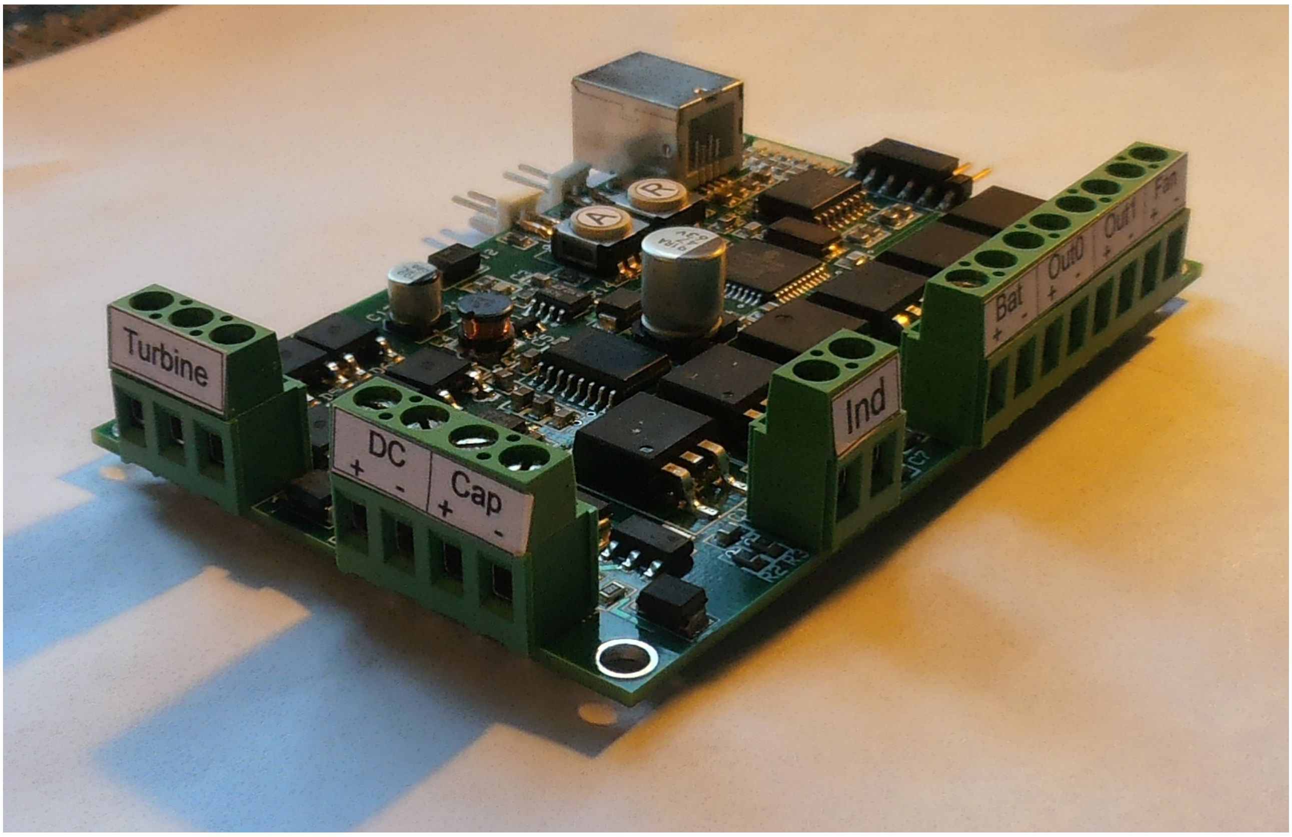
Model V3 Solar / Turbine Control Board User Manual

(Manual V0.1, Firmware 10, Wind V1.0)



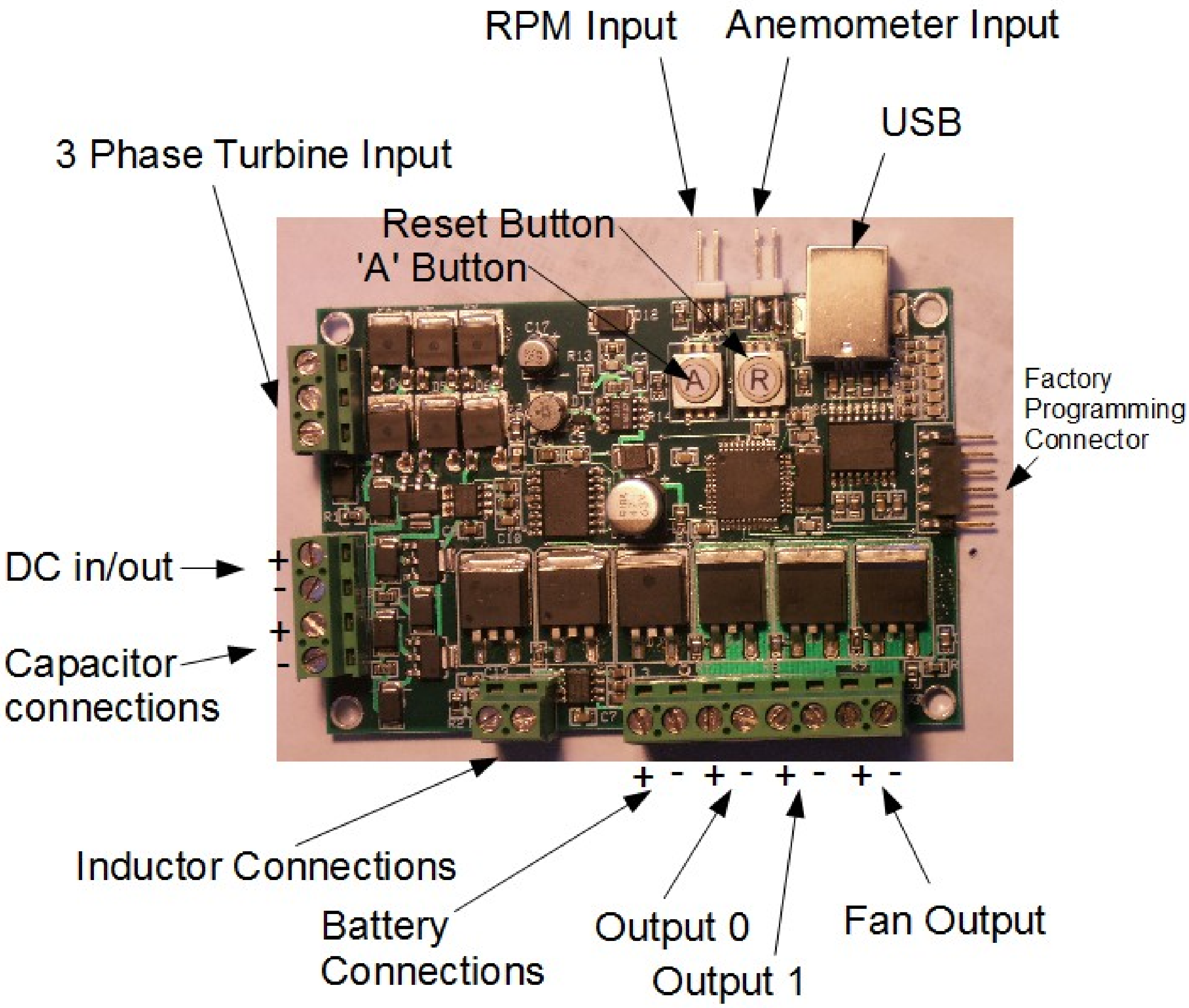
Overview:

