The 2.8 watt, $100 Laser Upgrade for MPCNC

Rev: 1.0 **Leo69**

1.0 PURPOSE: This is a step by step guide for installing and configuring a 2.8w laser upgrade on your MPCNC. The guide will be very thorough for beginners but will assume that you have some understanding of basic mechanical assembly and electronics. A "baby step" approach will be taken and the idea is to make one connection at a time and verify the output so mistakes can be identified and fixed before moving forward. Please read the entire instruction before you get started and be sure to use eye protection around the laser at all times. Those who are experienced should be able to skim through this and focus on the driver tuning instructions. If you have any questions, please ask them on the forums so everyone can benefit. This guide is intended for Mostly Printed CNC builds in their stock configuration, running on Arduino/ Marlin firmware and Ramps 1.4 board. I personally will not answer any questions from anyone who deviates from these instructions. If you want to do it your own way then by all means, be a trailblazer and share your knowledge with the community! Please let me know if I can make any improvements or corrections and if this guide helps you with a set-up then post on the forum to encourage others.Thanks, Leo69.

2.0 RESOURCES:

2.1 Web resources

2.1.1 http://3dpburner.blogspot.com/ . An excellent resource for laser info and the primary source of my knowledge on the subject. Big thanks to Villamany for his great project and for his image2gcode software.

2.1.2 I have to mention the http://www.vicious1.com/ website and a huge thank you to Ryan for designing the most versatile, cost-effective CNC platform around today.

2.1.3 http://jtechphotonics.com/ Another good laser resource. Good product and lots of good info there too.

2.1.4 http://reprap.org/ The control behind our machines.

2.1.5 https://sites.google.com/site/dtrlpf/home DTR's laser Shop. Top Quality laser diodes and accessories. Well respected in the laser community.

2.1.6 http://laserpointerforums.com/ . Where all the laser gurus hang out.

3.0 PREREQUISITES:

3.1 Basic knowledge of electronics. Using a multimeter, connecting wires, difference between AC and DC, voltage and current, polarity.

3.2 Basic mechanical assembly knowledge.

3.3 Patience. THE **LASER WILL BE THE VERY LAST THING THAT GETS CONNECTED TO A POWER SOURCE.**

4.0 REQUIRED TOOLS:

4.1 A digital multimeter. Do not use a $3 harbor freight meter! They're ok for voltage measurements but I've found them to give inaccurate current measurements.

4.2 Small screwdrivers. Philips and Standard.

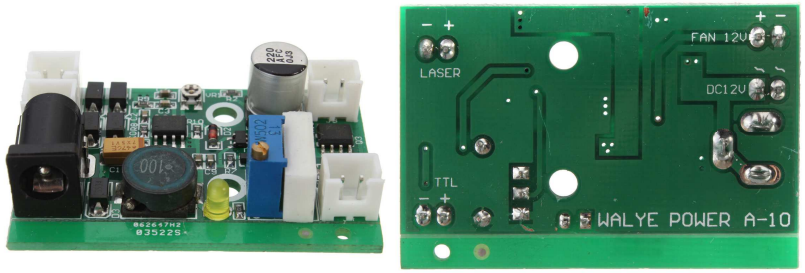
4.3 Test clips and jumper wires will be a big help when doing voltage and current checks.

4.4 Soldering iron, flux, and solder OR some other method for joining wires together.

5.0 MATERIALS:

5.1 **Laser module assembly**. This guide is for the Nichia NDB7875 laser diode. It's a great 2.8 watt 445nm diode and can be found at DTR's laser shop. DO NOT BUY THE DIODE BY ITSELF. Soldering laser diodes is very tricky so the best thing to do is to buy the fully assembled module which is the 12mm Copper host with the diode and lens already assembled and ready to go. Search their site for a **445nm 9mm Diode in Copper Module w/Leads**. It's available **with a three element glass lens for $70** or with a **405-G-2 lens for $90**. I personally use the 3-element lens and like it very much but the G-2 lens is supposed to be more efficient. Either will work great but the G-2 lens SUPPOSEDLY has a slightly larger spot size.

5.2 **Laser Driver**. Use a generic Chinese driver. These can be found on ebay by searching for '12V TTL laser driver'. Make sure the driver takes TTL control signal and can provide up to 3amps output power with a 12 volt DC power source. The price should be around $8 .Make sure you look at the images in the listing and compare them to the images below. The bottom of the board should read WALYE POWER A-10 or possibly A-8. I think A-10 is the newer revision of the board.



5.3 A **12mm aluminum laser heat sink**. Can be found for as little as $4. Spend more for a nicer one if you plan to run the laser for extended periods and at full output. This heat sink size is most commonly used so most MPCNC laser housing designs on Thingiverse will accommodate it. Plan on designing/modifying your housing if you decide to use a larger heat sink.

