axis and so forth. You should make the amplitude to y-axis mapping in such a way that all consecutive y-axis indices are used.

The figure below shows one such example.



The curve colors and y-axis title colors have been set to show the relationship between data and y-axis. Moving the cursor over the curve will also show that relationship in a pop over.

In order to format the graph with minimum y-direction size, click on a y-axis index pop up button. That will refit the graph at that time. The refit depends on the current axes limits so you may want to refit every so often. As your need for y-axes increases so will your screen size. You may need to make DAQ Plot's main window very wide to accommodate all of your y-axes.

Ultimately, you may wish to export the plot to Graph Builder. For that make sure the Signal (or Spectra) window is the key window and then choose the Export ▶ Plot menu item. Your plot will be exported to Graph Builder (if installed on your computer). From there you can reformat the graph. I mention that because multi-y-axes is a very graphical representation and has many attributes that are preset and many more attributes that can be fine tuned.

DAQ Plot ► Overview ► Preference Style

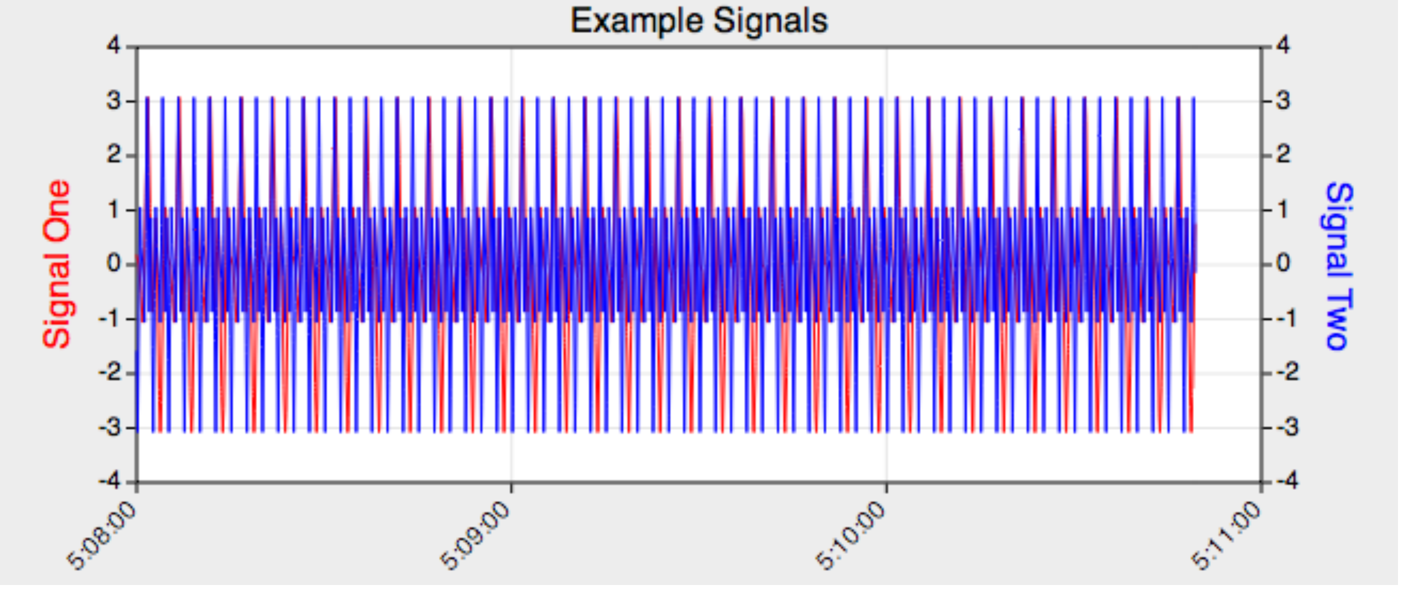
DAQ Plot has three interface styles which are:

Name	Description
Simple	(default) The user interface is direct and simple and does not include remapping. This is good for strip chart recording.
Standard	The user interface is the same as the Simple style type with the addition of the Derived Preference Pane.
Pro	The user interface is more complex and some obtuse settings are available. In fact, if you are not aware of the quirks of some settings then you may get results that are not immediately explainable. This is the only style that gives access to DAQ Command programming settings. Buffer length, device type, nonlinear mappings and other more abstract settings are available with this style.[1]

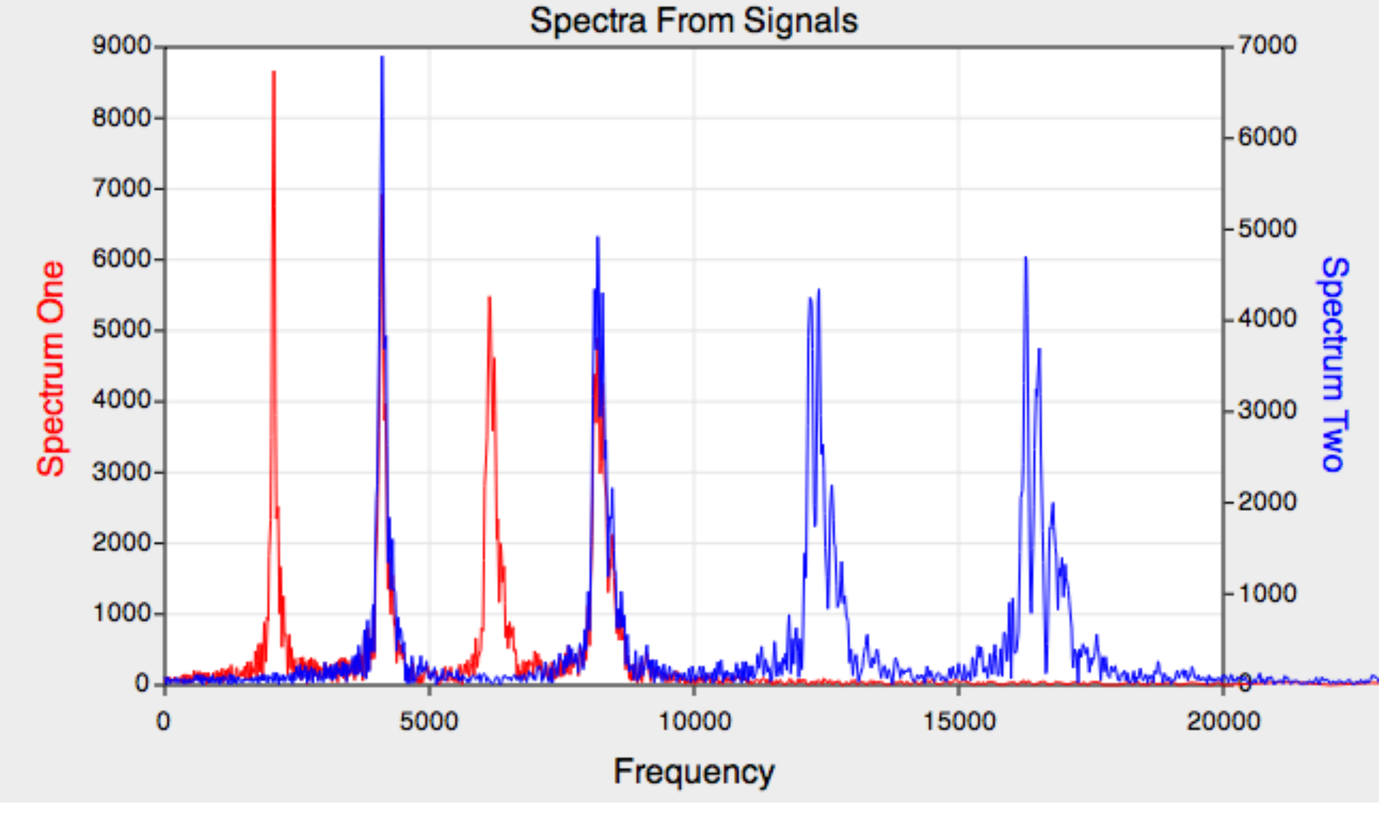
These styles are changed using the DAQ Plot ► Tools ► Change Styles ... menu item.

[1] The Pro style is only available as a Pro feature.

DAQ Plot launches with its main interface, which includes a multi-channel time sequence signal plot on an amplitude v.s. time or date plot or an associated format depending on the exact settings. An example of the signals is shown in this figure:



Using the DAQ Plot ▶ Windows ▶ Spectra... menu item brings forward the spectral representation of the signals, shown in this figure:



The spectral representation shows the signals transformed by a discrete Fourier transform. You can see from the plots above that the signal plot shows some periodicity in the signals, but it is the spectral plot that shows the periodic nature in a quantitative format which permits better analysis and isolation of the energy in the signals as a function of frequency. This section explains that spectral output representation.

General Description

The spectral output represents the frequency of the signals at the right hand side of the signal plot. The number of samples used to produce the spectrum for a signal is called the spectral-length. When starting acquisition you must wait for twice the spectral-length number of samples before the spectrum is computed accurately. If you use the slider to slide the signals back in time then the spectra are recomputed from the portion of the signals ending on the right hand side of the signals plot. In that sense, the spectra can be played back in time, just like the signals can. Thus the spectra output is a multi-channel frequency domain oscilloscope with playback capability. Keeping the slider all the way to the right keeps both the signals and spectra up to date.

Time Increment

The spectrum representation is converted from a uniformly sampled time signal. As such, you should either select the time sample interval and keep it fixed, or use hardware clocking which is by definition a constant time increment. Hardware clocking is preferred because it is a high sample rate method that is designed to have uniform time increment.

Time Window

The spectral plot is calculated from twice the spectral-length of samples (see Spectrum Graph Preferences to set that parameter). Hence you must run the signal for at least that amount of time (time increment times twice spectral-length) before the spectral plot is calculated with fidelity. The time samples used are always the ones at the right of the signal plot and then spectral-length number of samples back in time. That way, if you keep the time slider to the right then the signal plot will auto scroll to the most recent samples and the spectral plot will always be current.

The greater the time window selected (by changing the spectral-length) the greater the resolution of the spectral components.

Frequency Fidelity

The spectra output is implemented with a discrete Fourier transform. The output is magnitude, decibel-magnitude or phase. The output type and the number of time values used to compute the spectra are defined in the Spectrum Graph Preferences.

Define the following:

ΔT	The time sample interval of the signal.
ΔF	The frequency interval of the spectral output.
N	The spectral output length (defined in the graph preferences).
F_{max}	The maximum frequency of the spectral output.

Then $\Delta F = 1/(2\ N\ \Delta T)$, and $F_{max} = N\ \Delta F = 1/(2\ \Delta T)$. For example, if the hardware sample rate is 50,000 samples per second then ΔT = 0.00002 seconds (0.02 milliseconds) and F_{max} = 25Khz. This is the Nyquist Frequency of the spectral output. Even though the Nyquist Frequency defines the maximum frequency of the discrete Fourier transform it does not define the fidelity of the frequency reconstruction. That depends on the exact signal type, but in general the maximum frequency that can be reconstructed with a good amount of fidelity is about half or 5 times less than the Nyquist Frequency. So, at 50,000 samples per second, 5 times less than the Nyquist Frequency means that the highest frequency component for a quality spectrum should be about 5Khz.

Think about sampling a sine wave. If you were to be as unfortunate as to start sampling the sine wave right at its zero value and the sample rate was exactly twice the frequency of the sine wave then your sampling would always pick up a value of zero; not exactly representative of the sine wave. By sampling 5 times faster you would sample that sine wave at a rate greater than its period and would be able to reconstruct it better.

The short of it is: If you sample at N samples per second then expect the highest frequency to be represented on the spectral output with fidelity to be 1/5th to 1/10th that in Hertz.

DAQ Plot ► Overview ► Export

DAQ Plot acquires data, but that is of limited value unless you can get that data to other applications or reports. The process of doing that is called Exporting. There are many ways to export data which are described in this section.

Export Menu Items

Signal Plot	Sends the Signal Plot to Graph Builder. See the Graph Builder User Manual for further information.
Spectrum Plot	Sends the Spectrum Plot to Graph Builder. See the Graph Builder User Manual for further information.
Show Channel Values	Shows the actual data in a window.
Save Channel Values	Saves the actual data to a file. All data is saved according to the export settings in the Export Preferences
Show Curve Values	Shows the curve data values in a window. The curves are the current window curves, either the Signals or Spectra Curves. The spectra shows the full length of values while the signal values are clipped to the portion of the curve that is drawn.
Save Curve Values	Saves the curve data values to a file. The curves are the current window curves, either the Signals or Spectra Curves. The spectra shows the full length of values while the signal values are clipped to the portion of the curve that is drawn.

The Channel Values output shows the data directly from the data buffer of DAQ Plot while the Curve Values output shows data which is represented by the curves shown on the respective window. As such, you can use the curve settings to clip the Curve Values in time and to output different spectral representations such as linear and DB.

Stdout

Use the stdout option in the Export Preferences to output to stdout (many times the console). Extra feature: If you run DAQ Plot at the command line then you can redirect stdout to a file using standard unix methodology.

Backup

Use Decoding Backup to export to another process while at the same time running DAQ Plot, or to efficiently and automatically post-process data directly from the backup files.

Format

The export plain text format is tab delimited list of columns and rows. Each column is optional and defined by the Export Preferences. Each row is one time-sample worth of data:

```
Index Second Channel-1 Channel-2 ... Channel-16
...
Index Second Channel-1 Channel-2 ... Channel-16
```

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DAQ Plot ► Overview ► Glossary

You can read this section starting from the beginning and reading to the end. If you get to the end and understand everything then you will be able to read any section of this manual and understand it well.

Terminology	Definition
Amplitude	The amplitude is shown by DAQ Plot in its signal viewer, spectrum view and at other locations. In a basic setup, the Amplitude is the voltage collected from a piece of hardware and the amplitude index if the channel index of the hardware device. In more complex settings the amplitude is the result of several different data mappings using the Derived and Data preferences. The derived preferences can map a channel to arbitrary amplitude index, or combine channels to one amplitude, so the relationship from channel to amplitude need not be straightforward.
Channel	Each input source has one to sixteen channels of data. Those channels can be mapped in various ways to amplitudes (see Amplitudes). By default, there is no mapping so that initially the amplitude index is the channel index (a one to one correspondence) of a device.
Electron	An electron is a very small piece of material, so small that it can not be seen directly. Electrons are everywhere and are flowing through your body all the time and help your brain think and your heart beat as well as perform other useful functions.
Battery	A battery is a device that stores electrons and will release those electrons when you attach it to something like a flash light.
Electricity	When electrons move then that movement is called electricity. It is also called electricity when electrons don't move but rather push against something in order to move.
Voltage	Voltage is the amount that electrons push against something. The more those electrons push, the more voltage they have. Now you know why high voltage wires are labeled as dangerous! If those electrons push hard enough they can go right through your body, and make a nasty burning hole while doing it! Ouch! Notice that the electrons don't have to move to have voltage, they just have to push hard.
Current	Current is the amount of electrons passing through something at any point in time. To have current, the electrons need to move. If presented with an obstacle those electrons may not be able to move unless those electrons have a high enough voltage. So, to have useful electricity you need to have electrons with a high enough voltage and a high enough current.
Circuit	A circuit is a connection of wires that form a path through which electrons can flow. If that path is broken then the circuit is called broken, and is, in fact, no circuit at all.
Wire	A wire is a long thin piece of material, usually metal, that can be used to allow electrons to go from one piece of a circuit to another.
Dielectric	A dielectric is a material that resists the flow of electrons. If electrons push hard enough then they will flow through any material, but dielectrics are materials that do not permit electrons through unless those electrons push very hard. Usually if electrons flow through a dielectric those electrons push so hard that they break the dielectric apart in an explosion or fire.
Conductor	A conductor is a material that lets electrons go through it easily. Copper, aluminum, steel, and most other metals are good conductors.
Resistor	All materials resist electrons flowing through it. Electrons have a hard time getting through some materials, while with other materials electrons move freely. A resistor is a material that lets electrons pass with some difficulty, but not too much. Electrons are only subject to a resistor for as long as they are in the resistor. The longer electrons flow through the resistor, the more the resistor has the opportunity to resist the electron.
Potential	Potential is voltage. Usually potential is referred to as "electrical potential" to distinguish it from other potentials, like your potential to graduate school.
Rheostat	A Rheostat is a device that can change resistance. You can buy a rheostat at an electronics shop like Radio Shack. I used one called a Audio Taper/1Meg Ohm potentiometer. When you buy your rheostat it will most likely be encased in a small metal cylinder. It doesn't look like a long wire at all. That is because that long wire is wrapped around a piece of plastic shaped like a donut which is then placed in the metal cylinder. After you have had a good time with your own rheostat I would suggest prying the rheostat apart and unwinding the wire if you can. The wire on a rheostat is usually glued to the piece of plastic, so it may be hard to take apart. When I was a kid I took everything apart. Sometimes I put them back together again too. Remember: If you can't take it apart then you can always cut it in half.
Potentiometer	A Potentiometer is a rheostat. When a potentiometer is placed on a circuit board it is many times referred to as a *pot*. I don't like the term potentiometer because it refers to a meter that measures the electrical potential of a circuit. A rheostat varies resistance, while a meter measures it. One "observes" while the other one "performs". This issue is common in electronics because many basic electrical devices were discovered and successfully used before they were fully understood so they were never really named right in the first place.
Terminal	A terminal is a piece of a device where you can attach a wire, for example by soldering it, wrapping it, or screwing it to the terminal.

Signal	A signal is a sequence of values, in this case voltage, measured over time and displayed as a curve.
Strip Chart	A strip chart is the paper output of a device with a pen or series of pens that write onto a scroll of paper as the paper moves under the pens while the pens apply pressure to the paper and hence write on the paper. Each pen move back and forth on a lever independently to produce a curve for each pen. The movement of the pen is proportional to the voltage applied to its solenoid. As such, the horizontal axis has units of uniform time and the tangential axis is in units of voltage. Such a device is called a strip chart recorder. That is a metaphor for more modern systems such as DAQ Plot that show signals in a similar form. DAQ Plot could have been called "Strip chart Recorder" except that DAQ Plot also has a built-in spectrum analyzer, feedback control loops, output channels and many other things. In addition, DAQ Plot embeds device drivers and other machinery necessary for its operation.
Thomas Edison	Thomas Edison was not the guy who invented the light bulb, nor did he invent electricity. He did tinker a lot and was also a fairly shrewd business person.

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DAQ Plot ► Preferences ► General

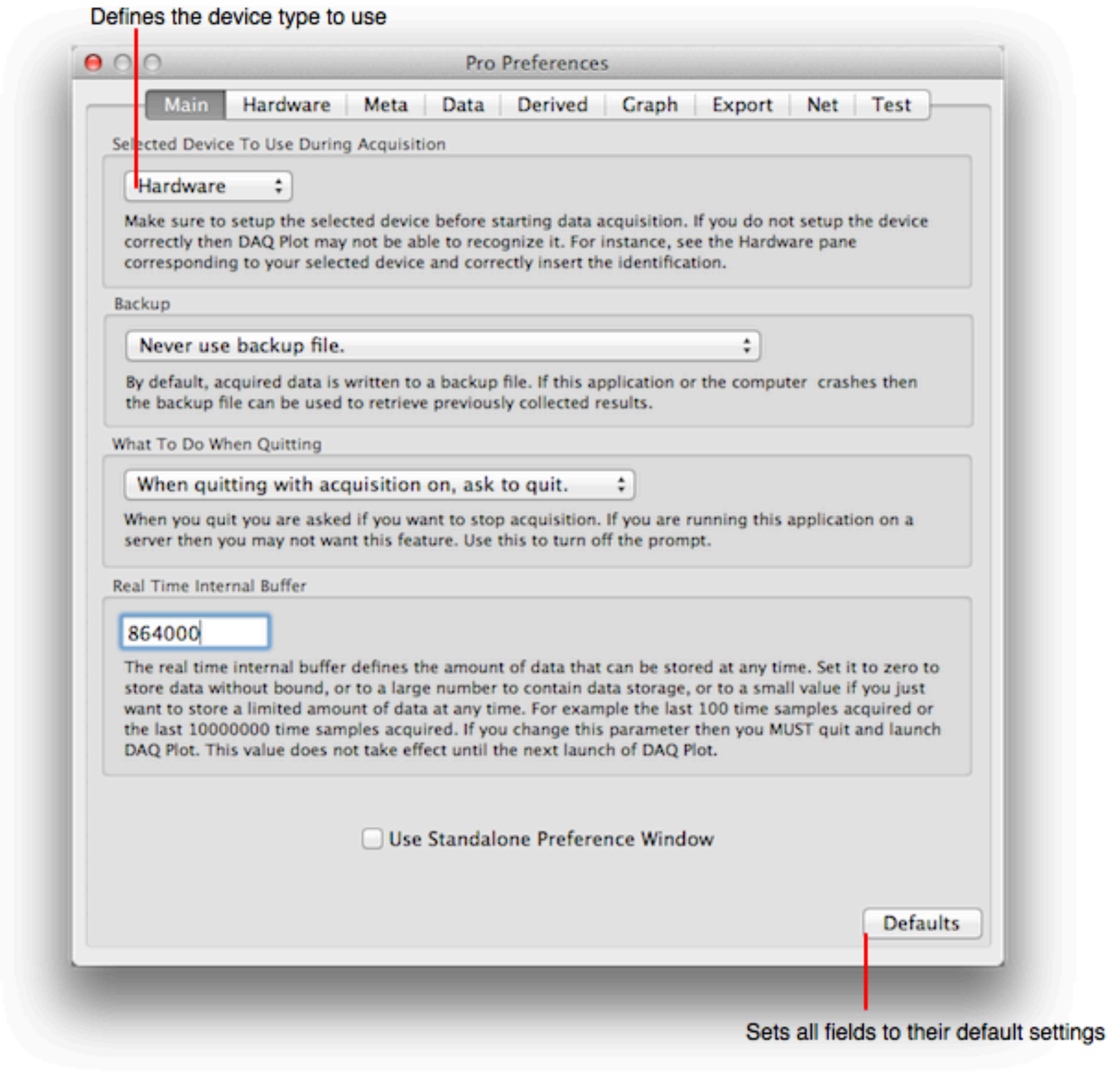
Most of the attributes in DAQ Plot are set using the preference pane. See a section below for more information.

General Preferences

Main	Main Attributes.
Data	Data Attributes.
Export	Export Attributes.
Derived	Derived Attributes.
Graph	Graph Attributes.

DAQ Plot ▶ Preferences ▶ General ▶ Main

Main preferences are used to define the device type and parameters common to the entire program. To view the Main preferences use the Pro Style (See: Preferences Style). The following diagrams the Main preferences pane.



Field settings are defined as:

Selected Device To Use During Acquisition

Defines the device type to use during acquisition. Keep set at Hardware if you are collecting data from a data acquisition device, or set to Test if you are using the Test device, see Simulation tutorial.

Backup

Select one of the backup options to engage the real-time backup. The backup is only used between sessions and is implemented for crash purposes in mind, however it can also be used to stop a run and come back to it later.

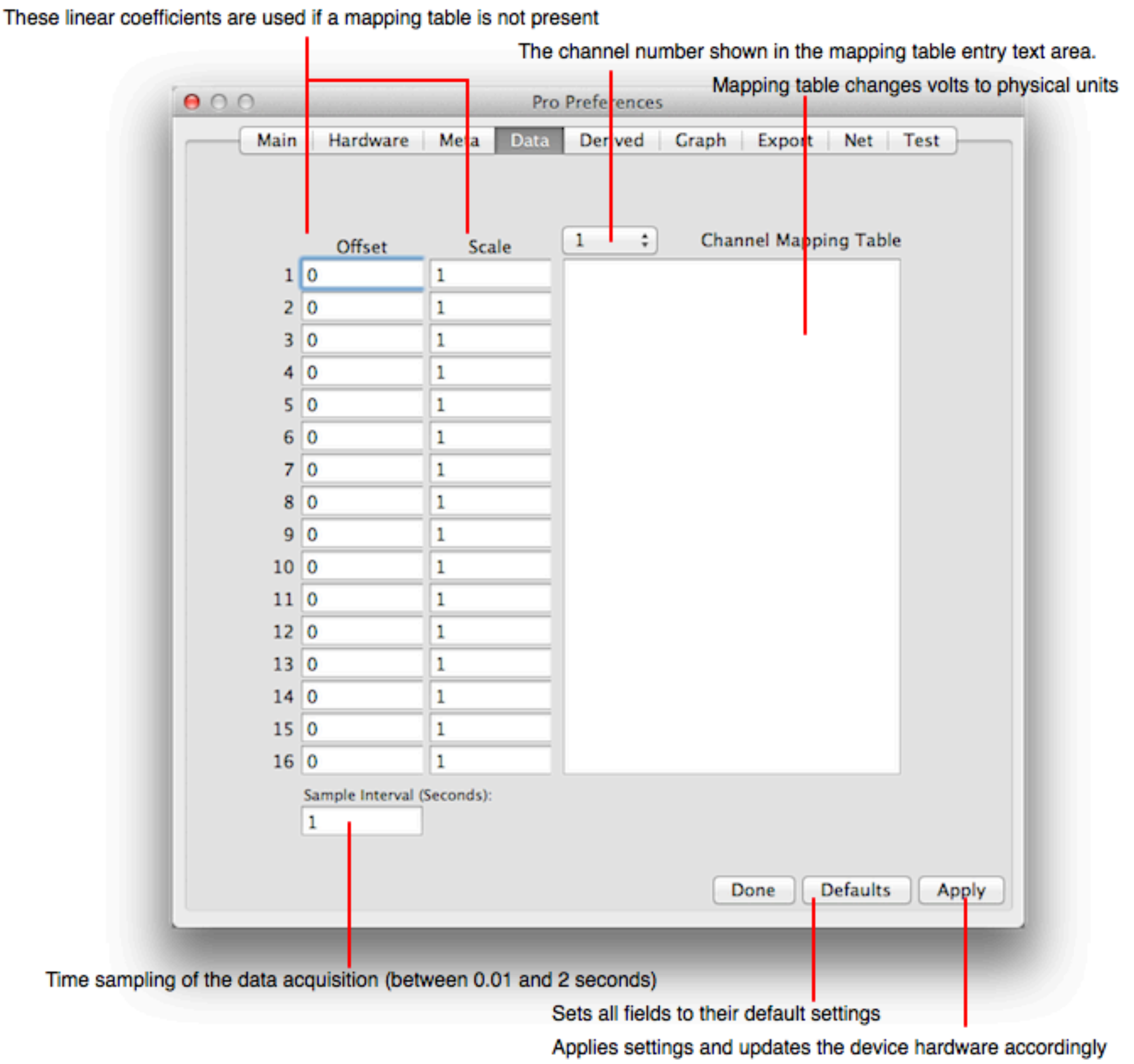
What To Do When Quitting

Select one of the options to change how DAQ Plot quits.