The V3 Solar / Turbine Control Board is a device that not only can control and convert power from solar panels or wind turbines, but also act as a scientific instrument for doing wind turbine experimentation. The list of board features are:

- Up to 100v input (200v version available)
- Charges batteries banks up to 48v
- On board 3 phase rectification for 3 phase AC input
- DC input for solar or DC generators
- On board voltage (and turbine) limiting
- USB 2.0 interface for configuration and data logging
- 2 switched outputs that turn on and off based on battery voltage
- Fan output for high power appications that need cooling air.
- Programmable battery voltage limits
- Programmable V-I curves for turbine operation
- Programmable MPPT parameters
- Modes for scientific exploration of wind turbine properties

Electrical Connections

This diagram shows the electrical connections to the board:



Three Phase Turbine Input: This is the input from the turbine. The alternator of the turbine can be hooked in either Star or Delta configuration. It makes no difference to the controller. None of these inputs should be grounded. The maximum voltage (phase to phase) is 100v (200v on some units.) If this voltage is exceeded, then those phases will be shorted for 1/2 cycle or less. This will protect the board and reduce the speed of the turbine slightly. Normally this hardware limiting is a last resort and software will control the turbine before the voltage gets that high.

DC in/out: This is connected to the output of the 3 phase rectifier. These terminals can be used to measure the input voltage. Then can also be used to feed DC power into the controller, either from a solar panel or a DC generator. **Note: Since this is an input and an output, a blocking diode must be used when connecting power sources to these terminals.** It is normal for these terminals to have the battery voltage on them, when there is no turbine power coming in.

Capacitor connections: These terminals are for the input capacitor. A 270 uf, 200v capacitor is included with the board. This size capacitor is good for up to 200 watts, Depending on the voltage and current.   If more power is expect to go through the board, a larger capacitor should be used. Be sure to connect the cap with the correct polarity (+ to +, etc.)

Inductor Connections: These two connections are for the inductor. The inductor should be approximately 1mH for moderate powers (10 amps output). An easy way to construct a suitable inductor is to wrap 120 turns of #18 wire around a soda can, and wire tie it. Gapped ferrite core inductors can also be used, but the sizing of these inductors is a complicated problem and needs to be Engineered. The air core inductor is simple solution.

Battery Connection: This is the connection to the battery. Usually a lead acid type of battery will be used, but nothing prevents NiCd or NiMH from being used if the right parameters are put in the controller. These connections carry current to the battery, but also carry current from the battery to the outputs when they are on. Large gauge wire should be used for these connections. It is strongly suggested that a fuse (2-3x expected current) be put between the battery and the control board. The highest voltage allowed on the battery terminals is 60v.

Output0 and Output1: These are switched outputs to go to devices run by the battery. Each output will turn on when the battery hits the 'on voltage' and it will stay on until the battery goes below the 'off voltage'.   Both the on and off limits require that the voltage say above or below for a minimum amount of time before the trip point triggers. This prevents noise from accidently turning an output on or off. Possible uses for these outputs include turning on a dump load if the battery voltage gets too high, or enabling an inverter to power things in a cabin and turning off the inverter if battery voltage gets too low to prevent battery damage.   **Note: These outputs are low side switched. This means the + terminal is always live, and the – terminal is the one that turns on and off.** Do not wire these outputs into circuits with a common ground or that ground will activate your devices. The transistors on these outputs can handle more than 30 amps. If you are going to put large loads on these terminals, make sure to use large wire.

Fan output: A third output is provided to run a fan. The firmware in on the board turns this output on when significant current is flowing through any of the switching circuits. Even a little air moving across the board helps keep it's temperature down and makes the board run more efficiently. The power used in a small 2" or 3" fan will easily be paid for by increased efficiency.   This output runs at battery voltage, so if you are running a 12v battery system, you need a 12v fan. A 24v battery system would need a 24v fan, or 2 12v fans in series.   This output is an identical circuit as Output 0 and Output 1 so it can put out very large currents. **Be careful not to short it!**

RPM Input: This input is for a sensor to measure the RPMs of the turbine. The sensor should be a switch closure that closes once per revolution of the turbine. This input is debounced in software so no external conditioning circuitry is necessary. The RPM input is used for data logging only and is not required by the board for turbine control.

Anomemeter Input: This input is for an anomemeter. This input is designed for an Inspeed Vortex Wind Sensor (http://www.inspeed.com/anemometers/Vortex_Wind_Sensor.asp) , which closes a contact once per revolution and has a calibration of 2.5 mph / Hz. This input is debounced in software and no external conditioning circuitry is necessary. Also cable lengths to the Anomemeter can easily be 100ft, possibly longer. The upper limit of length is currently unknown. This input is used for data logging only and is not required by the board for turbine control.

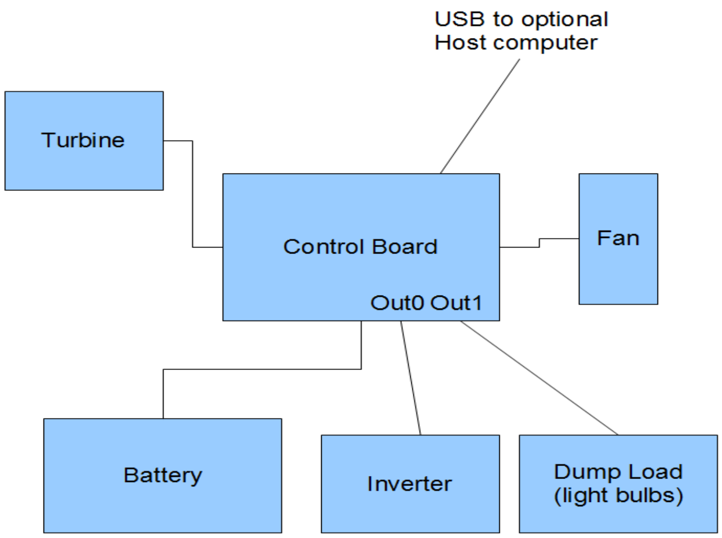
Factory Programming Connector: This connector is used to program in the firmware at the factory. It is not usable by the user. However logic voltage is present on this connector. Take care that it does not short against a case or any other object.

'A' button: This button can be read by the firmware of the card. Currently it's only purpose is to determine if the board runs normally or goes into flash mode when the board boots. **If high voltages are coming from the turbine to the board, the user may want to push this button with a wood dowel or pencil to keep some distance between the board and his hand.**

Reset (R) button: This button resets the processor. If everything is working, it should rarely have to be used. Even if the processor gets confused it should reset itself via watchdog timer. When using this button, give it only a quick push. The processor has no idea when it's going to be reset, and it's possible that it could be caught with transistors turned on in bad combinations. The shorter the reset, and the sooner the processor can initialize things to make sure the board and turbine is safe. **If high voltages are coming from the turbine to the board, the user may want to push this button with a wood dowel or pencil to keep some distance between the board and his hand.**

Setting up the System:

This diagram shows a typical wind turbine system.