5.4 A **12volt 40mm fan**. Available at Vicious1 store or ebay. About $2 - $3.

5.5 An MPCNC **housing** for your laser. Lots of options on thingiverse and Vicious1 web site. Find one that suits your needs.

5.6 **4 conductor cable** to run from the laser/fan to your driver/Ramps boards. I recommend 18AWG or thicker for the lengths and power levels involved. Most 4 conductor stepper motor cable will work, just check to make sure its 18AWG or thicker.

5.7 You may need electrical tape, heat shrink tubing, cable ties, or any other random supplies to clean up your wiring.

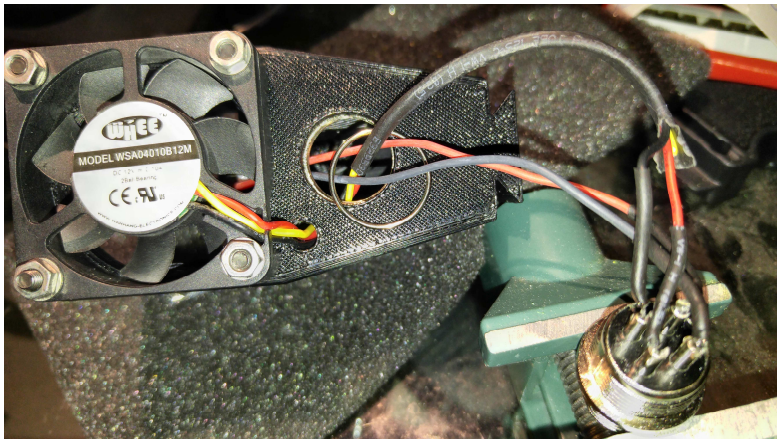
5.8 **Power supply**: The laser driver requires a 12 Volt DC power source with 3 amps current. You most likely already have a 12v power supply on your MPCNC. The entire MPCNC probably uses about 5amps to run the control and the motors so if your power supply can put out 8 amps or higher then you can just tap into that for your power source. If not, find a 12v, 3 amp power supply on ebay. Shouldn't cost more than $10.

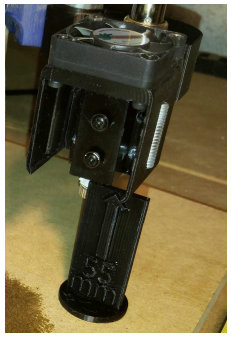
5.9 **Thermal Paste**: Arctic Silver is great but the cheap stuff will be fine too.

5.10 **4k to 10k ¼ watt resistor**: This is a safety measure. When power is applied to the Marlin/Ramps board, the TTL pins are fully energized for a couple of seconds while the firmware initializes. This will cause the laser to turn on for a few seconds every time you plug in the power supply. This resistor can be soldered across the TTL +/- terminals to keep this from happening.

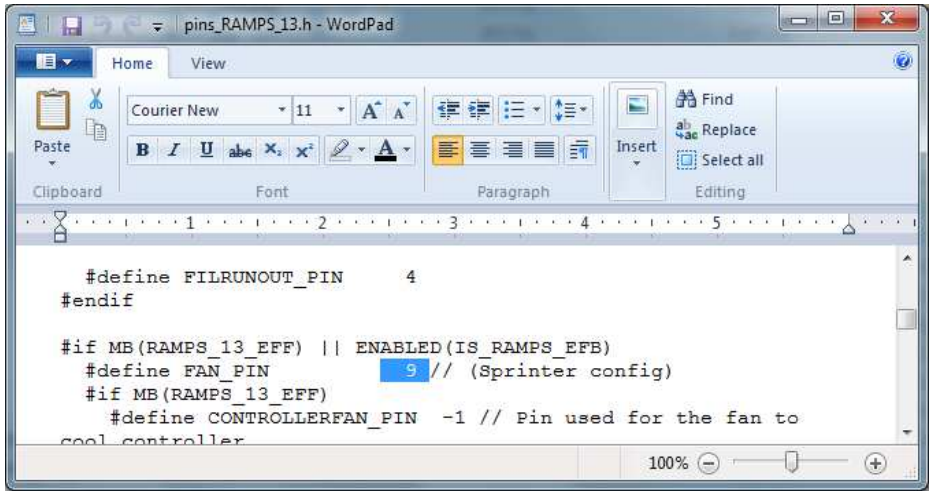
6.0 PROCEDURE:

