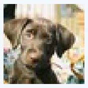
Lithium Battery Solar USB/ iPhone/ Arduino Charger

by JoshuaZimmerman on July 12, 2012



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I'm a middle school science teacher in Milwaukee, Wisconsin. I like making random things and then teaching my students how to do the same. I also run a little website where I sell some of the things I make in order to pay for more things for me to make.

Intro: Lithium Battery Solar USB/ iPhone/ Arduino Charger

One of the most fun and useful projects on instructables is to create your very own solar USB/ iPhone charger. They're not overly difficult to make, nor are the parts overly expensive or hard to find. For the most part they do a rather good job of charging up small gadgets. Mostly.

The big flaw in the DIY solar charger world are the batteries. Nearly all the designs on instructables (including all of my designs) use standard NiMh rechargeable batteries. They're cheap, easy to find, and very safe to use. The problem is that their capacity and voltage are both low, and the gadgets we keep wanting to charge are getting bigger and better batteries.

For instance an iPhone 4 has a 2,000mAh battery inside of it. Now that isn't too tough to charge up decently with a well made solar charger using 2 or 4 AA batteries. On the other hand an iPad 2 has a 6,000mAh battery pack on it. Not so easy to charge up.

The solution for these problems is to ditch NiMh batteries and turn to Lithium batteries.

In this guide I will show you how to make your very own Lithium battery charger. One that is cheap to make, easy to build, and most importantly safe to use.

(Oh and help me win the Instructables Green Tech Contest by voting for this project! An iPad would be great for my classroom! Even better, I'll build a massive Lithium powered charger to run the iPad. It'll be 100% green in my classroom.)

Step 1: What you need

Electronics Parts:
5V (or greater) Solar Cell
3.7V Lithium Ion Battery
Lithium Battery Charge Controller
DC-DC USB Boosting Circuit
2.5mm Female Panel Mount Plug
2.5mm Male Jack with Wire
1N4001 Diode
Wire

Building Supplies:
Electrical Tape
Shrink Tubing
Double Sided Foam Tape
Solder
Altoids Tin (Or other enclosure)

Tools:
Soldering Ion
Hot Glue Gun
Drill
Dremel (Not necessary but good to have)
Wire Cutters
Wire Strippers
Helping Hand
Safety Goggles

This guide will show you how to make a Solar powered version of this charger. You can also easily ditch the Solar section completely and rely on USB to charge up the Lithium battery.

While many of the parts for this project can easily be found at most online electronics store, a few items like the "DC to DC Boosting Circuit" and the "Lithium Charge Controller Board" are more difficult to find. As this guide continues I'll provide you with several options on where to get most of the parts as well as a detailed rundown of what each one does. Then you can make an informed decision as to which one best meets your individual project needs.

As a disclaimer I will say that I do sell both finished versions of this charger, parts to make this charger, and complete kits on my website BrownDogGadgets.com . You don't need to get these parts from me, and I'll be showing you several other places to buy the parts at in case what I have doesn't meet your needs.

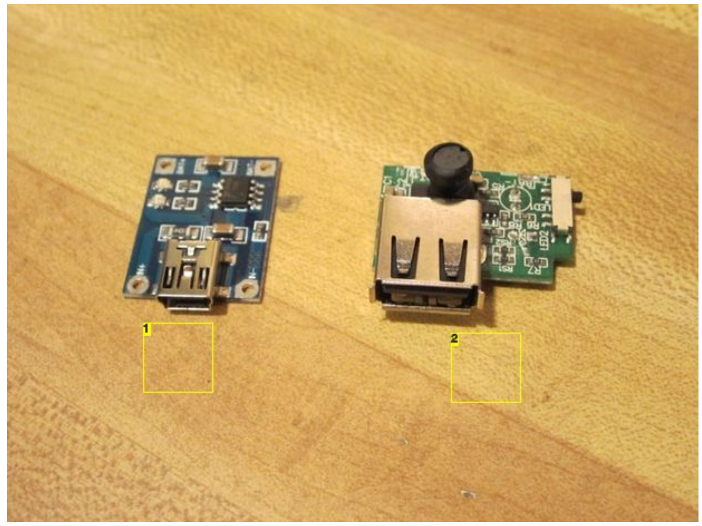


Image Notes
1. Charge Controller
2. USB Boosting Circuit

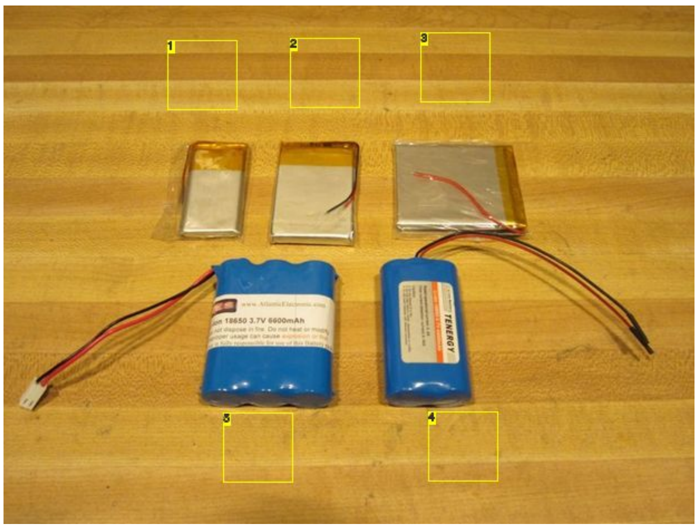


Image Notes
1. 1,100mAh
2. 2,000mAh
3. 2,600mAh
4. 4,400mAh
5. 6,600mAh

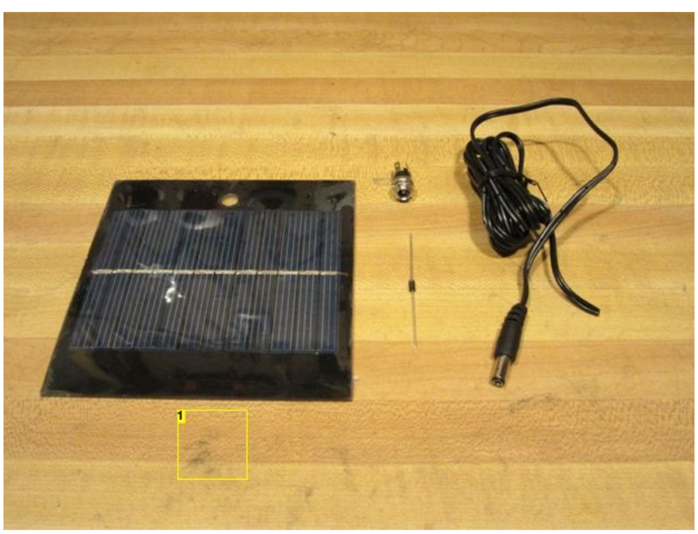


Image Notes
1. 6V 230mA

Image Notes
1. Vintage!
2. Mystifying
3. Minty
4. East meets Mint

Step 2: What Are Lithium Batteries?

