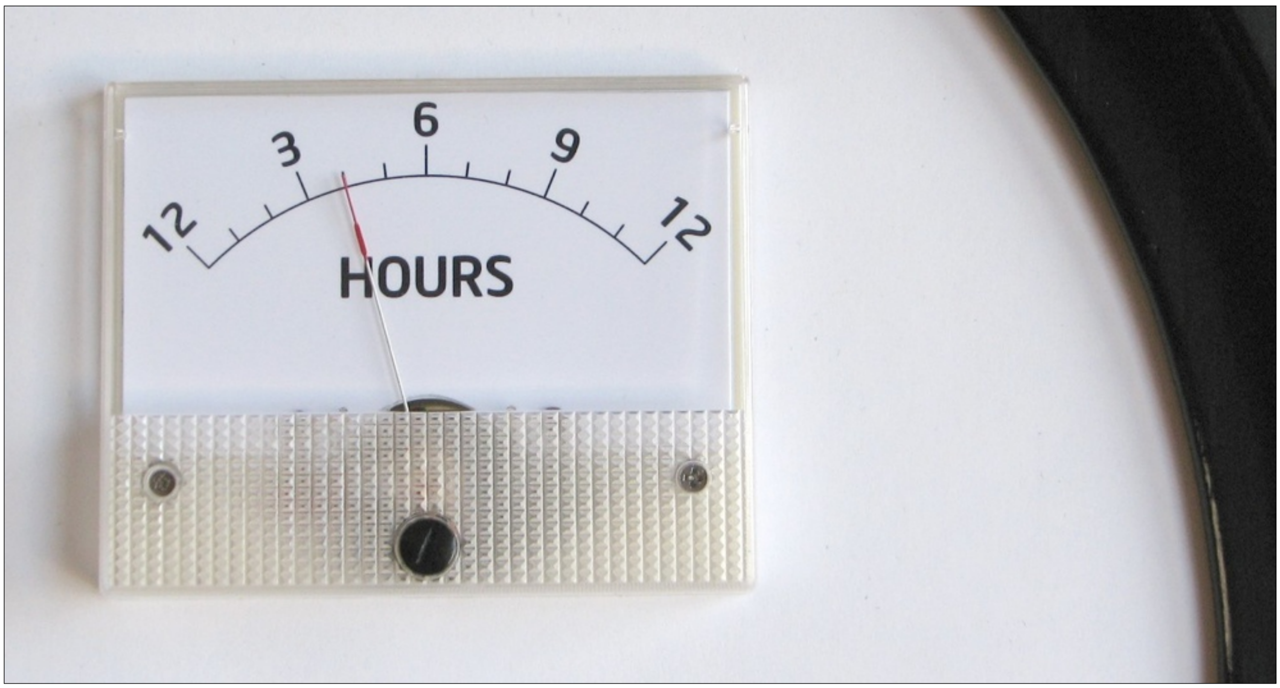
CHRONULATOR PM2V

Assembly Instructions



Version 2.0

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ShareBrained Technology

Legal

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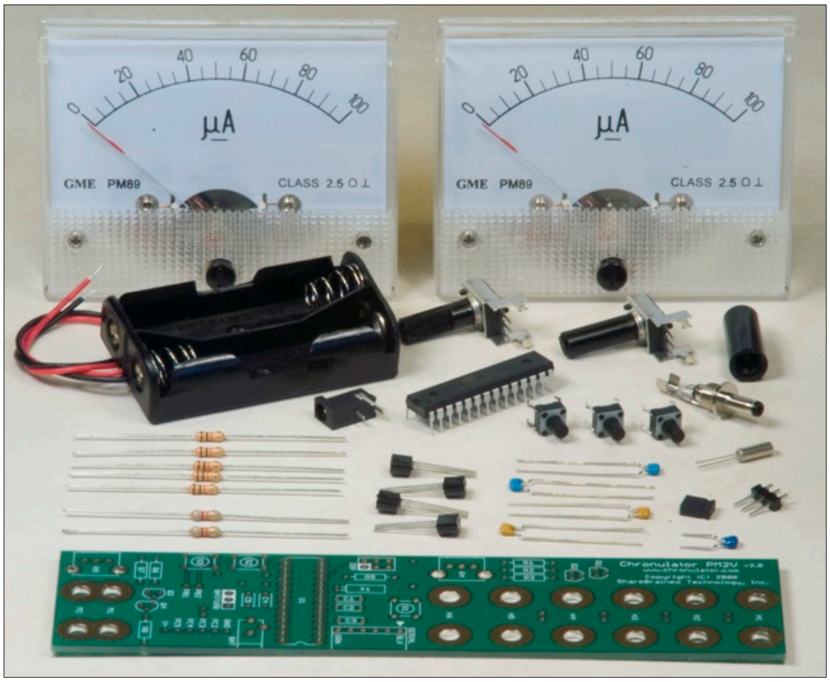
The builder is responsible for ensuring that this device does not cause harmful interference, as determined by your country's laws. In the US, the FCC (Federal Communications Commission) determines interference rules and outlines them in their Part 15 Rules.

CHRONULATOR PM2V

Introduction

The Chronulator is a clock. Or is it? That's up to you, because we're giving you all the information you need to customize it. Dress it up like a motorcycle's tachometer and oil pressure gauges. Or make it look like a piece of Frankenstein's lab equipment. Maybe the meters show the temperature of your beer fridge. Or the ping times for your Web server. It could count down to the next appointment on your calendar, or show the change in your stock portfolio. Or... Or?! We don't know! Surprise us!



About This Kit

This kit requires no prior electronics assembly experience. It's constructed using a prefabricated circuit board which requires little hand-wiring. The components have pins which go through holes on the circuit board and make hand-assembly easy for people with average motor skills.

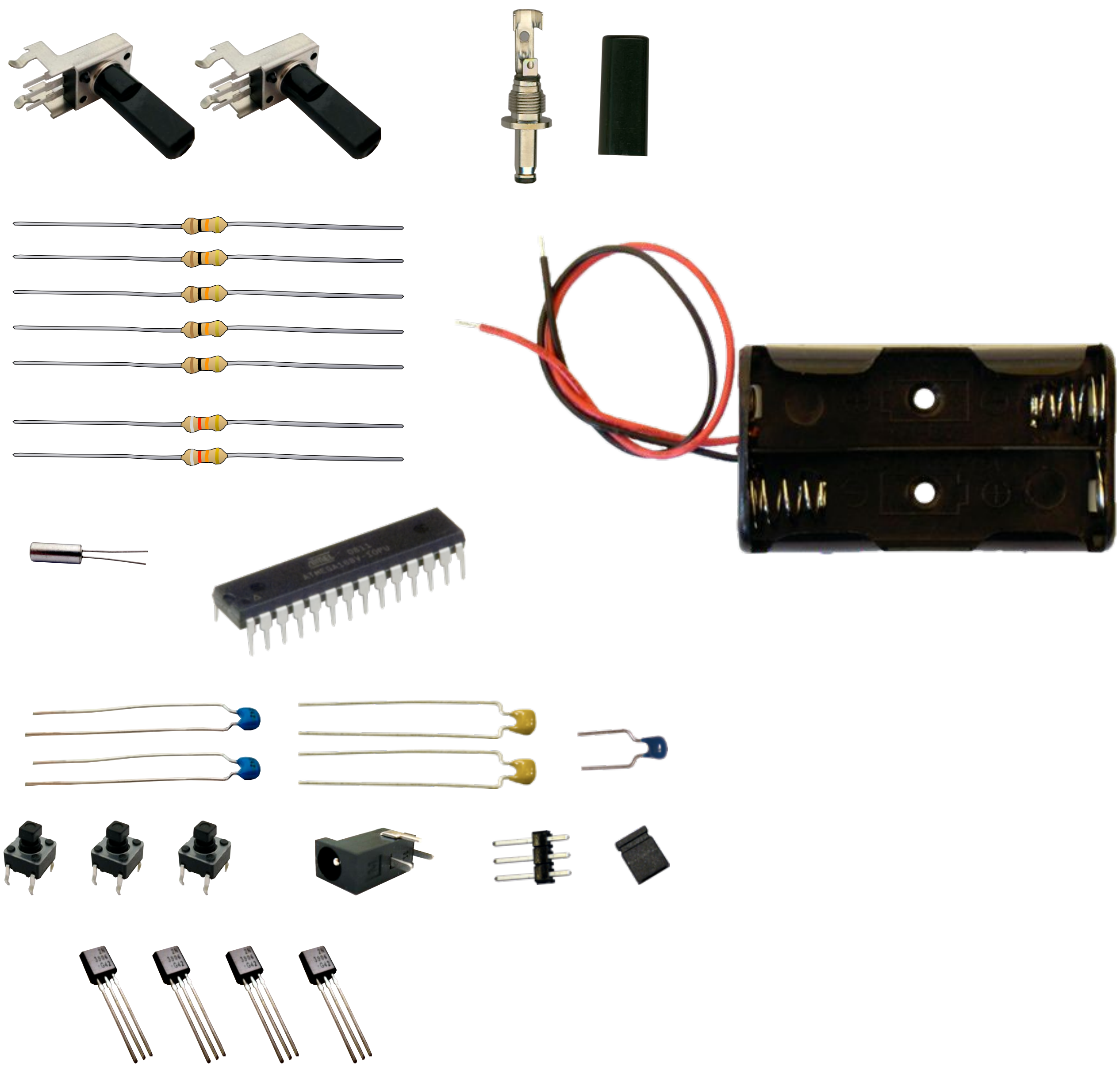
The Chronulator is thoroughly documented. This document describes how to assemble the kit. Other documents, including the circuit schematic, parts list, printed circuit board design, software source code, and programming tools, are posted to the ShareBrained Website (www.sharebrained.com/chronulator). You're invited to take advantage of this information to make the Chronulator do whatever you imagine. And over time, we hope you and other Chronulator-makers will share what you've done, through our online forum or our Flickr tag "chronulator".

