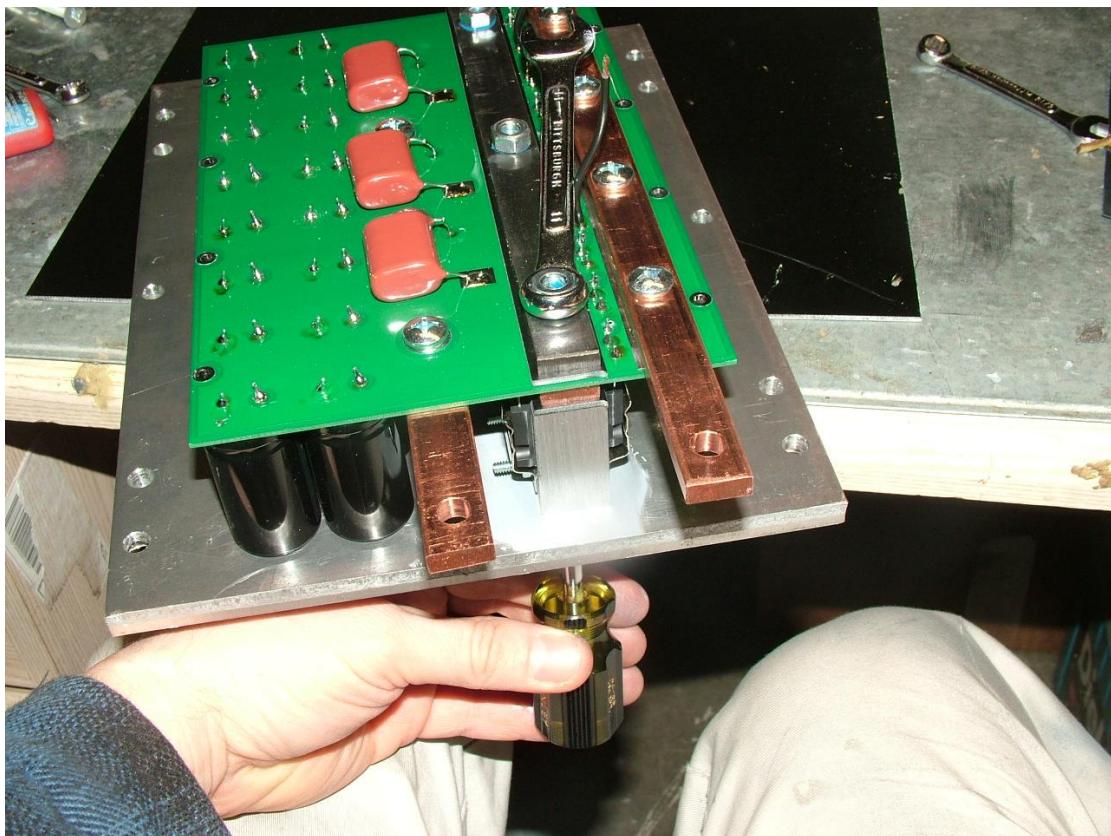




Paul & Sabrina's EV Stuff!

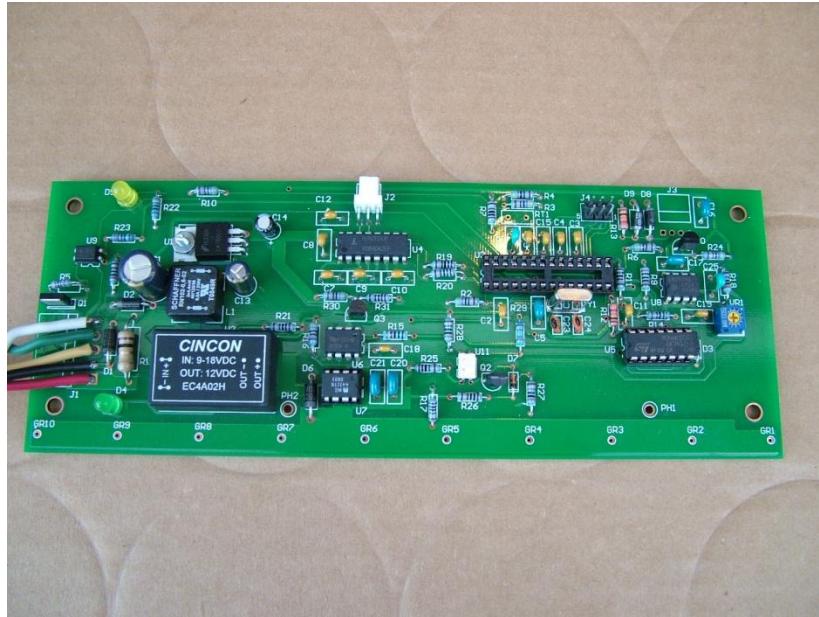
Motor Controller Assembly Directions



Paul & Sabrina Holmes

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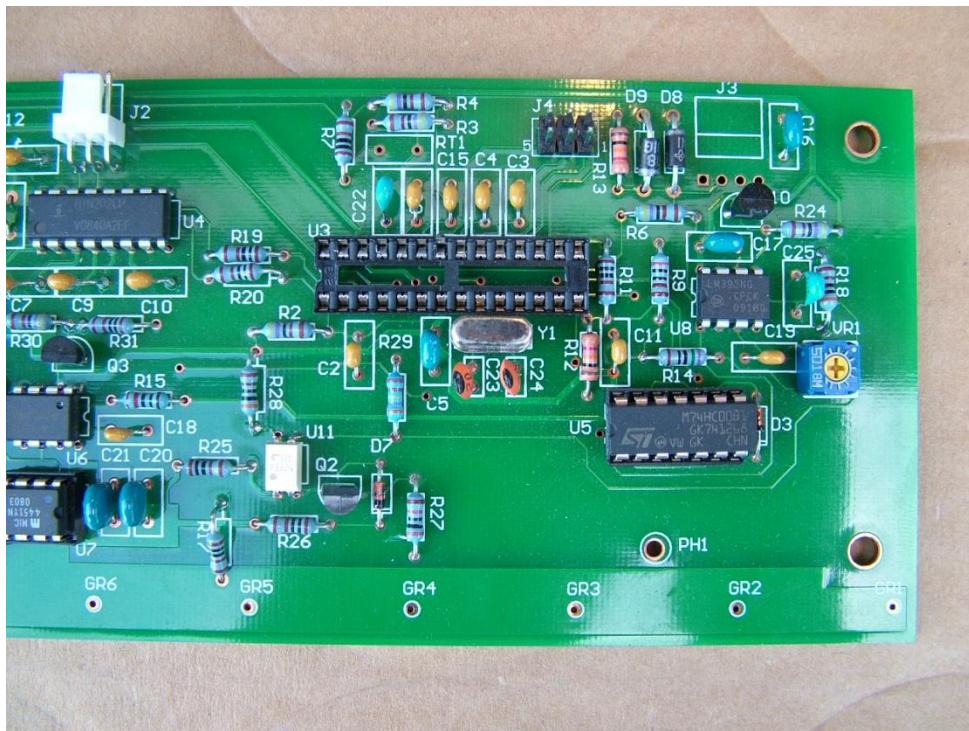
Solder all the parts of the control board. It should look like this when you are done. Don't worry about GR1 through GR10, and PH1 and PH2 until the very end of the assembly process:



Here's a close-up of the left side. Notice the screw holding down U1. Also, make sure U2 is inside the white box, and just solder the pins that poke through. There are extra holes on the PCB for U2 that are unused. Ignore them. They were for "no connection" pins that turned out not to be on the CINCON. Also, make sure L1 has the orientation in the picture!



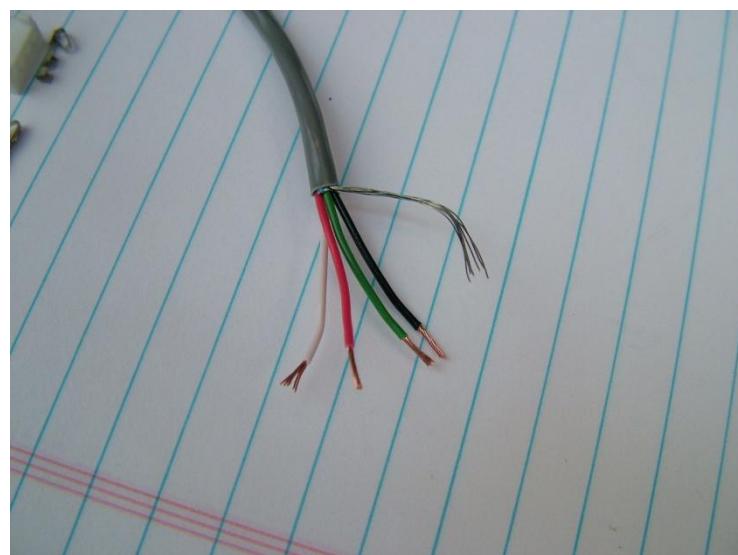
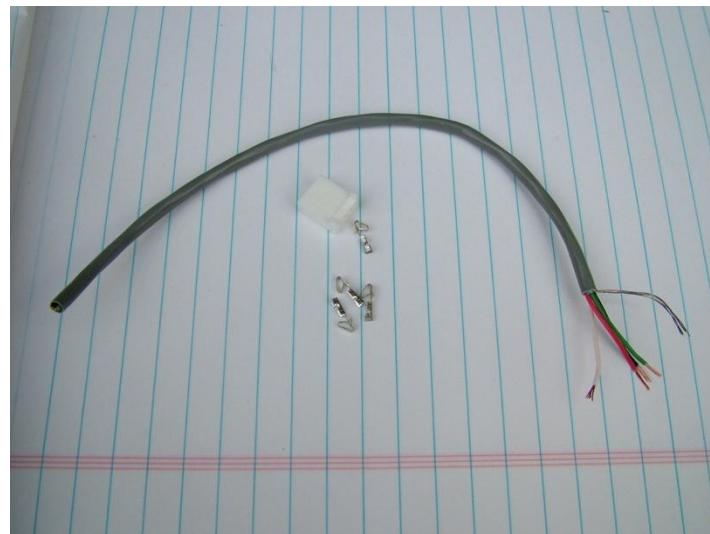
Here is the right side. Don't worry about soldering RT1 until later. It's annoying to have RT1 dangling around when you are trying to solder the control board, or trying to mount it or whatever.



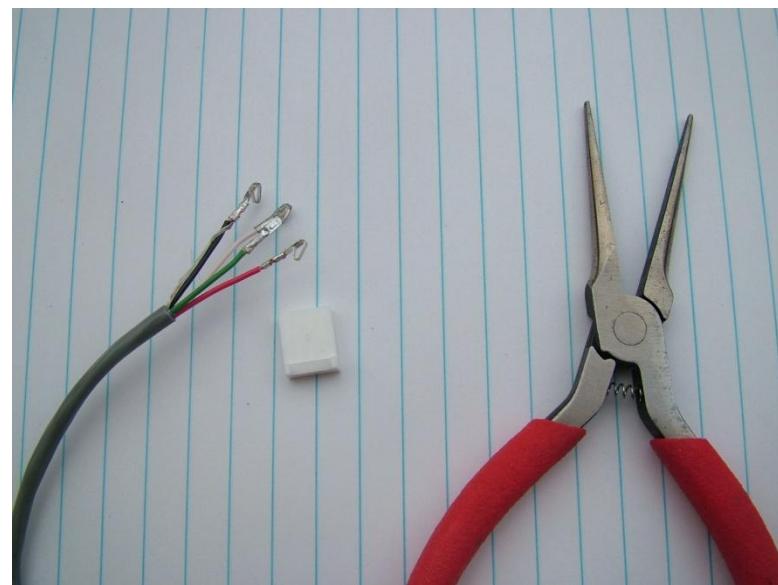
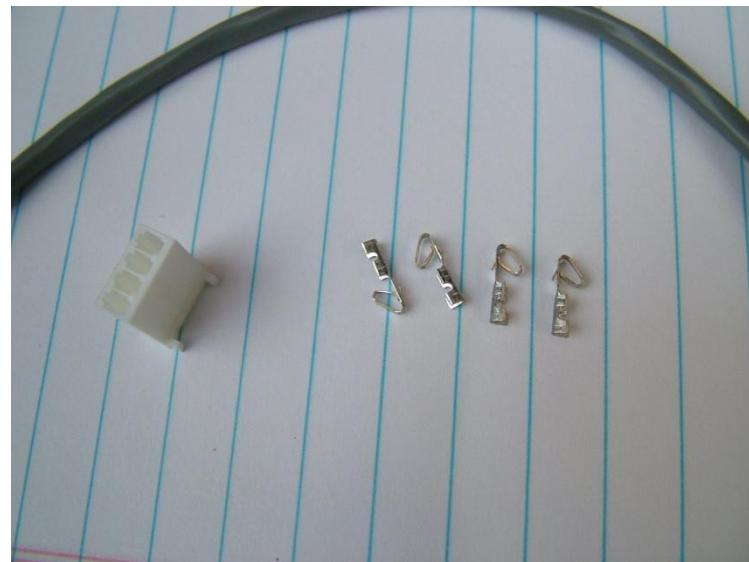
The connectors at J3 and J4 are optional. I think it gives a more reliable connection just to solder the wires right into the holes at J3. J4 is no longer needed, since the chip can now be reprogrammed through J2 using the serial port on your computer. The connectors for J3 and J4 don't come with the kit. They can be ordered from Digikey or Mouser if you really want them.

Here's a sequence of pictures for building the cable for J3:

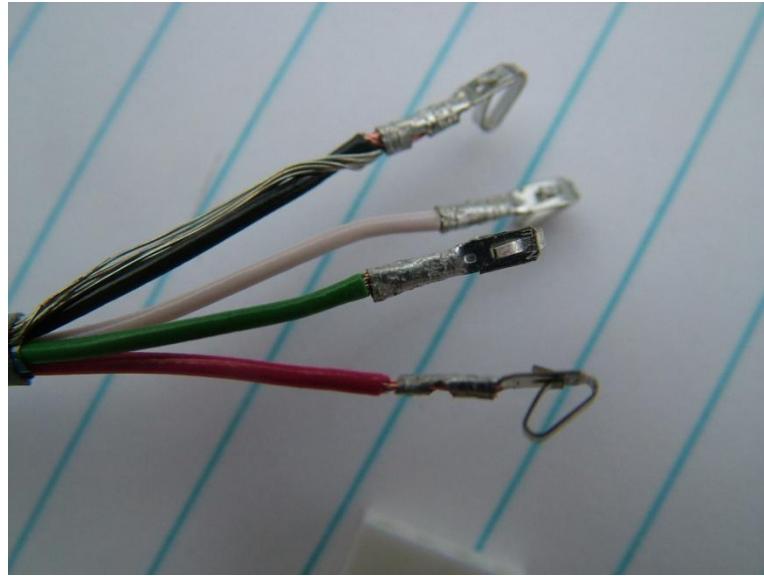
Start with the grey cable that is the shorter of the two that come in the kit. It's also the only one with 4 wires inside. Red, White, Green, and Black. Well, there's also the ground wire, which has no plastic around it. It looks silver colored. Strip one end of the grey sheath off. About 1"-1.5" is good. Then strip off the end of each of the 4 wires. Take off about 0.25" (or 5-7mm).



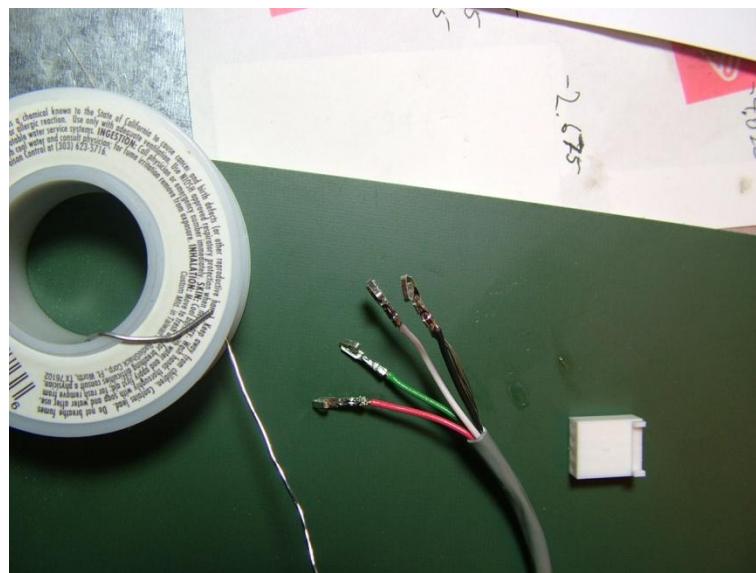
Now take 4 little pins, and clamp the 4 wires onto the 4 pins. The black wire should be twisted together with the bare ground wire. Use needle nose pliers to close the ends around the wires.



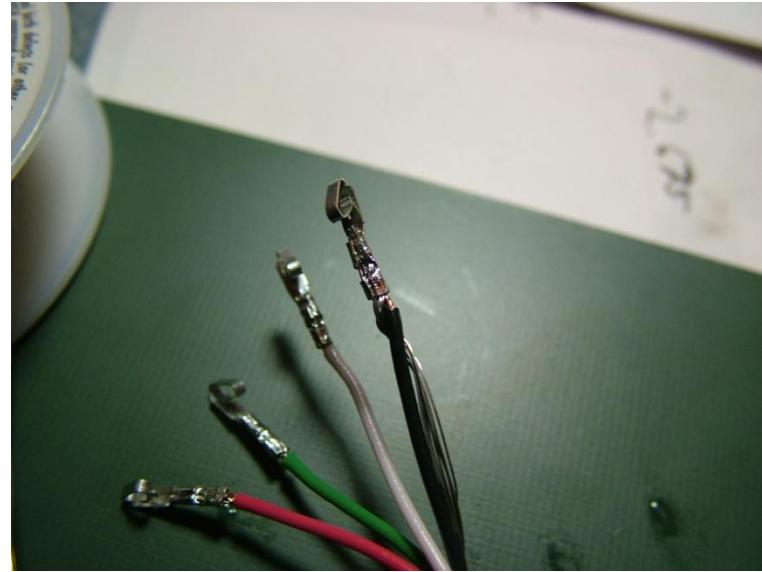
Notice that the ground wire is connected with the black wire.



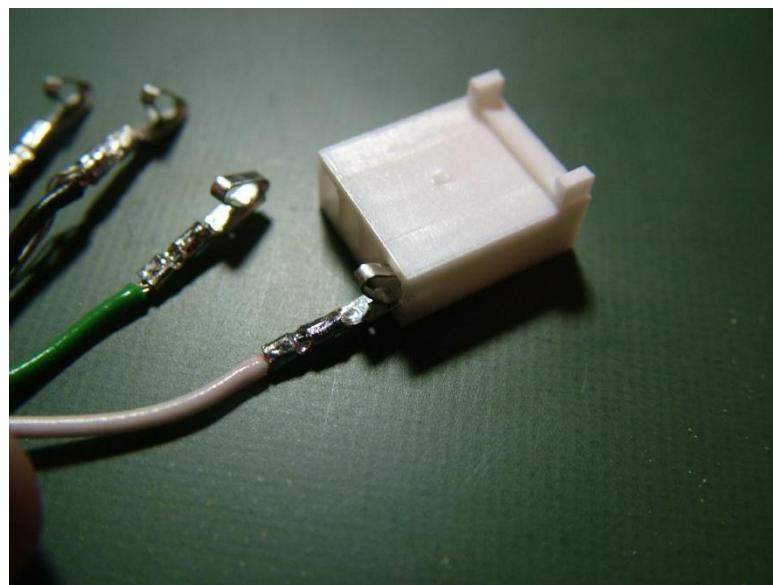
Now solder all 4 to make sure the connection is perfect. **Not too much solder**.



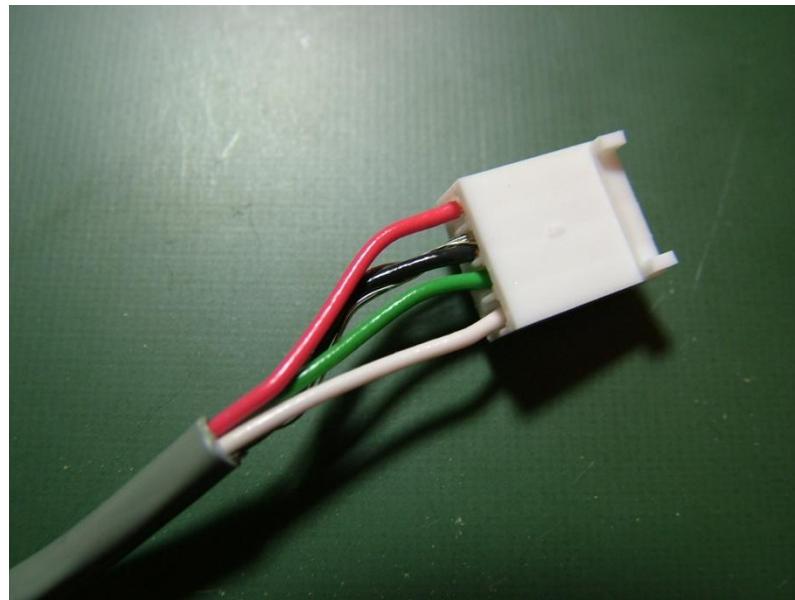
Here's what it looks like after soldering:



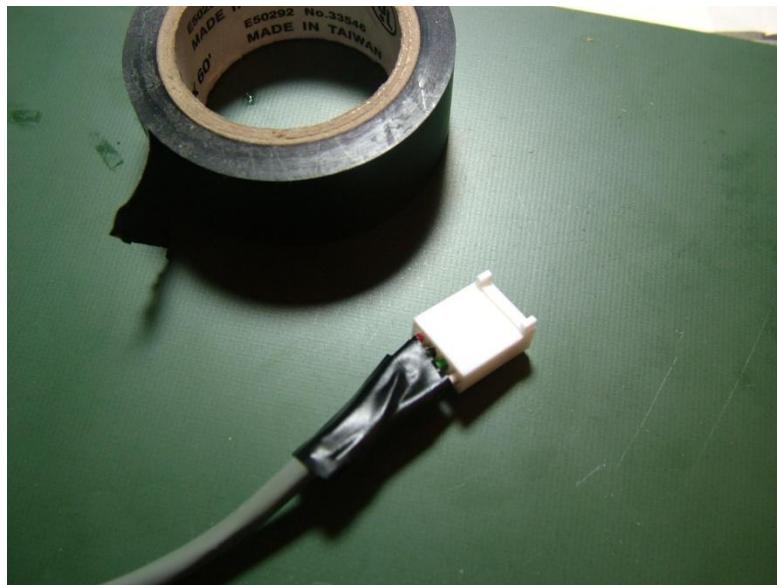
Insert a pin into a hole like in the picture.



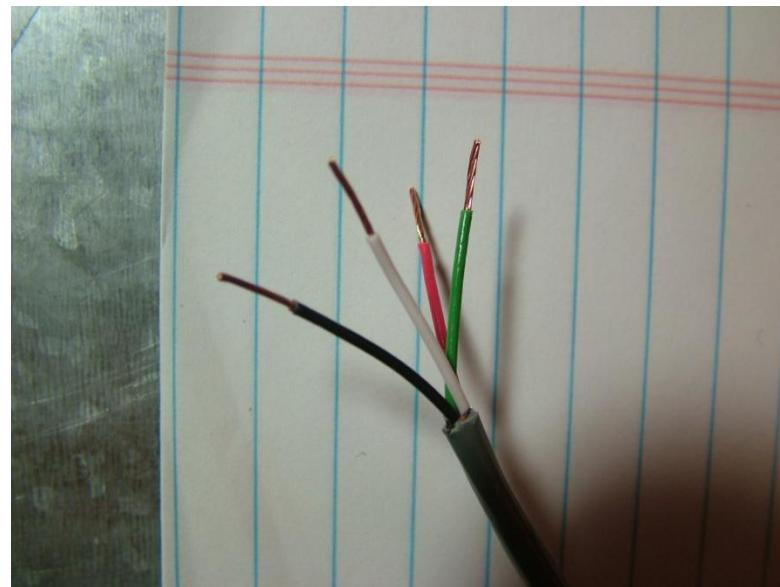
Make sure you follow the order of RED, BLACK, GREEN, WHITE!



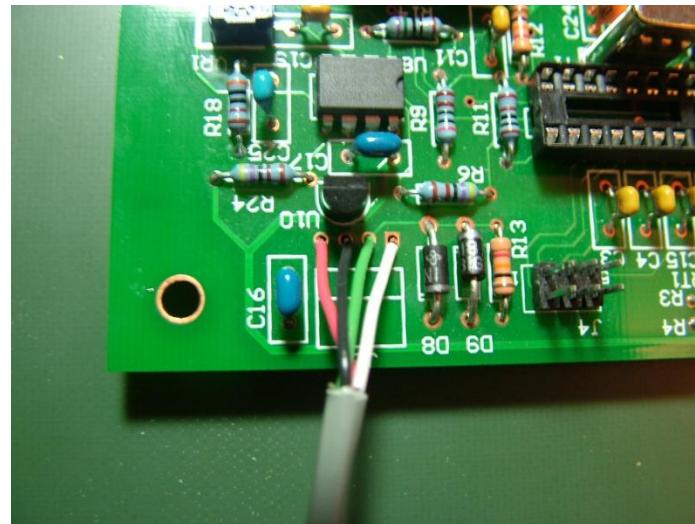
Use a little electrical tape just to keep the bare ground wire from touching anything.



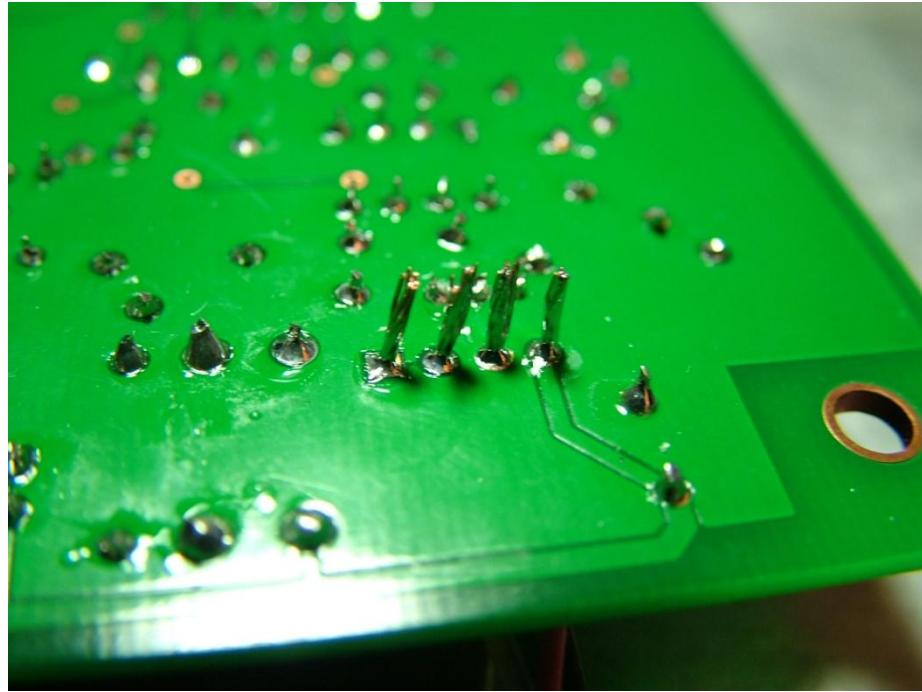
Now strip off about 1 inch of the grey sheath from the other end. Cut off bare silver colored ground wire, so that it is flush with the grey sheath. Strip the wires so that about $\frac{1}{2}$ " is exposed (1-1.2 cm or so).



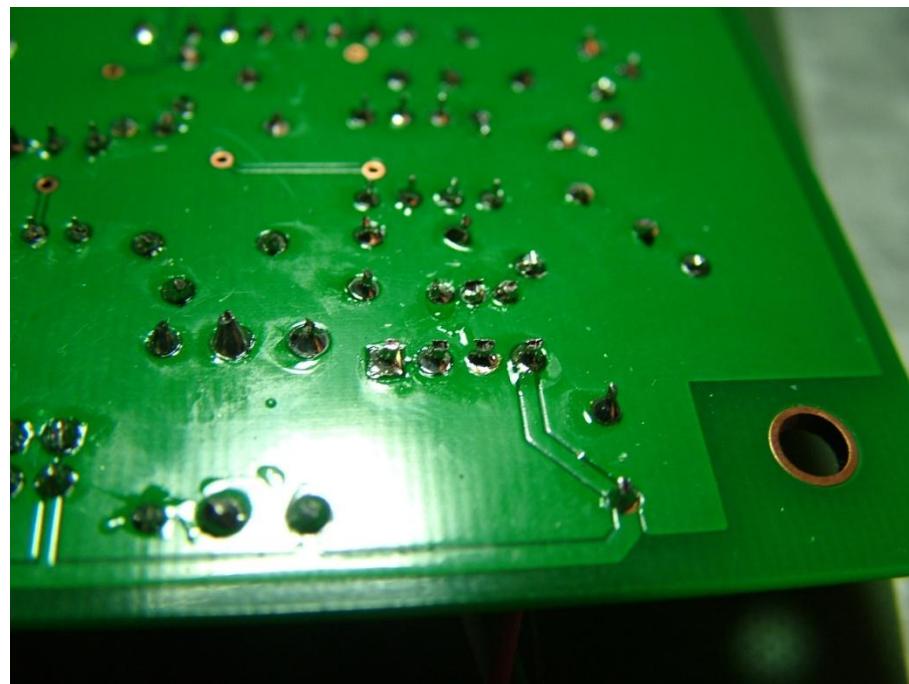
Insert each wire into the 4 holes of J3 like in the picture below. The order from left to right is **RED, BLACK, GREEN, WHITE!!!** This is very very important!



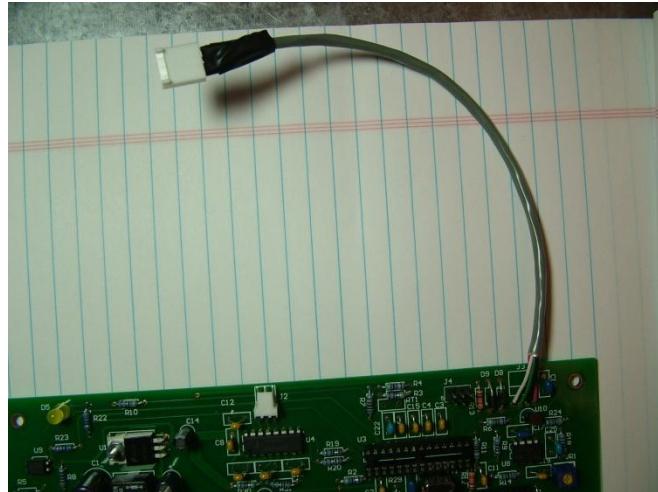
Flip the control board over and solder the 3 wires into place.



Chop the wire down.