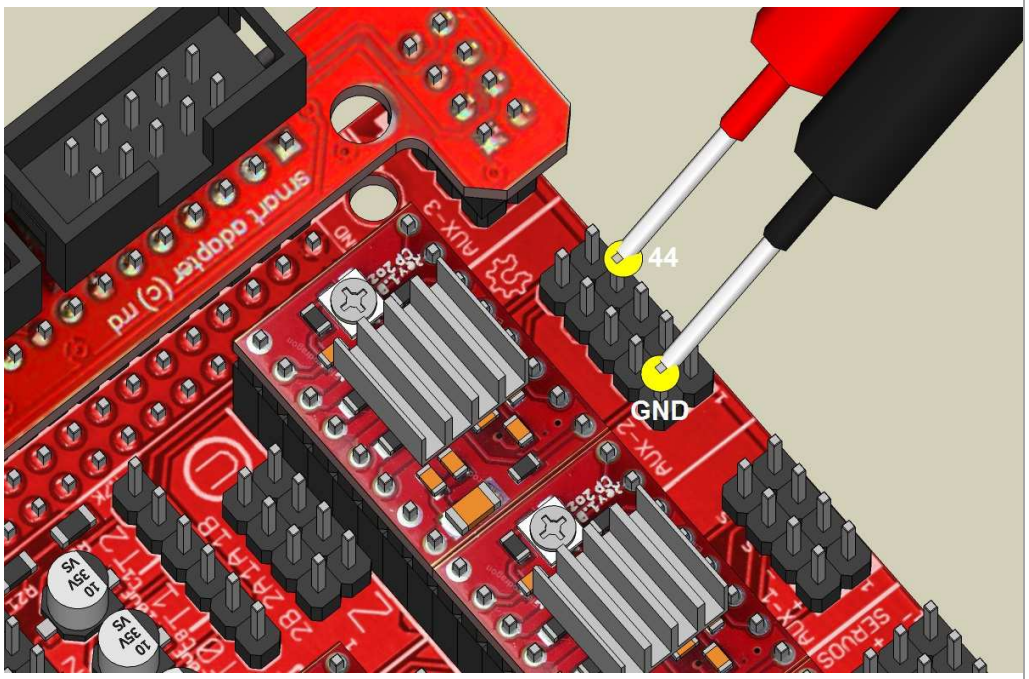
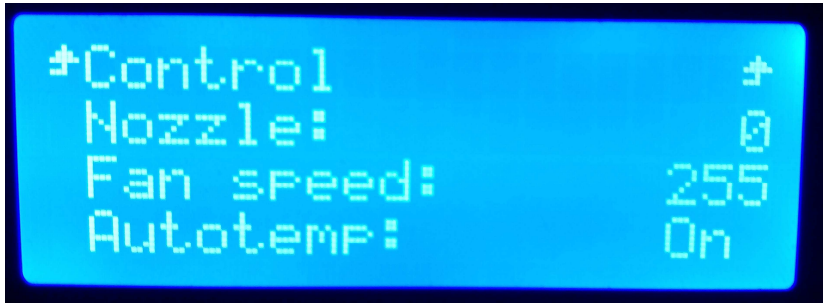
Section A: Mount the Laser

Step	*Visual*
1. Install the laser module in the heat sink but put some thermal paste into the 12mm bore on the heat sink first. The lens assembly and threads should be exposed on one end. Secure the laser using the screws on the heat sink but don't over tighten. 2 Install the heat sink in your chosen housing and install the fan too.	
3 Connect the 4-conductor cable to the fan and laser module. Use connectors of your choice. I personally prefer the 4-pin XLR connector for quick hook-up/removal. 4 Run the 4-conductor cable to the location of your Ramps board and power supply. I highly recommend you use masking tape to write down the function of each conductor (Laser+, Laser-, Fan+, Fan-) and apply the tape to the wire ends for easy identification later on. DO NOT MAKE ANY CONNECTIONS TO THE RAMPS BOARD OR POWER SUPPLY YET.	

Step	Visual
5 Set the height of the laser so that the bottom of the heat sink is approximately 55mm from the work surface. This is a good place to start and can be adjusted later. You should set a scrap piece of wood under the laser because it WILL get burned once you start tuning the driver.Don't use any scrap materials that will produce noxious fumes.	