Buffer length

This is an expert setting and you need to take care while setting this attribute. For additional information see Buffer Support Note.

The data attributes defines how signals from a device get mapped into the data which gets displayed and stored in a signal file. It is used to define a mapping between Voltage and Physical Units, for example volts to pressure. The following diagrams the Data preferences pane.



Mapping Coefficients

The offset and scale field defines a linear mapping between volts and physical units and is defined as:

```
physical unit = voltage * scale + offset
```

The channel mapping table defines an arbitrary curve between volts and physical units in terms of x y pairs. The format is like:

```
x1 y1
x2 y2
...
xN yN
```

Data points that have voltage out of the interval {x1, xN} are mapped to the respective limit constant. For example, if the voltage is less than x1 then that voltage gets mapped to the constant x1.

The linear mapping coefficients will be used if a channel mapping table for a particular channel index is not specified.

Sample Interval

The Sample Interval field defines the starting sample interval of the acquisition when DAQ Plot first starts up. After that use the corresponding value on the main window. Sample interval can be between 0.01 and 2.0 seconds in 0.01 increments.

How To Derive Mapping Coefficients

To derive the mapping coefficients apply the following methodology. First measure the voltage at two known physical units values. For example, if you are measuring temperature then measure an ice cube and then body temperature. Define those values as:

```
v1 = voltage measured from the ice cube
v2 = voltage measured from the body
```

```
t1 = ice cube temperature (32 degrees fahrenheit)
t2 = body temperature (98.6 degrees fahrenheit)
```

Then the offset and scale are:

```
scale = (t2-t1)/(v2-v1)
offset = t1 - v1 * scale
```

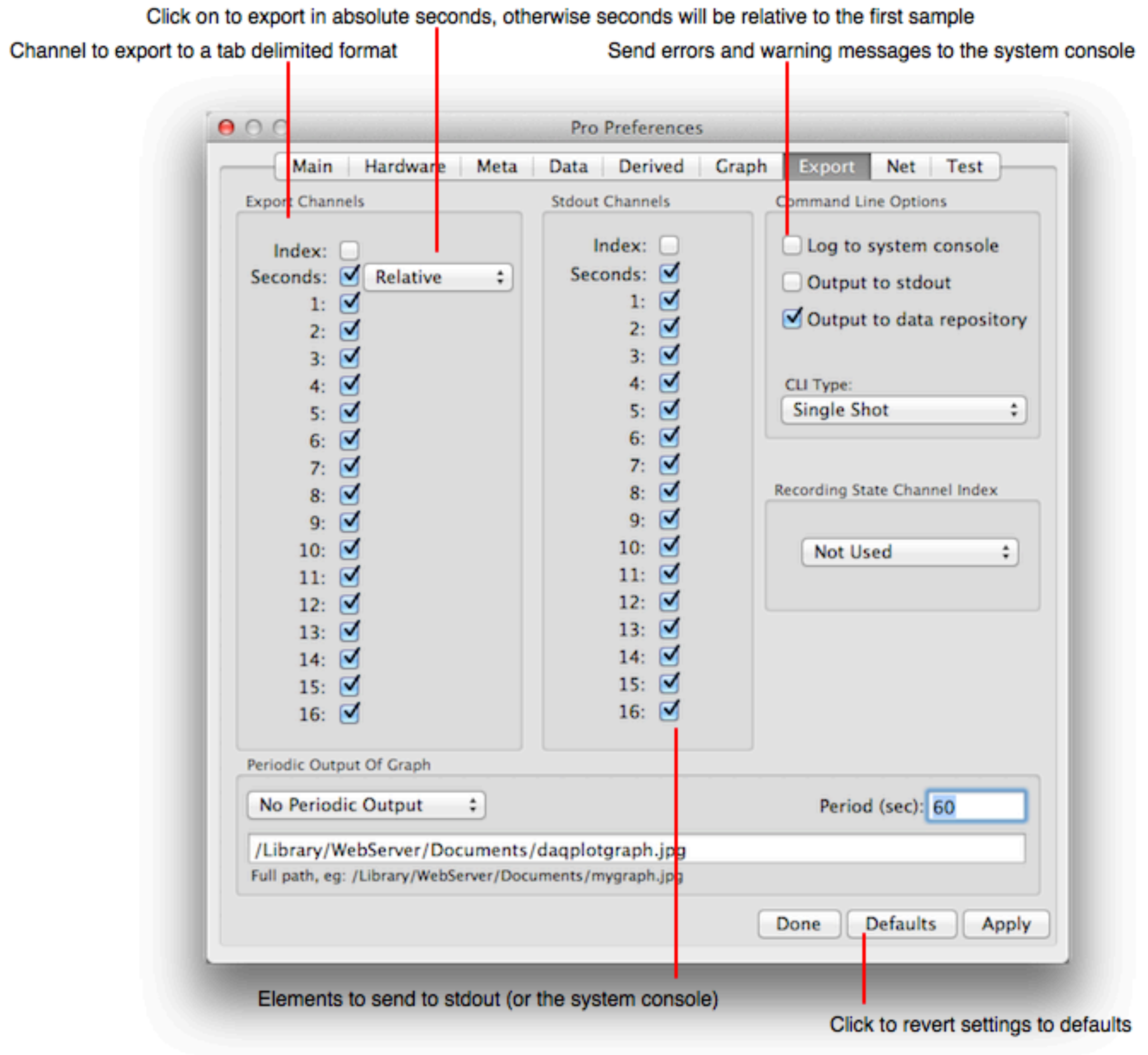
If you wish to use the table lookup then simply enter the values as:

```
v1 t1
v2 t2
```

into the channel mapping table. But make note of the fact that voltages sampled by a probe at temperature less than that of ice (t1) get defined as ice temperature, and voltages sampled by a probe at temperature greater than body temperature get mapped to body temperature. By adding voltage and temperature pairs at lower and higher temperatures you can build up a more extensive mapping, but only need do so if your sensor is nonlinear.

DAQ Plot ► Preferences ► General ► Export

The export attributes defines how data gets exported to other applications. The export format is tab delimited with columns being index, seconds and amplitude channels and rows being sample index. The pane shown below is used to set what gets exported.



These settings get used by the Export facilities as well as DAQ Command.

Export Channels

Defines which elements get output to tab-delimited text output formats. The options are index, second and channel values. The seconds can be output in relative values (0 being the first sample time) or absolute seconds since 1/1/1970.

Stdout Channels

Defines which channels output to stdout, which can then be used as input to DAQ Command. By selecting only the channels you are interested in you can minimize the amount of output processed by the DAQ Command.

Command Line Options

- **Log to system console**: If checked then a log of all text messages will be directed to the system console in addition to the DAQ Plot console, otherwise those text messages will only appear on the DAQ Plot console. This is good for making a permanent log of events.
- **Output to stdout**: If checked then the Export Channels (seconds and amplitude values) will output to stdout in addition to the graph and other UI locations. This must be selected for use with the DAQ Command.
- **Output to data repository**: If checked then the acquired data is stored to the internal buffers of DAQ Plot. Keep this on during normal use, but turn it off if configuring for DAQ Command.
- **CLI Type**: If "Single Shot" is selected then the DAQ Command will only execute one iteration of an acquisition. If "Continuous" is selected then the DAQ Command will output at the sample interval defined in DAQ Plot. That sample interval value is shown in the main window as well as the Data preference tab.

Recording State Channel Index

Sometimes it is convenient to have an external source control the recording of data. For example, a manual button for turning on and off acquisition. The idea is to get an actual hardware toggle switch (like a low power light switch) so you can manually turn recording on and off, just like a light bulb. In addition, such a feature can be used in conjunction with sensor feedback, so for instance if something reaches a certain temperature then acquisition can turn on. The idea of using a hardware switch and not the computer screen seems to be better accepted because the switch can be located next to a machine with sensors and is easy to understand for operators. In addition, such a feature is indispensable for high sample rates where manually turning recording on and off fast enough is impossible.

The Recording State Channel Index defines which analog input channel is used for the purpose described above. If the voltage for that channel is equal or greater than one then recording is on, otherwise it is off. The Recording State Channel Index pop up button defines this channel. The default selection is "Not Used" meaning that all analog input channels are used to record voltage data (hence there is no recording state feature). When a channel index number is selected then the corresponding analog input channel is used for the mentioned purpose. Note that the signal unit for this feature is voltage, not calibrated amplitude. Also note that while recording is off, data acquisition is still on. This is needed so DAQ Plot can determine when to turn recording back on according to the value of the voltage on the recording state channel.

Periodic Output Of Graph

If on, the graph presented by DAQ Plot will be written to disk according to the following parameters:

- **Output Type**: If set to JPEG then a JPEG image will be written. Otherwise no output will be written.
- **Period**: Defines the period in seconds to save the graph output. For example if set to 60 then the graph will be written every minute to the specified Full path.
- **Full path**: The absolute path on the file system of the computer DAQ Plot runs on to save the image. The directory of this path must exist and you should specify it as an absolute path (with a leading slash) and also specify the file name with extension jpg.

The intended use is to output for web distribution so the Full path should be in the Document root of your web server configuration. However, the graph can be written anywhere accessible to the computer.

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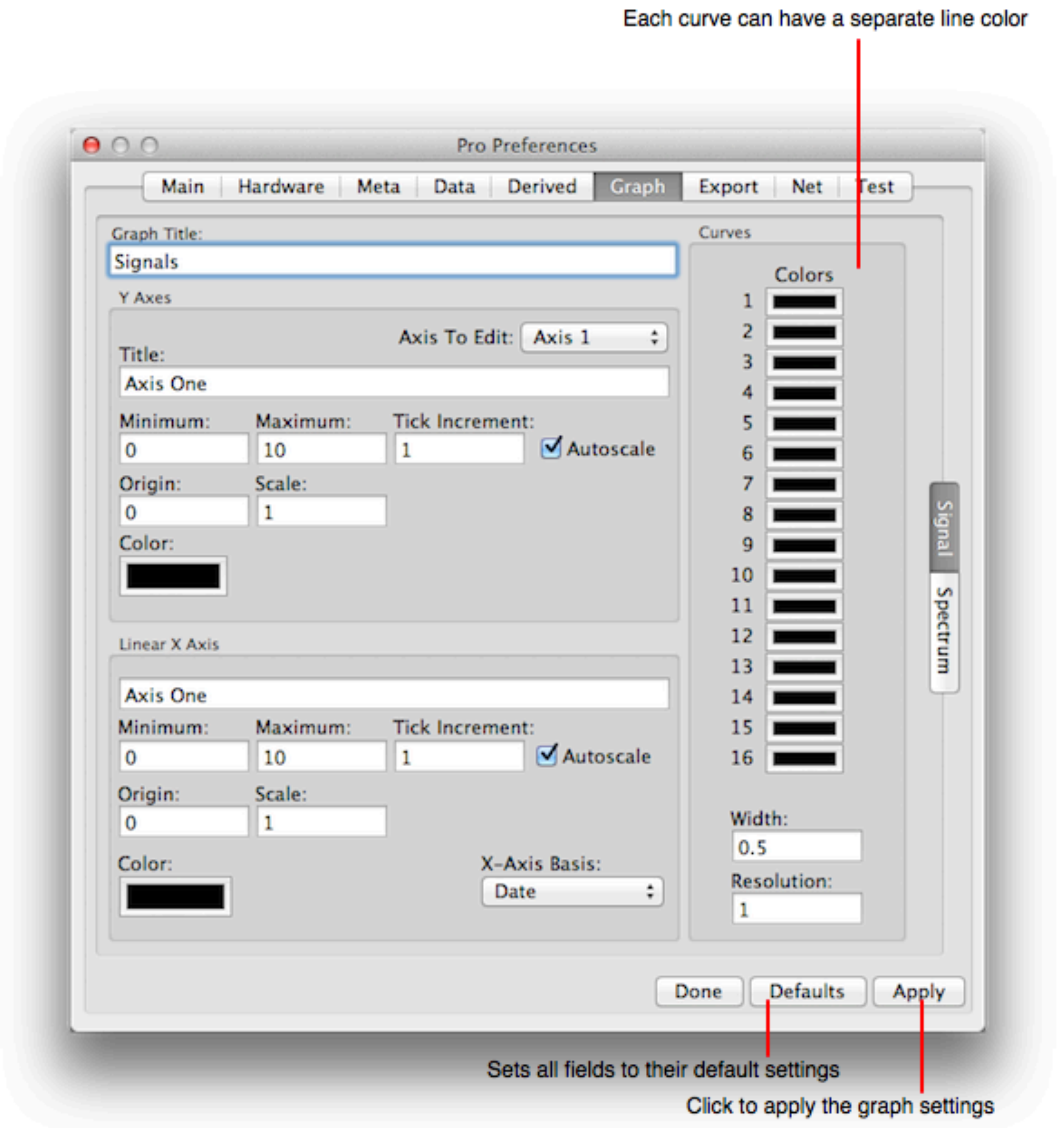
DAQ Plot ▶ Preferences ▶ General ▶ Graph

Signal Graph

The following diagrams the Signal Graph preferences pane.



Graph Title: The graph title can be set using this field.

Each y-axis attributes can be adjusted per the input fields. First select the axis number to edit and then set the parameters for that axis.

Common Axis Attributes:

- Title: The title of the y-axis.
- Minimum, Maximum and Tick Increment: The y-axis limits. The axis is autoscaled by default. If you do not want autoscaling then turn that off in which case the Minimum, Maximum and Tick Increment values are used instead.
- Origin and Scale: Remaps the axis label values according to the linear mapping. Since there are many other remappings possible it is probably best to leave these at their default values (identity mapping) otherwise things get confusing. The origin and scale attributes only change the graph label values. If you need to alter the data values with a linear mapping then see the Data preference pane.
- Color: Defines the y-axis title color. To associate a y-axis to a curve (color) set both to the same value. Remember: Click the color well bezel to bring up the color panel.

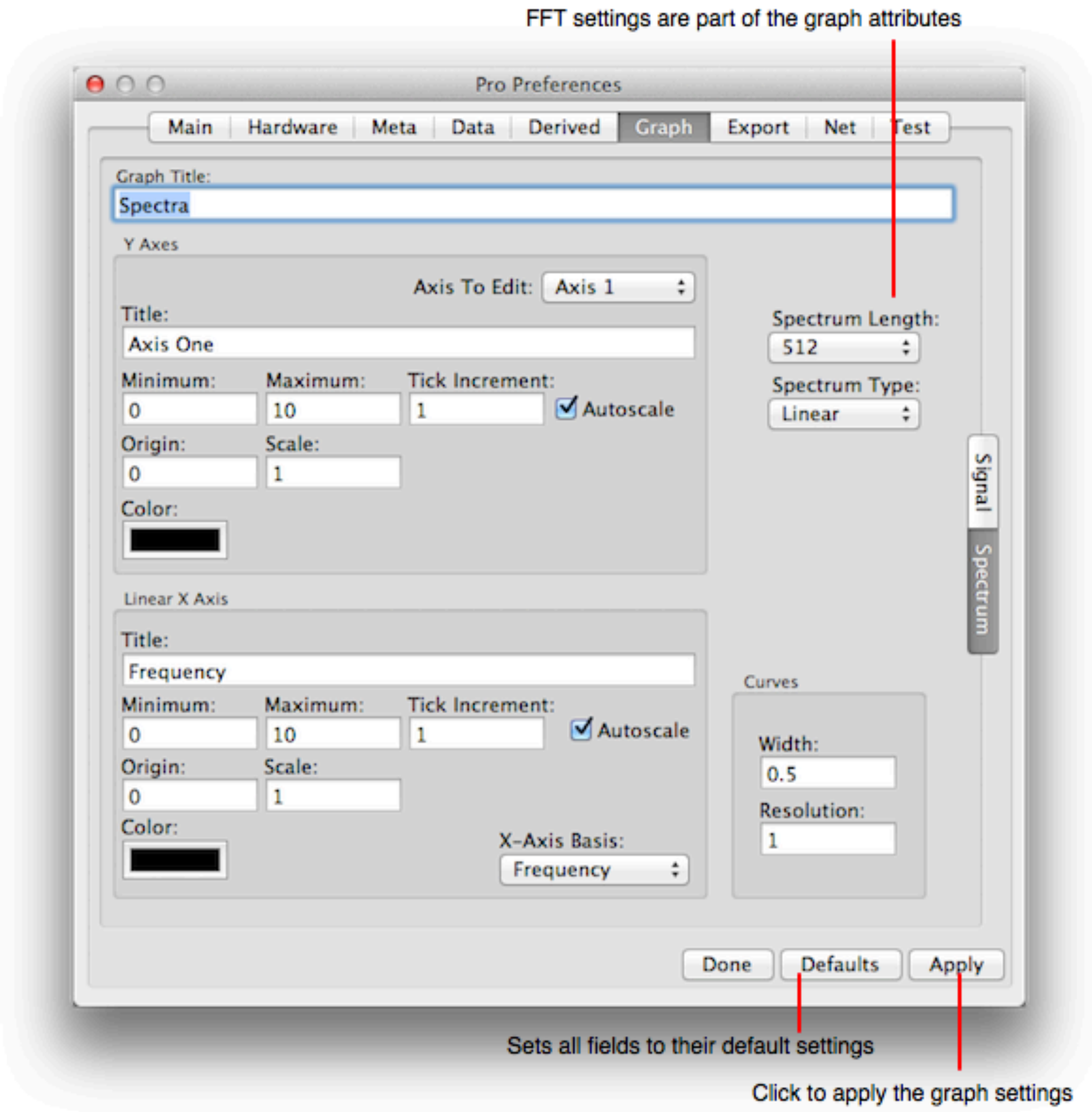
X-Axis Basis: Normally the x-axis is time and date. But, you can alter that by selecting a different x-axis basis. The basis is either Sample Index or another channel. For example, if it is Channel 1 then other channels (such as channel 2) have their normal y-value, but their x-value is that of channel 1's y-value. Such plots are called many things including trajectory plots, phase space plots, x-y plots, etc.

Linear X-Axis Attributes: When the X-Axis Basis is not Date then it is a normal linear axis and the attributes are similar to the y axis attributes.

Curve Attributes: The color, width and fidelity of each curve can be altered using the appropriate settings. Resolution is normalized to one pixel on a screen and should remain 1 while plotting. You may want to set it to 0 before exporting a graph for the maximum resolution, but after exporting set it back to 1. For screen display, any value less than one is overkill.

Spectrum Graph

The following diagrams the Spectrum Graph preferences pane.



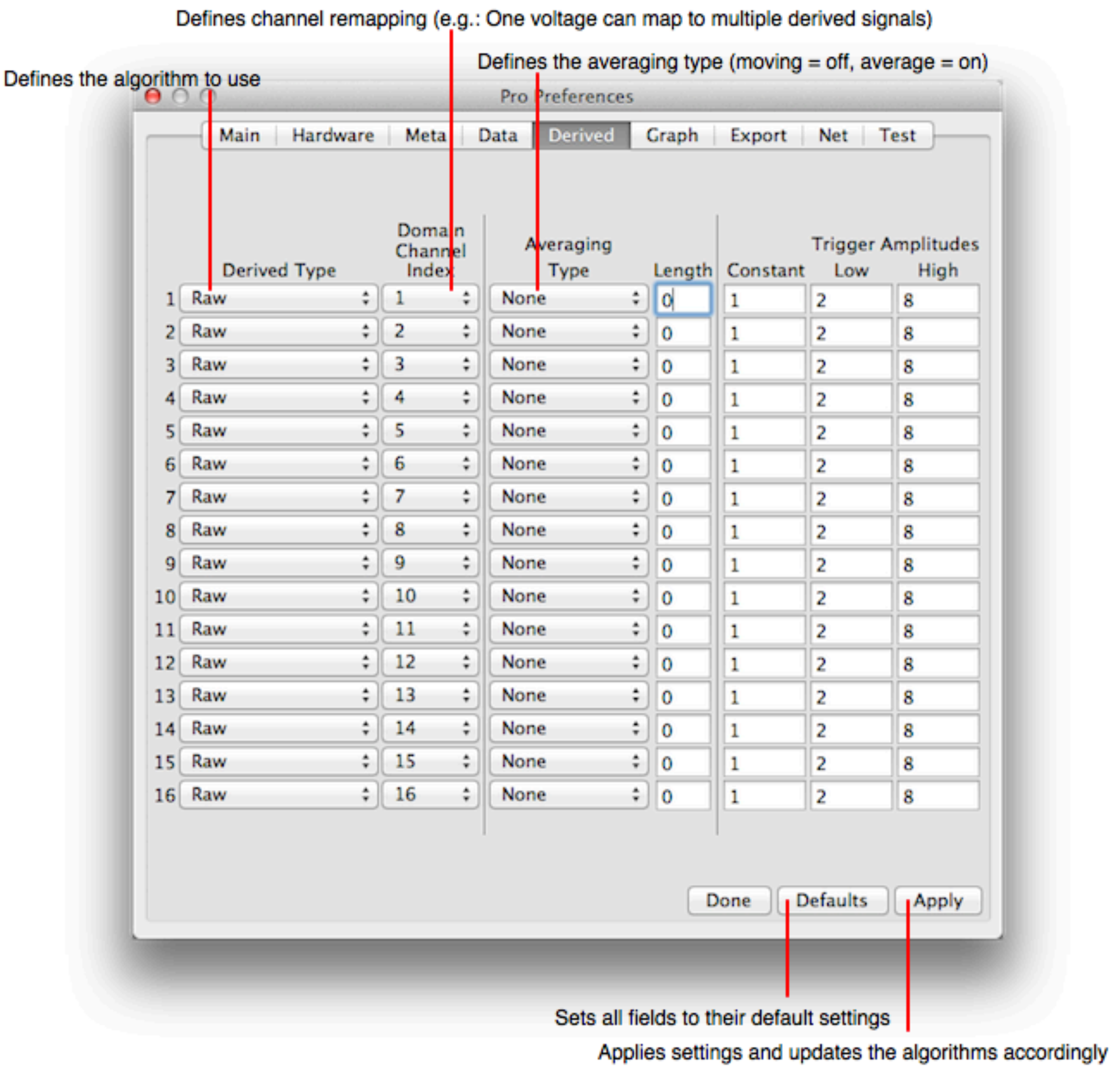
Common Axis Attributes: Most of the graph attributes are similar to the Signal Graph above, see that section for descriptions.

Spectrum Length: The Spectrum FFT length is considered a graphical attribute. Set it to the value that you want.

Spectrum Type: The Spectrum type can be either linear or power (log-mapped) and defines the y-direction value (mapping).

DAQ Plot ► Preferences ► General ► Derived

Derived data maps data from the Data space to predefined representation. To turn this preference style 2 on see Preferences Style. For example, it can map voltage to a moving averaged speed. The following diagrams the Derived preferences pane. For a general discussion about derived mappings see Derived Support Note.



Each row defines the derived parameter values for a channel. Each column is now explained:

Derived Type

The Derived Type is one of:

Raw	Outputs the raw data signal, remapped to physical units per the specifications in the Data pane, but otherwise not altered.
Average	Outputs the averaged raw data. Raw will not average, so if you need to average the raw data choose this derived type. Other derive types average also, but that is a derived-average not a raw-average. This setting sets a raw-average.
Up Trigger	Outputs the up-trigger result in terms of 0 for no trigger and 1 for trigger. Using this along with an average produces smoothed event information.
Down Trigger	Outputs the down-trigger result in terms of 0 for no trigger and 1 for trigger. Using this along with an average produces smoothed event information.
Bi Trigger	Outputs the trigger result in terms of 0 for no trigger, 1 for up-trigger and -1 for down trigger. Using this along with an average produces smoothed event information.
Up Counter	Adds one to the derived value each time the up-trigger is detected.
Down Counter	Adds one to the derived value each time the down-trigger is detected.
Bi Counter	Adds one to the derived value each time the up-trigger is detected and adds -1 each time the down-trigger is detected.

Up Window	The range is initially 0 until the up-trigger is encountered and then the range changes to 1.
Down Window	The range is initially 1 until the low-trigger is encountered and then the range changes to 0.
Bi Window	The range is initially 0, changes to 1 when the domain value reaches the up-trigger and then changes back to 0 when the domain value reaches the low-trigger.
Add	The domain value is added with the previous channel's derived value.
Subtract	The domain value is subtracted by the previous channel's derived value.
Multiply	The domain value is multiplied with the previous channel's derived value.
Divide	The domain value (numerator) is divided by the previous channel's derived value (denominator). If the denominator is zero then in order to prevent a NaN condition the result (range) is set to zero.
Speed	Outputs the speed, which is the distance between pulses divided by the time between pulses. The distance is defined by the constant. This is triggered off the leading edge of the pulse (up-trigger).
Integration	Outputs the integration, which is the area under the curve where the data points are interpolated by a line segment to form the area boundary.
Optional	Outputs a Raw signal only if one of the other derived quantities outputs. This is very useful for minimizing output. It is strongly suggested that you set all unused channels to Optional. That way data is output only when a derived event occurs.

Channel Index

Defines the data channel from which the derived channel is computed from. For example: If you have one channel of data and want to see that channel's raw data signal and the derived value at once then you can set channel one's derived type as Raw and channel two's derived type as what you want and the channel index to one.

You can also use this to graph a derived channel and the same derived channel, but with an averaging. It can also be used to separate up and down triggers and define different trigger values for up v.s. down triggers. There are many ways to use this index mapping. Note: Sometimes this type of index mapping is referred to as a scatter map.

Averages

Averages take the derived signal and remap it into a average with length specified in the Average Length field. Note that, for example, if the average length is 100 then the first average signal will not be output for 100 events, after that the moving average outputs at each event while the bin average accumulates average length number of events and then outputs again.

The bin average is good for high sample rate in order to reduce white noise and the volume of output. The moving average smoothes the signal out without reducing the amount of data.