Average Wind Turbine System

The safest order to hook connections up to the board would be this:

1) Inductor and input capacitor

2) outputs and fan (if necessary)
3) Battery
4) Turbine or solar input

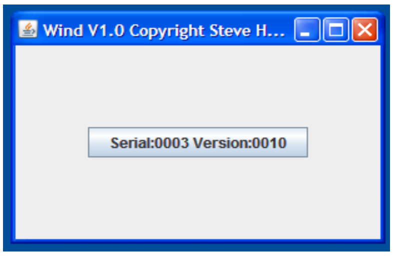
The board uses the battery as a source of power and a place to dump power, therefore it is absolutly necessary that the battery is always hooked up when there is a turbine or solar panel providing power. Other connections are less critical and can be mated while the board is live. Just take care not to short anything while doing it. **Never disconnect the battery connection while the board is converting turbine power. Doing so can cause a high voltage spike in the circuitry that could cause damage.**

Interfacing with the computer via USB: The control board communicates with a host computer (PC) via a USB 2.0 connection. No special drivers are necessary to talk to the board, only the 'Wind' software. USB has a cable length limit of about 15ft. If you need a longer connection cables with repeaters can be used.

Java Run Time Package: In order to use the 'Wind' software, the Java 7 Runtime software needs to be installed on the computer. This will come on the CD with the board, but you can also download the latest version from http://www.oracle.com/technetwork/java/javase/downloads/java-se-jre-7-download-432155.html

Starting the Wind software

The wind software can be started by clicking on the icon for the program. It should start with a small window that lists the machines that are found on the USB interfaces. If one controller board is hooked up, the window will look something like this:

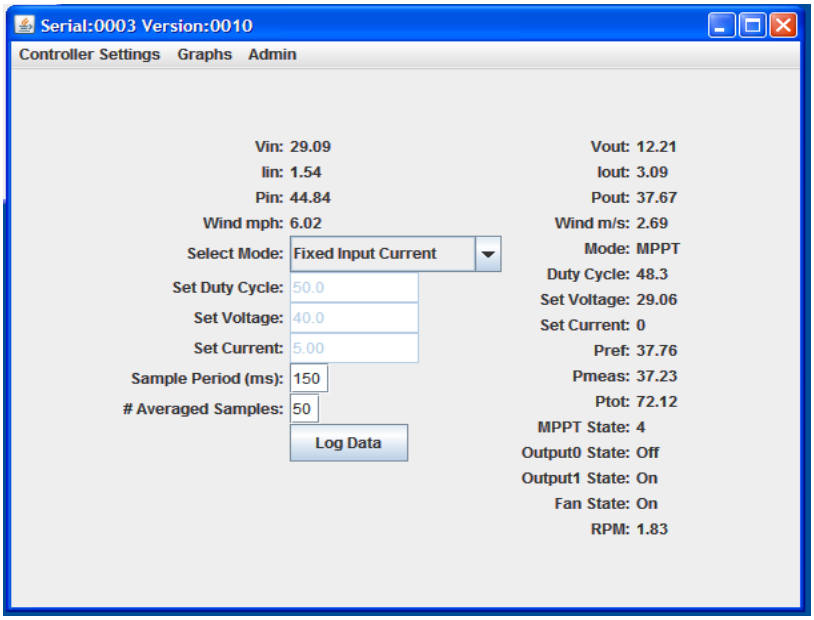


The botton in the window indicates the serial number of the control board, and it's firmware version. If more than one controller is plugged into the computer, each one is listed like this:

If your window looks like the one below, with no machines listed, it means the software didn't see any machines. Possible causes are: 1) The USB isn't plugged in. 2) The control board isn't hooked to a battery, and thus has no power or 3) The libraries needed for USB communication aren't in the directory with the Wind program. 4) The controller board is in flash mode, or is broken.

Control Window

Once you get to the point of having a machine listed in the first window, you can push on the button and it will bring up a control window for that board, that looks like this:



Lets go through each of the fields and explain what they are:

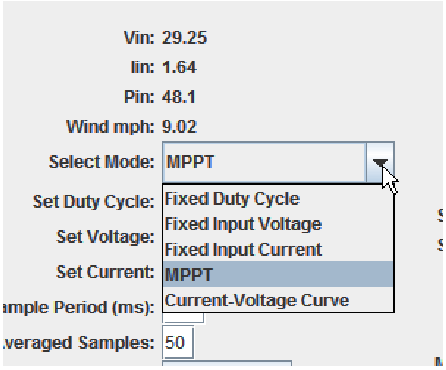
Vin: This the measured input voltage from the turbine or solar panel. It's the value on the DC terminals (rectified AC). The units are volts DC.

Iin: This is a measure of the current coming in from the turbine. This measurement is done between the DC input and the input capacitor so that it is lessed affected by the switching of the buck converter on the board. The units on this measurement is amps.

Pin: This is a measure of power coming in from the turbine or solar panel. The units on this measurement are watts.

Wind mph: If an anomemeter is hooked up to the controller board, this will show the windspeed in miles per hour.

Select Mode: This is a drop down menu that lets you select which mode the controller is to run. One thing that should be noted about this selector is for the user to command the controller. It doesn't always indicate the mode of operation that the controller is in. (The display directly to the right does that.) This is especially true right after the wind software starts.



There are currenlty 5 modes to choose from this include:

Fixed Duty Cycle: In this mode, the user enters a duty cycle and the buck converter just holds that duty cycle. This is a test mode, and there are no safetys in place to protect the turbine or battery when in this mode. When in this mode, if the duty cycle is set small, the turbine will easily run up to high speeds.

Fixed Input Voltage: In this mode the user enters a voltage, and the controller will vary the duty cycle to keep the input at that voltage. This mode can be used to simulate hooking the turbine up to a battery bank that would hold it's output at 12v or 24v. This is a test mode, and when the controller is operating in this mode, there are no safeguards active to protect the turbine or battery.

Fixed Input Current: In this mode the user enters a current, and the duty cycle is varied to hold that current. This is a test mode and when the controller is operating in this mode, there are no safeguards to protect the turbine or battery. In this mode, if the current is set too low, the turbine will easily run to high speeds.

MPPT: In this mode, the controller fine tunes itself to find the best voltage and current to get the most power. This mode is generally used for solar panels. It may also be useful for turbines that have nice steady air. In this mode, the controller also monitors the battery voltage, and if it exceeds a limit, it will start detuning the settings (less input current more input voltage) to keep the battery voltage under the limit. This prevents overcharging.

Current – Voltage Curve: In this mode, the controller attempts to follow a current voltage curve that is programmed by the user. The controller measures the input voltage. It then looks up the set current and attempts to change the duty cycle to pull that current. In the mean time that will effect voltage, and that will again be measured, looked up, and the current readjusted. This mode generally works best for wind turbines because the controller can react very quickly to wind gusts.

Set Duty Cycle: This text box is where the user will enter the fixed duty cycle for Fixed Duty Cycle mode. When in this mode, this text box is enabled. When in other modes, this box is disabled and the user can not edit it. The units for this input are percent of time on. For example a duty cycle of 25 is on 25% of the time and off 75% of the time. After entering a number, push the enter key to make it take effect.

Set Voltage: This text box is where the user will enter a fixed input voltage for Fixed Input Voltage mode. When in this mode, the box will be enabled for editing. When in other modes, this box is disabled and the user can not edit it. The units for this input are volts. After entering a number, push the enter key to make it take effect.