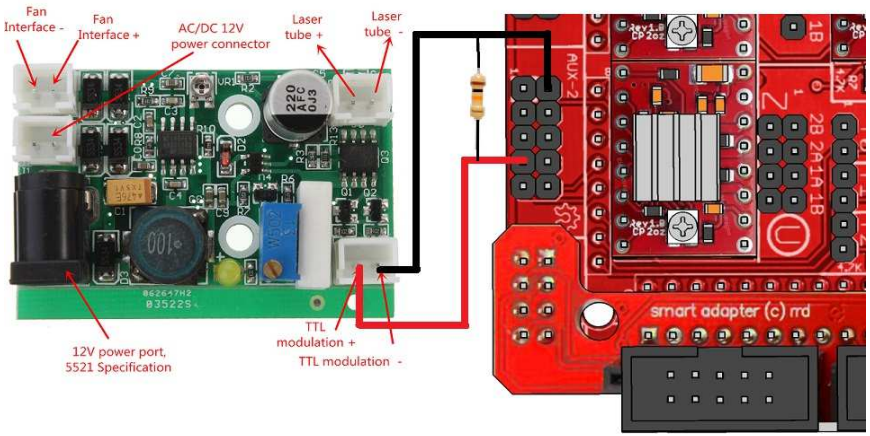
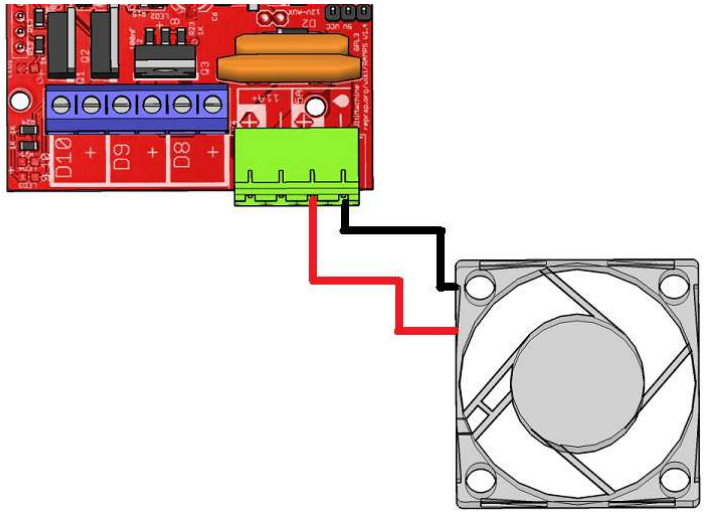
Section B: Prepare your firmware (5v TTL control signal)

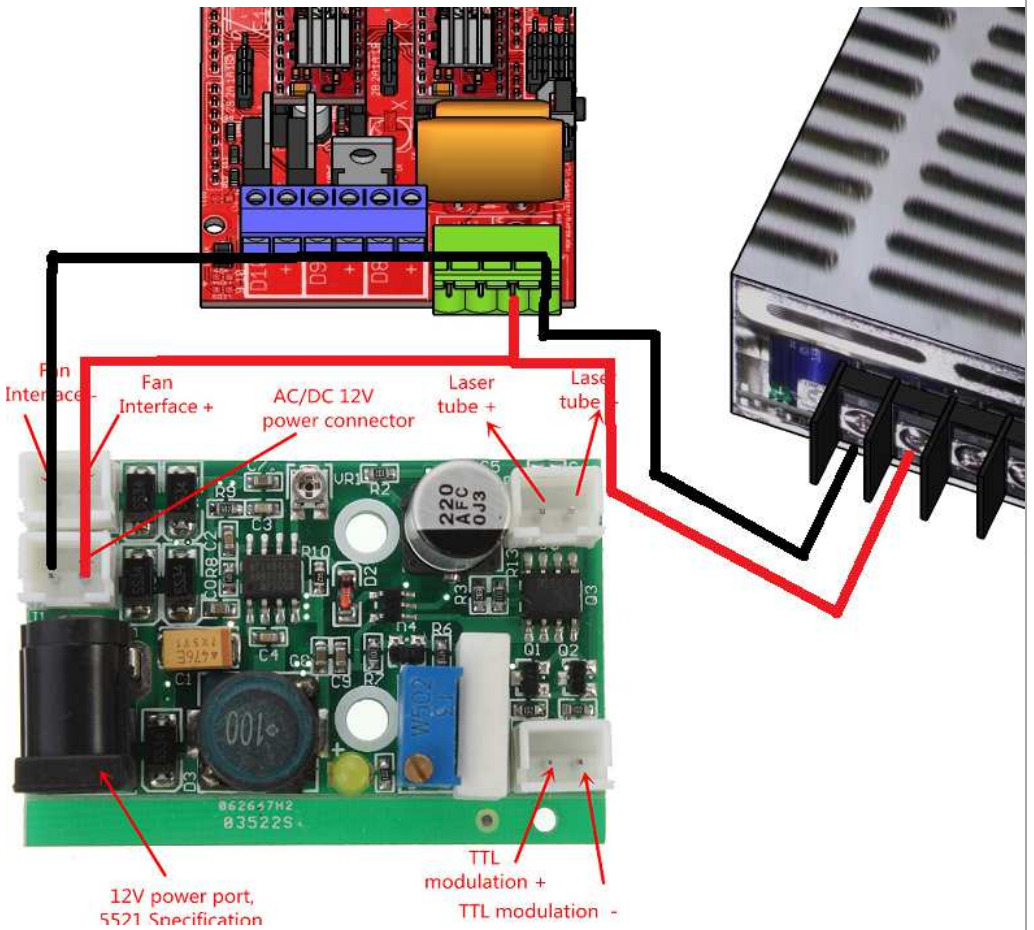
Step	Visual
1. The laser driver requires a 5 volt TTL input control signal. The Marlin fan control Mcodes (M106 and M107) will be used to control the laser .Unfortunately,the Ramps fan output (D9) is a 12 volt signal so we can't use it. We'll need a quick firmware edit to remap the fan output from pin D9 (12v) to pin 44(5v). 2 Make a backup copy of your Marlin firmware folder first. Open the pins_RAMPS_13.h file in your Marlin firmware folder with a text editor (wordpad). Search for the line where the fan pin is assigned and change it **from pin 9 to pin 44**. 3 Save the changes and flash the revised firmware back onto your Mega board.	

