XTension Smart Meter Reader

The XTension Smart Meter Reader is a through-hole electronics soldering kit. It counts the calibration pulses from some “smart” meters and sends information of realtime electric use to the XTension home automation system. More info at:

www.MacHomeAutomation.com

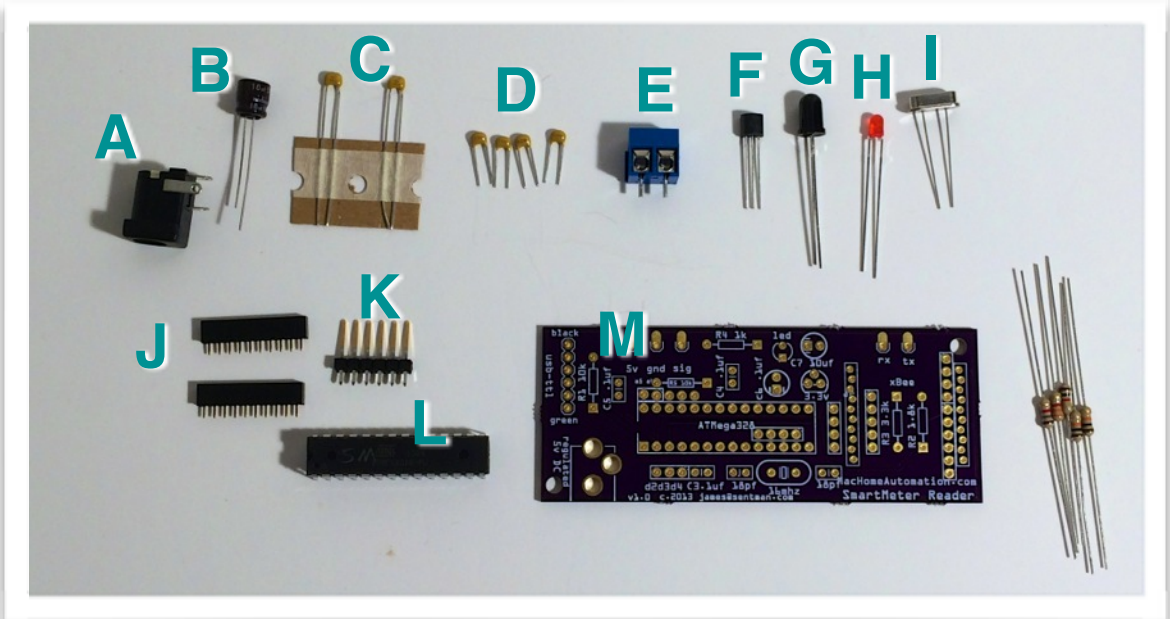
All portions of this manual are important, **but the more important ones are bolded.**

Which Meters Are Supported:

This is an incomplete list. Even these meters might have the calibration output disabled in their firmware, but it’s a good starting point.

Sensus iCon iSA21 and iSA2	centered above the display	use sensor 2
Itron or Schlumberger C1S or C1R, C2S or C2SR	on top of can pointing up	use sensor 2
GE I-210 & 210+	front panel below to the right of the display	use sensor 1
Elster R1S/REX	left of 2 LED’s below and right of the display	use sensor 1
Elster REX2	left of 2 LED’s to the right of the display	use sensor 1
Itron SS1S1L	to the right of the display	use sensor 1
Echelon E2L model 83020-2680A EM50202-NES	top of 2 LED’s right of the display	use sensor 1

What’s Included in the Kit:



(A) 1 DC power jack
(B) 1 10 uf electrolytic capacitor
(C) 2 18 pf capacitors (on paper strip with black line marking on top)
(D) 4 0.1uf capacitors (unmarked, bulk or on tape)
(E) 1 2 connector screw terminal
(F) 1 3.3v regulator
(G) 1 phototransistor
(H) 1 3mm LED
(I) 1 16mhz crystal resonator
(J) 2 xBee headers
(K) 1 Arduino programming header
(L) 1 pre-programmed ATMega 328 with Arduino boot loader
(M) 1 printed circuit board
2 10k resistors (brown black orange)
1 1k resistor (brown black red)
1 3.3k resistor (orange orange red)
1 1.8k (brown grey red)

Additionally one of 2 sensor packages will be included that should be able to get a signal from any of the above listed meters. Both sensor types are designed to use either velcro patches or 3M removable picture hanging strips so that the sensor can easily be removed if needed.

Depending on what you ordered, your kit may come with pre-programmed xBee radios to get the data into XTension.

What's Not Included

- The sensor needs a **single pair of wires** of whatever length necessary to get from the meter to the computer/radio board. These can be separated by as much as 50 feet.
- The radio board is designed to fit into a **4" square weatherproof electrical box**. It needs to be mounted within reach of an electrical outlet for the 5v power supply, and within xBee range of the XTension computer.

- The sensors are attached to the meter with either **Velcro or 3M picture hanging strips**.

- The radio board requires a **5v regulated power supply** with a standard 2.5mm center positive barrel jack. There is no onboard regulation so using a non-5v or unregulated power supply will likely destroy the ATMega. I recommend this one:

  http://shop.evilmadscientist.com/productsmenu/partsmenu/179

- If you're providing your own xBee radios, refer to the xBee configuration document for more info on setting them up. In short, a series 2, non-api routing endpoint with the serial baud rate set to 9600 is required. The board will support any configuration of series 2 radio, chip antenna, wire antenna or Pro. 900mhz long range xBee or bluetooth radios will also work, but these will require changes in the setup on the XTension side. The serial lines are available on

pads so that even non-xBee methods of getting data into XTension will work. Keep in mind it's 5v TTL level serial, and cannot be just plugged into a regular RS232 port.

- At least **two Series 2 xBee radios will be needed**. If you're out of range then adding another xBee in the middle will forward on the signals. For the connection to the computer an xBee/USB carrier board is also needed. Either of these works well:

  http://www.adafruit.com/products/247
  https://www.sparkfun.com/products/8687

Adafruit also has an excellent selection of xBee radios, I recommend these:

  (2 MW output) http://www.adafruit.com/products/968
  (63 MW output) http://www.adafruit.com/products/967

- The chip is flashed with the Arduino boot loader and the source code is available. To upload new firmware requires a **TTL serial cable** like:

  http://shop.evilmadscientist.com/component/content/article/51-accessories/210-ftdifriend

or

  http://www.adafruit.com/products/70

- Y**ou may need to shade the meter** from direct sunlight.

Tools Needed:

- You'll need a reasonably **fine tipped and well functioning soldering iron and solder.** Either the traditional leaded solder or the newer lead free variety will work fine. A simple plug-in 15 watt iron is fine, but don't try to use a classic Weller gun model.

- **Flush cut snippers** are necessary to trim the component leads from the back of the board.

- **Wire strippers** for preparing of the cables for the sensor.

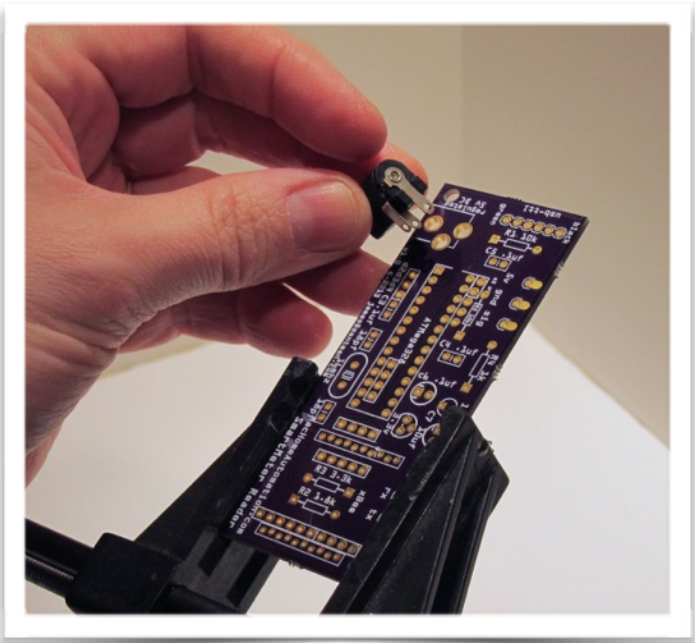
- A **multimeter** for testing of the xBee power supply.

- A board holding **vice or clamp** as shown in the pictures is not strictly necessary but makes things easier.

- A **resister lead former** is not necessary, but makes things easier and very neat and tidy.

  http://shop.evilmadscientist.com/productsmenu/partsmenu/68-bender

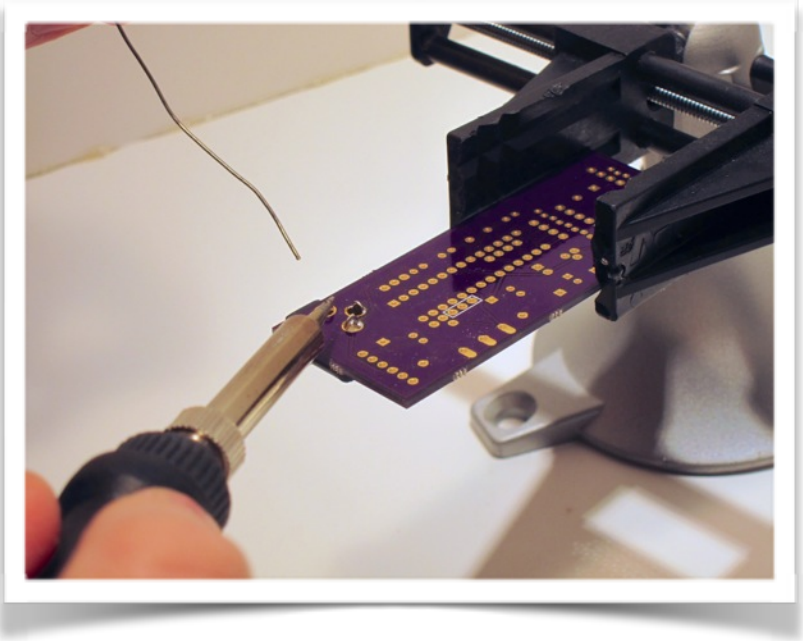
Step 1: Place the Power Jack



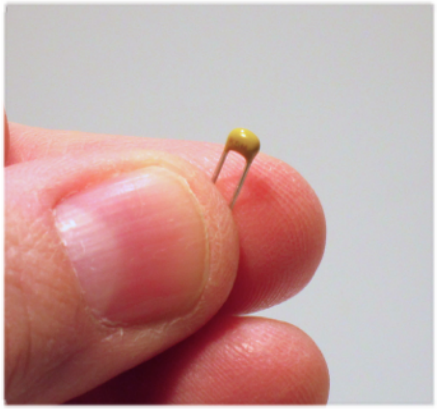
The Arduino runs at 5v and 16mhz in order to have good enough timing to accurately read the pulses. The xBee radio requires 3.3v. The first thing we're going to build and test is the 3.3 volt regulator section for the xBee.

Place the Barrel Jack as shown. It only fits one way. The opening points down off the board and there should be enough friction on the pads to hold it in place and keep it from falling out as you turn over the board to solder it.

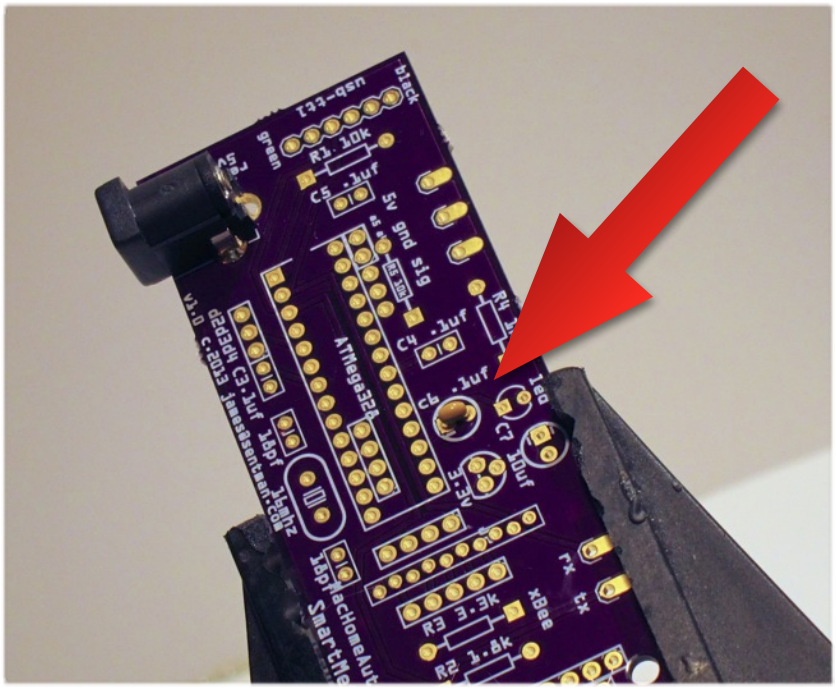
It is not necessary, or probably even possible without making a huge mess, to entirely fill in the large mounting holes. Make sure that each side of each tab is soldered to the edges of the hole.