The model fit, velocity and acceleration averages are based on a real-time adaptive non-linear model to the data. The model is most accurate while interpolating and for that the centered type fit is provided. But a centered fit is not good when the average needs to reflect the data immediately. For that a forward type fit is provided which uses only previous data to compute a fit to the data at the current time value.

The Average Type is one of:

None	No average is applied.
MC-Mean	A moving centered arithmetic mean is computed. This is good for smoothing white noise and it is certainly a well known thing to do. However, the average output is delayed in time which is not always a good thing.
MC-Fit	A moving centered model fit to the data. This fit has high fidelity, however since it is a centered fit it also is a delayed average.
MC-V	A moving centered velocity of the data.
MC-A	A moving centered acceleration of the data.
MF-Fit	A moving forward model fit to the curve. This is best for real-time curves because the average reflects the leading edge of the data. However, the MC-Fit may actually be better for post processing purposes.
MF-V	A moving forward velocity fit to the curve.
MF-A	A moving forward acceleration fit to the curve.
BC-Mean	A bin centered arithmetic mean is computed. Since bin values are only output every average length number of samples this is really good for high-speed acquisition where the sampling is oversampled and the intent of the average is to average out white noise.
BC-Fit	Bin centered fit to the data.
BC-V	Bin centered velocity fit to the data.
BC-A	Bin centered acceleration fit to the data.
BF-Fit	Bin forward fit to the data.

BF-V	Bin forward velocity fit to the data.
BF-A	Bin forward acceleration fit to the data.

Velocity is the first derivative of the model to the data. Acceleration is the second derivative of the model to the data. A Centered fit is the fit at the midpoint of the average interval. A forward fit is the fit at the latest time value of the average interval.

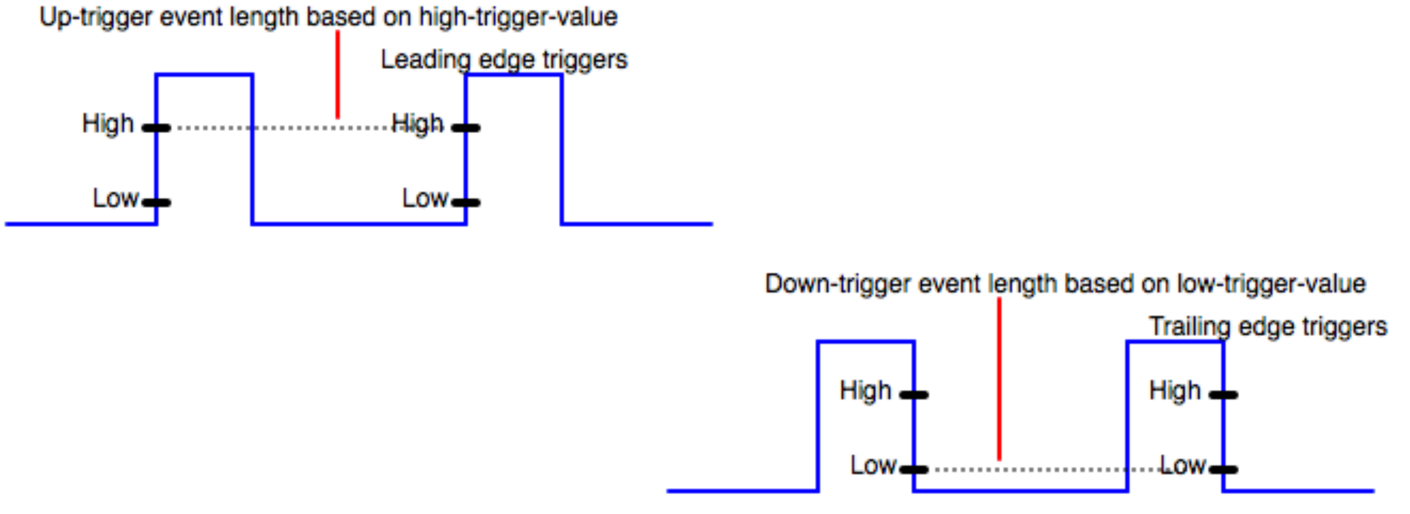
How to pick an average length? A general model fit, no matter how good, can not perform a miracle. There must be some overriding orthogonality to the fit v.s. unfit nature of the signal. Usually that orthogonality is white noise v.s. a low-frequency signal compared to the noise. The fit averages the white noise and outputs its mean, which is theoretically zero thus leaving the superimposed signal. A problem occurs because, due to the average, the signal reflects past data as well as present. To overcome this the forward adaptive non-linear model fit algorithm is used to effect a predictive computation of the value at the current time the signal is being sampled. The length of the fit should be about 6 times less than the instantaneous period of the signal. In practice, a length of 20 seems to be good, but for very noisy or corrupt signals a higher length may be needed. Note that by sampling faster you can increase the average length because the desired signal quantity should be invariant with sample rate.

Constant

Some derived types require an additional constant. The speed type is the only one requiring a constant at this time. For speed, the constant is the distance between pulses in the speed computation.

Trigger Amplitudes

Triggers are changes in a signal that indicate an event. The signal model for the event is based on a pulse as diagrammed below. The low and high states are implemented to reduce and theoretically eliminate sensitivity to noise. Given an ideal signal only one trigger value would be needed, however in practical use that is not reliable enough, hence the two trigger values.



The up-trigger event occurs at the high-trigger-value and has seconds collocated at the high-trigger. The down-trigger event occurs at the low-trigger-value and has seconds collocated at the low-trigger. For the pulse shown below, the up-trigger is on the leading edge and the down-trigger is on the trailing edge of the pulse. Had the pulse been reversed-vertically then the edge detection v.s. down and up would also be reversed.

Note that this signal processing is done in software so the signal resolution (sample time) must have high enough fidelity (resolution or small enough sample time) to resolve the pulse's features.

Most of the attributes in DAQ Plot are set using the preference pane. See a section below for more information.

Hardware Preferences

Basic USB	Basic USB.
Standard USB	Standard USB.
Pro USB	Pro USB.
Serial Port	Serial Port.

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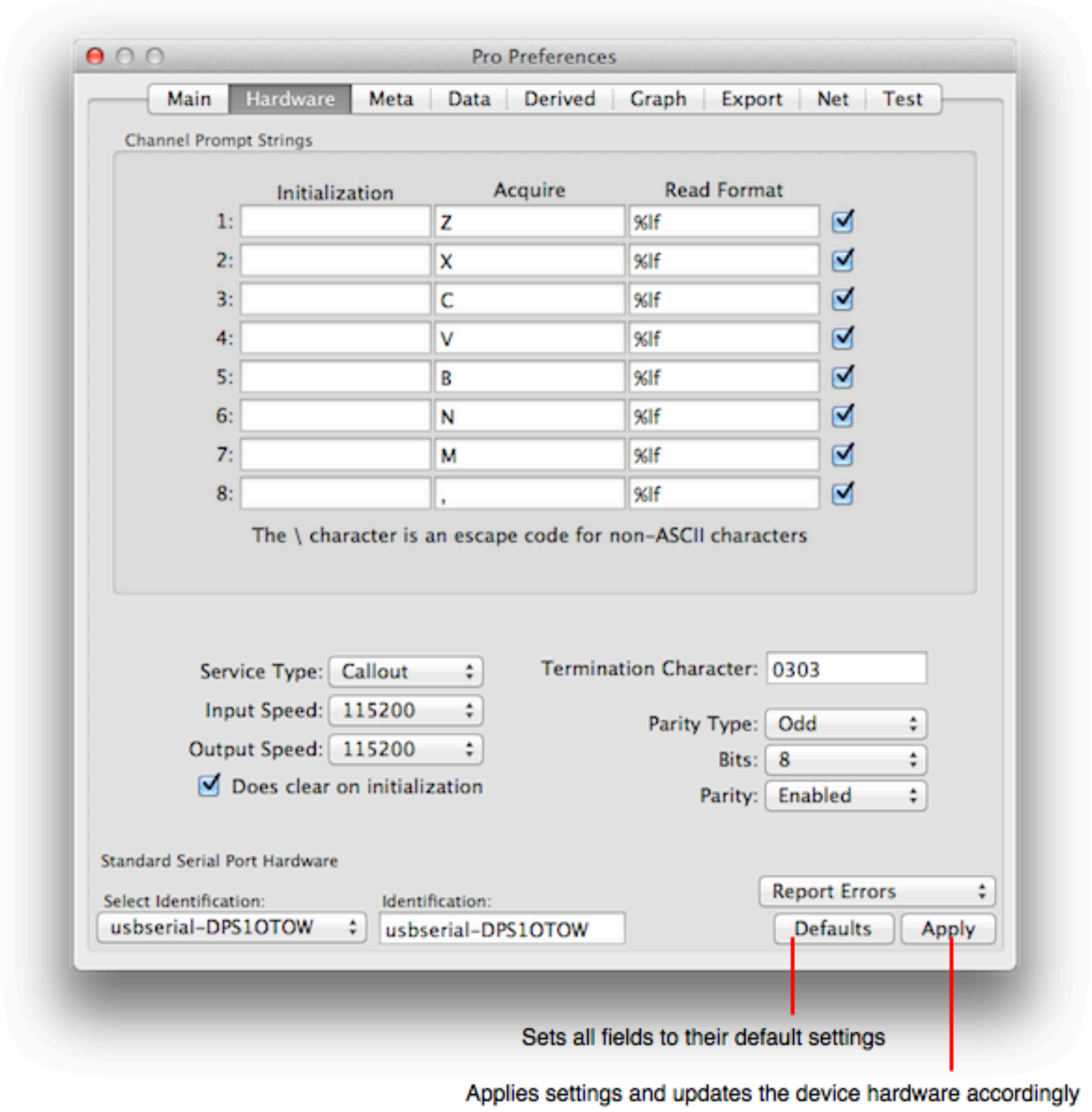
DAQ Plot ▶ Preferences ▶ Hardware ▶ Basic USB

The Basic Hardware preferences sets the state of the Basic Hardware. The Basic USB hardware device is a DAQ device front ended by a USB controller and connector. Although it is called "Basic USB" it uses serial port protocol and the preferences are those of a serial port device.

Before setting the preferences make sure to do the following:

- Before using the Basic USB hardware make sure to install the separate driver as specified when you purchased the hardware.
- Plug in the Basic USB hardware before launching DAQ Plot. As with all serial port devices, there is no enumeration notifications so that DAQ Plot will only register serial port hardware that is attached to your computer when it is launched.

The following diagrams the Basic USB DAQ hardware device preferences.



Identification Number

The Identification Number specifies the DAQ hardware unit to configure and use. In the case of the Basic Hardware that ID appears as "usbserial-DPS1OTOW". Select the identification similar to that and then click Apply.

Analog Input

There are 8 channels of analog voltage each of which are single ended. If you have a bipolar sensor then you need to accommodate the second wire coming from the sensor. Often that is accomplished by attaching it to ground but that is not alway the case. The second wire could also be specified to be connected to a voltage source or other reference voltage. You may also be able to trick DAQ Plot into a differential measurement by connecting a sensor to two input connectors and using the Derived preferences to subtract the input values.

Screw Connectors

Use the following Input Screw Connector Key to determine which channel goes with which screws. See Connectors for additional information.

Input Screw Connector Key

Channel Index	Screw Label	Acquire Code
1	1	Z

2	2	X
3	3	C
4	4	V
5	5	B
6	6	N
7	7	M
8	8	,

Applying

No state of the hardware will change without clicking the Apply button. That is because all the states are interrelated and applying only a partial setting could put the hardware in a state where it records data in a non-nominal state. Hence, only click the Apply button when you are satisfied with all the settings.

Other Serial Port Attributes

The Basic Hardware device presents as a serial port device so when selected shows the serial port preference pane. The default values for a serial port device are set to those required for the Basic hardware. Click the "Defaults" button to set or reset the serial port parameters to those required for the Basic Hardware and then click the Apply button. For additional information on serial port attributes see: Serial Port.

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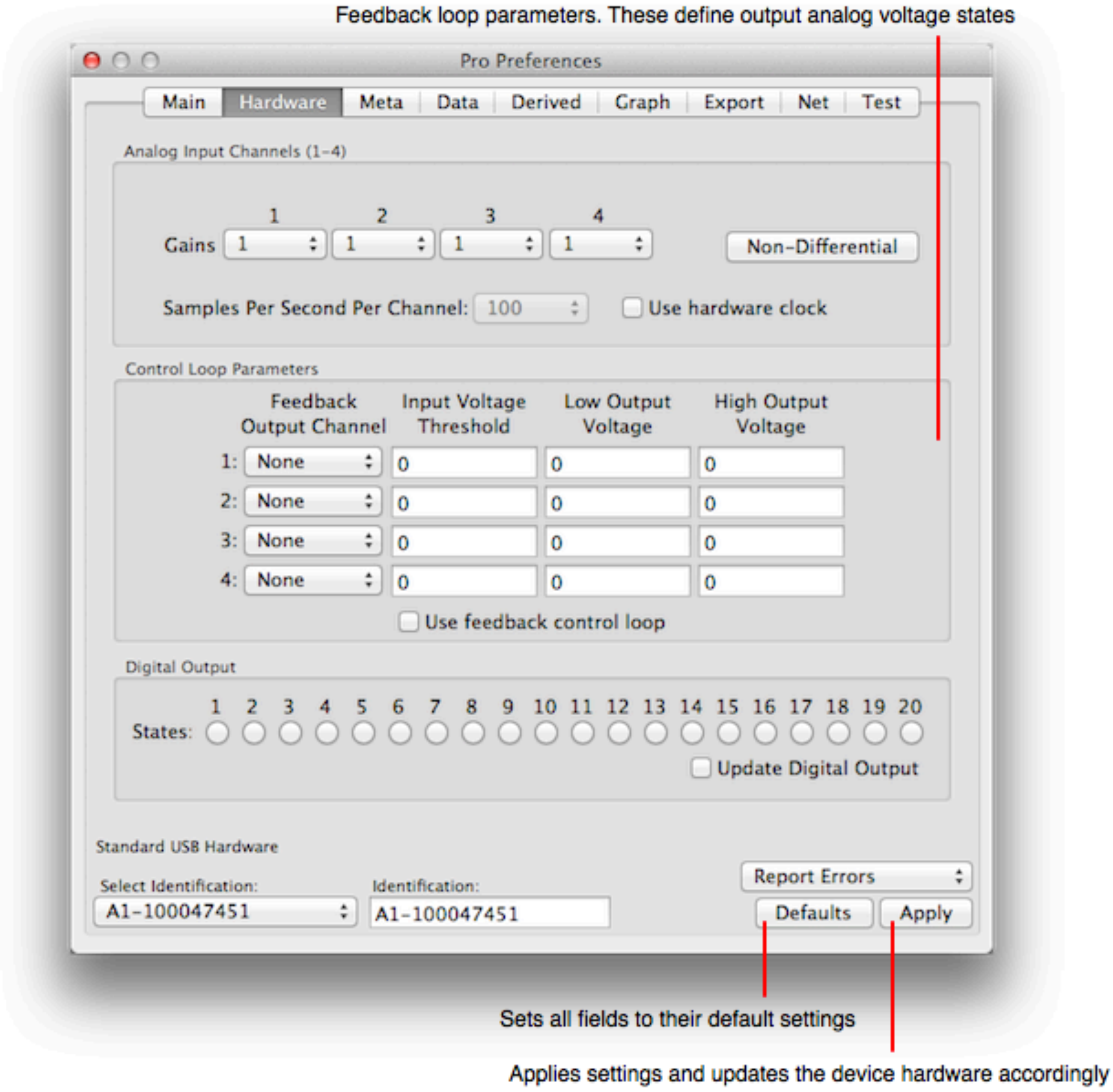
DAQ Plot ► Preferences ► Hardware ► Standard USB

The Standard Hardware preferences sets the state of the Standard Hardware. The following diagrams the Standard USB (Universal Serial Bus) DAQ hardware device preferences.



Identification Number

The Identification Number specifies the DAQ hardware unit to configure and use. If there is more than one DAQ hardware unit on your computer's USB bus then you need to select the correct one. Normally the identification number is a serial number is printed on the DAQ device, however if it is not then select a identification number, enable hardware clocking and click the Apply button. During hardware clocking the status LED on the device blinks. Once you've associated the hardware to a identification number you should probably record the identification number on the DAQ device itself. Repeat this process for all identification numbers to identify each device. You can also use the digital channel settings and monitor them, or other input or output indicators to find the device to identification number association.

Analog Input

There are 4 channels of analog voltage input each with their own gain setting. The Gain controls a pre-amplification of the signal before digitization. The gain is post-decreased after the digitization so that the recorded voltage is invariant with respect to the gain setting. The gain does affect the effective resolution of the signal and as a consequence decreases the dynamic range of the channel and is especially important for low voltage (millivolt) signals. Make sure that the gain settings will not cause the voltage to amplify greater than 10 volts (the limit of the hardware input voltage).

The differential button defines whether the hardware is wired for differential or non-differential sampling. Gain settings are only valid for the differential setting.

If you choose to use the high-speed hardware clocking then the Samples per second entry is used instead of the sample interval on the main window. In addition, because it is hardware clocked the timebase increment is uniform and will not depend on the host load. Non-hardware clocked data has a timebase variability of a few percent, which is not a problem because the time at each point is recorded and is not assumed uniform anyways. Hardware clocking requires a dedicated USB device so make sure to turn off the feedback, digital and other options which can disrupt the data flow.

Screw Connectors

Use the following Input Screw Connector Key to determine which channel goes with which screws. See Connectors for additional information.

Input Screw Connector Key

Channel Index	Differential	Non-Differential
1	AI0 - AI1	AI0
2	AI2 - AI3	AI1
3	AI4 - AI5	AI2
4	AI6 - AI7	AI3

Control Loop

The Control Loop Parameters define a common feedback algorithm. Set each channel as you wish. First set the output channel, then the input voltage at which the output voltage will change. Finally set the output voltage values. The Low Output Voltage will be outputted when the input voltage is below the Input Threshold Voltage. The High Output Voltage will be outputted when the input voltage is above the Input Threshold Voltage. A common setting is 0 and 5 respectively so that when the input voltage crosses a threshold the output voltage is changed from 0 to 5 volts and can be used to activate another device.

The feedback control only occurs when the Use feedback control loop switch is selected. Special Note: If you use high-speed clocking then the feedback signals may interfere with data acquisition so you should probably not use high-speed clocking and feedback at the same time.

Digital Output

Digital controls set a low and high state of each digital output terminal. The low state is 0 volts, the high 5 volts. Channel 1-4 are the screw terminals IO0, IO1, IO2, IO3 respectively. The others are the DB pins in consecutive order. These states can be used as switches to define other hardware states.

Reporting

The USB device can report additional information to stdout (the console). The report pop up button sets the threshold of reporting. Silent for no reporting, Error to report errors only all the way up to All, which will report errors, summary results and some state changes. If you choose Summary or above and restart the USB device then it will report the firmware version of the hardware upon restart.

Applying

No state of the hardware will change without clicking the Apply button. That is because all the states are interrelated and applying only a partial setting could put the hardware in a state where it records data in a non-nominal state. Hence, only click the Apply button when you are satisfied with all the settings.

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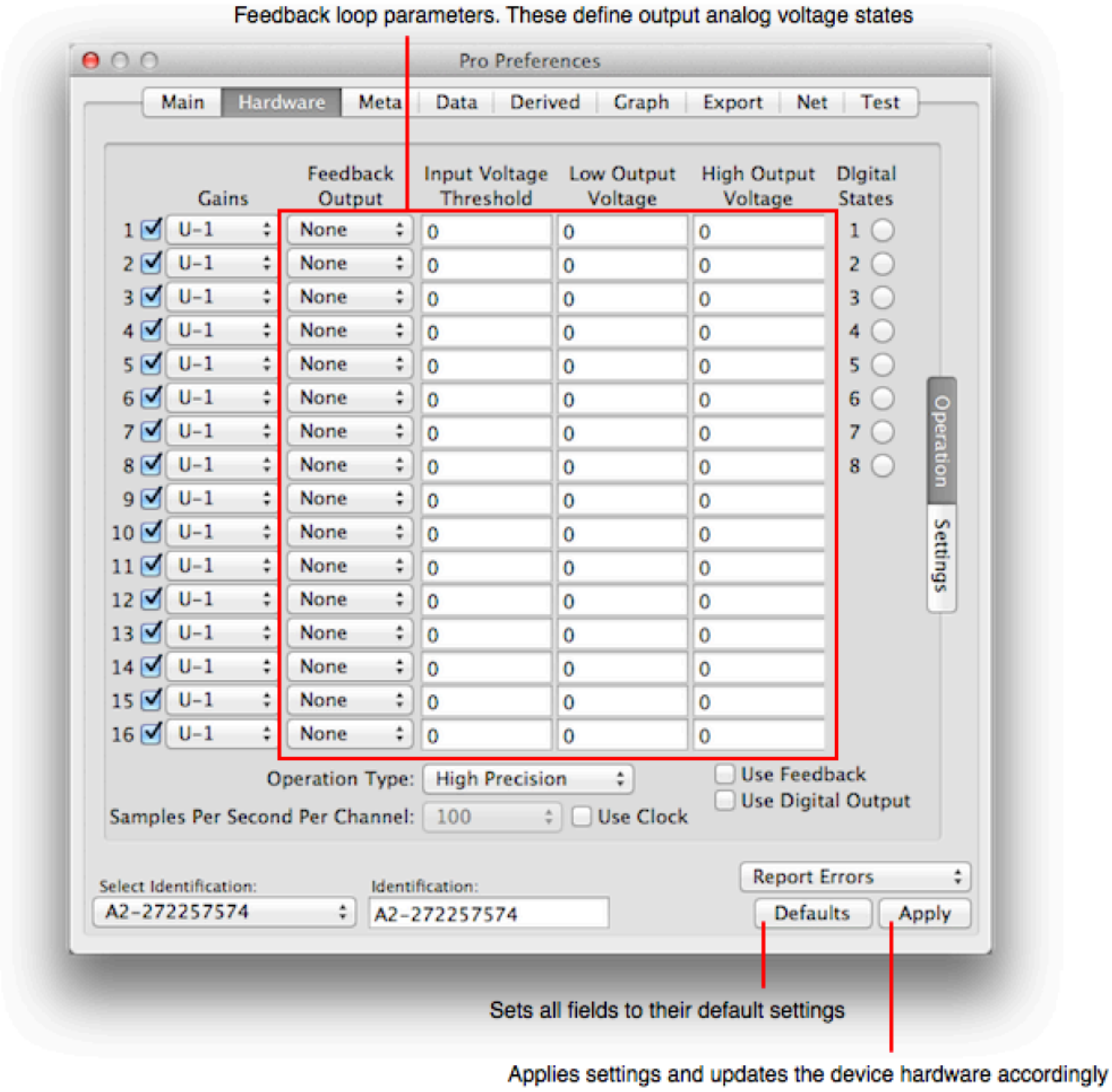
DAQ Plot ► Preferences ► Hardware ► Pro USB

The Pro Hardware preferences sets the state of the Pro Hardware. The following diagrams the Pro USB (Universal Serial Bus) DAQ hardware device preferences.



Identification Number

The Identification Number specifies the DAQ hardware unit to configure and use. If there is more than one DAQ hardware unit on your computer's USB bus then you need to select the correct one. Normally the identification number is a serial number printed on the DAQ device, however if it is not then select a identification number, enable hardware clocking and click the Apply button. During hardware clocking the comm LED on the device looks on all the time. Once you've associated the hardware to a identification number you should probably record the identification number on the DAQ device itself. Repeat this process for all identification numbers to identify each device. You can also use the digital channel settings and monitor them, or other input or output indicators to find the device to identification number association.

Analog Input

There are 14 channels of analog voltage input labeled from 1 to 14. Channel 15 is a temperature sensor output inside the unit and channel 16 is the unit's voltage source reading. Channels 15 and 16 can help calibrate, or refactor, signals based on environmental considerations. See the Screw Connector section below for channel index to screw terminal mapping.

Analog Input States

Each channel can be turned on or off. Turn all channels off except the ones you are using by clicking the switch next to the channel number in each row. Turning off unused channels will cause the hardware to sample faster as well as eliminate spurious channel output whose values are voltage floaters (have no potential reference) and may appear random in the output.

Important: Analog Input indexes always start at one and are sequential so if you turn off a state then higher index are moved down by one. For example: If you have only Analog Input index 3 and 6 states on then those channels are remapped to 1 and 2 and are shown on the graph as curve 1 and 2, etc. and the device appears to have only two channels (as many as are turned on). Thus if you use the Meta Device then you can multiplex pro hardware to 16 channels even though the physical number of channels is modulo 16.

Analog Input Gain

There are 14 channels of analog voltage input each with their own gain setting. The Gain controls a pre-amplification of the signal before digitization. The gain is post-decreased after the digitization so that the recorded voltage is invariant with respect to the gain setting. The gain does affect the effective resolution of the signal and as a consequence decreases the dynamic range of the channel and is especially important for low voltage (millivolt) signals. Make sure that the gain settings will not cause the voltage to amplify greater than 5 volts (the limit of the hardware input voltage). There are 8 gain settings: 1, 2, 4, 8 both unipolar (0 to 5 volts) and bipolar (-5 to 5 volts) designated by U-1, U-2, U-4, U-8, B-1, B-2, B-4, B-8 in the user interface.

Gain Mapping Indicator

Gain Nomenclature	Description
U-1	Unipolar gain of 1 (range 0 to 5 volts).
U-2	Unipolar gain of 2 (range 0 to 2.5 volts).
U-4	Unipolar gain of 4 (range 0 to 1.25 volts).
U-8	Unipolar gain of 8 (range 0 to 0.625 volts).
B-1	Bipolar gain of 1 (range -5 to 5 volts).
B-2	Bipolar gain of 2 (range -2.5 to 2.5 volts).
B-4	Bipolar gain of 4 (range -1.25 to 1.25 volts).
B-8	Bipolar gain of 8 (range -0.625 to 0.625 volts).

Clocking

If you choose to use the high-speed hardware clocking then the Samples per second entry is used instead of the sample interval on the main window. In addition, because it is hardware clocked the timebase increment is uniform and will not depend on the host load. Non-hardware clocked data has a timebase variability of a few percent, which is not a problem because the time at each point is recorded and is not assumed uniform anyways. Hardware clocking requires a dedicated USB device so make sure to turn off the feedback, digital and other options which can disrupt the data flow.