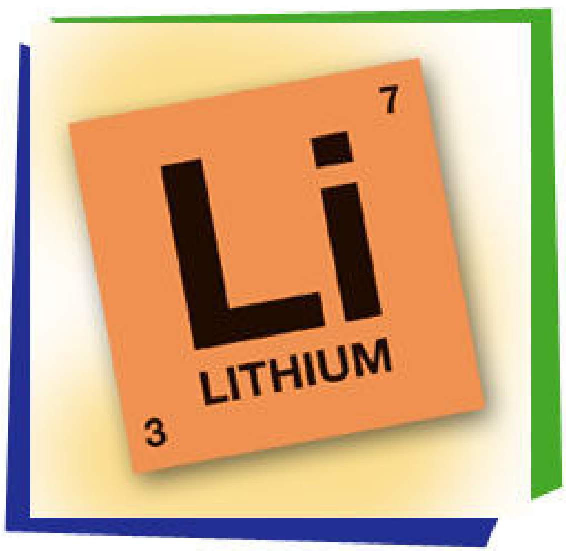
Whether or not you know it, you've probably got a one in your pocket right now. And one on your desk. And one in your purse/ backpack. Lithium Ion batteries run most modern electronics. They provide a large capacity of power, a high voltage level, and a high number of recharges for their size. This as opposed to rechargeable AAs which are are most always NiMh in composition.

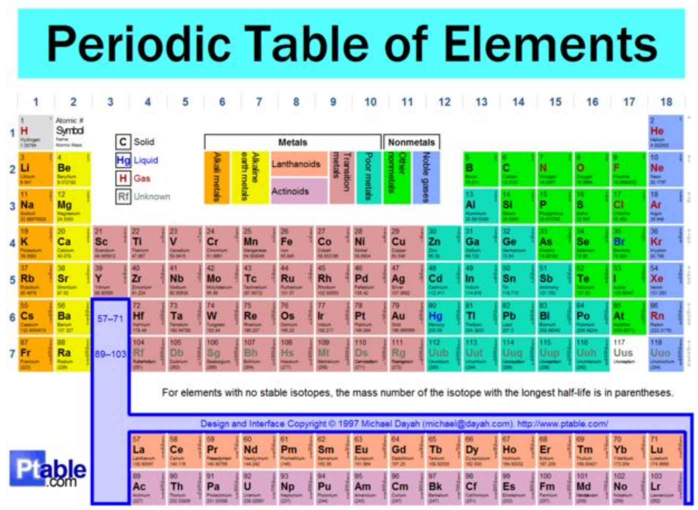
In case it's been awhile since high school chemistry for you, the difference between your standard rechargeable AA battery and a Lithium Ion battery are the chemicals inside. Take a look at the Periodic Table and you'll see that Lithium is on the far left in the first column, where all the most reactive elements live. This as compared to Nickel which hangs out in the middle of the table with a lot of random unreactive stuff. (And if you want to know why it's so reactive, thats because it only has one lonely valance electron. Which I'm sure at least one of my 8th grade science students probably still remembers. Sigh... teenagers.)

This is why Lithium often gets a bad rap. Since it's so darned reactive it can sometimes get out of control. A few years back Sony made a bad batch of laptop batteries, some of which started on fire randomly. (Did you know Sony makes a good chunk of the world's laptop batteries, for most major brands?)

This is why we must take certain precautions when dealing with Lithium Ion Batteries. In order to maintain a very precise voltage when charging. The 3.7V batteries we're using in this guide need to have a charging voltage of 4.2V. A volt high or a volt low can mean an out of control chemical reaction which can lead to danger.

This is why you must be careful when dealing with Lithium Batteries! While they are quite safe when handled with care, if you start doing things you shouldn't you can end up with big problems. Treat them with the respect they deserve.