Inventory

Take a moment to examine the parts included with your kit. If you're missing a part, please let us know posting to our forums (www.sharebrained.com/forums) or by e-mailing info@sharebrained.com.

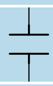
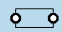
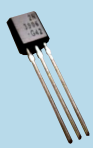
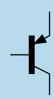
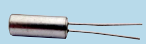
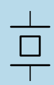
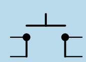
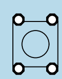
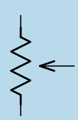
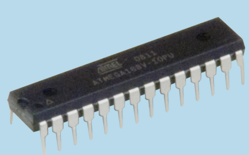
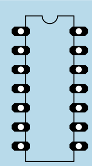
The printed circuit board (green fiberglass with silver holes) is not pictured

Some kits include two analog panel meters inside two white cardboard boxes labeled "100uA".



Components

This kit is built from common electronic components used in billions of electronic devices the world over (and a few in outer space). These components appear as standard symbols in circuit schematics. On circuit boards, white, silkscreened markings show where components are inserted and soldered.

	Component	Schematic	Board	Description
Resistor				Restricts the flow of electricity, allowing the circuit designer to control how much electricity enters a portion of the circuit.
Capacitor				A reservoir for electricity, capacitors store energy for later release.
Transistor				Acts as a valve, allowing a small electrical signal to control the flow of another (and often much larger) signal.
Crystal				A piece of quartz precisely cut to vibrate at a certain frequency when electricity flows through it.
Switch				Much like a light switch -- a mechanically-operated device that allows electricity to flow when the switch is pressed.
Variable Resistor				A mechanically-controlled resistor. As the knob on the variable resistor turns clockwise, the resistance increases.
Microcontroller		(varies)		Integrated circuit chips that behave as very simple computers, capable of running small programs, storing information, and sensing and reacting to the outside world.

How It Works (the short version)

This clock uses a digital microcontroller chip to keep time and show it on a pair of analog meters. The clock uses a quartz crystal, just like those found in wristwatches, to keep time. The current hour and minute are turned into two signals which move the meter needles.

The quartz crystal is connected to the microcontroller chip. This crystal generates a signal that pulses thousands of times a second. The microcontroller counts these pulses to keep track of seconds, minutes, and hours. The microcontroller takes the hour and minute counts and translates them into signals which are fed to the two meters.

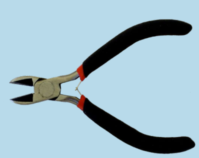
The meter needles move according to how much electrical current goes through them. If no current is flowing through a meter, the needle rests at the left side. As the current through the meter increases, the needle will move further to the right. Eventually, at the meter's maximum current limit, the needle will be at the far right side of the meter. The clock indicates a particular hour or minute by sending through the meter the amount of current necessary to move the needle to the appropriate place on the meter's scale.

Assembly

It's easy to assemble this kit without making any errors. Just go slowly and double-check your work.

These instructions tell you to solder the components in "height" order. The smallest parts are soldered first, the largest parts last. This makes it much easier to solder the board. When you flip the board over, the parts you're soldering are the tallest on the board (so far), will support the board, and will be pressed firmly against the board. So you don't have to hold the parts against the board with your fingers. It's nice to have both hands free when soldering. Even better, you don't need to worry about burning your fingers on the hot components as you solder.

Required Tools:

Soldering iron		25W pencil iron (RadioShack 64-2070) or other low -powered, fixed-temperature soldering iron capable of 600°F (315°C)
Solder		0.032" rosin-core solder (RadioShack 64-017) or other light-weight rosin-core solder. Don't use solder thicker than this if you can help it.
Wire cutters		Small diagonal cutters (RadioShack 64-2951)

Soldering

Electronic circuits are built from components with metal contacts or leads. The circuit board acts as the wiring between components. Solder is used to join components to the wiring of the circuit board.

In short, soldering is a bit like gluing. You're not welding the components to the board -- welding connects parts together by melting metal from the parts themselves. Instead, soldering joins parts using a lower-temperature "glue" metal. In electronics, solder typically contains a combination of tin, lead, or silver. Solder often contains rosin, which helps clean the joint as the solder melts.

The key to soldering is to heat the joint so the solder melts completely and flows throughout the joint. Solder only adheres to what it melts to. So it's important to heat the joint, not the solder. The solder will melt when it touches the heated parts of the joint. You know you have a good solder joint when it looks shiny and wet, even after it's cooled.

To ensure the solder flows well, you need good heat transfer from the soldering iron to the joint. If the tip of your soldering iron isn't shiny, it won't efficiently transfer heat to the joint.

You should have a wet sponge on hand to wipe the soldering iron tip. This keeps the tip shiny and removes blobs of solder which could interfere with your work. In extreme cases, you may need to sand the tip clean of solder and oxidization (when it's cool, of course).

The larger the joint, the longer it will take to heat it. In this project, all the joints are small and require only a few seconds to heat the joint, melt the solder, and let the solder flow through the joint.

Use as little solder as possible. You should form a nice, shiny joint. If you use too much solder, you'll have a big blob of solder develop on the other side of the board. That blob could be so large that it touches other solder joints and causes shorts which prevent your clock from working.

It's important not to overheat components, as it will damage them. Try to heat a joint for no more than five seconds at a time. And give a component five seconds to cool before applying heat again. This rest period also lets your iron reheat for the next joint.

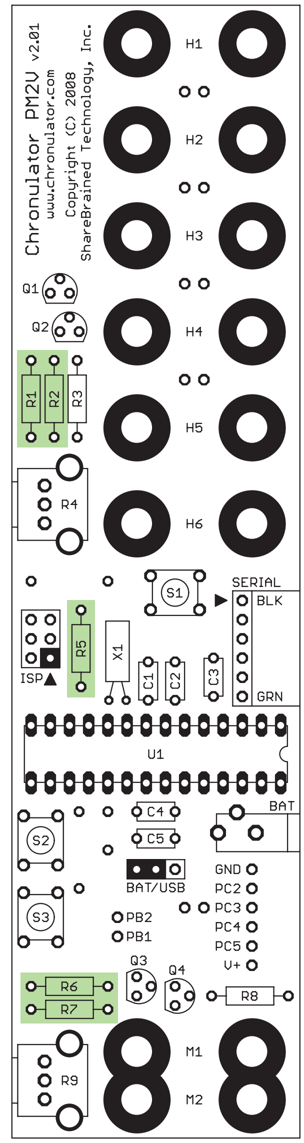
Hot solder and rosin can destroy the finish of many surfaces. Choose a surface that can endure the heat, or at least lay down a protective layer of newspaper. (This is the voice of experience. Ask my mom about our dining room table when I was a kid.)

Many types of solder contain lead, so remember to wash your hands and work surface when you’re finished.

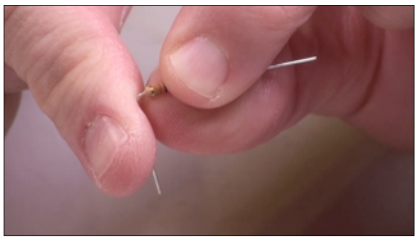
Soldering releases some amount of toxic smoke. It won’t kill you on the spot (or you wouldn’t be reading this). But there are certainly long-term consequences to breathing too much of this smoke. Be sure to work with decent ventilation.