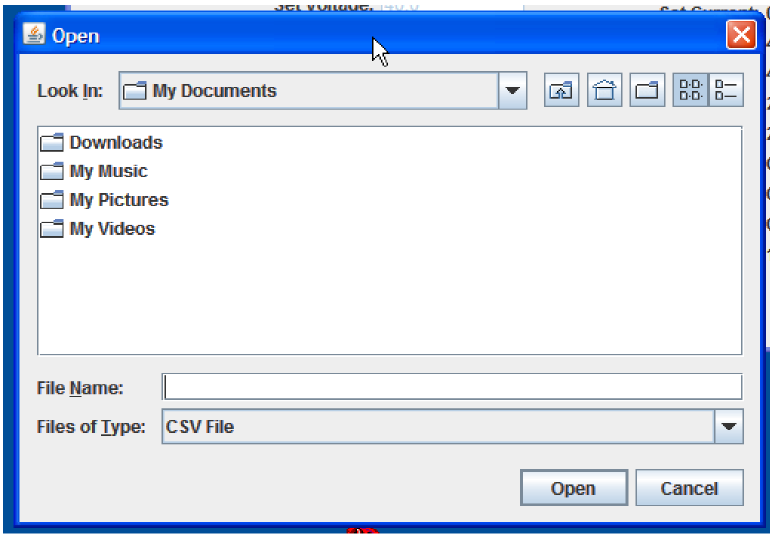
Set Current: This text box is where the user will enter a fixed input current for Fixed Input

Current mode. When in this mode, the box will be enabled for editing. When in other modes, this box is disabled and the user can not edit it. The units for this input are amps. After entering a number, push the enter key to make it take effect.

Sample Period: This entry determins how often the host software will poll the controller board for information. The units on this entry are milliseconds. Generally most computers can easily handle getting information every 100 ms. However a lower end computer that is handling lost of graphs, or multiple controllers might have trouble keeping up, and 150 or 200ms might be a more appropriate settings. The symptoms of falling behind are irratic and wild values on the measurements. After entering a number in this text box, push the enter key to make it take effect.

 # Averaged Samples: This input determines how many samples are averaged together to create a data point. For instance if this input is set to 100, then 100 samples are averaged together. The results of the average are passed to the rest of the program for logging and graphing. Analog measurements on a board that is switching power are inherintly noisy. By averaging many measurements together, the noise can be averaged out and the measurements made much cleaner. This input combined with the Sample Period determine how fast data points are generated. If the sample period is 100ms, and we average 50 samples, then a data point is generated every 50 samples * 100ms = 5000ms or 5 seconds.   While doing adjustments you may want to set this so that your update rate is 1 second. But for long term logging or graphing, 10 seconds is probably more appropriate. After entering a number in this text box, push the enter key to make it take effect.

Log Data: This button is used to start logging data to a log file.   When the button is pushed, this dialog box comes up to let you select the location and file name for the log. The log file is text with comma seperated values, and all information goes into the log file.



Vout: This is the measured output (battery) voltage. The units on this measurement are volts.

Iout: This is a measurement of current out of the buck converter. The units on this measurement are amps. If there are no outputs (or fan), then this is the amount of current going into the battery. However if there is an output on, then this measurements indicates the total current to the battery and that output. The best indication to see if charge is going into or out of the battery it to look at Vout.

Pout: this is a measurement of power out of the buck converter. The units on this measurement are watts. As with Iout, this is measured at the output of the buck converter and this measured power goes to the batter and the outputs.

Wind m/s: If there is an anemometer plugged into the controller board, then this output shows the wind speed in meters per second.

Mode: This display shows the mode that the controller is operating in. This is the status back from the controller so this is the true mode the controller is running in, as opposed to the drop down menu to the left, which may not be correct.

Duty Cycle: This display shows the duty cycle in units of percent on. In fixed duty cycle mode, this display show echo the settings by the user. In other modes, this will show what the controller is automatically doing to the duty cycle to achieve the goals imposed by the other modes.

Set Voltage: This display shows the input set voltage in units of volts. In Fixed Input Voltage mode, this display should echo the user's Input Voltage set point. In MPPT mode, it will show what the controller is setting this parameter to in order to find maximum power.

Set Current: This display shows the set point for the input current in amps. In fixed current mode, this should echo the user's set point. In I-V curve mode, it will show the current setting for the input voltage as extracted from the user's curve.

Pref, Pmeas, and Ptot: These displays were added to debug MPPT mode, but since they are in the display, I will explain them. Pmeas is a rough measure of power in watts of what the MPPT alg saw on it's last sample. Pref is the power it saw on last time it felt it had a good power point. i.e. Pref is the power to try to beat when hunting. Ptot is just the power measurement being totaled as it's being measured. As slow sample speeds this display doesn't make sense.

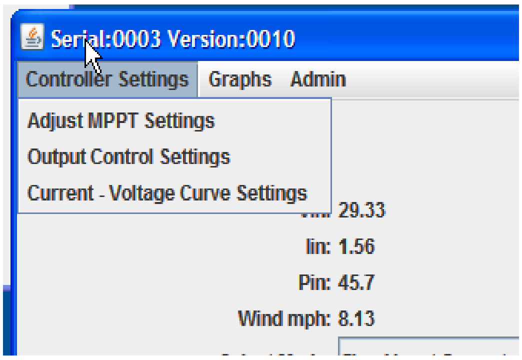
MPPT State: This was another display that was added for debugging. This indicates the state that the MPPT state machine is in. The states are as follows:

0) The controller has rreturned to what it believes to be a peak power voltage, it is letting things stabalize before taking a measurement. This state can be held extra long according to the MPPT settings.
1) The controller is taking a measurement on the current peak voltage point.
2) The controller is remembering the measurement from 1, this state is very short and rarely seen.
3) The controller is preparing to take a measurement one step up and has adjusted the voltage and is letting things stabalize.
4) The controller is currently taking a measurement for one step up.
5) The controller is deciding if up was better or not. (This is a short state and rarely seen in the displays.) The results determine of the higher voltage is kept or not.
6) The controller is preparing to take a measurement one step down and has adjusted the voltage and is letting things stabalize.
7) The controller is currently taking a measurement for one step down.
8) The controller is deciding if down was better or not. (This is a short state and rarely seen in the displays.) The results determine if the lower voltage is kept or not.

Output0 State, Output1 State, Fan State: These displays show if these outputs are currently on or off.

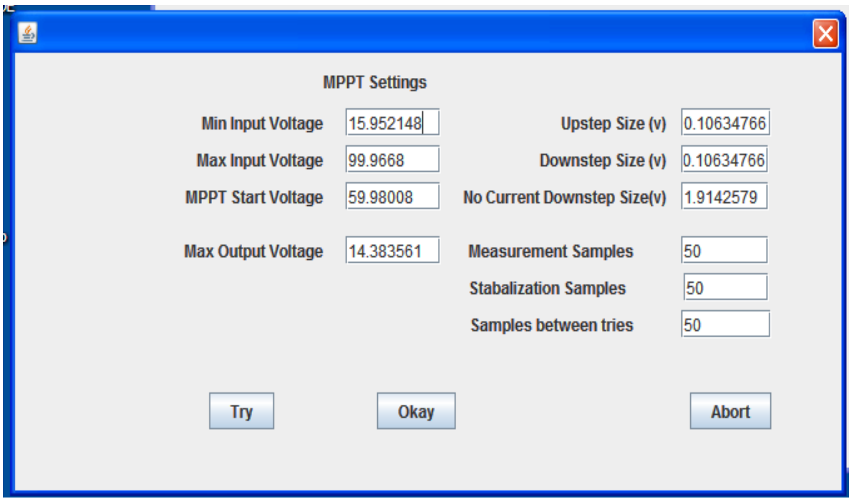
RPM: If an RPM sensor is wired into the controller board, this display shows the revolutions per minute.