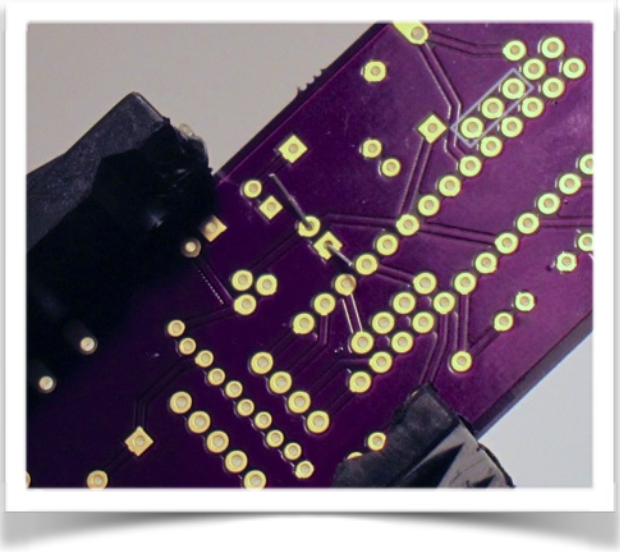
Step 2: Install Capacitor C6



There are 2 values of capacitors that look the same in the kit: four 0.1uf caps and two 18 pf caps. The 18 pf ones are marked with a black line on top. For this step you're looking for the 0.1 uf caps, which are unmarked.

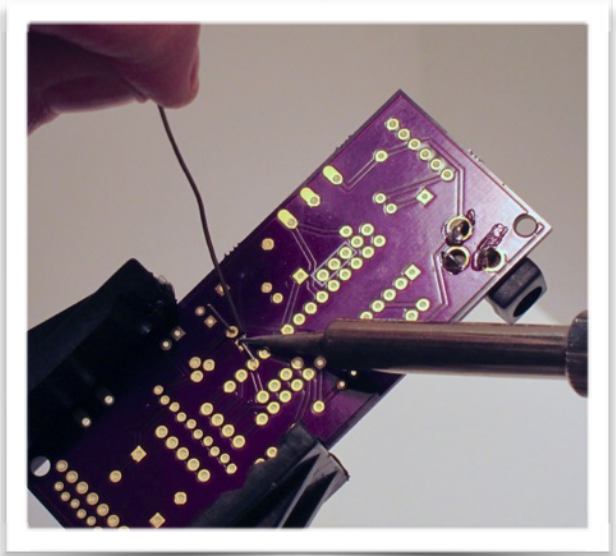


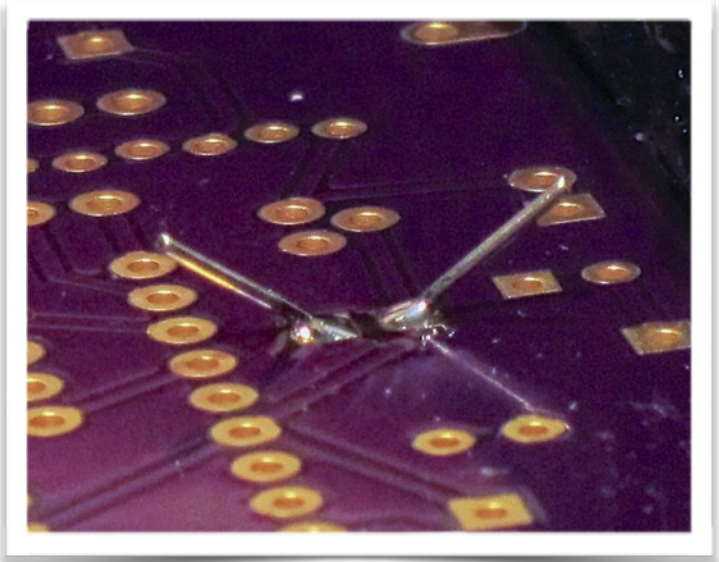
Though the silkscreen on the board shows a negative marking for this capacitor, the one supplied is not polarized and it doesn't matter which way it goes in.



Once you have the capacitor placed, bend the leads out to either side to hold it in place as you turn the board over to solder.

Solder the leads. The first few steps of these instructions assume you're not a professional kit builder and go over the details. Make sure you have a clean soldering iron tip. Use a wet sponge or brass mesh tip cleaner before and after each soldering step. The crust of burned rosin that forms makes it harder to heat the board. Try to heat both the pad and the lead at the same time, using the edge of the tip and not the very end. Apply solder after a second of contact. As the solder melts it will flow into the hole around the leads, and you want enough to form a little bulge evenly and cleanly covering the whole pad.

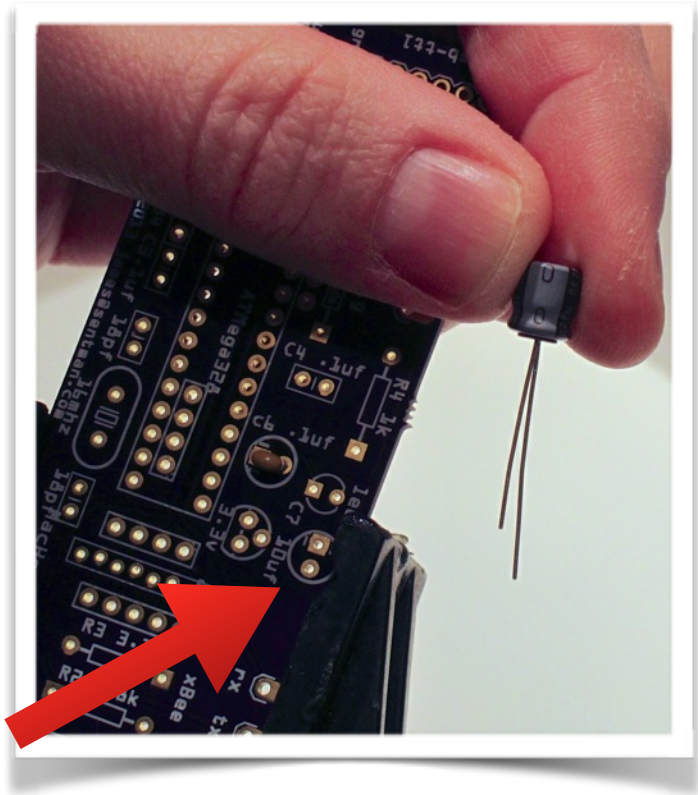




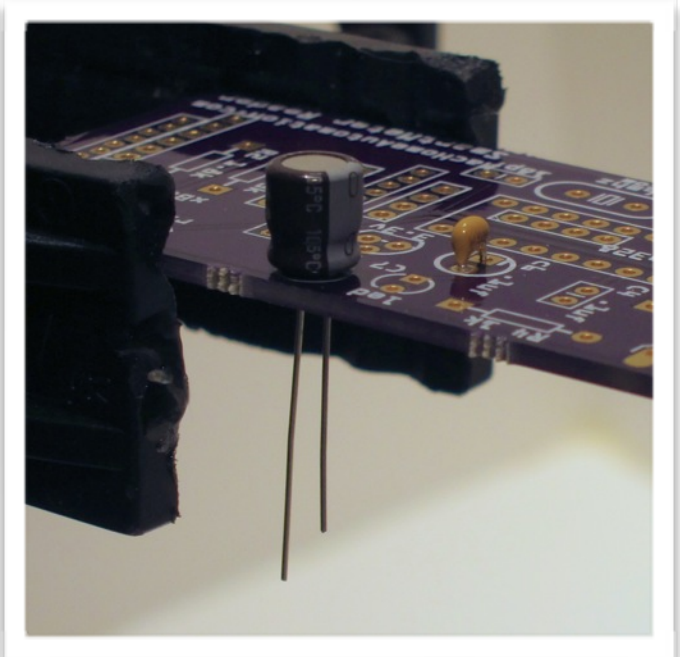
When you're done, you want to see something like this. The puddle of solder is firmly attached to the pads on the board, not sitting on top like a ball, and has drawn up around the leads a little. There are no messy edges or blobs and no solder is touching any adjacent pads.

Once you're finished soldering each part, use your flush cut clippers to trim the leads. **Don't trim so close to the board that you damage the solder connection.**

Step 3: Install Capacitor C7

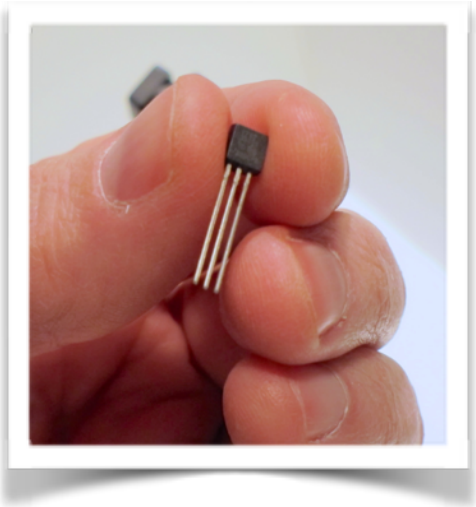


Cap C7 is another part of the 3v power supply for the xBee. **It's the only polarized or electrolytic capacitor in the kit. So for this one, plus and minus matter.**

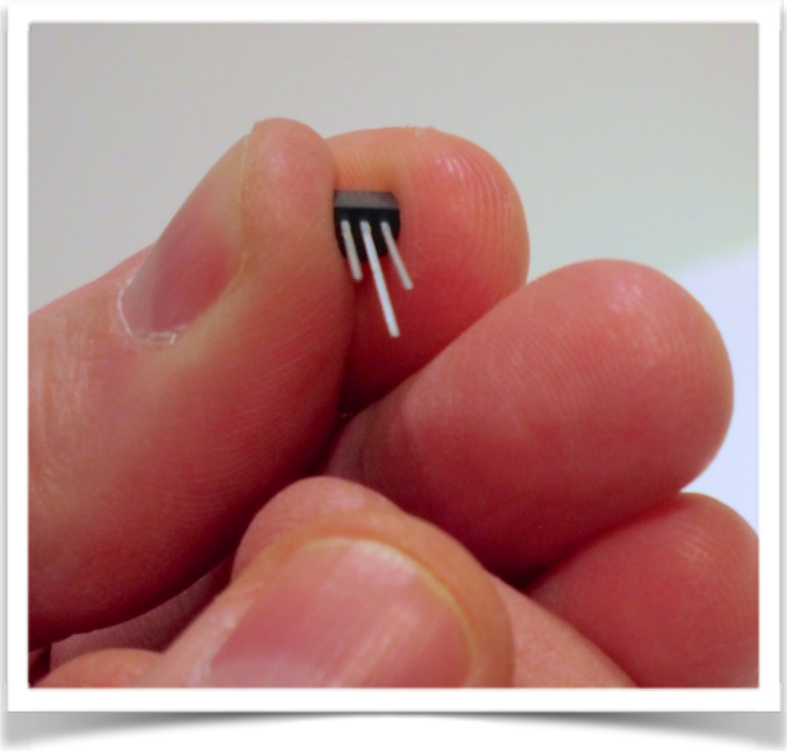


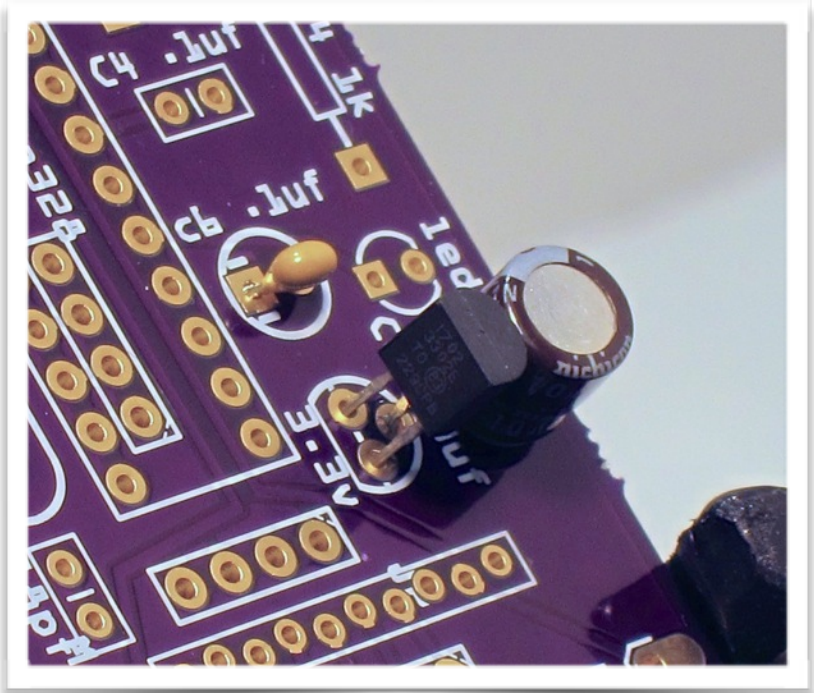
Make sure the short lead marked "-" goes through the square hole marked "-" on the board. Bend the leads, turn it over, solder and trim them.