Step	*Visual*
4. Confirm that the firmware change was effective by connecting the positive lead of your meter probe / test clip to pin 44 and the negative lead to ground on the AUX2 terminal block. 5. Set the meter to read DC volts in the 0-10v range and power up your Marlin/Ramps board.	
6. Use the LCD menu to turn fan to full power (255).From the main menu go to CONTROL→TEMPERATURE→FAN SPEED→ and set the fan speed to 255, Click knob to enter your selection. Alternatively, you can use your PC host software to send command **M106 S255** via USB. 7. Confirm that the fan speed is set to 255 on the LCD display.	

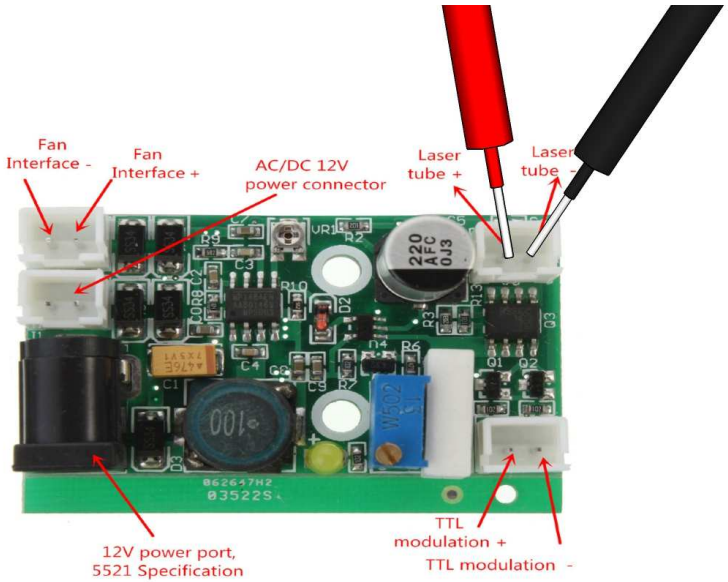
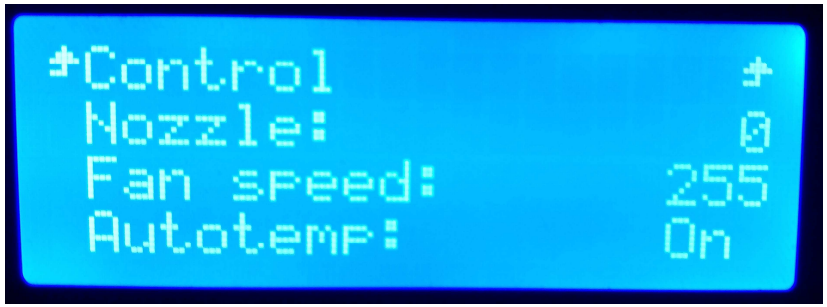
Step	*Visual*
8. Verify that the voltage reading is approximately 5v at pin 44 with the fan speed at full (255). If it is, try setting the fan speed to half that value (127) to see if the voltage drops to approximately 2.5v. If you're not getting these approximate readings then go back and review this section, otherwise continue.	

Section C: Connect TTL input, Fan, and Driver power.

Step	*Visual*
1 UNPLUG POWER SUPPLY WHILE MAKING ANY CONNECTIONS. 2 Now that you've verified your TTL signal line you can go ahead and connect a wire from pin 44 on Ramps board (TTL+) to the TTL+ input on the laser driver. 3 Connect another wire from the GND pin at the AUX 2 terminal block to the TTL- input on the laser driver. 4 **OPTIONAL SAFETY MEASURE**: A resistor should also be permanently placed across the TTL +/- terminals on the driver. This will keep the laser from being energized while the firmware initializes.If you don't do this then make sure you put laser goggles on EVERY time you first plug in the power with the laser connected!	
5 UNPLUG POWER SUPPLY WHILE MAKING ANY CONNECTIONS. 6 Take the fan+ and fan- wires from the 4-conductor cable that you routed to the Ramps board earlier. Connect them directly to your 12v DC input connections on your Ramps board. That way the fan will always run if the MPCNC is running.	