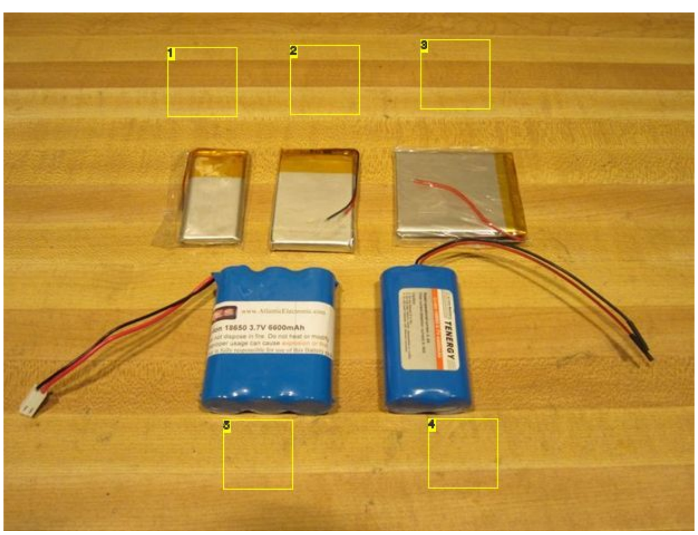


Image Notes

1. 1,100mAh
2. 2,000mAh
3. 2,600mAh
4. 4,400mAh
5. 6,600mAh

Step 3: Choose a Lithium Charge Controller

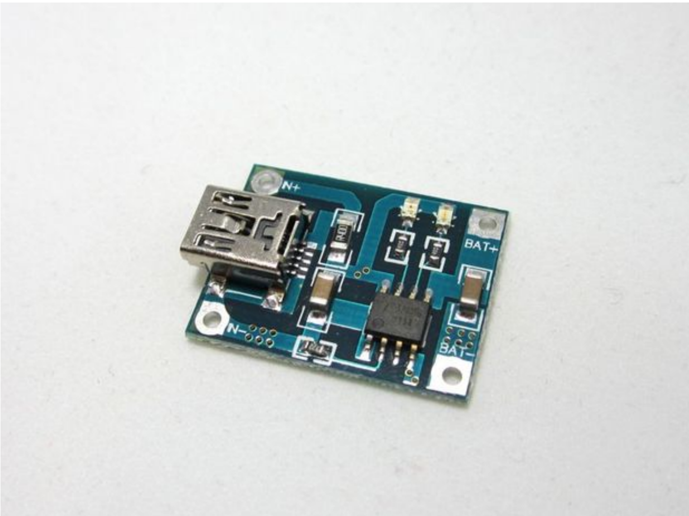
As reactive as Lithium batteries are all you really need to be safe is to have a circuit that controls the voltage going to your battery.

While you could make your own charge controlling circuit, it's far easier to just buy one that you know works. For this you have several options.

Adafruit is now on it's second generation of Lithium Charge Controllers that have several options for power input. They're very nice, but a bit on the large size. Not at all small enough for our Altoids tin sized enclosure.

I sell some small Lithium Charge Controller Modules on my site. These are the ones I use in my kit and in this guide. I like them because they're small, simple, and have status LEDs for charging and when the battery is full. Like the Adafruit charger you can also use the USB port on it to charge up the Lithium Battery if you lack sun. (Something that is very handy for any solar charger.)

No matter what you use, be sure that you know how to use it and what goes where.



Step 4: USB Circuit

Most modern gadgets can charge via USB. It's become the standard world wide. So why do we need a special circuit for it? Can't I just wire up a generic USB port directly to the battery?

The problem is that USB operates at 5V of power. The Lithium Batteries you'd want to use with this project are only 3.7V of power. The USB Circuit I have in this project is a DC to DC Boosting Circuit. Meaning it bumps up the voltage so our gadgets can actually charge. (This as opposed to a lot of USB chargers on instructables that use 9V or 6V worth of batteries and then drop down the voltage, which makes using solar very difficult.)

The circuit I'm using, and sell on my website, is a surplus circuit from some random charger that I found after a lot of testing. It's more or less a clone of the Adafruit Minityboost Circuit . Except it's cheaper and already made for you.

So yes, you can find a cheap USB charger online and take it apart BUT listen up. What you want to find is one that goes from 3V (AKA 2 AA batteries) up to 5V (AKA USB). What you don't want to do is take apart a wall USB charger or a car USB charger. Those convert higher voltages to lower voltages, which is the exact opposite of what we're trying to do.

Also, keep in mind that while the USB Circuit I have and the Mintyboost both work with Apple Products, many USB chargers do not. Apple products check the data tabs on USB to see what they're plugged into. If they don't see any power flow over the data tabs, something no other gadget does, then they won't charge. Believe me, I've tried a lot of cheap circuits off eBay only to find that my iPhone 4 rejected them. You don't want this to happen.

Image Notes
1. Works with Apple gear.

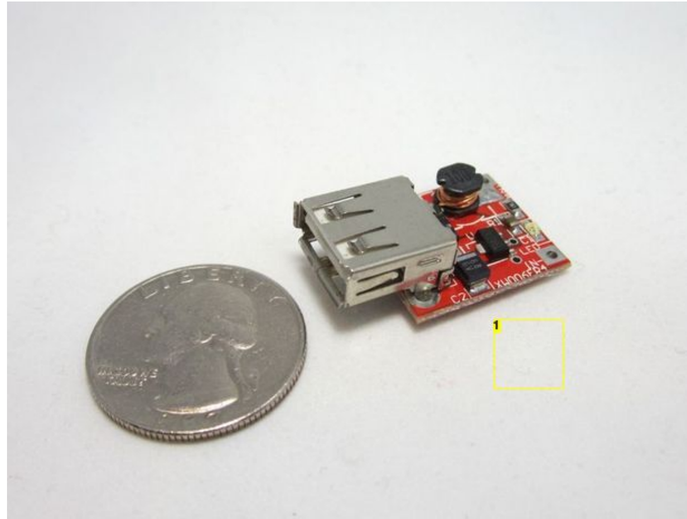


Image Notes
1. Does not work with Apple gear.

Step 5: Choose a Battery

Do a quick google search and you'll find a wide array of batteries with different sizes, capacities, voltages, and prices. It can be a tad confusing at first.

For this charger we're going to be using a 3.7V Lithium Polymer (Li-po) Battery. One that is probably very similar to the one in your iPod or cell phone. For this project you really want to be using a 3.7V battery, as thats what our Charging Circuit is designed to charge.

While it should be a non issue, you need to get a battery with a built in Overcharge / Undercharge protection. May time sites will call this "PCB Protection." (Looking at you eBay.) This just means that there is a small circuit board and chip that makes sure the battery stops charging or stops discharging at the right time.

Since you can easily find many different batteries out there your big concern should be the physical size of the battery along with it's capacity. The size really depends on your enclosure. In this guide I'll be using an Altoids tin for a case, so my size is rather limited. While I would have loved to fit a 4,400mAh battery inside an Altoids tin I instead have gone with a 2,000mAh battery instead.

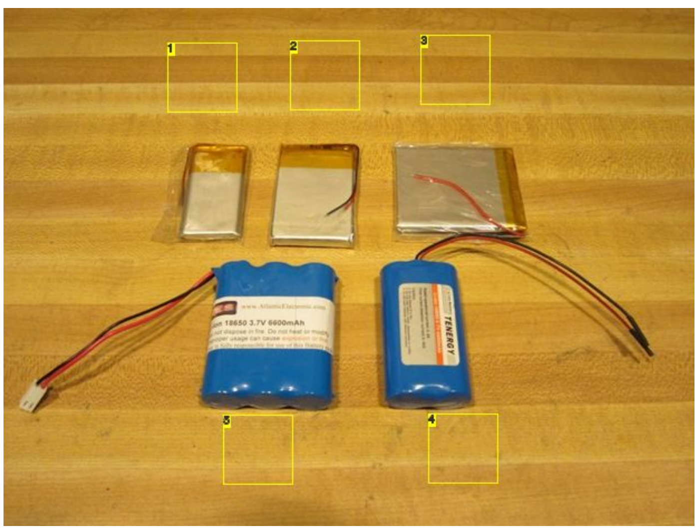


Image Notes
1. 1,100mAh
2. 2,000mAh
3. 2,600mAh
4. 4,400mAh
5. 6,600mAh

Step 6: Wire up the Solar Cell

If you're not making a solar powered version of this kit, skip ahead.

