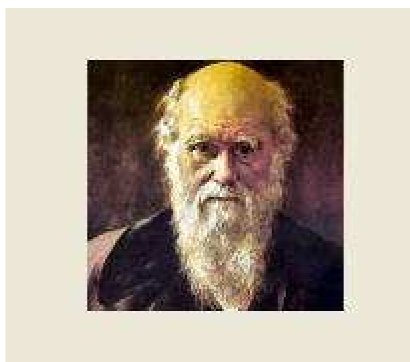
Darwin pulse engine users manual.

Version 1.00

The care and feeding of the DARWIN printer port pulsing engine.



Introduction:

The Darwin engine is designed to drive up to 9 step/direction motors and up to 128 input signals, 128 output signals and a maximum of 12 encoders on up to 4 printer ports in a 32 bit Windows OS. Successful usage has been reported on XP, VISTA and Win7 systems.

With the advent of Mach4, plugins for the Mach series must allow for a full configuration of their hardware rather than rely on a generic setup capability from within the Mach core. This means that a user must setup their hardware from within a plugin specific to their hardware and with each motion control plugin being different, manuals will be a requirement in Mach4 to allow configuration to be completed properly. This manual will therefore deal with configuration of whatever hardware you have connected to your system in terms of its connection points through a printer port to the controller software. Please keep in mind that further configuration or scripting may be further required under the Mach4 core program for final use. This manual will deal only with the issues involved in getting data streaming between Mach4, your hardware and back.

Darwin is likely the last of the Windows printer port timers. As the historically ubiquitous 25 pin printer port has now become rather rare and the Microsoft OS's more difficult to trick into real-time operation, the requirement for printer port operations is slowly going away. Darwin then, is released in hopes of allowing those who wish to keep printer port based machines running as long as possible a path for upgrade to a hopefully more stable platform in the future.

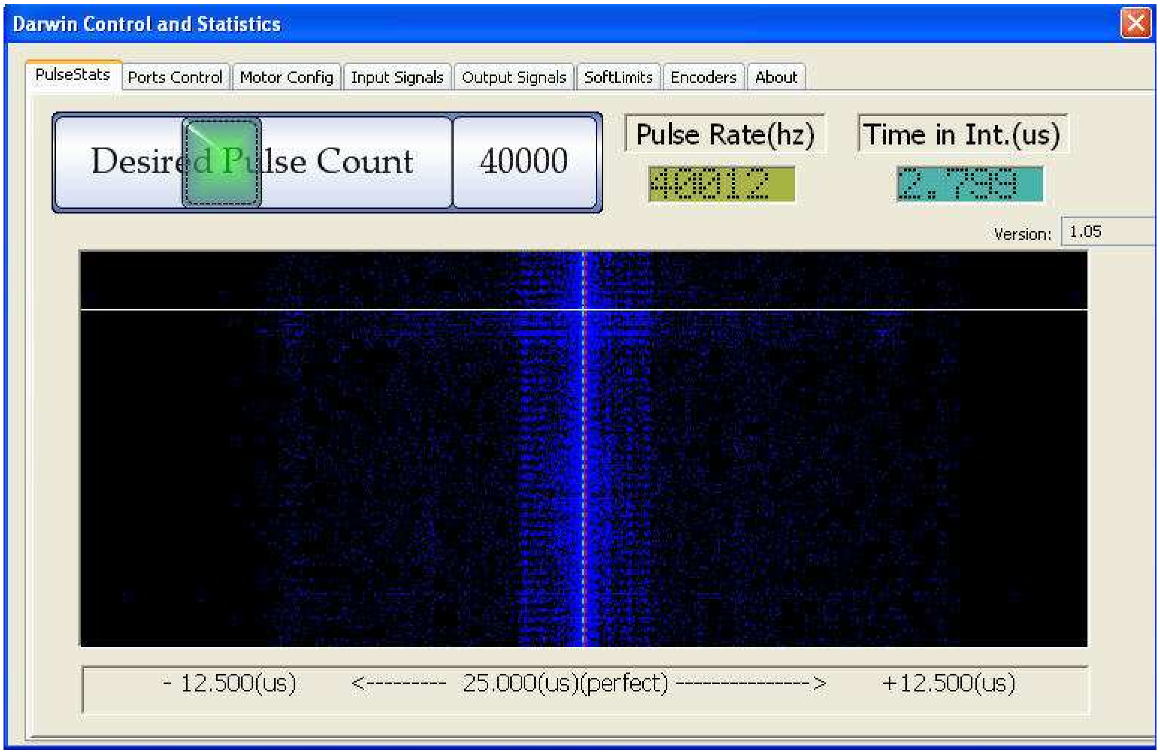
1.0) Installation:

Installation of the Darwin driver is automatically done when installing Mach4. See Mach4 documentation for specifics of installing the printer port driver option. Once installed, you need only to select the plugin as your main driver from within Mach4.