Step 4: Install the 3.3 Volt Regulator and Test It



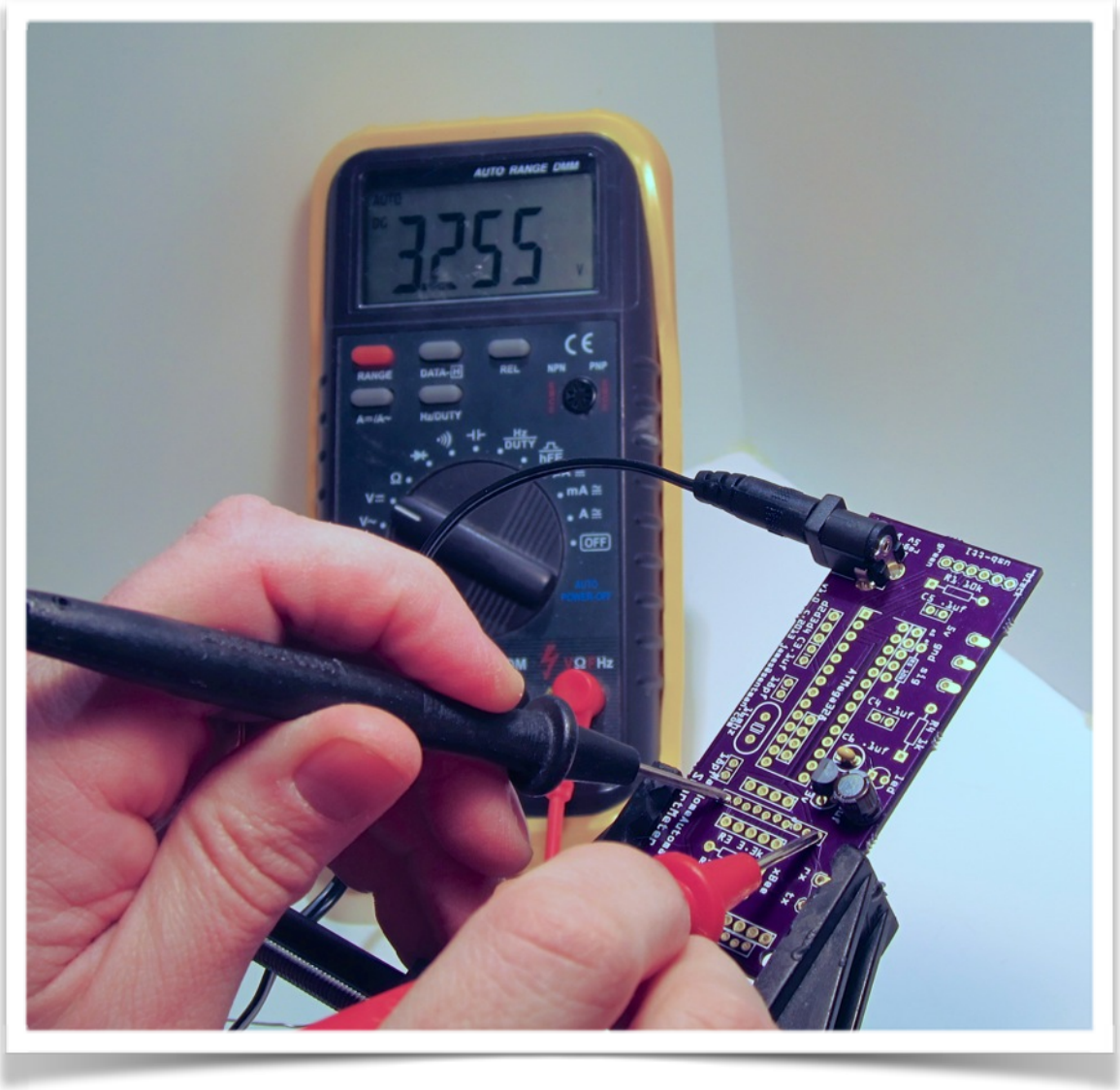
The 3.3 volt regulator looks like a transistor. You need to form the leads into a slightly different shape. Gently pull the center lead down slightly so that the device can more easily fit into the triangular arrangement of holes on the board.





The place on the board is labeled as “3.3v” and is between the 2 capacitors you’ve already finished. The flat side of the regulator lines up with the flat side of the silk screen outline.

This fits tightly enough in the board that you won’t have to bend the leads on the other side. Solder, and trim the leads.



Plug in your 5v power supply and test between the **first and last pin** of the left hand xBee header on the board.

The xBee headers are the smallest holes on the board and have a zig-zag pattern which makes them easy to spot. There are 2 headers. You're checking the one next to the voltage regulator. It should read around 3.3 volts. Mine shows 3.25 which is fine.

If yours doesn't read anything, first unplug the power supply from the board and test the output of the wall wart. Then look closely at the soldering and placement of the first 4 components.

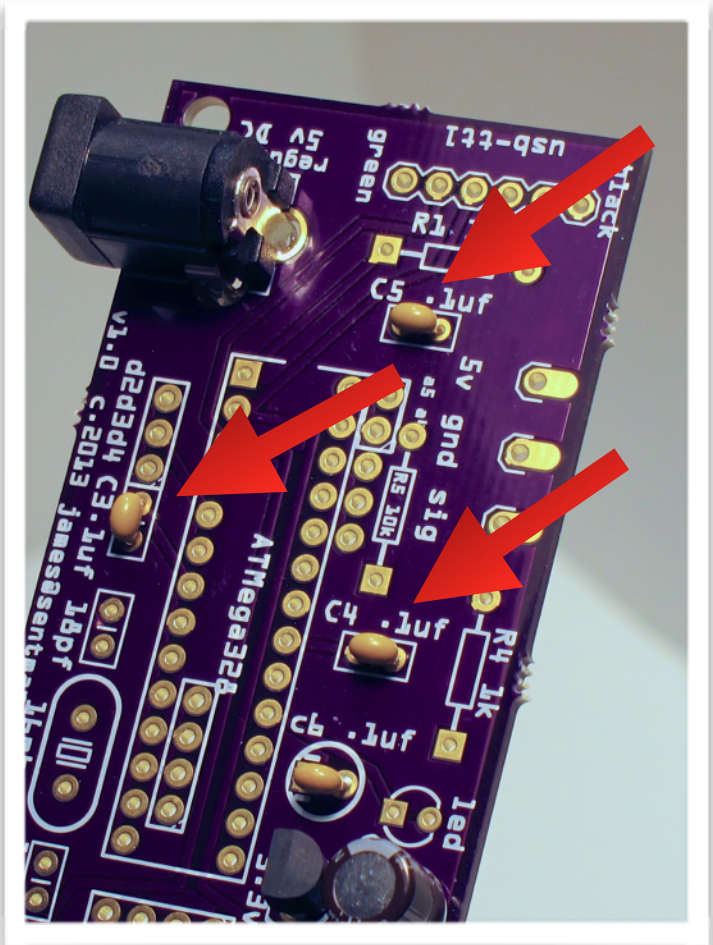
Step 5: Place the Rest of the 0.1uf Capacitors

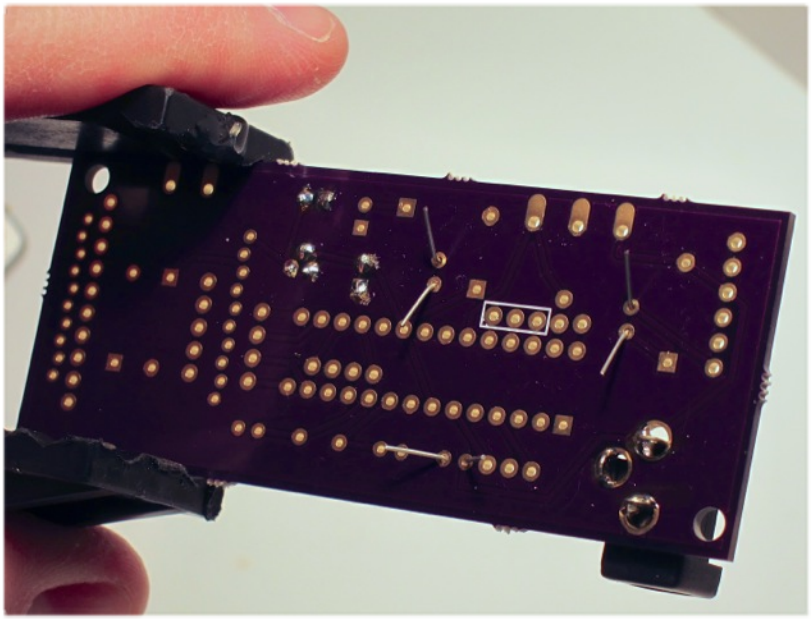
There are 3 more 0.1uf capacitors to place: C3, C4 and C5.

C3 is the decoupling capacitor for the ATMega chip. It provides filtering for power fluctuations. **C3 is close to some holes that bring out more of the Arduino digital pins for your future DIY pleasure. Make sure the cap is not in the first 3 holes, but in the last 2 in the row labeled C3. There is a silk screened line between them.**

C4 is a filter on the analog input side to help stabilize the reference voltages.

C5 is part of the poweron reset circuitry.