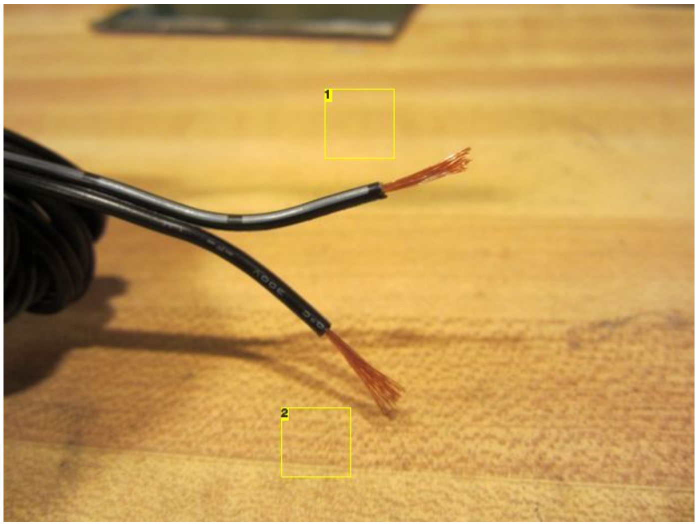
In this guide I'm using a 5.5V 320mA solar cell which is encased in a hard plastic. Any large solar cell will do, but ideally for the Charge Controller you want your solar cell between 5-6V in power.

Take the end of the Male Jack Wire and split it in two. Then strip the ends a bit.

The wire with the white stripe is negative, the wire that is all black is positive.

Solder the wires to the appropriate tabs on the back of the solar cell.

Use either electrical tape or hot glue to cover the solder points. This protects them and helps relieve strain.



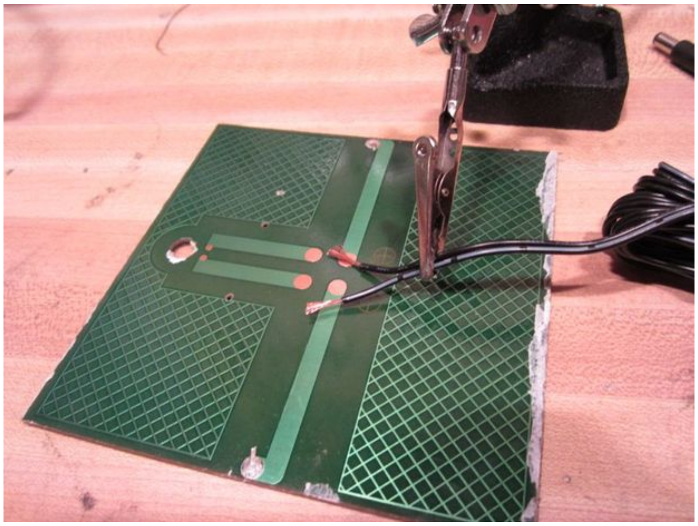


Image Notes
1. Negative
2. Positive

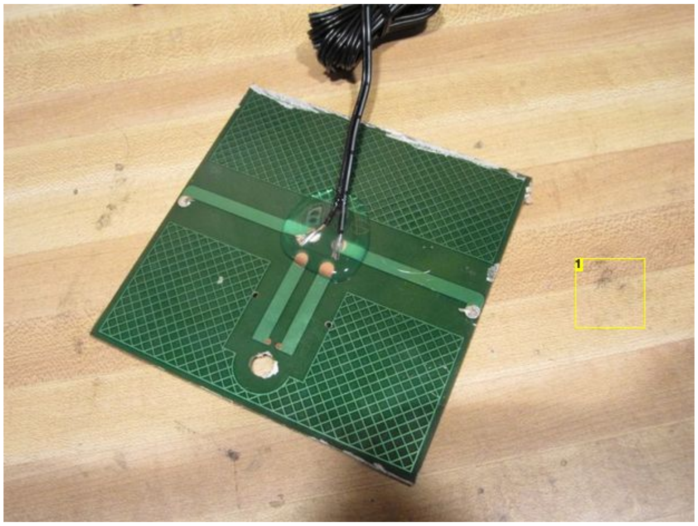


Image Notes
1. Melty Goo Phase

Step 7: Drill The Tin (or case)

Because I'm using an Altoids style tin I need to do some drill work. For this I'll be using a drill and a Dremel.

Before you do any work on the tin you should probably lay everything in the tin to see if it all fits. Figure out where everything goes before drilling. Use a marker to indicate where everything should go.

Once you have you spots picked out you can get to work.

For the USB Port you can do one of two things. You can use a large tin snip to cut strait down from the top of the tin, or you can drill out a USB sized hole in the side of your tin. I'll be drilling out a hole.

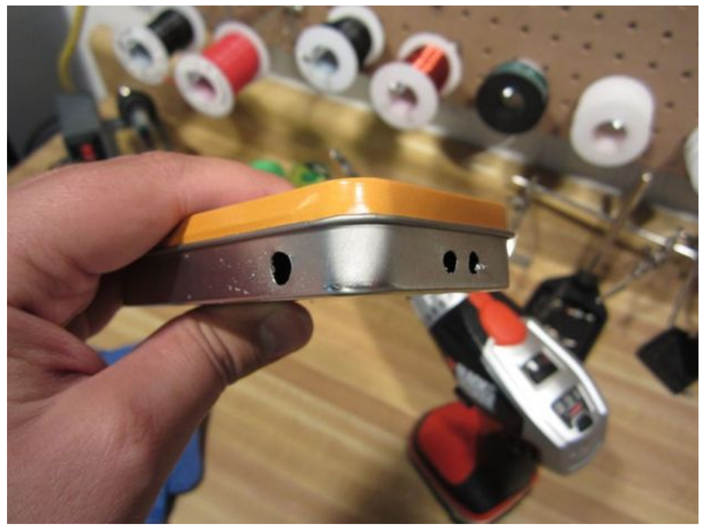
First, put the USB port up to the side of the tin. Mark along the outside.