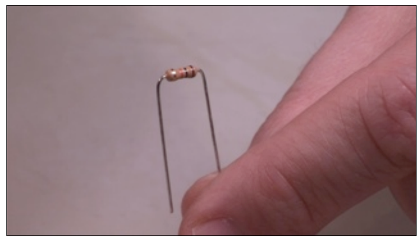
Resistors R1, R2, R5, R6, R7

Brown/Black/Orange/Gold stripes
10K Ohm

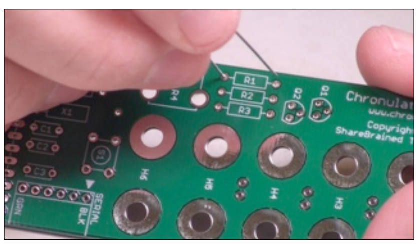


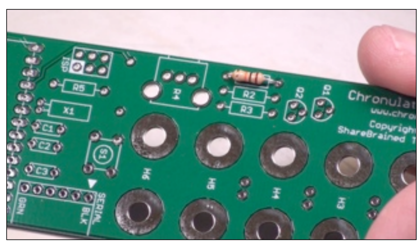
Using your fingers, bend the resistor wires at right angles so both wires are parallel:



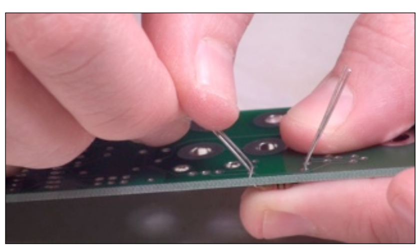


Insert the resistors into the circuit board at locations R1, R2, R5, R6, and R7 (marked in the diagram at the right). It doesn't matter which way the resistor is oriented -- a resistor works the same in either direction.

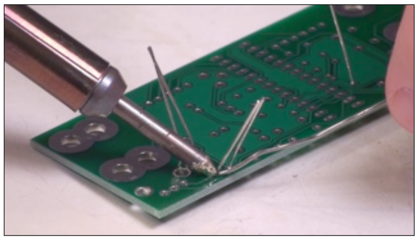
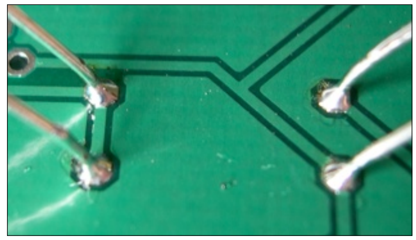




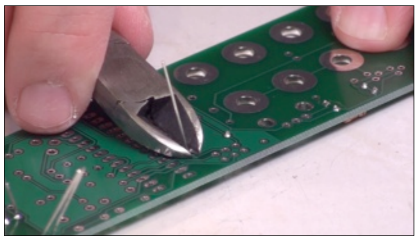
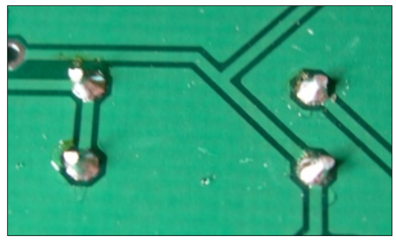
Turn the board over so the resistor wires are accessible. Bend the wires out slightly to keep the resistors from falling out of the board while you're soldering.



Press the board gently against the table to hold the parts in place. Solder both wires of each resistor to the corresponding metal holes in the board.

Clip the excess wire from the resistors.

Resistors R3, R8

Gray/Red/Orange/Gold stripes
82K Ohm

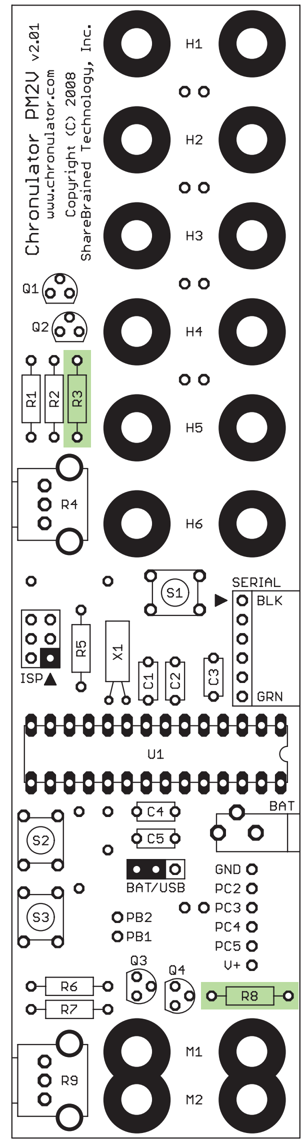
Bend the resistor wires at right angles so the wires are parallel (same as before).

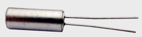
Insert the resistors into circuit board locations R3 and R8.

Bend the wires a bit to keep the resistors from falling out.

Press the board against the table and solder the resistors to the circuit board.

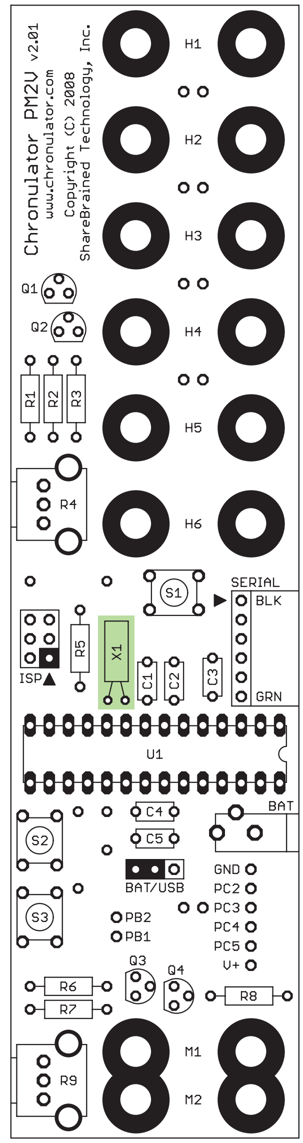
Clip the excess wire from the resistors.



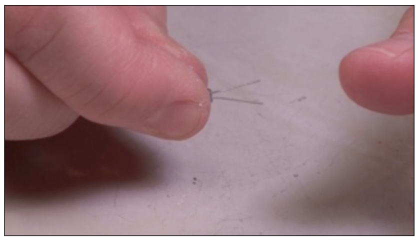


Quartz Crystal X1

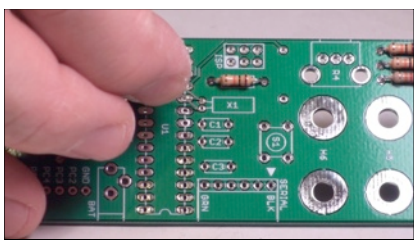
Sliver, cylindrical metal package
32.7680KHz

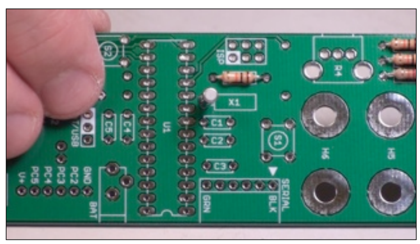


Bend the pins of the crystal apart just a bit. It'll be easier to insert into the circuit board when the pins are spread apart.

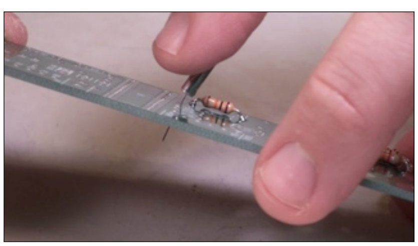


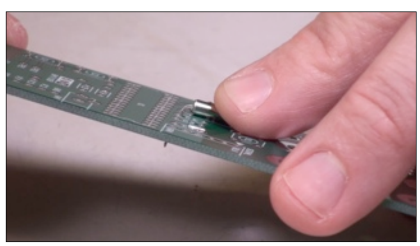
Insert the quartz crystal into the circuit board location X1. It doesn't matter which pin goes in which hole. Push it into the board until the cylindrical part is about 1/4" (7mm or so) above the board.





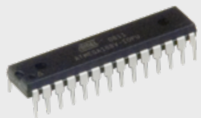
Bend the crystal down to lay in the white square X1 on the board.





Turn the board over and solder the crystal to the board. To avoid damaging the crystal, don't solder for more than five seconds without letting the crystal cool. You will only need a little bit of solder, as the crystal's pins are thin and the circuit board solder pads are small.