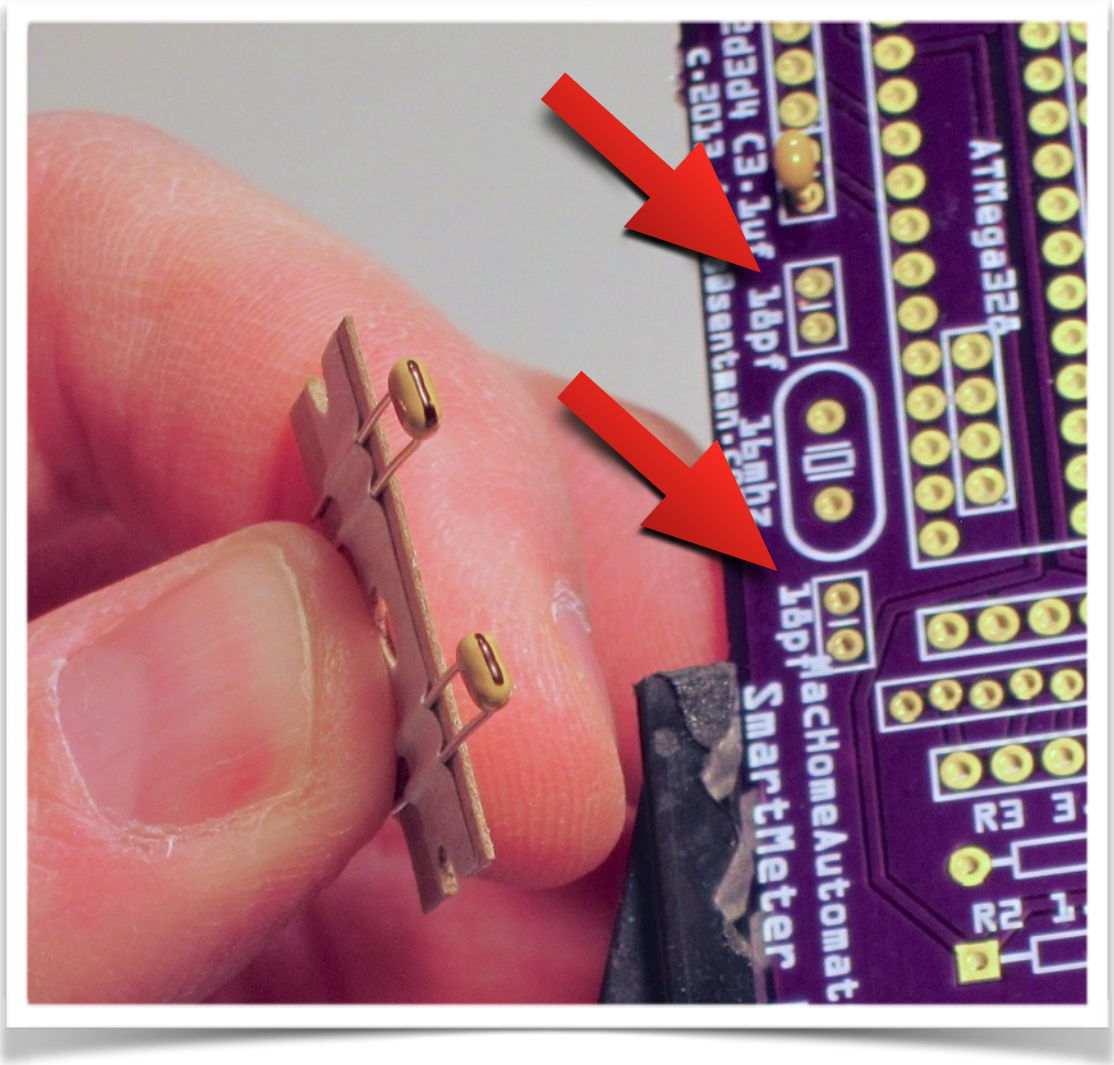




As you place them, bend the leads out on the backside to hold them in place.

Solder them and trim the leads.

Step 6: Place the Two 18pf Capacitors

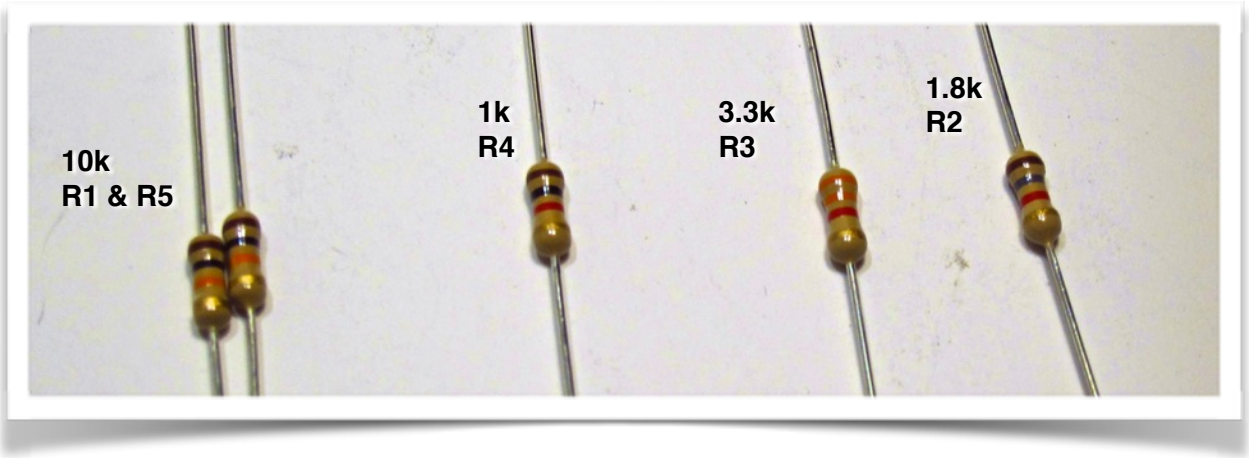


The two 18pf capacitors are part of the clock crystal resonator circuit for the ATMega. They are placed on either side of the 16mhz crystal. On the board they are labeled “18pf” rather than C1 and C2.

The 18pf caps are marked with a black line to help tell them apart from the 0.1uf caps.

Place them, bend the leads to hold them, solder them and trim the extra leads.

Step 7: Place the Resistors



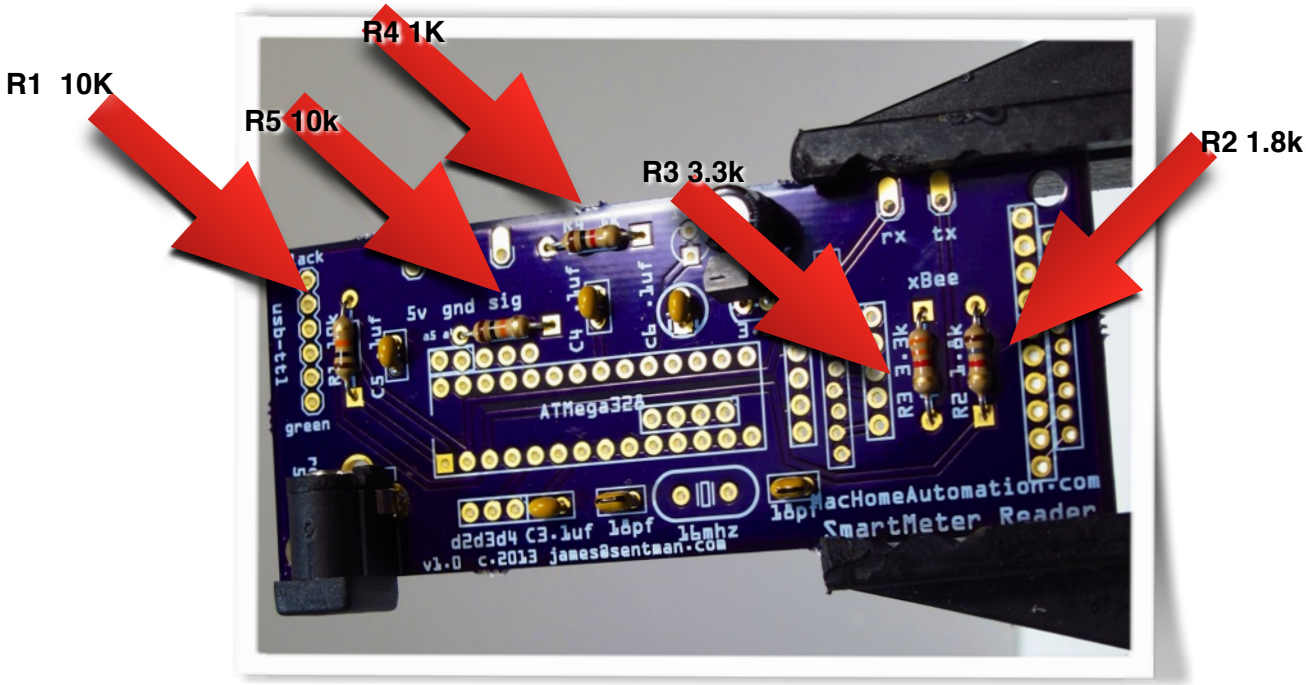
There are five resistors to place.

There are two 10k resistors marked Brown Black Orange. They go in positions R1 (part of the power-on reset circuit) and R5 (part of the analog voltage sensor).

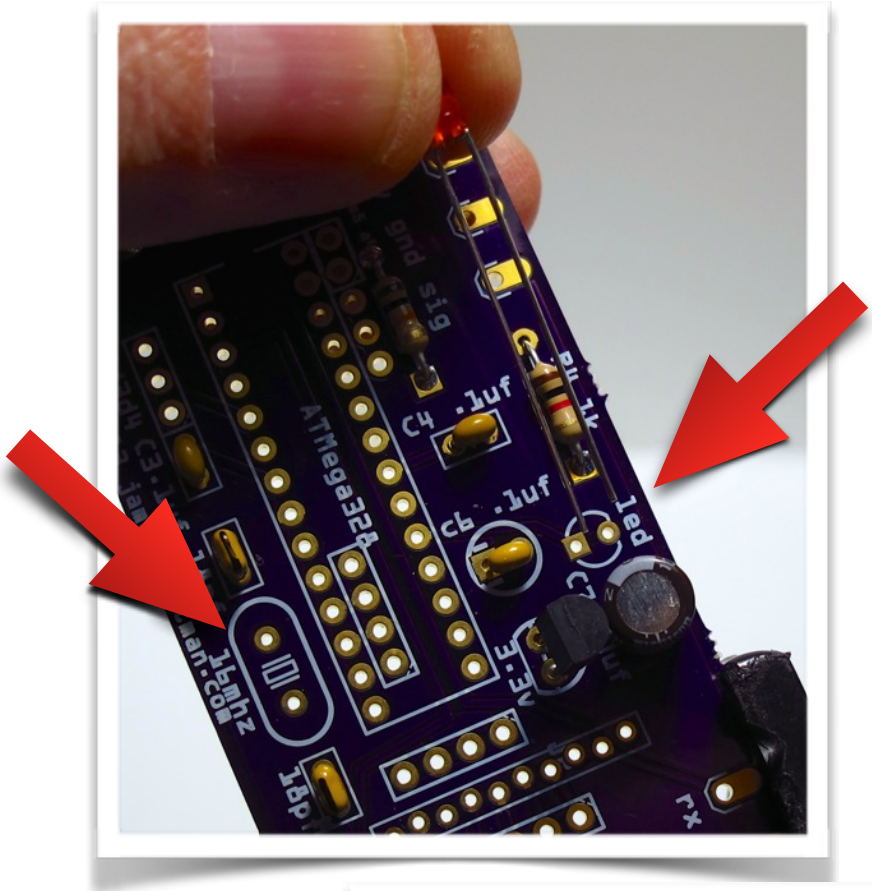
There is one 1k resistor marked Brown Black Red. It goes in position R4. This limits current to the LED.

The 3.3k marked Orange Orange Red goes in position R3.
The 1.8k marked Brown Grey Red goes in position R2.

R2 and R3 together are a voltage divider that reduces the 5v serial data from the Arduino to 3v.