Configuration:

2.0) Pulse Frequency and Main Diagnostic:

Darwin's configuration can be selected from within Mach4's config menu .Once selected you'll be presented with the main diagnostics graphic. (Fig. 1)
From this screen you can determine a bit about how your system is reacting to the driver as well as set the primary drive frequency you will use for your system. The only configuration item available on this screen is the selection of the drive frequency. Sliding the slider labeled "Desired Pulse Count" will change the driver's timer as it slides. **Be cautious of running it too fast,** if your system cannot handle a very high speed you can cause your system to lock up by sliding it too high**. It is advised to set it to 40,000 or less** unless you know you specifically require a higher speed.



(Fig 1) – Main Diagnostics Screen

2.1) **Diagnostics**:

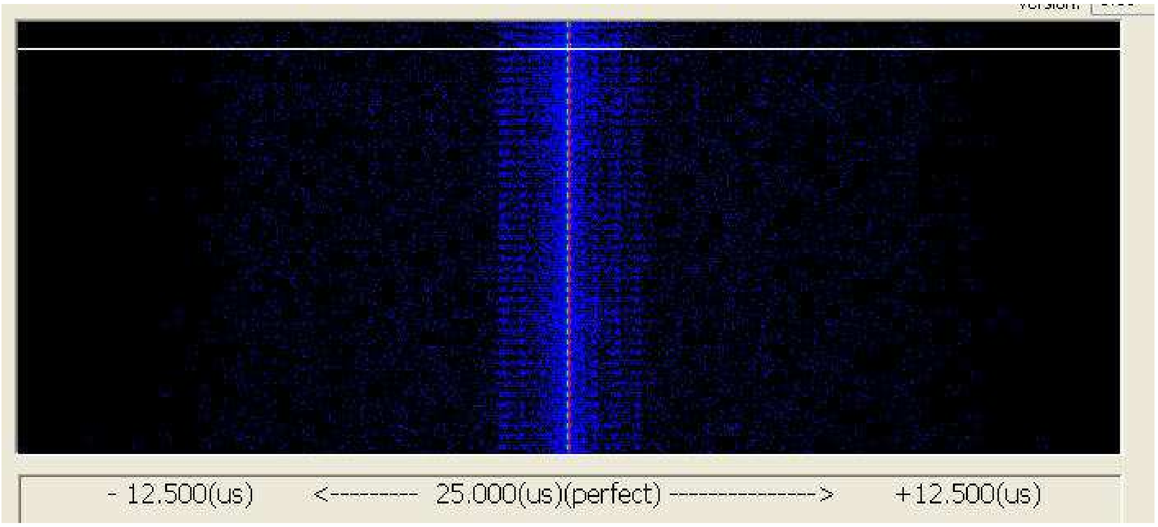
This screen also has a diagnostic function. It is used to give an idea about how your system is reacting to a printer port driver. Not all systems respond well to such a driver. Mach3 experience has shown over 95% have no issues, however that 5% with trouble is still a very large number of machines, so it's a good idea to have a general knowledge of how your system is doing in terms of stability.

The above graphic indicates a system running a timer very well. First, the actual pulse rate measured is 40,012 where 40,000 is commanded. This is an error of only 0.03%, which in terms of commanded speed is very tight. There is no accepted answer as to what percentage would be considered intolerable but I would expect if you have more than 1% off from target a problem likely exists. See final **Debugging** topic for suggestion of what to do if your numbers are off from expectations.

Also on this screen is a number showing the time in interrupt. in microseconds. This is the amount of time the driver is taking to do its job once starting the interrupt cycle. If this is too large the system is being stressed, usually by too many ports or too many signals being used. Again, since the number of ports and/or signals one can use depends highly on the speed of your system its hard to pin a number here. However, if the number hits the time between interrupts you will lock up your system. For example, the setting above is 40,000 pulses per second, if we divide that into 1 second we find each interrupt will happen 1/40000 = .000025 second or 25uS. So if the "Time in Int" hits 12.5us, we

are using 50% of the system time for pulsing activity. That's probably quite acceptable, but at 25us the system will lock up, so it's best to keep this at a maximum of 50% as a typical number. As you can see on my system, its at about 2-5us typically.

That confusing looking blue screen (fig 2):



