PWM Instructions for Passenger Vehciles

## LCD And PWM Controller Instructions

Main Components

1. The LCD Display/Controller module. This device shows you the important readings of your PWM, and also controls the PWM so that it maintains its constant current maximum amperage. This device should be mounted in the passenger compartment of your vehicle so you can see at a glance what is going on with your HHO system.
2. The PWM itself. This is the actual PWM in an aluminum enclosure that does the work of controlling the power to an HHO cell.

Connection Instructions

The LCD display connects to the PWM with a Cat5 cable. Plug the Cat5 cable into the receptacle in the Display. It gets its power through this cable.

While you are initially setting up your HHO system, it is handy to have the display near your pwm so you can easily monitor what's happening when you are first setting things up. Later, when you have everything working properly, you can run the Cat5 cable into your passenger compartment and permanently mount the display where you can see it.

Connect your PWM to the cell and battery. These are clearly marked on the PWM as Batt+, Batt-, HHO+ and HHO-. Use the 10 gauge wire for these connections. Also see the connection diagram below
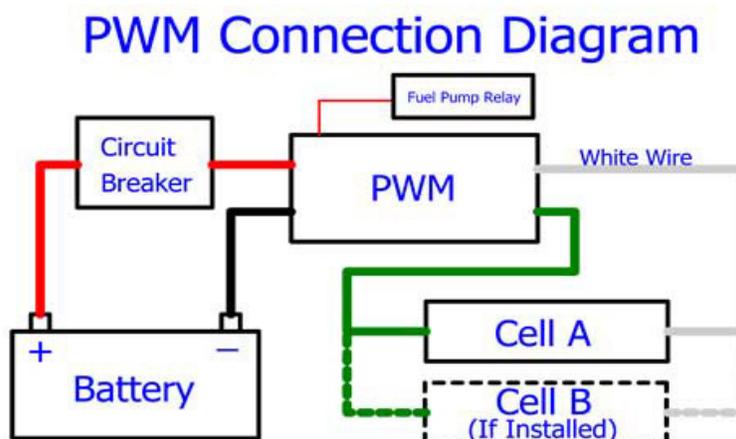
The HHO+ and HHO- terminals get extended to your cell or cells. Don't confuse these with regular power and ground. Once they come out of the PWM they must not be allowed to connect to other power and ground circuits in your vehicle. They must only connect to the terminals of your HHO dry cell.

We use 10 gauge cable for these high current wires for nearly all installations. But if you anticipate long cable runs or higher amperages, then you should use the chart below to determine the wire gauge you should use.

Wire Gauge Selection Table 12 Volt Circuit

AMPS	3'	5'	7'	10'	15'	20'	25'
0 to 5	18	18	18	18	18	18	18
6	18	18	18	18	18	18	18
7	18	18	18	18	18	18	18
8	18	18	18	18	18	16	16
10	18	18	18	18	16	16	16
11	18	18	18	18	16	16	14
12	18	18	18	18	16	16	14
15	18	18	18	18	14	14	12
18	18	18	16	16	14	14	12
20	18	18	16	16	14	12	10
22	18	18	16	16	12	12	10
24	18	18	16	16	12	12	10
30	18	16	16	14	10	10	10
40	18	16	14	12	10	10	8
50	16	14	12	12	10	10	8
100	12	12	10	10	6	6	4
150	10	10	8	8	4	4	2

Small Green Terminal Block

There is a small green pluggable terminal block used for low current connections to the PWM. It's easiest to unplug the terminal block and then install the wires. When you are done, plug the terminal block back in. There are screws you can use to secure the block into the PWM.

Connections

12/24 Volts In:

Used to power the PWM. It draws very little amperage - less than 150 milliamps. This will take any voltage from 12 up to 32 volt systems.

- **Float Switch:**
Connect the other float switch wire here.

- **Ground:**
Provided as an easy way to connect a wire to ground. Use this terminal for the other float switch wire.