There is a menu bar at the top of the control window with 3 menus: Controller Settings, Graphs and Admin. The control settings menu allows you to open 3 different windows for adjusting how the controller works.



MPPT Settings Window

The MPPT settings window is opened by selecting the 'Adjust MPPT Settings' option in the control window's menu.   It looks like this:



All settings in this window effect MPPT mode, and only MPPT mode. The fields are:

Min Input Voltage: This is the lower limit for how low a voltage the MPPT algorhythim will go. At a minimum set this above your max battery voltage. If you are attempting MPPT with a turbine, then you'd probably set this higher to avoid stalling the turbine. The units on this entry are volts.

Max Input Voltage: Generally this can be set to the limit of the controller board which is 100v (or 200v). If you want to keep the voltage lower for safty reasons, it can be set lower. The mppt alg will not exceed this voltage, and will increase the duty cycle if necessary to keep the voltage lower. The units on this entry are volts.

MPPT Start Voltage: When the input voltage is below the min input voltage, the mppt alg goes into off mode.   Then the input voltage comes back up, instead of hunting from the low voltage, it will start at this Start Voltage. This allows the user to 'suggest' that the MPPT start looking for a peak power point at a higher voltage first. For turbines this also allows the turbine to spin up before the board starts loading it. The units on this entry are volts.

Upstep Size: This setting determines how big a step the MPPT alg will make when hunting in the upward direction. The units on this input are volts.

Downstep Size: This setting determins how big a step the MPPT alg will make when hunting in the downward direction. The units on this entry are volts.

No Current Downstep Size: If the voltage set point is so high that its above the sources open circuit input voltage, no current will flow. In this case you want the controller to lower the voltage more quickly so that it gets in a range were it at least sees some power and can start fine tuning. This step size happens when the controller sees no current. The units are volts.

Measurement Samples: This entry determines how many samples the controller will average to make it's power measurements. In the controller firmware, a sample happens every 8ms. So averaging 100 samples would be averaging for 800ms, 1000 samples, 8 seconds, etc. This input can range from 1 to 32000. For solar panels a value of 50 seems to work fine. For wind turbines, much larger values are needed.

Stabalization Samples: This entry determines how much time (in 8 ms samples) the controller will wait after making a voltage adjustment before it starts to make a measurement. Solar panels react almost instantly so this number can be small (50). Wind turbines have inertia and need a much longer time to react to changes.

Samples between Tries: If you think about it, if the controller is constantly trying new settings to see if it can find a better one, then it only spends 50% or less time on the best power point that it found. This setting lets you increase that time. When the controller believes it's on a peak power point, it will wait this many samples before it tries to hunt again. So by setting this to 1000, it will spend 8 seconds on a good point before it looks for something better.

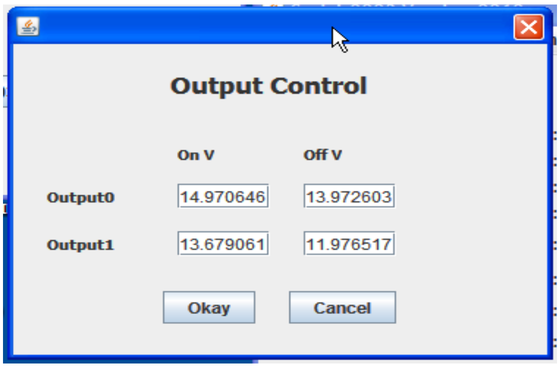
Try Button: If you hit the 'Try' button, the current settings will be applied and you can see how they work. Yet the MPPT settings window remains open so you can still cancel and return the settings to what they were.

Okay Button: Hitting okay will program the settings into the controller, and close the MPPT settings window.

Cancel Button: Hitting the cancel button will undo all changes to the settings and close the MPPT settings window. Use cancel if you did a try and didn't like the results.

Output Control Settings Window

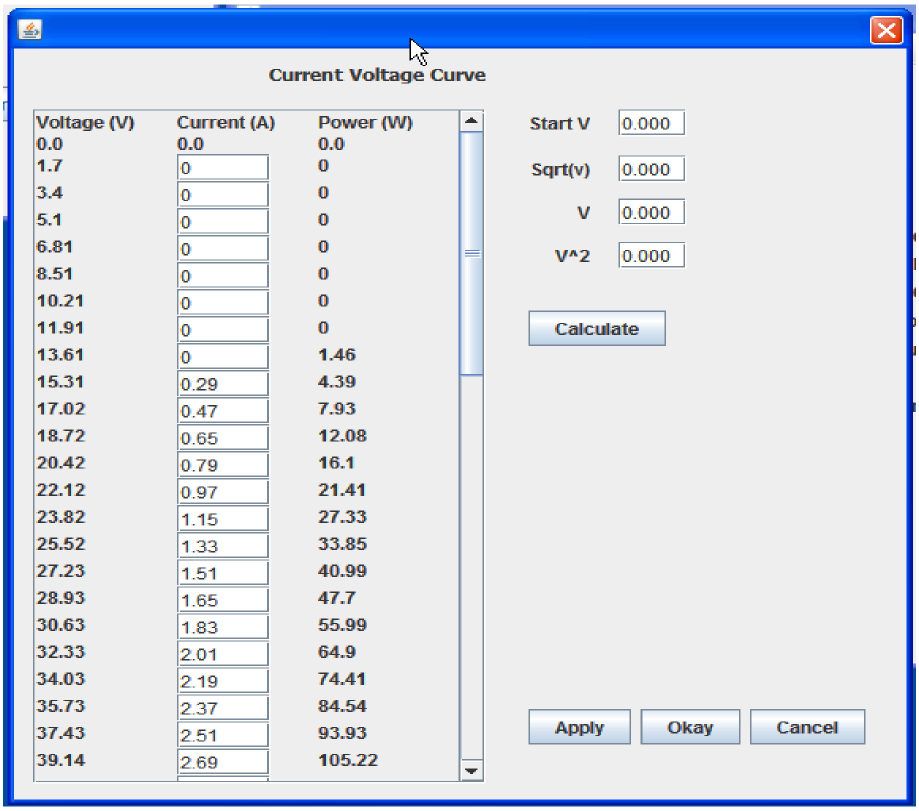
The output control settings window is opened by selecting the 'Output Control Settings' menu option in the control window's menu. It looks like this:



Each output has an On voltage and off voltage. When the battery (output) voltage exceeds the on voltage that output will be turned on. When it goes below the off voltage, it will be turned off. When the controller first boots, all outputs are off until they exceed their on voltage. Hit Okay to keep the settings, or Cancel to discard the new settings.