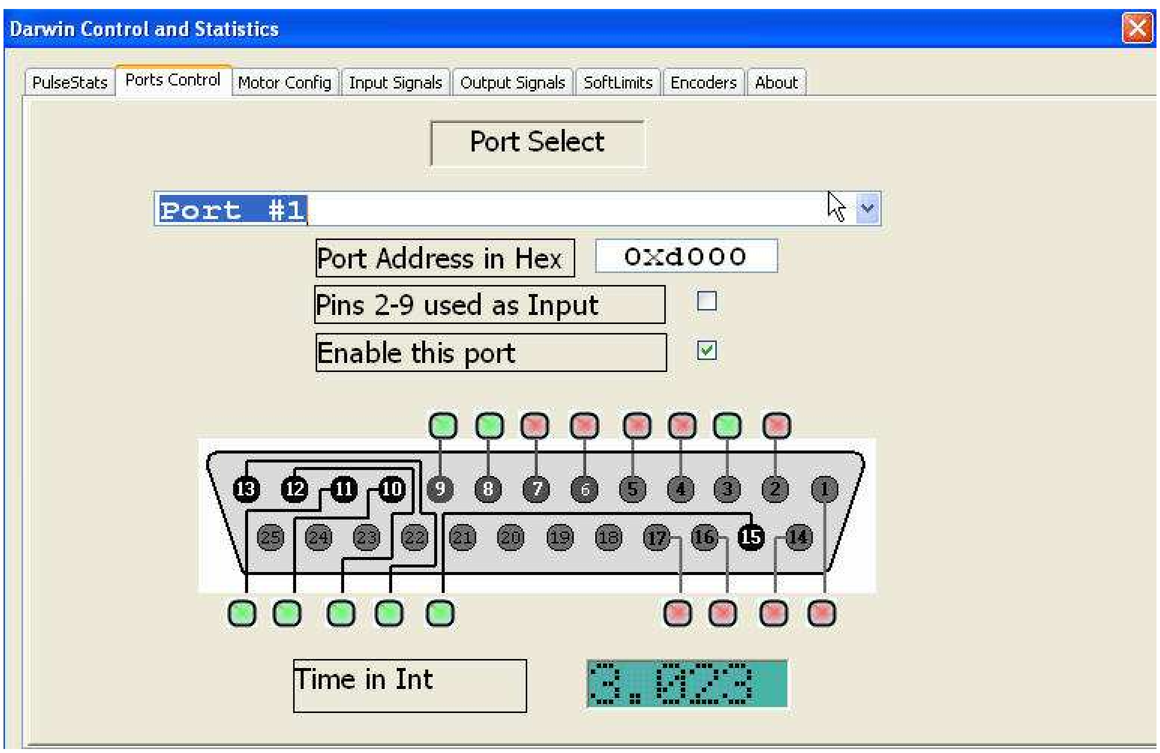
(fig 2) Timer history plot.

This confusing screen is the historical plot of how your timer is doing over the past few seconds. Not too confusing at all once you know how it is made. Each interrupt period a series of statistics are taken. One of them is the amount of actual time passed since the last interrupt. Ideally as we figured out in the last second, each interrupt should be occurring 25us from the time of the last one. This graphic plots on each horizontal line the times of several thousand interrupts. If multiple readings show the same time (ex: 25us) then the dot for that point on the line gets brighter. Hence, on a well functioning system a bright line should be in the dead center at 25us (at 40,000 pulse count).

In any timer a decision must be made when an interrupt is late. Say we have a 25us timer, and for whatever reason (ie: DMA access..etc) an interrupt is delayed by 3us so it comes it at t = 28us. The timer must now decide what is best, to wait 25us for the next interrupt, or to wait only 22us so that in the end the average will still be 25us. Darwin is a periodic interrupt, so for each late interrupt one is expected to be early. This is a good thing in CNC as it helps time variances in a timer to be ignored by a stepper motor since the steppers phase relationship tends to be kept in better sync with the shaft. What this means is that for any late interrupt, we should expect an early one to follow. This IS happening if the plot shows a bilateral symmetry. The above graphic shows that nicely and is the expected response of a well running system. We can also see the major variance is about 2us or so either side of center which is again a very good statistic. The largest variances appear as small low intensity dots at around 12us, but they happen rarely enough not to matter. That is about all this screen can tell you, but that's enough to judge if the timer is working well or not. If you have a similar graphic on your screen as the one displayed here, then you should be able to achieve good output for your CNC system. If the screen is one color (normally red) it means the timer is not yet running or for some reason is unable to start its interrupt sequence.

3.0) Ports Configuration:

Figure 3.0 shows the ports configuration tab for Darwin. This tab configures up to four ports to be used for your timer. Typically only 1 port is used in cnc operations for a hobbyist but two ports are getting more common and rarely more than two are required. While Darwin can handle up to four ports it is suggested that timing limitations on most systems will limit you to 2 ports. Each systemic read or write of a signal takes valuable system time (Time in Interrupt) so the limiting factor will be the total number of inputs and outputs used. When enabling ports keep an eye on the "Time in Int" display to ensure it does not get too high and try to keep it less than 50% of the total interrupt time.



(Fig 3 – Port Configuration)

The drop down list box shows the current port you have selected. The port address used for that port can be found in your systems device manager for that port and shows the resource address required. On many systems this will be the legacy address of 0x378 however this may vary between systems. Shown in fig 4 is my own system which uses a PCI Lava Printer Port. As you can see my port selection of 0xd000 came from this resource allocation. The “0x” portion of this number indicates the address is in hexadecimal which is the standard display of such port addresses.