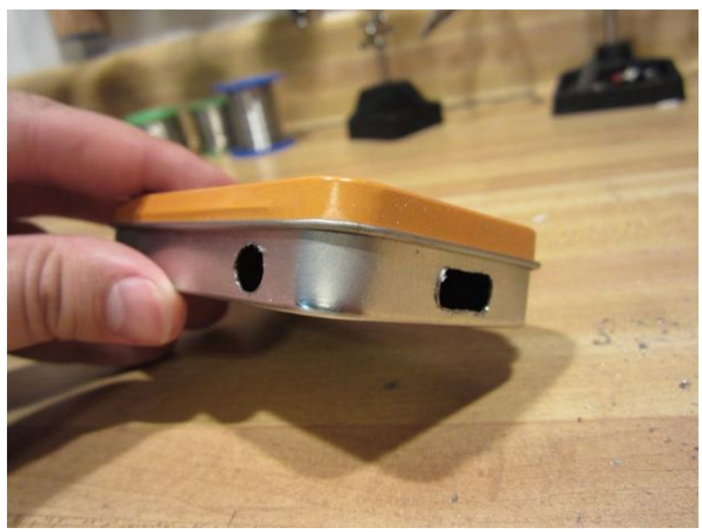
Use a drill to drill two or more hole inside that circle.

Use your Dremel to file and cut the remaining space out. Using a large clamp to hold down the tin is advised. Holding it with your hand will probably cause you to lose a finger or two.

Once done check to make sure the USB port fits through the hole you made.

To make a hole for the 2.5mm female panel mount, just drill a hole. Use a Dremel to make it larger is need be. (If you're not doing the solar side of things, ignore the 2.5mm section all together.)





Step 8: Wire Up The Charge Controller

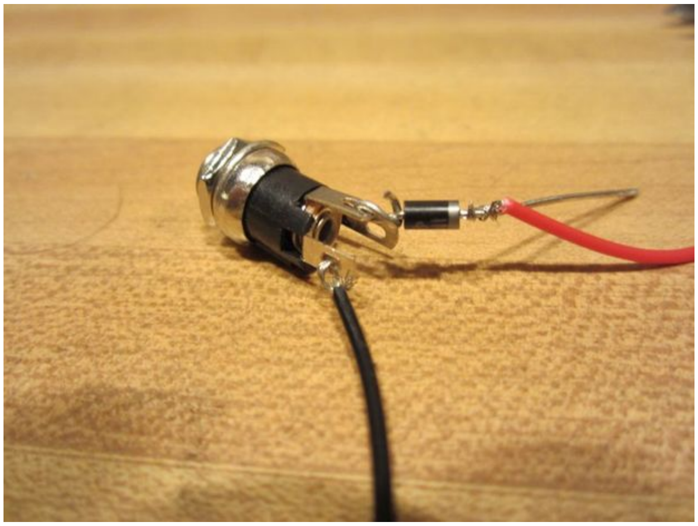
One of the reasons I like using this little charge controller is that its hard to screw up. There are 4 solder points on it. In the front next to the mini-USB port are where we hook up the DC power, which in our case in solar, and the two spots in the rear are for the battery.

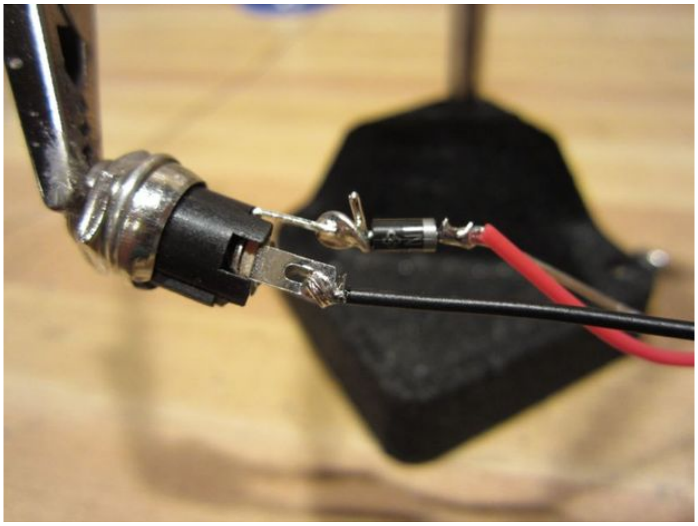
Lets first wire up the 2.5mm Female Plug to the Charge Controller. All we need to do is run two wires and a diode over from the Plug to the Controller. (You can also use your Shrink Tubing in this section as well if you want.)

Grab your 1N4001 Diode, 2.5mm Plug, and Charge Controller. Put the female plug down in front of you. Going from left to right the three prongs are such. The Left is negative, the middle is positive, and the right is not going to be used.

Take a wire and wrap it around the negative leg of the Plug, with the other end going to the negative "in" spot on the board. Solder and be happy. (You can cover up the leg of the Plug with some shrink tubing if you want.)

Now take another bit of wire and wrap it around the leg of the diode that has a bar on it. Wrap close to the base of the diode to ensure we can save as much space as possible. Wrap the other leg of the diode (the side without the bar) to the middle leg of the Plug. Again, as close to the base of the diode as you can. Lastly connect the wire to the positive "in" solder point on the board. Solder and rejoice. (Again, you can use shrink tubing to make the connection with the plug secure.)