I-V Curve Settings Window

The I-V Curve settings window is used to edit the curve that the controller will try to follow in i-v curve following mode. This window is opened by selecting the "I-V Settings" menu option in the control windows menu. It looks like this:



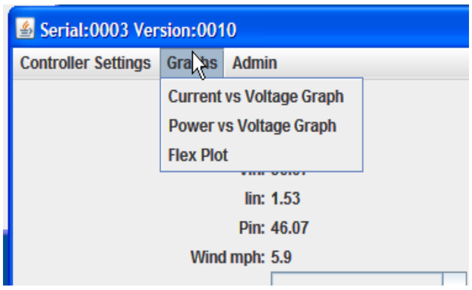
On the left is a scollable list that allows the user to enter a programmed current for each voltage point. There are 62 programmable points between 0 and the max controller voltage.

Entering invidual points can be a lot of work and time consuming, therefore a shortcut method has been provided. Using the StartV, Sqrt(v), (V) and (V^2) blanks a curve can be calculated and automatically entered. The curve will be generated with the equation: I = n * sqrt(v - StartV) + m * (v – StartV) + p * (V – StartV)^2. Enter the numbers into the blanks, then hit Calculate to have them populate the table.

The Apply button is used to make the table take effect without closing the dialog box. (Like Try in the MPPT window.) If you like the results, hit okay. If you don't change the table or hit cancel to return to the previous settings.

Graph Menu

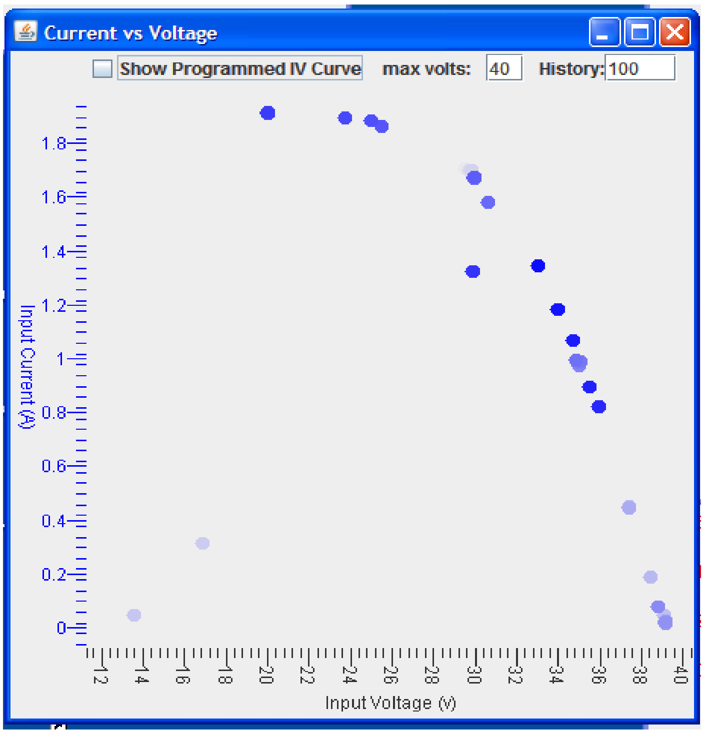
The control window's graph menu can be used to open several different types of graph windows.



These include the Current vs Voltage Graph, Power vs Voltage Graph, and the Flex Plot.

Current vs Voltage Graph

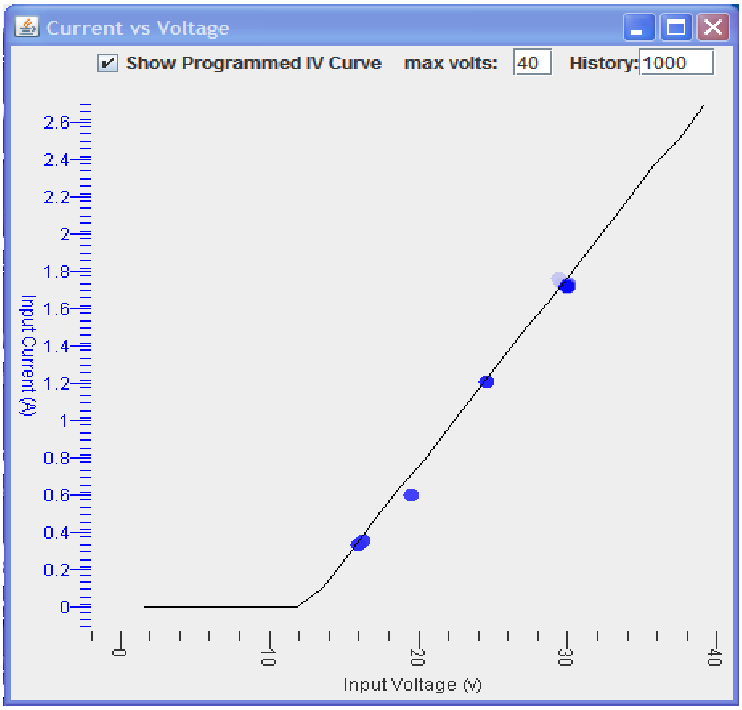
The Current vs Voltage Graph looks like this:



For every sample, a point is put on the graph based on input voltage and input current. The newest points are dark blue and the oldest points faid to white. As points are added and removed, the scales automatically adjust. Control inputs are:

History: This is the number of points to keep on the graph. If the history is set to 100, then points will be added until there are 100 points on the graph. After that when a new point is added, the oldest point is remove. The graph can be cleared by temporarily setting the history to a small number like 5.

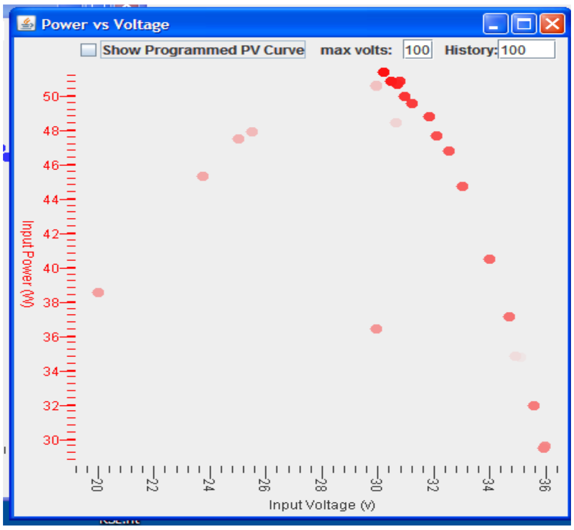
Show Programmed IV Curve: Checking this box causes the IV curve that's programmed in the controller to be plotted on this graph as a line. The curve is plotted from 0v to the number in the **Max Volts** blank. Using the Max Volts to control the plotting range, allows the user to see only the range of the programmed curve that is important for his turbine. Here is an example:

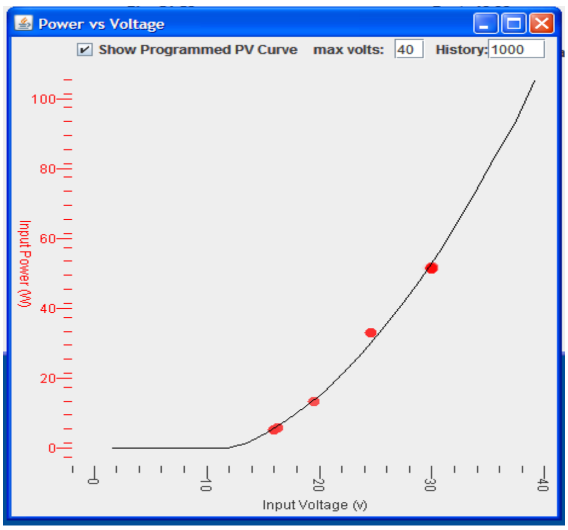


If the Max Volts were set to 100, then the line would have been drawn to 100v, pushing the scales to a much larger range, and making the I-V points harder to read.