Step	*Visual*
7 UNPLUG POWER SUPPLY WHILE MAKING ANY CONNECTIONS. 8 Connect your 12V DC laser power source to the laser driver. This can be a standalone power supply or you can tap into the Ramps power source if it can supply enough current for the MPCNC AND the laser (8 amps MINIMUM) 9 After making all of these connections, plug in the power to make sure the fan is spinning in the right direction. It should be blowing air down onto the laser assembly and work surface. You should now have everything connected except for the laser module itself. If everything looks good, unplug power and continue to the next section to start the driver tuning process.	

Section D: Driver adjustment – VOLTAGE SETTING

Step	*Visual*
1 Connect your meter probes/test clips to the laser output terminals on the laser driver. OBSERVE POLARITY. 2 Set your meter to read DC voltage in the 0-10v range.	
3 Plug in your power supply/s. 4 Use the LCD menu to turn fan to full power (255).From the main menu go to CONTROL→TEMPERATURE→FAN SPEED→ and set the fan speed to 255, Click knob to enter your selection. Alternatively, you can use your PC host software to send command **M106 S255** via USB. 5 Look at the display to verify the fan speed is set.	

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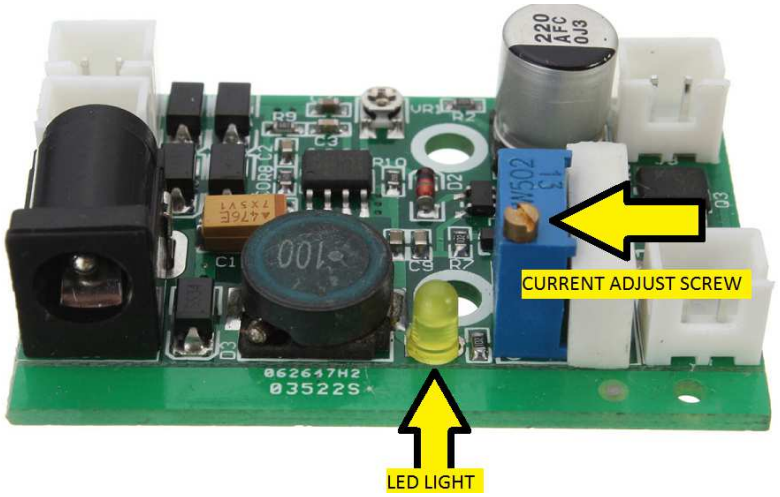
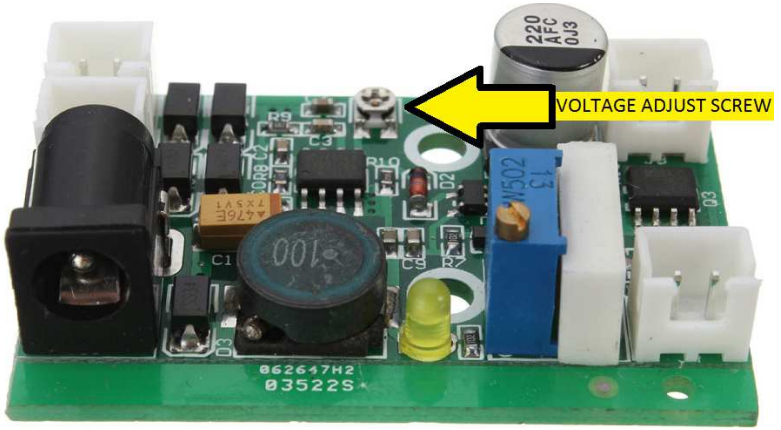
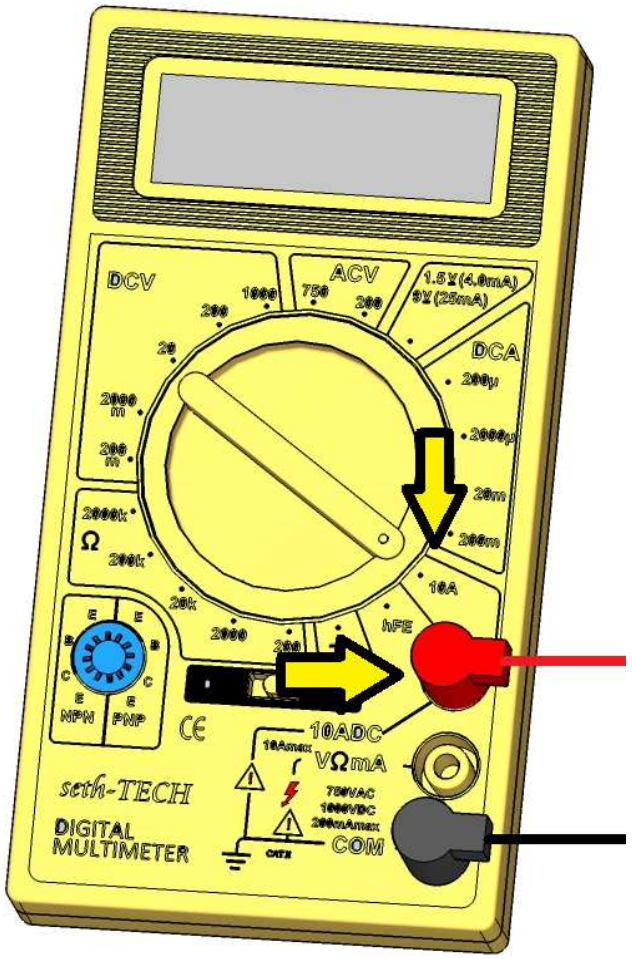