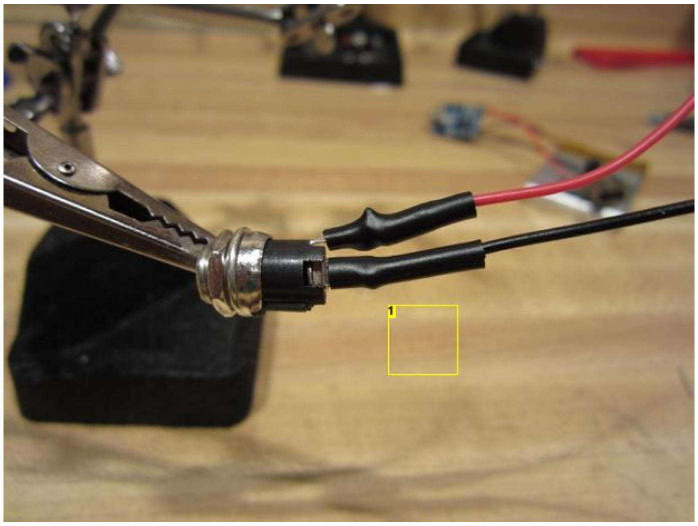


Image Notes
1. Shrink tubing is nice, but not necessary.

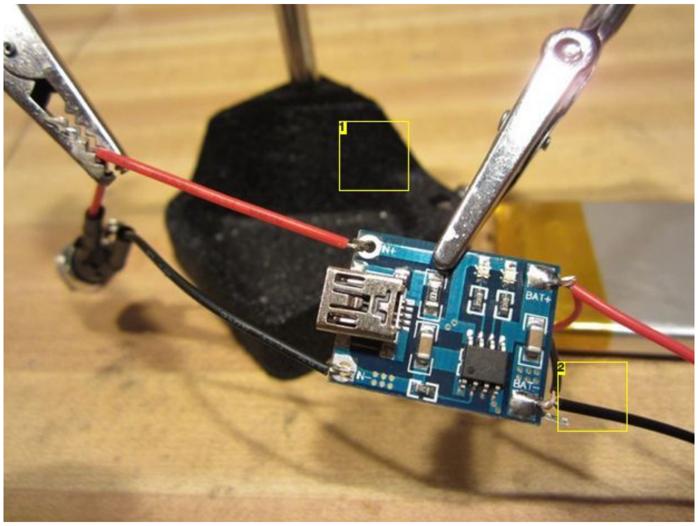


Image Notes
1. DC In is on this side.
2. I originally wired up the USB and battery first. It honestly doesn't matter which you do first.

Step 9: Wire up the Battery & USB Circuit

From this point on you only need to solder four additional points.

What we want to do is wire up both the battery and the USB circuit to the Charge Controller Board. For this you'll need to cut some wire.

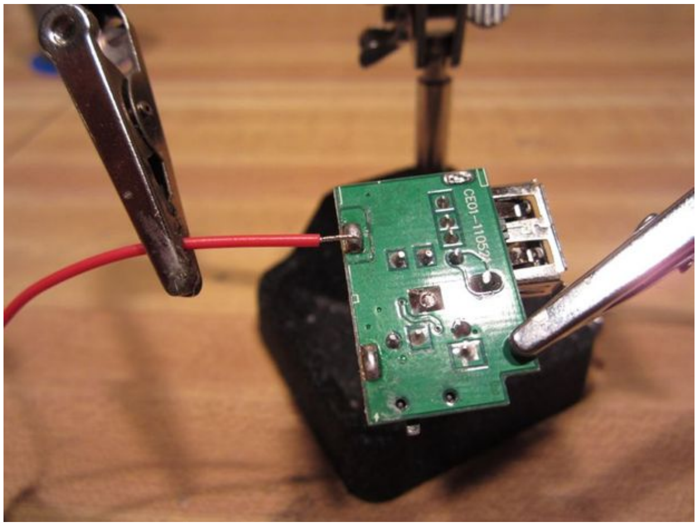
Solder some wire onto the Positive and Negative points on the USB Circuit. They're on the underside of the board.

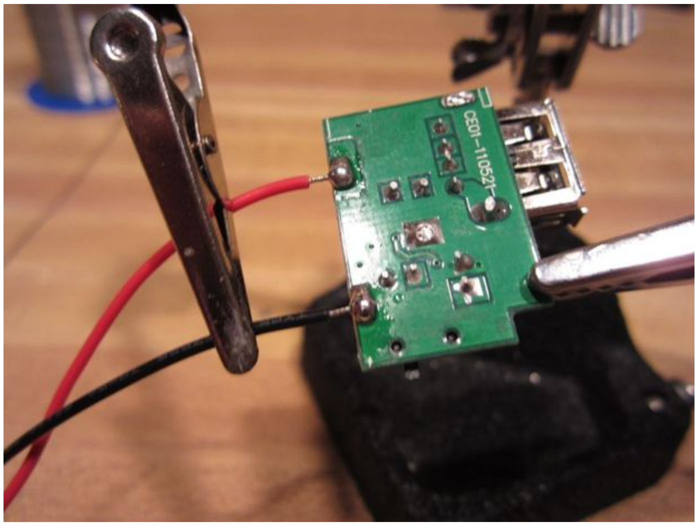
Once that is done twist those wires together with the wires coming off your Lithium Battery. Be sure you're hooking up the Positive wires together, and the Negative wires together. (Red is Positive and Black is Negative, in case you've forgotten.)

Once that twisting is done, just solder to the Battery points on the back of the charge controller board. I like to put the wires through the holes before soldering.

You're actually 100% done with the electrical aspect of this project. Take a deep breath and relax.

It's also a good idea to test out your circuit at this point. Everything is wired up and should work. Grab an iPod or anything USB and see if it works (if the battery is low or dead your gadget might not charge). You can also take it out in the sun and see if your solar cell starts charging up the battery. You should see the little red LED on the charging board turn on. You could also use a mini USB cable to charge up the battery as well.





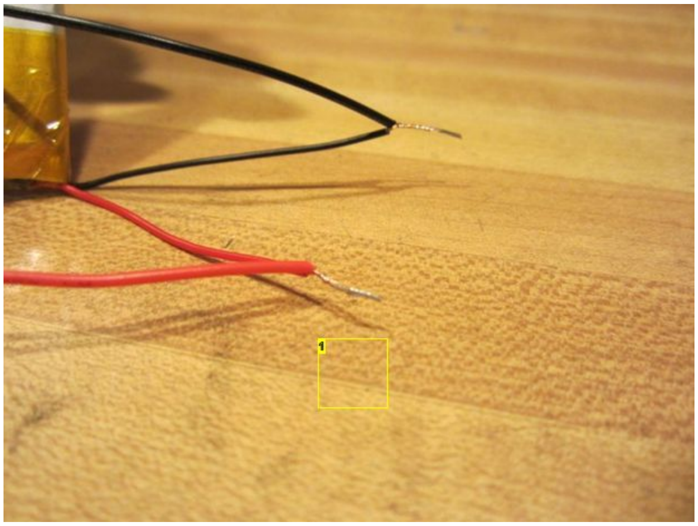


Image Notes
1. Twist the wires from the USB and from the battery together.