Power vs Voltage Graph

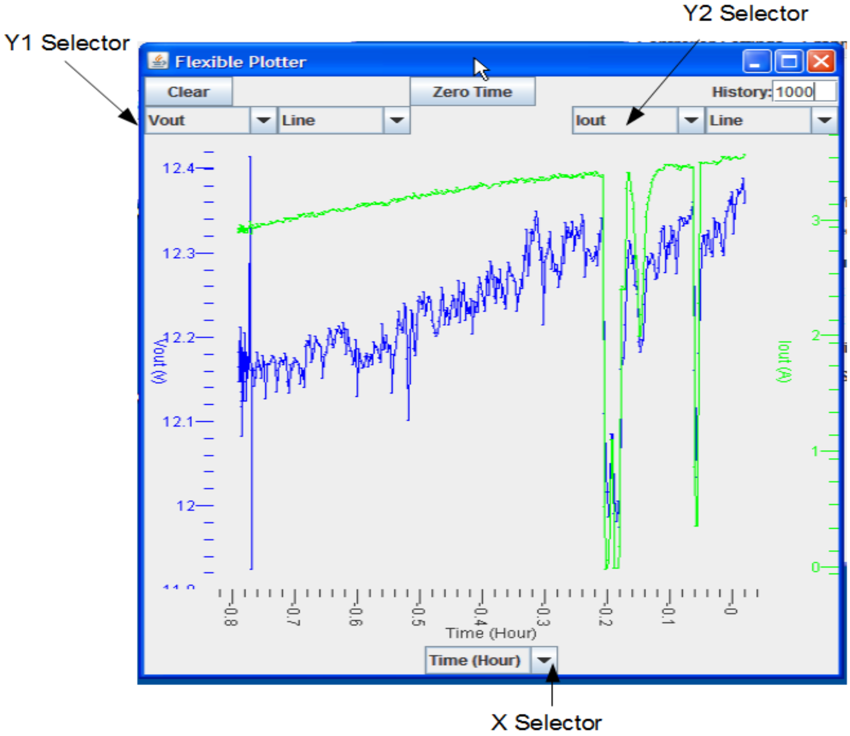
The Power vs Voltage graph is functionally identical the the Current vs Voltage graph except that it plots power vs voltage instead of current. The color is also red to make it easy to distinquish the two types of graphs.





Flex Plots

The final and most useful type of graph window is the Flex Plot. The Flex plot window allows the user to plot anything vs anything in two different styles. Unlike the other graphs, many Flex Graphs can be open on the computer at one time, each set up to display different data. The flex plot looks like this:



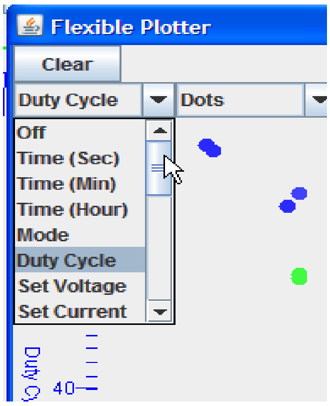
The controls of a Flex Plot are:

Clear: Erases all the points off the graph

Zero Time: This is useful if time is one of your axis. Time by default is zero when the Flex Graph is opened. However if you want to zero the time (Maybe to make the time on several Flex Plots agree), you can do it with this button. Since after zeroing time, time will jump backwards to zero, it's usually best to clear the graph right after zeroing time.

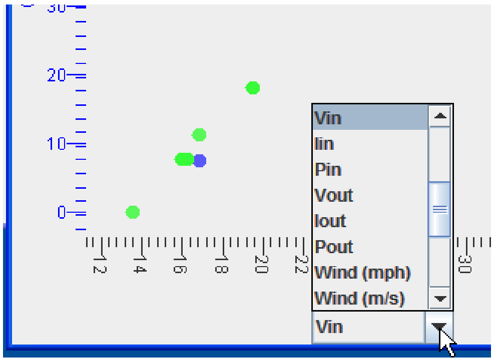
History: Like in the other graphs, this entry determines how many points are shown on the graph before older points are removed. The history can be set to numbers as large as 5000. (Maybe larger depending on computer power.) The Flex Plot system automatically keeps an internal history of 1000 points, so you can change the graph history up and down (or any other setting) and instantly see the data. If you want a history larger than 1000, then you'll have to wait for the additional points to come in.

Yselectors: These drop down menus are used to select what type of data is represented by the Y axis. You have the choise of many items including: Time (sec), Time (min), Time (hours), Mode, Duty Cycle, Set Voltage, Set Current, Vin, Iin, Pin, Vout, Iout, Pout, Wind (mph), Wind (m/s), Pref, Pmean, Ptot, Load0 State, Load1 State, Fan State, and RPM. Selecting 'Off' disables that Y axis. The Y1 data is plotted in blue, and the Y2 data is plotted in green.

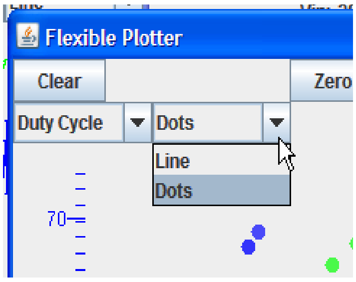


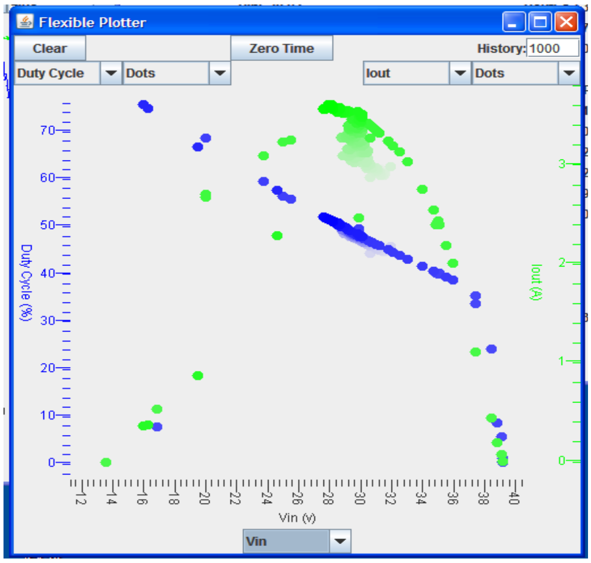
There are more options than show in the tiny menu, so you have to use the scroll bar to get to them all.

XSelector: Similar to the Yselectors, the X Selector is used to choose what type of data is represente by the X axis. This menu includes the same choices as the Yselectors. If you choose 'Off' Nothing will show on the graph.