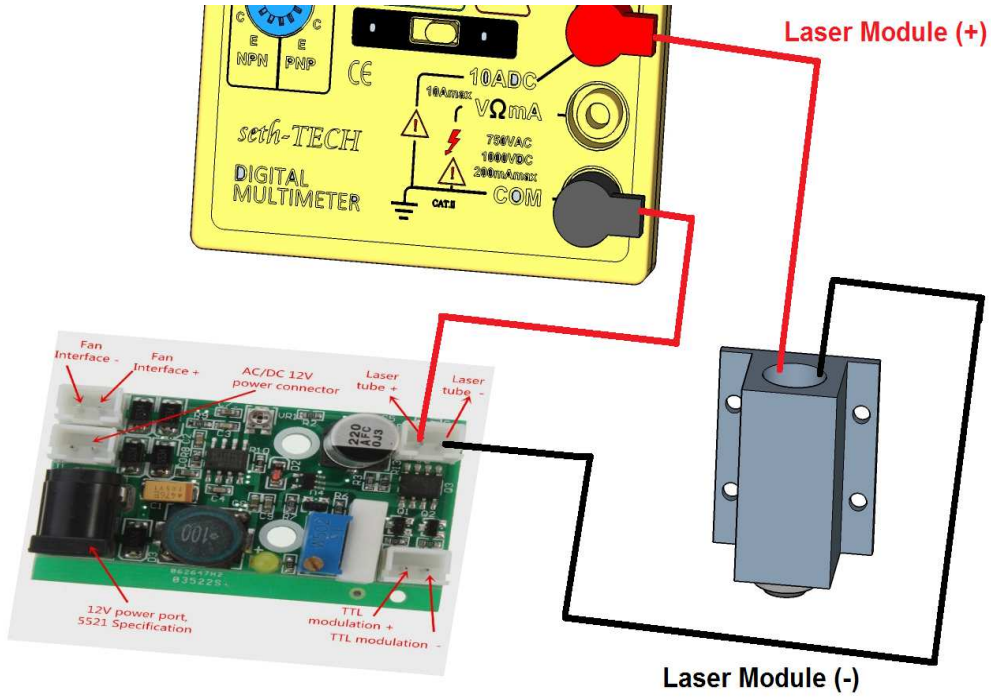
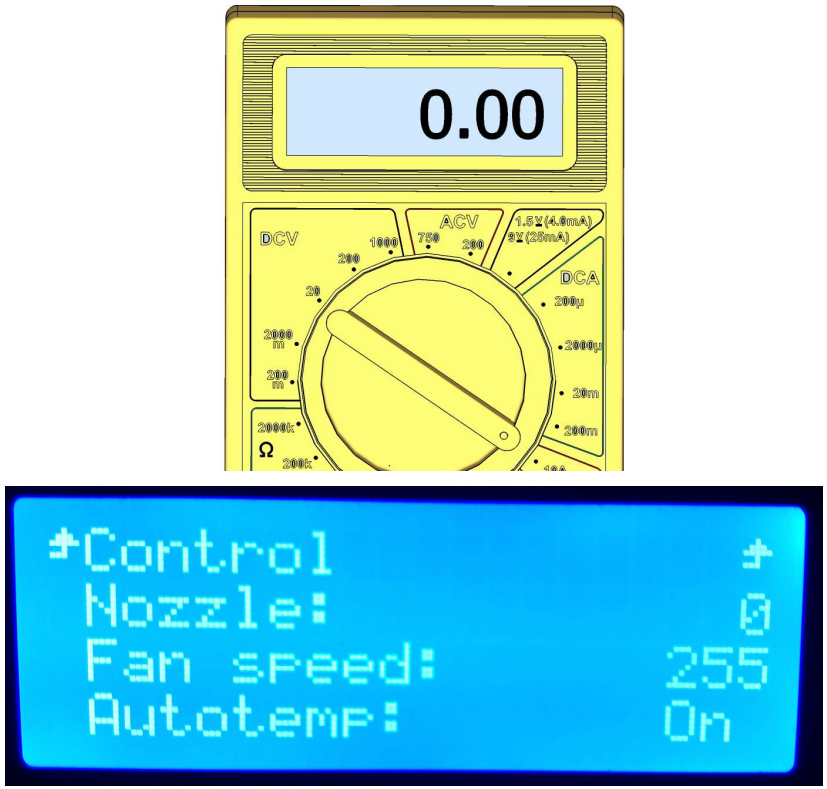
Step	*Visual*
6 Look at the LED light on the driver board. This light is very important. It will come on when the current level is high enough to make the board operate. **We want this light to be on when we set the driver voltage.** 7 If the LED is NOT on, you'll probably also notice a low voltage (near 0 volts) reading on your meter. Take a small flathead screwdriver and turn the CURRENT adjust screw clockwise until the light comes on. **It may take more than one turn as the CURRENT adjustment is a multi-turn type.** 8 Stop turning the CURRENT adjustment once you see the LED is on. You should also notice the voltage reading on the meter has risen now that the driver is running.	
9 Now we want to turn the VOLTAGE adjust screw VERY slowly. It is NOT a multi-turn adjustment so it is sensitive. 10 Watch the voltage reading on your meter. Set the voltage **to 6.5 volts** by turning adjustment screw clockwise to increase voltage and counterclockwise to decrease voltage. 11 **Once the voltage is set to 6.5 volts, leave the voltage adjust alone. Now go back and turn the CURRENT adjust screw counterclockwise until the LED LIGHT turns OFF**. We need the current very low before we connect the laser module. Don't worry, your voltage setting will remain where you left it. 12 <u>Unplug all power once you've completed these steps successfully.</u>	