The Pro hardware has a limit of 50,000 samples per second. As such the Samples Per Second Per Channel times the number of analog input channels on should not exceed 50,000. For example: with one channel on the Samples Per Second Per Channel can be no greater than 50,000. With 5 channels on the Samples Per Second Per Channel can be no greater than 10,000. Other limiting factors are USB bus load and type, computer type and output state. The actual Samples Per Second obtainable may be less than the 50,000 limit.

Special Notes: There are a few limitations in streaming mode. Generally you must be aware of the following:

- Streaming channels should be turned on consecutively. For example: streaming only channel 2 and 3 is OK, but not 2 and 4.
- Streaming should be in multiples of 2.
- Streaming at high clock rates and high computer load on a slow computer may produce communication backlogs that exceed the internal buffers.

Always verify that streaming has reasonable efficacy before settling on a streaming configuration. Streaming efficacy will depend on your computer and USB bus hardware as well as the load you place on your computer.

Screw Connectors

Use the following Input Screw Connector Key to determine which channel goes with which screws. See Connectors for additional information.

Input Screw Connector Key

Channel Index	Description
1-14	AIN0 - AIN13 respectively
15	Hardware unit temperature sensor output in Kelvin
16	Hardware unit voltage source value.

Control Loop

The Control Loop Parameters define a common feedback algorithm. Set each channel as you wish. First set the output channel, then the input voltage at which the output voltage will change. Finally set the output voltage values. The Low Output Voltage will be outputted when the input voltage is below the Input Threshold Voltage. The High Output Voltage will be outputted when the input voltage is above the Input Threshold Voltage. A common setting is 0 and 5 respectively so that when the input voltage crosses a threshold the output voltage is changed from 0 to 5 volts and can be used to activate another device.

The feedback control only occurs when the Use feedback control loop switch is selected. Special Note: If you use high-speed clocking then the feedback signals may interfere with data acquisition so you should probably not use high-speed clocking and feedback at the same time.

Digital Output

Digital controls set a low and high state of each digital output terminal. The low state is 0 volts, the high 3.3 volts. Channel 1-8 are the screw terminals FIO0-FIO7 respectively.

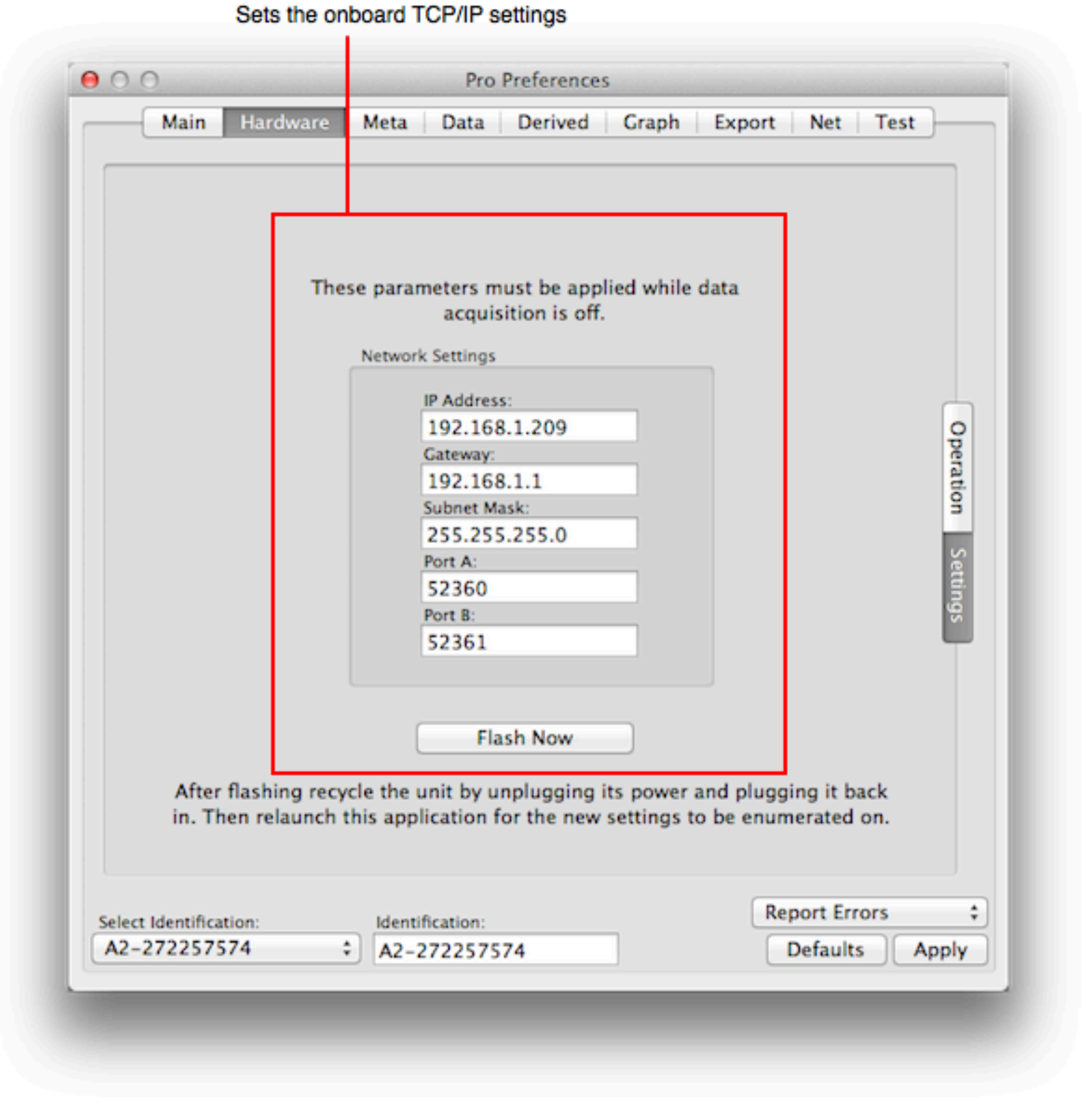
Reporting

The USB device can report additional information to stdout (the console). The report pop up button sets the threshold of reporting. Silent for no reporting, Error to report errors only all the way up to All, which will report errors, summary results and some state changes. If you choose Summary or above and restart the USB device then it will report the firmware version of the hardware upon restart.

Applying

No state of the hardware will change without clicking the Apply button. That is because all the states are interrelated and applying only a partial setting could put the hardware in a state where it records data in a non-nominal state. Hence, only click the Apply button when you are satisfied with all the settings.

Ethernet Settings



The Settings sub-pane allows the setting of the hardware's ethernet parameters. If you use the ethernet interface then make sure to synch. those settings with the Hardware References.

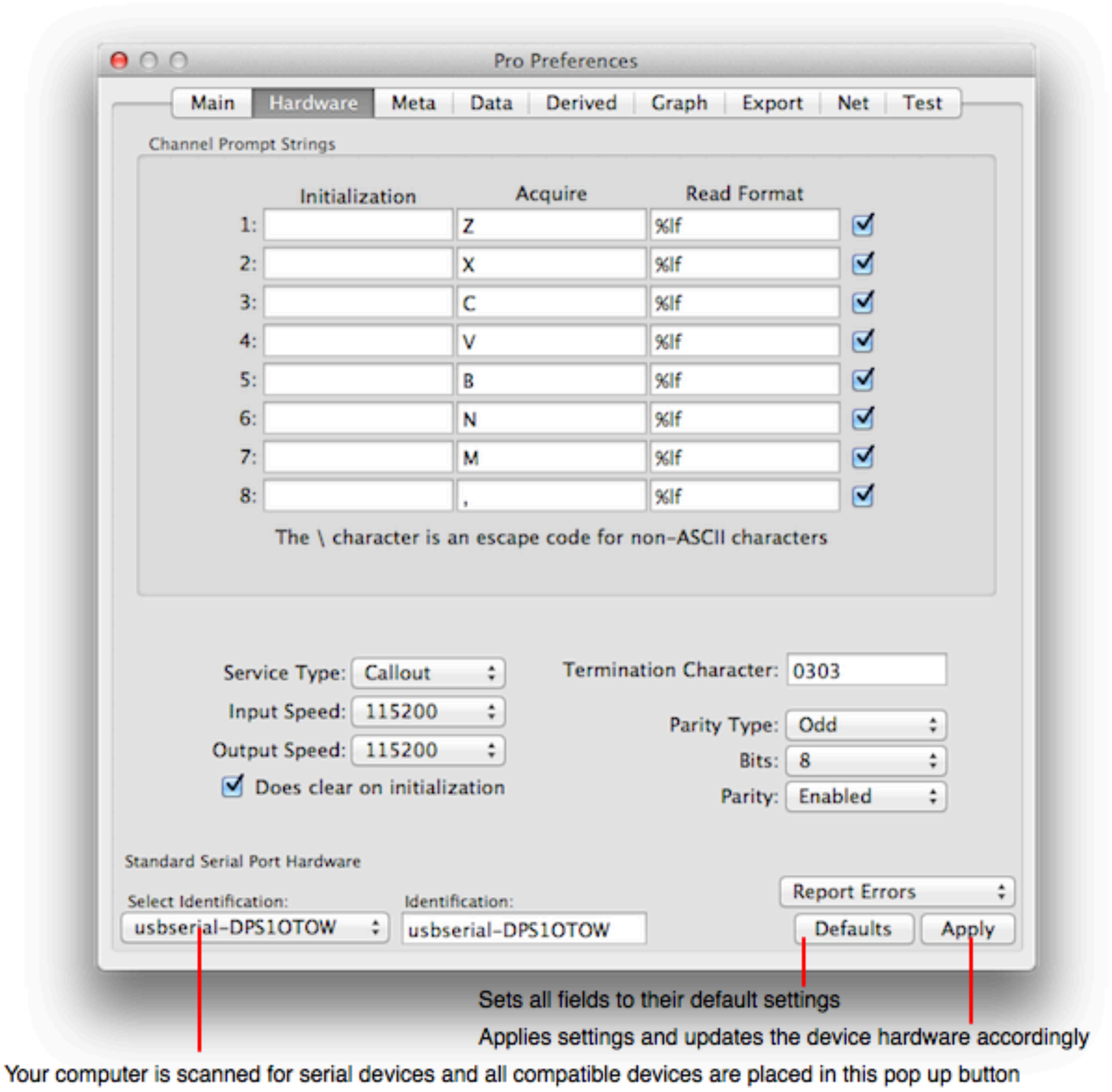
Important: If you use the ethernet interface for high sample rates then in Terminal apply the following commands first and then relaunch DAQ Plot.

```
sudo /usr/sbin/chown root:wheel "/Applications/DAQ Plot.app/Contents/MacOS/DAQ Plot"
sudo /bin/chmod u+s "/Applications/DAQ Plot.app/Contents/MacOS/DAQ Plot"
```

Once relaunched DAQ Plot will reduce its permissions so that it will not be a over-privileged application. If you use the USB interface then you need not perform this step.

DAQ Plot ► Preferences ► Hardware ► Serial Port

The Serial Port Hardware preferences sets the state of the Serial Port Hardware. The following diagrams the Serial Port device preferences pane.



Upon launching DAQ Plot serial port devices show up in the Identification pop up button. Choose a device to enter it into the Identification text field, configure it using the appropriate fields and then click Apply.

A note about serial port enumeration (system detection): In general, serial port devices do not give notification to DAQ Plot when they are plugged in and unplugged. As a result, if you plug in a serial port device while DAQ Plot is running then DAQ Plot has no way of determining if that device is present. You must quit DAQ Plot, plug in your serial port device and then launch DAQ Plot. Likewise, if you disconnect the serial port device while DAQ Plot is running then DAQ Plot will not detect the disconnect, rather DAQ Plot will assume the device is generating an error or pause and try to acquire from it (harder). Either way DAQ Plot will appear to be hung because it is trying to acquire data from hardware that does not exist and, unlike USB device protocol, there is no system notification regarding the absence of the device. So, keep serial port devices plugged into your computer while acquiring data.

Serial Port device protocol is defined for each channel independently as: Write the Initialization string to the serial port then repeat the Acquire string in an acquisition loop. The data outputted as a result of the Acquire string is decoded using the Read Format string. For each acquired returned string there is a termination character which is a delimiter letting DAQ Plot know that the serial port device is done outputting data for a channel. Many times the termination character is an ASCII return character ('\r'), but it can be anything such as the octal value 0303. If the serial port device has no termination character (which may be a rare condition) then set the Termination Character field to be empty.

Use the backslash to escape characters in the command. The read format is the usual ANSI-C format specifier. All characters are optional except for the value format control string (which is %lf).

If a string is empty then it is not used during the acquisition. For example, if the Initialization string is blank then no initialization string is sent to the serial port device and instead the serial port device is presented with only the Acquire string.

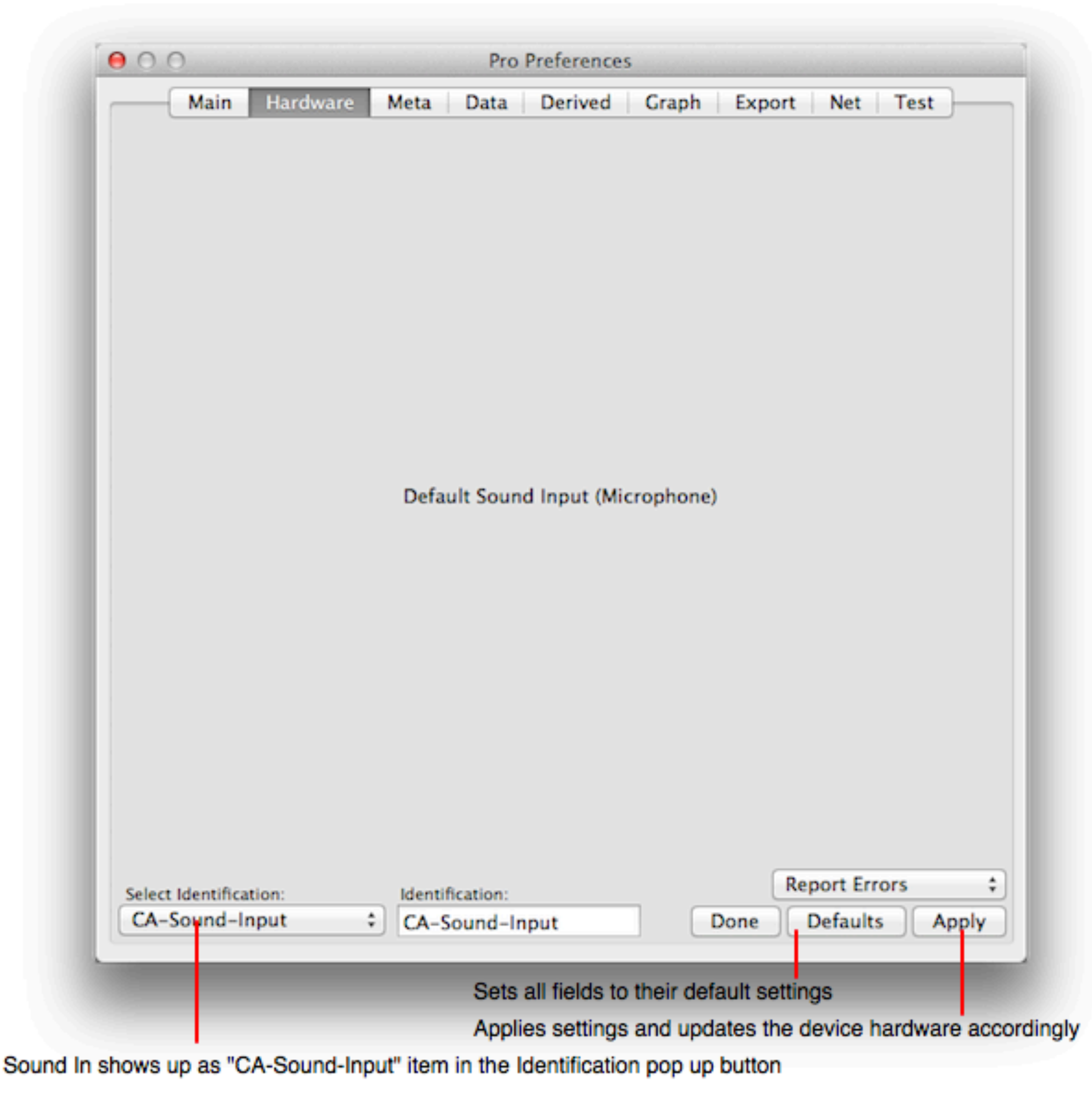
Serial port preference attributes are defined in the following table. For values specific to your device consult the manufacturer's specification sheet. In practice, these attributes may not be sufficiently documented in which case trial and error can often produce satisfactory results.

Adjustable Serial Port Parameters

Attribute	Definition
Input Speed	The serial port input speed. Legacy devices support 9600 (baud) but modern devices tend to support UARTS with speed of 115200.
Output Speed	The serial port output speed. Legacy devices support 9600 (baud) but modern devices tend to support UARTS with speed of 115200.
Service Type	One of Callout, Dialin or TTY.
Termination Character	The character that delimits the end of output from the results of an Acquire command. The entry for the termination character can be an escaped character (such as \r) or it can be an octal code. An octal code begins with 0. For the Basic Hardware the termination character is 0303.
Parity Type	Either Odd or Even.
Bits	Either 8 or 7.
Parity	Either Enabled or Disabled.

In any event, use of the serial port preferences is contingent upon the parameters above being sufficient to manipulate the serial port device. The features above are attributes of a "model" of a typical serial port device used for data logging. If the model reflects the use of the (as of yet unknown) serial port device you are using then DAQ Plot is sufficient. However, if the model does not reflect the serial port device's specifications then DAQ Plot will not work and then DAQ Plot's internals need modification.

The Sound In Hardware preferences sets the state of the Sound In Hardware. The following diagrams the Sound In device preferences pane.



DAQ Plot will enumerate the default Sound In hardware on your computer. To use it, select the CA-Sound-Input Indentification as shown in the figure above and then click the Apply button.

The default sound in, which is usually the built-in microphone, has no settable parameters. It's available mostly because the audio digitizer can be had for free as it comes with the computer.

DAQ Plot ► Preferences ► Device

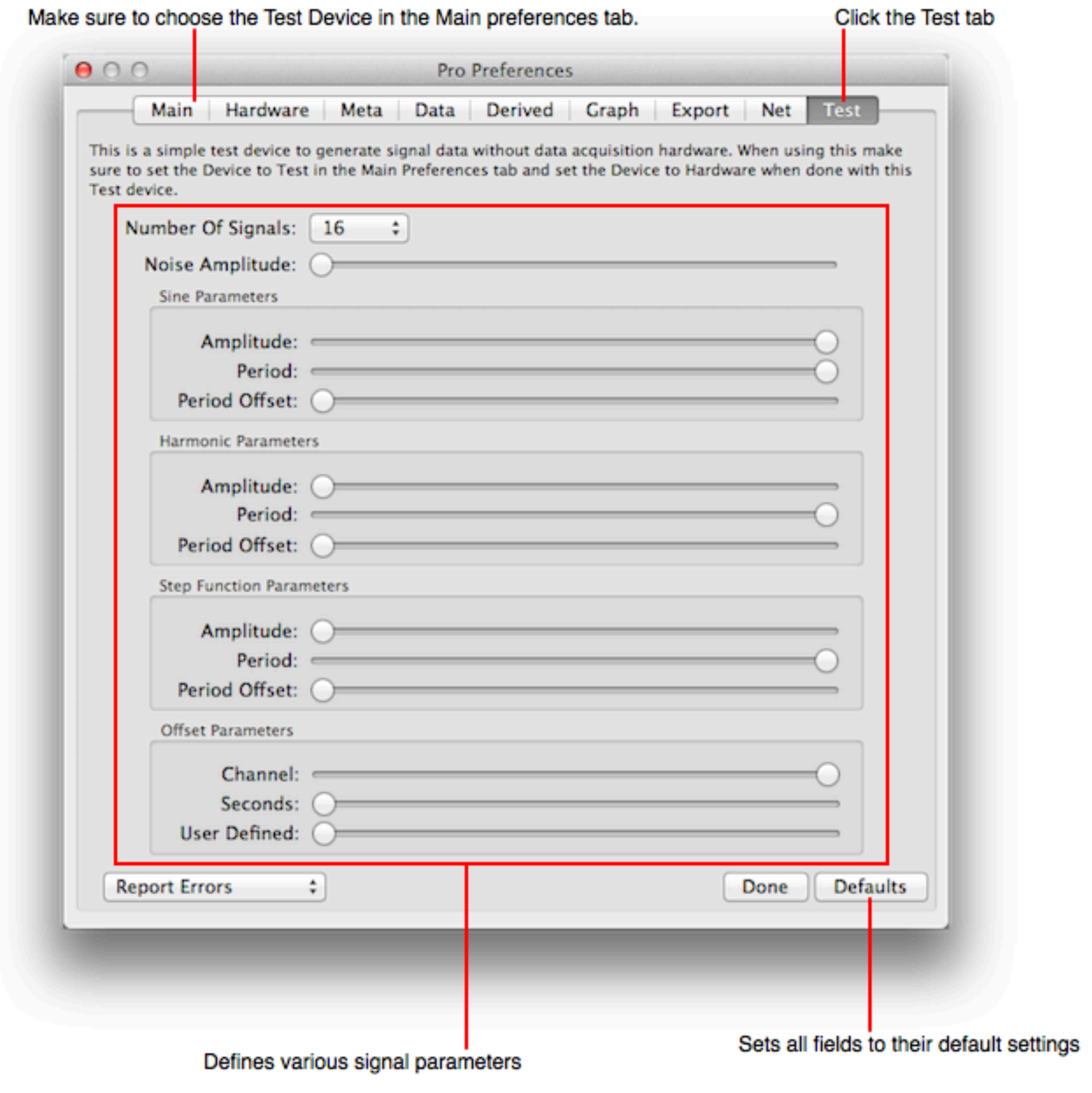
Most of the attributes in DAQ Plot are set using the preference pane. See a section below for more information.

Device Preferences

Meta	Meta.
Network	Network Attributes.
Test	Test Attributes.

DAQ Plot ▶ Preferences ▶ Device ▶ Test

The Test Device is used to demonstrate features of DAQ Plot, see the Simulation tutorial to learn how to activate this feature. The test preference pane is shown below.



The test device can be useful to test methodology for data storage and analysis without having hardware.

The following details the Test parameters.

- Number Of Signals: Varies from one to sixteen. Choose a number similar to what you will use in practice.
- Noise: Defines the amount of noise relative to the signal. This is very valuable for determining average and fit parameters in the Derived processing. Once you start using derivatives and feedback loops then noise plays an important role in determining algorithm selections.
- Sine Parameters: Defined by A sin(t P). A is the amplitude and is set between 0 and 10, P is the period and is set to one second per cycle when the slider is to the right and infinite (flat) when the slider is to the left. The Period offset slider offsets the period on a per channel basis so that the period can vary per channel.
- Harmonic Parameters: Defined by A (cos(t P) + sin(2 t P) + cos(3 t P) + sin(4 t P))/4. A is the amplitude and is set between 0 and 10, P is the period and is set to one second per cycle when the slider is to the right and infinite (flat) when the slider is to the left. The Period offset slider offsets the period on a per channel basis so that the period can vary per channel.
- Step Function Parameters: Defined by A when t is an even second and 0 when t is an odd second (excluding fraction) when the Period slider is set to the right. The alternate values are more rapid when the slider is moved left. The Period offset slider offsets the period on a per channel basis so that the period can vary per channel.
- Channel Offset: adds 10 times channel index when the slider is to the right and less offset as the slider is moved to the left. Move the slider all the way to the right to separate the signals and move the slider all the way to the left when looking at spectra so that there is no DC bias.
- Seconds Offset: adds the seconds value to each signal when the slider is to the right, and a lesser amount per channel when the slider is moved to the left.

- User Defined Offset: Each signal increases when the slider is moved to the right and decreases when the slider is moved to the left.

Notice how the Test signal has no Apply button, unlike Hardware Preference panes. That is because the parameters of the test signal are orthogonal, meaning one state does not invalidate another state. That is unlike programing DAQ hardware states where the states must be consistent with each other. Because the state of the test signals is applied when changed you can alter them dynamically and see the result in the plot output which also permits experimentation of the attributes in real time as they apply to more complex processing of the Derived parameters.

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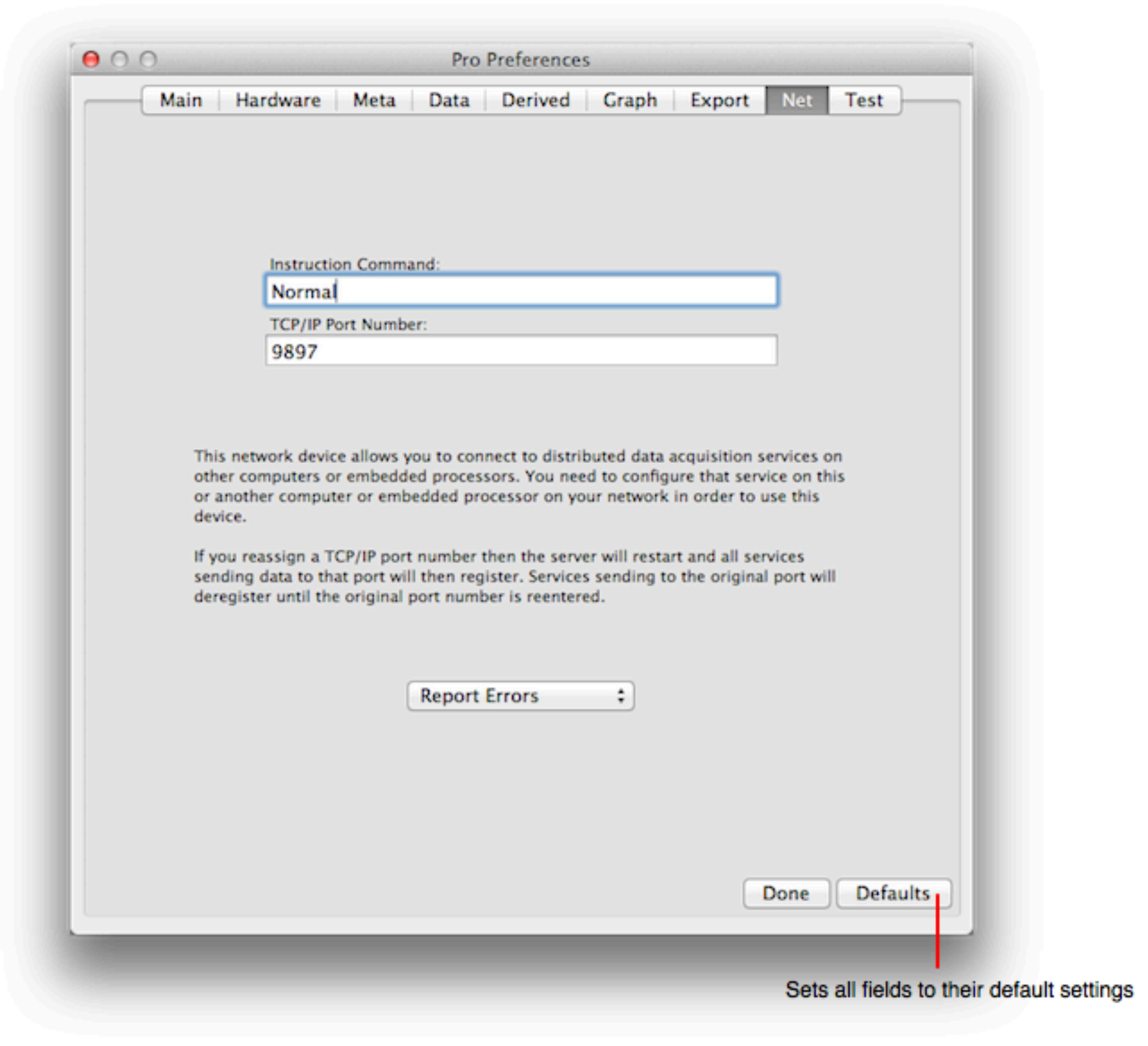
DAQ Plot ► Preferences ► Device ► Network

The following diagrams the Network device preferences pane.