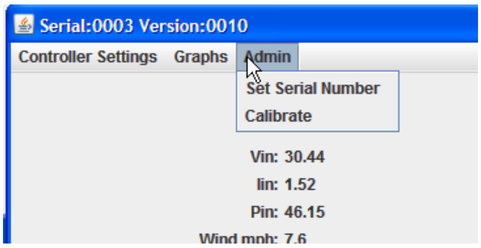
Line / Dots Menus: Each Y axis can either be plotted as lines or as fading dots. The Line / Dots menu lets the user select the style used. Plotting one set of data in lines and the other in dots is allowed. Here is an example of Dots mode:



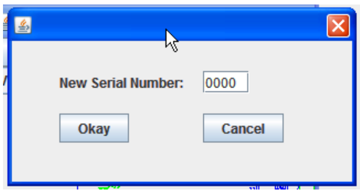


Admin Menu

The last menu in the control window is the Admin menu. This menu generally contains things the average user should stay away from. This menu may not even be available in the final version of software, but I'm leaving it for the testers.



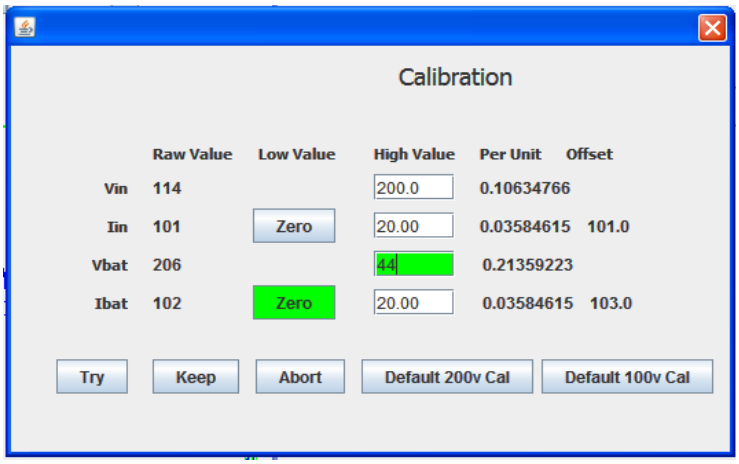
Set Serial Number Window



The user should never have to set the serial number of his board. However I have seen a rare bug at least once where the board forgot everything, including it's serial number. So this window would be used to reprogram it. Just type the number in and hit okay. Hit Cancel if you don't want to change it. When the board forgets, it's serial number becomes FFFF.

Calibration Window

This window can be used to adjust the calibration that's store on the board.



The calibration window is written so you can enter all or just some of the information, and still improve the calibration of the board. Controls are:

Iin Zero: Disconnect the turbine so that no current is flowing into the board. Then hit this button to record the zero of the current sensor. This button (as all other entry points) will turn green to indicate that a data point has been registered.

Ibat Zero: Again of you disconnect the turbine, no current will be flowing through the buck converter. Hit this button to record the zero level of the output current sensor.

Vin High Value: If you can set up your system to give you a nice constant input voltage, feed in a constant and significant (not close to zero) voltage. Let it stabilize for a few seconds and type in the voltage you are putting in and hit return. This will record the raw units for that number of volts.

Vbat High Value: Measure the battery voltage and enter the number here and hit return. Alternatively don't use a battery, but feed a power supply into these terminals so you can put in a higher voltage (up to 60v) for more accuracy. Just make sure the turbine is disconnected and any device on the outputs that might not like the high voltage.

Iin High Value: If you can set the system up to give a nice constant current then measure the input current, enter the actual number and hit return. Often it is helpful to go into Fixed Duty Cycle mode to provide stable currents for measurement.

Iout High Value: If you can set up the system to give a good constant output current, measure the current and enter the actual value in this blank and hit return.

Try: Hitting this button will apply the new calibration values without making them permanent (or erasing the old values.). Always try your new calibration values.

Keep: This button will program the new calibration values into the controller, erasing the old cal values, and then close the window.

Abort: This button will close the calibration window without making any changes to the controller.

Default 200v Cal, Default 100v Cal: If for some reason your contoller loses it's calibration information, and you don't have the proper equipment to do a real cal, you can hit one of these buttons (depending on if you have a 100v board or 200v board), to put in standard calibration values. These will be accurate to about 5%.

Every board is given a good factor calibration using power supplies before it is shipped. If you don't have the right equipment to make the measurements, it's best not to mess with the calibration. The most useful values to adjust in the calibration window are the zero current levels. These can be adjusted safely without touching anything else.

Note: all settings in the controller board are stored in raw units, not calibrated values like volts or amps. This means that if you recalibrate the board, the settings will stay exactly the same, but the numbers in the settings windows (volts, amps) will reflect the new calibrations. Check all your settings after you calibrate to make sure they are still what you want them to be.

Top 8 Ways to Ruin your Controller Board

1) Hook the battery up backwards so + / - are reversed. This is not good, and even a battery fuse will probably not save the board.

2) Short the DC terminals. Battery current will flow backwards through the board and cause several transistors to get very hot. A battery fuse may save you on this one. (Shorting other terminals is also not good.)

3) Walk up to the board with a big static charge on your body and touch the board or it's connections.Your body can charge up to 1000's of volts. Winter Jackets are infamous for building up this type of charge. Microelectronics and MOSFETs are very sensitive to high voltage. If you are lucky the jolt will only make the microcontroller forget it's programming. If you are unlucky the mostfets will turn half on causing lots of heat and excitement! Always ground yourself, or touch the negative battery terminal before touching the board or it's connections. Putting the board in a box, especially a grounded metal box will help prevent this.

4) Connect an out of control turbine to the controller. The controller is very good at keeping a turbine under control, but when connected to a turbine that's already spinning out of control, it may take several hundred milliseconds for the controller to get control. A lot of damage can happen in 100 ms. Hopefully the hardware limiting circuit would protect the board, but there is no reason to test it. Short the turbine to get it down to a reasonable speed before connecting to the controller board.

5) Disconnect the battery while power is flowing through the board from a turbine. The buck converter depends on being able to dump current to something at it's output. If the battery is disconnected, the voltage at the output can spike to 100's of volts. I have components on the board to try to protect against this, but they can only absorb limited amounts of energy. Don't put them to the test.

6) Connect a high voltage turbine before connecting the battery. The board needs the battery as a place to sink voltage. If the battery isn't there the high voltage of the turbine flows through the board to the battery terminals and violates the 60v limit. Components on the board will try to absorb the over voltage, but they can only take limited energy.

7) Try to program in someone else's firmware into the board. Bad firmware can easily turn transistors on in combinations that cause direct shorts across the battery. The results are transistors unsoldering themselves in seconds. I know because many boards were destroyed debugging firmware.

8) Run high powers (500w) through the board with no fan. As transistors get hot, they work worse and worse, and as a result get hotter. It's possible to hit the point of no return. This is called thermal runaway. I don't know the limits of the board because I don't have a source to push it hard enough. Just watch your temperatures. (But be careful about feeling things to see if they are hot, there are high voltages all over the left side of the board.) I use an IR thermometer that I got for about $15.00.

While learning to use the board, I highly recommend putting a 50 watt halogen bulb in series between the controller board and the battery. If you do something that shorts the board, the bulb lights instead of the board smoking. You won't be able to hook anything big on the outputs but for the first experimentation, it's a very good way to protect the board.

Also the most risky time for the board is when it's first connected to the battery because of the (slight) chance that it boots improperly. (I've never seen this on V3) The board uses about 1/3rd watt and can run for months on a car battery. I just leave my controller connected to the battery 24/7.