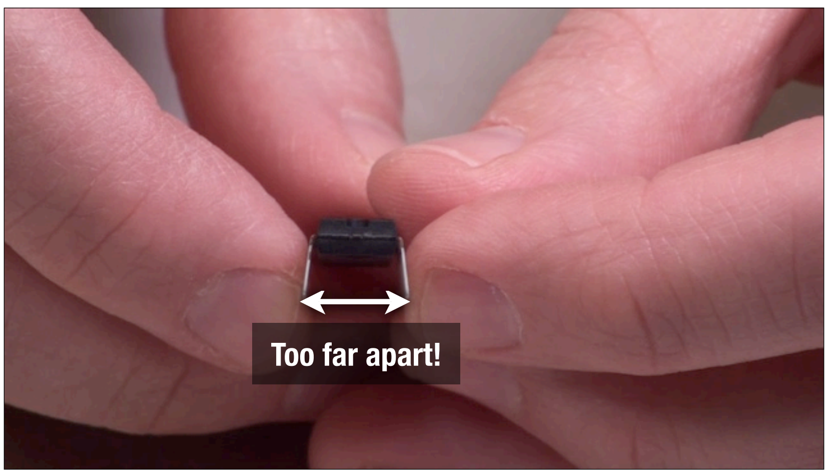
Clip the excess wire from the crystal.



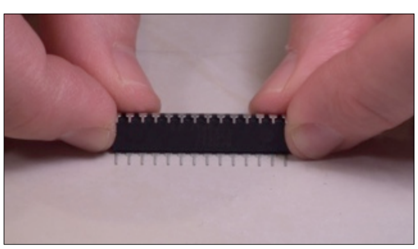
Microcontroller Chip U1

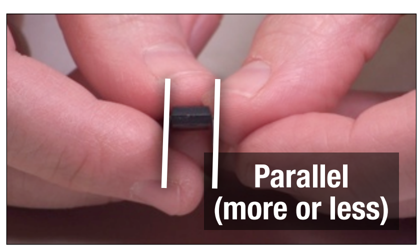
Black, 28 pins
Atmel ATmega168V-10PU

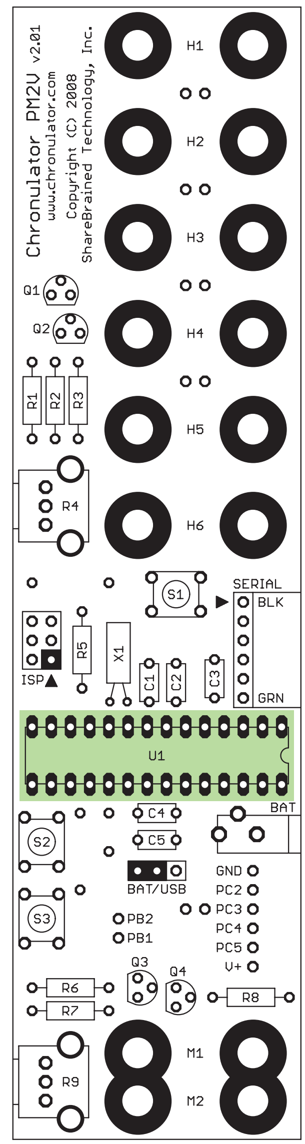
Typically, chips have pins that are spread too wide for the holes in the board. This helps keep chips from falling out of the circuit board when you're soldering, but makes it difficult to get the chip into the circuit board to begin with. So we'll need to squeeze the pins together a bit.



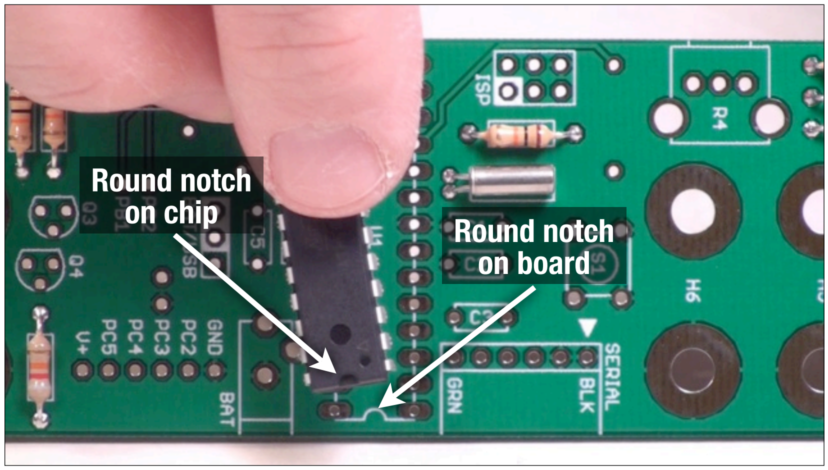
What works best for me is to take the chip by the ends and gently roll the pins on each side of the chip against a hard surface. Be gentle, we only want to roll the pins in far enough that the two rows of pins are parallel to each other.



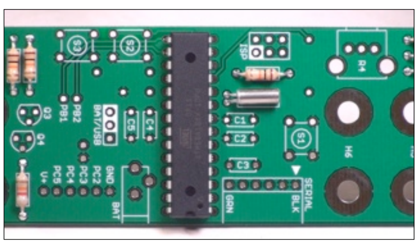
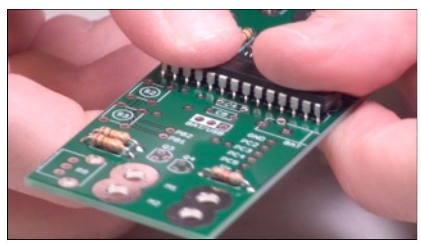




Notice the U-shaped notch at one end of the chip. Also notice the notch in the symbol for U1 on the circuit board. When inserting the chip, be sure the chip is turned so both notches are on the same end.



Gently insert the chip into the board. If the chip doesn't drop into the board, you may need to bend the pins of the chip inward a bit more (as described above) so the pins are all parallel to each other. Once the chip is in the board, give it a light squeeze to make sure it's firmly against the board.

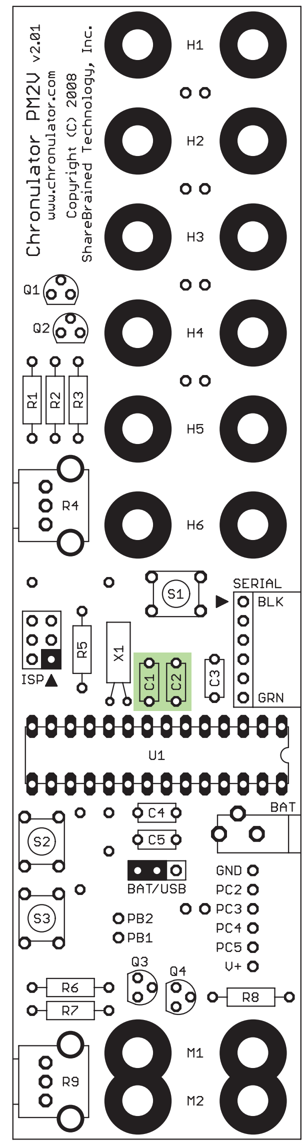



Turn the board over and solder all twenty-eight (28!!!) pins on the chip. Don't use too much solder -- if too much flows through the hole and out to the other side of the board, it'll make a mess.

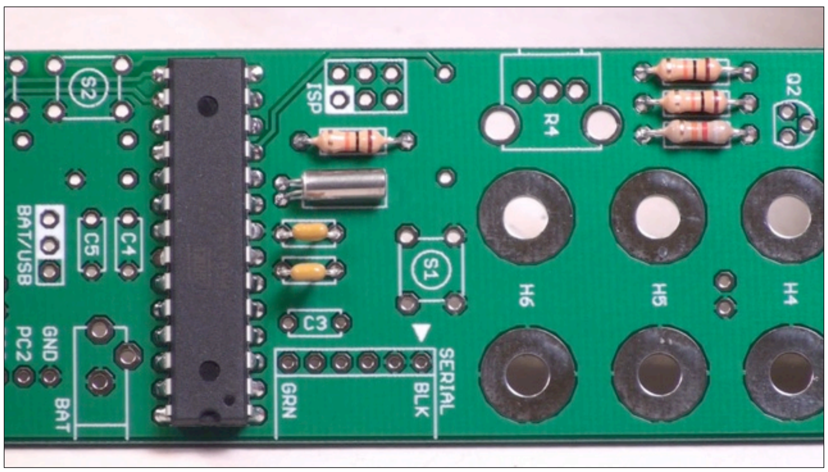
The pins are short on the microcontroller chip. You don't need to clip away the excess.