- **12V Out (500 mA):**
Can be used to power EFIEs, MAP Enhancers and the like. No more than 500 milliamps. You can also use this with 24 volt systems because the EFIEs need 12 volts.

Powering the PWM

The first terminal on the green terminal block powers the PWM's electronics. Any gauge wire can be used for this connection because it carries such a tiny amount of current. I usually use 24 gauge. This terminal would ideally connect to the fuel pump relay, which only gets power when the engine is actually running. The fuel pump relay circuit powers up briefly when the car is turned on to charge the system, but after that will only be on when the engine is actually running. Since this is the only time we want HHO to be produced, we use this circuit for the

source of our control voltage. This will ensure that the PWM is not running when the ACC switch is on, but the engine is not actually running.

However, you can also power it from any source that is activated by the key switch of the vehicle. In this case you must activate voltage sensing so that the PWM will not make HHO when the engine isn't running.

IMPORTANT SAFETY RELATED INFORMATION: You must make sure that your HHO system will not run when the engine isn't running. If you are making HHO when the key is switched on, but the engine is not turning, then you will have a dangerous situation. Be sure to test this circuit carefully to make sure it is only on when the engine is running. *If your HHO system is producing HHO while you are sitting in the car listening to the stereo, you can have HHO build up under your hood, and this can explode when you start your engine. So this point is vitally important.*

Connections to Your Cell

The PWM will work best with a standard cell configuration. You want to connect your PWM so that there are 5 neutral plates for 12 volt systems, and 11 neutral plates for 24 volt systems. This gives the correct plate to plate voltage for optimum HHO production efficiency. We define a neutral plate as any plate in the cell that doesn't connect to the PWM (ie has no connection tabs).

Multi-stack cells: A stack is defined as 2 hot plates (plates that have connection tabs), with 5 neutral plates between them. A 2-stack cell, or *Double Stack Cell* can be thought of as 2 adjacent cells. The center hot plate is common to both "cells" on either side of it. It can be either positive (HHO+), or negative (HHO-). The other PWM output wire is split to connect to the outside 2 hot plates. This is the connection method for a 12 volt electrical system. If you have a 24 volt electrical system then you would not use the center terminal on the cell at all. You would instead connect HHO+ and HHO- to the 2 outside terminals. This will give you 11 neutral plates. See the diagram below and also the diagram in the section on 24 volt systems (further down the page).

Similarly, if you have 2 cells, each with 5 neutral plates, then you would connect them in parallel for 12 volt systems and in series for 24 volt systems. The diagrams below show these configurations. But again, the simplicity is that you want 5 neutral plates for 12 volt systems and 11 neutral plates for 24 volt systems.
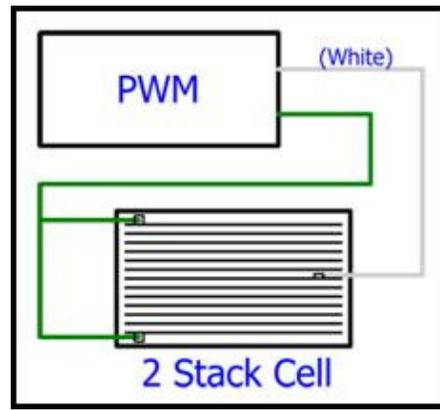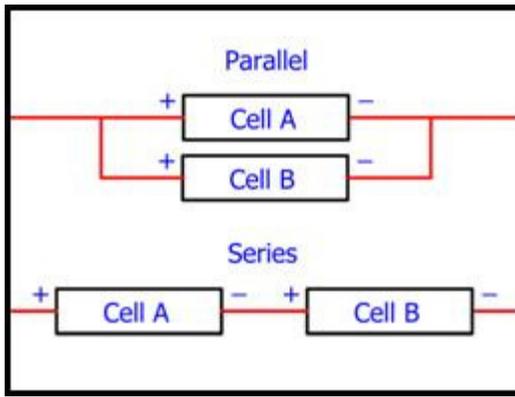
For our passenger hydrogen cells, you should not run more than 15 amps per cell, or per stack. See below for a description of multi-stack cells. This information is for understanding PWM installation only. But note that most people use more amperage than they need for best fuels mileage gains.