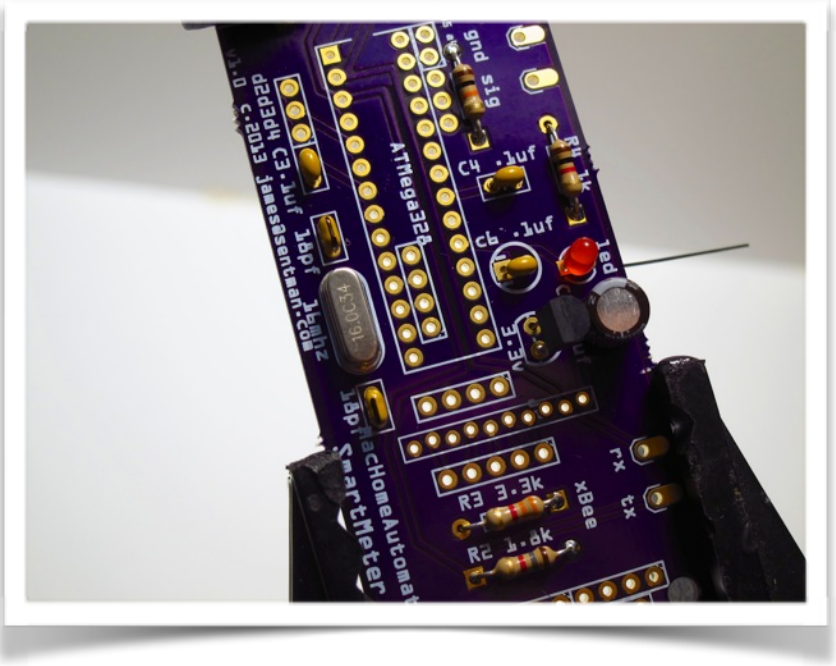
Step 8: Place the LED and the Crystal



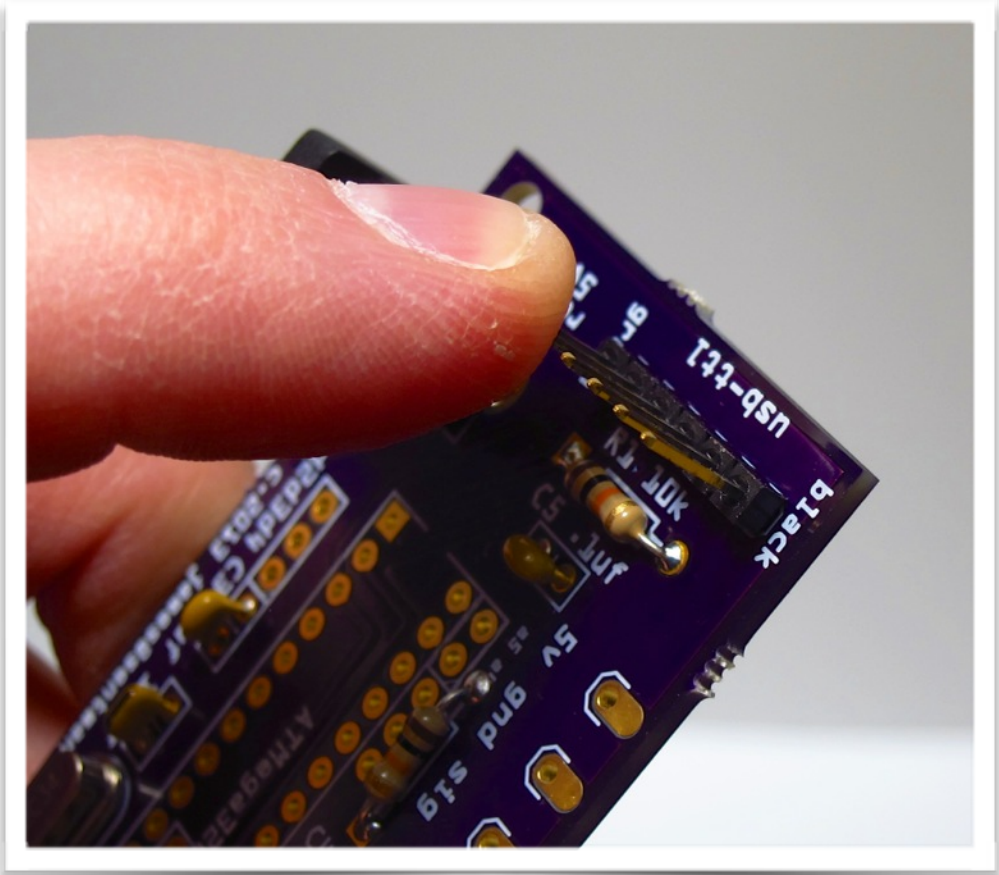
The LED is polarized so it matters which way it is placed. The 3mm LED has no flat side to line up with the silk screen so you must look at the lead length. **The LONGER lead must go into the square hole**.

The crystal is not polarized so it doesn't matter which way that goes in. The oval shaped spot on the board is labeled "16mhz"

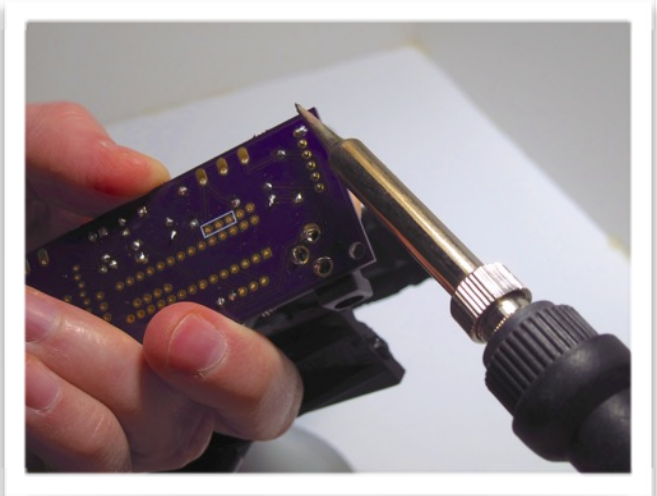
Bend the leads, solder and trim the leads.

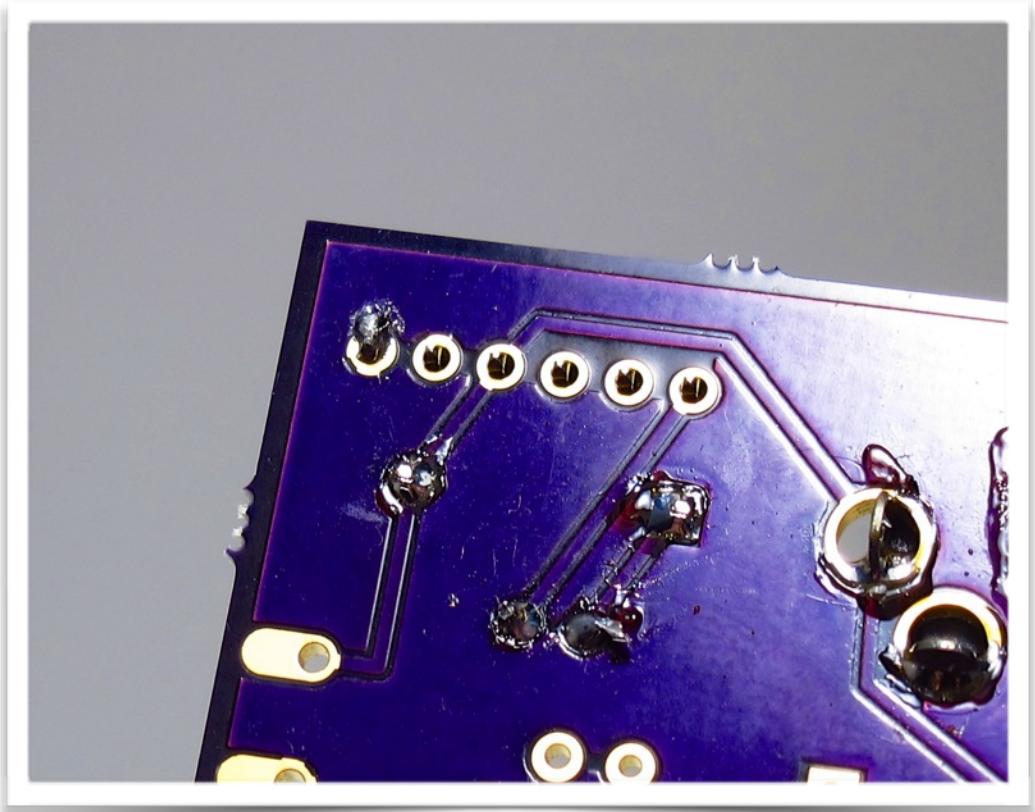


Step 9: Install the Programming Header



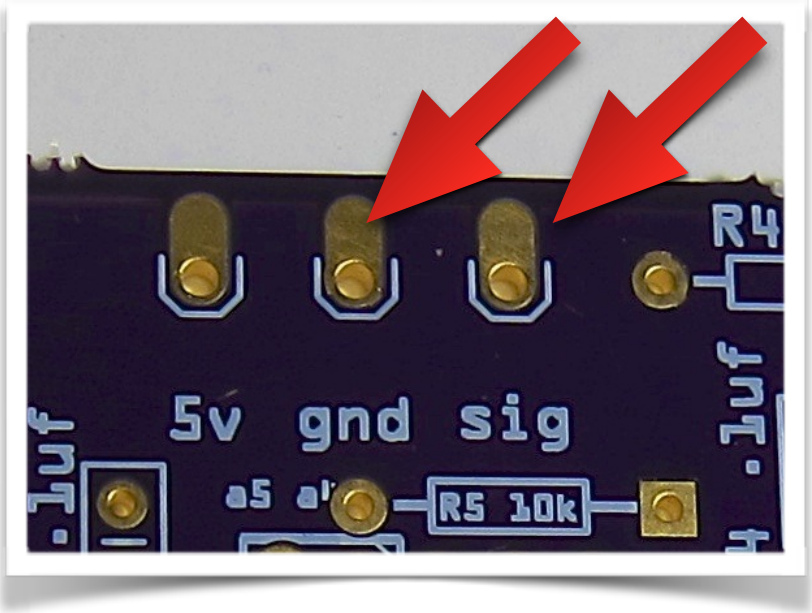
The programming header doesn't stick by itself, and you can't bend the leads. You need to hold it in place while you tack it with a little solder. Hold it with your thumb and get a small blob of solder on your iron. Tack the backside of the pin **FURTHEST from your finger** and you won't get burned. **Don't tack the pin you're touching**!



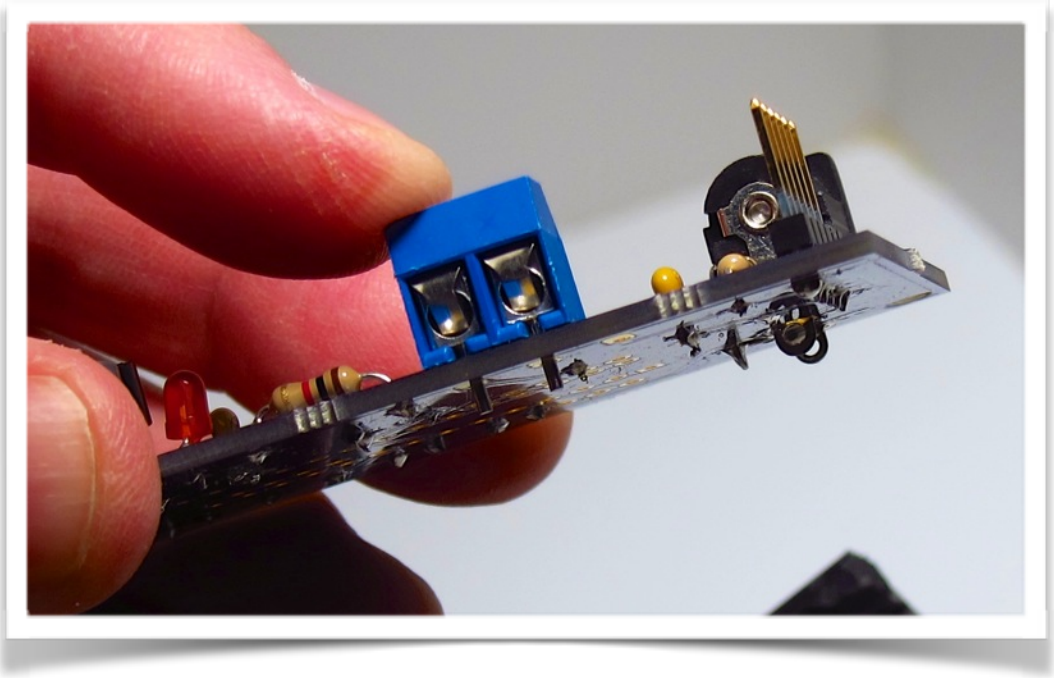


Here's mine after tacking. That is not a good solder connection, but it will hold it in place while we solder the rest of them. Start from the right side and solder them to the left (otherwise it will fall out when you melt the solder tack there). Touch up the tacked one when you get to it.