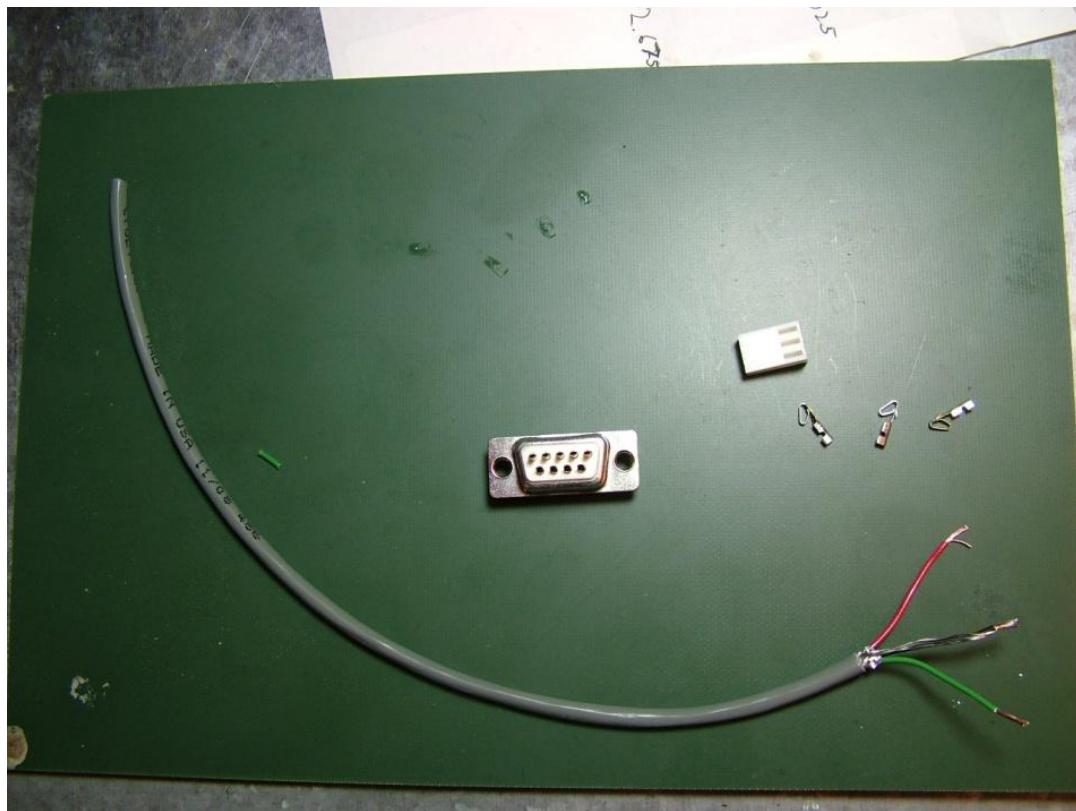


Hurray, you did it!

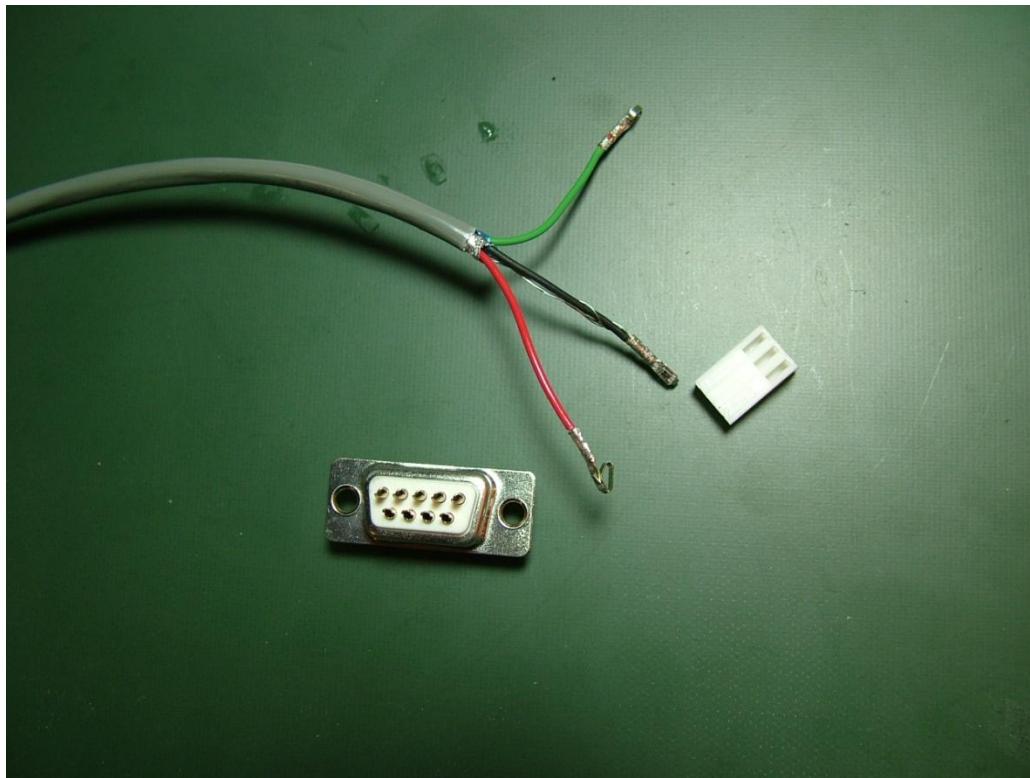


Now, let's do the cable for J2. You should have already soldered a 3 pin right angle connector with a white top into J2.

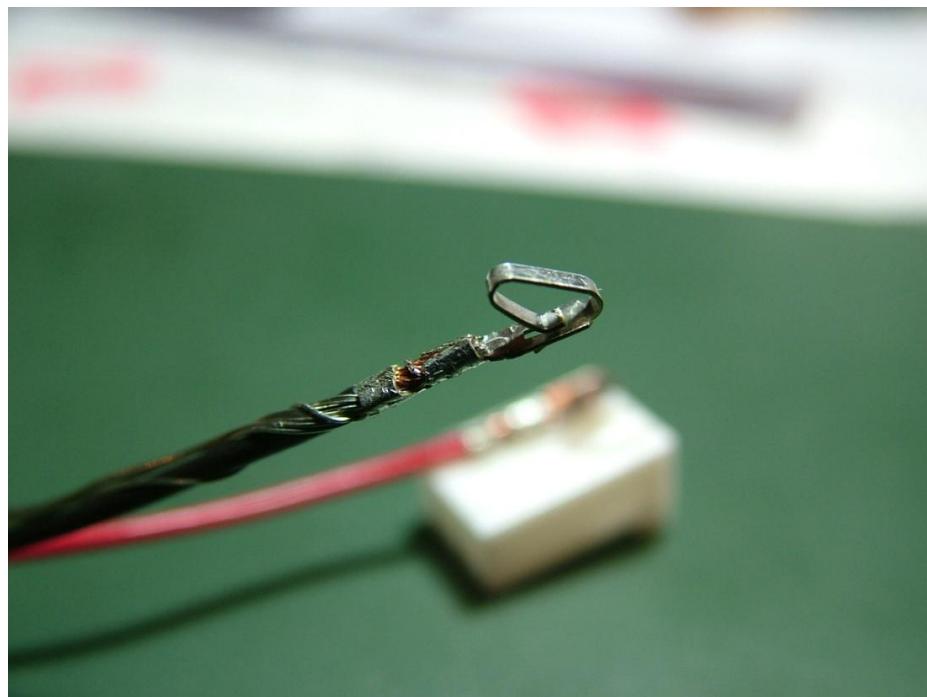
Start with this stuff... Strip off about 1.5" of the grey sheath, and peel away the foil. Twist the black wire and the bare ground wire together. **Yours might have a white wire instead of green.**



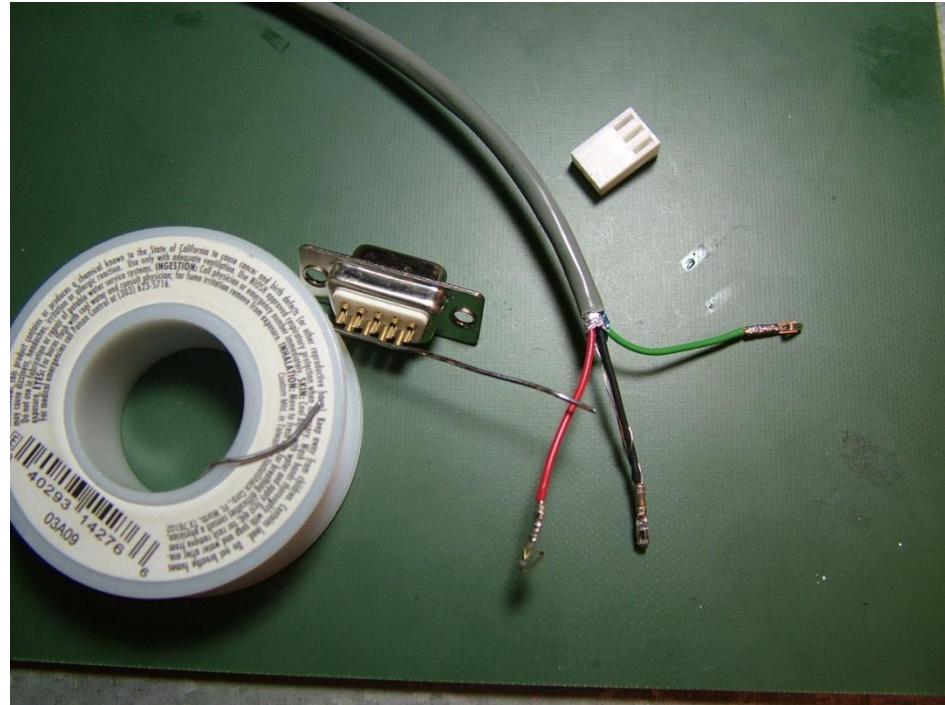
Crimp on the 3 crimp pins using needle-nose pliers:



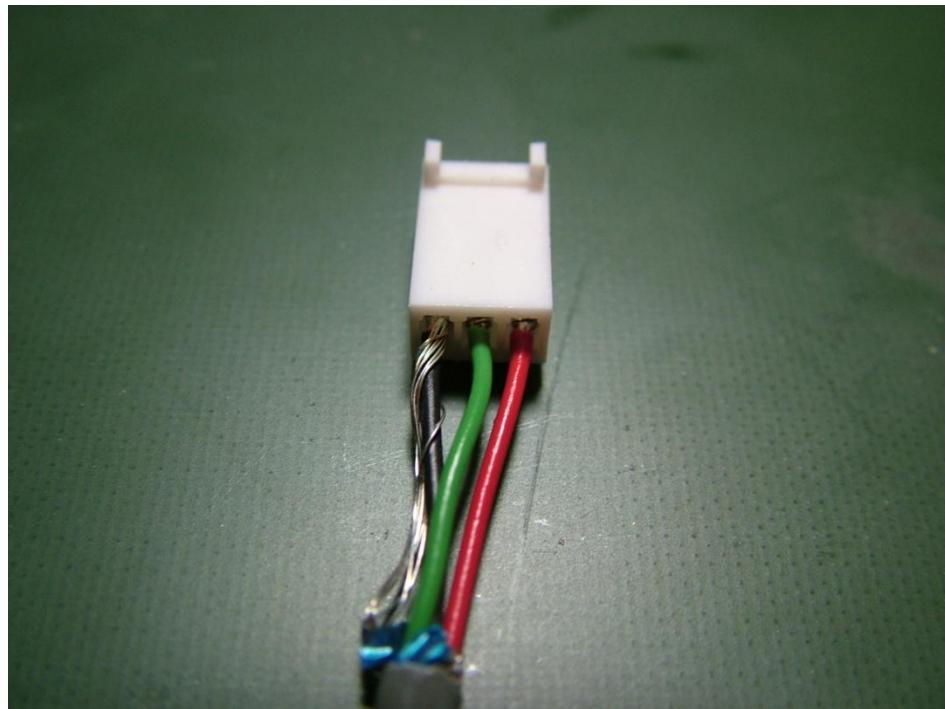
Just look at that beautiful crimping job! ☺



Solder the crimp pins to the wires to make sure you get a very solid connection.



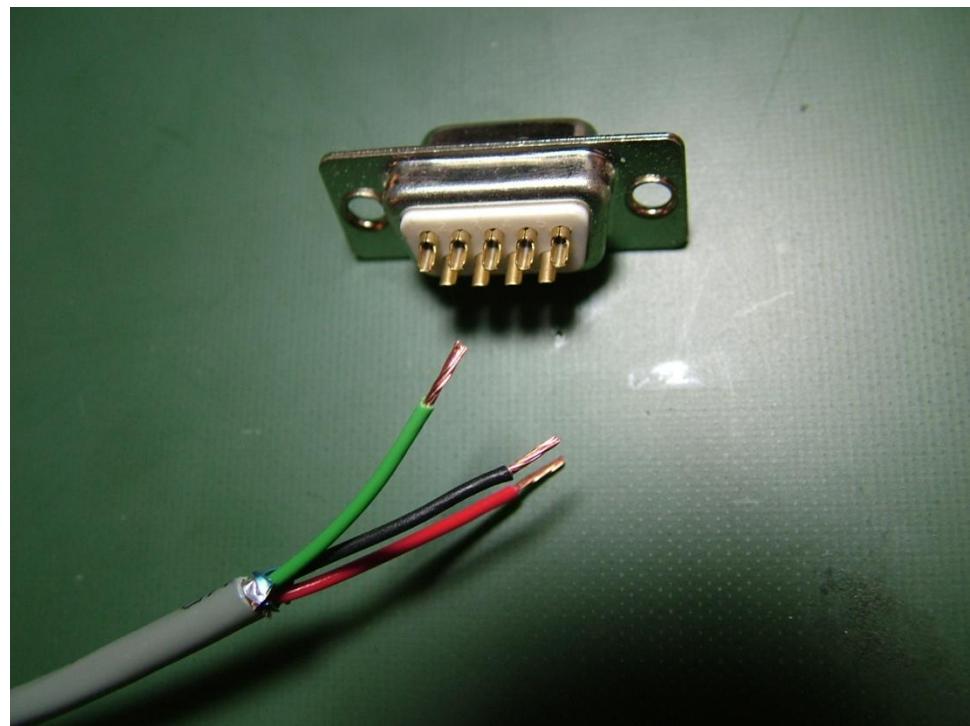
Push them into the white housing in the following order. BLACK, GREEN, RED, from left to right (or black, white, red if you have a white wire instead of green):



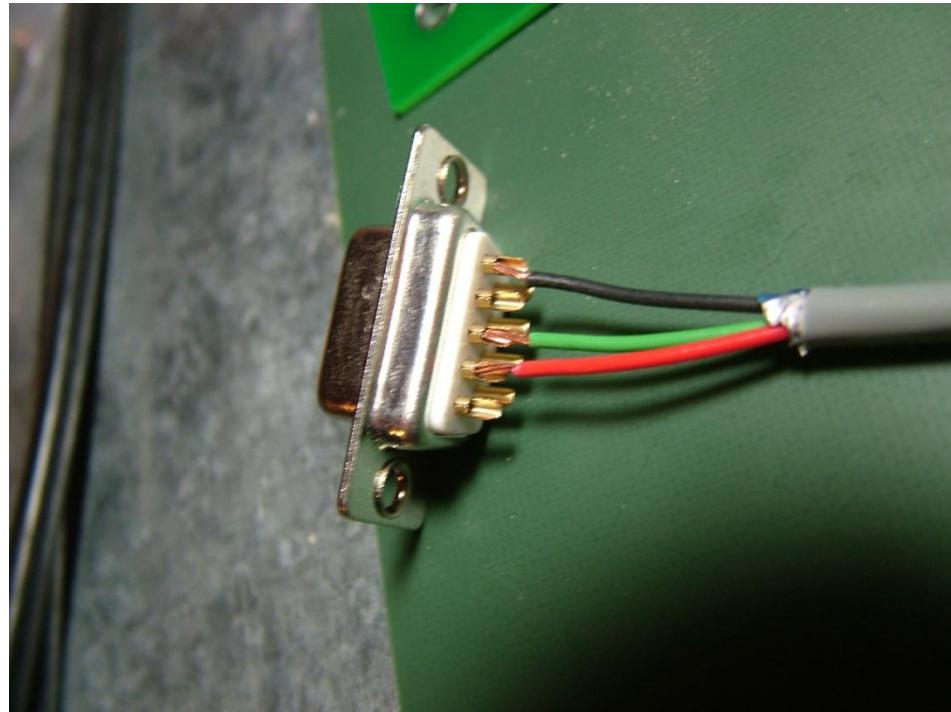
Tape around the end to keep the ground wire from touching anything it shouldn't.



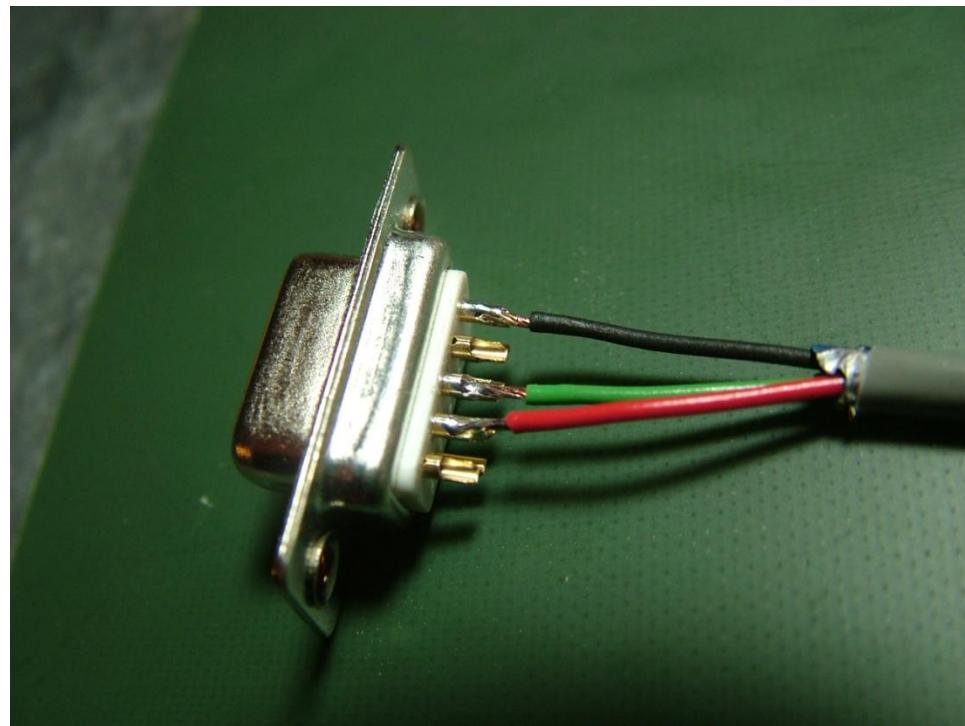
Now get ready to solder the other end to the 9 pin female serial connector.



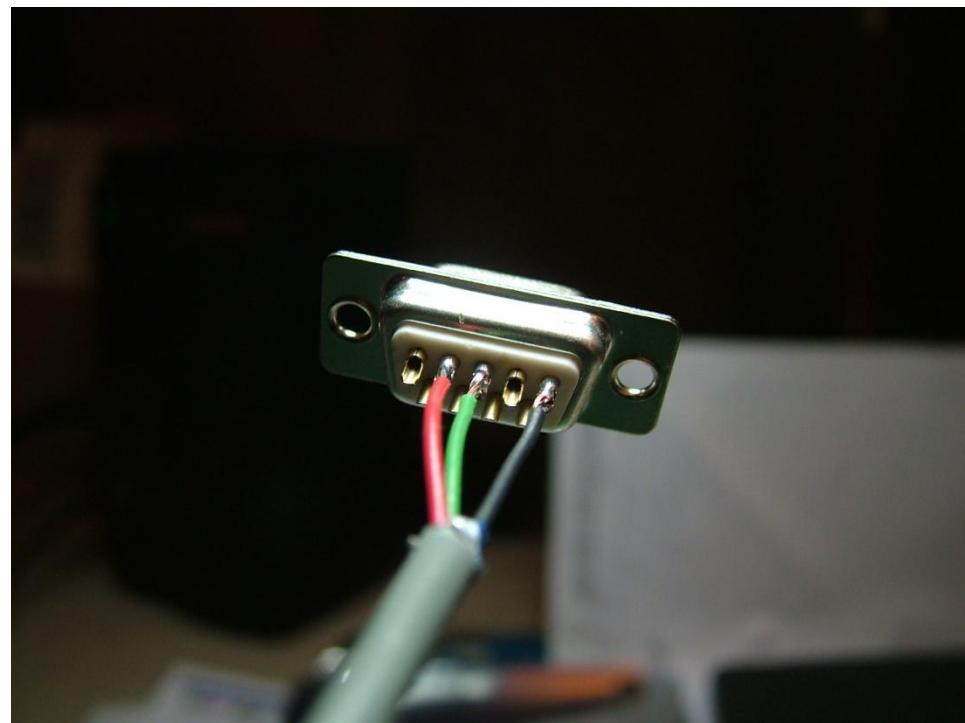
Push the wires into the holes. They should hold there. Notice the order! Red, Green, Black. Also notice which holes they go into!



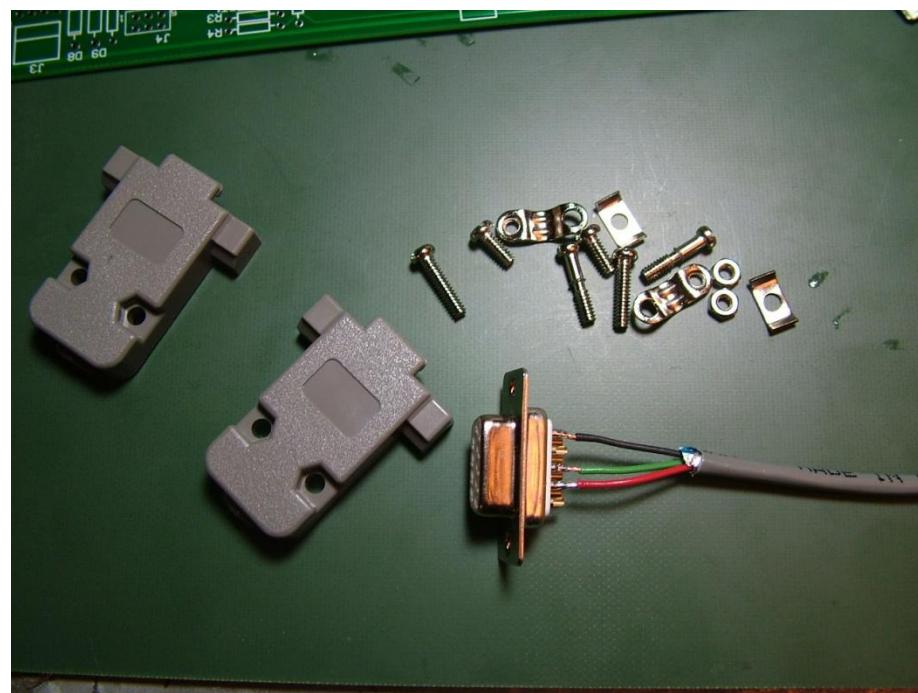
Hurray, the soldering is done.



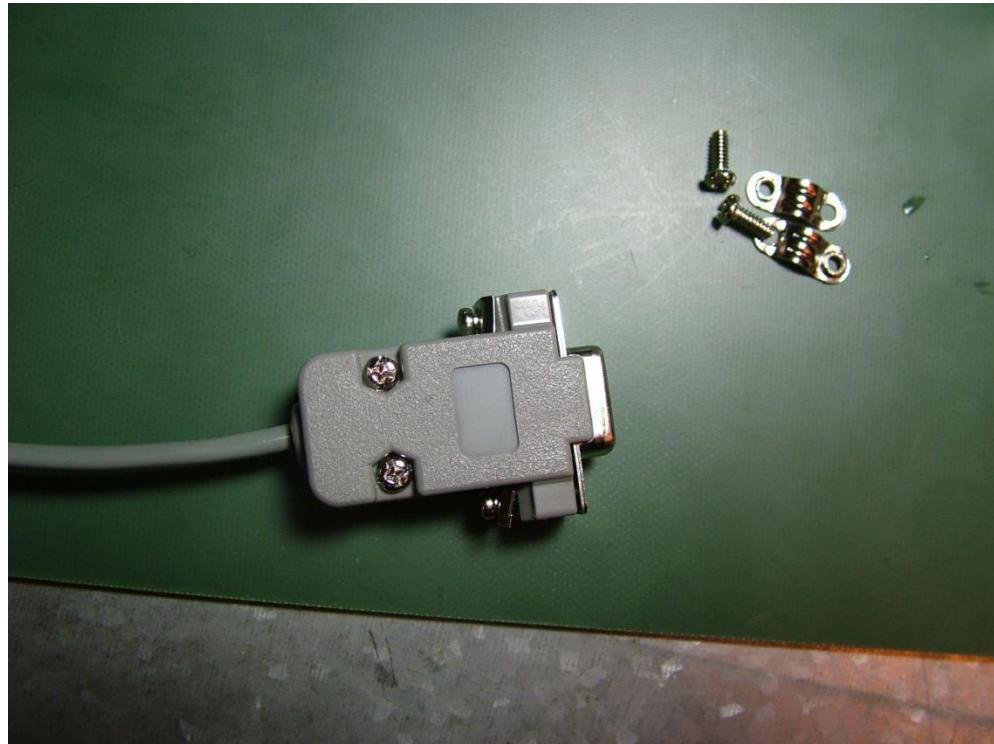
Here's another angle, to make sure you know which holes in which to put the wires:



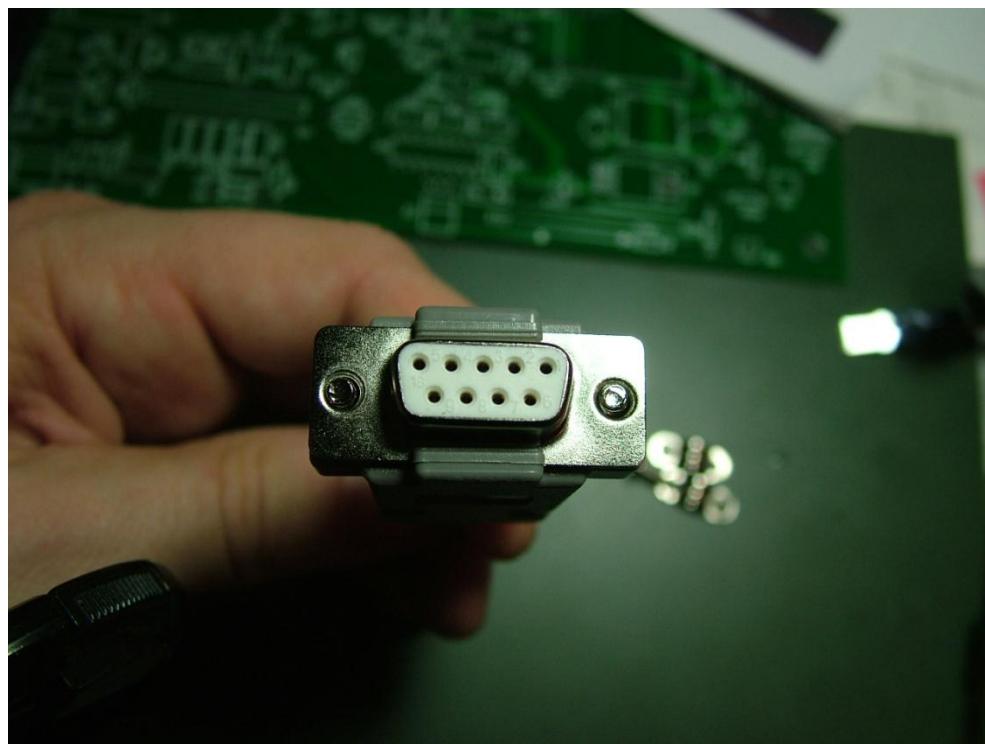
Now get the housing.



Put it all together. It's like a puzzle. You can do it! It only took me like 5 tries! I don't know what those other pieces are for. ☺



Here's what it looks like from the front:

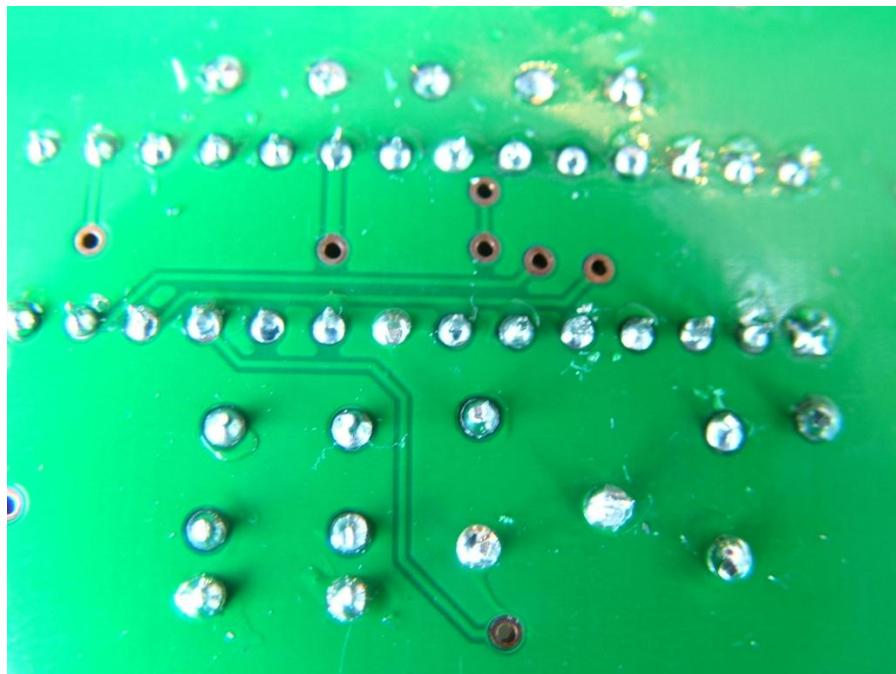


To get RT1 ready to solder to the control board you need to attach the thermistor (black thing) to the twisted pair wire. Your twisted wire pair may be different colors. It should look like this:



The 2 leads get soldered to RT1 at any time you want. (I usually wait until the end of the controller assembly process.) Use some electrical tape to insulate the leads of the thermistor after soldering them to the twisted pair wire.

Be VERY careful when soldering the components to the control board. Don't let the solder bridge the little isolation rings around the solder pads. Too much solder can make the whole thing not work at all. Use a fine tipped soldering iron for the pads that have the ring around them, and use a heavier tip for the pads that are a part of a ground plane, since those take more heat to get the solder to flow.