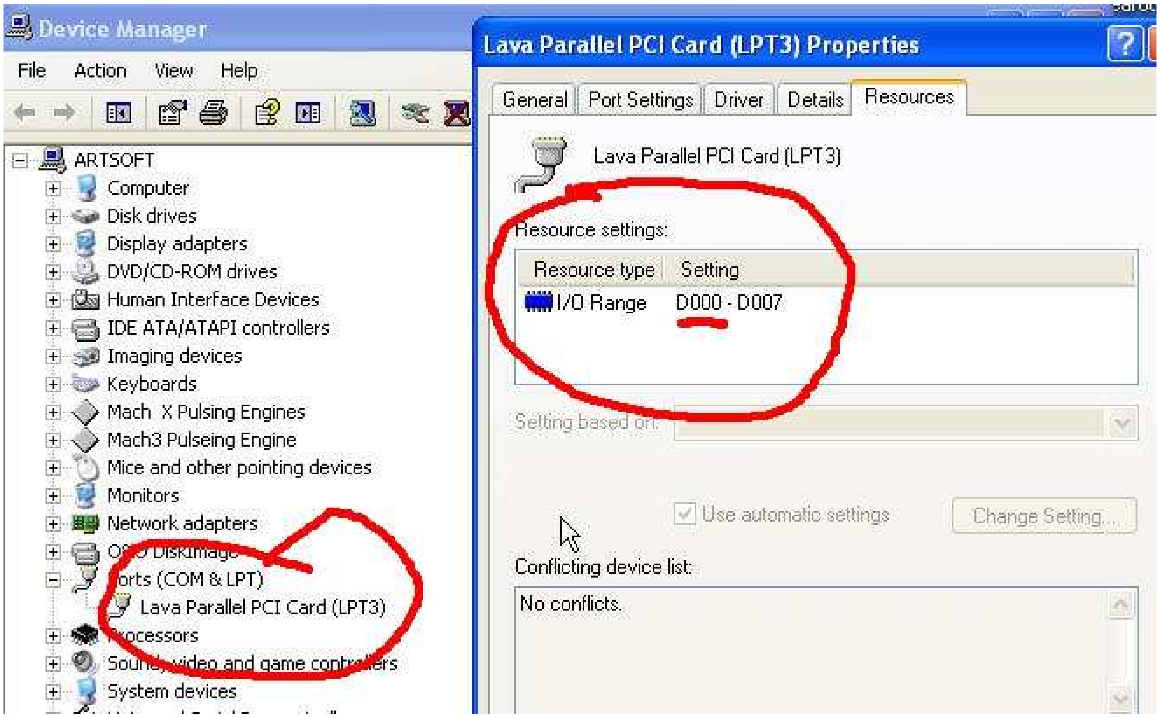


Fig 4 - device manager example of port address. Right click on Lava Parallel to select “show properties” to get this menu.

NOTE: TURN OFF YOUR CNC MACHINE DURING INITIAL CONFIG OF DARWIN.

It is possible during config to have the ports put out values which can for example turn on spindles or move motors, for this reason before configuring Darwin please ensure all power to your CNC machine is switched off , or unplug the printer ports from their cables.

Once you have changed the address of the port (if you have to), you can decide if this port will be used as inputs or outputs on its pins 2- 9. Typically leave this set to output unless you’re aware of how to use such pins as input. Check the box to use them as inputs. Checking the Enable box will instantly enable this port. You will get a warning to that effect and if , after saying its OK to turn on that port you find the system locks up or reboots check very carefully the port address was correct, an incorrect address can cause very serious run time problems in Darwin.

You may repeat this process for up to 4 ports, but as mentioned earlier keep your eye on the time in int statistic and keep it below 50% of interrupt total time allowed. (Which is (1/kernalfreq) * 0.5) or 12.5us at 40 KHz pulse timing.

Diagnostics Value:

This screen is also valuable for diagnostic purposes. The LED's on the graphic will Display current pin levels on all ports. This is the true low/high reading for that port and do not reflect options such as signal inversion. These pin LED's are a good way to test if a home switch or other signal is being seen by the printer port and should be step #1 in determining why a signal is being ignored or not seen.

4.0) Motor Configuration

Figure 5 shows the Motor configuration screen in Darwin. In this screen you may turn on and diagnose up to 9 motors. Each of these motors can be axis motors or can be set as off axis motors such as Spindles that run asynchronously from axis operations.