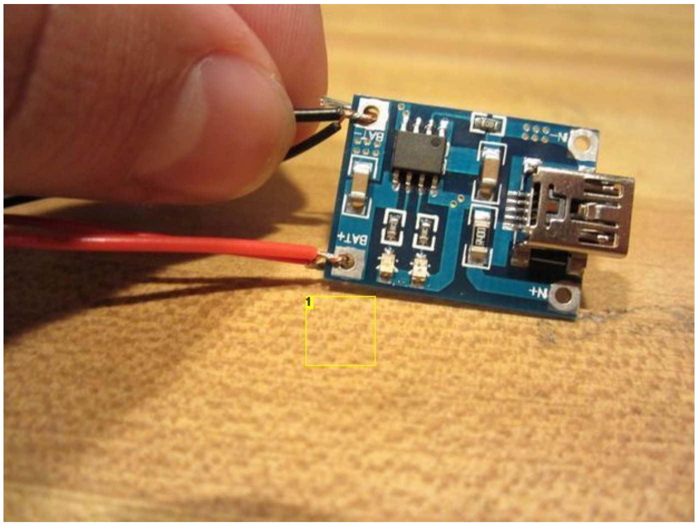


Image Notes
1. Wire things up to the board.

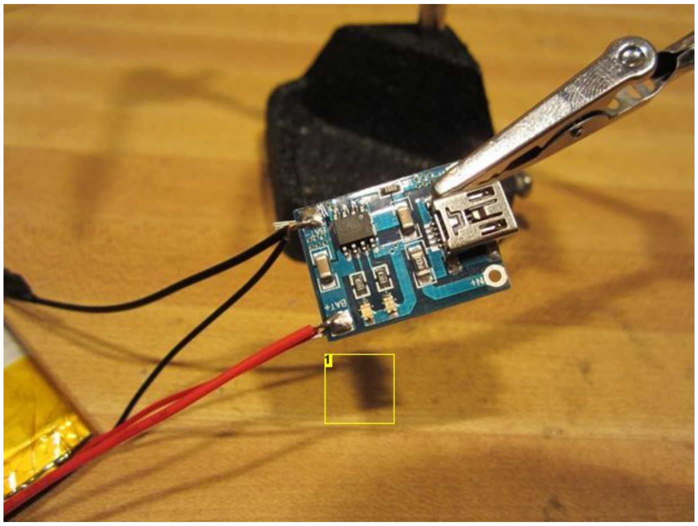


Image Notes
1. Solder

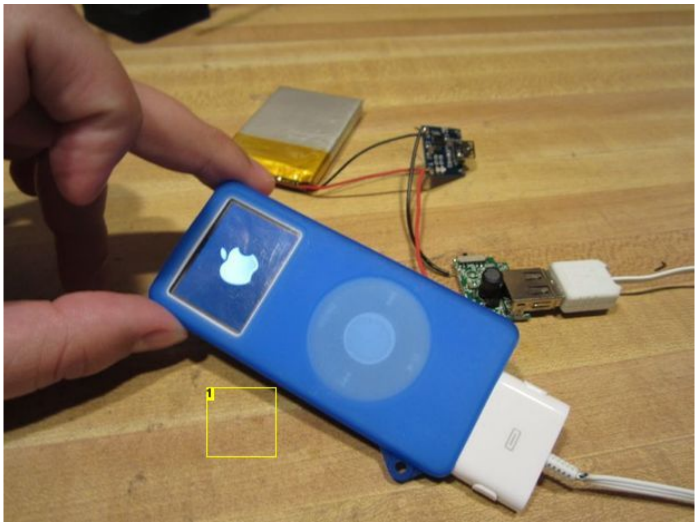


Image Notes
1. It works!

Step 10: Insulate EVERYTHING

Before we jam everything into the tin, it's probably a good idea to make sure our tin doesn't cause a short. If you're using wood or plastic enclosures, ignore this.

Using Electrical Tape put down several strips along the bottom of your tin and the side of your tin. The areas where the USB circuit will be, and where the Charge Controller will be hanging out. (In my pictures you can see that I've left the Charge Controller free floating.)

You really don't want a short.

To make sure our solder points are secure you can apply either electrical tape to them, or a dab of hot glue.