Capacitors C1, C2

Orange, ceramic, long wires
18pF



Insert the capacitors into the circuit board at locations C1 and C2. It doesn't matter which wire goes in which hole.



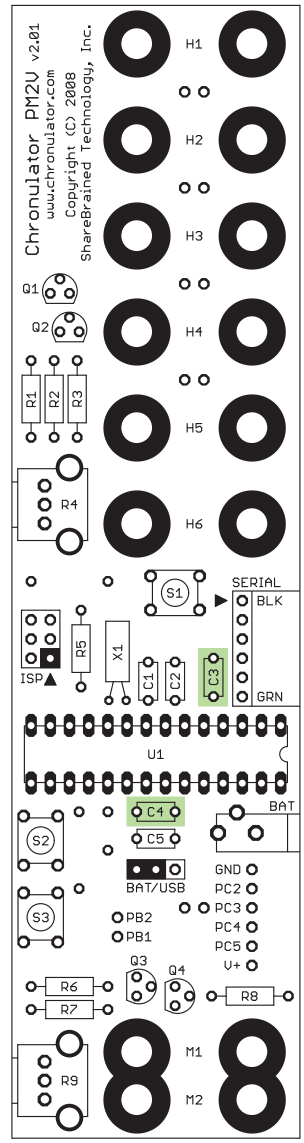
Bend the capacitor wires away from each other to hold the capacitors in place.

Solder the wires of the capacitors to the circuit board.

Clip the excess from the capacitor wires.

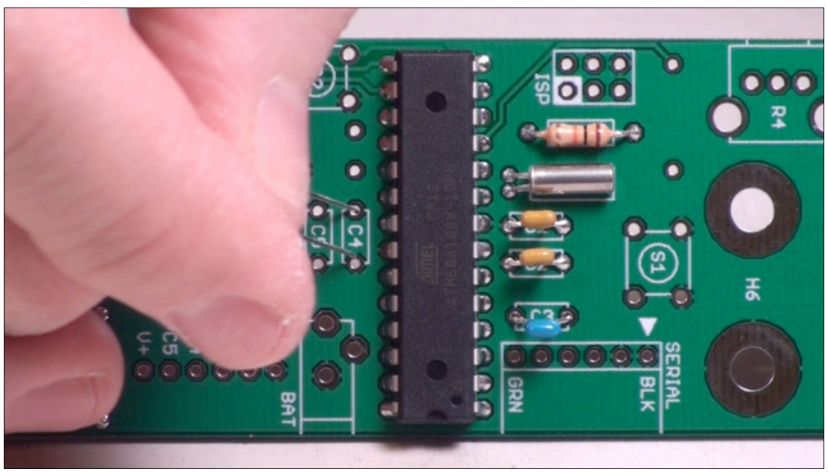
Capacitors C3, C4

Light blue, ceramic, long wires (1inch, 2.5cm)
0.1uF



There are two varieties of blue capacitors in this project. For this step, you want the light blue capacitors with long (1-inch, 2.5cm) wires. The other, dark blue capacitors, with short (1/3-inch, 1cm) wires, will be used in the next step.

Insert the capacitors into the circuit board at locations C3 and C4. It doesn't matter which wire goes in which hole.



Bend the capacitor wires away from each other to hold the capacitors in place.

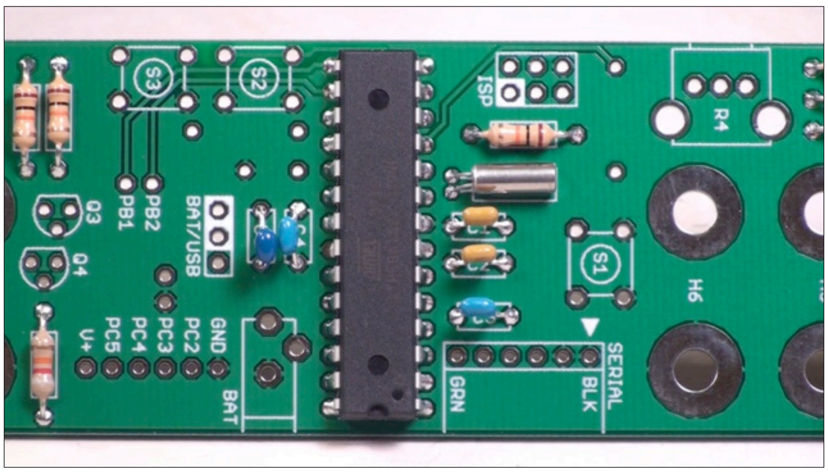
Solder the wires of the capacitors to the circuit board. Be careful not to accidentally get solder on the nearby holes, or that extra solder may block you from inserting other components later on.

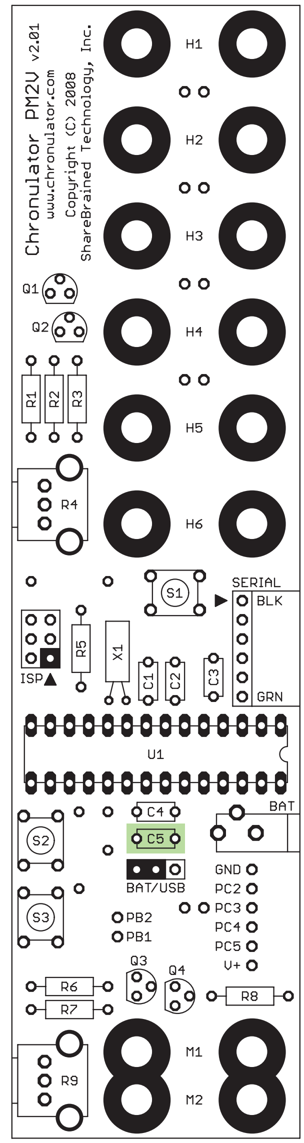
Clip the excess from the capacitor wires.

Capacitor C5

Dark blue, ceramic, short wires (1/3inch, 1cm)
10uF

Insert the capacitor into the circuit board at location C5. It doesn't matter which wire goes in which hole.





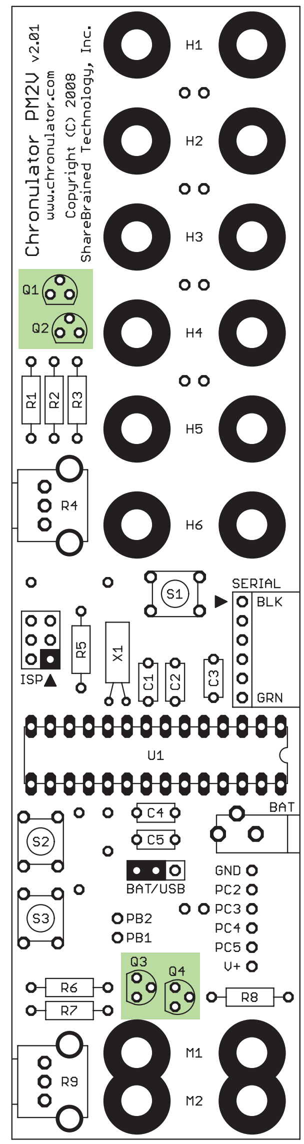
Bend the capacitor wires away from each other to hold it in place.

Solder the wires of the capacitor to the circuit board.

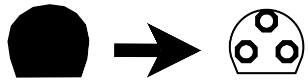
Clip the excess from the capacitor wires.

Transistors Q1, Q2, Q3, Q4

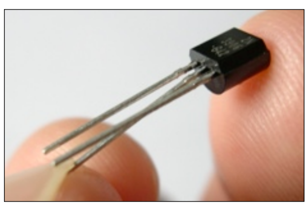
Black, three wires
2N3906

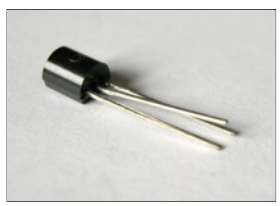


Note the shape of the black part of the transistor. When inserted correctly into the circuit board, the shape of the transistor will match the shape of the symbol on the circuit board.

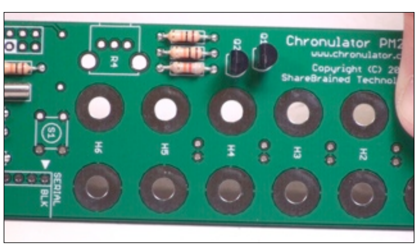


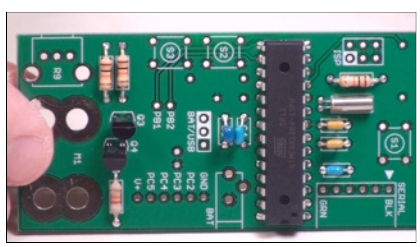
Using your thumbnail, bend the middle wire back (away from the flat face of the transistor). Bend it back about 1/10 of an inch (a few millimeters) behind the other two wires. This is to match the holes in the circuit board.