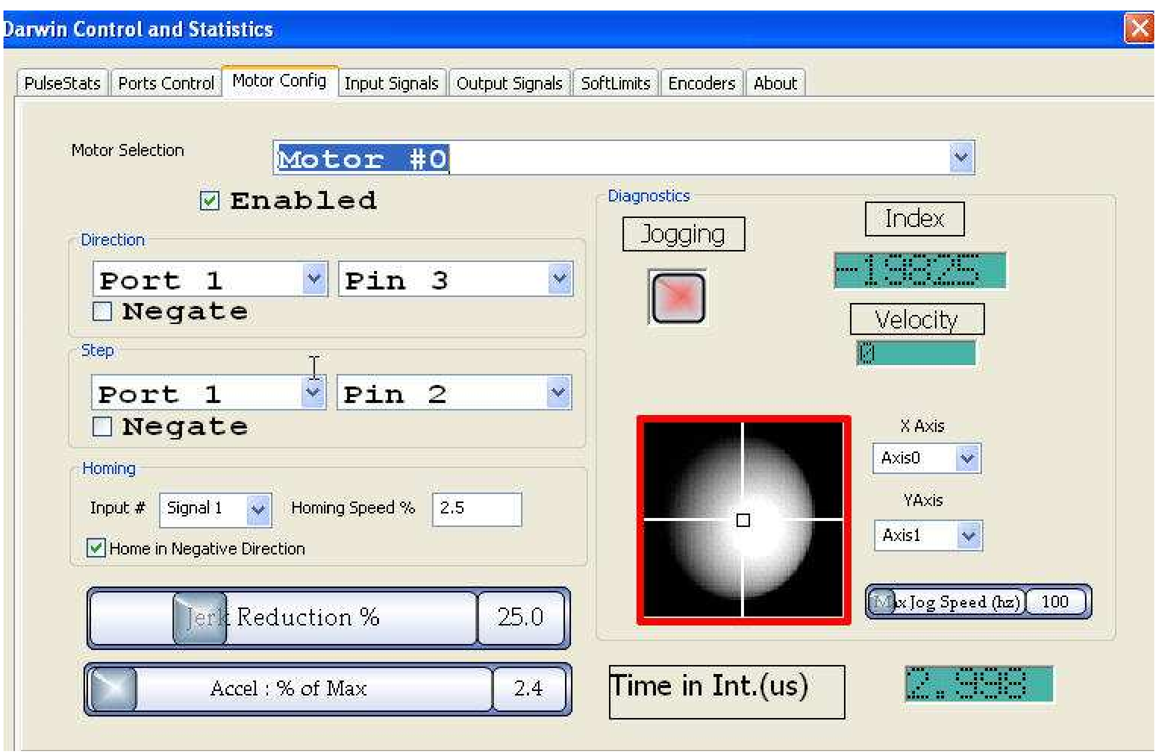


Fig 5 – Motor Configuration

The first setting is the actual motor you wish to configure. This is a drop down list with motors labeled from 0 to 8 for a total of 9 motors. Normally one should consider motors 0, 1 and 2 as the X, Y and Z motors. See Mach4's documentation on motor to axis numbering considerations if any exist on your system.

For each motor you will run repeat the following settings.

1) Set the Port and Pin for the Direction signal for this motor.
2) Set the Port and Pin for the Step signal for this motor.
3) Check the Enable Box for this motor.
4) If the step or Direction signal needs to be inverted check the Negate box for that signal. If, in general operation the motor is going backwards to expected operation check or uncheck the Negate box for the Direction pin for that motor.
5) Set a Homing input number if desired. You may wish to come back to this setting as you may not have yet set the input signals. This setting basically ties an input number to an axis as its home input signal. Homing is a Darwin Function so it needs to know what switch, if any is the home switch for that axis.
6) Ignore for now the other settings on the page. These are described below but are not required during setup but instead are diagnostic entries and selection to tune operations once setup is complete.

Diagnostics Value:

Several settings exist on this page for diagnostics work to help in determining a problem or in aid of tuning for smoother operation of your system. Review here the capabilities of these controls so you will know how to use them in general operations, but ignore them during initial setup.

Jerk Reduction and Jerk Acceleration:

This is a sliding control which controls the amount of Jerk Reduction in system jogging. Darwin has a high order jogging control built in. While not used in Mach4 as a jogging facility (Mach4 does jogging with waypoints), Darwin does use jogging in sequencing such as homing or probing. These Jerk controls then control smoothness during those operations and should be tuned after the system is fully setup.

Please keep in mind a Jerk Reduced motion is slower than normal linear speed motion and can negatively affect an operation such as probing as the stop distance can be higher.

If you don't probe however, tune this for best homing response once your system is fully working.

The Jogging LED shows if a jog is in operation. This led should be off unless an axis is jogging currently. If an axis is jogging its velocity (in steps/second) will be displayed. Its current index is shown at all times. The Square box with a globe in it is a mouse jogger used in diagnostics. The system should be fully setup and enabled prior to trying to use this as many things such as Charge pumps or Enable signals can stop this diagnostic from working. The X and Y axis buttons select which motor is tied to what axis in the click box and the Max speed is set by the Max Speed slider to the right bottom of the screen.

5.0) Input Signals

Figure 6.0 is the Input Signals configuration screen. Similar to the other config screens you simply select a signal of interest from the dropdown. Signal #1 is the first signal available and you may select up to 128 of them.