Connection Method for 24 Volt Systems
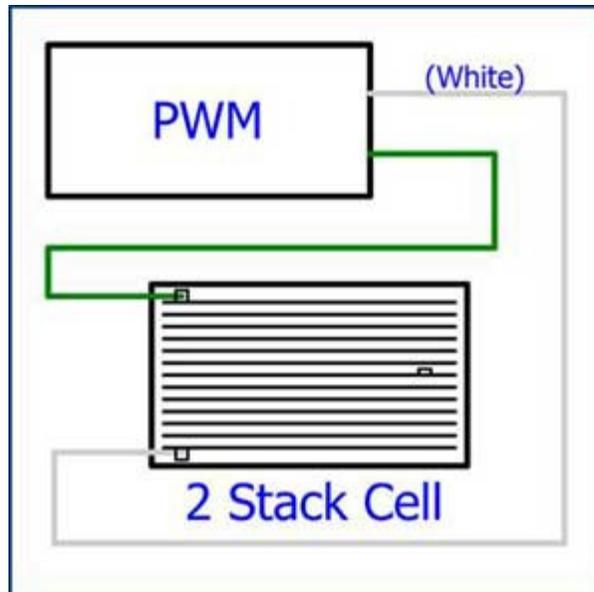
Display/Controller

Once all the wiring is connected, you may turn on your ignition and turn on the switch on the PWM. If your installation was successful you will see the display light up and start telling you information about the electrical environment and the operation of your cell.

The controller for the system is built into the display module. It is the controller

that actually adjusts the current and monitors the activity of the PWM. While the system is running, it provides information to the user as to volts, current, frequency, duty cycle and if any errors are present, will display them.

The display on the right is in normal operating mode, and the display on the left is in error mode. While operating normally, the display will show Amps and Duty Cycle on the top line, and Volts and Frequency on the bottom line. However, when an error is being displayed, the error takes up the bottom line of the display, until it is cleared. In this mode, the top line shows Amps, Volts and Duty Cycle. Starting with version 2.5, there is one more aspect to the display. When the PWM is turned off, it will show that it is off. Instead of displaying a Duty Cycle of 0% it will say "Off" preceded by a letter indicating why it is off. These are the possible letters:

- M Off: means the PWM is off by menu command.
- T Off: means it is off because of the Trigger function.
- V Off: means it is off due to the Voltage Sensing function.
- H Off: means the PWM is shut down because the circuit board is too hot.

Programming Instructions

To program the PWM, we use the knob below the Liquid Crystal Display. Press the knob once to enter setup. Now you can turn the knob to cycle through the different functions. When you get to the function you want to make changes to, press the knob again, and you'll enter that setup screen.

To make the changes, you will use the knob and button. Use the knob to navigate through any options available, and then press the knob once to select the new setting. Some screens have multiple settings, and you turn the knob to make any needed changes, and press the knob to accept each setting. Finally, turn the knob

to the final screen that is labeled, "Exit". You must press the knob at this screen to ensure that your changes are recorded in memory.

The video will show you how to use the PWM. Note: As advancements and refinements are made, there may be slight differences between the following video and your controller. The instructions should be consulted where there is any discrepancy.

Please copy and paste the link below to access the video (bottom of page)

http://www.hydrogen-generators-usa.com/hho-pwm.html

Here's the full listing of the Menu Items, not all of which are shown in the video:

1. On/Off. Use this menu option to turn the PWM on or off in software. There is no switch in the cab to turn off the pwm. But you can do it in software, and the PWM will remember this state after power is removed and it is again restarted.