Push the transistors gently into circuit board locations Q1, Q2, Q3, and Q4, matching the shape of the transistor to the symbol on the circuit board. When properly inserted, the black part of the transistor sits about 1/4" (7mm) above the surface of the board.



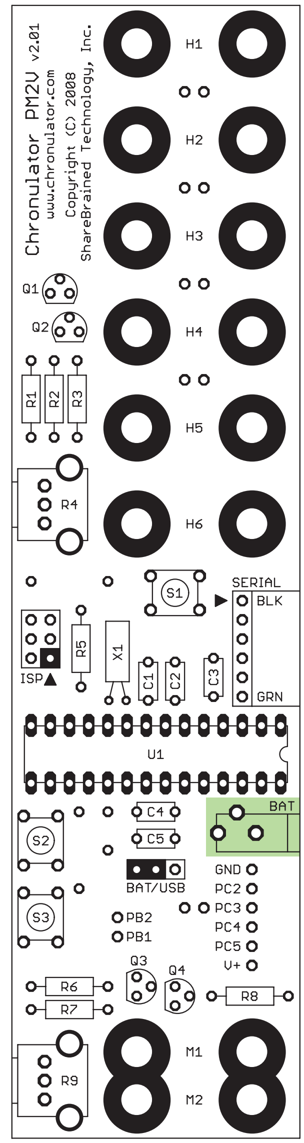


Turn the board over and solder the transistor wires. Don’t hesitate to rotate the board as necessary for easier access with your soldering iron. Be careful not to overheat and damage the transistor. Don’t solder for more than five seconds without letting the transistor cool off.

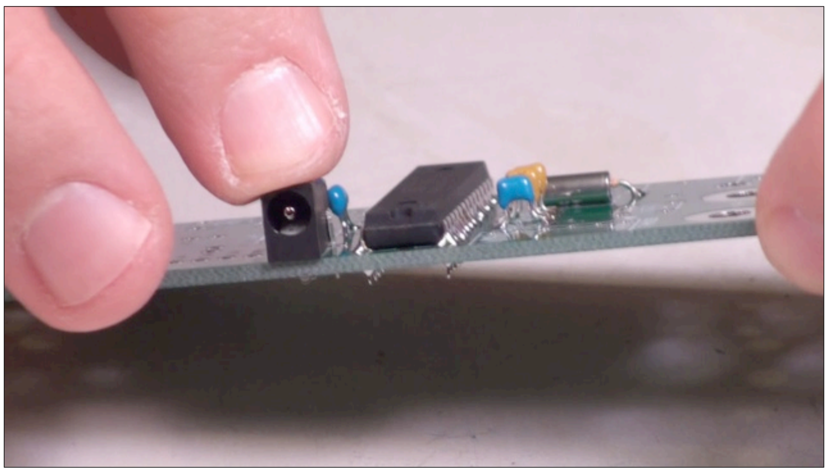
Clip the excess wire from the transistors.

Jack BAT

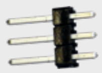
Black, three pins, barrel-style power connector



Insert the jack into circuit board location BAT. It should only fit one way.

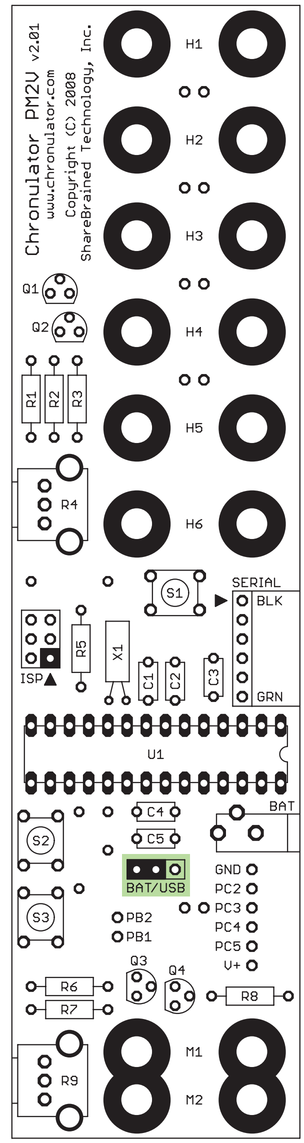


Solder the three pins of the jack. They'll take a fair amount of solder because the holes are big. But don't overdo it. Once you have the hole filled, you're done. It's possible to use so much solder that you create a solder bridge underneath the component, between the pins. (In other words, a short circuit you can't see. Not fun.)

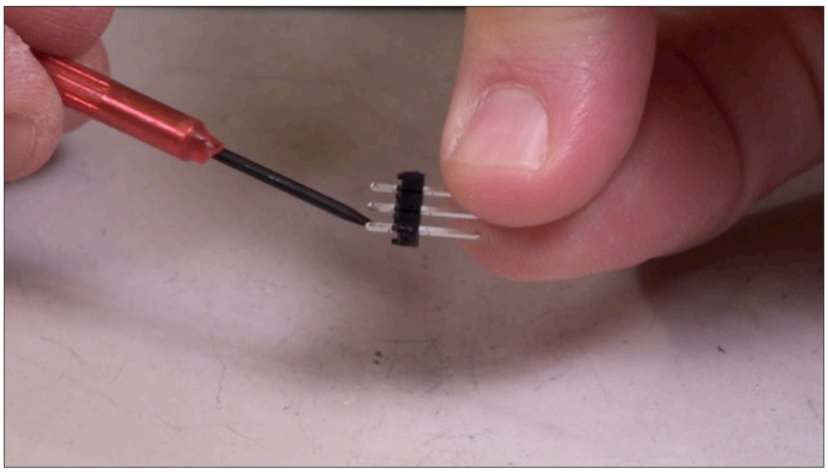


BAT/USB Header

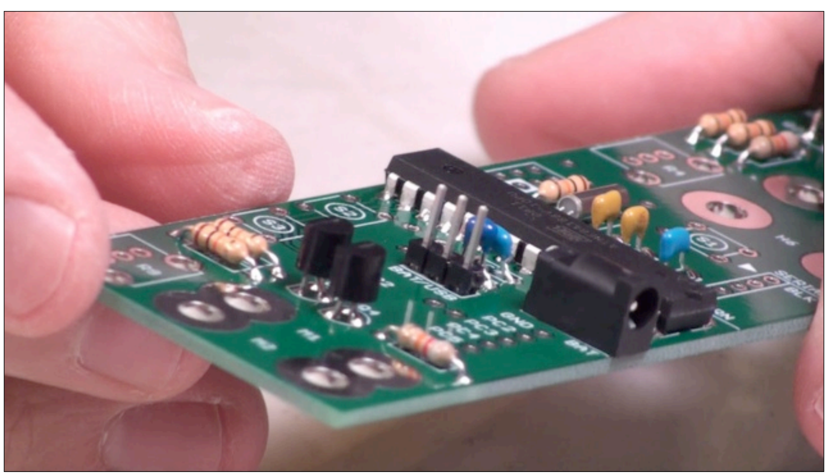
Three-pin header



Note that the three-pin header has long pins on one side and short pins on the other.



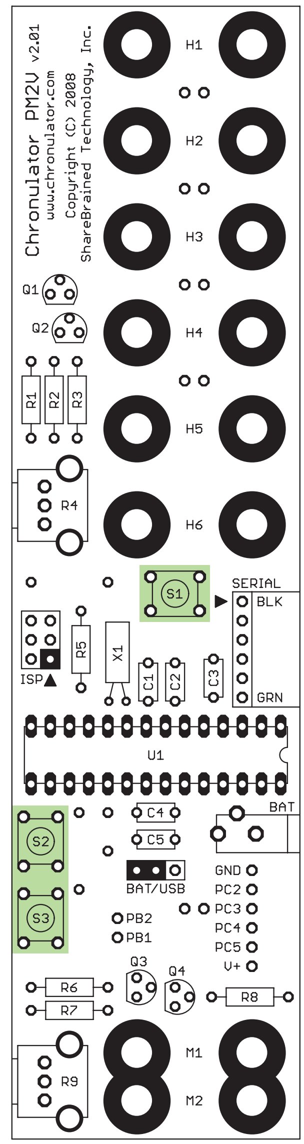
Insert the short pins of the three-pin header into the circuit board at location BAT/USB.