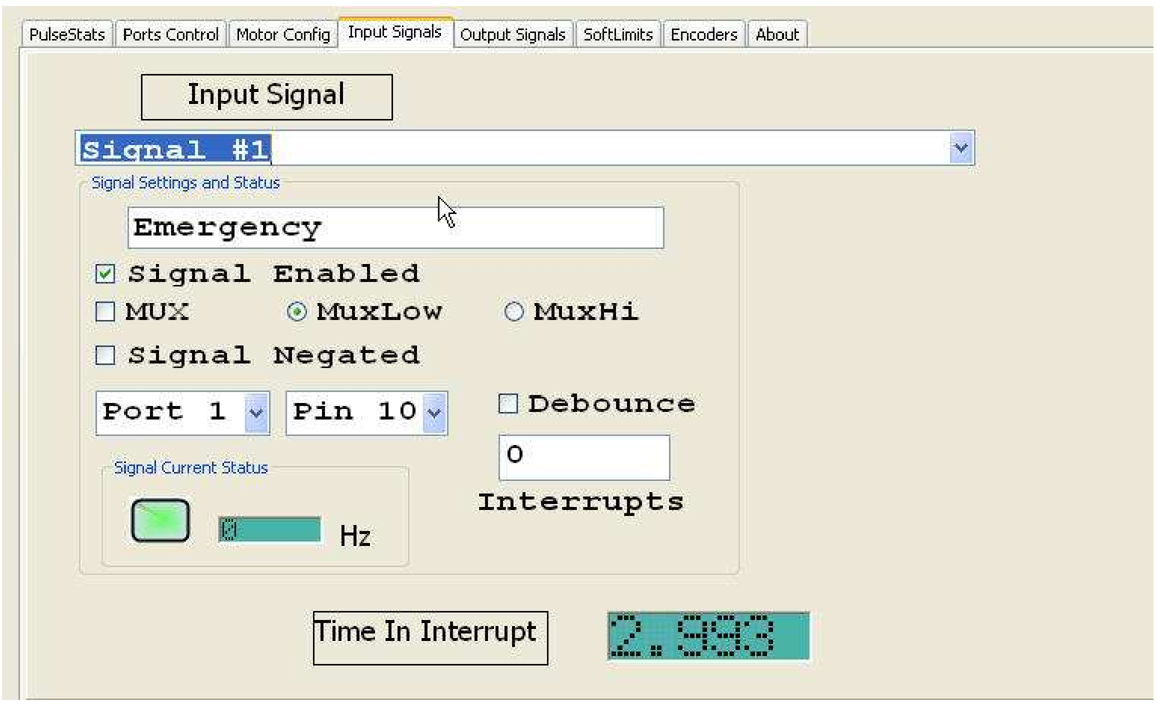


Fig 6.0 Input Configuration

Repeat the following for all inputs to your system.

1) The Name box (currently showing "Emergency") is used to name a signal. The name is unused within Darwin but it is propagated back to Mach4 so that you can select and manipulate signals based on a name rather than an id number. Simply type a new name in this box to store it in the system
2) Check the Enable signal box. Signals not enabled will be ignored.
3) Select MUX if this is a MUX signal. (See following section on MUX'ing)
4) Select Mux High or MuxLow if MUX is checked.
5) Negate signal if you wish "Active" to be considered a low on the pin.
6) Debouce the signal if desired. Debounce tells the system that any signal, to be considered valid, must hold its level a set number of interrupts. This is a type of

noise rejection. Set this to reduce noisy signals. A suggestion of 100 as an interrupt number is reasonable.

7) Select the port and pin for this signal

Repeat for all input signals used.

MUX Processing:

Muxing (Multiplexing of signals) is available for all inputs and outputs of Darwin. In the outputs config of Darwin you may set a Charge Pump output signal. This signal, if available, becomes the MUX control signal. This Charge pump signal has a frequency selection to allow any frequency to be put out.

An input (or output) that is mux enabled will only be put out or read during the time the charge pump pin is currently at the MuxHi or MuxLow setting for that pin. An intelligent breakout board can then use this charge pump to switch in 2 different signals for Darwin to read from one pin or write to any output pin. This process then allows for 2 inputs or outputs from any pin.

Diagnostic Value:

This screen has the indicator for “Current Status”, which will display green for active or red for inactive. It can also show as yellow. Any input has its frequency measured as a matter of input statistics and the hz box will show that signals current frequency.

6.0) Output Signals

Figure 7.0 is the Output Signals configuration screen. Similar to the other config screens you simply select a signal of interest from the dropdown. Signal #1 is the first signal available and you may select up to 128 of them.