2. Constant Amps. Use this screen to set the amps that the PWM will provide to the cell.

3. Volt Sensing. This item has several settings. The first is "Y" or "N", and sets whether volt sensing is activated. If not activated, the system will not shut down automatically on low voltages. If "Y" is selected then the next 2 screens will allow you to adjust the "On" and "Off" voltages. The On Voltage is the voltage that must be available in order for the PWM to turn on. Then, if the voltage drops below the Off Voltage, the PWM will shut down. In that case, the voltage must come back up to the On Voltage again in order for it to start back up. We recommend beginning with 13.0 volts for your On Voltage and 12 volts for your Off Voltage. See a further discussion of this item below.

4. Reservoir Level Alarm (Float Switch). This function causes the display to sound and show an alarm when the level in your reservoir gets too low. It requires that you have a float switch for your reservoir installed. There are 2 wires on the float switch. One gets extended and attached to the Float Switch Terminal on the PWM. The other wire gets connected to ground. A ground terminal has been provided on the PWM for this purpose. But you may also connect the other wire to any available ground if it is easier for you. In the LCD's menu, you would change the setting from "N" to "Y". You would also select the type of switch that you have; normally open or normally closed. This just means that the switch is either making contact when the reservoir is low on water, or it's making contact when it's NOT low on water. Most float switches work either way just by turning them upside down. Don't worry if you get the logic reversed. If it alarms when it shouldn't, then just change the Normally Open/Closed setting.

5. Calibrate. Press this button to calibrate the amps display to your PWM. This step only needs to be done once.

6. Enter Codes. This is used to enter codes that affect the operation of the PWM. Mostly we use these codes to turn on and off a number of PWM functions. When you find that your PWM triggers an error so frequently that it becomes an annoyance, then you can use one of these codes to turn off checking that error. To enter a code, turn the knob to cycle through the available numbers and characters available. The available numbers are 0-9 and A-F. When you get to the number you want, press the button, and you'll be advanced to the next character position. Again, turn the knob to select the 2nd character, and so on. When you have entered the last character, press the knob one more time on the blank space to complete your entry. If you have entered a valid code, the word "Saved" will flash onto the screen for a moment. If you enter an unrecognizable code, then "Invalid" will be displayed shortly. Entering an invalid code has no effect whatsoever. So, if you are entering a code and accidentally enter a wrong character, then just press the button twice and start over.

The following codes are recognized:

    25350 - No Load check off
    25351 - No Load check on

    3AC2F0 - Instant Amps Check off (Deleted after v1.29)
    3AC2F1 - Instant Amps Check on

    C187A0 - Total Amps Check off (Deleted after v1.29)
    C187A1 - Total Amps Check on

    2EE040 - Runaway Amps Check off
    2EE041 - Runaway Amps Check on

    232250 - Fan Check off
    232251 - Fan Check on

    232252 - Circuit Board Temperature Check Off
    232253 - Circuit Board Temperature Check On

    232254 - Change LCD to work with Truck PWM (aluminum case - green)
    232255 - Change LCD to work with Car PWM (aluminum case - natural color)
    232258 - Change LCD to work with 20A PWM (aluminum case - natural color
    - no fan)

23225C - Change LCD to work with older black plastic PWMs.

143AC0 - Turn Passwords off (Added in Version 1.29)
143AC1 - Turn Passwords on
143AC2 - Change Password
143AC2 - Reset Password to "1"

1414x - Voltage Tuning - see below for instructions(Added in Version 1.29)

Trigger Function: (See Below)

2340 - Trigger function to be turned off
2341 - Trigger function to be turned on - with normal voltage - Hi voltage = PWM is turned on
2342 - Trigger function to be turned on - with reverse voltage - Low or no voltage = PWM is turned on.