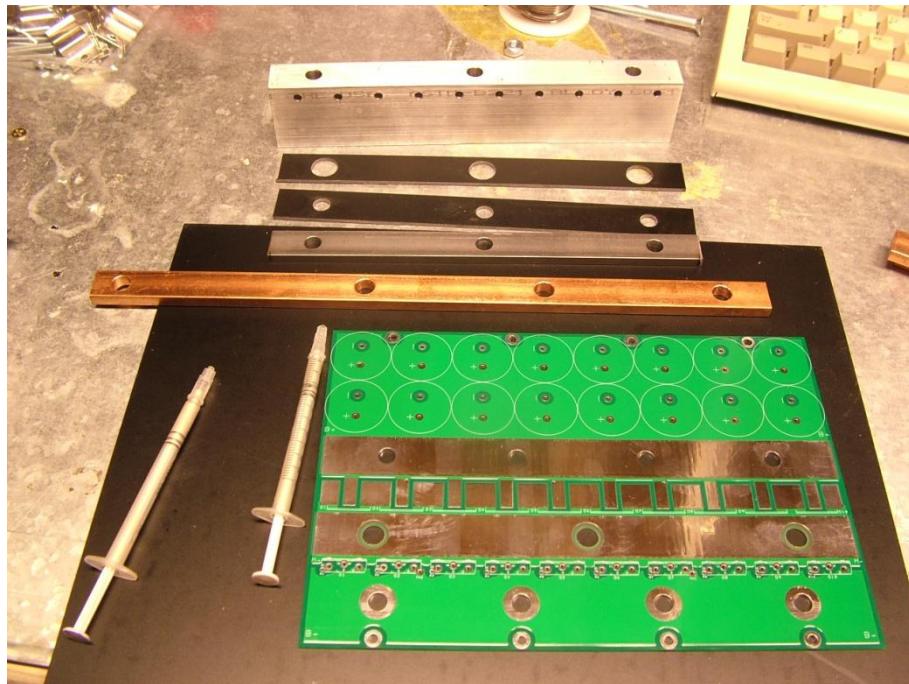


Here's a picture of the holes with the isolation rings bright because of light behind them. **Don't let solder cross over those Rings of Light!!!** In fact... Each time you do a solder joint, hold it up to the light to check it if you are new to soldering.

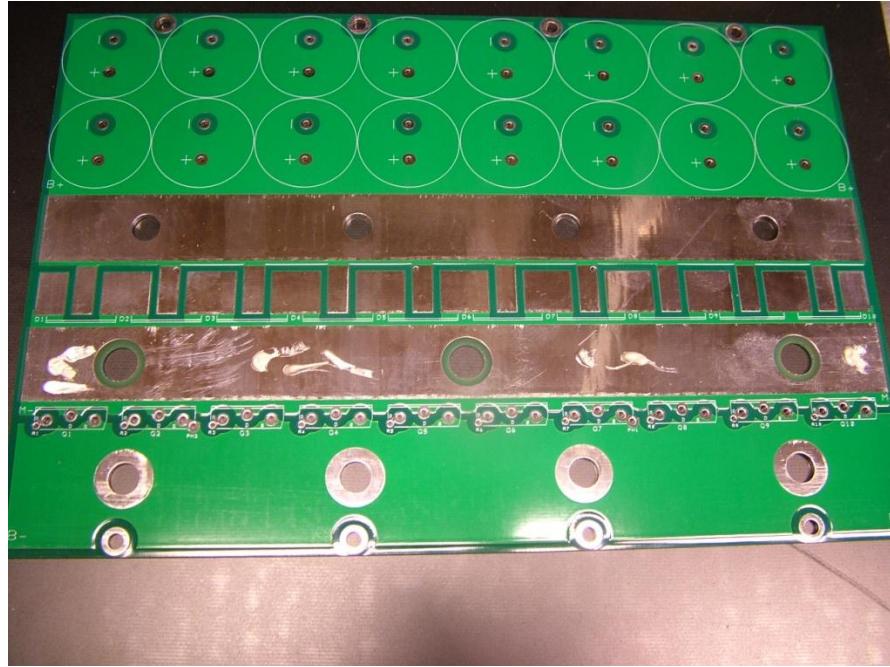


Before assembling the controller, check all the holes in the metals, to ensure that they don't have metal sticking up that would prevent good contact between surfaces. Using a $\frac{1}{2}$ " diameter drill bit is a good way to do this. Just gently drill over the hole, and it knocks the metal off of the edges. Also, take the 0.75" x 1.5" x 8" aluminum heat spreader and drill a 1/8" diameter, or so, hole in the center (doesn't need to be very exact at all) of one of the 0.75" x 1.5" faces. 0.25" to 0.5" deep is plenty.

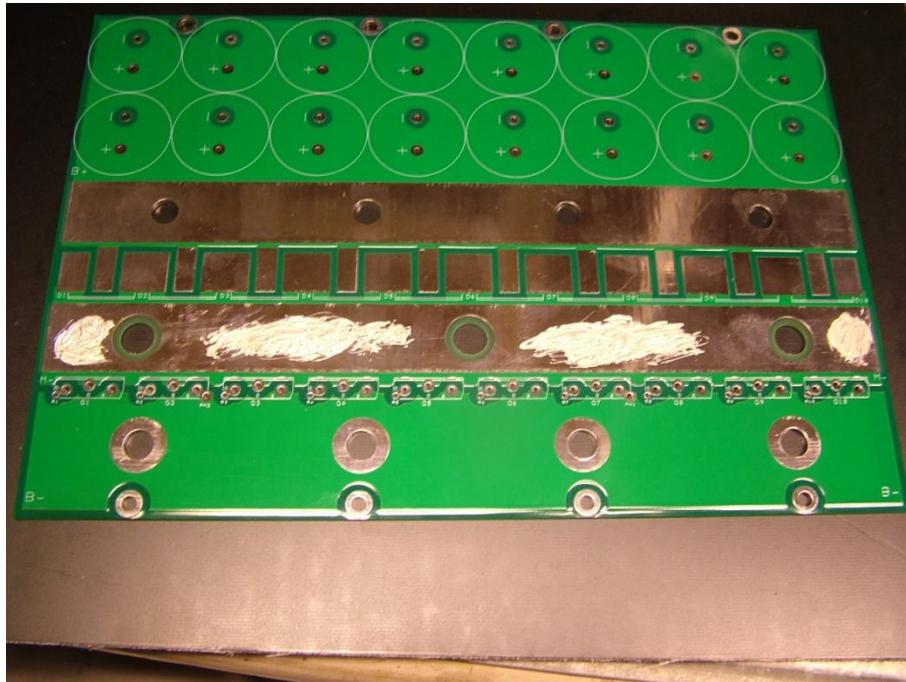
Now, gather the following items. The syringes are a 2 part silver conductive epoxy:



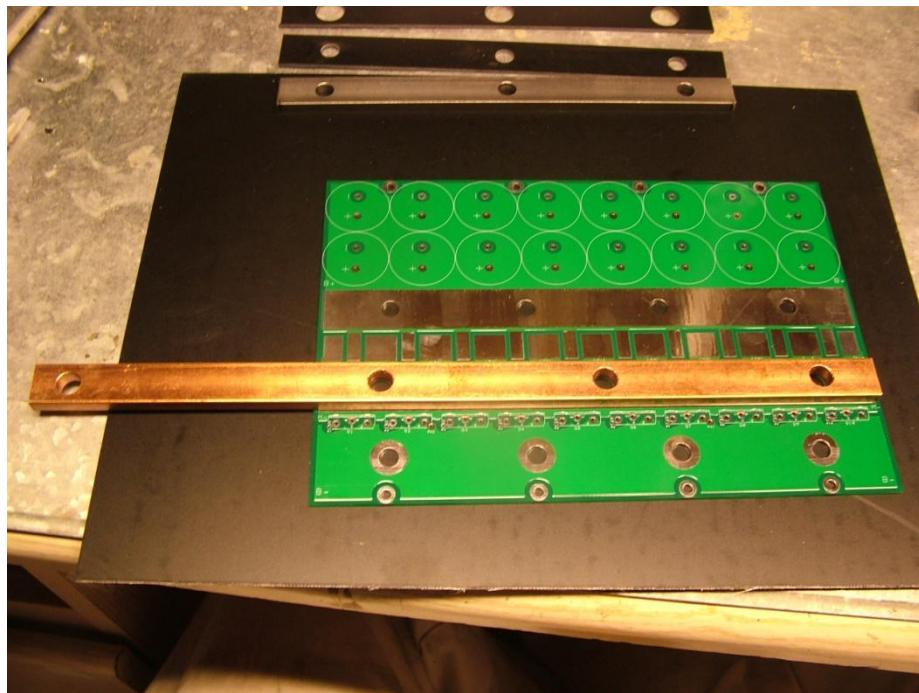
Put 1/3 of the silver conductive epoxy from each container onto the M- pad. It's a 2 part epoxy, so put equal amounts of each container and mix them:



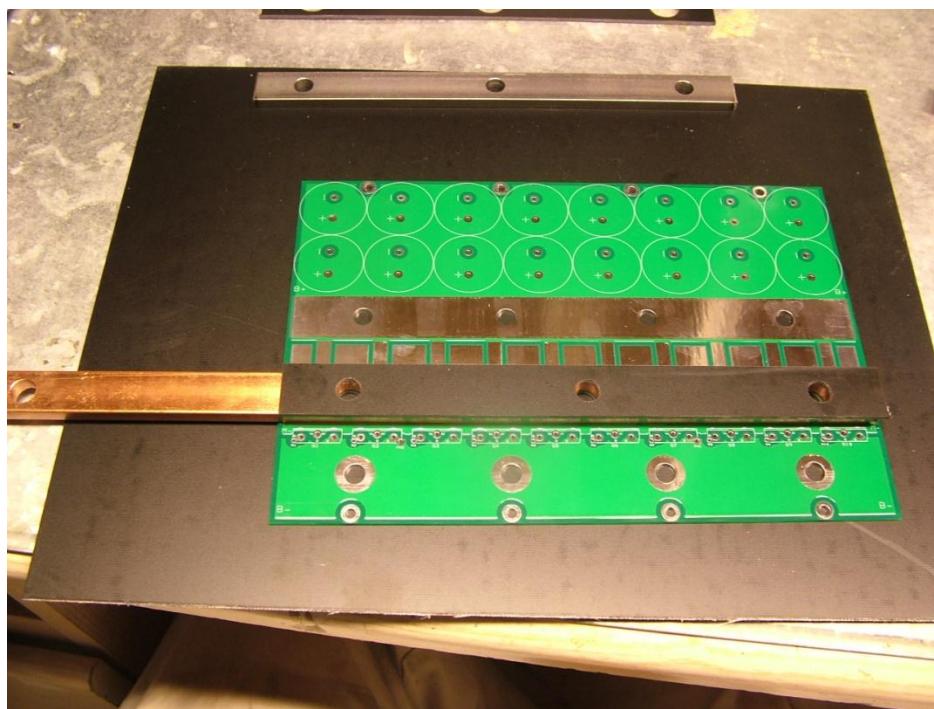
Then smoosh it around using your mother-in-law's toothbrush (or her toothpick, or whatever is handy):



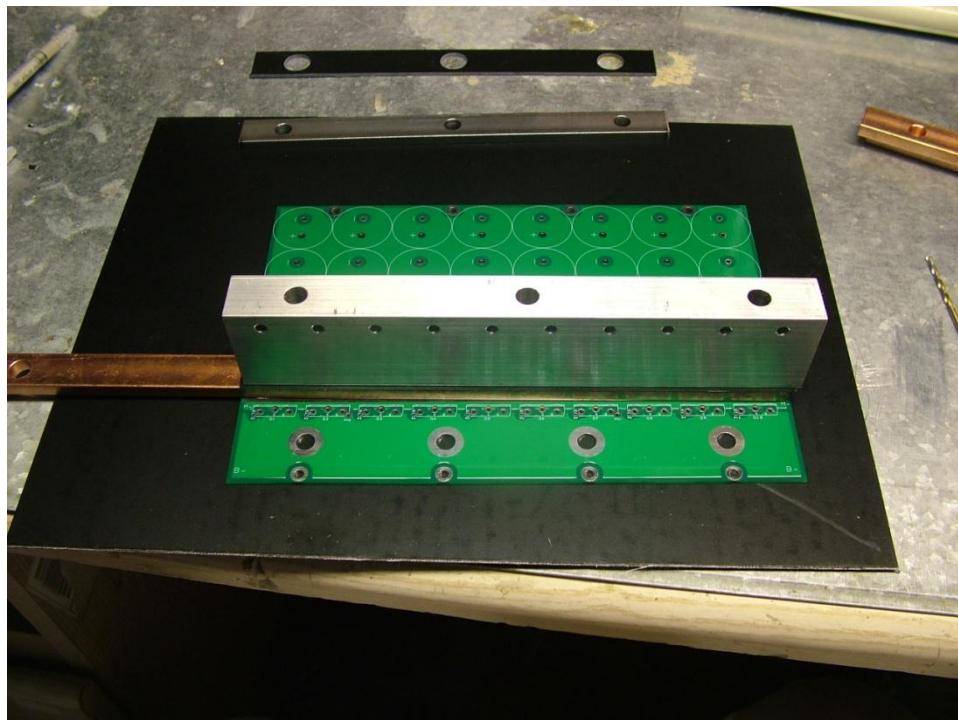
Now, stick the M- bar on. It's the long one. **Make sure it's pointing toward the LEFT**, and that the 16 white capacitor circles are at the top.



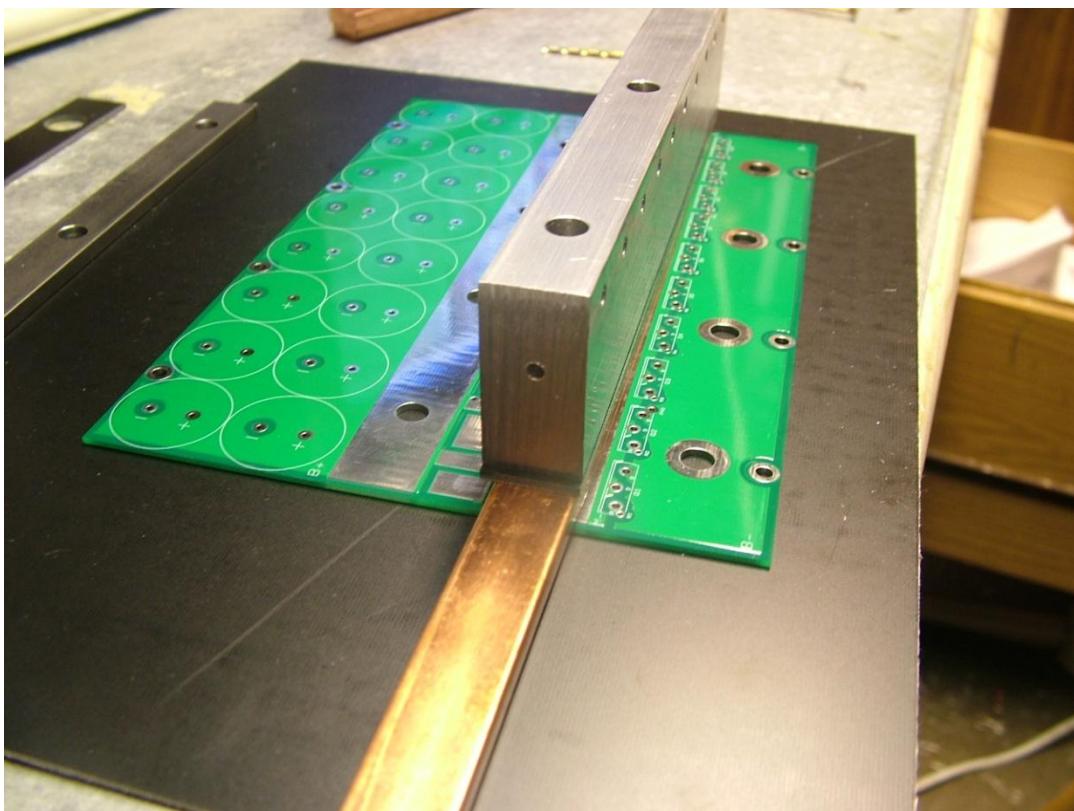
Now stick the fiberglass board with the 3 smaller holes on top of the copper bar. This will enable the M-bus bar to stay electrically isolated from the 0.75" x 1.5" x 8" heat spreader.



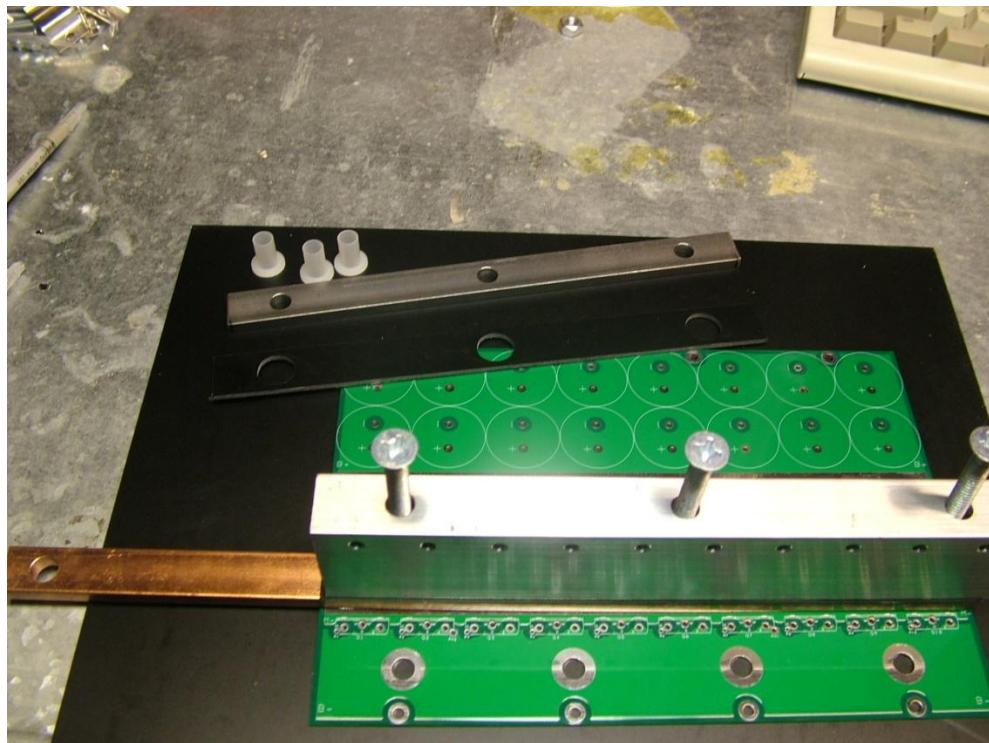
Now stick the aluminum heat spreader on top of the fiberglass isolation board.



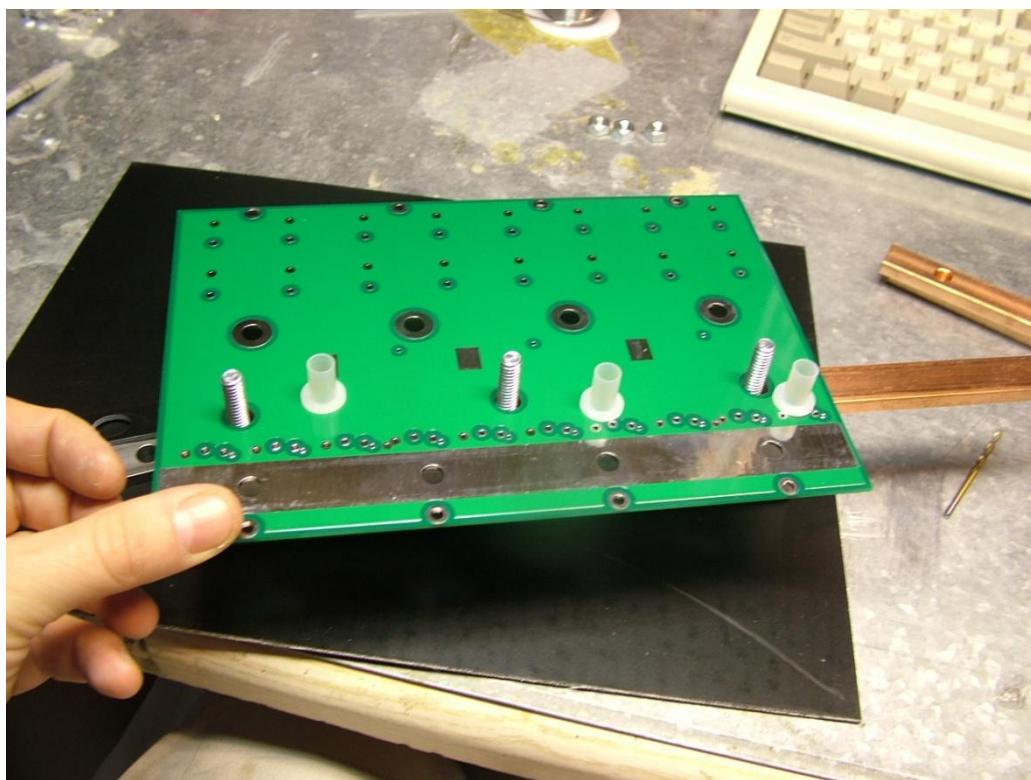
RED ALERT: Notice that the small hole in the 0.75" x 1.5" face of the heat spreader is on the end that the M- bus bar is sticking out!



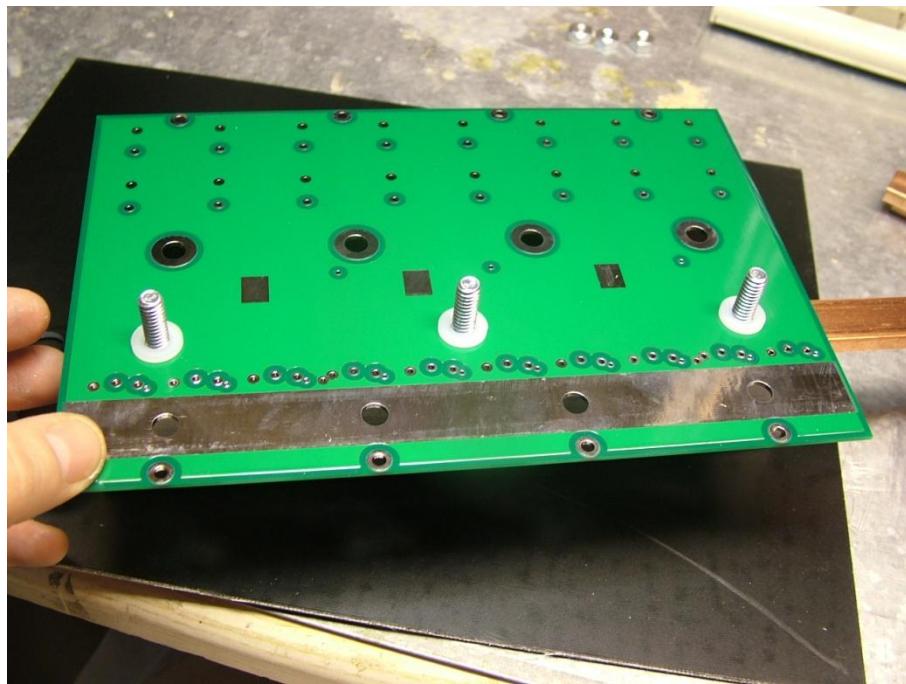
Now, stick the three long 0.25" x 2.75" flat head screws in through the heat spreader.



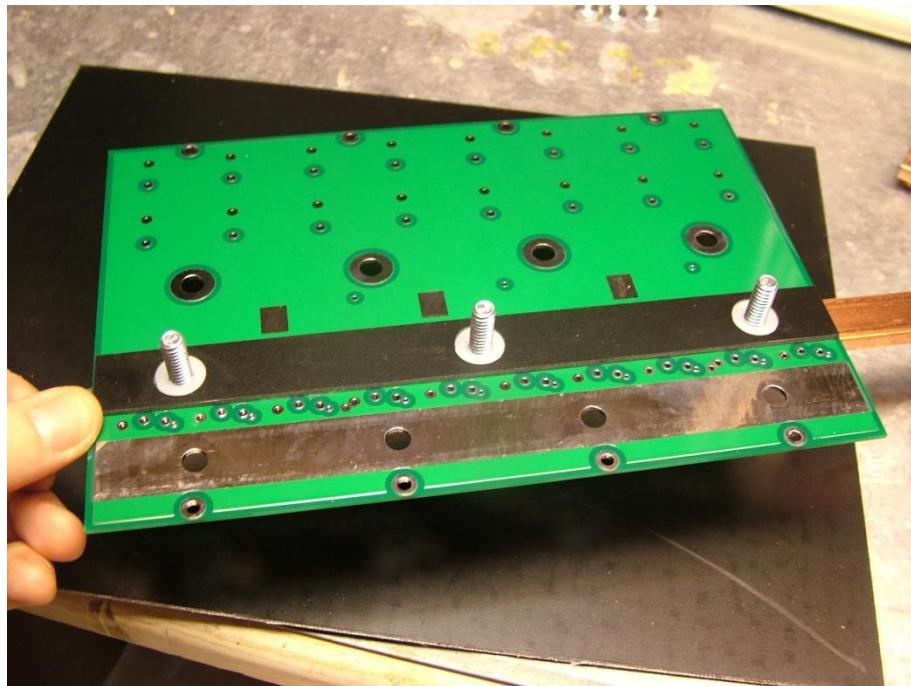
Now, carefully flip that whole thing over. Try not to let the bus bar slide around too much, so the silver conductive epoxy doesn't make a mess:



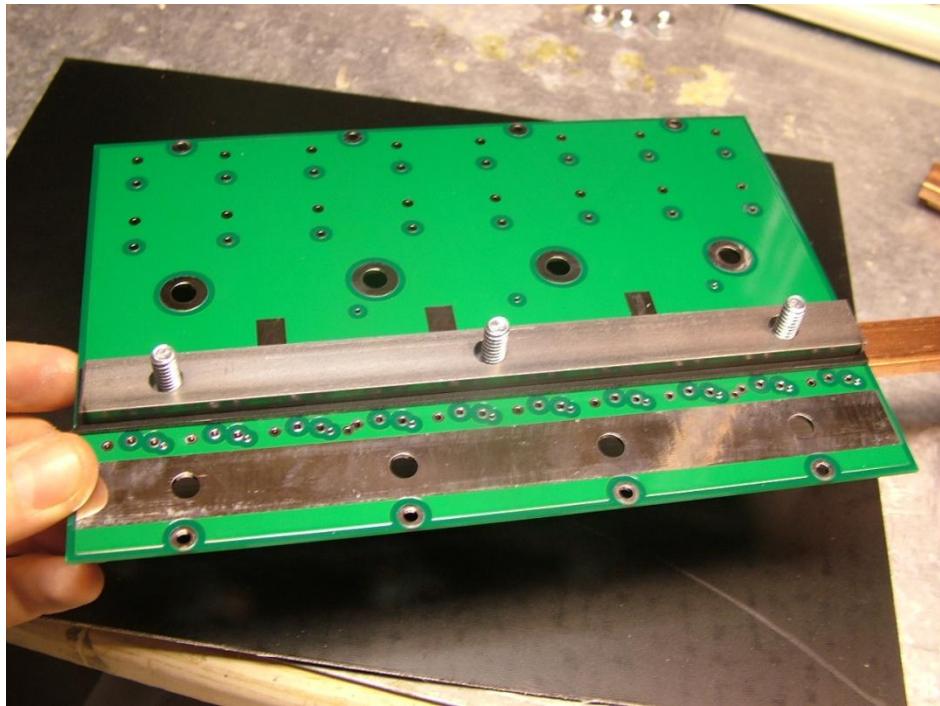
Now, stick the little plastic things (what on earth are those called?!) into the 3 holes. They make sure that the M- bus bar stays isolated from the 3 screws.



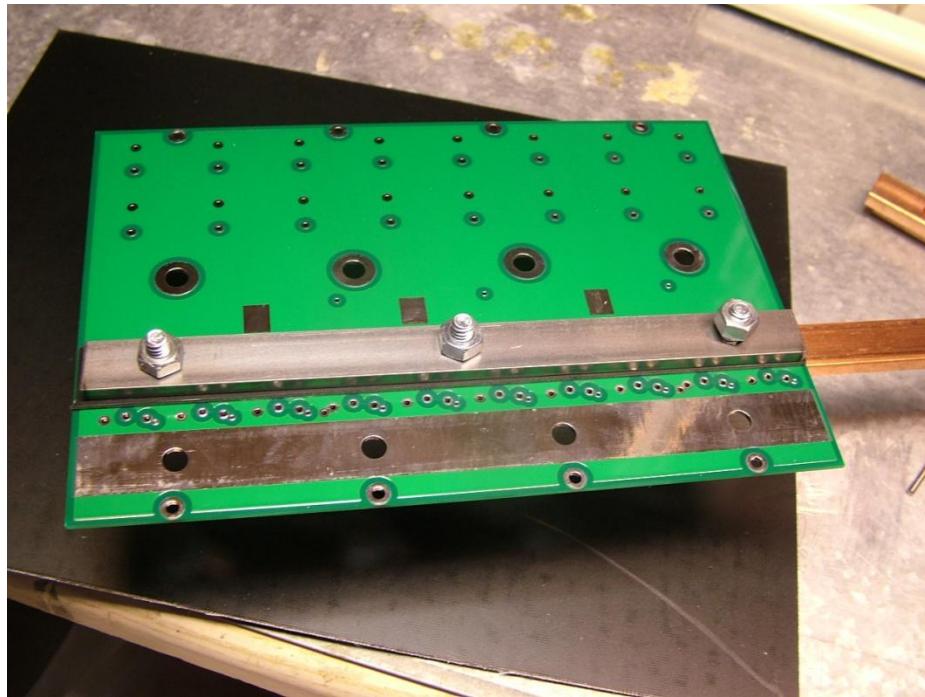
Now, take the thin fiberglass board with the 3 big holes and stick it on. The plastic things should fit nicely inside the big $\frac{1}{2}$ " holes.