This network device allows you to connect to distributed data acquisition services on other computers or embedded processors. To turn this preference style 2 on see Preferences Style. You need to configure that service on this or another computer or embedded processor on your network in order to use this device.

If you reassign a TCP/IP port number then the server will restart and all services sending data to that port will then register. Services sending to the original port will deregister until the original port number is reentered.

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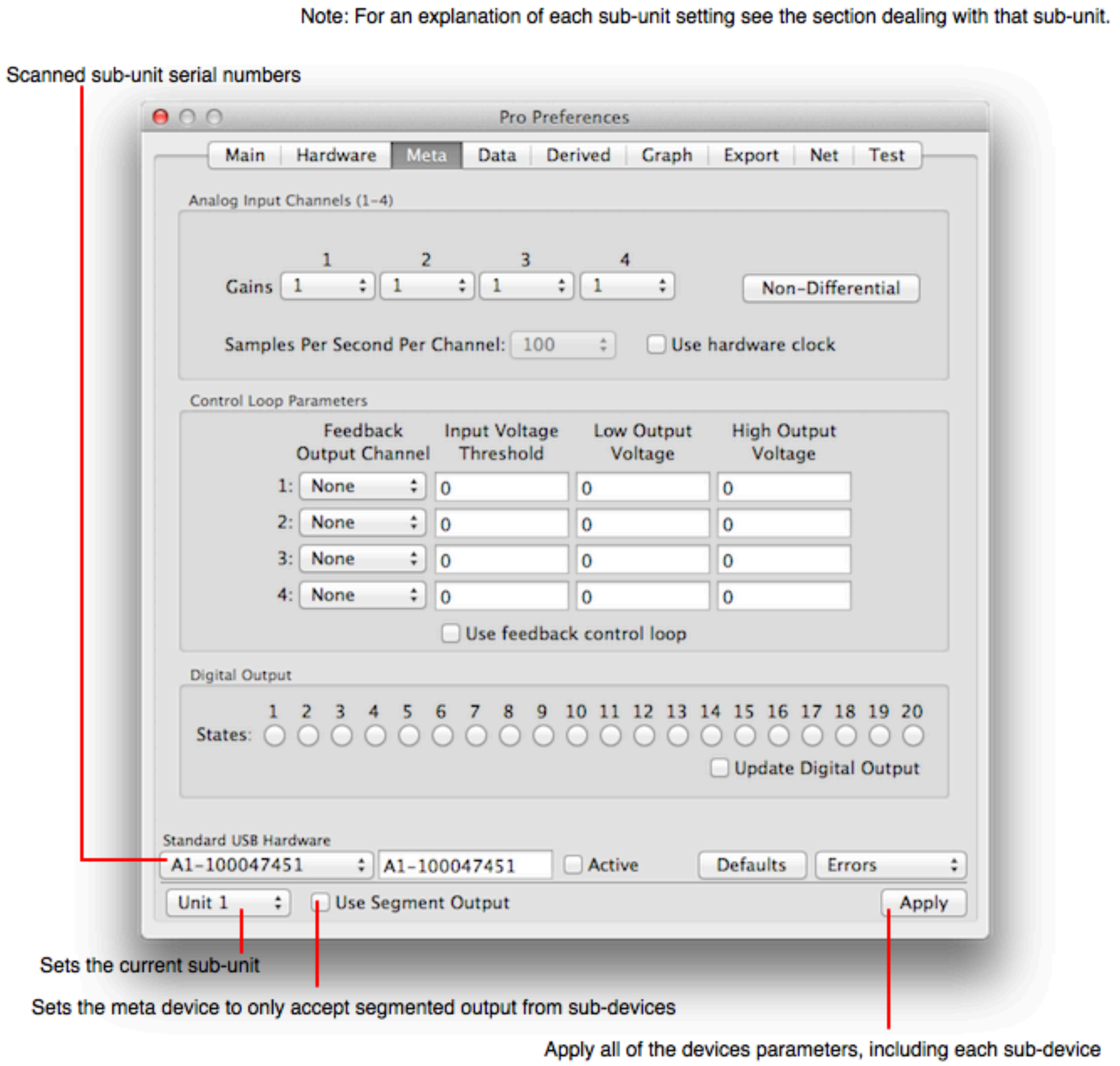
DAQ Plot ▶ Preferences ▶ Device ▶ Meta

Defines a meta device. To turn this preference style 2 on see Preferences Style. The following diagrams the Meta device preferences pane.



A Meta device is a collection of units (aka hardware). Those units are viewed and controlled by using the current sub-unit pop up button in the lower left. In design, a meta device can operate on any number and types and mixes of sub-units, but in this implementation it is constrained to a 4-unit meta device.

Alter any of the sub-device fields on the meta-device preference pane according to the sub-device specifications. See Hardware Preferences for a list of sub-device types.

When you click the Apply button all state information for all sub-devices is transferred to the device hardware so that the sub-devices are synchronized.

When you select the sub-device name or serial number make sure it is unique for each sub-device. If it is not unique then a hardware device will be set and sampled multiple times, which may be the desired effect, but probably not. Make sure to only make active those sub-devices that are desired using the Is Active switch. If a non-existent device is active then the results are unspecified.

The meta device partitions sub-device state information, but the Analog Input channels are sequenced according to the sub-device number. So, if each sub-device has 4 analog input channels then the meta device has 16 channels. The sequence is regardless of whether the sub-device is active or not so that if you make a sub-device active or inactive it will not affect the Analog Input channel index.

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DAQ Plot ► Tutorials

The following is a brief list of tutorial sections:

Tutorials

First Project	This describes the entire process of using DAQ Plot from beginning to end for a simple use.
Battery	Describes using a battery as a signal.
Rheostat	Describes using a rheostat as a signal.
Temperature	Describes using a temperature probe as a signal.
OhmsLaw	Gives an explanation of ohms law.
Simulation	Describes using the Test signal.
Movie	Shows a movie on the use of DAQ Plot.

DAQ Plot ► Tutorials ► First Project

This is a step by step tutorial on how to first use DAQ Plot. Launching DAQ Plot will show the signals window. Once you acquire voltage signals they will show on the signals window as curves. The rest of this tutorial explains how to get a voltage signal.

Prerequisites

1. Connect compatible DAQ hardware. This tutorial will assume that you are going to use the Basic Hardware. The Basic Hardware is the DLP-IO8-G data acquisition module. To buy that hardware please email sales@vvi.com or consult a retailer such as DIGIKEY www.digikey.com or if you are not in the United States then a retailer local to your area. For other hardware, such as Standard Hardware and Pro Hardware, email sales@vvi.com.

2. Skip this step for OS X 10.9 (Mavericks) computers as the driver is built in. Install an appropriate driver. The DLP-IO8-G uses a FTDI controller chip and hence the driver is available from FTDI, see: www.ftdichip.com and http://www.ftdichip.com/Drivers/VCP.htm. If you are unsure of this step then please email support@vvi.com.

Configure DAQ Plot

3. Launch DAQ Plot. Notice that the signals window comes forwards but otherwise nothing happens. Type command-, (or select the DAQ Plot ► Preferences... menu item) and in the resulting panel make sure the "Hardware" tab is selected and make sure the usbserial-* entry is selected in the Identification pop up button in the lower left of the Preferences window. Then click Apply, it is important to click Apply every time you make a change to the Hardware preferences and also when you first use DAQ Plot. The Preferences shown are the Basic USB Preferences, however if you had other hardware then selecting that hardware in the Identification pop up button would show other hardware preferences. For this tutorial, the preferences are all kept at their default setting so there is nothing more to be done. Close the Preferences window to then make the signals window the only window shown by DAQ Plot.

4. Select the Tools ► Turn Acquisition On menu item. You are now sampling voltage signals from the device. However, you probably did not connect anything to the device so the voltages are uninteresting so the signal curves are equally uninteresting (probably just approximate horizontal lines). If you quit DAQ Plot while acquisition is on then the next time you launch DAQ Plot the acquisition will start automatically.

5. In the Sample Intervals text field enter 0.1 (a tenth of a second) and click the Return key. Now voltages are sampled ten times faster than the default which is one sample per second.

That should be the end of this tutorial because you are now sampling voltage, but no voltage in particular. That is a unsatisfying so lets apply a known voltage in order to produce a varying signal on the signal plot (i.e.: change the curve).

Add A Voltage Source

6. Click off all the switches on the signals window except the first switch, hence only a single voltage will show on the plot, the voltage associated with screw terminal one.

7. Get a small wire, about 5 inches long and of gauge around 16 and strip the last centimeter or so of insulation from both ends.

8. Insert one end of the wire into the "5 V" screw terminal and tighten that screw down on the wire. Then place the other end of the wire into the adjacent screw terminal labelled with the numeral one.

9. Put the wire into terminal one and take it out. Put it in again and take it out. Notice the signal curve goes from (about) zero to five volts whenever you touch the wire to terminal 1. Slight note: Technically the signal "floats" when you remove the wire from terminal 1 since no voltage is being applied to that terminal and hence whatever is available to the terminal at the time is digitized. Many times a floating signal is an arbitrary voltage value but many times it is also near zero volts if the circuit board is designed that way.

Conclusion

This is truly the end of this tutorial. The next step is to connect a sensor or electrical circuit to the DAQ screw terminals. The voltage needs to be from 0V - 5V, but otherwise you are pretty much on you own at this point. See the Rheostat tutorial for a quick idea. You can sample up to eight voltages with the Basic Hardware, remember to turn back on the curves 1-8 on the signals window so that the voltages are displayed. The Basic Hardware is a basic "data logger" piece of hardware. Use other hardware for other features.

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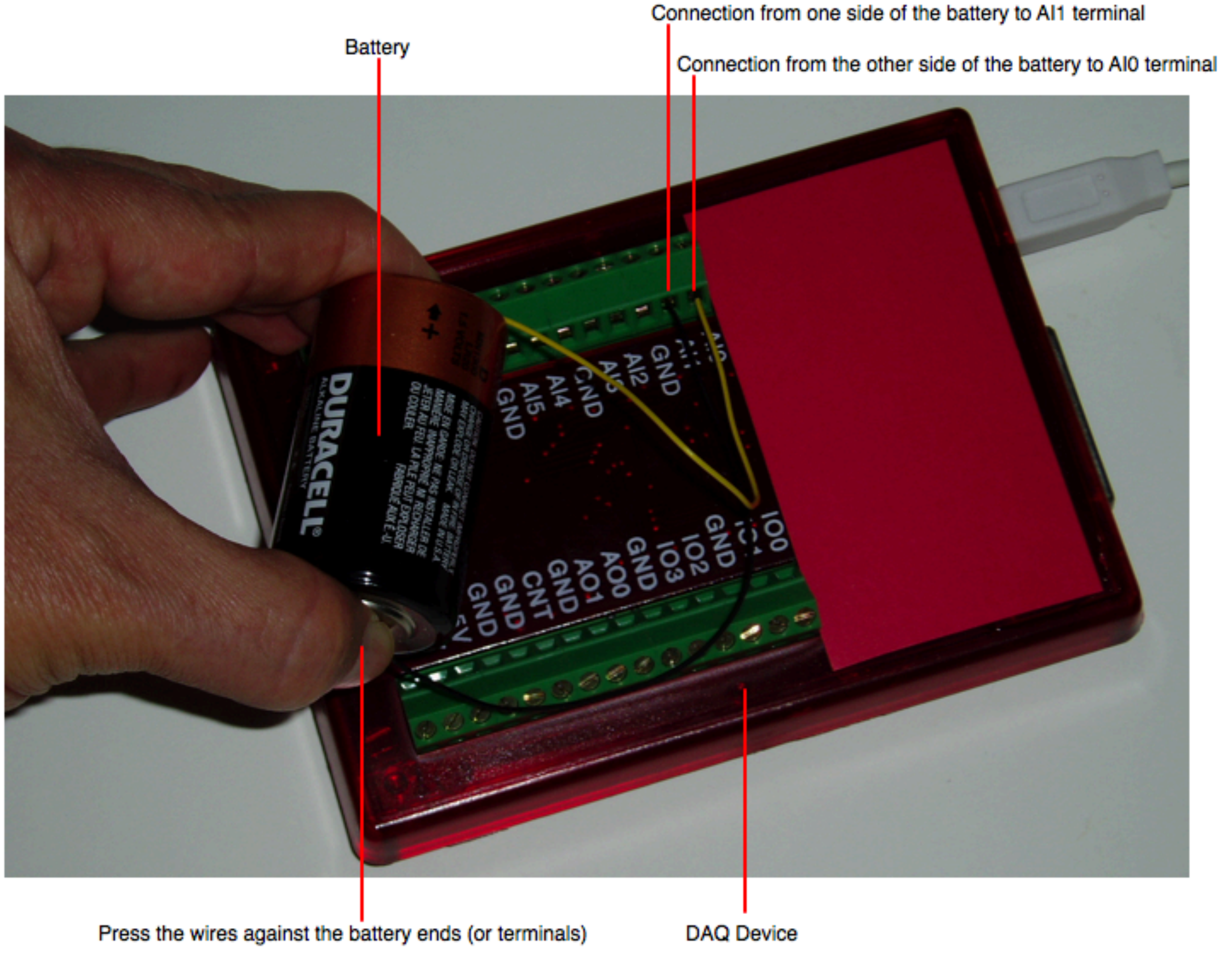
[DAQ Plot](#) ► [Tutorials](#) ► Battery

The DAQ hardware measures voltage, so the first experiment should be the measurement of a constant voltage source. A battery is the most common form of voltage source. Get a battery with voltage between 0 and 10 volts. Any household battery will do. A A size battery is a good size to hold in your hand. Then wire it to the DAQ as shown in the following diagram.



Run the DAQ Plot application to see the voltage of the battery. For example, if the battery is rated at 1.5 volts then the measured voltage should be around that, normally something like 1.42 (or negative 1.42). Batteries are not very well calibrated so the voltage on the label is rarely what the actual voltage is. After measuring the voltage for a few seconds then flip the battery over and measure it with connection in the other direction. You will see how the voltage signal flips from positive to negative, depending on the orientation of the battery connections.

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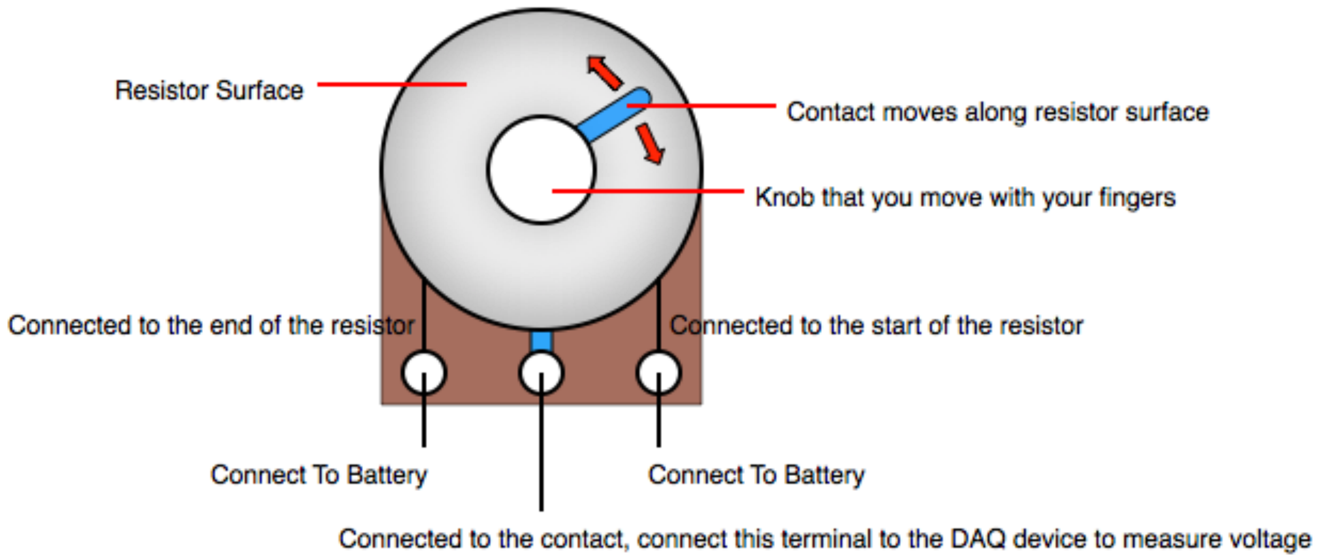
DAQ Plot ► Tutorials ► Rheostat

A rheostat is a device that changes resistance. Using Ohms Law and keeping the current constant you find that by changing resistance the electricity will change in voltage. Thus a rheostat can be used to change the voltage of electricity that flows through it.

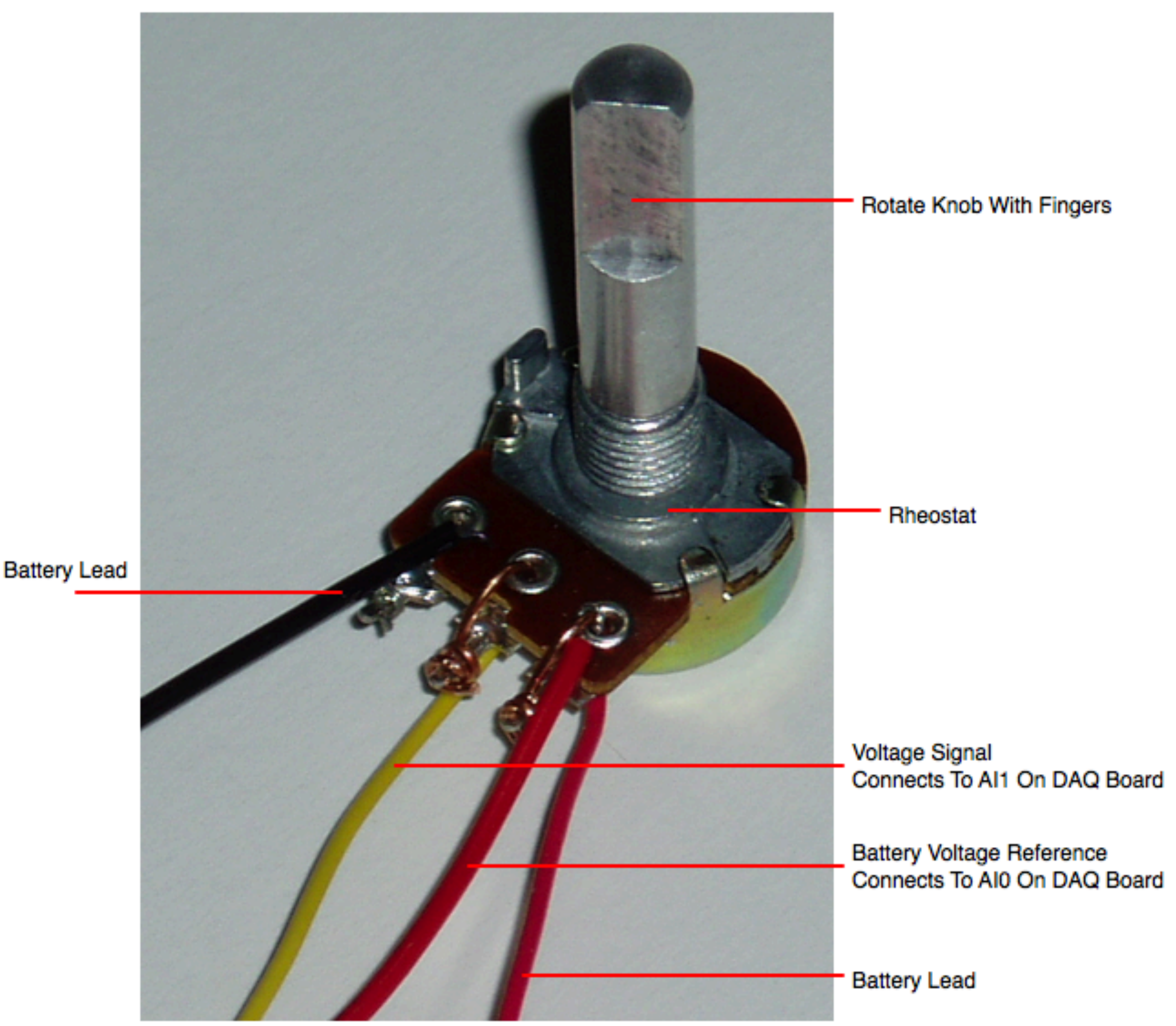
You can buy a rheostat, also called a Potentiometer, at an electronics shop like Radio Shack. I used one called a Audio Taper/1Meg Ohm potentiometer. A typical rheostat is diagrammed below.

Top-Down View Of Rheostat



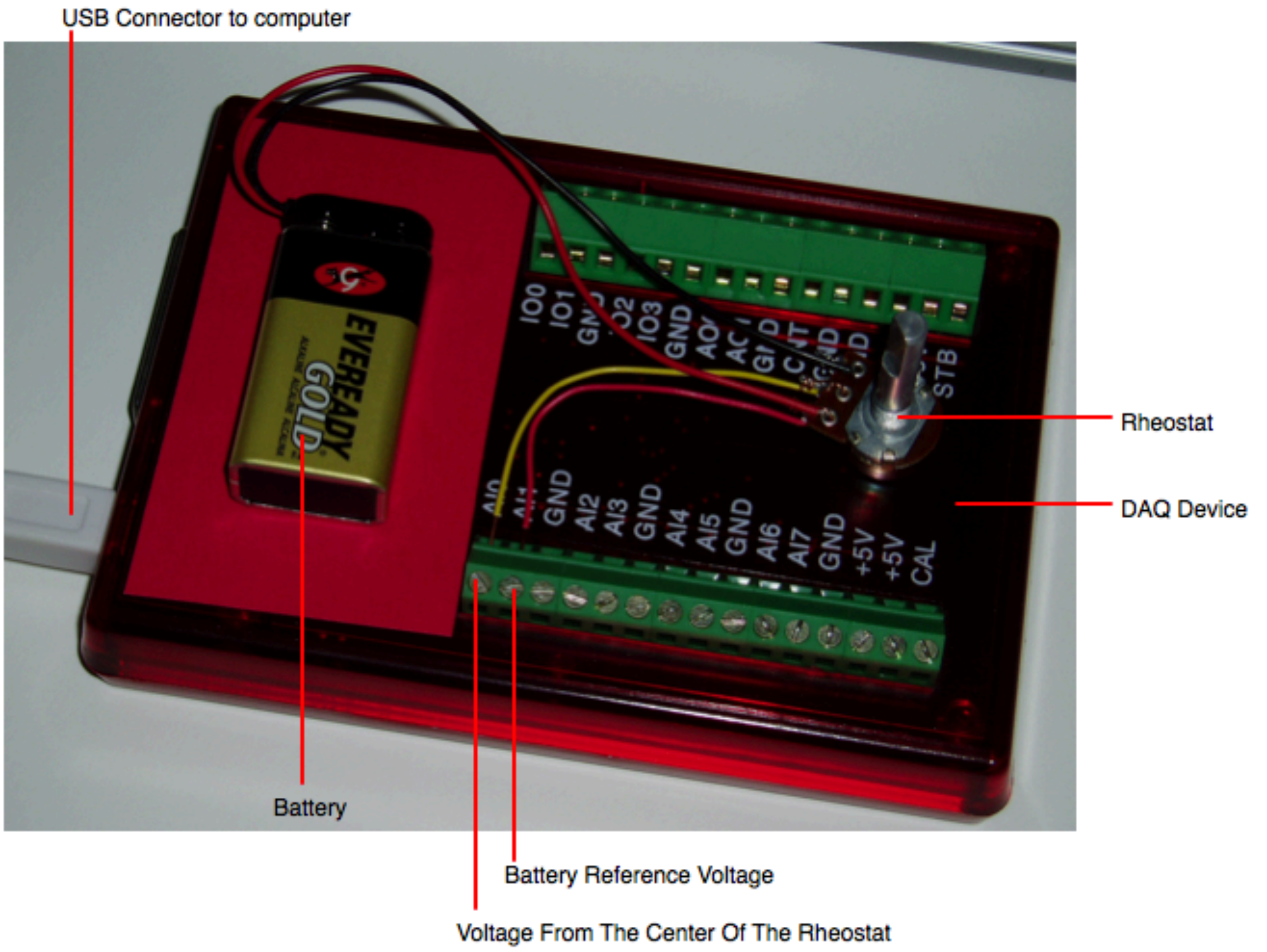
The actual rheostat I used is wired as in this picture:

Rheostat Connections



The following diagram shows how the rheostat is hooked to the DAQ device.