Frequency functions:

14CB0F0 - turn frequency menu item off
14CB0F1 - turn frequency menu item on
14CB0F2 - turn frequency menu item on but hide it again after next power on

When using higher frequencies on large cells (above 10") or with an extreme number of plates (more than 25 plates), the cell develops a large capacitive kickback onto the PWM. I've seen voltage spikes of over 150 volts come back out of a cell that was running at 12 or 24 volts. Our commercial PWMs employ a capacitor to absorb these spikes. But running high frequencies on cells with a large plate area, causes the amount of energy coming from these spikes to increase. This can cause the capacitor to overheat and fail, and if that happens, the spikes will kill the mosfet chips. For this reason the frequency function is turned off for the commercial PWMs. If you increase the frequency, please monitor the temperature of the biggest capacitor on the circuit board. As long as it stays cool, you're OK.

7. Frequency: If this menu item has been activated, it will show up here. Just set the frequency to the desired number and press enter.

Voltage Sensing

During your initial set up of your HHO system, we recommend you keep this set to "Off". We don't want your PWM shutting off for unknown reasons while we are

trying to get everything working for the first time. However, you will want to use this function as it provides another layer of safety on top of the control wire discussed above. By turning this function on, and getting the voltages set correctly, the PWM will shut off when the engine stops running due to low voltage.

The voltage of your vehicle's electrical system is actually only nominally (in name only) 12 volts. When the engine is shut off, the battery will usually provide less than 12 volts. If any kind of current demand is being made on it, such as would be the case with an HHO system running, it will drop to below 12 volts. However, when the engine is running, the alternator produces well over 12 volts to the electrical system so that the battery will charge. If you measure the voltage at your battery when the engine is running, you will usually see about 13.5 volts or a bit more. We are using this voltage difference to sense when the engine is not running, and to use it as an additional layer of safety.

In the general instructions above, we gave you some voltages to use for this function. You should actually make a few measurements on your system to make sure these voltages are the best to use for your vehicle. For instance, we want the On Voltage to be low enough that it will always come on when it should, but not so low that it will come on when it shouldn't. To test for a good On Voltage, let your car run at idle, then turn on all the devices you will likely ever use. Run your HHO generator at the amperage you plan to use. Turn on your head lights and your stereo, and run you're A/C with the fan on high. Now measure the voltage. You'll want your On Voltage to be below this voltage.

Now turn off all of the accessories, and turn off the car. Measure the voltage. You will find that it quickly drops down to 12 volts or a little below. You'll want your Off Voltage to be above the voltage you see now.

After activating this function, if the voltage drops below your off voltage threshold, the PWM will set it's duty cycle to 0, effectively turning the system off..

Getting these voltages correct is easy to do, and will give you an extra layer of safety with your HHO system. Between this function, and the control wire, we are making very certain that HHO not being produced unknowingly, nor when the engine is off. This is an important safety consideration. You never want your system making HHO while the engine is not running and therefore instantly consuming it.

Password Function

A password function has been added at the request of some of my OEMs. This allows an OEM to lock out the menu after he gets everything set up correctly for his customers. To get to the menu, one must enter a password. This feature can

be turned on and off via the Enter Codes menu command as described above. Once you correctly enter the password, you will be "logged on" until the next time the PWM is powered off. This is by design so that you don't have to keep entering the password when you need to go in and out of the menus during setup

To change the password, go to "6.Enter Codes" on the menu. Enter 143AC2. Then exit the menu. Now, push the button to go back into the menu. Instead of the menu appearing, "Password?" will appear on the screen. Enter the new password followed by a blank space. Note passwords are a maximum of 8 hexadecimal digits. If you enter a longer password, only the first 8 digits will be recorded. Password default is "1", so if you activate this feature you will want to put in your own password. **Be careful to write it down.** If you lock yourself out of the menu, you will have to send your controller in for re-programming before you can access the menus again.

Trigger Function

This is a feature on Commercial PWMs only. Further, Commercial PWMs sold prior to 10 March 15 do not support this feature. You must be sure that your PWM supports this function before using it. You can test your hardware by testing the resistance of the Trigger port to ground. If it is over 5K, then it is supported. If it is nearly 0 resistance, then you know it is not supported on that model.