Step 10: Install the Sensor Terminals

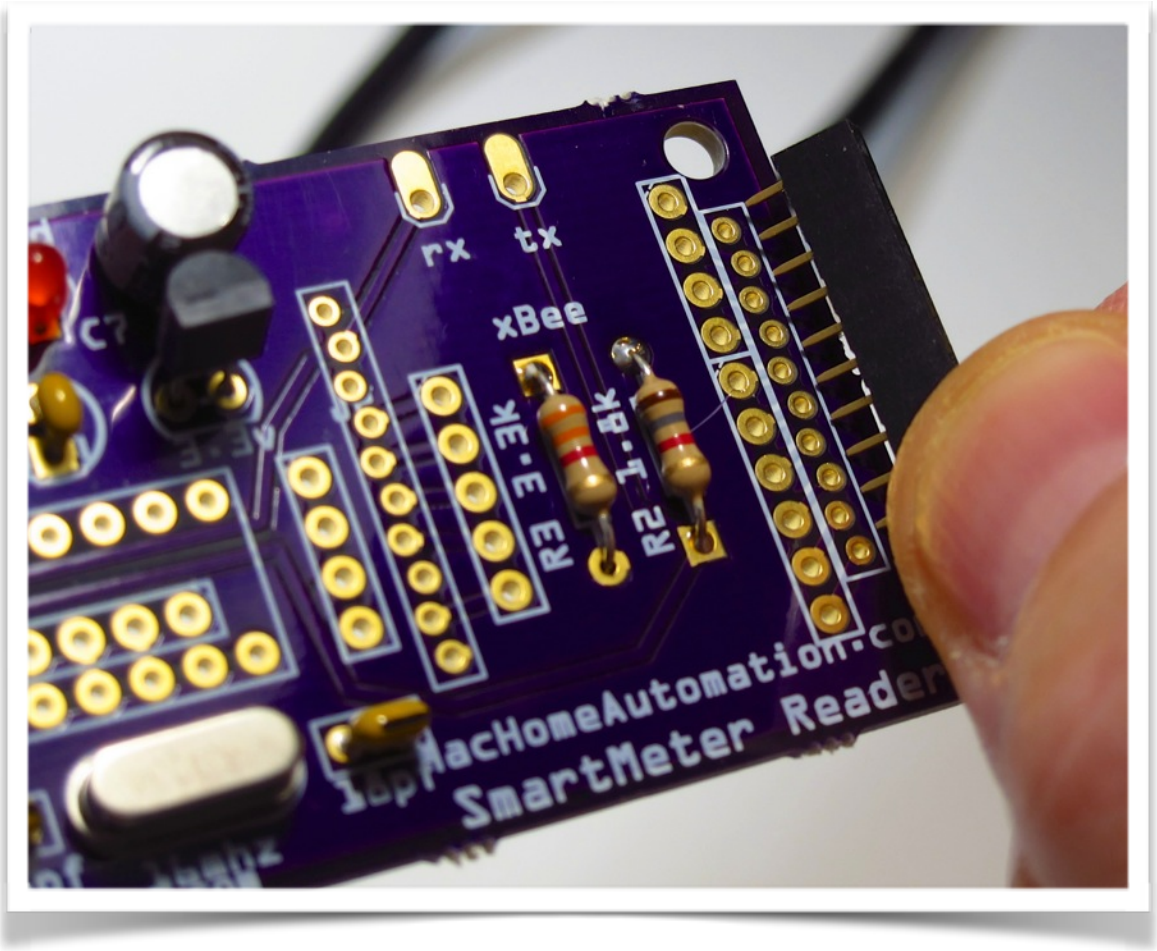


When you place your 2 terminal block make sure that it is in the "sig" (for signal) and "gnd" holes leaving the 5v hole open. There may be other sensor types in the future that require power. This one does not.



Use the same soldering trick here as for the programming header. Hold one corner with your finger while being careful not to touch the screw or other metal parts. Tack a tiny glob of solder on the backside to hold it in so you can turn it over, and then properly solder the 2 pins.

Step 11: Install the xBee Headers



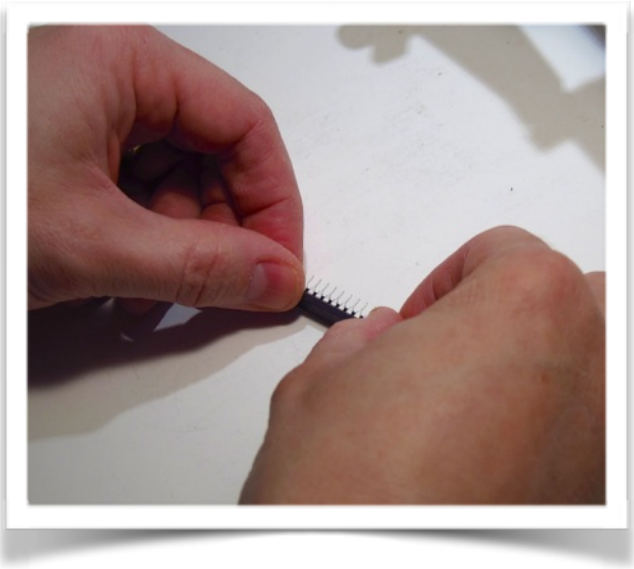
Place the 2 xBee headers on the board. They are the smallest pitch of any of the pins and so the most difficult to solder. The zig-zag pattern of the holes is supposed to provide enough friction to hold them in place while you solder, but this may not work. You may have to use the trick from above of holding one side and tacking the other from underneath.

They are tricky to get just right. Take your time. If they are not flat and perpendicular to the board it will be difficult to get the xBee to mount. **The headers can suck solder into the socket portion, making it impossible to get the xBee to seat properly or even work at all. Solder them quickly with only a tiny amount of solder. Don't let them soak up as much as they want**. Since the pins are so close together take extra care to ensure that none of them are shorted to neighbor pins with larger than necessary blobs of solder.

Do not just solder the xBee directly to the board. It is necessary to remove the xBee for its own firmware updates and to change configuration options. It must also be removed to reprogram the ATMega firmware.

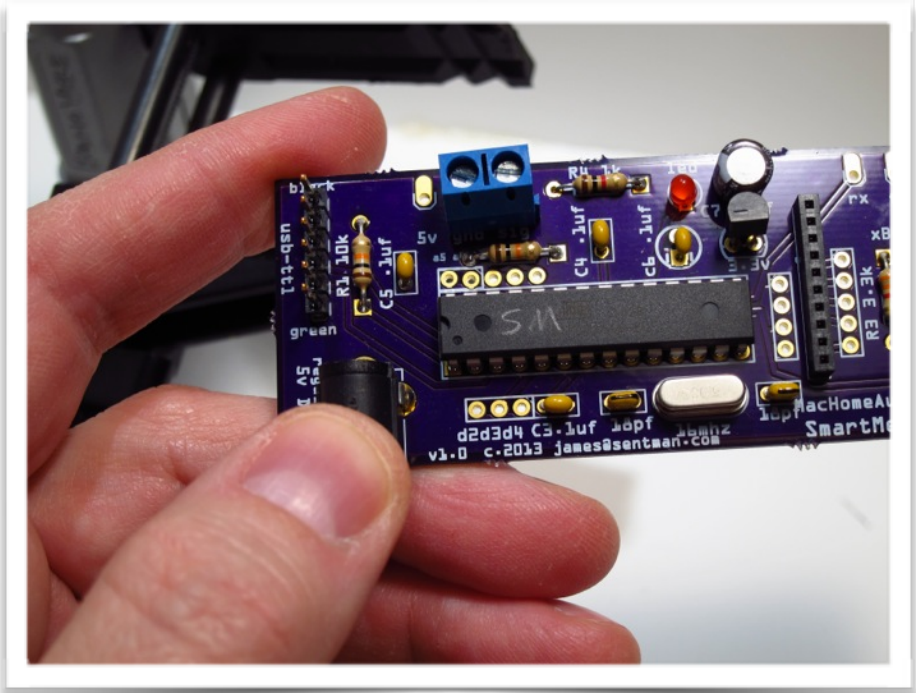
Step 12: Install the Processor

It may be necessary to straighten the pins on the ATMega so that they will go through the holes. It's easy to damage or break the pins by forcing them into the holes. **It's very difficult to fix a pin that has rolled under the chip without breaking it if it wasn't aligned and was forced down to the board. Take your time and align them carefully.**



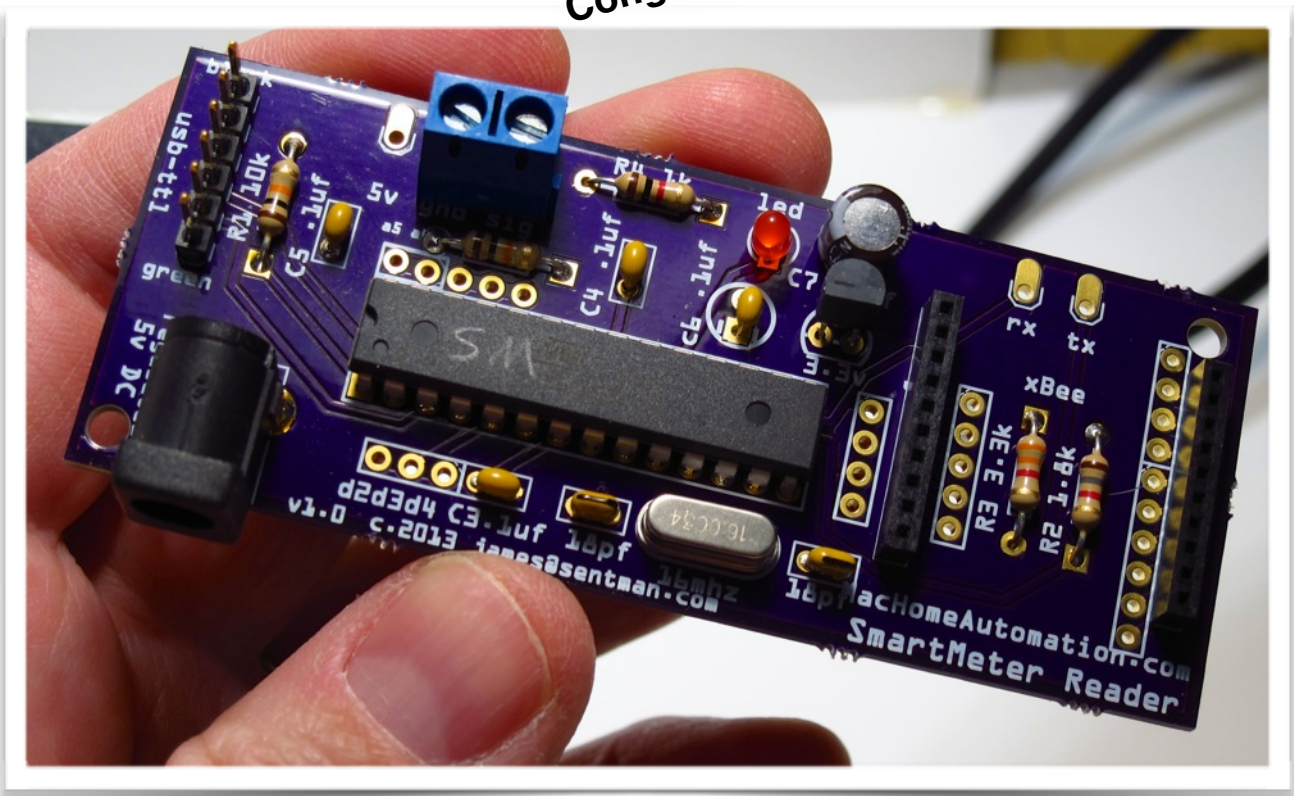
Grip the chip gently with both hands and press the pins on a flat surface, gently rolling the chip up until it's perpendicular with the table. Turn it over and do the same for the other side. Move it only a little at a time. It's better to do it again and add a little more adjustment than to undo it entirely if pins get tilted inwards.

Once seated there should be plenty of friction to hold it in place as you turn the board over and solder it. Try not to overheat the chip and watch for solder bridges between the pins. I generally work from opposite sides and alternate so that no one section gets heated too much.

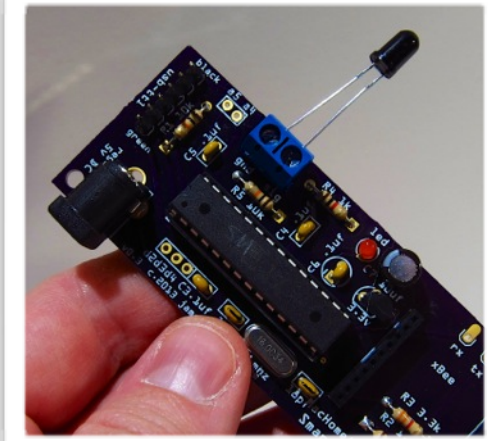


Step 13: Testing the Finished Board

Congratulations! Almost done!