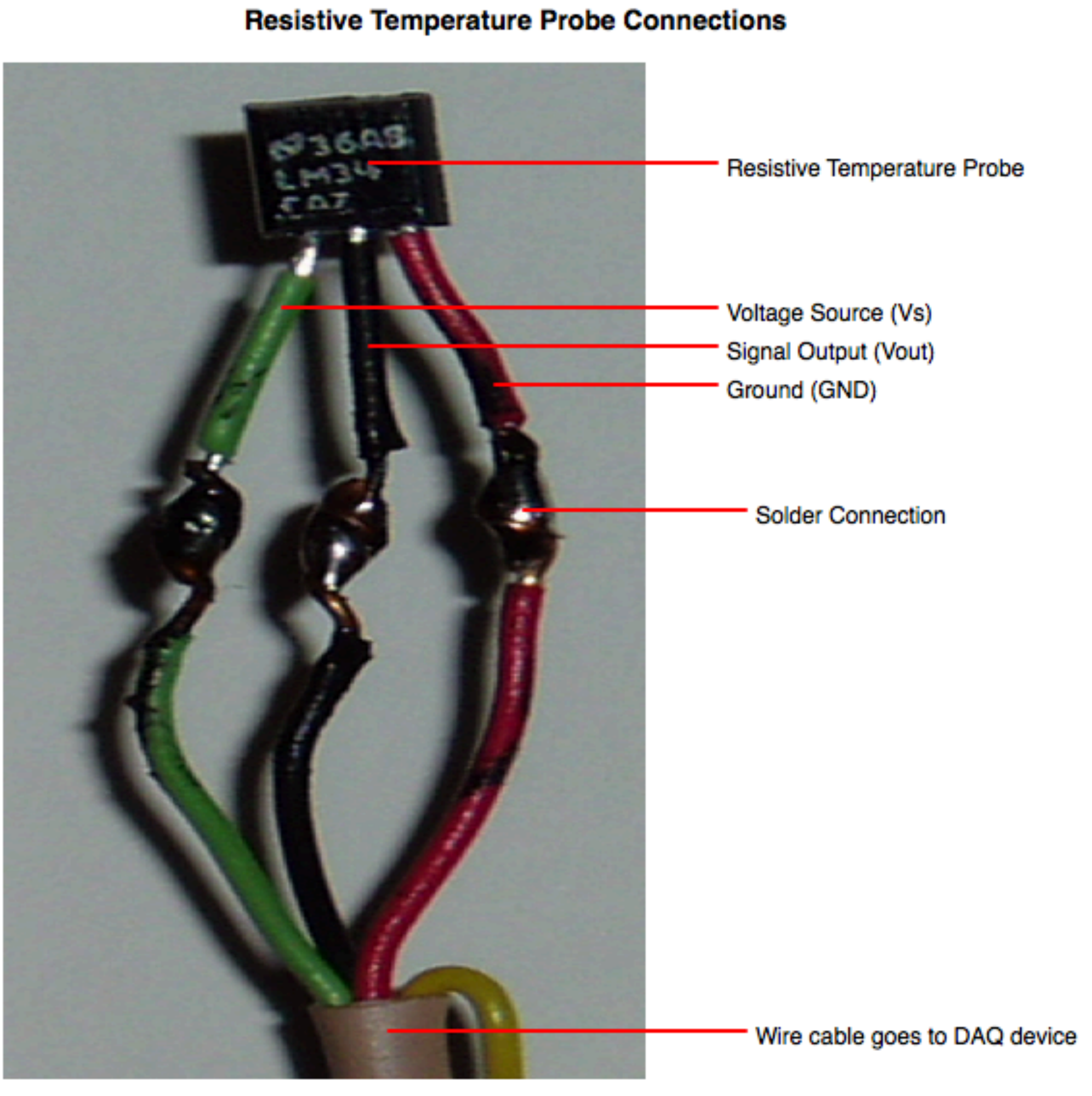
Adjustable Voltage Measurement Setup



By turning the rheostat knob you change the voltage and thus change the value of the curve shown on the DAQ Plot graph.

How does a rheostat work? A segment of wire resists the flow of electrons through it. If you double the wire length then you double the resistance. A rheostat has wire coiled around a donut piece of plastic inside it so that a long piece of wire can fit in it. Each end of the wire is connected to the outside connectors of the rheostat. There is also a movable dial, just like on a clock, inside the rheostat that revolves around and touches the wire inside. That dial is connected to the middle connector on the outside of the rheostat. By changing the dial location you change the length of the wire from one end to the dial. By changing the length you change the resistance and hence the voltage from one outside connector to the middle connector. The best thing to do is to take apart the rheostat and see for yourself.

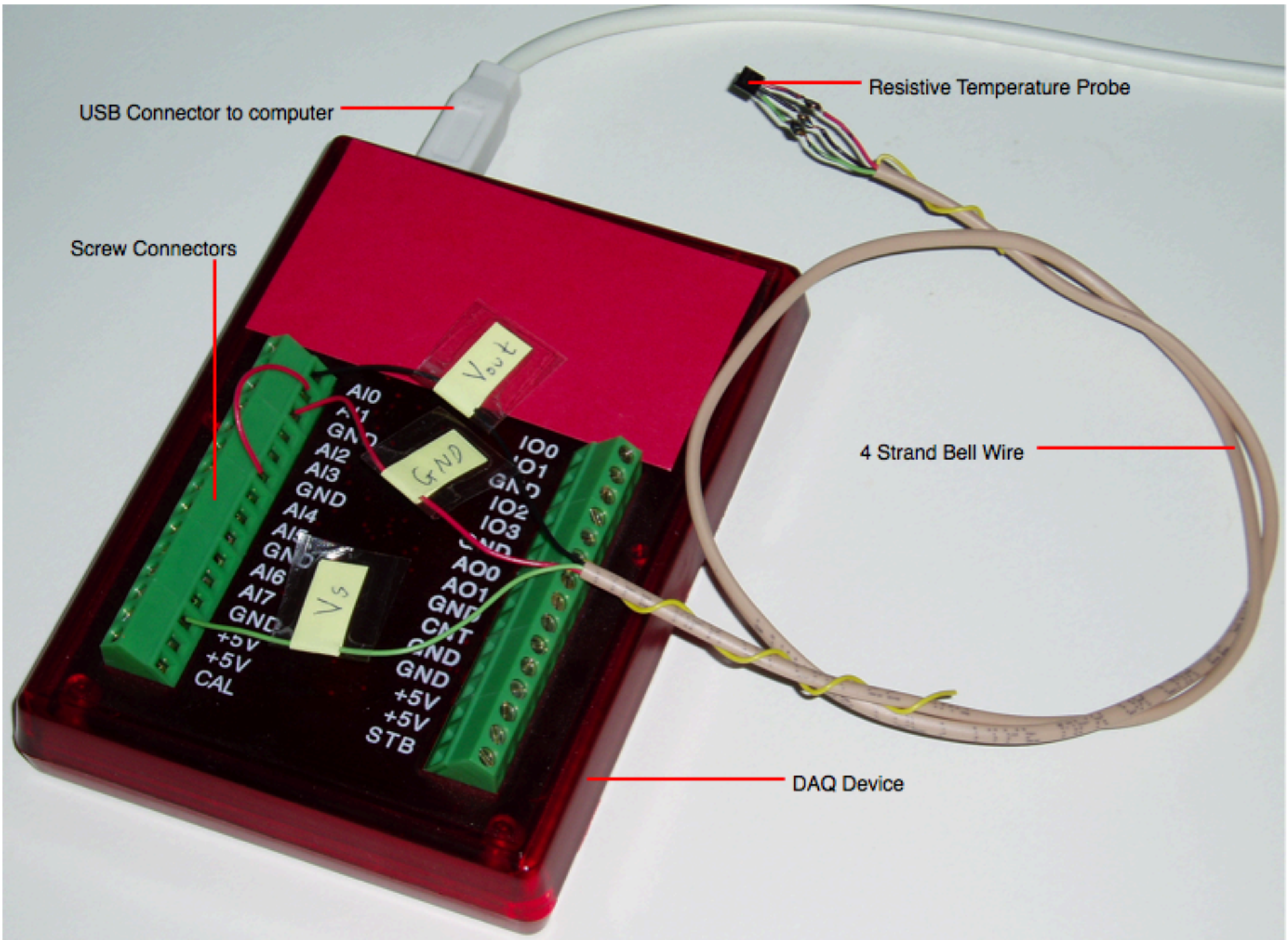
This experiment shows how to hook up a sensor to the DAQ device to measure heat. The sensor is diagrammed below and was purchased at Digi-Key with part number LM34CAZ-ND. Type that part number in the search field to get the order information. Then click the Technical/Catalog Information link to download the data sheet in PDF format. Once you buy the sensor solder wires to it as shown in this diagram:



You can use any wire you wish, but I like bell wire. Bell wire is a solid strand wire that is used for telephone connections (i.e.: the old Bell Telephone companies). You can buy it at Radio Shack or any electrical company. It commonly comes as 4 wires per cable because it is used in house wiring for two-line phones, each phone line using two wires.

The following diagram shows how the sensor is hooked to the DAQ device.

Temperature Measurement Setup



The sensor produces a voltage proportional to heat. That voltage is connected to the AI0 connector of the DAQ device. That voltage has to be compared to some other voltage, which in this case is a ground voltage. Hence, the AI1 connector is wired to the ground connector on the DAQ device.

Once you get it set up then you can measure your body temperature, coffee, an ice cube or any other temperature. You should recall the sensors limitations and not measure a burning match, at least do not measure in the flame, but you can measure in its proximity.

You can use the calibration constants in the Preferences of DAQ Plot to rescale the graph to the measurement is in terms of temperature. To do this first measure an ice cube, that will be the voltage for 32 degrees Fahrenheit. Then measure your mouth temperature. That is at 98 degrees. Then apply a linear equation to solve for the slope and y-intercept of the graph Voltage v.s. Temperature and insert those values as calibration constants.

Electricity has three properties which are described here:

Terminology	Definition
Voltage	This is the "pressure" that electricity exerts. The greater the voltage, the greater the pressure. In a typical home or office environment a nine volt battery is commonly considered to exert little pressure, but an electric wire with 100,000 volts can exert enough pressure to poke a hole through many materials. However, in a laboratory setting nine volts can exert so much pressure as to damage instrumentation. So, the idea of voltage as pressure and what it means intuitively is relative. Note that electricity can exert all the "pressure" it wants to and the thing it exerts against does not necessarily have to move, but when there is movement than that is called Current.
Resistance	Resistance is the difficulty electricity has getting through something. If there is no resistance then electricity moves without difficulty, but if the resistance is large then electricity has a hard time getting from one place to another and may not move at all.
Current	Current is the amount of electricity that actually moves.

Each of the three properties of electricity is measured in its own unit, described here:

Unit	Definition
Volt	Voltage is measured in the unit called Volt.
Ohm	Resistance is measured in the unit called Ohm.
Amperage	Current is measured in the unit called Amperage. The word Amperage is often shortened to Amp.

Ohms law states:

"Voltage equals resistance multiplied by current"

Most of the time the electrical properties are denoted by symbols according to the following:

Symbol	Definition
V	Voltage
R	Resistance
I	Current

So that Ohms Law, in arithmetic notation, is written as:

$V = I \times R$

Notice that if you keep the current (I) at the same value and change the resistance (R) then the voltage (V) must change proportional to resistance. For the purpose of experiments, such as the Rheostat experiment, you apply Ohms Law to change the voltage by changing the resistance. The Temperature experiment also uses Ohms Law because the sensor changes resistance, which in turn changes the voltage of the electricity going through it.

DAQ Plot depends on DAQ Hardware to acquire external signals. However, you can simulate many of the features of DAQ Plot without hardware by using a "Test Device" which is a simulated signal produced by software. To institute this feature use the following steps.

1. Launch DAQ Plot.
2. Click the Tools ► Change Styles ... menu item and select the Pro style. That exposes many options including a Test device.
3. Click Command-, or click the the DAQ Plot ► Preferences ... menu item to bring forward the Preferences panel.
4. In the Preferences panel, click the Main tab (the default) and then choose "Test" as the "Selected Device" To Use During Acquisition.
5. Click the Tools ► Turn Acquisition On menu item.
6. Then, in the Preferences panel, click the "Test" tab and alter the parameters according to your needs. Notice that when you move the slider knobs the signals change. In this way, you can understand each parameter of the Test signals.
7. When you are done testing and have hardware then reselect "Hardware" as the "Selected Device To Use During Acquisition".

Notice how the Test device implements a noise component to the signal. This is very valuable for determining average and fit parameters in the Derived processing. Once you start using derivatives and feedback loops then noise plays an important role in determining algorithm selections.

For additional information on the Test parameters see the Test section.

DAQ Plot ► Support

If you have a question that is not explained in this manual then please contact support@vvi.com so that we may answer your question and update this manual as needed.

The following is a brief list of support sections:

Support	
Question Answer	A brief list of question answers on subjects that are not covered elsewhere in this manual, or not obvious to find.
Efficient Use	How to more efficiently use DAQ Plot from the perspective of computer resources.
Derived	Further explanation of the Derived features.
Windowed Integration	An example of using the Derived features for Windowed Integration.
Enumeration	What happens when you plug in and unplug USB devices that conform to enumeration functionality.
Useful Formulas	Description of some useful formulas.
Buffer	Discussion about the buffer maintained by DAQ Plot.
Hardware Failure	What happens during a hardware failure.
Managing Backup	Describes how to use the backup.
Decoding Backup	Describes how to decode the backup files.

Question Answer

Below are answers to commonly asked questions about DAQ Plot. If you have a question please mail support@vvi.com.

Q: Why do DAQ Plot windows not look like the windows annotated in this manual?

It is probably because you are using the Simple Preference Style and in order to show all the features this manual describes the Professional Style. See the next question for additional information.

Q: How do I turn on the Pro features?

See: Preference Style.

Q: How do I totally reset DAQ Plot?

Launch the Terminal application and type this at the command line:

```
rm ~/Library/Preferences/com.vvi.DAQPlot.plist
rm -r ~/Library/VVI/DAQPlot
```

Then relaunch DAQ Plot and reconfigure it. There should not be a situation where you need to reset DAQ Plot, but a reset can be used just incase.

Q: I attached the DAQ device but the program still says it is not attached. How do I get DAQ Plot to recognize the device?

First configure the device. See Hardware Preferences for example. Set the correct identification string and then click the Apply button. Then go to the Main Preferences and select the device type and click Start Acquisition.

Q: I just installed DAQ Plot and inserted the license key but it doesn't work. What do I do?

Try rebooting your computer. DAQ Plot installation does not need a reboot, but some computers may be configured in such a way that a reboot is required.

Q: What is the data limit of DAQ Plot?

By default, DAQ Plot will store the last 864,000 values per channel. At any point in time all data is retained until you reach 864,000 values per channel and then the last 864,000 are retained. For example, if you have sampled 1,000,000 points then DAQ Plot will retain the last 864,000 values and the first 136,000 values are lost forever. You can adjust this parameter. For additional information see Buffer.

Q: The voltage readings and curves of terminals I have not connected seem to dance around, how do I prevent that?

Turn all channels off except the ones you are using by clicking the switch next to the channel number in each row of the hardware preference pane. Turning off unused channels will cause the hardware to sample faster as well as eliminate spurious channel output whose values are voltage floaters (have no potential reference) and may appear random in the output.

Q: Is DAQ Plot a real-time data collection application?

Technically the answer is no. In practice, DAQ Plot is designed so that there is no data loss or failure of any kind. However, you can overwhelm your computer and cause data to be lost. For example, if you run a huge program that fills up all your computer's RAM and it starts paging and at the same time you are using the backup option then there is a chance that the hard disk backup and paging operations will temporarily lock one another and for that brief moment data will be lost. For additional information see Hardware Failure.

Q: I want to collect data with DAQ Plot, but want to post-process it myself. How do I do that?

Turn on the DAQ Plot backup facilities and then when you quit DAQ Plot, or actually at any time even while running DAQ Plot, you can write a program to read the backup files and process the data yourself. The backup files always contain the most recent data. See Decoding Backup for additional information. You can also finish a data run and Export the data to a spread sheet using tab delimited text.

Q: Where do I get sensors that can work with DAQ Plot?

You can use the DAQ hardware and software to measure and display nearly anything. All you have to do is find the appropriate sensor to convert what you want to measure into voltage of the appropriate range (and amp limits).

For example Digi-Key sells discrete sensors. If you click on that URL (http://www.digikey.com) and search for "temperature sensor LM34" (without the quotes) you will get a list of various temperature sensors. Click the LM34CZ-ND link to by your own temperature sensor. You can also buy other sensors by typing in other keywords, for example, type "pressure sensor".

Another good source for sensors is Omega. They sell packaged sensor devices so you will not have to solder the leads to a wire.

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DAQ Plot ► Support ► Efficient Use

DAQ Plot is extremely optimized for real time operation. However, the larger your problem the more horsepower you will need. It is conceivable that you can run DAQ Plot at 100Hz without any concerns regarding efficiency, but at higher sample rates more care needs to be taken to get things right. This section outlines some issues regarding efficiency.

Choose The Lowest Sample Rate For Your Problem

You should choose the lowest sample rate for your problem. Don't be concerned with oversampling, but if there is no reason to do so then you are just generating voluminous amounts of redundant data.

Turn Off Unused Curves

Use the signal window to turn off unused curves, even if they are flat at zero. This will not only save on resources, but will also allow the graph to autoscale better.

Turn Off Unused Acquisition Channels

Use the Hardware Device Pane to turn off unused channels. Sampling a channel usually causes a delay in the hardware device itself.

Choose The Right Buffer Length

You should keep the buffer length at the default unless you need to store more points. At 50,000 samples per second the default buffer will only store about 17 seconds of data. That may not be enough for your situation, or may be just fine. For example, if you are interested in spectrum information only then the default buffer size is fine. If you use the Derived pane to resample the data into bins for example then the resulting data rate will be lower and you will be able to store more information.

Look At The Performance Meter

Use the main menu item DAQ Plot ► Tools ► Show Performance to see how your computer is performing. At 100Hz sample rate the bars should be short to none. At 50,000 samples per second the bars will be greater. If your system is overtaxed then a red "System Overload!" text will appear.

Run A Test Case

Run a test case before starting your actual data sampling. Make sure to do a full run. If you do something outside the operations of the test case then that can cause difficulty. For example, if you run a huge simulation while acquiring data then your computer may run out of free memory in which case things will grind to a halt and the acquisition will fail. DAQ Plot is designed to provide as much data immediately while still buffering operations incase of some momentary loss of resource, but nothing can overcome a catastrophic abuse of resources.

DAQ Plot ► Support ► Derived

The Derived Preferences give access to some powerful nonlinear mappings. The Derived Preferences section defines those mappings, but there are some ways of using those mappings that are not immediately recognizable. This section gives some ideas regarding such usage.

Plotting The Same Channel

To plot the same channel on a graph select the same index in the Channel Index column for two different channels. For example, to see the raw and curve fit results of channel one, in channel row 2 select Derived Type Average, Channel Index 1, Average Type of MF-Fit, length of 20 (for example) and click Apply. Channel 2 will be the remapped channel one.

Derived Channel Alters Data

When you use a derived channel it maps the source data which means any data saved with DAQ Plot is derived data, not the raw voltage signals.

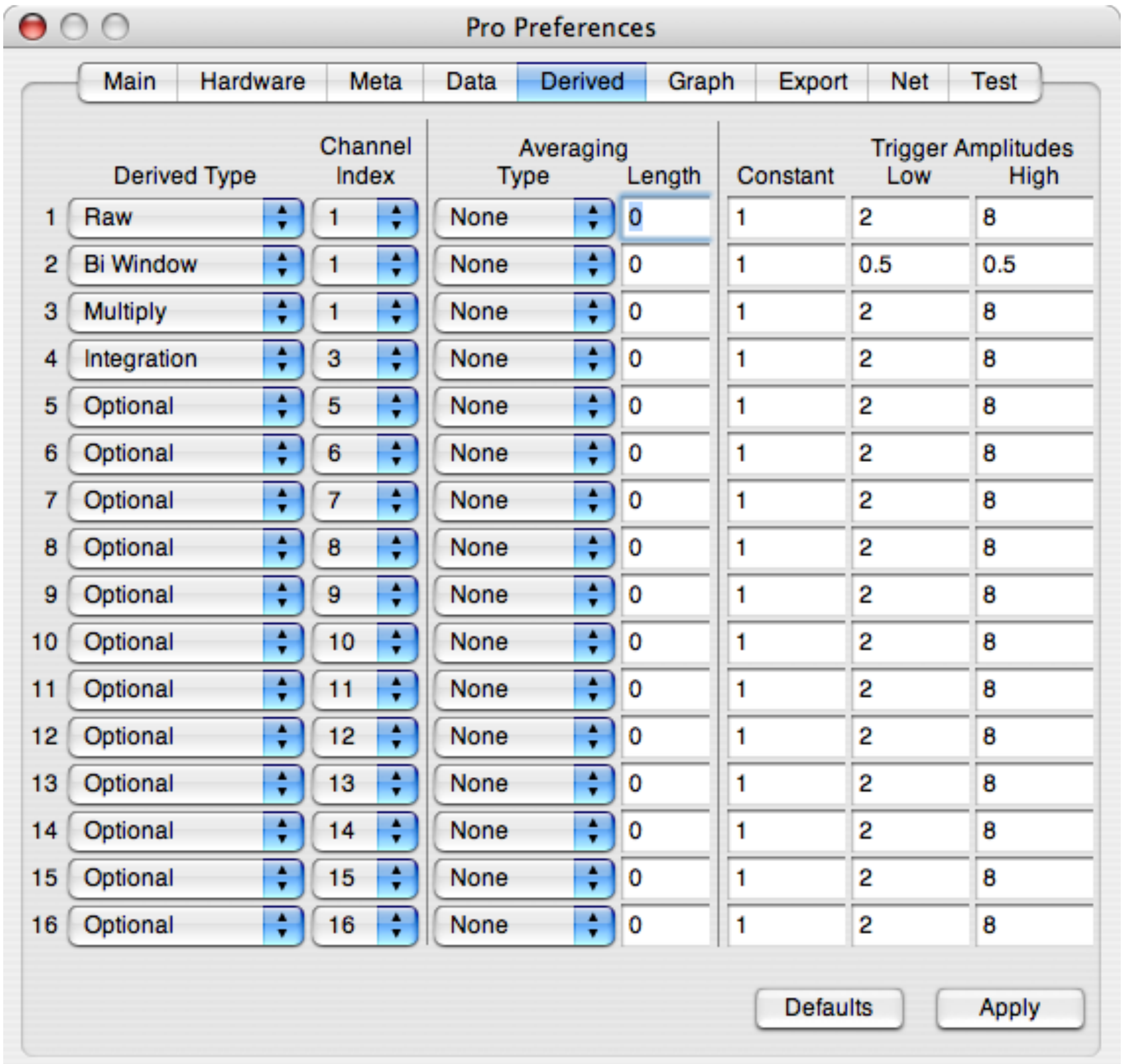
Composite Mapping

Derived mappings are applied one channel after another beginning with the lowest channel number (1). Thus you can build composite mappings. For example, if you data is in channel one then for channel two, use a Channel Index mapping of 1 and for Channel three use a Channel Index of 2. Then Channel three will be the twice mapped result of channel one. For a thorough example of a composite mapping see Windowed Integration.

DAQ Plot ► Support ► Windowed Integration

The Derived Preference Pane has many options, some are straight forward and easy, some are straight forward but require a little thought and some are not straight forward and settings may only be known a posteriori. This section shows a more advanced use, a windowed integration.

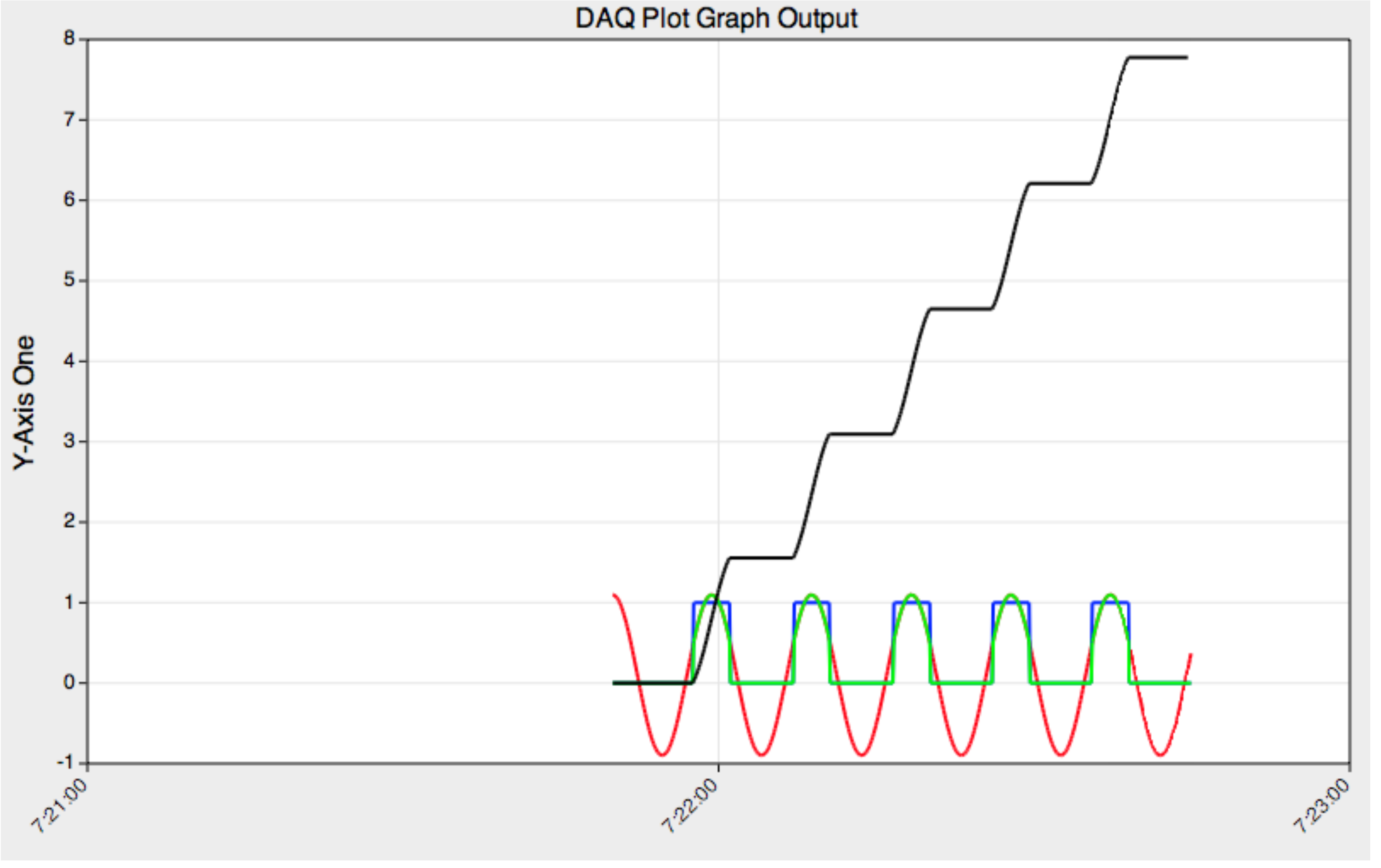
The Derived Preference Pane settings are shown in the figure below and each row is described below the figure.