Section E: Driver adjustment – CURRENT SETTING

Step	*Visual*
1 During the current adjustment we will actually be powering the laser module . Make preparations by PUTTING ON YOUR LASER GOGGLES and double-checking to make sure you have a scrap piece of wood under the laser assembly.IT WILL GET BURNED. **2** **<u>Unplug all power before making connections.</u>** 3 Prepare your meter by plugging your positive probe lead from the fused socket to the unfused 10amp socket. 4 Set the meter to read DCA (DC current) in the 0-10 amp range. 5 From the 4-conductor cable, locate the positive and negative leads for the laser module that were identified earlier.	

Step	Visual
6 To read current, the meter has to be connected in series with the load as shown. Connect the negative laser module lead directly to the Laser module (-) terminal on the driver. 7 Connect the positive laser module lead to the positive probe on your meter. 8 Connect the negative probe on your meter to the Laser Module (+) terminal on the driver. This way the current will flow through the meter when power is applied. 9 Before applying power you should double check your meter settings, all electrical connections made so far (TTL, Power, etc..), laser goggles on….	

Step	*Visual*
10 It is important that you remembered to turn the current down after you set the voltage in the last section. Plug in power supply/s and double-check to make sure the LED light on the driver is OFF before going further. If the light is on then go back to Section D- Step 11 and make sure you completed that step. 11 With everything powered on and your meter connected, you should see a current reading of zero or very close to that. 12 Use the LCD menu to turn fan to full power (255).From the main menu go to CONTROL→TEMPERATURE→FAN SPEED→ and set the fan speed to 255, Click knob to enter your selection. Alternatively, you can use your PC host software to send command **M106 S255** via USB 13 Look at the display to verify the fan speed is set. 14 At ths point the LED on the driver should still be off, current reading near 0, laser off, and fan speed at full (255)	

Step	*Visual*
15 Use a small flathead screwdriver to rotate the CURRENT ADJUST screw clockwise. Remember this is a multi-turn adjustment so it will take multiple rotations to adjust the current. 16 Watch the meter, the LED light on the driver, and the laser (GOGGLES ON!). Once the current reaches a threshold of about **.15 amps** you should see 3 things happen. The LED light on the driver will come on, the current reading on the meter will be approximately **.15 amps,** and you should see the laser start to project a beam. 17 At this point you'll just have to continue rotating the CURRENT ADJUST screw clockwise until you reach the desired current level. For longer life you should set the **current between 1.75 and 1.8 amps.** By the time you reach this point you'll probably be burning the material under the laser and a campfire smell will be in the air☺ **If at any time you find that the current reading does not continue to rise as you rotate the adjust screw, stop and try a different meter. I found that the cheapo $3 harbor freight meters don't seem to rise beyond 1.4 amps depite continued adjustment.** 18 Once your current is set you can go ahead and disconnect power. Disconnect your meter from the circuit and make your permanent connections between laser (+) and laser (-) on the driver and the laser module. 19 All that remains now is to focus the laser and start burning stuff to find your ideal settings.