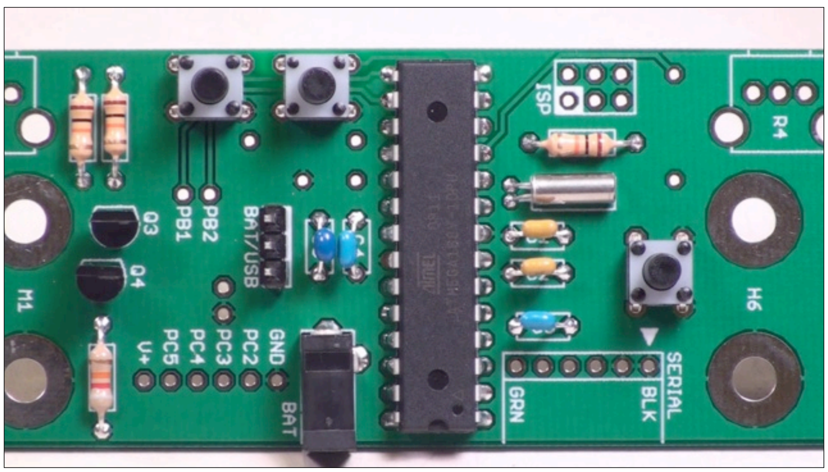
Turn the board over and solder the three pins of the header to the board. Do not insert the jumper at this time, as it'll make soldering the remaining parts more difficult.

Switches S1, S2, S3

Miniature, circuit board mount, push-button



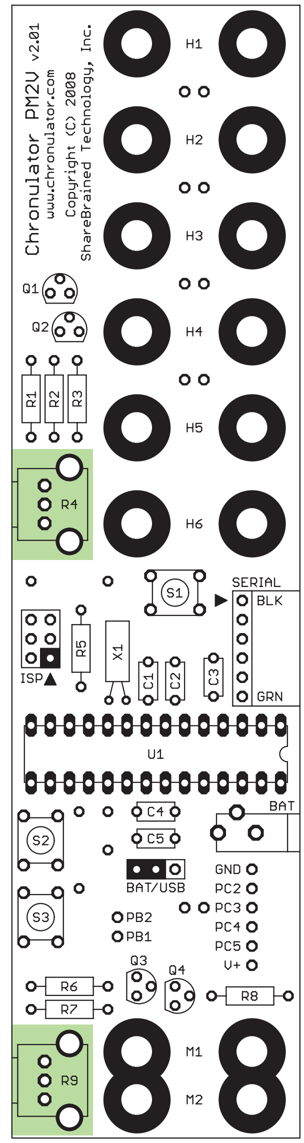
Insert the switches into the circuit board at locations S1, S2, and S3. Since the pins on each switch are in a rectangular arrangement, the switches will only fit in two orientations. Either orientation is fine. The switches snap into the board. Once you line up the pins with the holes, press them firmly into the board.



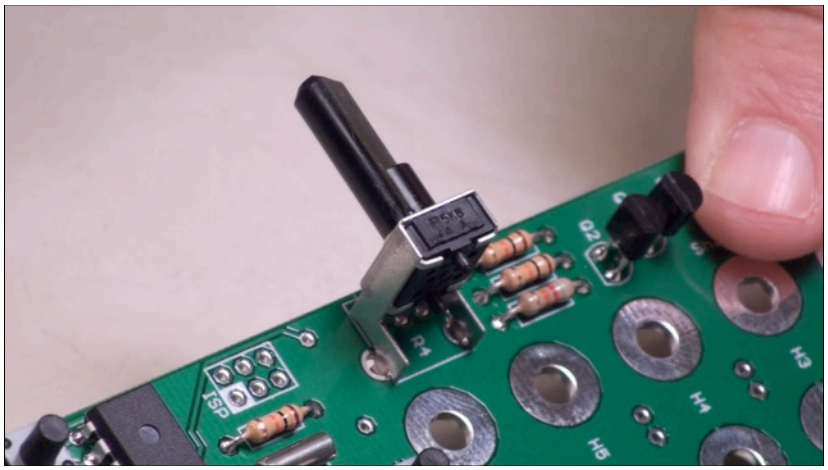
Solder the four pins of each switch.

Variable Resistors R4, R9

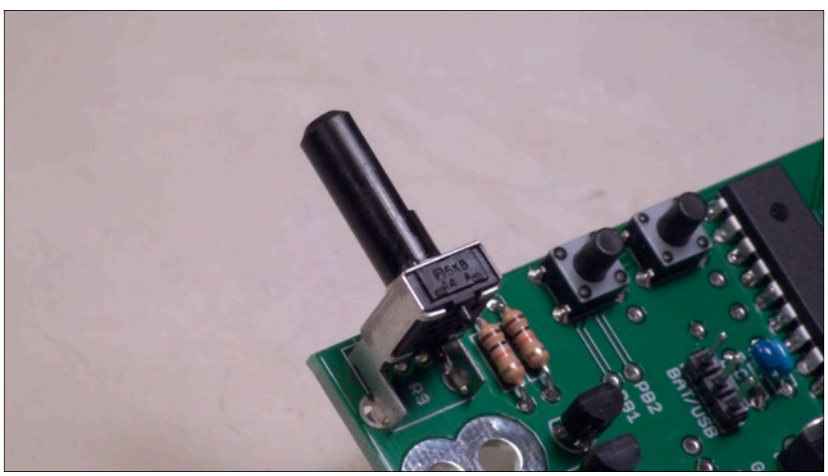
Circuit-board mount, right-angle
5K Ohm



Insert the variable resistors into circuit board locations R4 and R9. They only fit one way (you needn't prove me wrong!).



R4, inserted



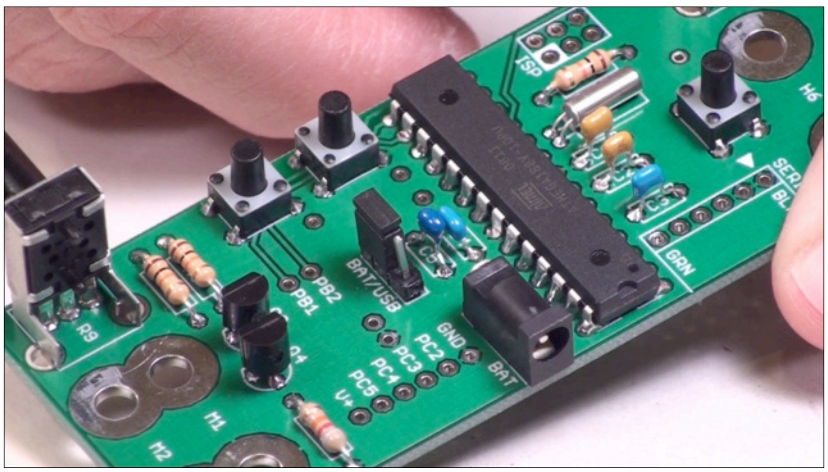
R9, inserted

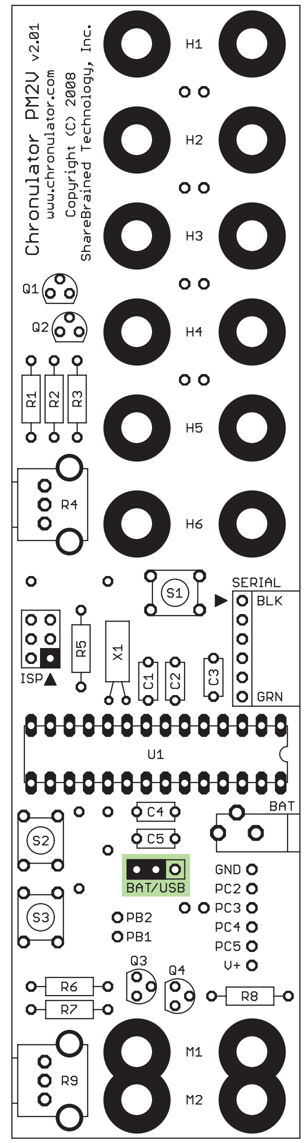
Solder the three small holes on each variable resistor. Do not solder the two big holes of each part. It's difficult because the holes are so large, and it's not really necessary, anyway.

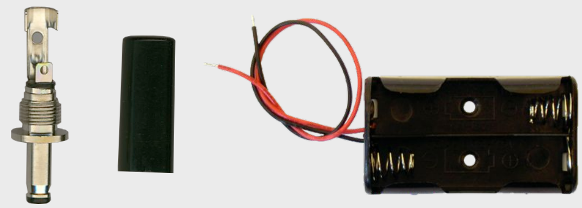
BAT/USB Jumper

Two-pin jumper

Take the two-pin jumper and insert it over the two header pins above the “BAT” side of the BAT/USB label.