When wiring up the PWM, you make the following change for use of the Trigger function. At the "12/24 volts In" port, connect to any switched circuit. We no longer want a circuit that is only on when the engine is running. We want a circuit that comes on any time the key is turned on. That way you can set your menu, even if the engine isn't running. As long as the trigger port isn't activated, the PWM will not allow current to flow. Then connect the Trigger port to a circuit that is only on when the engine is running - or conversely, you connect it to a circuit that is off when the engine is running, but goes high when the engine is off (such as an oil pressure lamp). Whatever you use, be sure to test it carefully to make sure it behaves like you think.

You turn the Trigger function on and off using the "Enter Codes" menu option. It is turned on by default for models that support it. See the specific codes above to activate and de-activate the feature. When the trigger function is used, the PWM will not operate unless the voltage is correct on the trigger port. Use the Standard trigger function for connecting to a circuit that provides voltage when the engine is running. Select the Reverse trigger voltage for a circuit that provides voltage only when the engine is NOT running, such as with an oil pressure indicator. The threshold voltage is about 2.5 volts or so. Below that is considered Low, and higher than 2.5 volts is considered High. The trigger port can accept 50 volts of

plus or minus polarity.

Voltage Tuning

This function was added to increase the accuracy of the voltage display. In some cases the display can be off by as much as 0.2 volts. This has to do with the accuracy of the the electronic components where the voltage is measured. To increase the accuracy of the voltage display, you must use an accurate meter. Connect the red probe to the **Batt+** on the large black terminal block. Attach the black probe to the **Batt-**. For best results connect your probes directly to these 2 terminals, and not to other "equivalent" locations. It's best to do this test while the engine isn't running so that the voltage is very stable.

Compare the voltage on your meter to the voltage that the PWM shows you on the display. If the voltage on the display is lower, you need to add voltage, and if the display shows a higher voltage, you need to subtract. Voltage is changed using the Enter Codes menu step. The code to enter is 1414x, where the "x" is replaced with a number that will cause the voltage to add or subtract. Replace "x" with 0-5 to add voltage. The higher the number, the larger the amount added. Entering "0" will add a voltage so tiny, you won't see the display change. Entering "3" is 8 times as much as entering "1". Replace "x" with 6-9 to reduce voltage. Using "6" reduces the voltage by a tiny amount. Entering 7-9 reduces it by the same amounts that 1-3 adds voltage. Further, replacing "x" with "A" or "B" will reduce the voltage by even larger amounts. By adding or subtracting as needed, it's possible to get the display to match exactly to an accurate meter.

Troubleshooting:

If the LCD Controller/Display is lit up and appears to be functioning correctly, but the button is unresponsive, try holding the button down while powering up the system. The software in the controller supports multiple hardware platforms. The procedure of holding down the button at power-up is a way to switch between the 2 different controller circuit board designs.

Error messages and their meanings:

- Fan Stopped - The fan is not turning. This could be an obstruction, or it could be a failed fan. Either way, the PWM is programmed to shut down if the fan fails. This is so it won't overheat.
- Low Liquid - You must have the Level Sensing activated in software in order for this one to show up. Note, that Level Sensing is turned off by default. See the description of this function at #3 in the Programming Instructions section above.