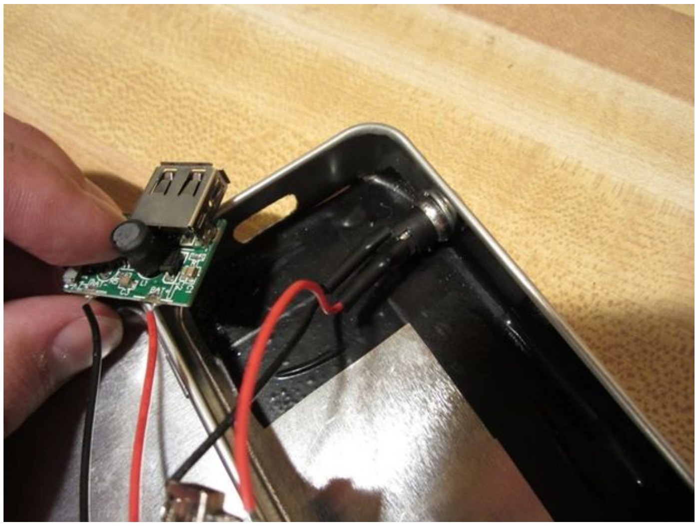
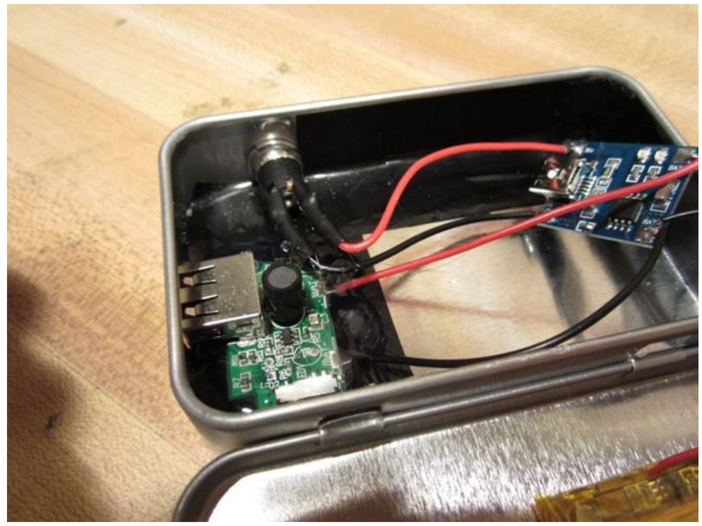
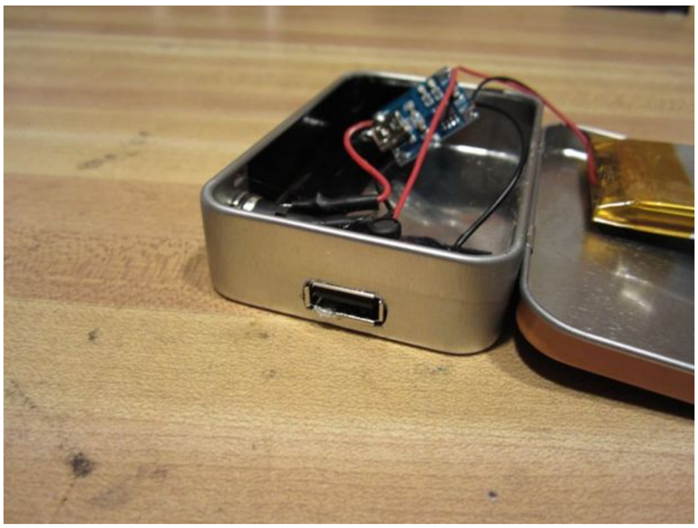
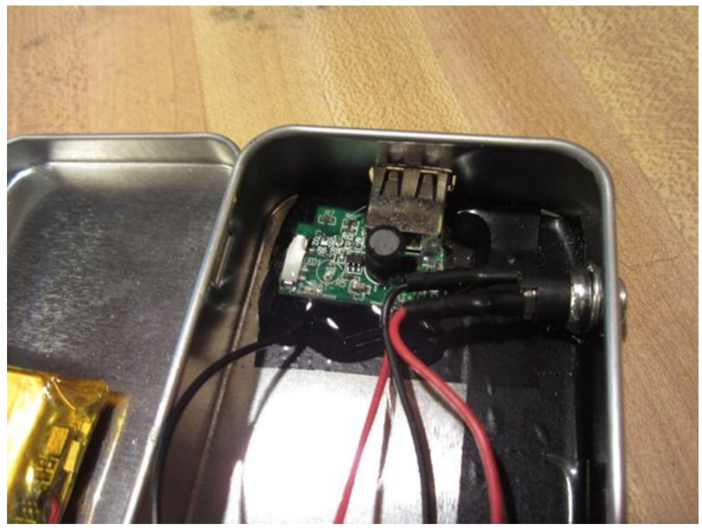
Step 11: Jam It All In

When putting everything in the tin, first start with the 2.5mm Plug. As you need to screw it into place it's kind of important that you put it in first.

Once in and secure try putting your USB circuit into place. If everything fits, start out by putting a small dab of hot glue down and working your circuit into place. Once into place cover it with hot glue.

(The USB Circuit I'm using has a switch on the side. If you're using my circuit make sure the switch is put all the way back. That sets the circuit to "charging" mode.")

Lastly you have your battery. You probably don't want to use hot glue on it. Some double sided tape or a loop of electrical tape will hold it down.


Step 12: Rejoice

Well thats about it actually.

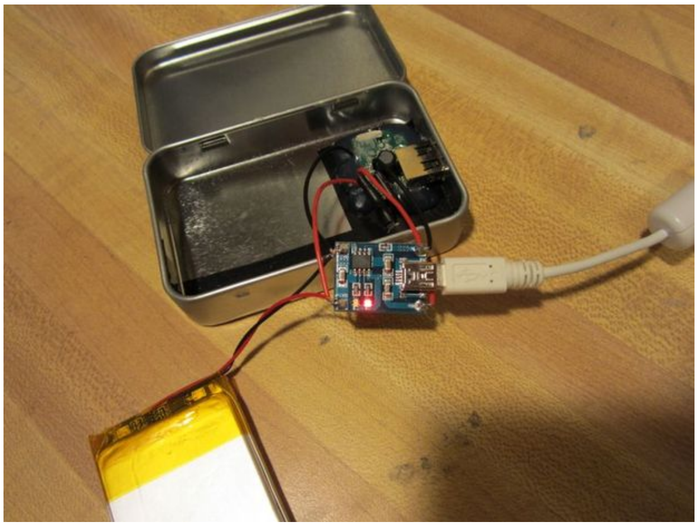
You can now either charge up the battery via the mini USB port on the Charging Circuit or via Solar power. The red status LED on the Charge Controller board means the battery is charging, the blue pops on when the battery is full.

On a recent plane flight I was able to charge up my iPhone 4 over 80% (while in Airplane mode and listening to music). That was with a 2,000mAh battery. A 4,400mAh or 6,600mAh battery would do a heck of a lot more. Especially with an iPad or another tablet.

This is a great little project to get yourself started with Lithium batteries, something that I know a lot of people are hesitant to do. As Lithium and Controller prices fall hobbyists would be silly not to go that route, especially in the area of micro controller powered projects. Lithium batteries are particularly good for very small projects as they come in insanely small sizes. A great power source when you're trying to shrink down your death ray.

So if your'e looking to make a very high powered solar USB charger for your cell, tablet, iPad, iPod, iPhone, GPS, or Arduino project you really can't go wrong with this solution. Especially when you can put it in such a cute tin!

As I said before, you can find these parts from a variety of sources online or you can grab them off my own website BrownDogGadgets.com . All the money I make goes either to one cute brown dog, or to fund more projects.

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