The mapping takes the voltage from channel 1, called the domain signal, and transforms it 4 times into the windowed integration, which is called the range signal.

Row Number	Operation Type	Operand Channel	Description Of Mapping
1	Raw	1	This specifies to use the raw signal from the source channel one, i.e.: this is the domain value (vector, if you will) of the mapping.
2	Bi Window	1	This takes the operand from row one (the raw signal) and applies a threshold window to it. The result is placed in channel 2. The raw signal is assumed to start out at zero, increase and then decrease. This bi-window mapping maps that signal to zero until it reaches a value of 0.5 (high trigger) and then maps it to one until it reaches a value of 0.5 (low trigger) at which time it maps it to 0 again. Hence, the window is in the interval where the value is above 0.5.
3	Multiply With Previous	1	This mapping multiplies channel one (the raw signal) with the previous channel (the window) to produce a windowed representation of the raw signal.
4	Integrate	3	This mapping integrates the windowed representation (channel 3) thus producing the range value of the composite mapping.
5-16	Optional	N/A	These channels are set to optional, i.e.: they are not used.

The result of the mapping specified above and each of its intermediate mappings are shown in the figure below:



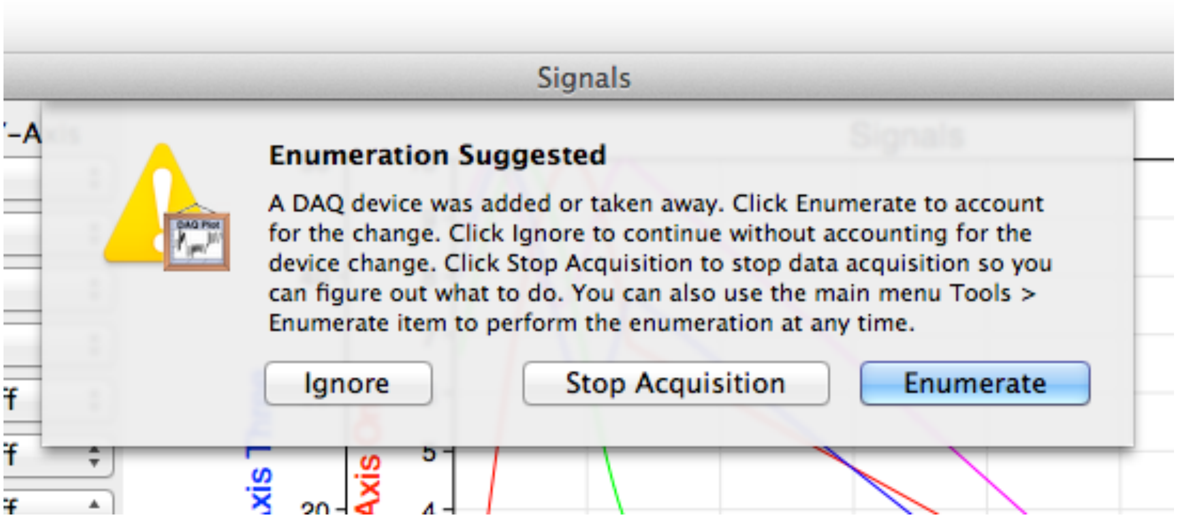
Channel Number	Curve Color	Description Of Signal
1	Red	This is the raw signal which is a cosine function offset in the y-direction by a small amount. Because of the offset in the y-direction any integration of the signal will be a sine function with a gradual increase as time goes on.
2	Blue	This is the window produce from the raw signal.
3	Green	This is the windowed raw signal.
4	Black	This is the windowed integration of the raw signal of channel one.

With this real-time composite mapping system many different mapping capabilities are possible. You do not have to use the same function for the window and integration. For example, the window may be produced from an analog input channel hooked to a device that senses the beginning of an experiment. To a large extent, the efficacy of the derived settings is a matter of imagination.

DAQ Plot ► **Support** ► **Enumeration**

Enumeration is the process of adding or taking away a DAQ hardware reference. That reference is usually a serial number of the DAQ device.

When a hardware device is added or taken away then DAQ Plot will sense it and ask what to do according to this panel:



Explanation of the options:

- **Stop Acquisition**: Use this to stop all data acquisition so you can figure out what to do. For instance, you may want to change hardware settings (see Hardware Preferences) before starting acquisition again.
- **Ignore**: Use this to ignore the added or removed DAQ hardware. You can enumerate later using the DAQ Plot ► Tools ► Enumerate menu item.
- **Enumerate**: Use this to enumerate. Added devices are added to DAQ Plot's references, removed devices are dereferenced.

If you disconnect the DAQ device you are currently sampling from you should reconnect it and click Ignore. The process of disconnecting an active usually causes an error, for that see Hardware Failure.

Temperature Conversion

Some Sensor output is in units of Kelvin. The following can be used to convert to other units.

- F = (9/5) * K - 459.67

Using the Data Preference Pane if you entered an offset of 459.67 and a scale of 1.8 then the analog input signal would be converted from Kelvin to Fahrenheit.

DAQ Plot ► Support ► Buffer

The Main Preference Pane permits you to change the internal buffer length of data recording. This section describes what that is and how and why to do that.

By default, DAQ Plot will store the last 864,000 values per channel. At any point in time all data is retained until you reach 864,000 values per channel and then the last 864,000 are retained. For example, if you have sampled 1,000,000 values per channel then DAQ Plot will retain the last 864,000 values and the first 136,000 values are lost forever. You can adjust this parameter according to the following criterion:

- **Increase the buffer length**: By increasing the buffer length you will be able to store more data. If you apply 10000000 instead of 864000 then you will be able to store 10 million data values per channel before you start to loose the earliest data values.
- **Infinite buffer length**: If you set the buffer length to zero (0) then the data storage is unbounded. That is good if you are aware that at some point you will run out of memory resources.
- **Constrained buffer length**: Sometimes you may be interested in only a certain amount of data, for example the last 10 minutes of data. If you sample at 100Hz then setting the buffer length to 6000 will accomplish that task.

WARNING!: If you change the buffer length and read in a backup file then if the new buffer length is less than the backup data length then data will be lost. Additionally, if you store an archive of the data with a signal file then the different buffer lengths may cause some obtuse anomalies. If you retain state information from run to run then it is best to keep the buffer length fixed.

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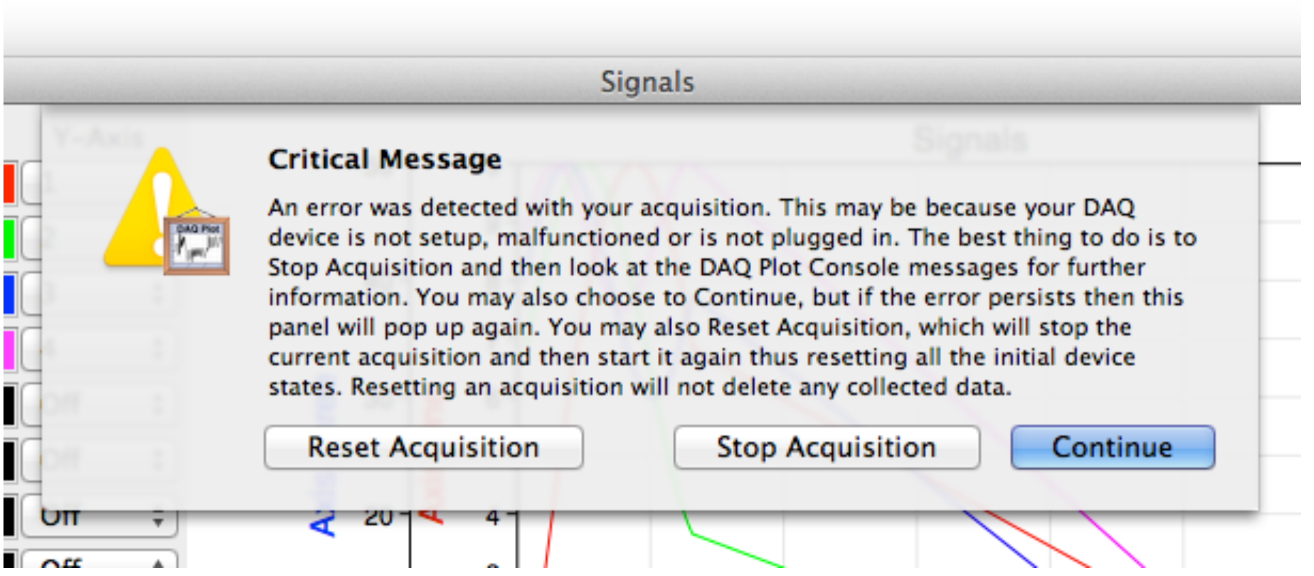
DAQ Plot ► Support ► Hardware Failure

When hardware fails then messages are written to DAQ Plot's console and you will also get this panel:



Explanation of the options:

- **Stop Acquisition**: Use this to stop all data acquisition so you can correct the situation.
- **Reset Acquisition**: Use this to reset the acquisition. Resetting involves stopping the current acquisition and then starting it right away, i.e.: it is a full reset.
- **Continue**: Use this ignore the error. Usually ignoring hardware failures is not possible and you will probably need to reset the acquisition to flush buffers, reset states, etc.

Causes Of Hardware Failure

Obviously if you disconnect the USB cable or unplug the power to the computer then you will encounter a catastrophic hardware failure. The list below itemizes some less obvious types of failure.

- If you collect millions of samples of data, try to export the data to a file, have limited RAM and continue data acquisition then there is a good chance you will overwhelm your computer and cause a hardware failure (USB buffer overrun). You will need to reset the acquisition to recover. It is recommended that you actually stop the data acquisition before exporting data or doing very large operations.
- There is a chance that if you run a very intensive application on your computer while acquiring data then that can cause a hardware failure. If your acquisition needs are critical then it is recommended that you run DAQ Plot and no other application beyond those normally running (such as the Finder, etc.). Some scientist acquire data while listening to iTunes for example, that appears to work well but is not recommended.

Hardware Failure Recovery

If you are concerned about hardware failure then turn on the Backup. Even if you unplug your computer's power you should still be able to recover previously collected data. For less drastic hardware failure you can simply click the Reset Acquisition button on the hardware failure prompt. If your failure is of a permanent type, for example if you apply wall outlet power to the DAQ device and it burns out, then you will need to replace the component in question. But at least your data will be intact if you turn on the backup.

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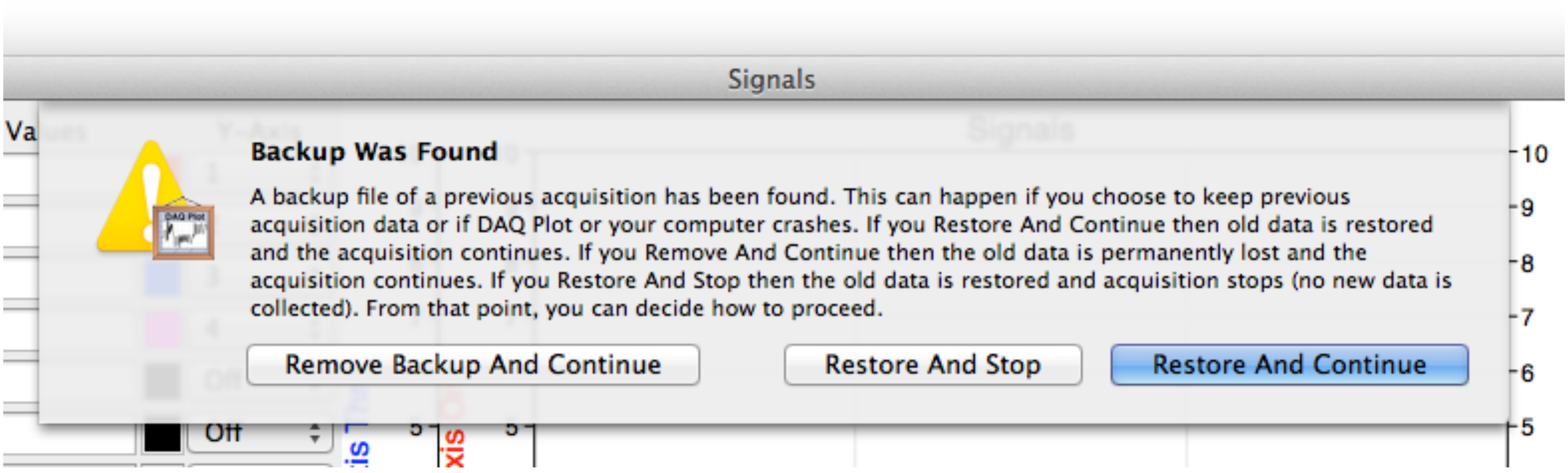
DAQ Plot ► Support ► Managing Backup

Backup files store the most recent data collected by DAQ Plot. To turn on the backup file processing see the Main Preference Pane. The backup file is related to the internal buffer of DAQ Plot. For additional information on that buffer see Buffer Support Note.

Once you turn on the backup it is used on the next launch of DAQ Plot, so you must quit and restart DAQ Plot to get a backup.

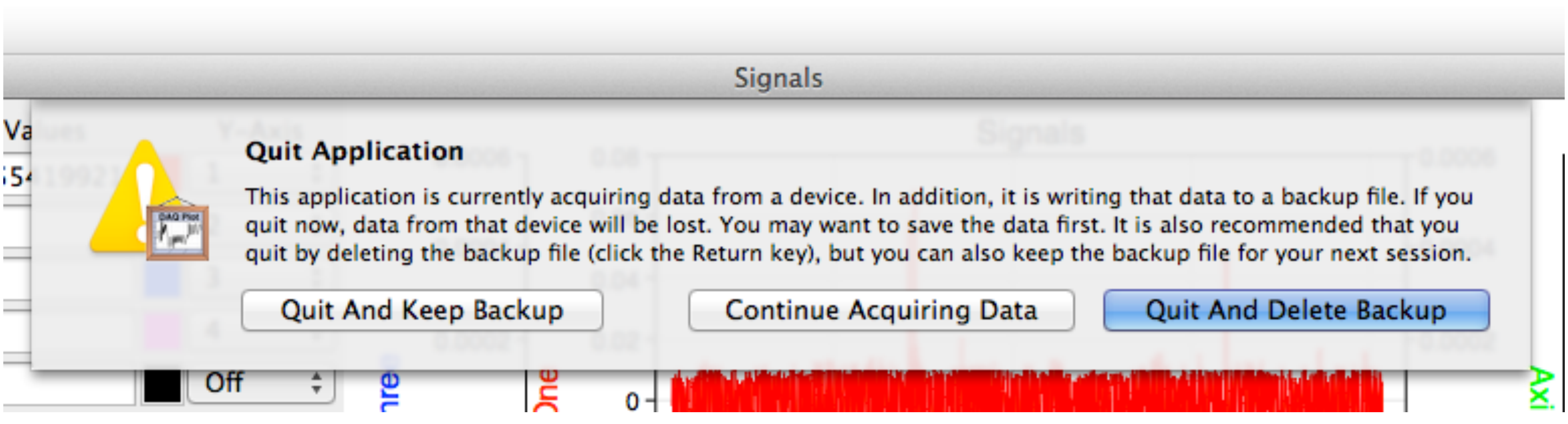
When a backup exists (and if the ask or use option is set, see Main Preference Pane) then upon launching DAQ Plot you will get this panel:



Explanation of the options:

- **Restore And Stop**: Use this to restore from the backup and then not acquire any more data. You later have the option to start data acquisition again and apply other features.
- **Remove Backup And Continue**: Use this to remove the backup and startup the acquisition again. Use this to get rid of an old run that you are no longer interested in.
- **Restore And Continue**: Use this to restore from the backup and continue with the data acquisition. Use this if your previous run was incomplete and you need to collect more data using the same acquisition parameters.

When you quit DAQ Plot, if there is a backup you will be prompted with this panel:



Explanation of the options:

- **Continue Acquiring Data**: Use this to abort quitting DAQ Plot and to continue collecting data.
- **Quit And Keep Backup**: Use this to quit DAQ Plot, but keep the backup. Normally you probably want to delete the backup because the data run is done with. But, sometimes you may want to keep it just because you want to append the current data run.
- **Quit And Delete Backup** : Quit and delete backup. This is the normal way to quit DAQ Plot and it assumes that you are completely done with the data acquisition and saved it either as an export file or a signal file.

Decoding Backup Files

You may want to use the backup file for other purposes by either keeping it after quitting DAQ Plot or by sampling it while DAQ Plot is running. For that see Decoding Backup.

DAQ Plot ▶ Support ▶ Decoding Backup

Usually you will probably want to Export collected data. There are plenty of facilities to export data. This section deals with a much more efficient real-time exporting of data which operates while DAQ Plot is running.

If enabled (see Managing Backup), DAQ Plot writes real-time backup files. You can use another program to decode those files. The next section explains this process using conventional unix and C-language constructs, but you can also use any other system available for this purpose.

Decoding Backup Files

Backup files are encoded in this binary format. The linear backup can be decoded using this code:

```
#import <stdio.h>
#import <string.h>

{
FILE *a_stream;

int desired_read_byte_length;
int actual_read_byte_length;
char *read_buffer;
char *read_buffer_location;
double *sample_value_location;
double *sample_value_end;
unsigned sample_state;
unsigned number_of_amplitudes;
double current_sample_value_c_array[16];
double current_second;

a_path = "~/Library/VVI/DAQPlot/Backup/default_1.backup";

a_stream = fopen(a_path, "r");

if(a_stream == SAF_NULL)
{
printf("No backup file\n");
return;
}

number_of_amplitudes = 16;

desired_read_byte_length = (number_of_amplitudes + 1) * sizeof(double) + sizeof(unsigned);
sample_value_end = current_sample_value_c_array + number_of_amplitudes;

read_buffer = malloc(desired_read_byte_length);

actual_read_byte_length = desired_read_byte_length;

while(1)
{

/*
Poll read with a throttle
*/

actual_read_byte_length = 0;
while(actual_read_byte_length != desired_read_byte_length)
{
read_buffer_location = read_buffer + actual_read_byte_length;
actual_read_byte_length += fread(read_buffer, 1, desired_read_byte_length, a_stream);

if(actual_read_byte_length = 0) usleep(1);
}

/*
Decode a single-time-sample amount of 16 channel data
*/

read_buffer_location = read_buffer;
sample_value_location = current_sample_value_c_array;

memcpy(&sample_state, read_buffer_location, sizeof(unsigned));
read_buffer_location += sizeof(unsigned);

memcpy(&current_second, read_buffer_location, sizeof(double));
read_buffer_location += sizeof(double);

for(; sample_value_location < sample_value_end; sample_value_location++)
{
memcpy(sample_value_location, read_buffer_location, sizeof(double));
read_buffer_location += sizeof(double);
```

```
}

/*
Got some data, so now process it here using your own code.
current_sample_value_c_array : 16 element double array with channel data.
current_second: The second since 1970 of the samples.
sample_state: not documented
*/

}

free(read_buffer);

fclose(a_stream);
}
```

DAQ Plot ► Hardware

This manual discusses four hardware types generally as follows.

- The Basic Hardware is the DLP-IO8-G data acquisition module. It has 10 bit resolution and is software clocked. To buy that hardware please email sales@vvi.com or consult a retailer such as DIGIKEY www.digikey.com or if you are not in the United States then a retailer local to your area.
- The Standard Hardware can be hardware clocked to 100 Hz has 12 bit resolution and has output channels for feedback loops. To buy that hardware please email sales@vvi.com.
- The Pro Hardware can be hardware clocked to 50,000 Hz has 12-16 bit resolution and has output channels for feedback loops. To buy that hardware please email sales@vvi.com.
- The Serial Port Hardware is any serial port based system that responds to the command set implemented by DAQ Plot and as defined in this manual. Many data loggers and modular data acquisition hardware fit this description.

For other hardware and custom driver solutions email support@vvi.com.

The following is a brief list and description of the Hardware sections:

Hardware

Basic	Describes the Basic DAQ Hardware.
Standard	Describes the Standard DAQ Hardware.
Pro	Describes the Pro DAQ Hardware.
Serial Port	Describes plausible (as yet unspecified) Serial Port hardware.
Sound In	Describes the Sound In hardware (your computer's microphone).

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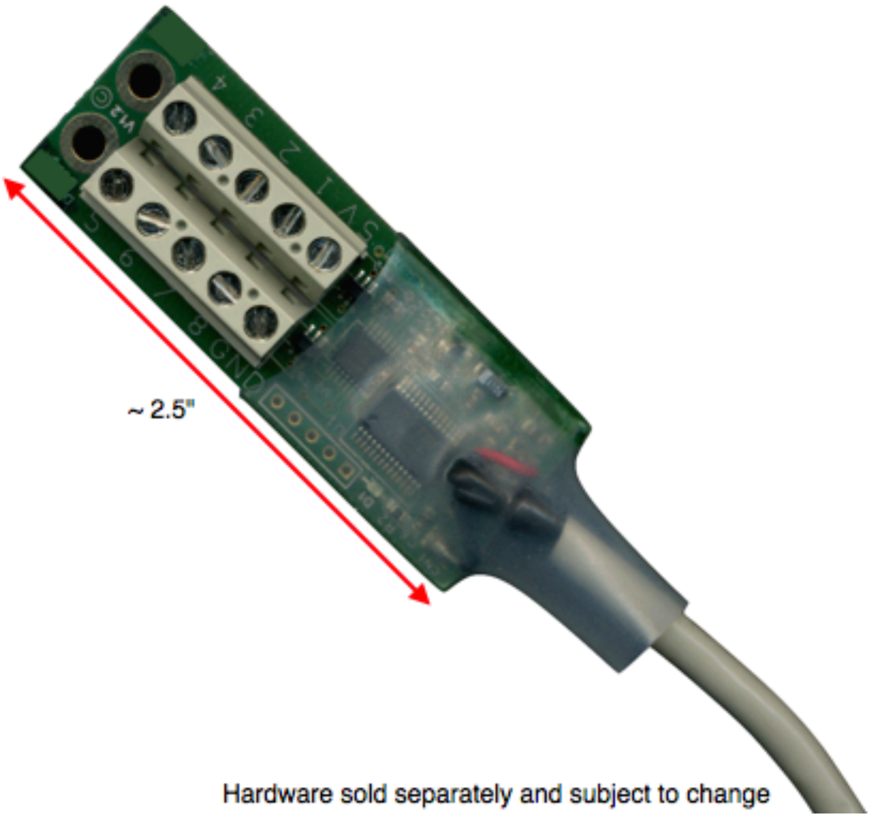
DAQ Plot ► Hardware ► Basic

The Basic Hardware is the DLP-IO8-G data acquisition module. To buy that hardware please email sales@vvi.com or consult a retailer such as DIGIKEY www.digikey.com or if you are not in the United States then a retailer local to your area.

Do not install a third party driver if this hardware is to be used on OS X 10.9 (Mavericks) as the driver is built into the operating system. To use this hardware on OS X earlier than Mavericks you must install a driver, see: www.ftdichip.com and http://www.ftdichip.com/Drivers/VCP.htm. If you are unsure of this step then please email support@vvi.com.

The hardware consists of a DAQ device front ended by a USB controller and connector of which 8 terminals are used for a total of eight voltage signals. Collectively it is called the "Basic USB" Hardware because of the USB connector even though the protocol is serial port. Basic hardware settings are described in the Basic USB Preferences.

The tutorial First Project describes how to use the Basic Hardware.