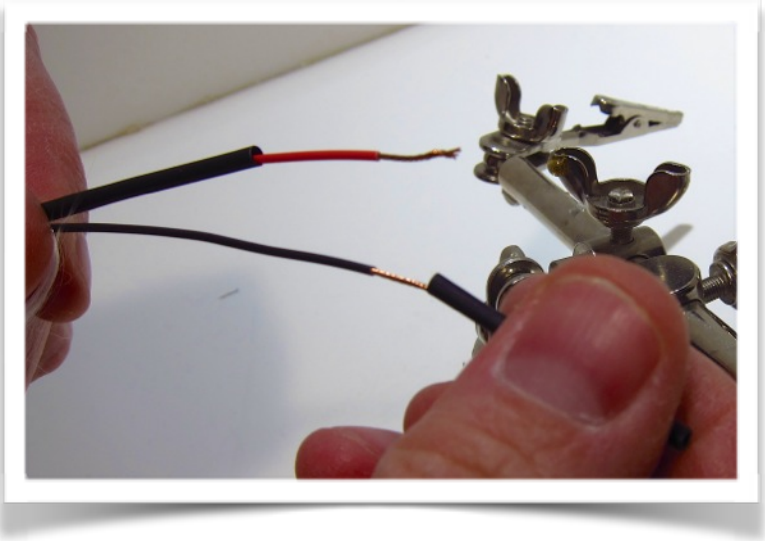
At this point you're ready to test the finished board! You can temporarily connect the phototransistor directly to the screw terminals. **The long lead must go into the terminal labeled GND**. With the sensor sticking out from the board as shown, you can take it to the meter and plug in the power while holding the phototransistor over the LED on the meter.



When you power on the board the LED will flash quickly, then hold steady for 3 seconds letting you know the firmware is loaded and working (this delay in startup also gives the xBee time to get associated with the network at power up so that messages or data aren't missed).

For the next 10 seconds the board is just sampling the output from the sensor, looking for the on and off levels given the ambient lighting. Without the sensor actually installed, this probably won't work in direct sunlight. Hold it steady for those 10 seconds. The LED should start flashing on and off with each watt hour of power that your meter is measuring.

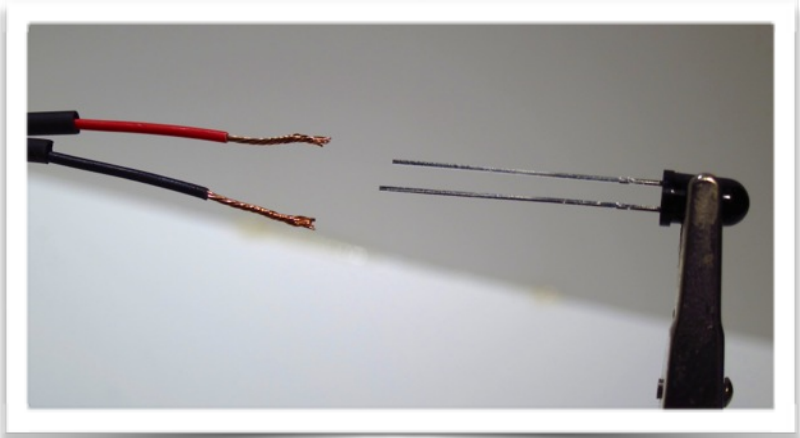
Step 14: Building the Sensors

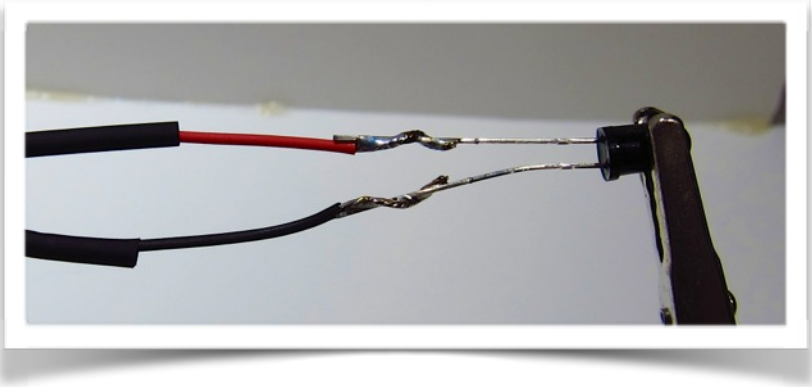


Attaching the phototransistor to the wire is the same for both sensor designs.

The sensor lives outside unprotected. Properly heat shrinking the leads and connections is important. Strip back enough of the insulation so that you can slip the small heat shrink pieces over the wire.

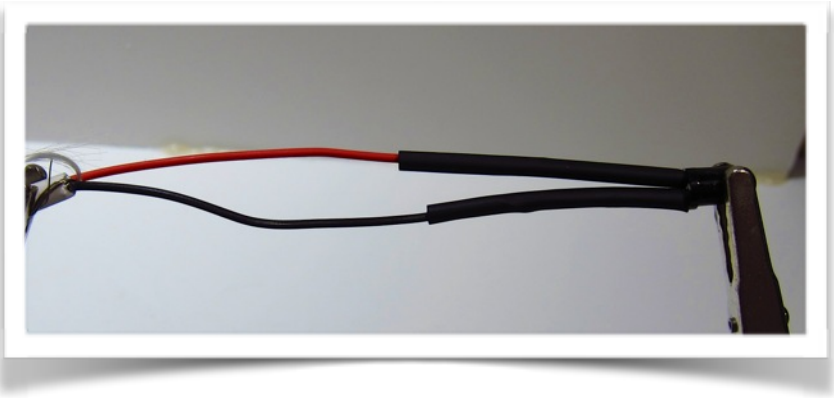
The long lead from the phototransistor needs to be connected to the GND terminal on the board. Make sure to connect it to the black or otherwise marked wire in your wire pair so that you can find it again on the other side. If you get it backwards it won't hurt anything. It just won't work until you swap it around.

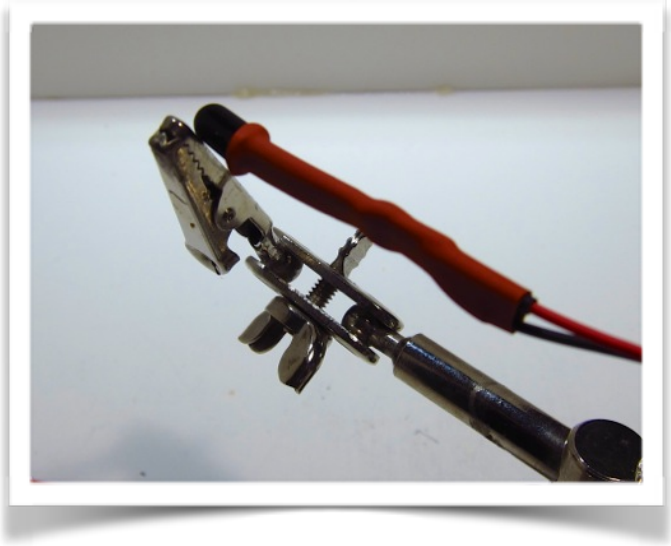




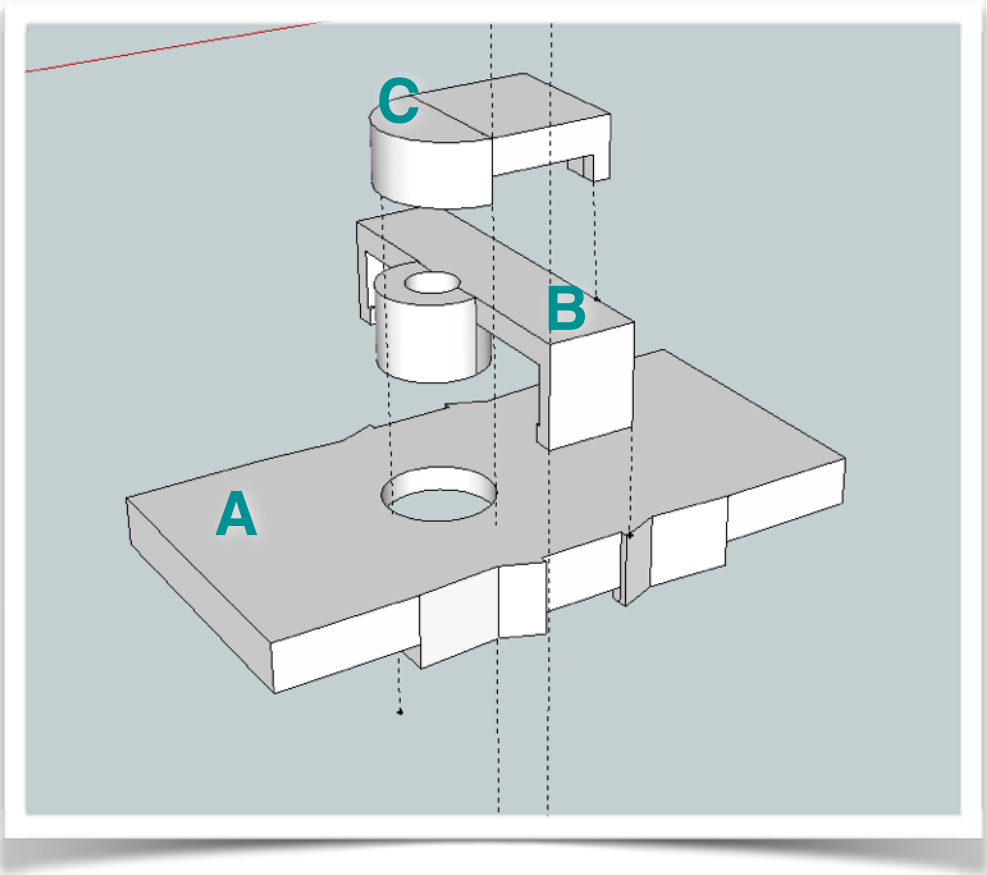
Before soldering make sure you've cut back enough outside insulation (if your wire has any at all) so that you can get the heat shrink **far enough away from the solder joint so that it doesn't start to shrink while you're soldering the sensor.**

Once the joints have cooled a little, slide the heat shrink back up and apply some heat.





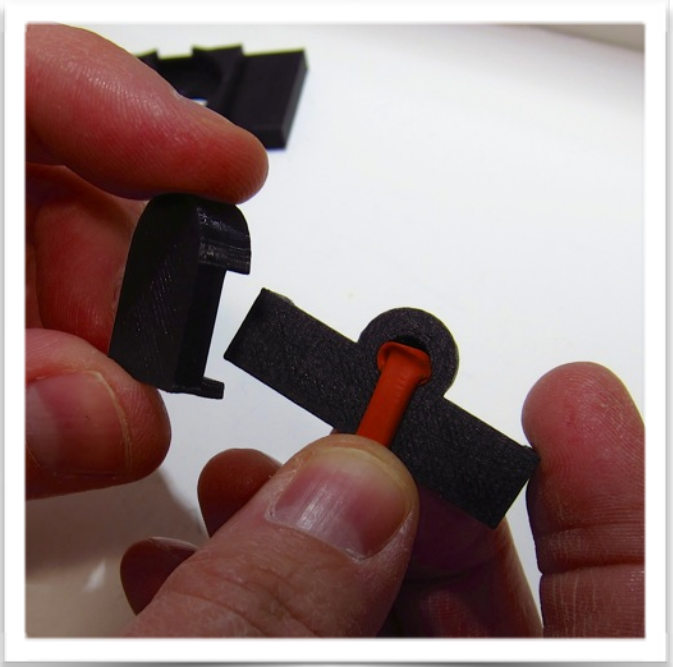
Put the larger heat shrink over the whole assembly from the LED down. Don't cover the LED or it won't fit inside the sensor plastics.