Now add the steel bar with the 3 holes in it. This gives support so you will be able to bolt the screws down tightly without damaging the power board:



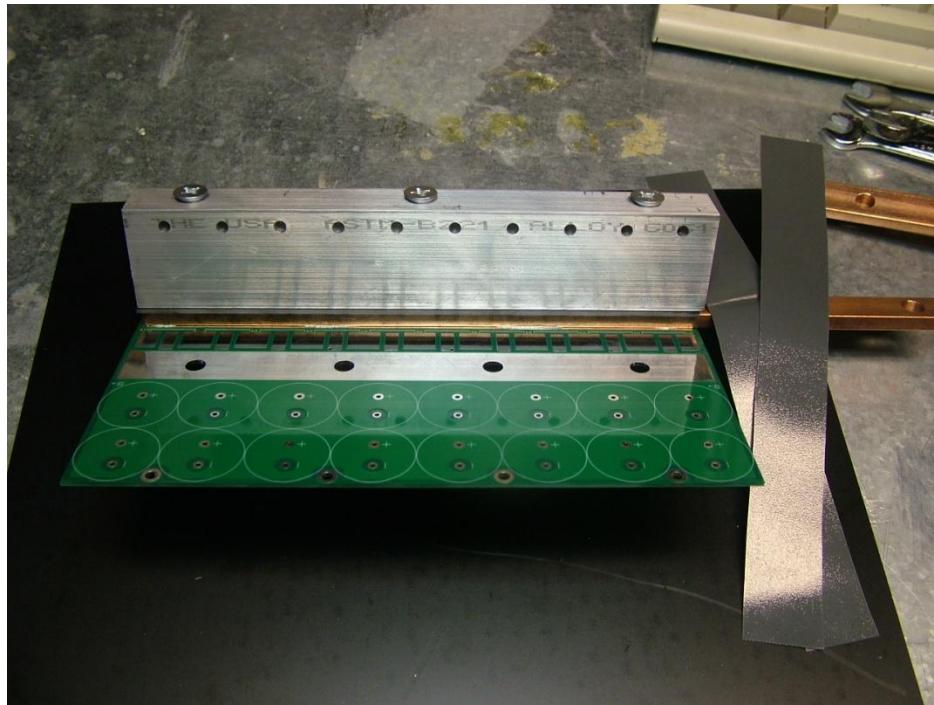
Now put the nuts on there:



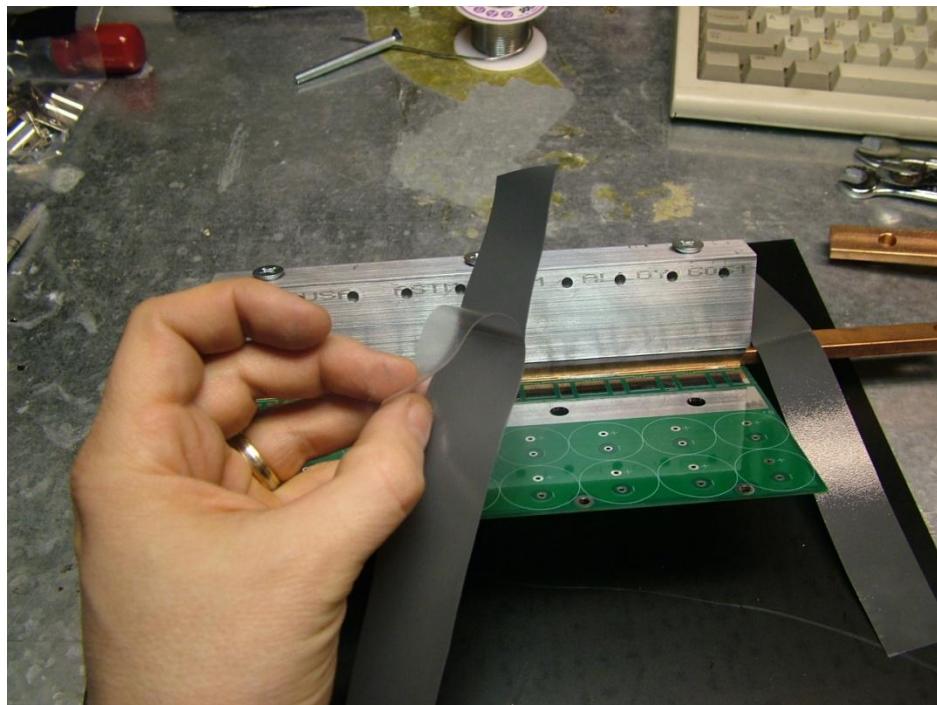
Now, tighten it down nice and snug, so the silver conductive epoxy gets good and squashed down under the M- bus bar. You will need a Phillips screwdriver and a 7/16" hex wrench:



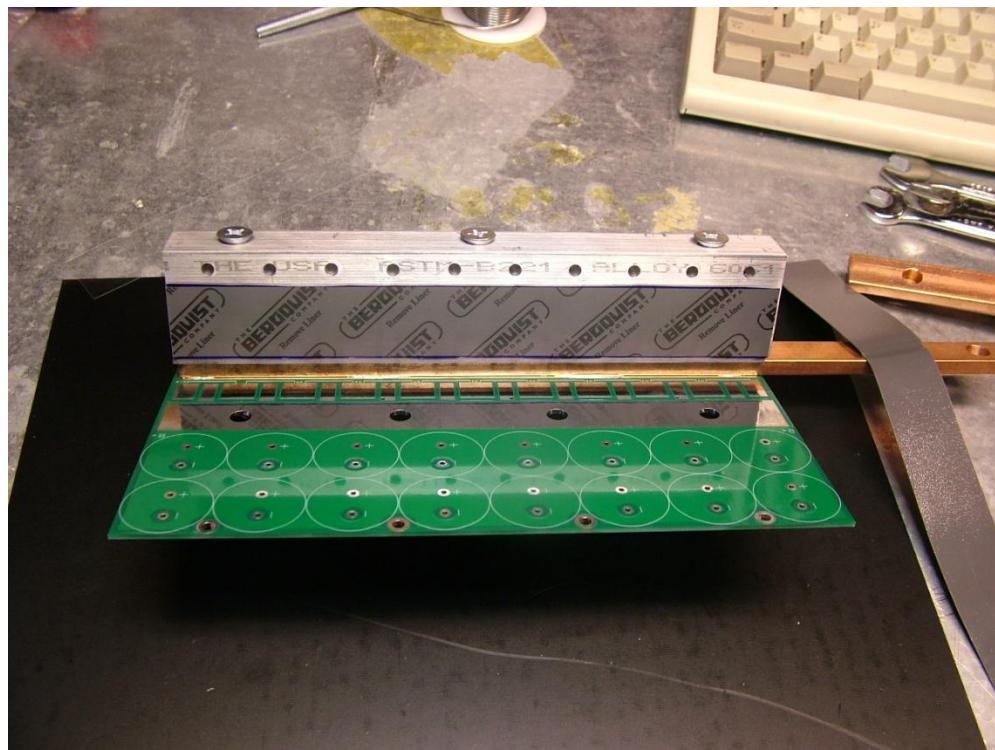
Now, get the 2 strips of grey isolation material ready:



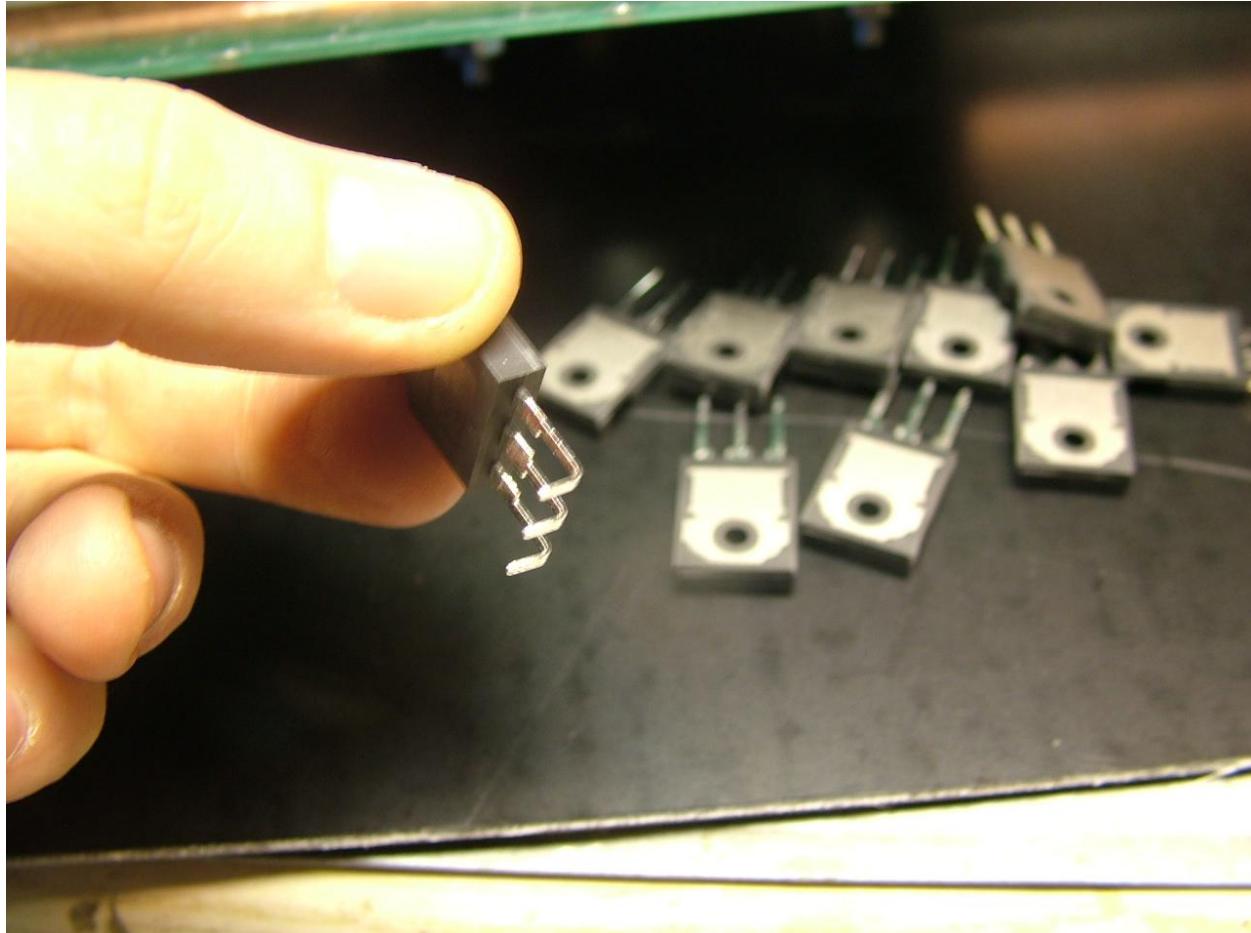
Peel off the side with no writing on it first:



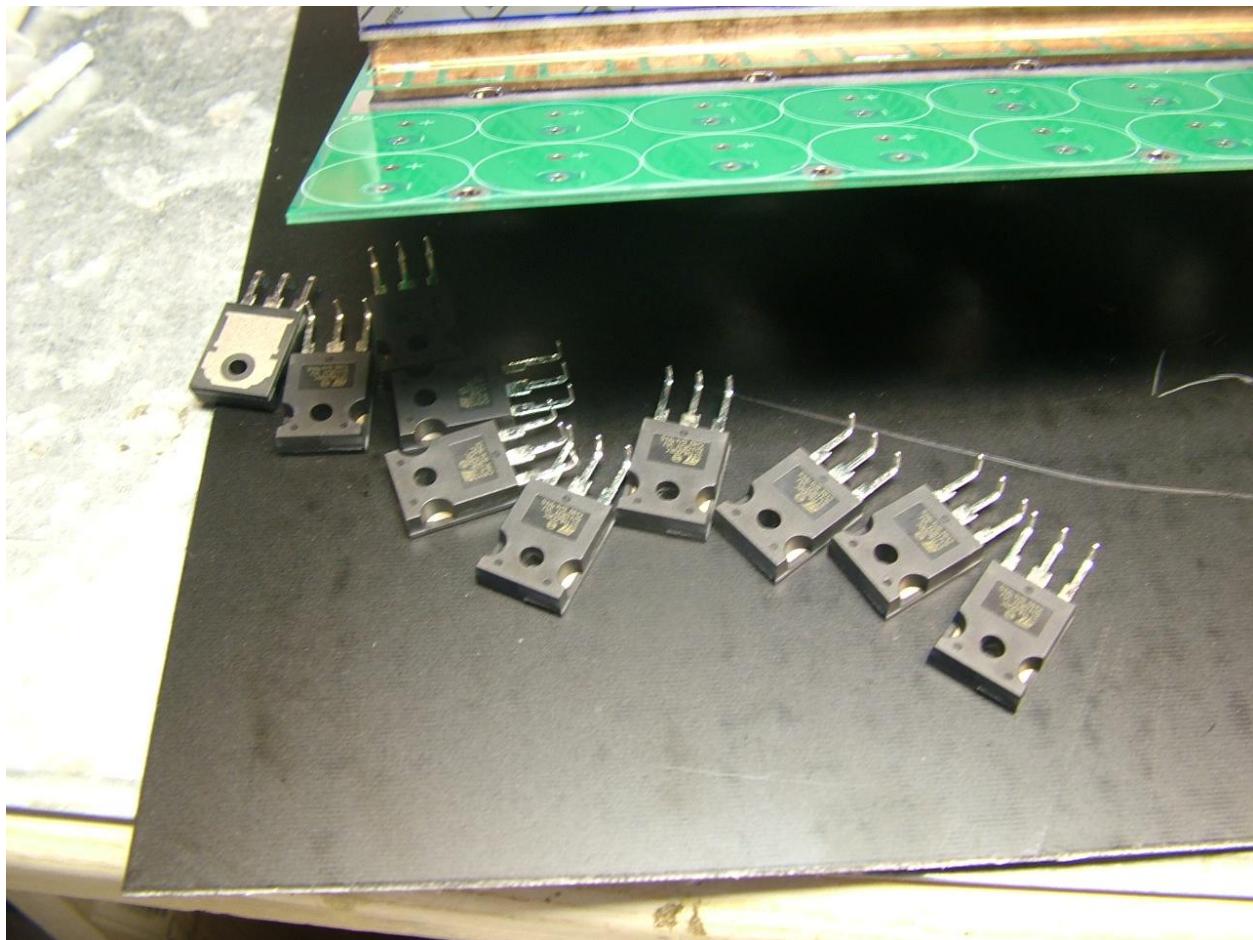
Now, stick it on. The isolation pad should basically just cover the heat spreader. It doesn't need to cover anything below the heat spreader



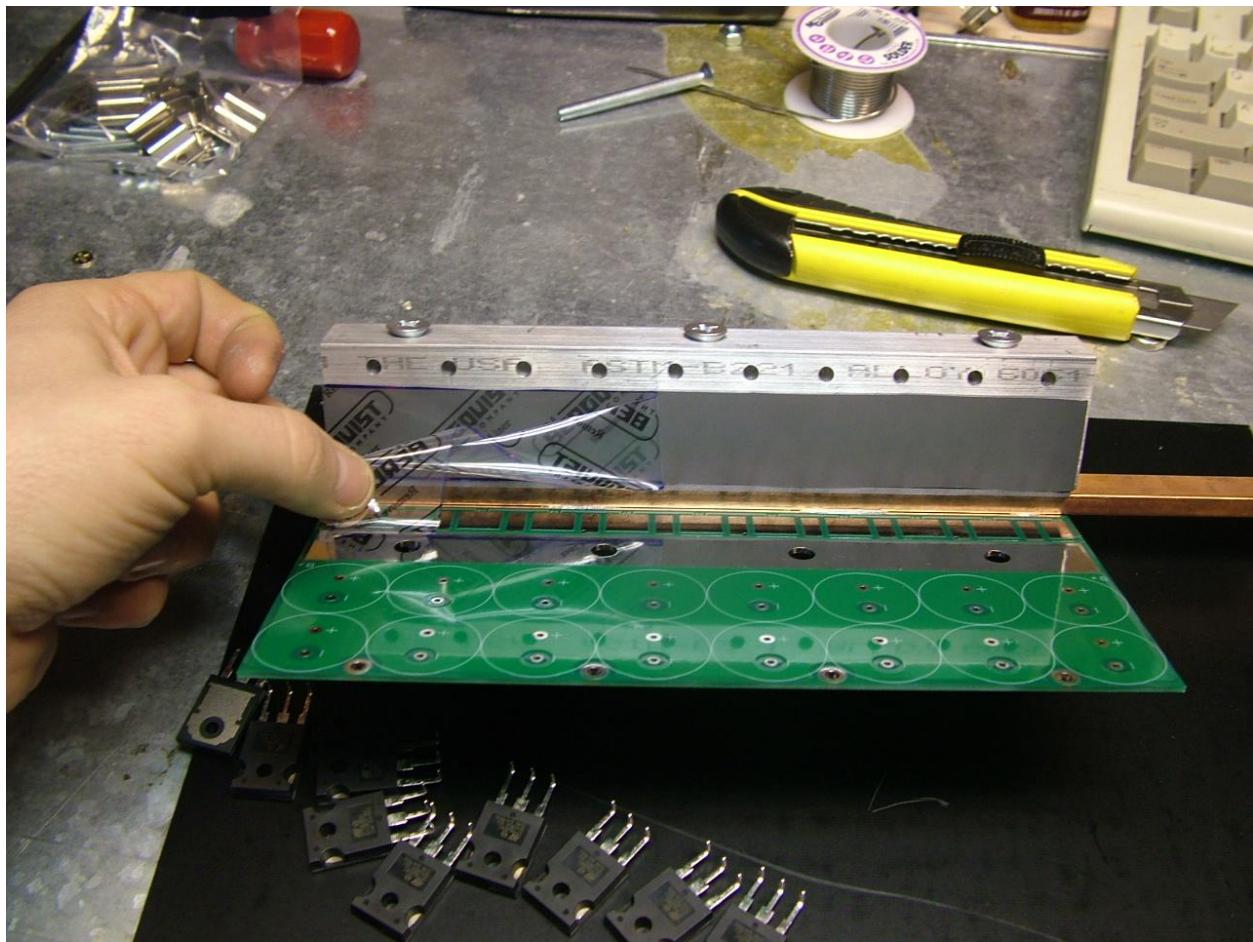
Now, get the ten STTH6002C diodes and bend the legs. I do a single bend of all 3 legs with needle nose pliers, so they all bend the same. Notice the metal backs of the diodes. It has a very distinct design. Make sure it looks like the picture below. If it just looks like a metal rectangle that's really shiny, you have the MOSFETs. By the way, you want the metal back to go against the heat spreader



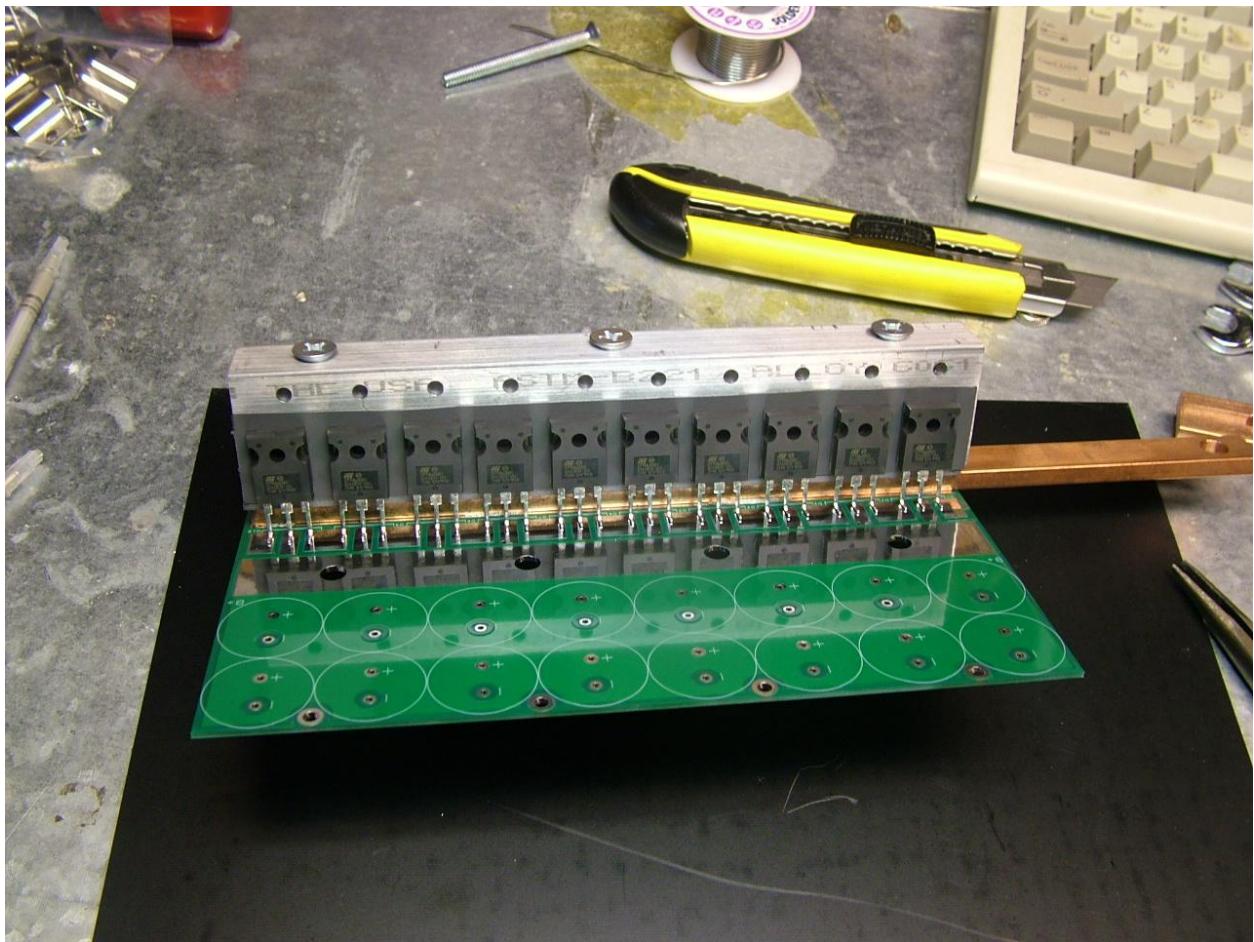
Bend the legs of all 10 of the diodes:



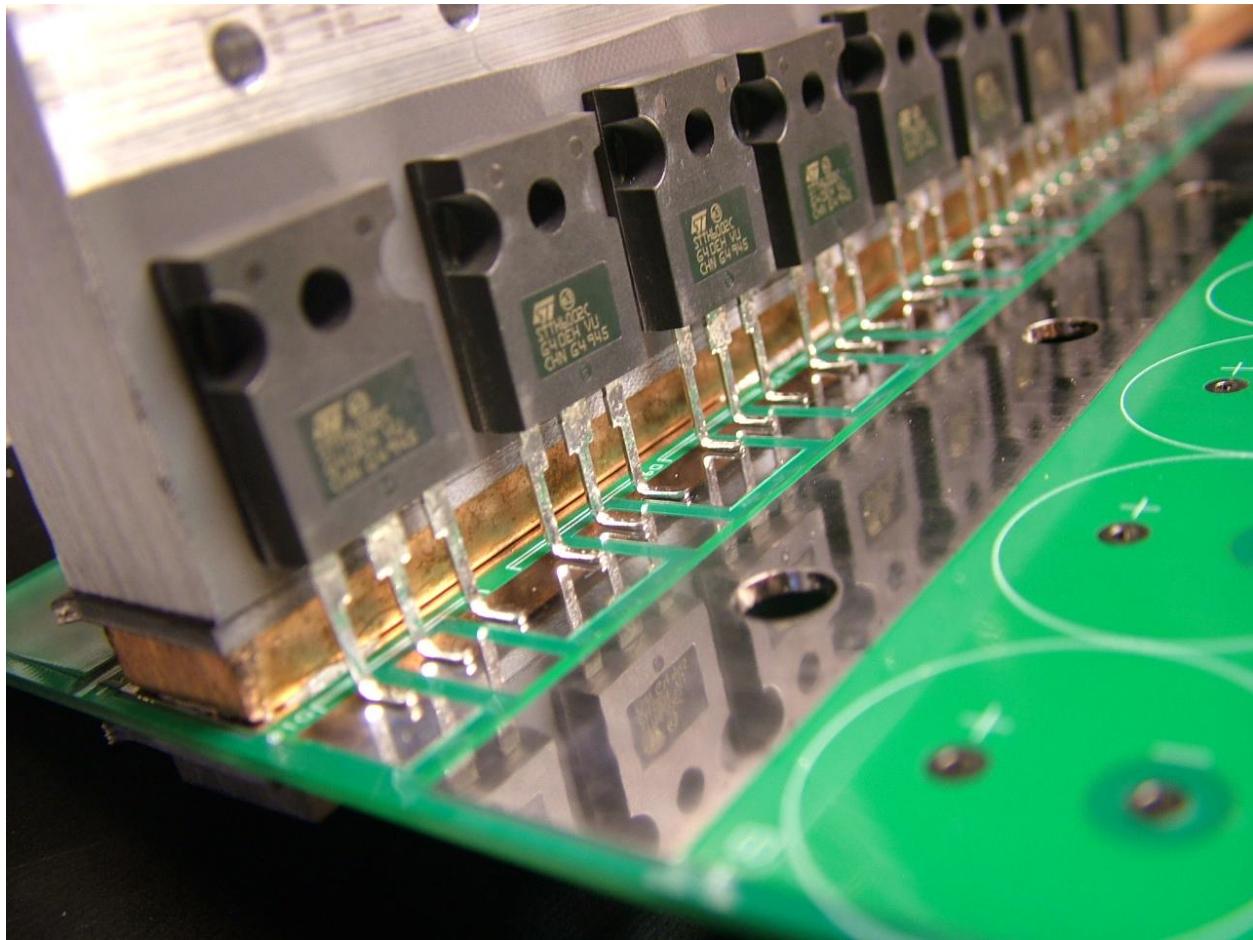
Now, peel off the front of the isolation material (the stuff that has all the writing on it). It works pretty well to get the peeling started by using a sharp edge like a razor at the corner:



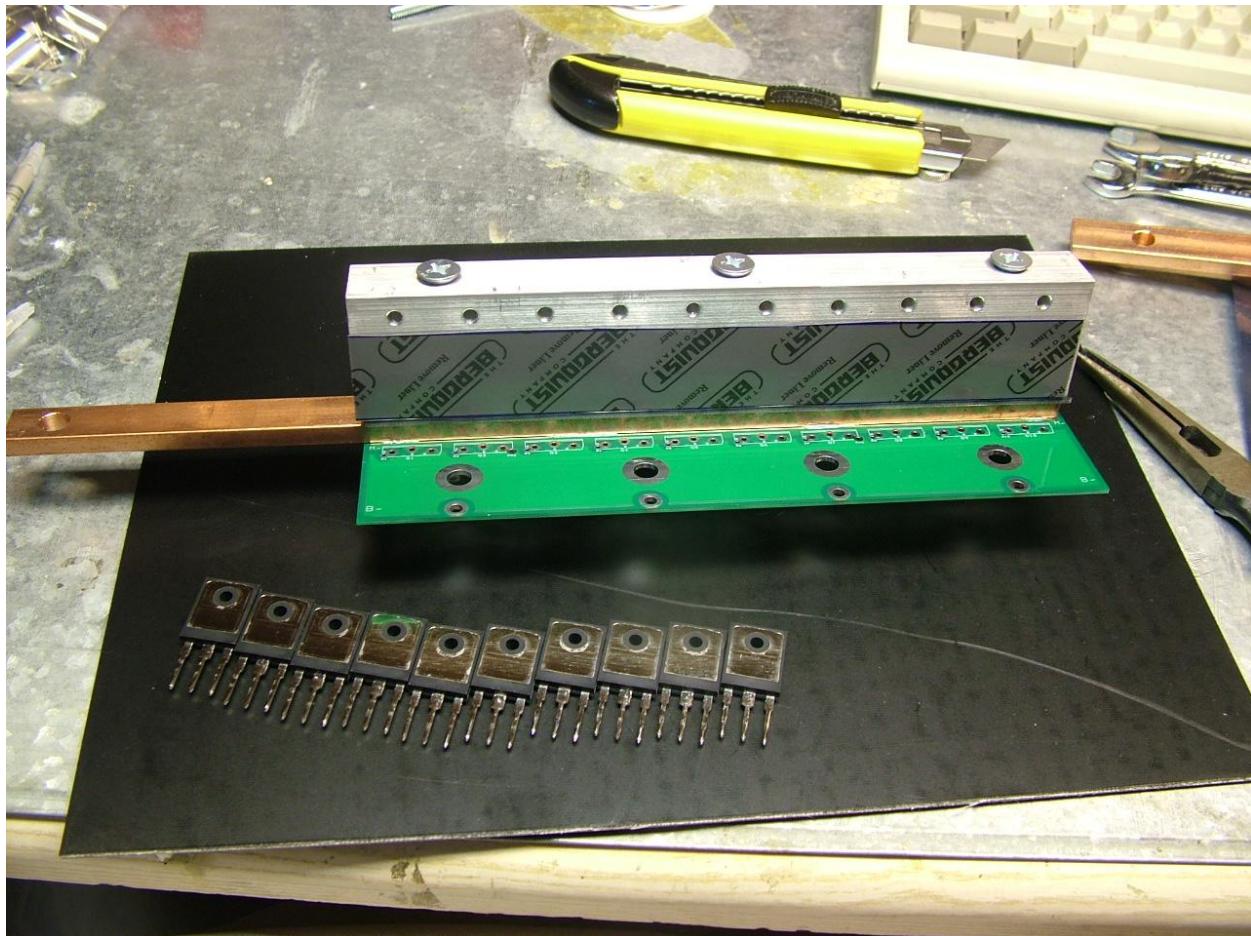
Stick all the diodes on. The backs will stick nicely to the tacky isolation material. Make sure that the legs are flush against the power board:



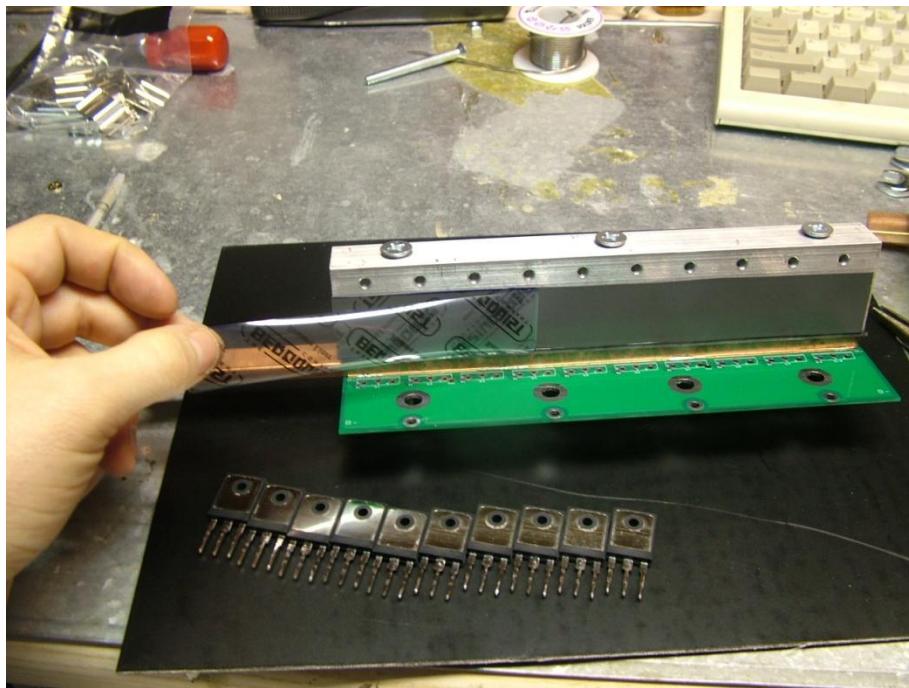
Notice that the middle legs go on the skinnier pad. Make sure the legs are bent so that the bottom of the black body of the diode is still on the heat spreader:



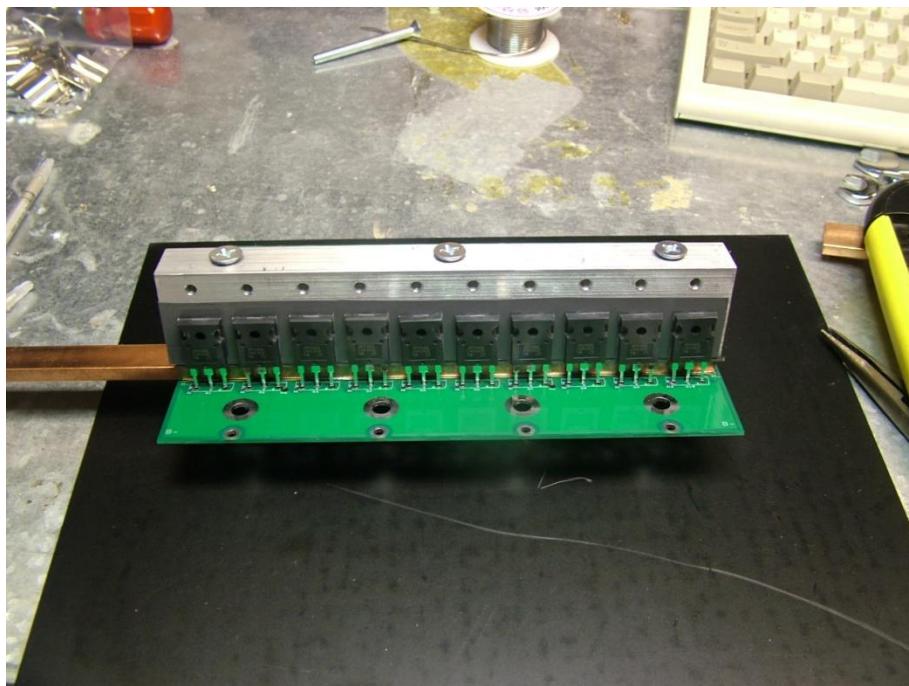
Now, spin it around, peel and attach the other piece of isolation material. Get the 10 mosfets ready to go! Notice how shiny the mosfets are on the back. Also, on the back it's a rectangular metal shape, which is very different from the metal shape on the back of the diodes. **DO NOT MIX THEM UP!**