Features

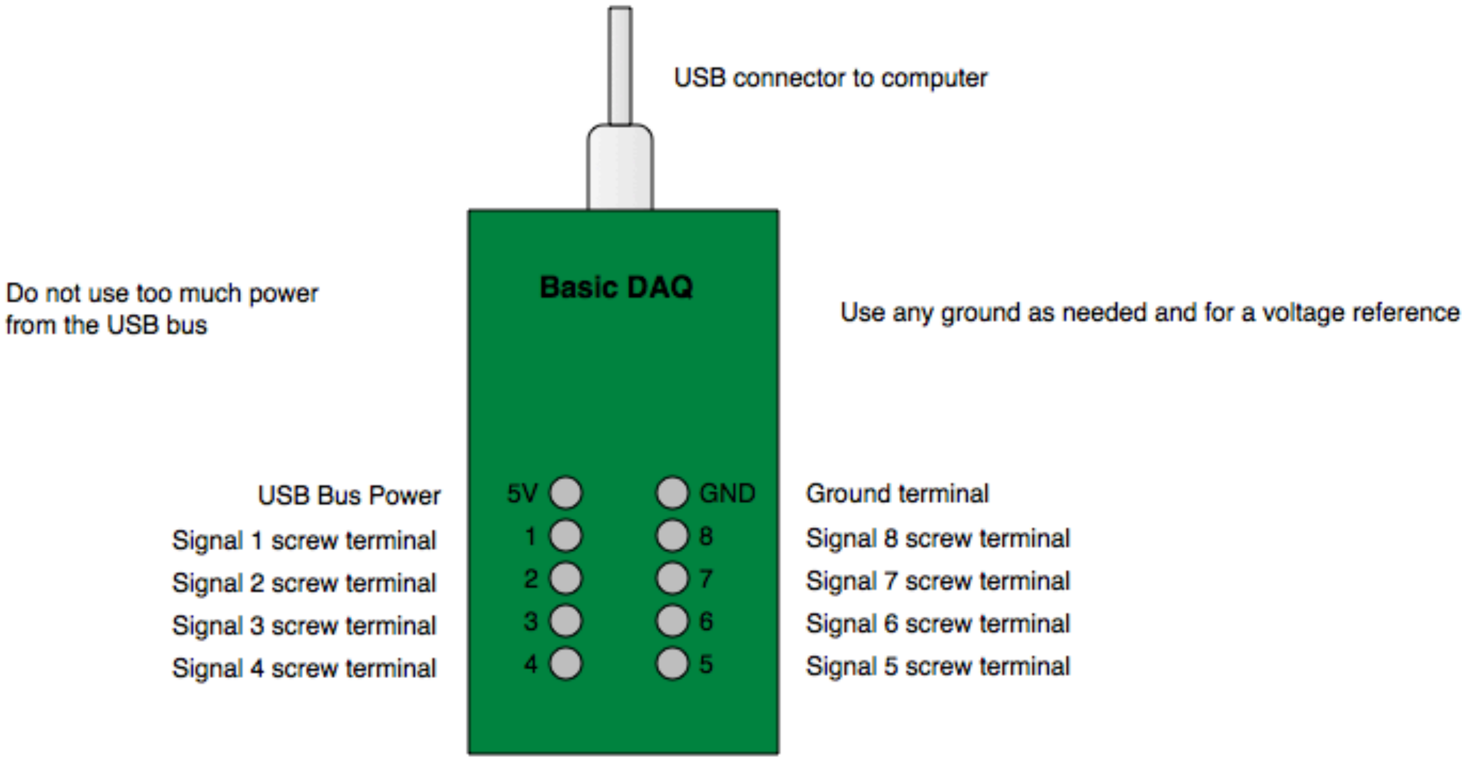
- Economical and compact data logger.
- DAQ Plot software, device driver and hardware.
- Small circuit board (approximately 2.5 x 1 inches) with an attached USB cable.
- Plug into USB port, emulates a standard serial port.
- 8 analog input channels. Dynamic range: 0-5V; Resolution: 10 bits.
- Clocking controlled by software timer.
- All voltage input channels are wired to screw terminals.
- Low cost DAQ with USB connector. Powered via the USB bus.
- Includes screw terminals on DAQ unit and integrated USB cable.
- Requires installation of 3rd party driver provided at time of purchase.
- Good for demonstration and educational uses and for any project that accepts a quick and inexpensive data logger to measure signals.

The following is a brief list and description of the Hardware sections:

Basic Hardware

Connectors	Describes the connectors to the DAQ device.
Specifications	Describes the DAQ hardware specifications.

The following schematic diagrams the connectors that you will be using.



The screw connectors 1-8 correspond to the curve index in the signal window. Each connector is a single-ended connection to a digitizer. Typically, a sensor has a signal wire which can be attached to any of the signal connectors, usually in order one to eight for up to 8 sensors, a ground wire which is connected to the GND terminal and a power wire which can be connected to the USB Bus Power (5 V) connector. Make sure not to overload the power.

The Basic USB Preferences are pre-set for the Basic Hardware and no changes need to be made. Upon first use of the hardware make sure to click the Apply button in the preference pane.

Each of the eight signal connectors is connected to only one digitizer and the 8 signals are digitized in sequence (multiplexed). Hence, if you have less than 8 signals then turn off all of the unused channels in the Basic USB Preferences (de-select the switches next to the Channel Prompt Strings) and click Apply. Since less signals are multiplexed each signal that is digitized will be sampled more often and hence the effective sample rate can be increased.

The following are the specifications for the Connectors to the Basic USB DAQ device. To setup the logic for these terminals see Basic USB Preferences.

Analog Input

Channels `1, ..., 8` are single ended voltage input connectors to a 10 bit A/D converter. They have a dynamic range of 0 to 5 volts. That means that the voltage resolution is .009765 volts (9.765 millivolts).

Power

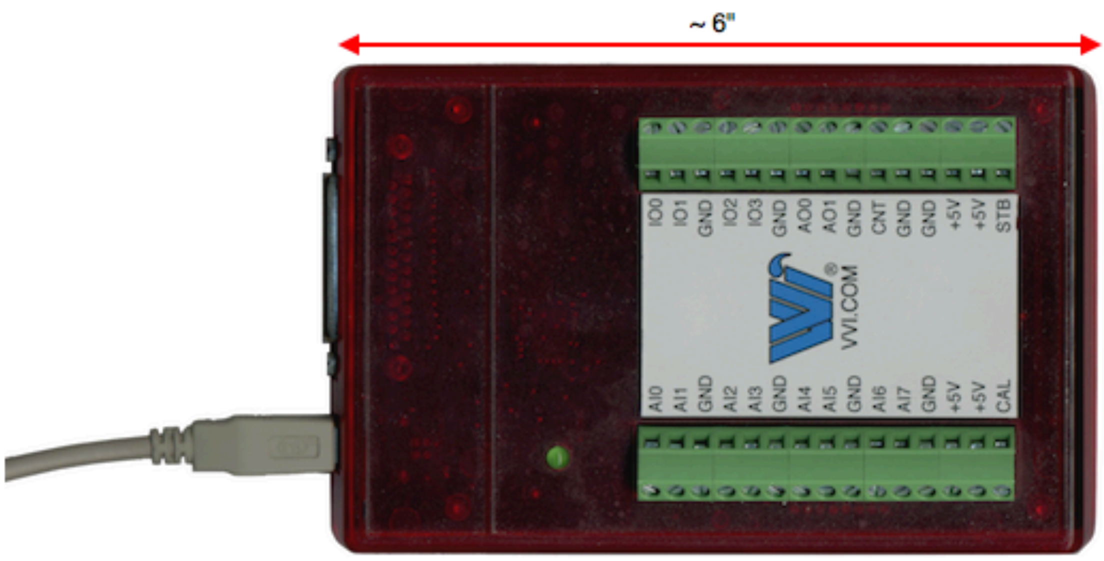
The terminal marked as `5V` is the power output connector. They are powered through the computer's USB bus so do not try to draw any more power than that rated for your computer, or powered hub if the USB device is connected to a powered hub. For many computers and powered hubs the maximum power that can be drawn is 450mA. If you need additional power then use an external power supply like from a transformer.

Ground

The terminal marked as `GND` is the ground on a common ground-bus. The ground is connected to your computer's ground so it may or may not be well isolated. Since it is a common ground there is no isolation between terminals, a fact that can lead to cross talk between sensors connected to the grounds.

DAQ Plot ► Hardware ► Standard

The hardware consists of a USB based DAQ device of which 8 terminals are used for a total of four voltage signals.



Hardware sold separately and subject to change

Features

• Good features and cost.

• DAQ Plot software, device driver and hardware.

• Plug and Play USB DAQ device. DAQ Plot automatically recognizes when you plug it in and, when configured, will automatically acquire from the hardware the next time it is launched.

• 4 analog input channels. Dynamic range: +/- 10V; Resolution: 12 bits.

• 20 digital output channels.

• 2 analog output channels, 10 bits of resolution, which are driven by DAQ Plot's feedback loop.

• High-speed hardware clocking for uniform time sampling from 1 to 100 samples per second.

• Low-speed clocking for sampling between a twentieth of a second and two minutes.

• Low noise pre-amplifiers for differential input voltage gains between 1 to 20.

• All voltage input and output channels are wired to screw terminals.

• Real-time adjustment of device states and real-time output of data which can be viewed and selected immediately.

• USB 1.1 controller also works with USB 2.0 in 1.1 compatibility mode. Designed and tested to work with USB wire and wireless hubs and multiplex on one USB bus. Powered via the USB bus.

• Includes screw terminals on DAQ unit and USB cable.

The following is a brief list and description of the Hardware sections:

Standard Hardware

Connectors	Describes the connectors to the DAQ device.
Specifications	Describes the UBS DAQ hardware specifications.

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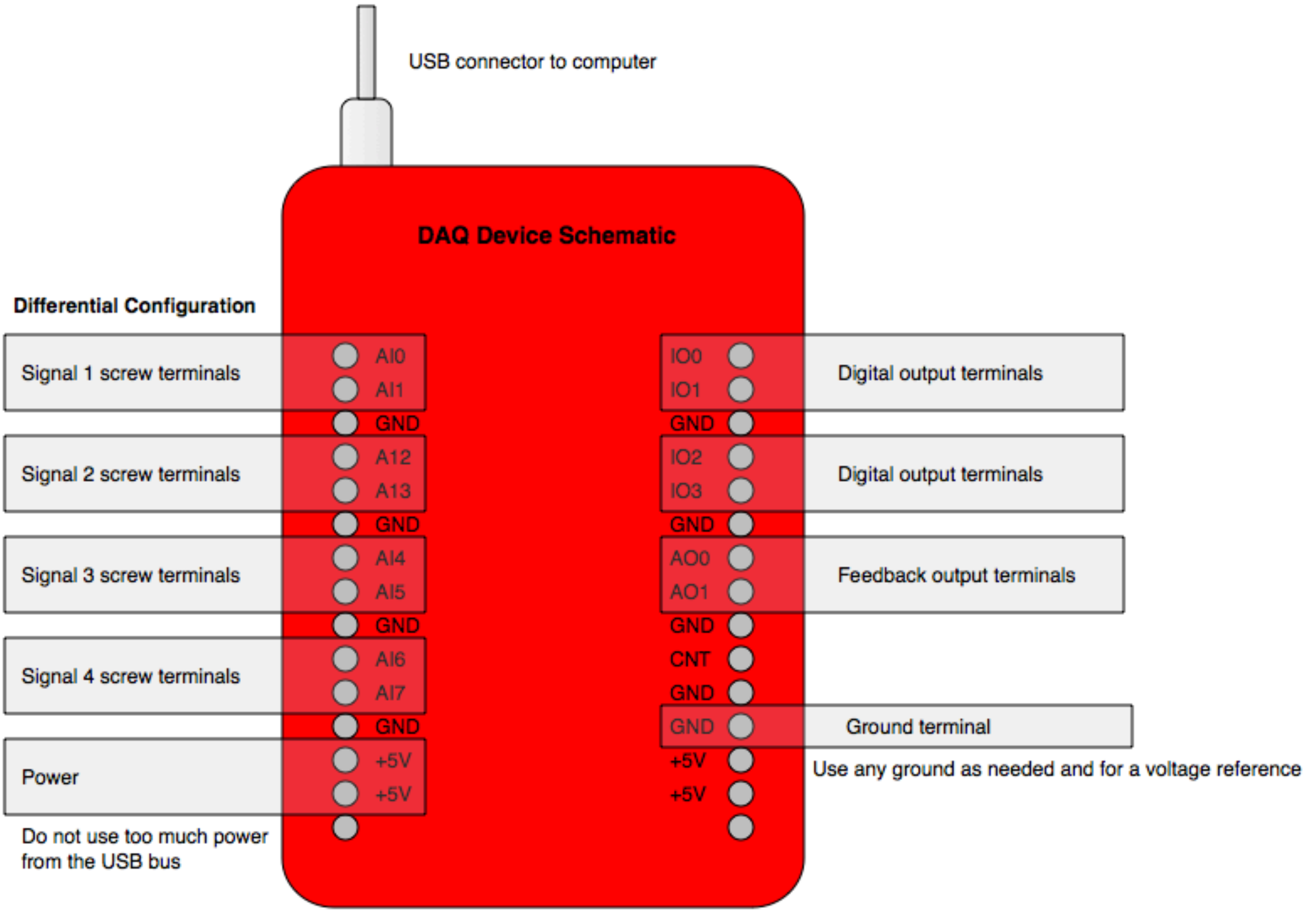
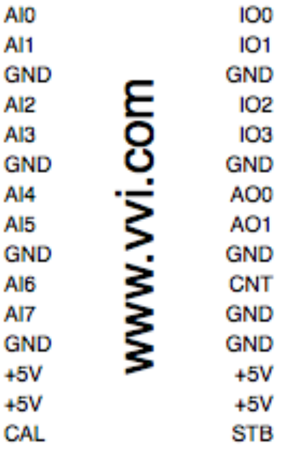
[DAQ Plot] ▶ [Hardware] ▶ [Standard] ▶ Connectors

The following schematic diagrams the connectors that you will be using.



To mark the connectors on your hardware device click this template figure:



and print the resulting PDF so you can tape it to the box.

To setup the logic for these terminals see [Standard USB Preferences].

The following are the specifications for the Connectors to the USB DAQ device. To setup the logic for these terminals see Standard USB Preferences.

Analog Input

Channels `AI0-AI1, AI2-AI3, AI4-AI5, AI6-AI7` are differential voltage input connectors to a 12 bit A/D converter. They have a dynamic range of -10 to 10 volts. That means that the voltage resolution is 0.004882 volts (4.882 millivolts). If a gain is set then it is applied before digitization. If the gain is 20 then the dynamic range is 0.5 volts and the resolution is 0.2441 millivolts. So, for low amplitude signals the gain setting can increase the effective resolution.

Analog Output

Channels `AO0 and AO1` are output voltage terminals. Their D/A converters are 10 bits and output in the range from 0 to 5 Volts. The values for them are set to the input parameters in the USB Preferences window.

Digital Output

Channels `IO0, IO1, IO2, IO3` are digital output voltage terminals. When a digital channel is set on it has the value of 5 volts, when off it has a value of 0 volts. Access to 16 other digital output channels are through the DB25 connector. You need a optional board to access those pins.

Power

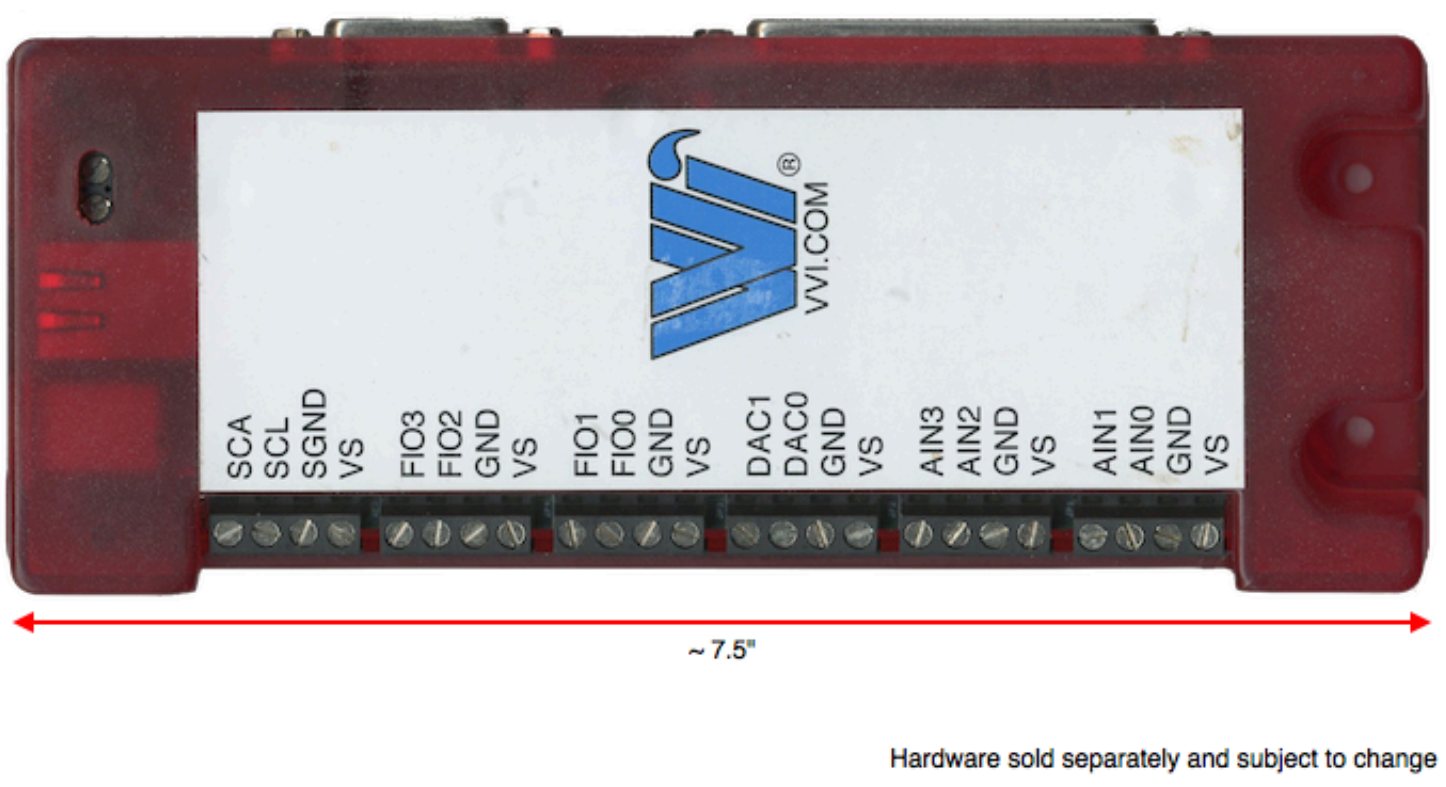
Terminals marked as `+5V` are power output connectors. They are powered through the computer's USB bus so do not try to draw any more power than that rated for your computer, or powered hub if the USB device is connected to a powered hub. For many computers and powered hubs the maximum power that can be drawn is 450mA. If you need additional power then use a external power supply like from a transformer.

Ground

Terminals marked as `GND` are grounds on a common ground-bus. The ground is connected to your computer's ground so it may or may not be well isolated. Since it is a common ground there is no isolation between ground terminals, a fact that can lead to cross talk between sensors connected to the grounds.

DAQ Plot ► Hardware ► Pro

The hardware consists of a USB based DAQ device of which 14 external terminals and 2 internal channels are used for a total of 16 voltage signals.



Features

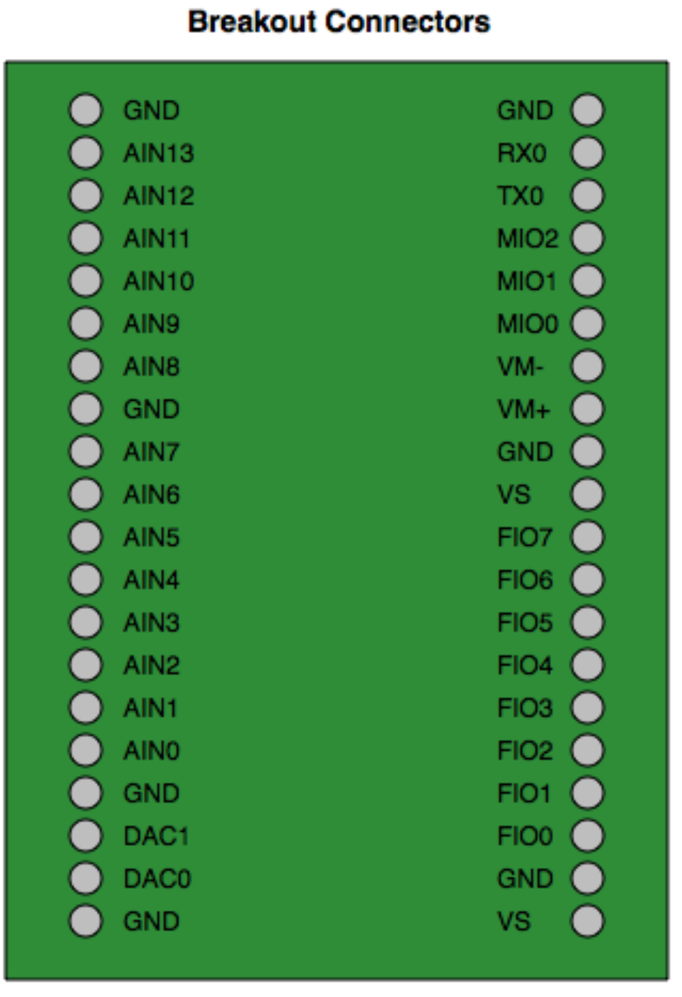
- High precision and industrial quality.
- DAQ Plot software, device driver and hardware.
- Plug and Play USB DAQ device. DAQ Plot automatically recognizes when you plug it in and, when configured, will automatically acquire from the hardware the next time it is launched.
- Connections include both USB and Ethernet. Choose USB for convenience or Ethernet for cabling needs.
- 14 analog input channels. Dynamic range: 0V to 5V; Resolution: 16 bits. Factory calibrated.
- High-speed hardware clocking for uniform time sampling up to 50,000 samples per second.
- 8 digital output channels.
- 2 analog output channels, 12 bits of resolution, which are driven by DAQ Plot's feedback loop.
- Low-speed clocking for sampling as low as 1/500th second in 12 bit mode and 1/200th second in 16 bit mode.
- Low noise pre-amplifiers for input voltage gains between 1 to 8.
- Real-time adjustment of device states and real-time output of data which can be viewed and selected immediately.
- All channels are accessible via screw terminals from an accompanying breakout board.
- USB 2.0 and 1.1 compliant full speed controller. Designed and tested to work with USB wire and wireless hubs and multiplex on one USB bus. Can be powered from the USB controller (up to 500mA) or an external power supply.
- Enclosure size approximately 75mm x 175mm x 25mm. Rated for industrial temperature range (-40 to +85 ?C).
- Includes screw terminal breakout board, USB and Ethernet CAT-5 cables and external power supply.

The following is a brief list and description of the Hardware sections:

Pro Hardware

Connectors	Describes the connectors to the DAQ device.
Specifications	Describes the UBS DAQ hardware specifications.

The following schematic diagrams the connectors that you will be using.



Terminals AI0-AI13 are the 14 analog input channels. DAC0 and DAC1 are the two analog output feedback channels. FIO0-FIO7 are the 8 digital output channels.

To setup the logic for these terminals see Pro USB Preferences.

DAQ Plot ► Hardware ► Pro ► Specifications

The following are the specifications for the Connectors to the Pro Hardware. To setup the logic for these terminals see Pro USB Preferences.

Analog Input

Channels `AIN0 to AIN13` are non-differential voltage input connectors to a 12 and 16 bit A/D converter. They have a dynamic range of 0 to 5 or -5 to 5 volts depending on the settings. That means that the voltage resolution is 0.002441 volts (2.441 millivolts) for the 12 bit setting and 0.000153 volts (0.153 millivolts) for the 16 bit setting for a 5 volt range. If a gain is set then it is applied before digitization. If the gain is 8 then the dynamic range is 0 to 0.625 volts and the resolution is 0.0191 millivolts at 16 bit unipolar setting. So, for low amplitude signals the gain setting can increase the effective resolution.

Analog Output

Channels `DAC0 and DAC1` are output voltage terminals. Their D/A converters are 12 bits and output in the range from 0 to 5 Volts. The values for them are set to the input parameters in the USB Preferences window.

Digital Output

Channels `FIO0 to FIO7` are digital output voltage terminals. When a digital channel is set on it has the value of 3.3 volts, when off it has a value of 0 volts.

Power

Terminals marked as `VS` are power output connectors. They are powered through the computer's USB bus so do not try to draw any more power than that rated for your computer, or powered hub if the USB device is connected to a powered hub. For many computers and powered hubs the maximum power that can be drawn is 450mA. If you need additional power then use a external power supply like from a transformer.

Ground

Terminals marked as `GND` are grounds on a common ground-bus. The ground is connected to your computer's ground so it may or may not be well isolated. Since it is a common ground there is no isolation between ground terminals, a fact that can lead to cross talk between sensors connected to the grounds.

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DAQ Plot ► Hardware ► Serial Port ► Specifications

There are many Serial Port Data Acquisition devices on the market. Many of these devices can be used as simple data loggers. The steps to using them are as follow:

- Find a suitable Serial Port hardware device. The Basic Hardware is one such device.
- If the Serial Port device does not have a serial port to USB converter then you need to purchase one of those and then also download and install the driver for it. Such drivers usually layer an emulation layer on the USB protocol so that it appears as a serial port device.
- Plug the serial port DAQ device into the serial port to USB converter and then plug that into the USB connector on your computer. Then launch DAQ Plot and go to the Hardware Preference pane and select the serial port device from the hardware selector. It may be that the serial port device will not enumerate according to DAQ Plot's specification so that there is no guarantee that an unknown serial port device can work with DAQ Plot.
- Note the specifications for your serial port device communication attributes. DAQ Plot permits you to adjust some of the common attributes, however such adjustments may not be expansive enough for every serial port device so there is no guarantee that the correct attribute selections can be made.
- Then configure the serial port preferences according to Serial Port Preferences.

The Sound In Data Acquisition device is the default Sound In that is configured on your computer. It is normally the microphone built into your computer, or more accurately it is the audio digitizer. To use it, select the "CA-Sound-In" Identification in the Hardware pane and click Apply.

Here are a few things to note about the Sound In device:

- This hardware option is provided mainly as as convenience. It is a single channel DAQ device with no settings and typically digitizes at 44.1 kHz, has band pass filters and may be of limited use.
- The Sound In device provides a convenient way to see sound on your computer.
- Configure the Sound In preferences according to Sound In Preferences.

DAQ Plot ► Legal

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The following is a brief list of Legal sections:

Legal	
License Agreement	The End User License Agreement.
Trademarks	A list of trademarks used in this manual.
Disclaimer	A list of disclaimers.

DAQ Plot ► Legal ► Disclaimer

Take Precautions

All the experiments and methods suggested in this manual have been previously used by VVI without any ill effects. However, you should be advised that there have been documented cases of spontaneous combustion of humans, ignition by low voltage sources such as cell phones, and the like. You should take all precautions while working with electricity. For example, close all sources of ignitable liquids and volatile substances. If you start measuring electrical sources, such as a wall outlet or any other source, then you need to take precautions commensurate with the health risks and assume all risks.

Various Specifications

Not all features described in this manual are available to all DAQ hardware types or purchase types. The features vary according to hardware, purchase type and various settings. Setting one feature may or will constrain applicability of another feature. Where practical, such limitations and relationships are specified in this manual. Features may also be only valid based upon computer type, operating system level, drivers installed or not installed and other parameters. In certain instances, third party drivers or software may interfere with the use of DAQ Plot. Because of the attempted real-time feature of DAQ Plot your computer system load may affect DAQ Plot performance. Although robustness has been designed into DAQ Plot due to the nature of unknown deployment situations there is no guarantee that DAQ Plot will operate similarly to computers it has been tested on.

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DAQ Plot™ v11.0.2

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