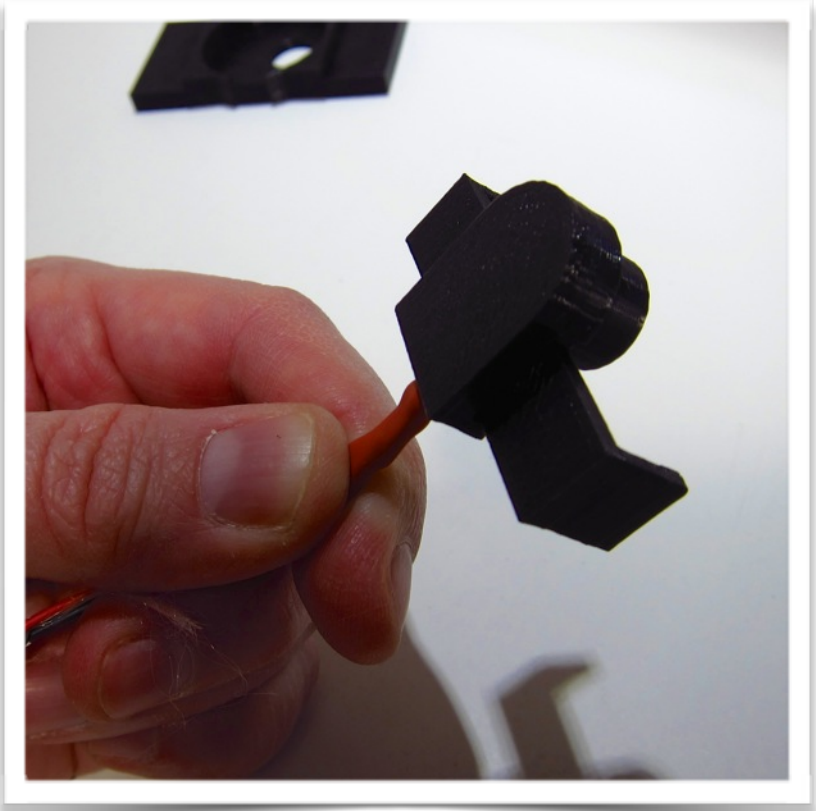


The type 1 mount has 3 parts. The base (A) is attached by velcro to the meter housing. The clip (B) holds the phototransistor sensor, and the cap (C) protects the wires.

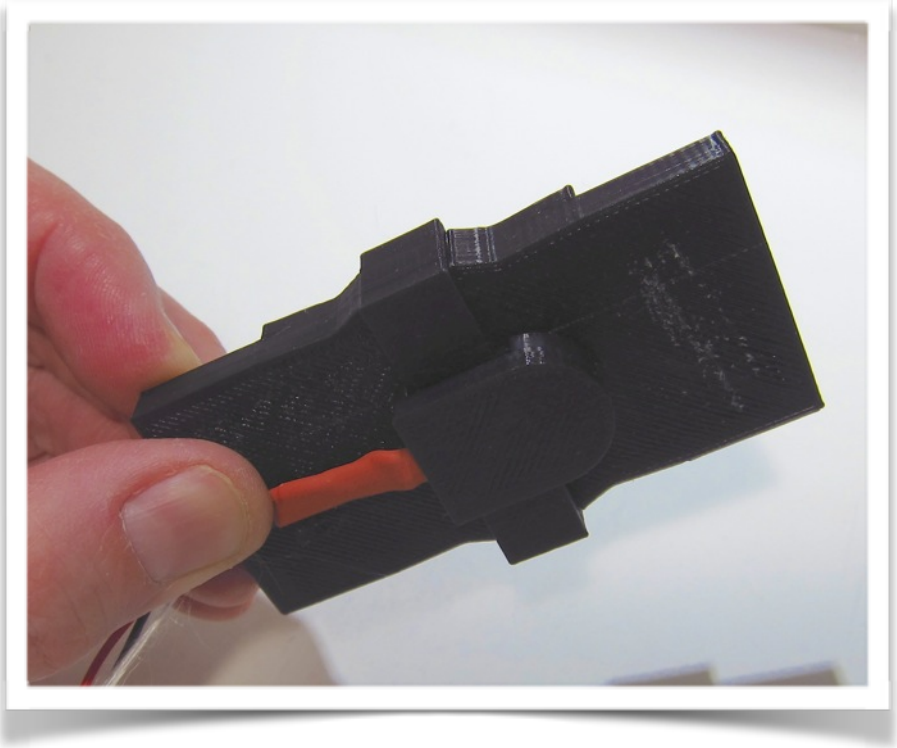
Insert the phototransistor from the back of the clip and bend the wires so that they fall straight down as in this picture's orientation.

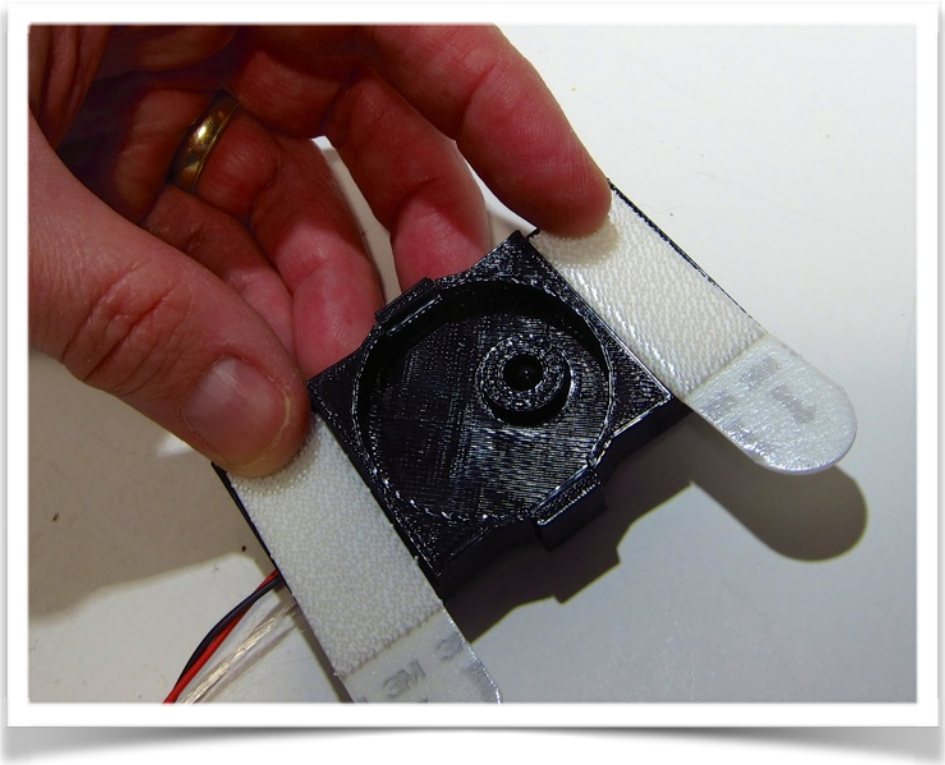
Apply some hot glue or other sealant and press on the cap which will cover the back of the phototransistor and protect the bend in the wires.



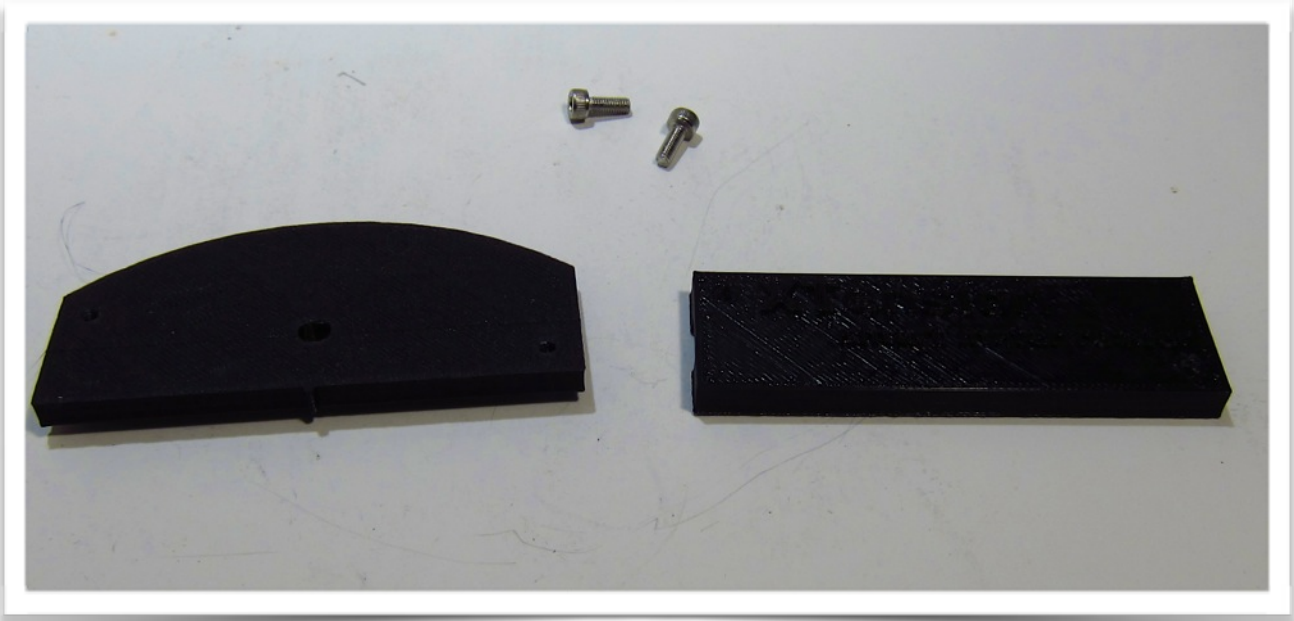


Here is a finished snap sensor assembly ready to be snapped over the base once it has been attached to the proper part of the meter.





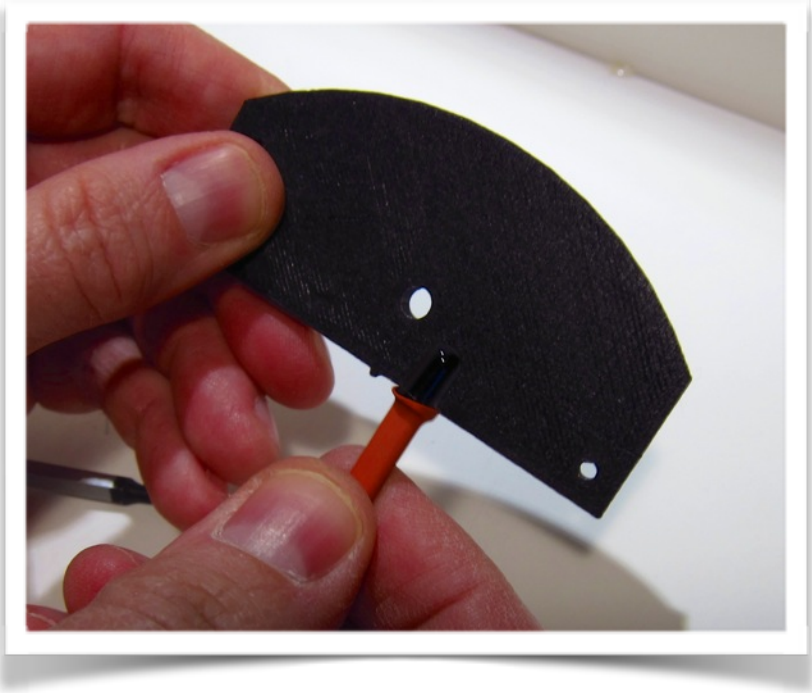
Here is the complete Universal Meter Mount with all pieces assembled and showing the placement of the 3M strips or velcro fasteners. The circular indentation is necessary to clear the features of some meter's housings. The picture shows the base with the clip sensor installed. **In order to properly install it on your meter, remove the clip (if you've already put it in for testing). Attach the Velcro or 3M strips and go to the meter. While looking through the hole, align it with the proper IR LED on your meter. Once it's in place, clip on the clip sensor.**



The second kind of mount is for meters with the LED centered and directly above the display, or meters with the IR LED pointing directly upwards from the top of the housing. This mount provides further shading from direct sunlight while still allowing the display to be read without removing the sensor.

The front piece is printed with the XTension name and has a channel for the wire from the sensor on its back. Start the 2 screws by hand into the plastic until they are just flush with the back of the plastics.

The second piece has the arch of the sun shield and indentations on the back for the velcro strips. **Put the LED through from the flat side pointing towards the indented side.**



Bend the leads to whichever side more easily reaches the radio/CPU installation.

Tighten the screws into the back piece to bring it all together. The pieces must be held tightly together as the screws begin to bite into the back piece. You can't tighten it up later if you have a gap at the beginning. But be careful not to over tighten the screws and crack the plastics.

Once the velcro or 3M strips are attached you can fine tune the alignment by eye. There is a small alignment tab on the bottom that shows exactly where the phototransistor is.