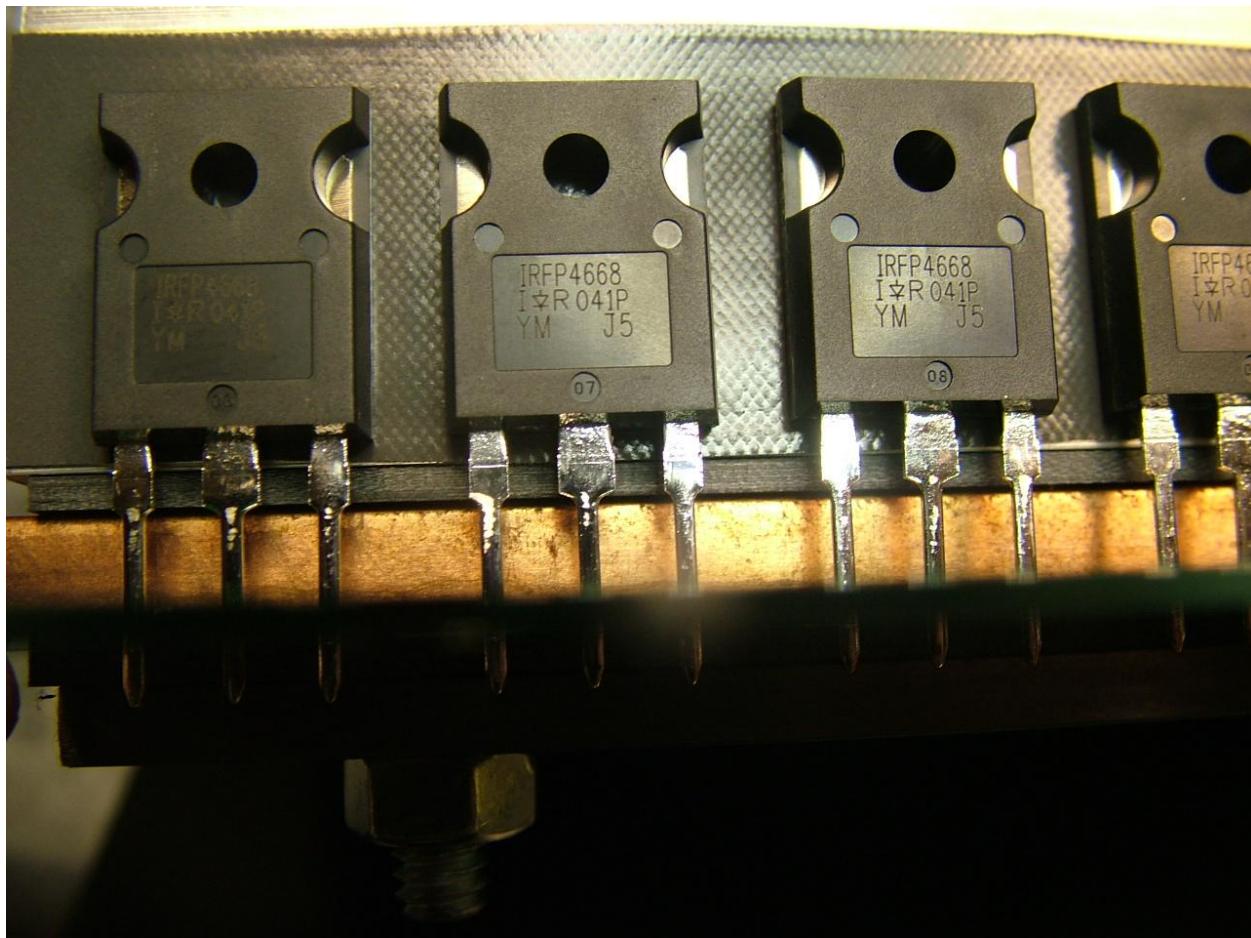
Peel off the front of the isolation material. You don't need to bend the legs of the mosfets:



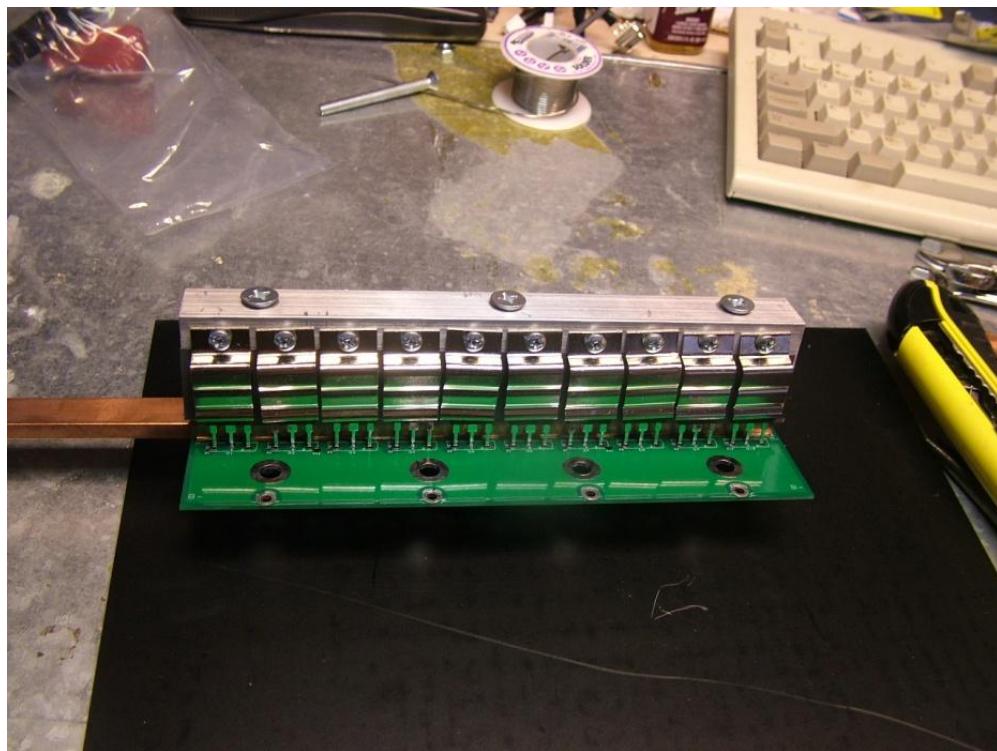
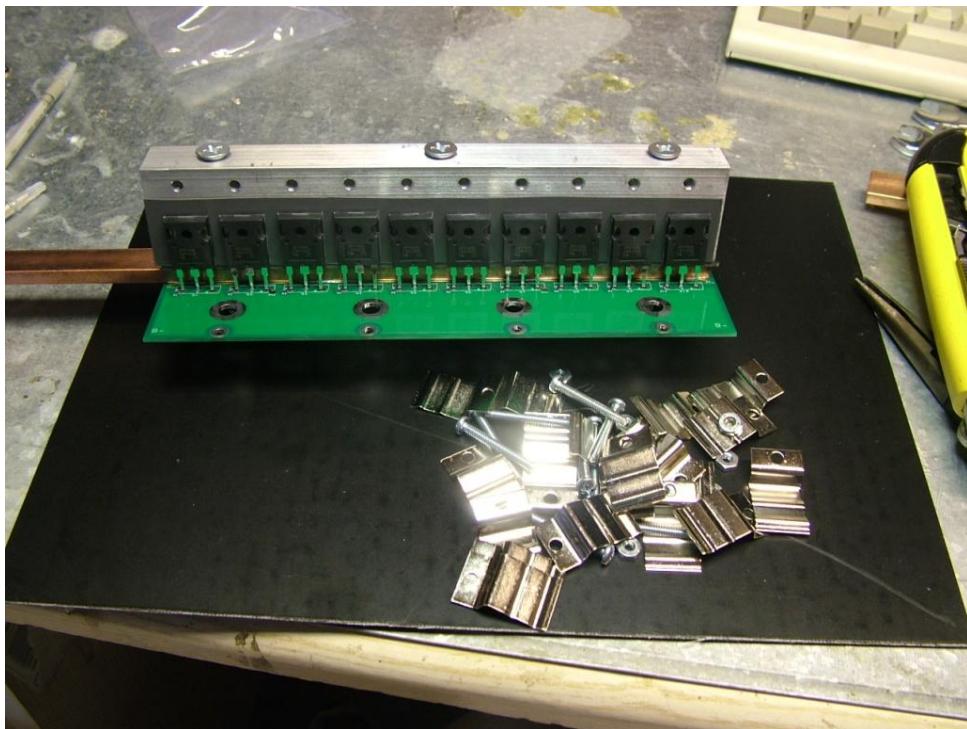
Push the MOSFETs through the holes, but not too deep! Make sure the bottom of the body of the MOSFET is still on the heat spreader:

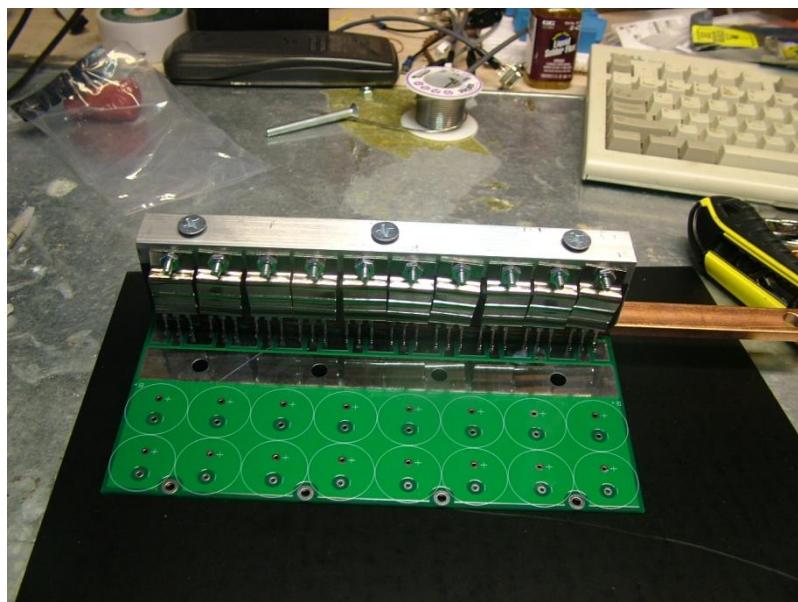


Here's a close-up of the MOSFETs:

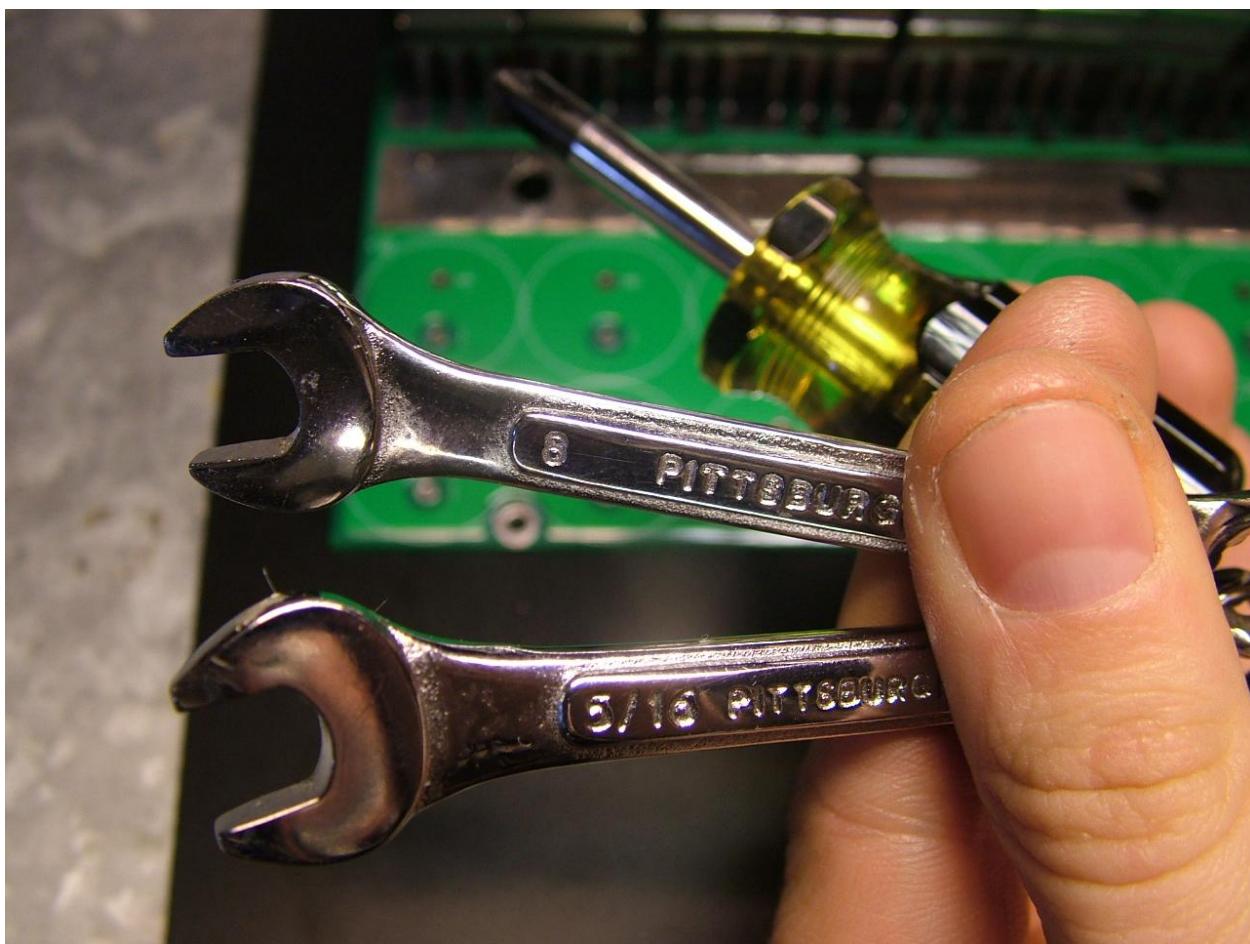


Get the 20 mosfet clips and ten #6 x 1.25" screws and nuts ready:

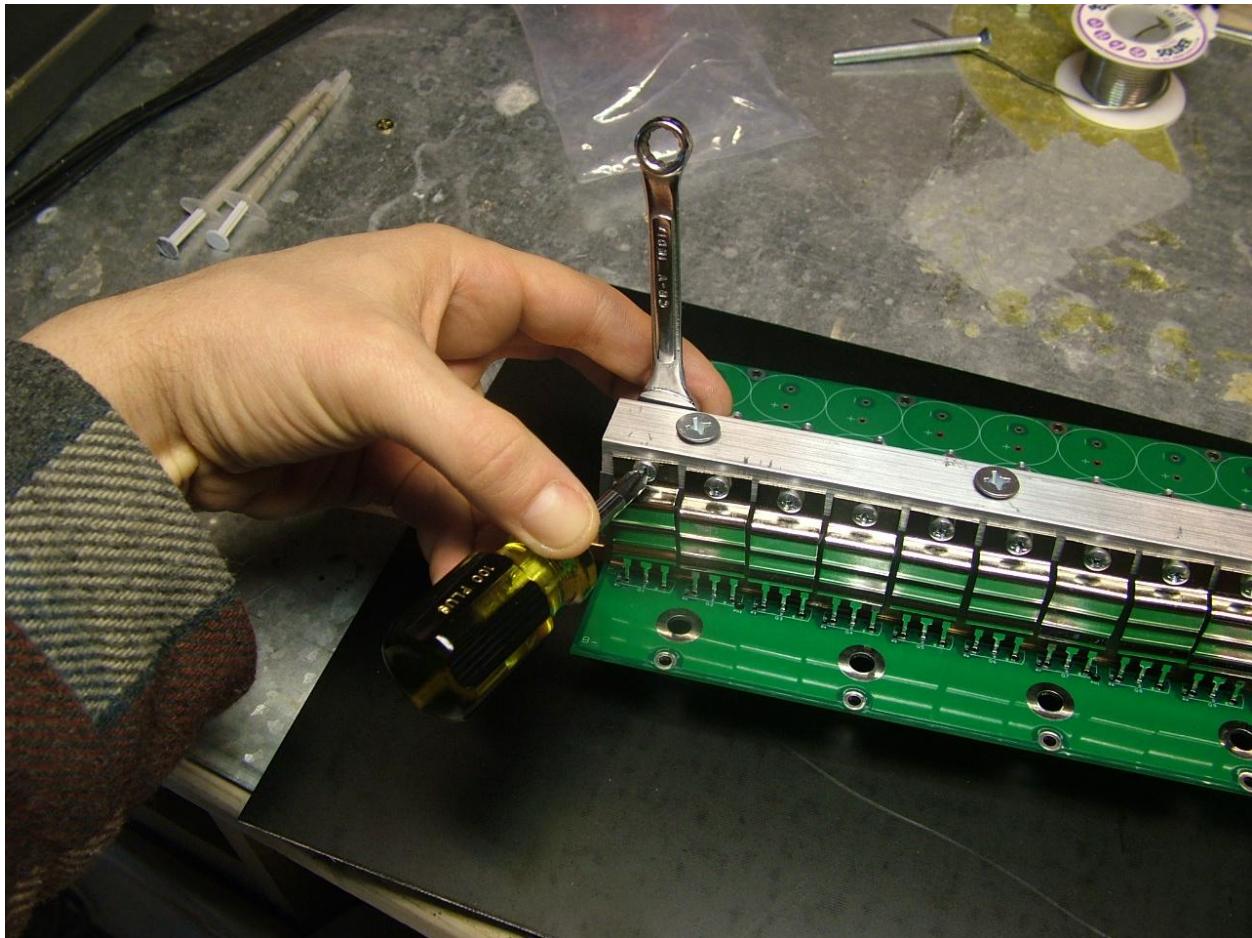




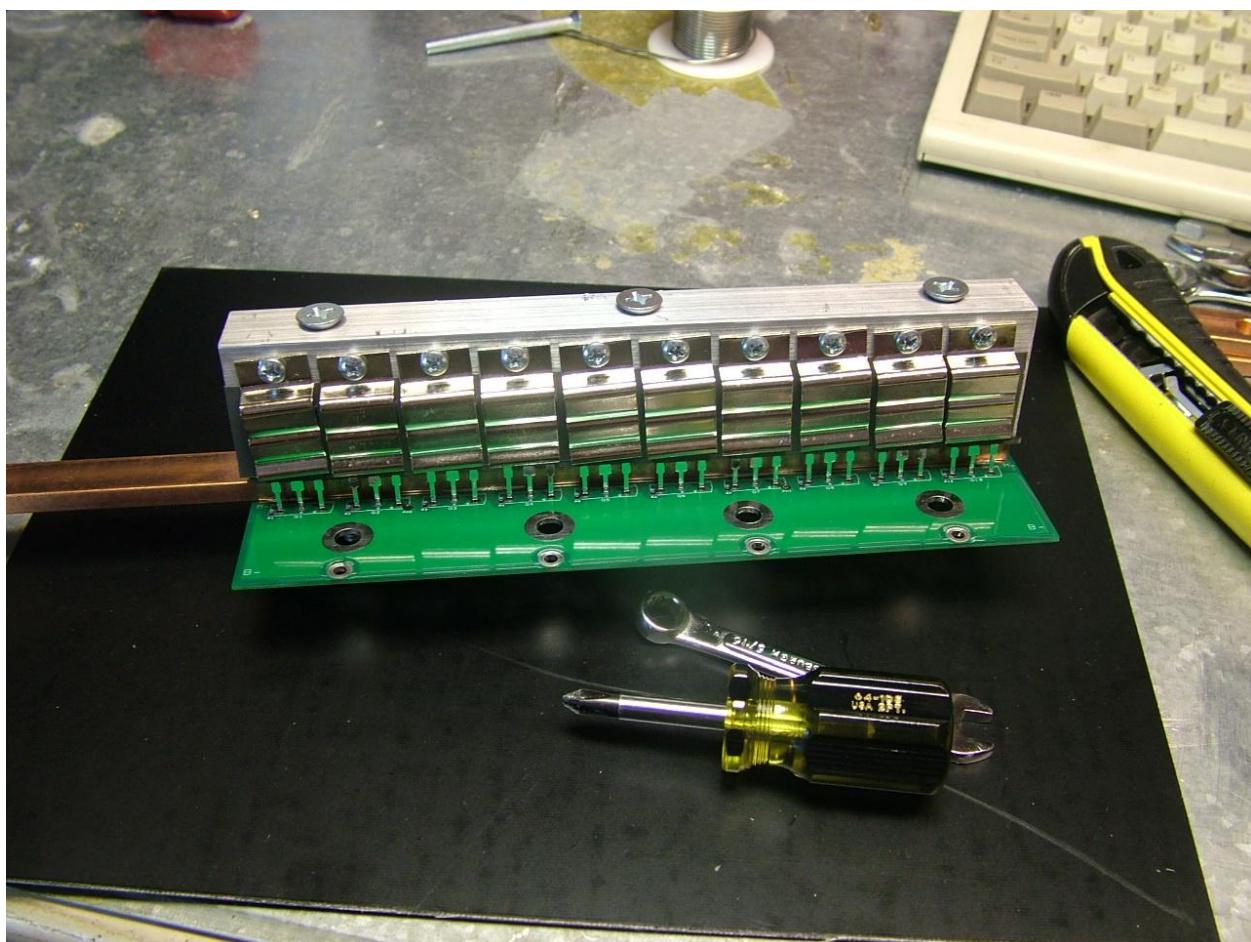
Now, get a Phillips screwdriver, and either a 8mm or 5/16" wrench ready:



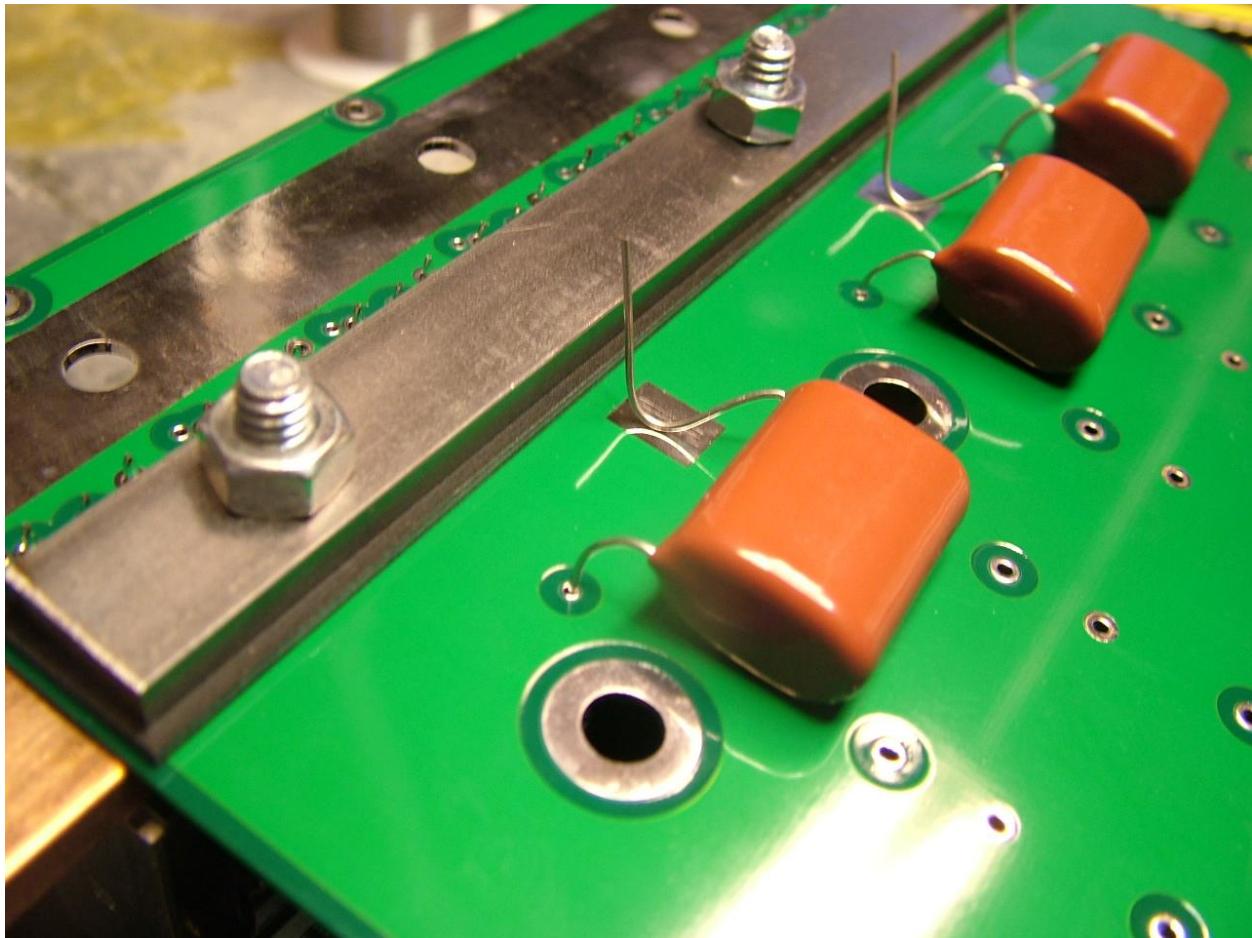
Use the screwdriver to tighten it down just a little bit, so they are firm against the back of the heat spreader.



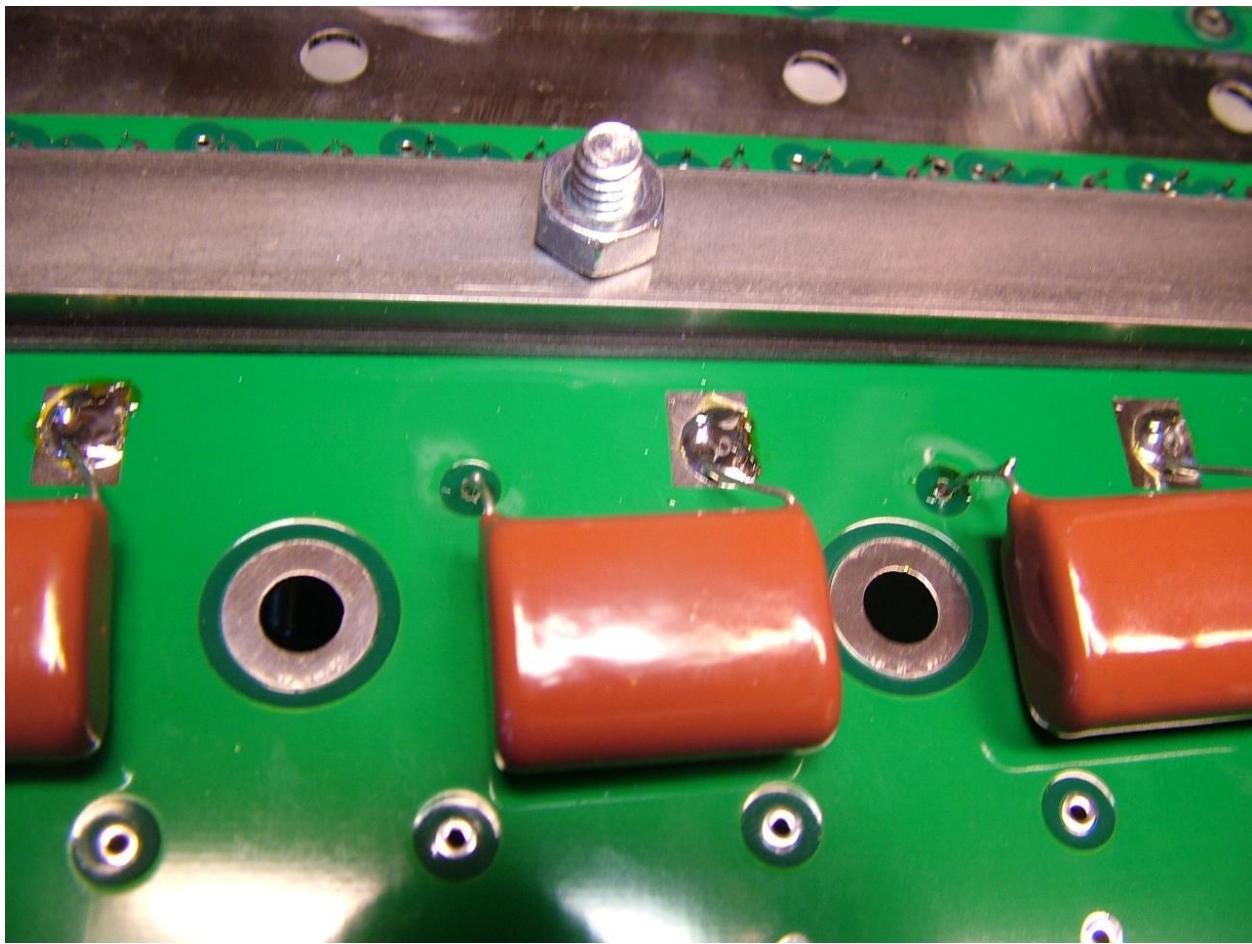
Make sure you don't miss any of them!