- Low Volt:PWM OFF - See the section on Voltage Sensing above. This error indicates that the voltage sensing system has detected a low voltage condition and has shut down the PWM. This function is turned off by default. You must activate it in the main menu if you want this check done.
- No Load - (must be activated after version 1.29) This error occurs when less than 3 amps are being drawn on the system, yet the duty cycle is above 50%. It is an informational error only. The PWM will continue trying to run a cell, with the only difference being that the duty cycle will not go above 50% until the error is cleared. It will continue to try to find a load to run.
- Hi Amps:PWM OFF - (must be activated after version 1.29) Instant amps too high. 10 A doesn't sound like much, and it isn't. However, if the duty cycle is at 5%, the instant amps being drawn by the system during that fraction of a second is 200Amps, which is enough to fry the mosfets. So we monitor this and shut the system down if these values are exceed.
- Hi Amps:Alarm - (must be activated after version 1.29) This one just means that amps have gone above the set point and is not coming back down.
- Emergency!
  Disconnect Cell!: This is a 2 line error, and is very insistent. This one occurs only if the PWM has lost control of the cell. The controller will try to reduce duty cycle, but the current doesn't stop flowing. In this case, current will flow until one of the cables to the PWM is disconnected. This requires action. It means that the PWM has been damaged, probably by being short circuited.
- If the normal display shows "T Off" in the upper right of the display, this means the trigger voltage is not present, so the PWM will not operate.
- If the normal display shows "H Off" in the upper right of the display, this means that the circuit board has become overheated and the PWM has shut itself down so it won't be damaged.

Software Revision History

Version 1.0: Changed default frequency to 65 Hz.

Version 1.1: Various cosmetic changes were made to the display.

Version 1.2: Rewrote all code for handling the encoder (control knob). Smoother operation of the knob resulted.

Version 1.21: Changed the main display layout so that errors could be reported.

Version 1.22: Added ability to change the frequency. Added error reporting for multiple errors.

Version 1.24: Added 'No Load' check to errors. Checks to be sure the system is drawing current and reports an error if less than 3 amps are being drawn at 50% duty cycle or more.

Version 1.25: Added 1) check for high instant amps - instant amps is defined as average amps (as displayed on the controller) divided by duty cycle. If that amperage is too high, the PWM will shut down to protect itself. 2) Checks for amps out of control. If a mosfet fries, it will pass current without any control by the PWM. This error alerts the user to disconnect the PWM - insistently. 3) Also checks for high amps condition in general and shuts down if found. 4) Brought all advancements made on the truck PWMs to the car PWMs Only difference is max allowed amps. 50A systems will have a "-1" after the software version, and 100A versions will have a "-2". 5) Auto calibrate menu item was replaced with a procedure that calibrates the unit at each startup. 6) Added a "Code Entry" step. This is for making changes to the programming after the display/controller has left the factory.

Version 1.26: Added ability to cancel the fan error which sometimes causes nuisance errors in cold weather when the fan is not needed.

Version 1.27: Added on/off switch in software. Amps calibration was added to the menu.

Version 1.28/9: Changed the fan error to display once every 45 seconds or so, but then go back to normal display. Added a password function so that a password can be required to use the menu. Deleted the following errors: No Load, Instant Amps, High Current. Many code optimizations.

Version 1.30-1.32: Minor bug fixes for new functionality.

Note: 100A Commercial PWM Software version is currently 2.28.

Version 2.3: No changes to software. This was just a consolidation of the various forms of the controller for different hardware platforms. From this point forward, the versions will have a suffix to indicate the PWM hardware it is designed for, as follows:
2.3t: 100A Commercial PWM, also known as the Truck PWM. Large green

anodized aluminum heat sink case.

2.3s: Older version of the Constant Current PWM that comes in a black plastic case. Replaced in Jan 2015.

2.3c: Constant Current PWM for cars. Comes in an aluminum heat sink case.

2.3a 20 Amp Constant Current PWM, available for a limited time. Same as CCPWM for cars, but 20 amps max capacity.

Future versions will be listed by number only. The suffix letter will remain the same as listed above.

Version 2.4: Minor bug fixes.

Version 2.5: Added Trigger function for new models of the Commercial PWM. Menu now shows "Off" in place of the duty% if the pwm is turned off by menu, trigger or voltage sensing. Added a timeout function so that if the PWM is put into the menu mode and forgotten, the menu will timeout and go back into run mode.

Version 2.6: Added support for high temperature error for car pwms. New codes for turning board temp error on/off, and for changing the controller for use with truck, car and the older black plastic PWMs.

Version 2.7: Added ability to turn off "Test Rig" function. Added ability to change hardware types by holding down the knob/button at power up.