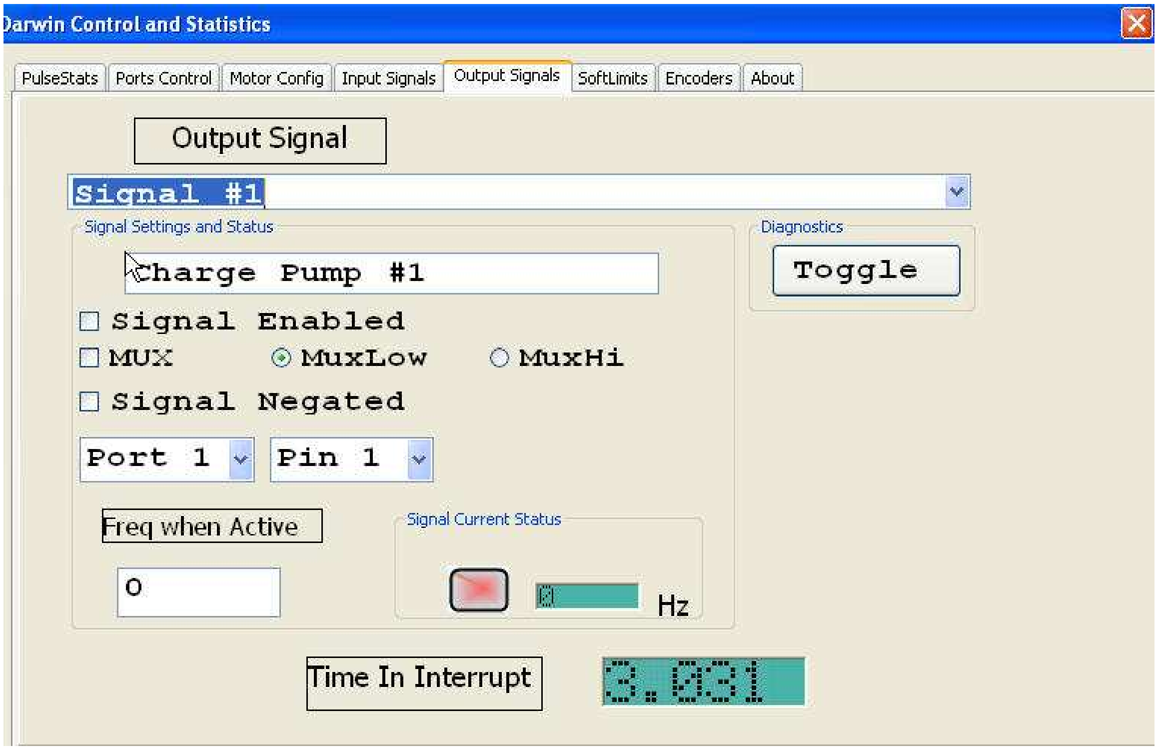


Fig 7 – Output Signals

Repeat the following for all inputs to your system.

1) The Name box (currently showing "Charge Pump#1") is used to name a signal. The name is unused within Darwin but it is propagated back to Mach4 so that you can select and manipulate signals based on a name rather than an id number. Simply type a new name in this box to store it in the system.
2) Check the Enable signal box. Signals not enabled will be ignored.
3) Select MUX if this is a MUX signal. (See input section on MUX)
4) Select MuxHigh or MuxLow if MUX is checked.
5) Negate signal if you wish "Active" to be considered a low on the pin.
6) Debounce the signal; is desired.
7) Set Port and Pin for this signal

Diagnostic Value:

The output state led on this page shows the current state, green for on, red for off and yellow for toggling signal with the "Hz" box showing the current frequency. The Toggle button will force a signal toggle to occur for troubleshooting purposes.

SoftLimits:

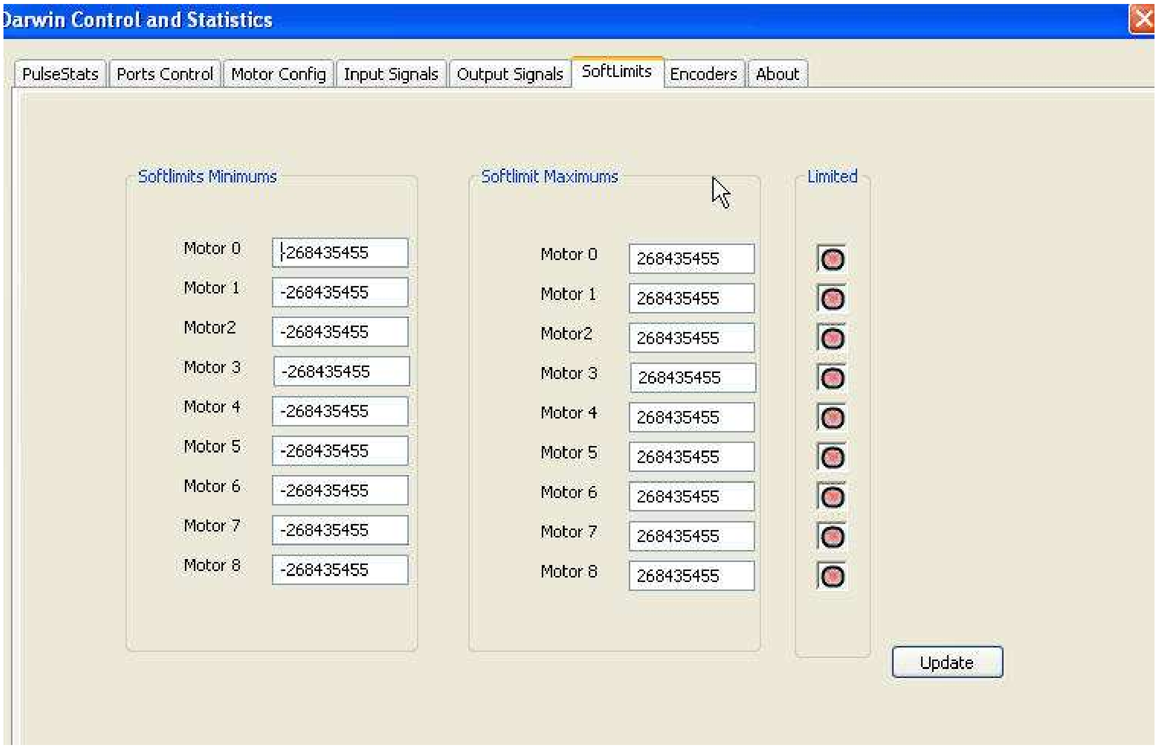


Fig 8 - Softlimits

Softlimits are simply limits that will cause any motor to ignore motion if violated. Currently they are defaulted to large numbers in either direction. LED’s on the right show green if any axis is out of limit tolerance. Hit Update to have the system recheck validity of an axis after changing softlimits. This will not cause an Estop. It simply will cause no motion outside the envelope specified. For example if you tried to cut a circle with a radius of 100mms and your Softlimits were set to 50, you would end up cutting a square 50mm box, not the circle you expect. Use Softlimits only if you always home your machine, its usefulness is dependent on homing being used. The limits are in Steps, Darwin has no knowledge of distance or units of measure, it deals only in steps.

Encoders:

Darwin can record the operations of up to 12 encoders. It doesn’t use encoders for any purpose as yet, but can report them to Mach4 for its usage. See Fig 9.0

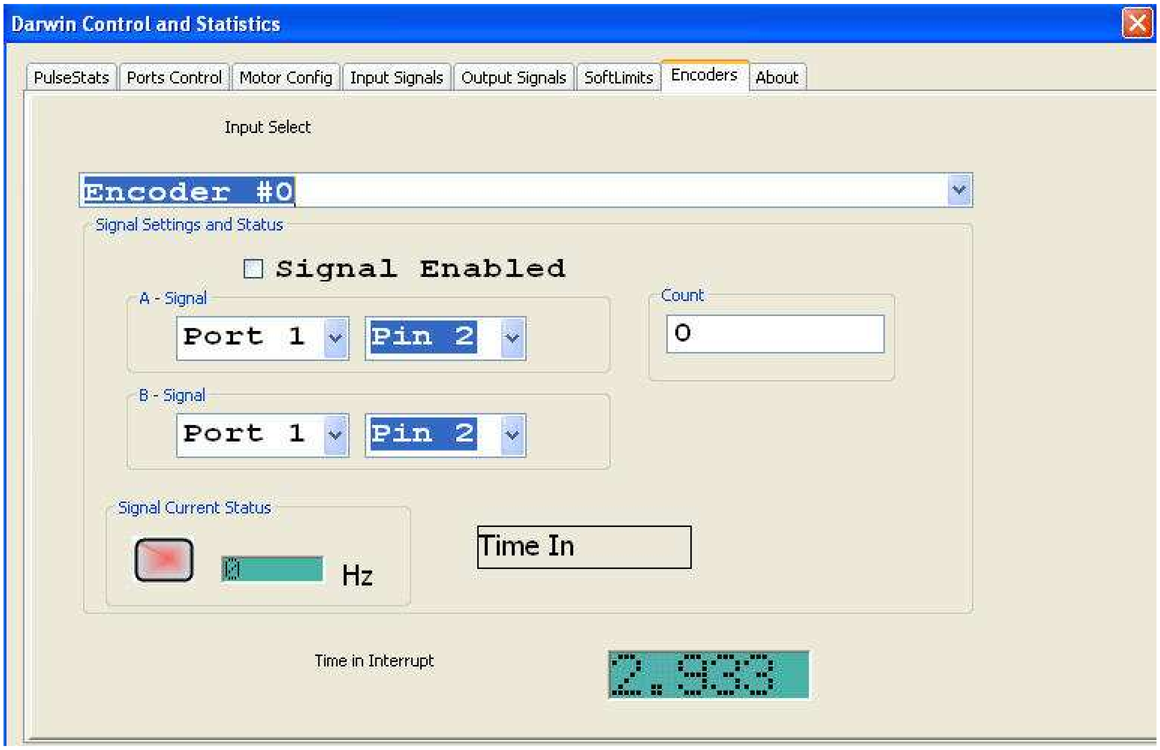


Fig 9 Encoders

To Setup encoders simply repeat the following for each encoder to be set up.

1) Select encoder number.
2) Check Enable
3) Set port and pin for both the A and B inputs. Index is not read by Darwin.

Diagnostic Value:

The current status is used only to show the encoder is turning or not, it is red when stopped and yellow when turning. The frequency is shown in the "Hz" box and the count in the "count" box.

SUMMARY – NOTES