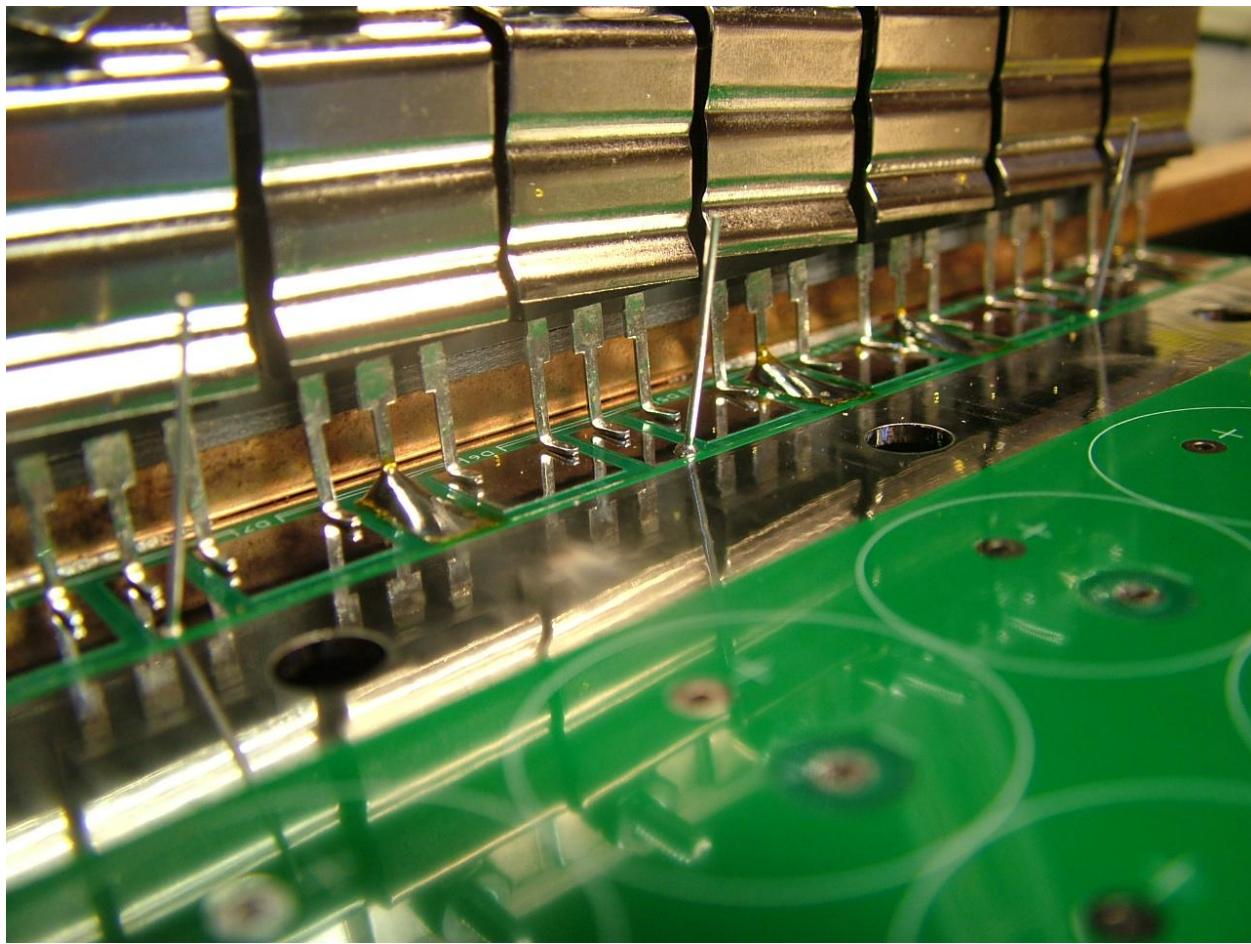
Now, flip it over, and bend the legs of the 3 polypropylene capacitors so they go like this. Then solder them into place. You will need a high powered (maybe 200 watt or 250 watt) soldering gun.



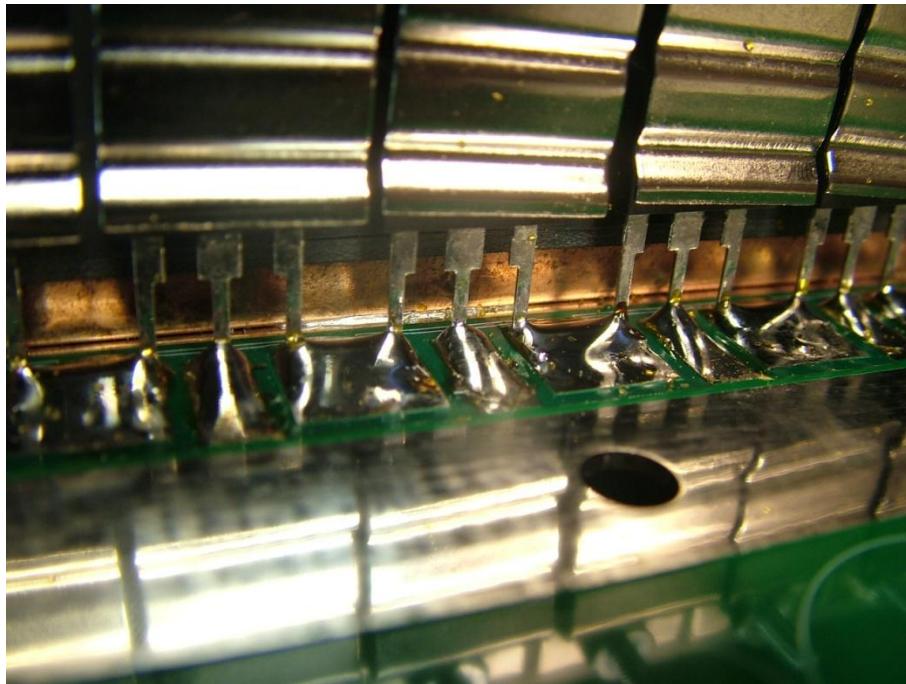
This is how it looks after they are soldered:



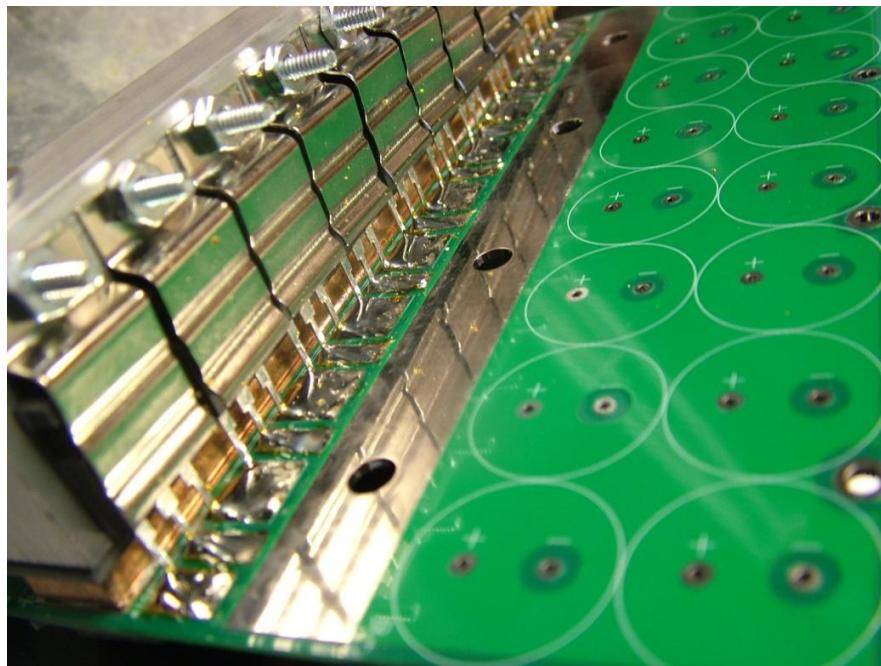
Chop off the legs of the capacitors that are now sticking out, and solder the legs of the diodes:



The legs are now soldered!



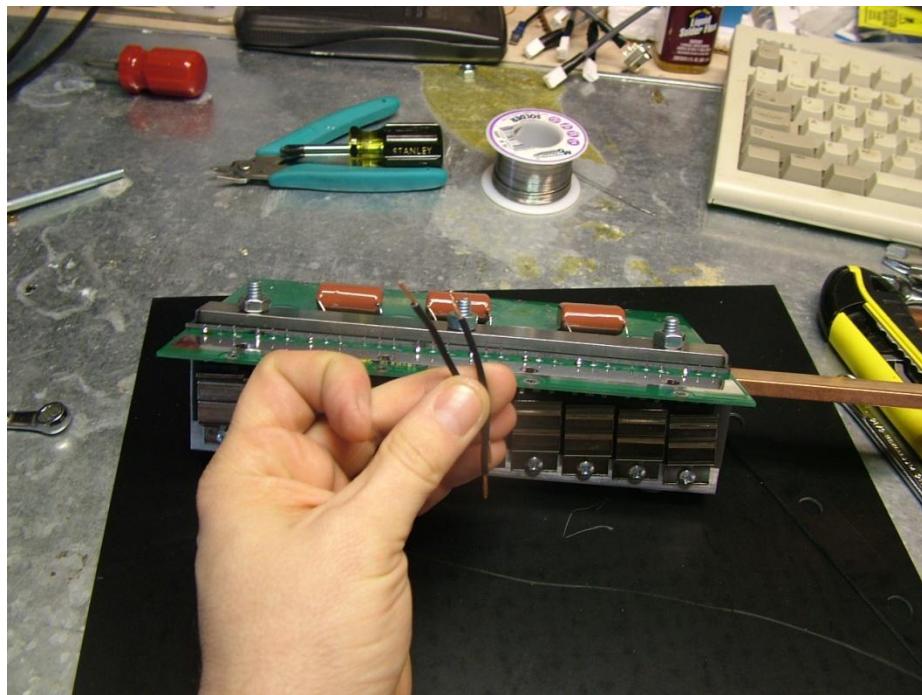
Once the diode legs are soldered, go back and tighten the clips all the way down. Sort of hold the clips in place so they don't slide around when you screw it down. Once it gets quite a bit harder, and the clips start sliding around, you can stop. **I've found that it's best to do the full clamping force on the diodes AFTER SOLDERING THEM!!! If you clamp them all the way before soldering, the legs won't be flush with the board anymore because it is dang near impossible to keep the clips from sliding around when the clip reaches its maximum tightness.**



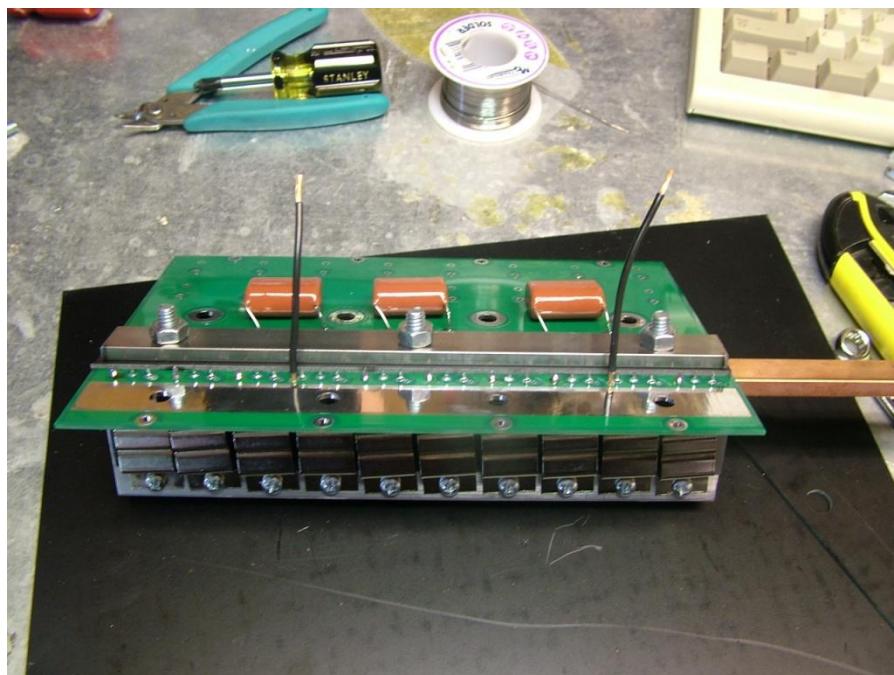
Now, get the bag marked PH1 and PH2, strip the ends of the wire, and solder them in to the power board:



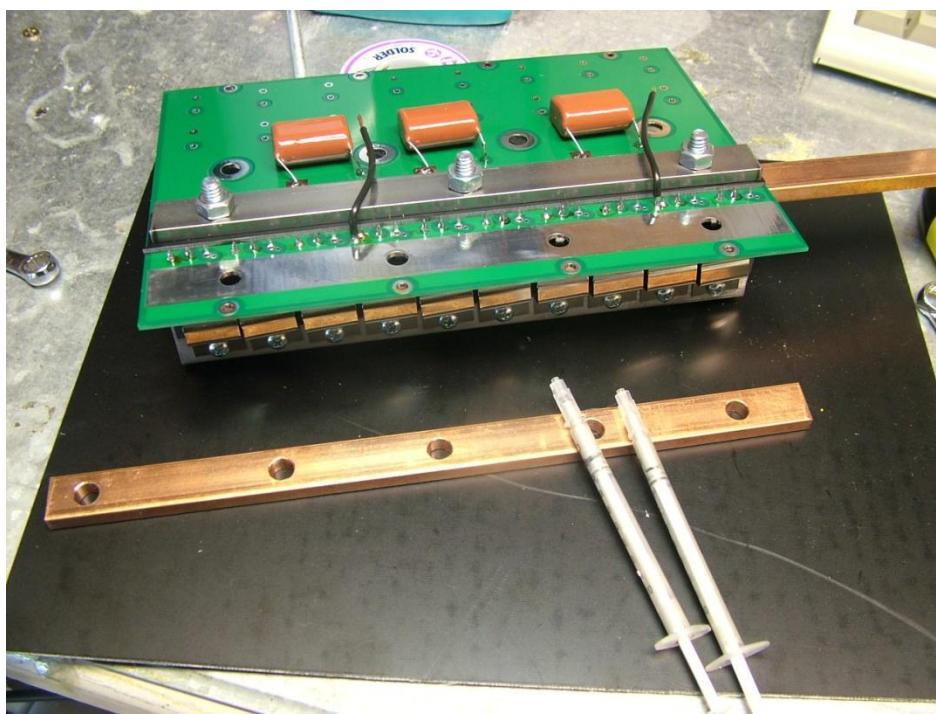
Strip both ends of the PH1 and PH2 wires:



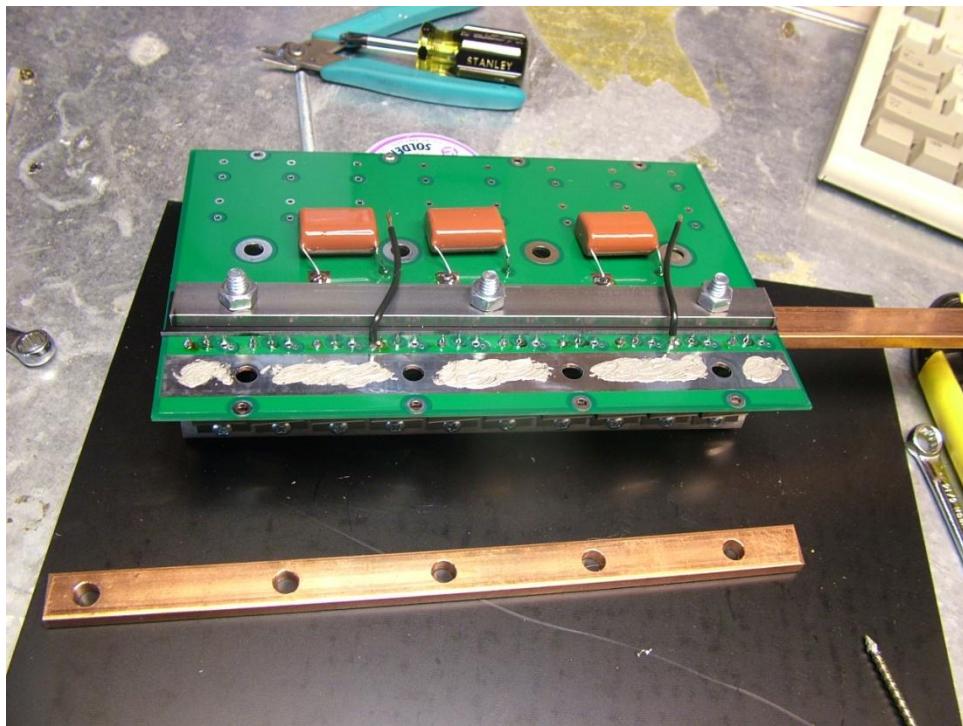
Notice the holes that the 2 ground wires go into. Solder the wires in. Also, solder the middle and left leg of each of the MOSFETs from this perspective of the MOSFETs being upside down. On the other side of the board, those legs are labeled S and D. That stands for Source and Drain. Leave the legs unsoldered that have the small holes next to them. Those are the gate legs, and are labeled G. The 10 small holes are labeled R1 to R10:



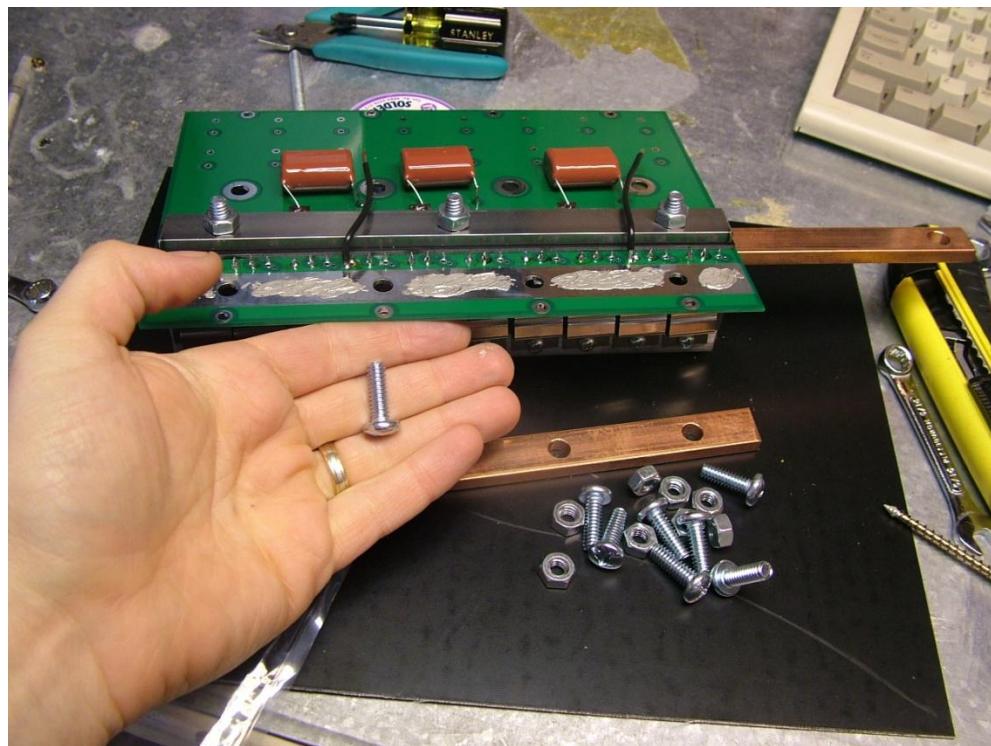
Now, get ready to attach the B- bus bar:



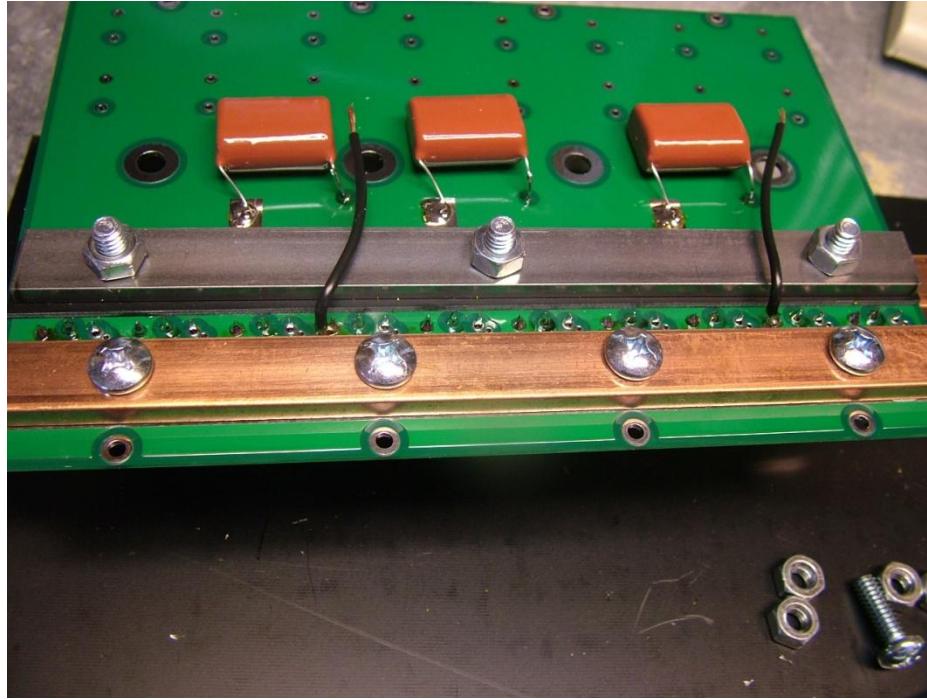
1/3 of each of the 2 parts of the epoxy again:



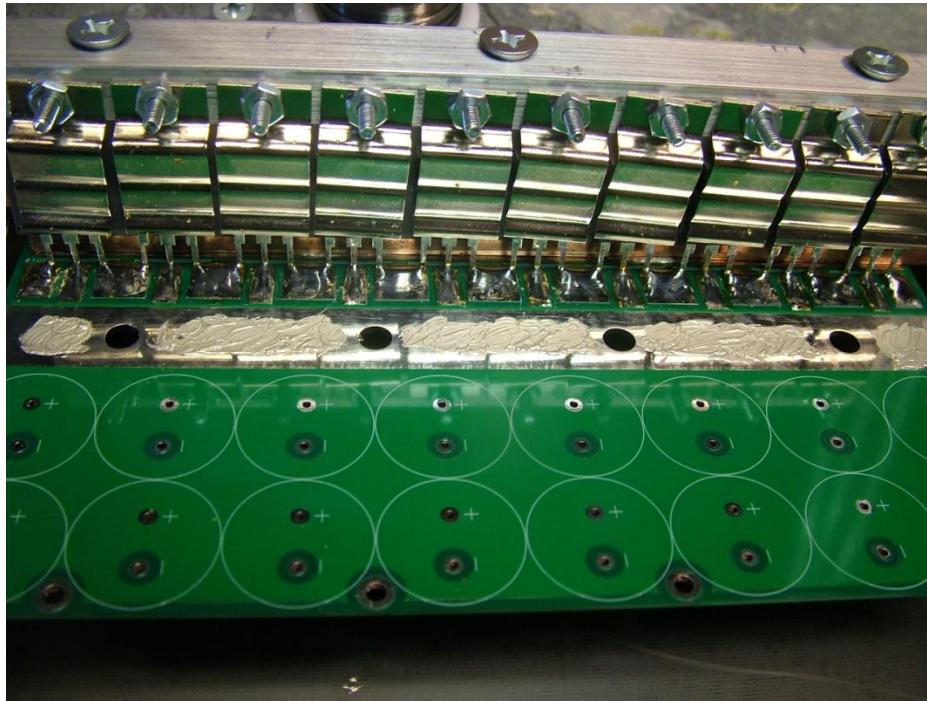
Get the eight 0.25" x 0.75" machine screws and nuts:



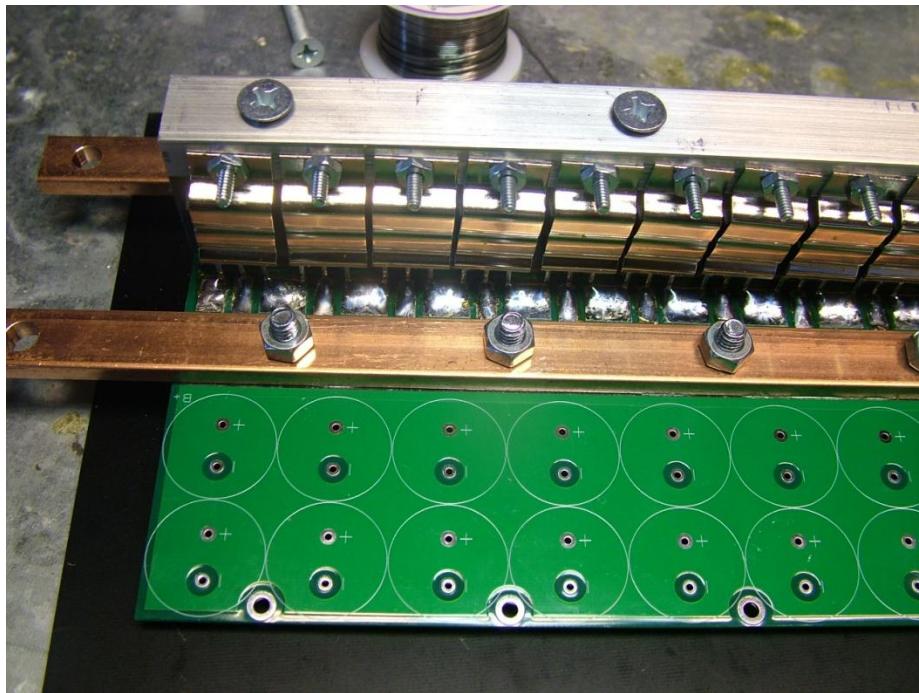
Bolt the B- bar down. You will need a 7/16" wrench and a Phillips screwdriver. Make sure the B- bar is sticking out the opposite end of the controller as the M- bar. Also, make sure that the bolts through the B- bar go in as the picture shows. If you put the screws through the other side instead, the screws might stick out too much and interfere with the mounting board that will be added later.



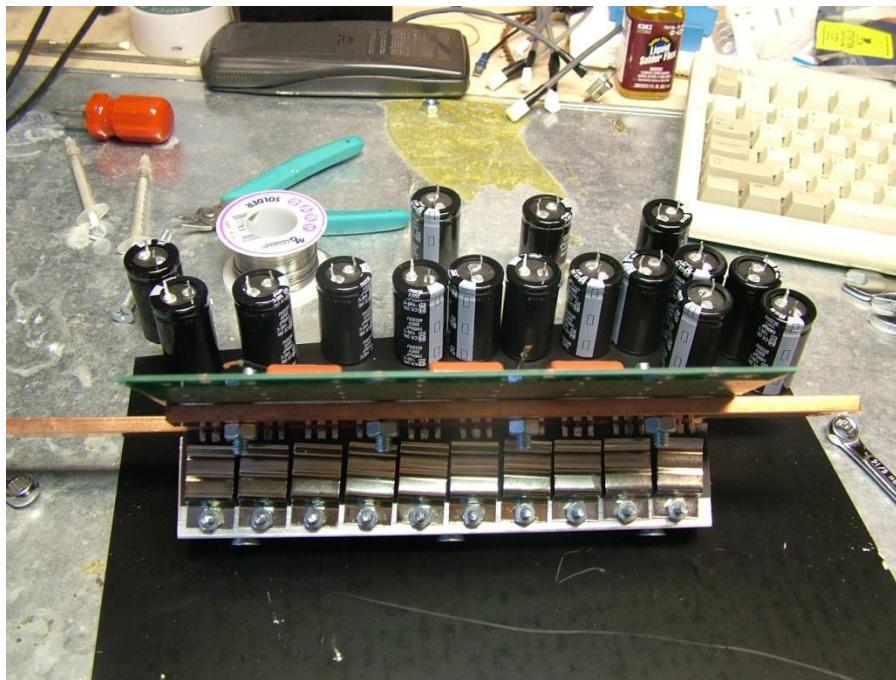
Now, add the rest of the silver conductive epoxy to the B+ bar pad:



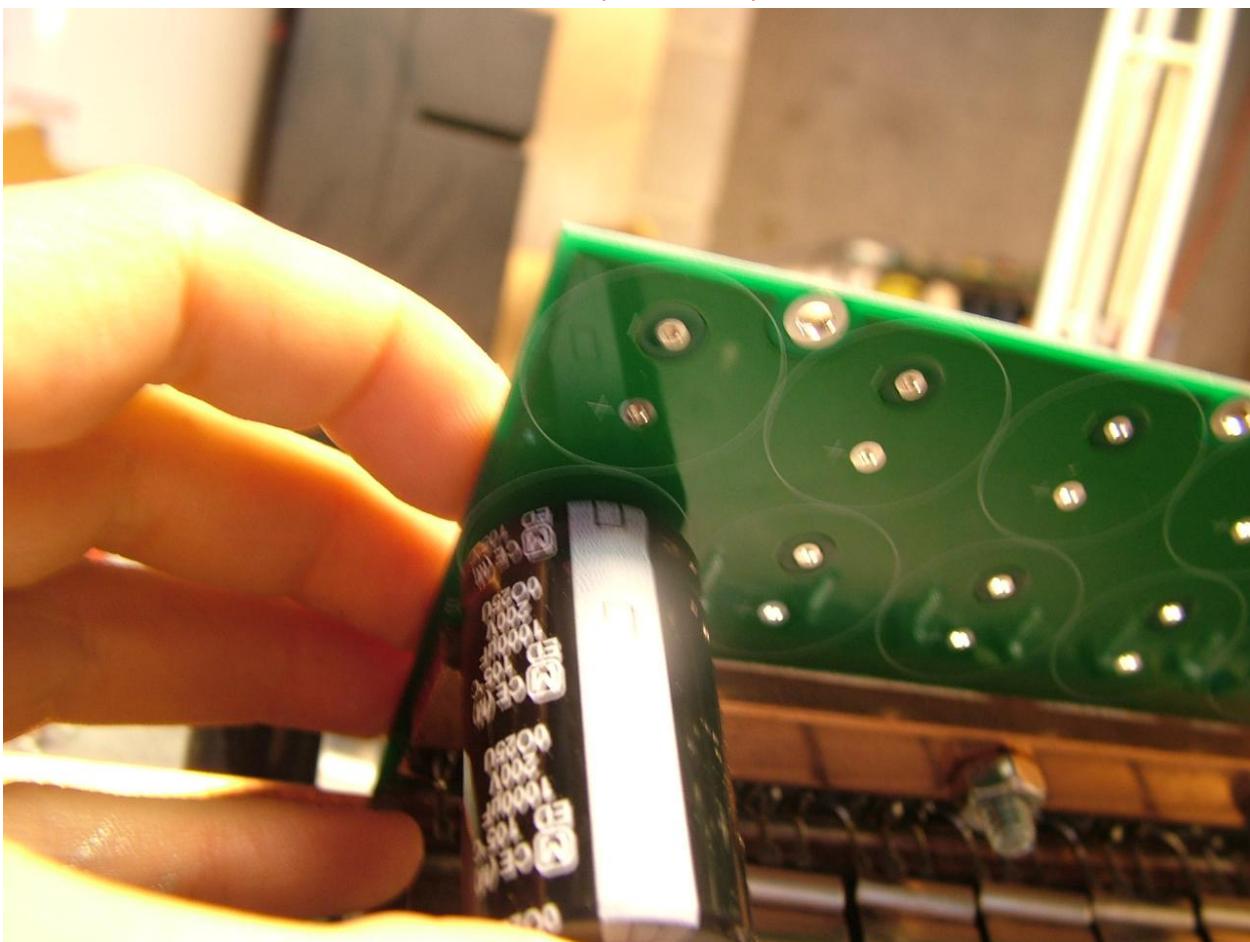
Now attach the B+ bus bar! Notice the orientation of the screws holding down the B+ bar. This way, they will not interfere with the future mounting board. Also, notice that The B+ bar goes out the same direction as the B- bar.



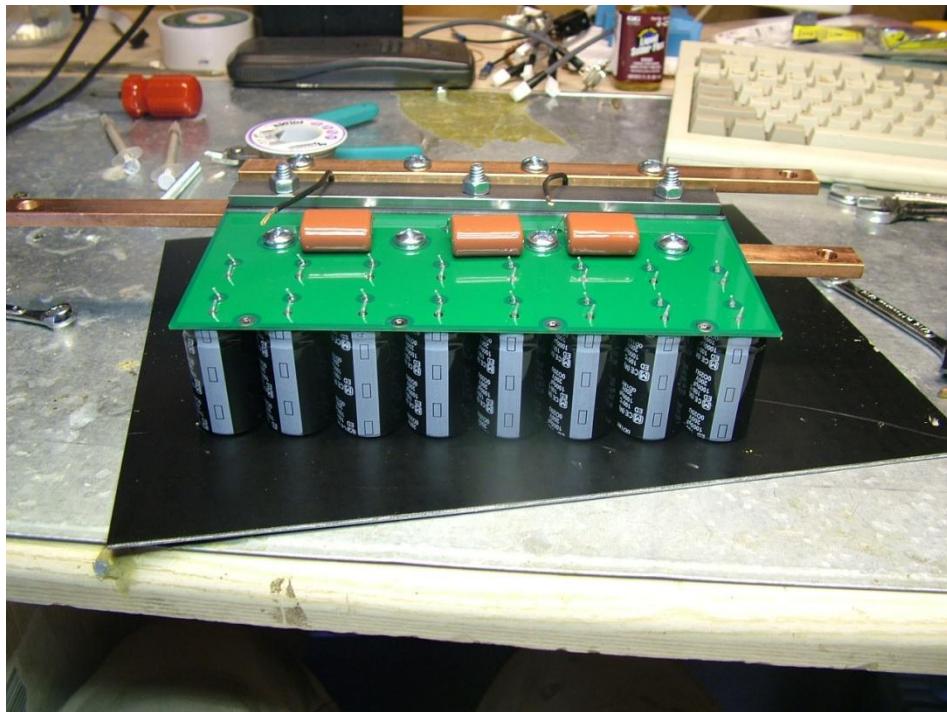
Now, get the 16 big black capacitors ready. They go in next:



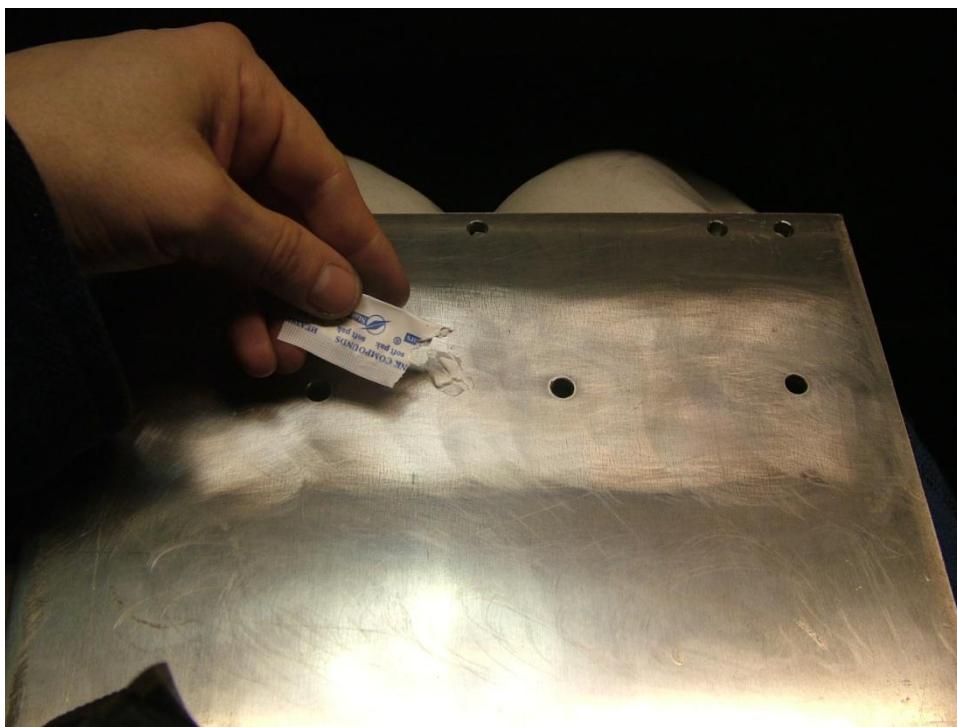
Notice the orientation of the capacitors! Pay attention to + and -!!!



Push all 16 capacitor in. Make sure that the capacitors are pushed all the way through, so that the top of each capacitor is pushed against the power board. Then, solder them into place! You will need the Big Bertha 200watt or 250watt soldering gun.



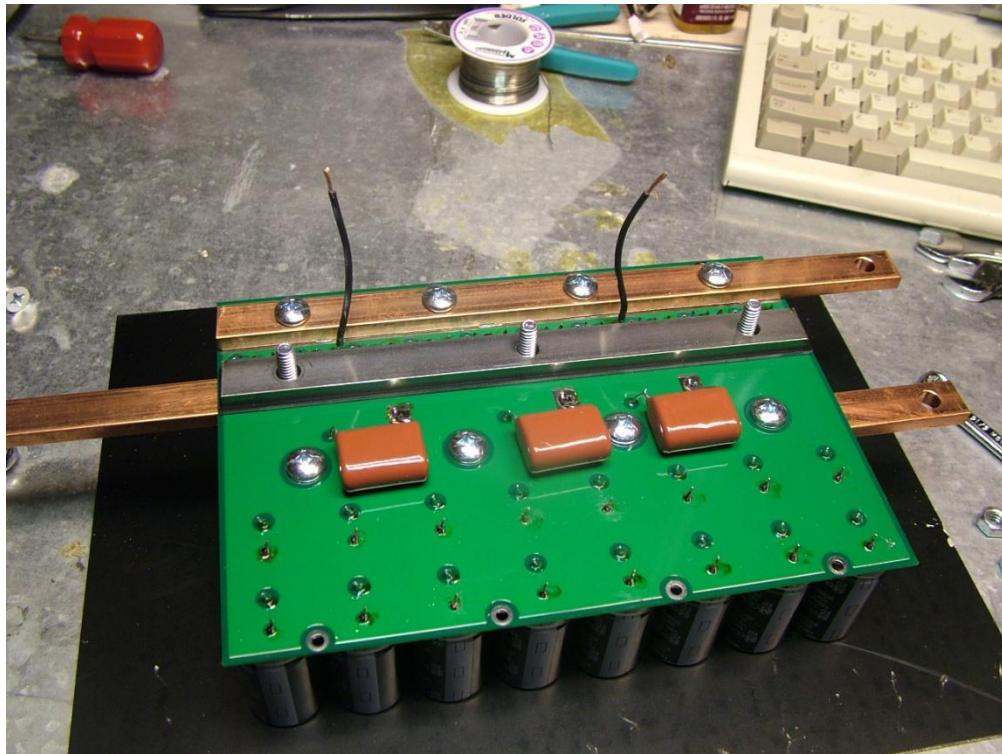
Now, get the 8" x 11" x 3/8" aluminum plate, and sand down the area in the picture below nice and smooth. Then add a very thin layer of thermal grease. This is where the heat spreader will be bolted to:



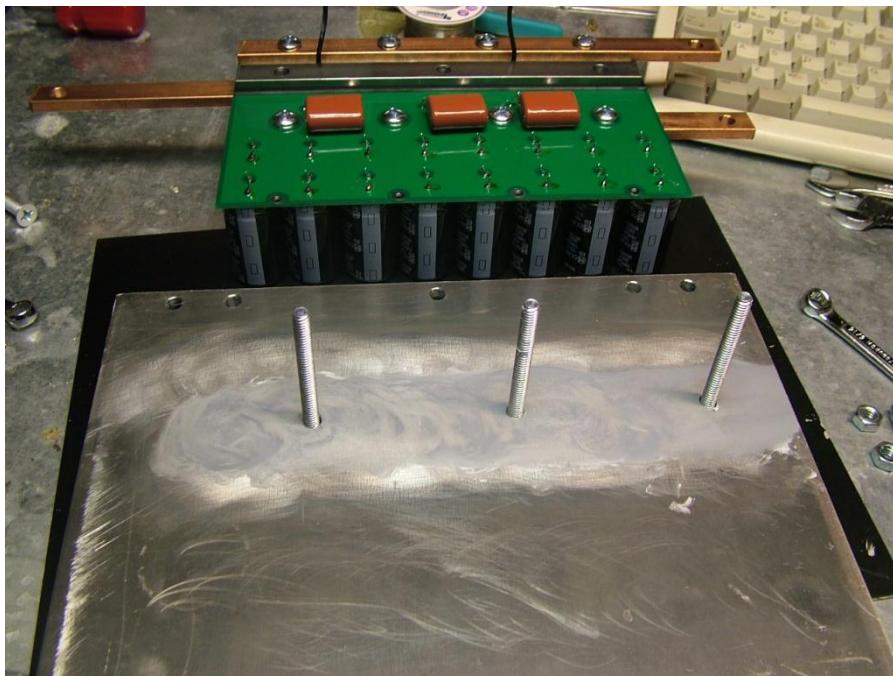
Ooh, that's nice! All smooshed around, nice and thin:



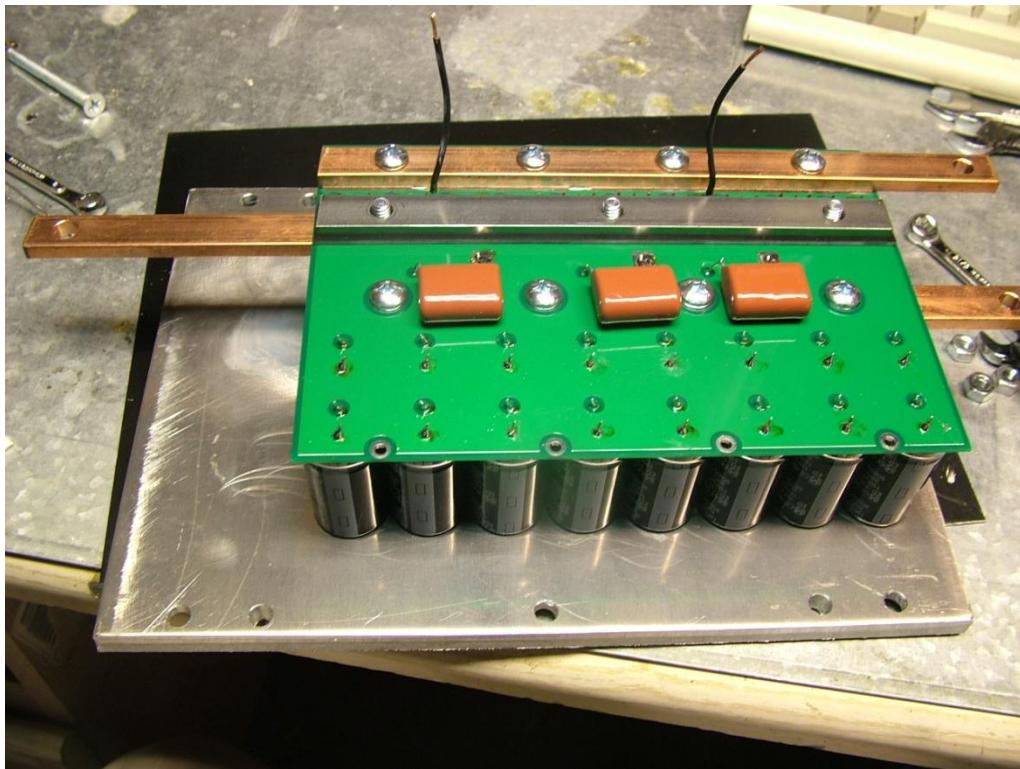
Now, unbolt the 3 nuts in the picture below and remove the three 0.25" x 2.75" machine screws by gently lifting the controller by the copper bus bars:



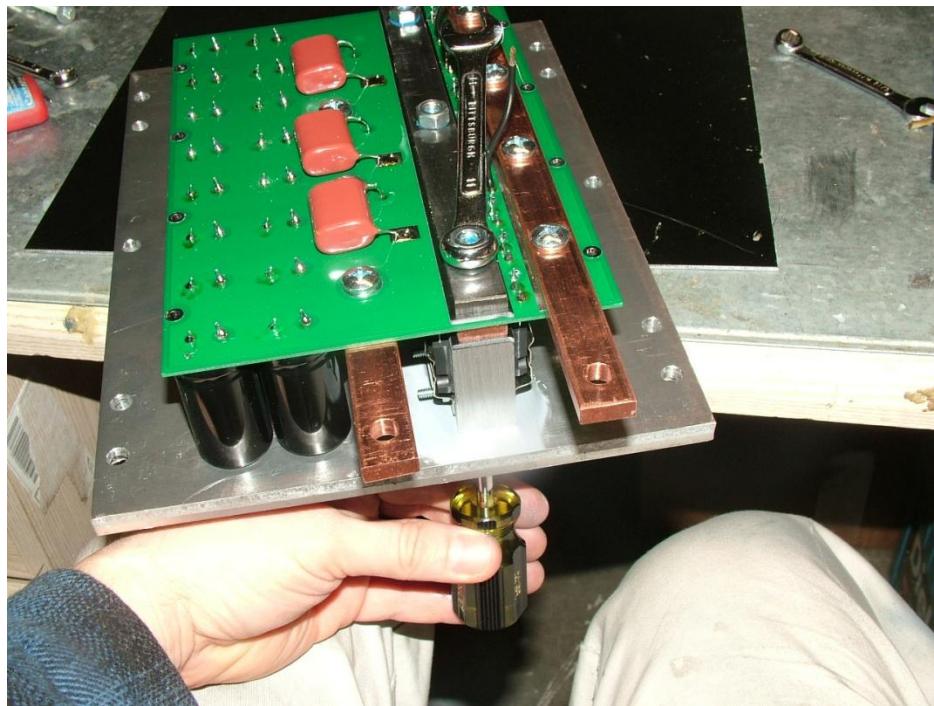
Now, put the 3 screws through the aluminum plate like in the picture below:



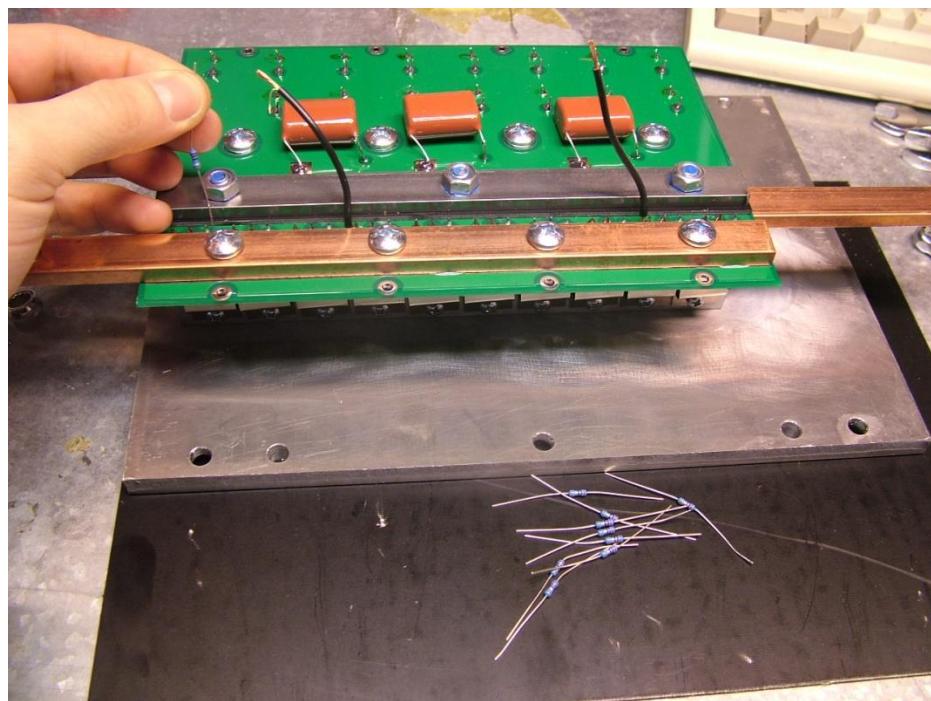
Now, gently lift the power section, and lower it so that the 3 screws go through the 3 holes in the picture:



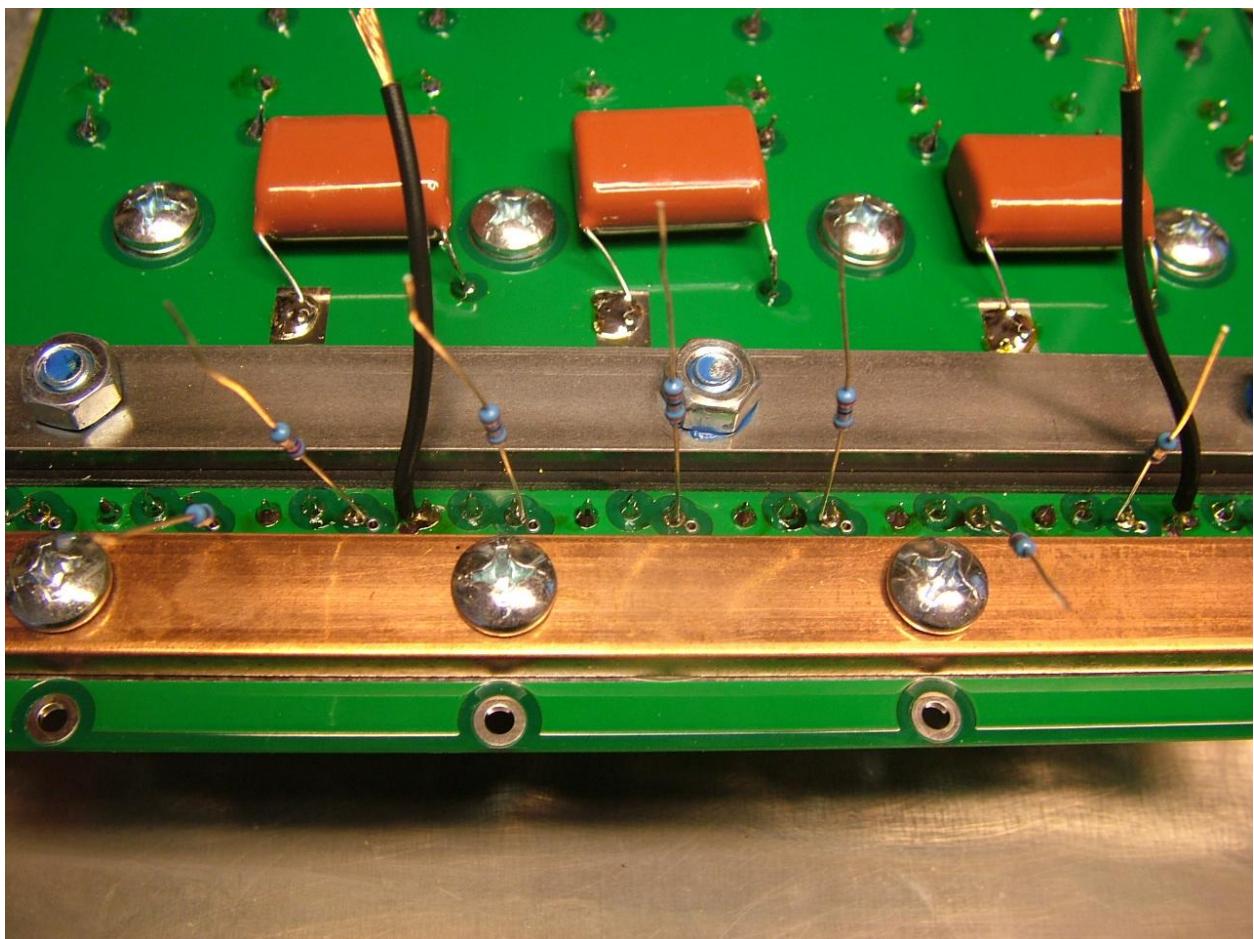
Now, get the 7/16" wrench and Phillips screwdriver, add a little Locktite to the threads if you want, and tighten down the 3 nuts nice and snug:



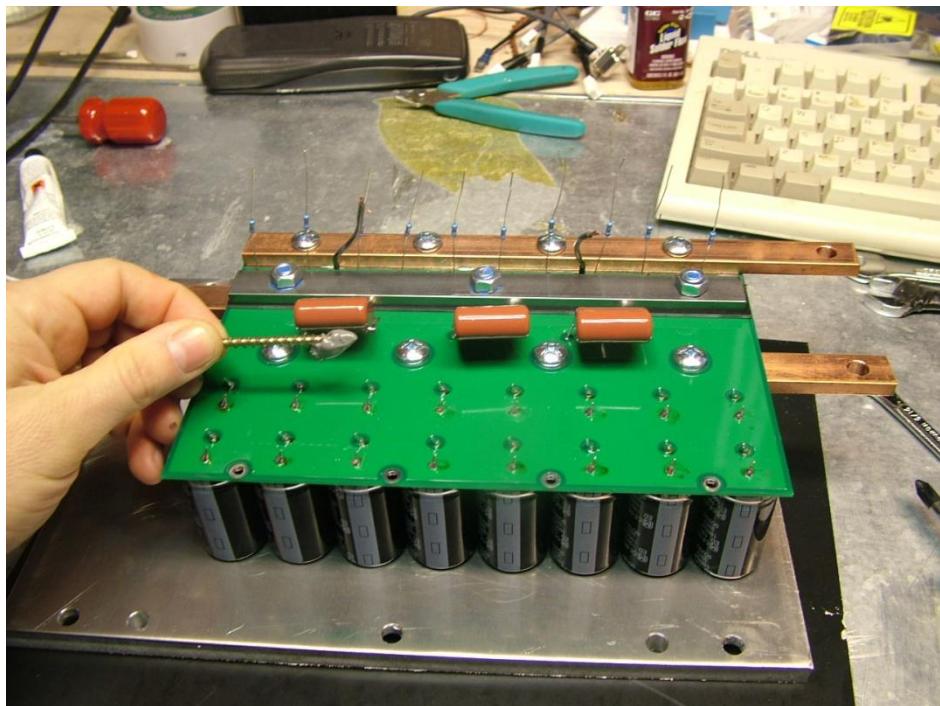
Now it's time to add the 10 gate resistors. They are in the package labeled GR1...GR10. If you are curious, that stands for gate resistor 1 through gate resistor 10. ☺



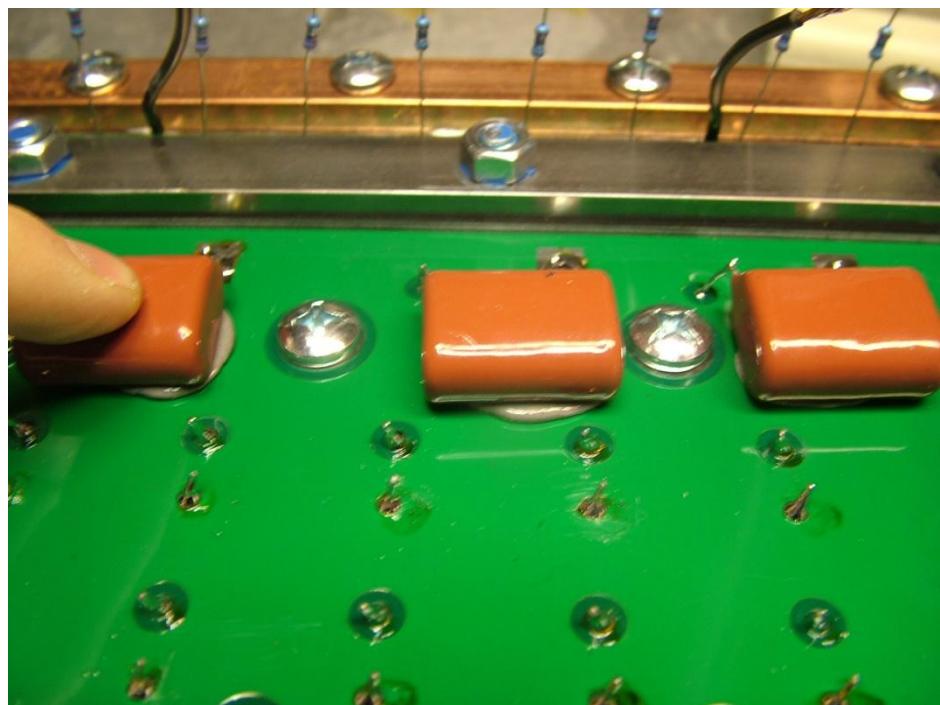
I just stuck the gate resistor legs in the same holes as the gate lead of the MOSFETs. You can use the small hole right next to the mosfet gate lead instead if you want. It doesn't matter. Solder the gate resistor leg and the gate lead of the MOSFET to the power board at the same time. **Use the low power soldering iron to solder them!!! You won't need much heat! Don't use the high powered soldering gun!**



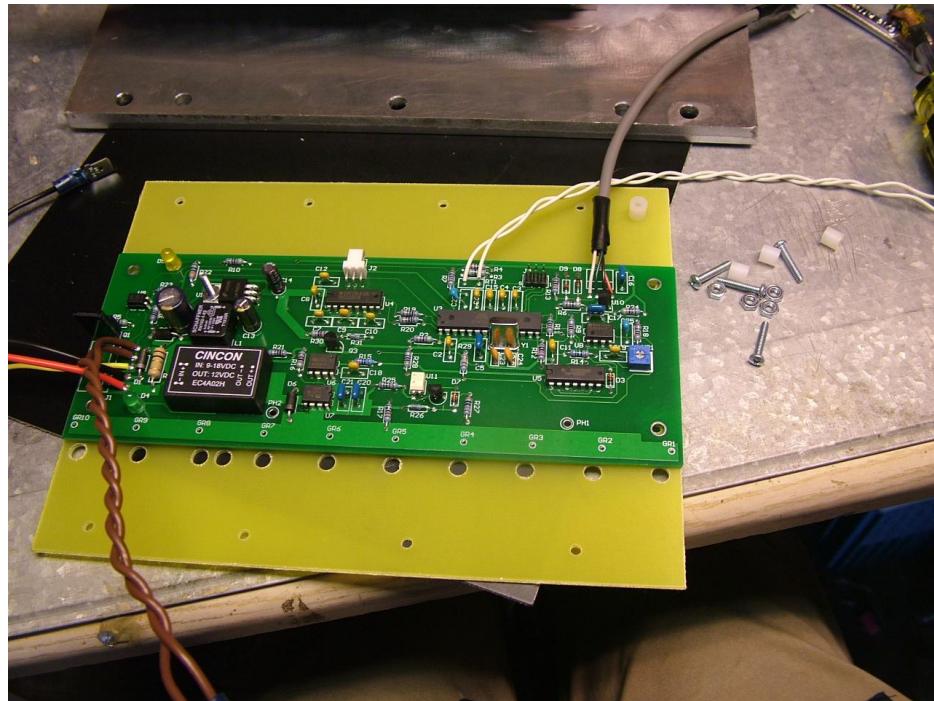
Stick some sort of glue underneath the 3 red capacitors, so they don't bounce all over the place! I used JB Weld in this picture:



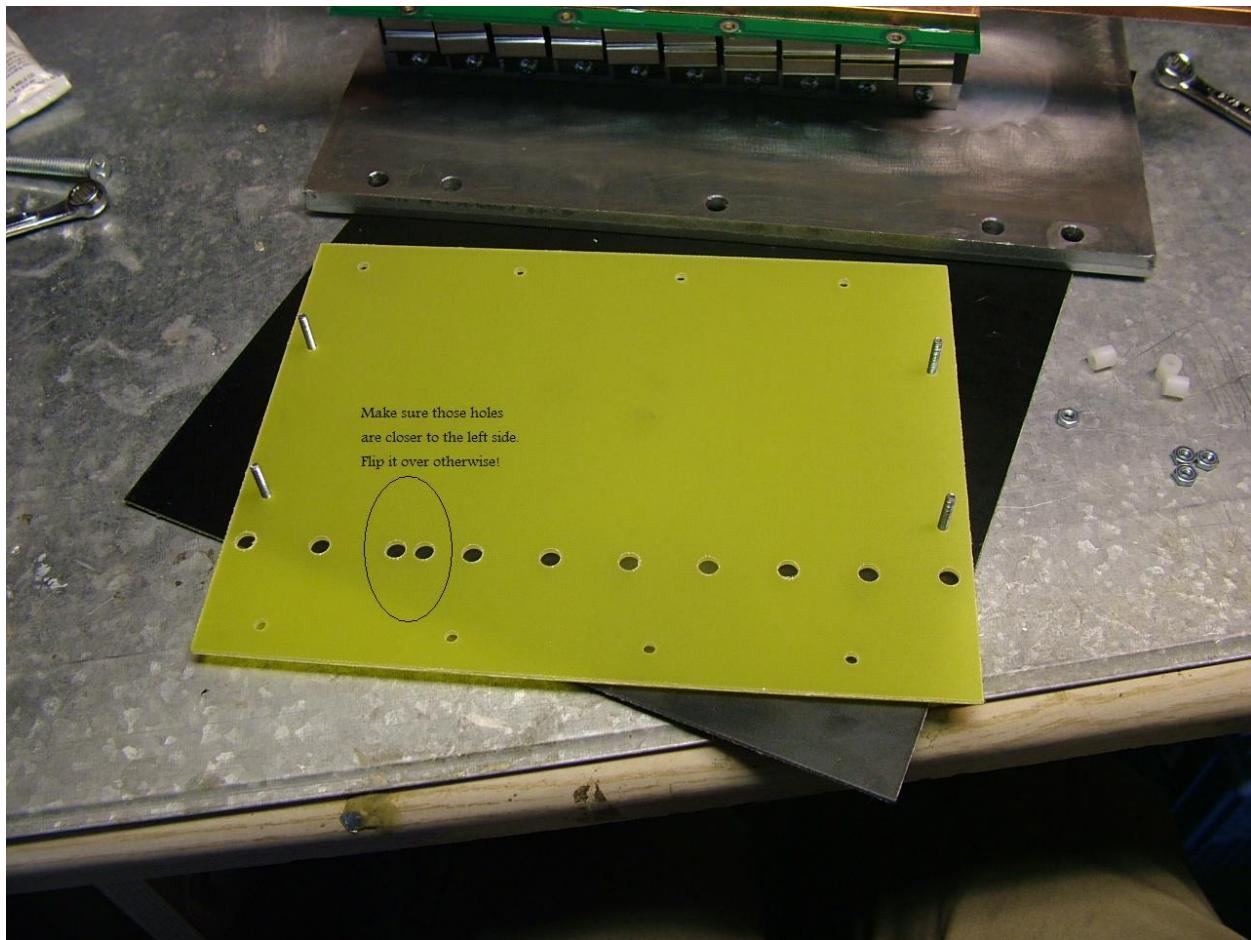
Now, squash them down:



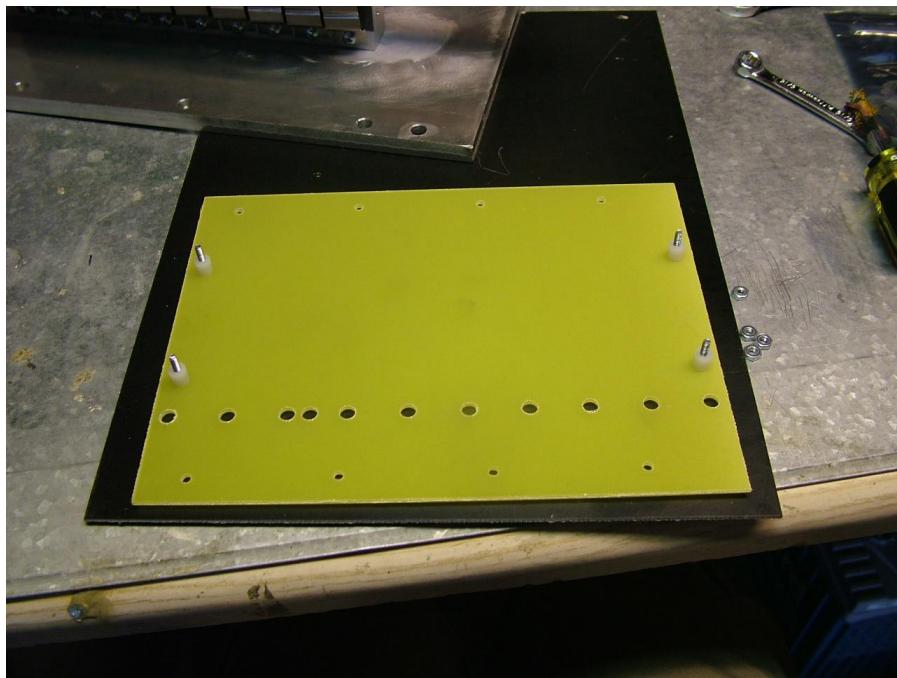
Get ready to attach the control board to the mounting board. You will need the short nylon standoffs, and the 5/8" x #4 machine screws and nuts too:



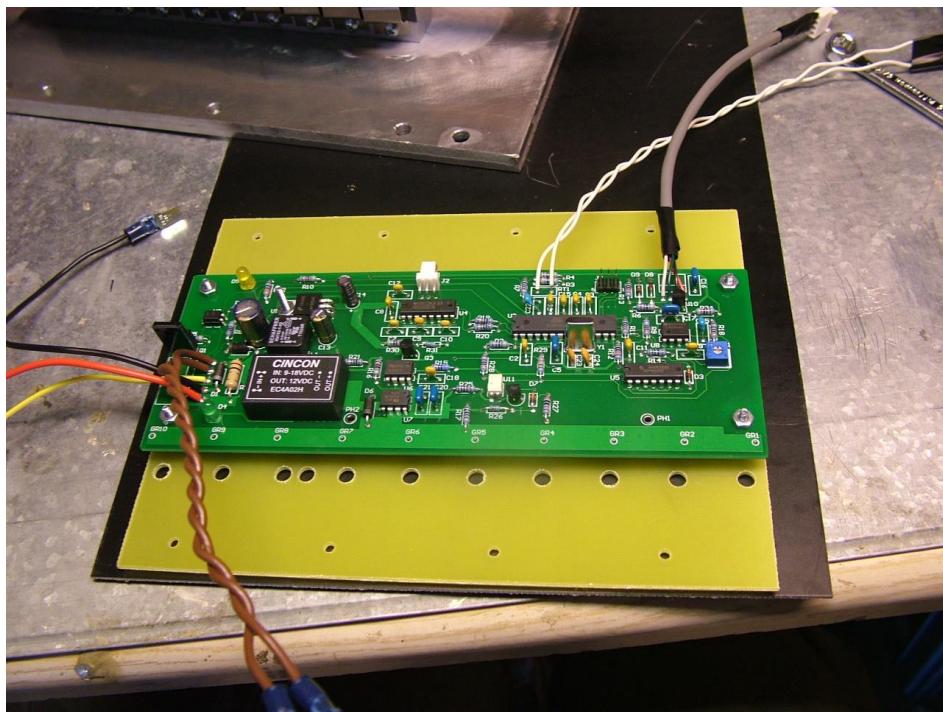
First, put the 4 screws through like in the picture. NOTICE THE ORIENTATION OF THE MOUNTING BOARD!!! The 2 close holes are nearer to the left side than the right side



Now, add the 4 nylon spacers:



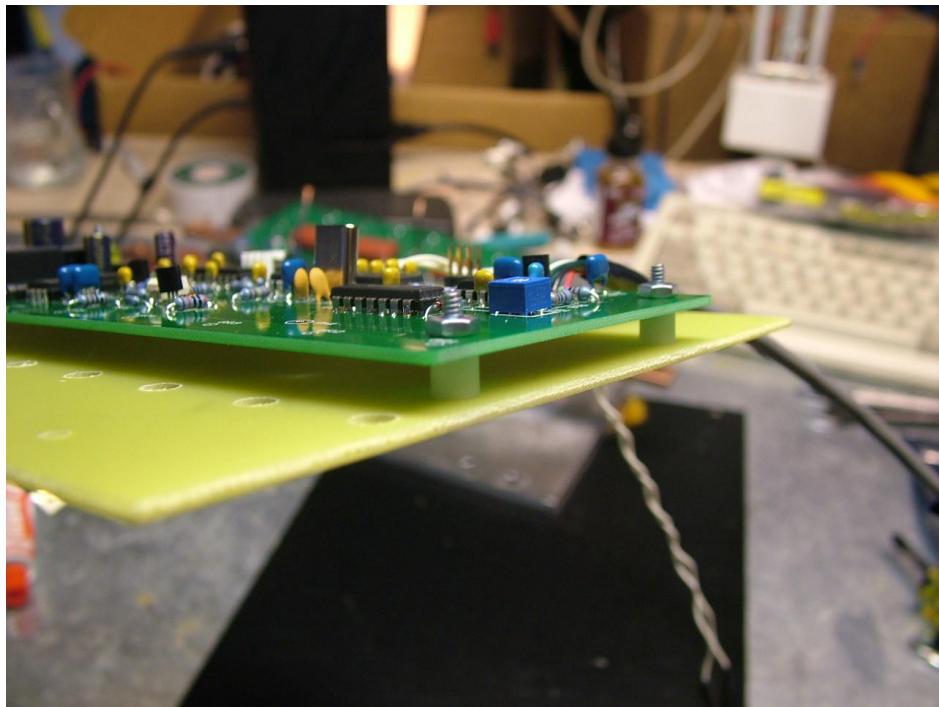
Now, put the control board on, and tighten it down with the 4 nuts:



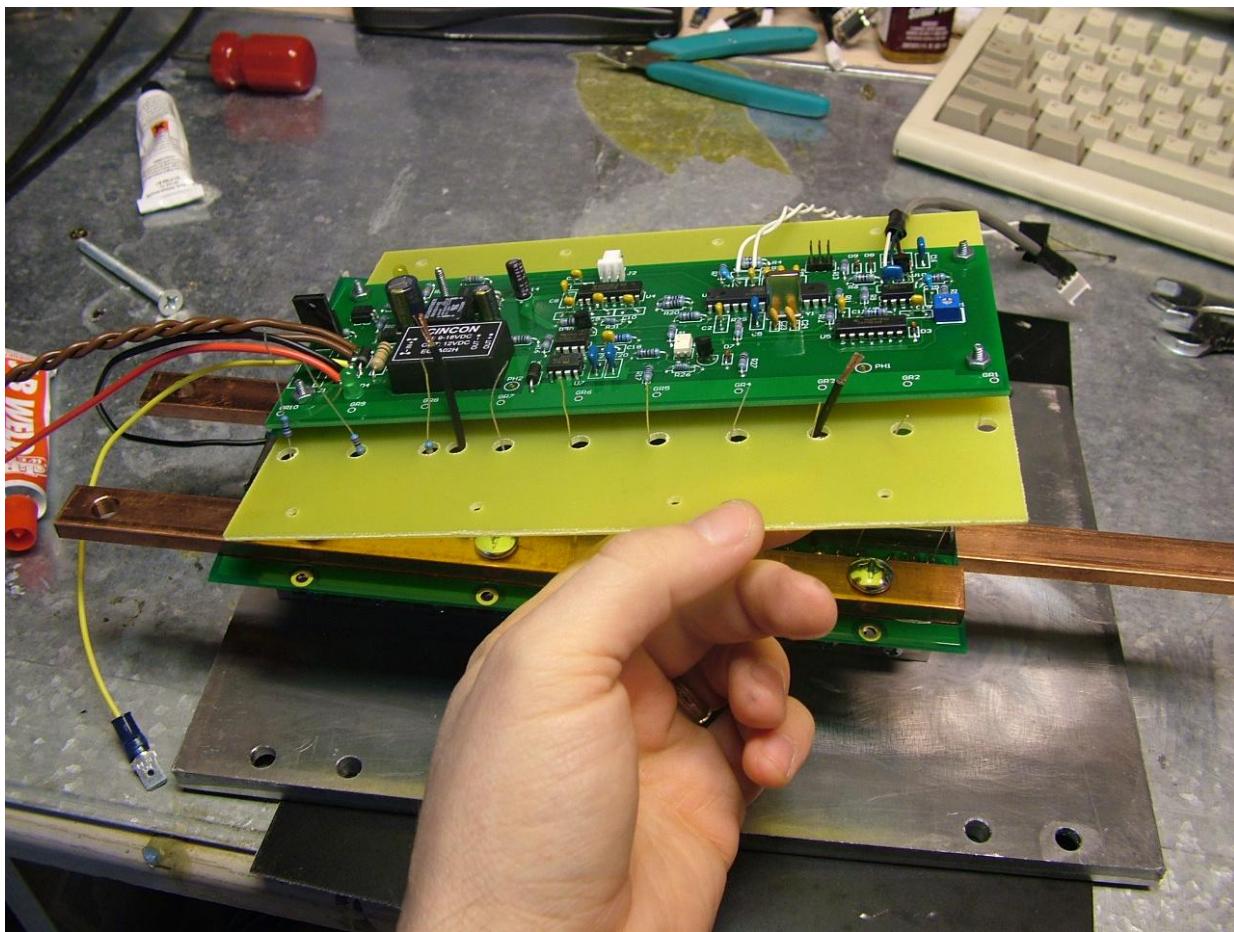
You will need a $\frac{1}{4}$ " hex wrench:



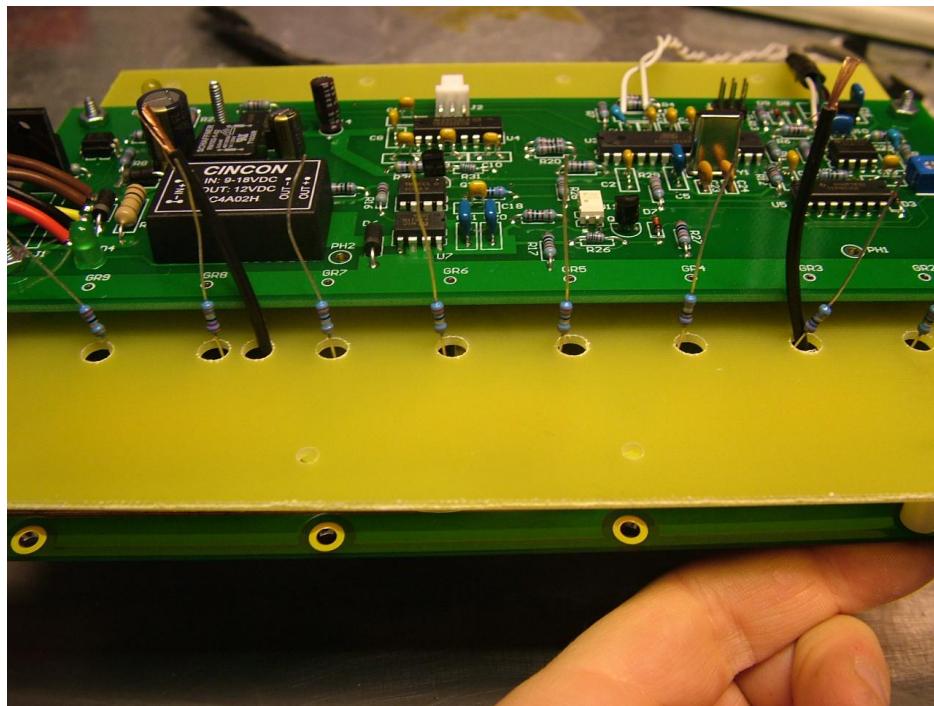
Ooh, look at that... So pretty:



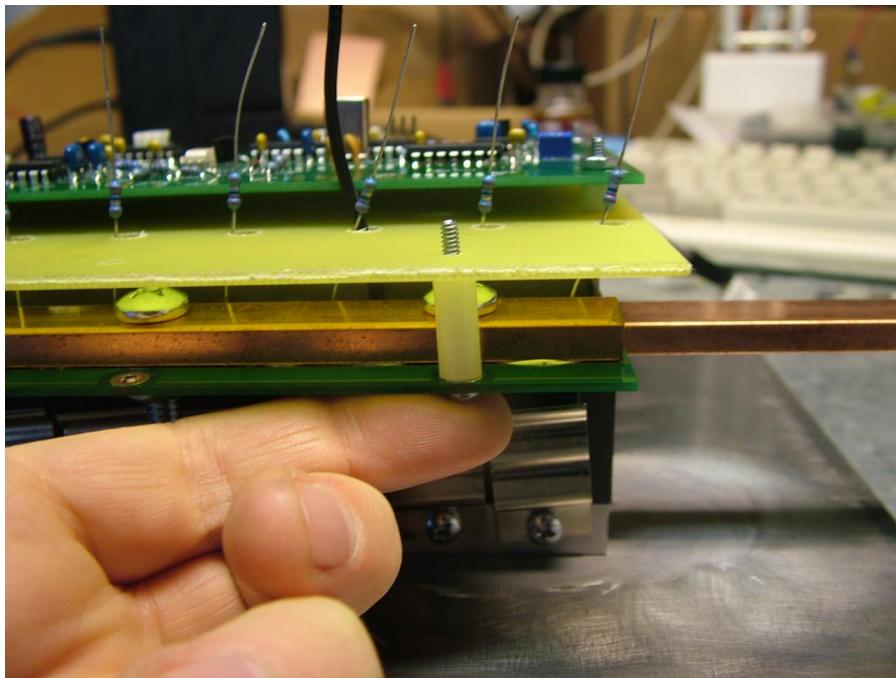
Now, feed the gate resistors and 2 ground wires through the holes in the picture below. The 3rd hole from the right has both a ground wire and a gate resistor through it. That hole has been drilled larger than the others for that reason.



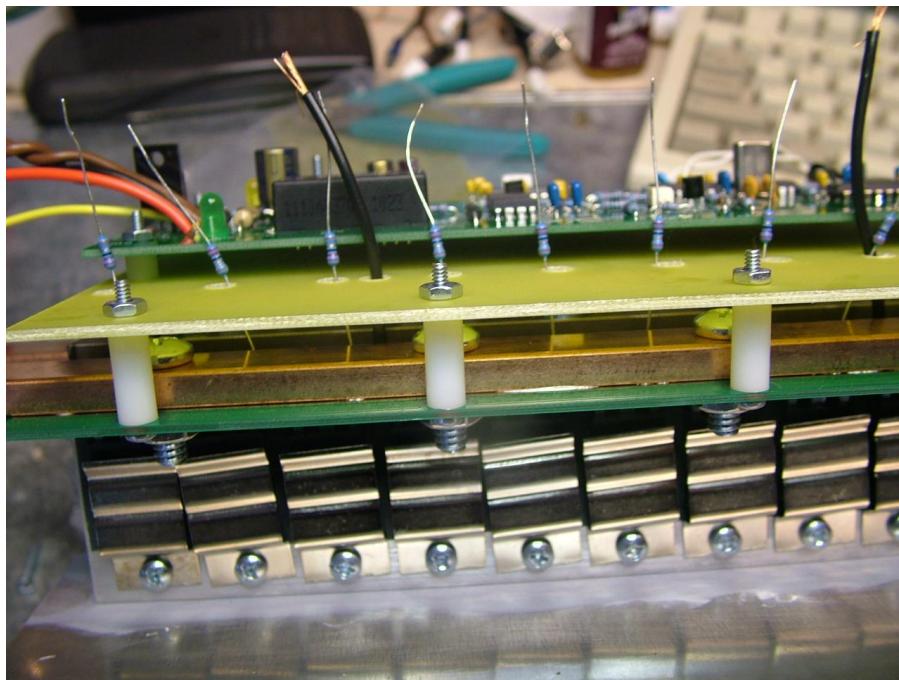
Once the resistors and ground wires are all the way through, add the eight 0.6" nylon spacers and the 1" x #4 machine screws:



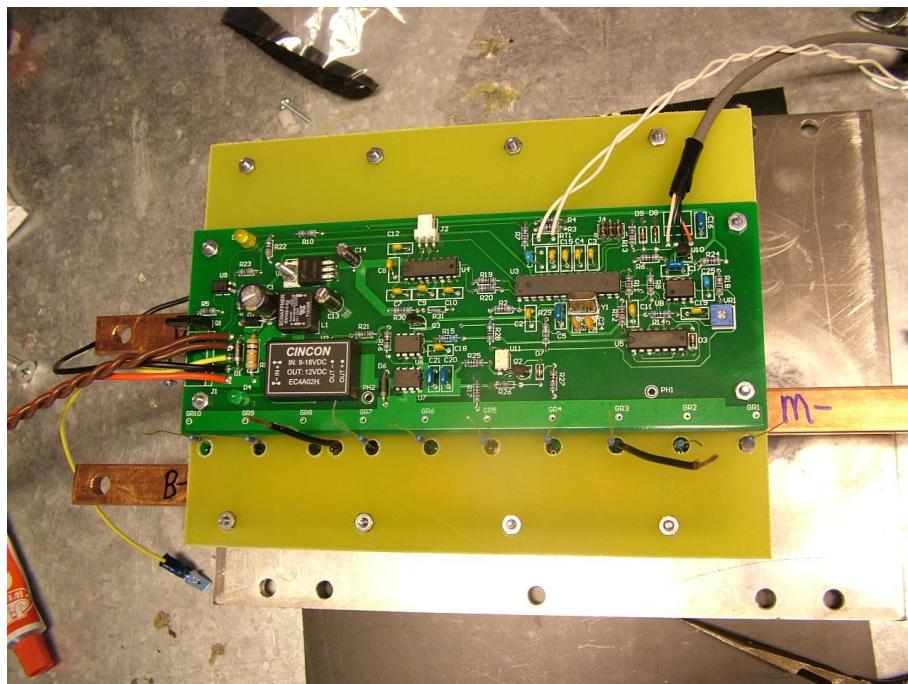
After 8 of these buggers, that mounting board isn't going anywhere!



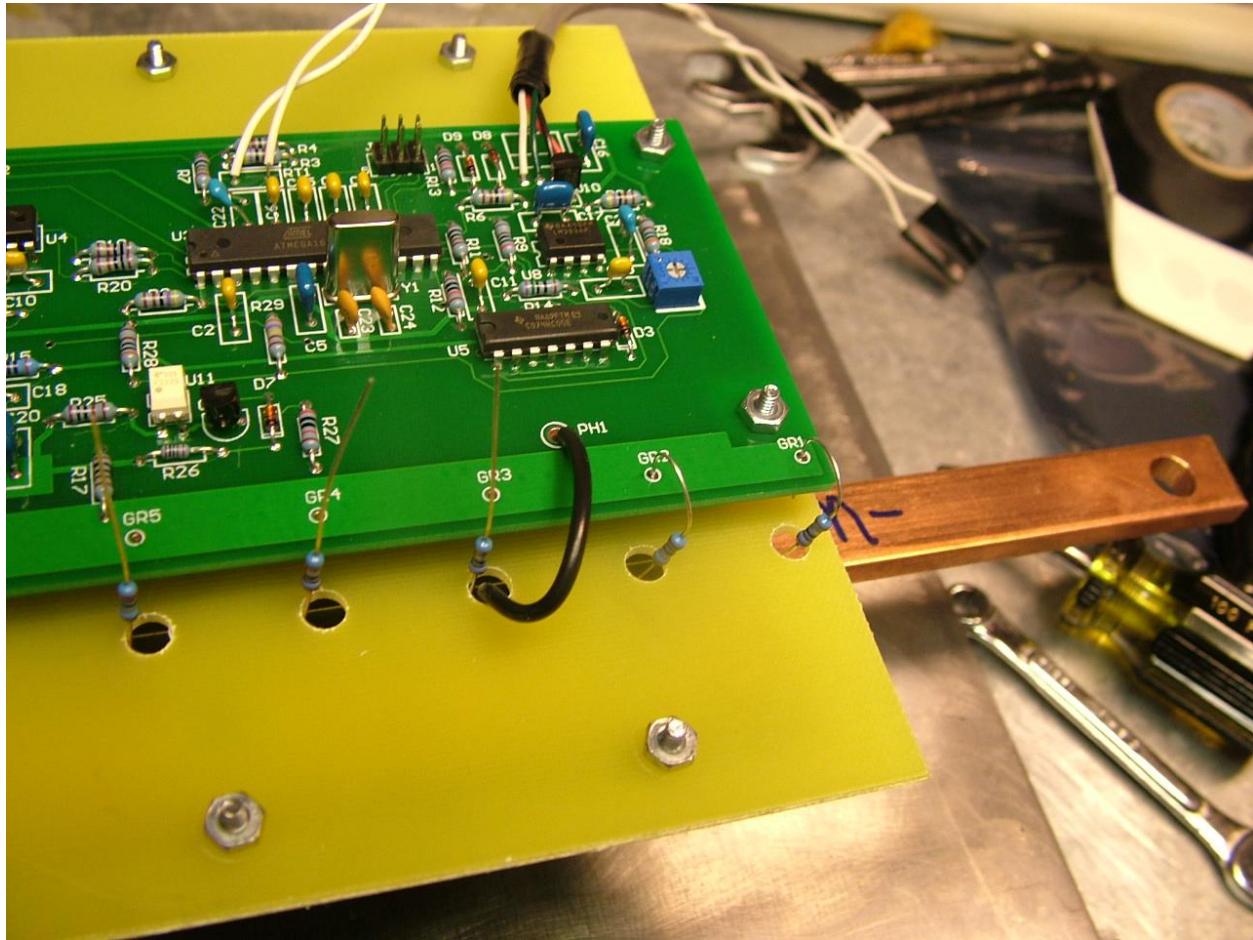
Nice and snug!



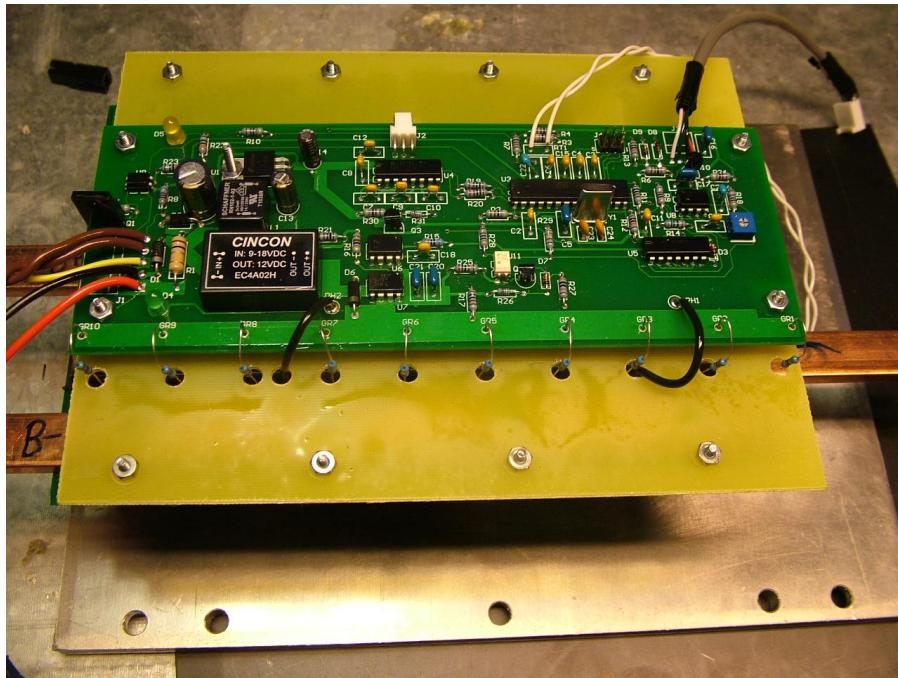
Just so everyone knows, B- is on the lower left, M- on the middle right, and B+ is on the upper left:



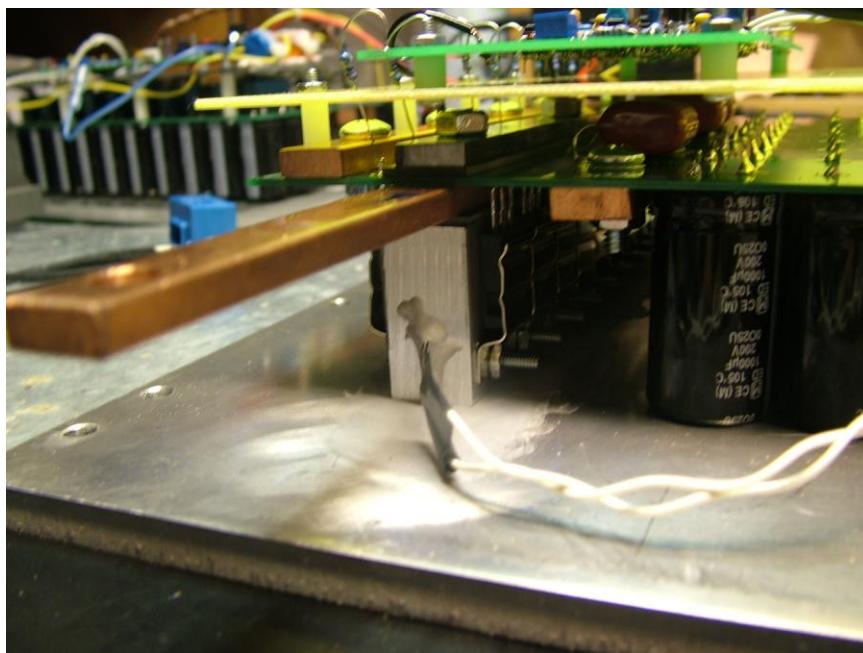
Now, feed the resistors through their respective holes, and also the 2 ground wires. The ground wires go through PH1 and PH2. Solder them into place! You will need a pretty hot soldering iron to get the gate resistors to stick nicely, since there's quite a copper plane on the top and bottom of what you are soldering to:



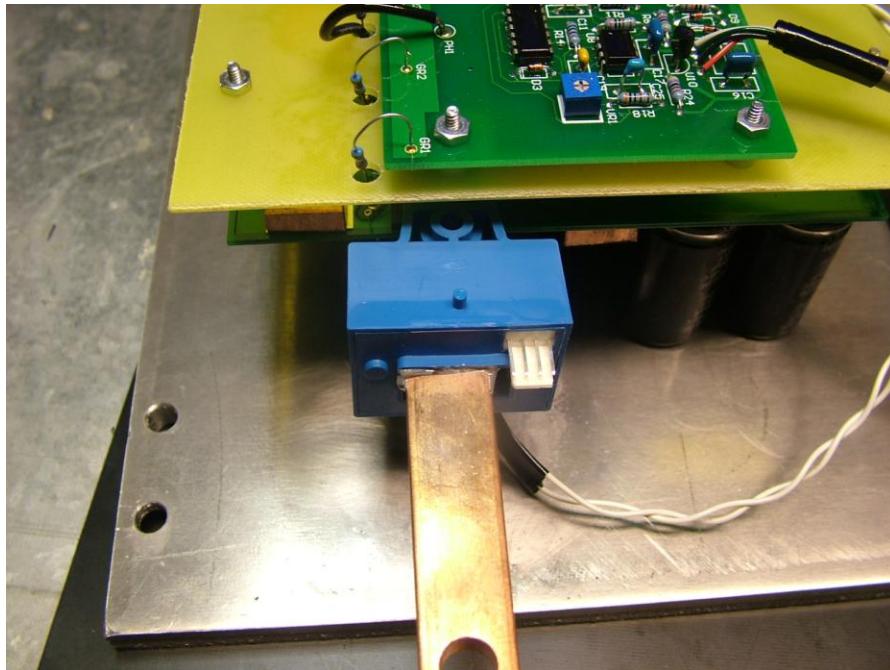
Hurray! The 10 gate resistors and the 2 ground wires are soldered in!:



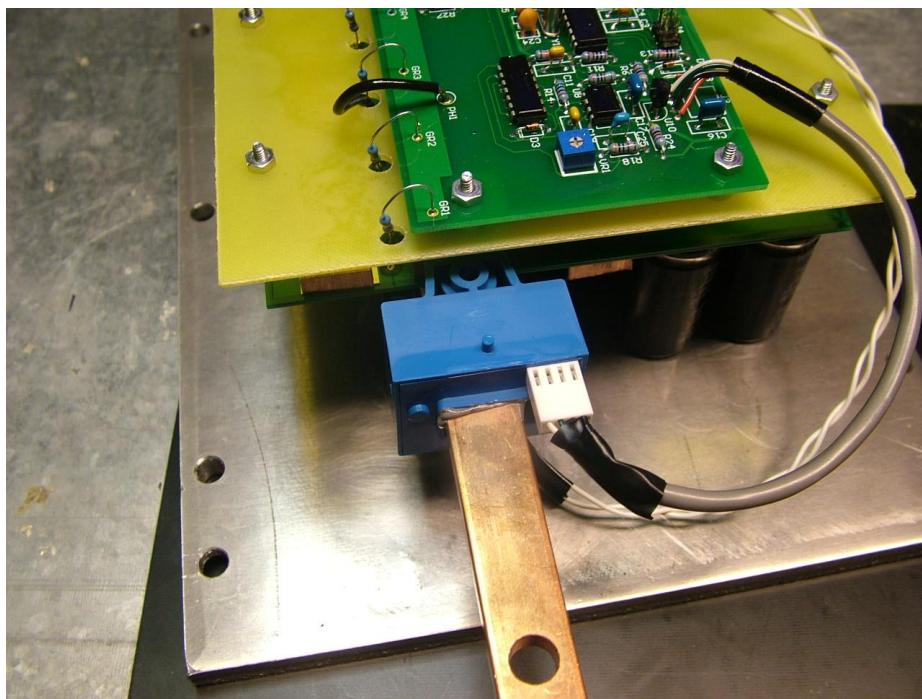
Next, if you haven't already, solder RT1 into place on the control board from the top, and push the thermistor head into the hole in the heat spreader that is on the 0.75 inch x 1.5 inch face that is just below the M- bus bar. Glue the thermistor head into the heat spreader. JB weld works well.



Now, glue on the current sensor. JB Weld works well. Hehe. I love JB Weld. **Notice the orientation of the current sensor! Make sure you have it like in the picture:**



Now connect the current sensor to the control board:



ATTACHING THE ENCLOSURE

Take the metal enclosure with inner dimensions 11 inch x 6.75 inch x 4 inch, and 0.75 inch wide wings. Drill the 10 holes and bolt it down with the 0.25" x 0.75" flat head machine screws. For drilling the holes, I mark the holes on one side, drill them, then bolt that side down, then mark the holes on the other side, remove the enclosure, drill those holes, and then attach the enclosure again. The 4 unused holes are so the controller can be bolted down to a heatsink or something. Cut out and glue on the end caps. For cutting the Lexan, a Dremel works OK.



VEHICLE INSTALLATION

The black wire gets connected to 12v battery ground.

The red wire gets connected to some sort of on/off switch, which is connected to the car's 12v battery +. You don't want the controller on all the time, so an on/off switch is important.

The twisted pair of wires connects to the 5k potentiometer. 0 Ohms means 0 throttle, and 5000 Ohms means full throttle. It doesn't matter which wire gets connected to which lead of the 5k pot.

TURN-ON AND TURN OFF SEQUENCE:

For startup, turn on the 12v power to the controller. The 12v power to the controller should be from the auxiliary 12v battery, or a DC-DC converter. **The 12v supply must not share the same**

ground as the car's high voltage battery pack. Next, pre-charge the capacitor bank. Finally, close the main contactor and drive away.

For turning off, open the main contactor (and the pre-charge circuit if it isn't already open) and then turn off the 12v power to the controller.