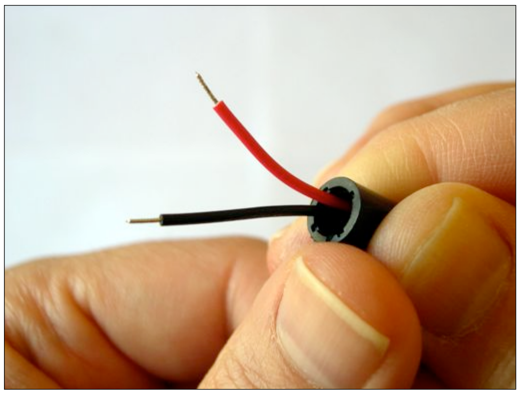




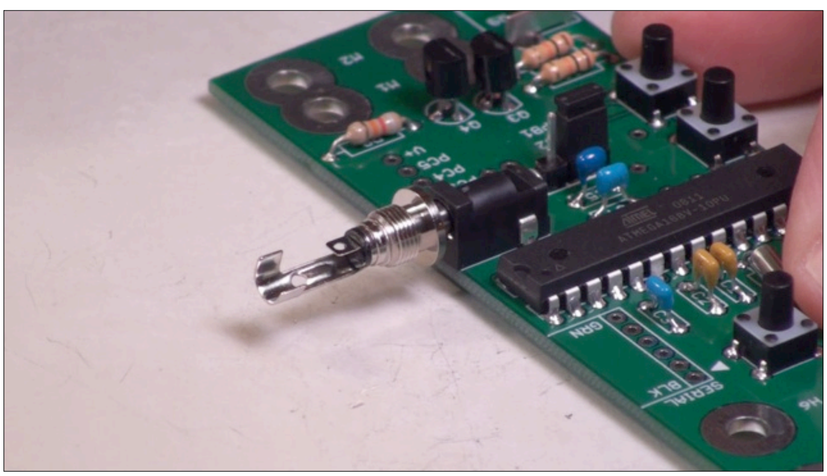
Plug, Sleeve, and Battery Holder

Chrome and black plastic, barrel style

One end of the black plastic sleeve has threads inside. The other end has a smaller, smooth hole. Thread the red and black wires of the battery holder through the smaller hole in the sleeve, so they come out through the threaded hole of the sleeve.

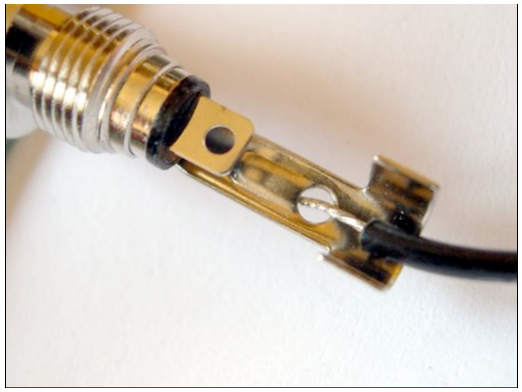


Insert the chrome plug into the BAT jack on the circuit board. The circuit board will prevent the plug from rolling around as you solder wires to it.



There are two solder connections to make on the plug. Note that there are two tabs on the plug -- a small tab and a long tab. Each tab has a small hole. In the next few steps, we'll attach the battery holder's black wire through the hole in the long tab and the red wire through the hole in the small tab.

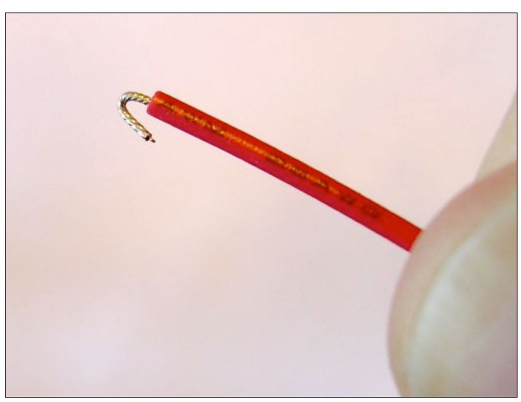
Thread the metal tip of the black wire into the hole on the long tab. The black wire should rest between the two prongs on the long tab.



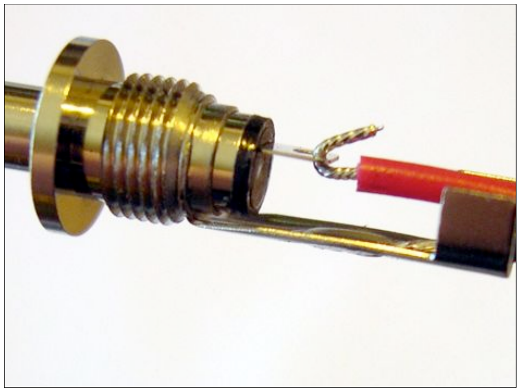
Turn the circuit board over to look at the back side of the plug. There's an indentation in the back side, next to the hole. The metal part of the black wire should lay in that indentation. Flatten the metal part of the wire against the indentation a bit.

Solder the black wire to the long tab. Be sure to heat the tab long enough for the solder to flow over the tab a bit. It's important that your solder joint be relatively flat so the plastic sleeve can fit over it. You can slide the black sleeve up and screw it temporarily, just to check the fit.

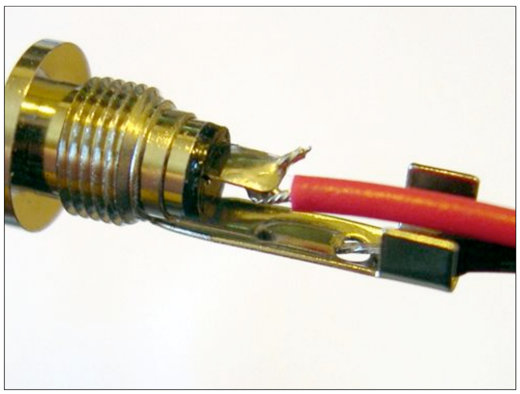
Use your fingers to fold the bare metal portion of the red wire to make a hook.



Turn the circuit board over so you can access the short tab. Hook the red wire through the short tab on the chrome plug. Hook the wire from the bottom side so the end of the wire sticks out.



Solder the red wire to the short tab on the chrome plug. Use enough heat and solder



Trim any excess from the end of the red wire.

Make sure that the metal parts of the red wire and black wire do not touch each other, or you will short out your battery.

Unplug the plug from the circuit board connector. Slide the black plastic sleeve up to the chrome plug and screw it on to the plug.

Changing the Meter Face Graphics

The meters that come with the kit are labeled for 0 to 100 "uA" (microamps), a scale which makes it hard to tell the time. But changing the panel faces is easy. We provide example artwork you can use (download from www.sharebrained.com/chronulator), or you can make your own from our templates. Remember, your clock doesn't need to read "Hours" and "Minutes" -- it could say "RPM" or "Altitude", as long as you know how to interpret the scale on the meter.

Required tools:

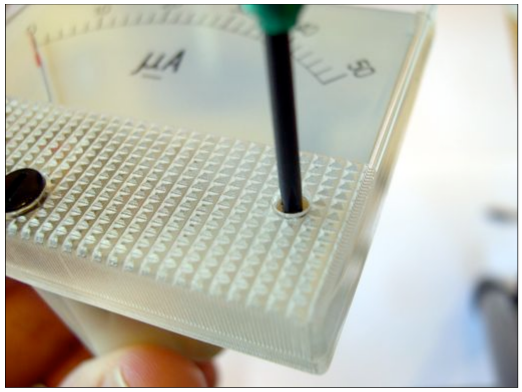
Computer printer	We've had good luck with a basic home inkjet printer.
Printer photo paper	Consider matte photo paper -- you don't want it too shiny.
X-acto knife	Some sort of precision paper-cutting implement.
Small Phillips screwdriver	#0 or #1 are good sizes to use.
Glue stick	The pen style is easier to apply around the delicate meter needle.
Tweezers	Optional, but very helpful for moving the needle bumpers around.

Print out the meter face graphics. When you do this, use high-quality photo paper, and the appropriate high-quality setting on your printer. You'll want a crisp, deep image for the face of your meter. Also, when printing, set Adobe Acrobat Reader to "No Scaling". If Acrobat Reader scales the artwork, it won't fit properly when you insert it into the meter.

Cut out the graphics using an X-acto knife. At first, just cut out the four sides of the meter. You can cut out the "D" shape and screw holes later. Cut gently, or the paper will buckle and the edges will look nasty. Consider using a ruler to keep your cuts clean and straight.

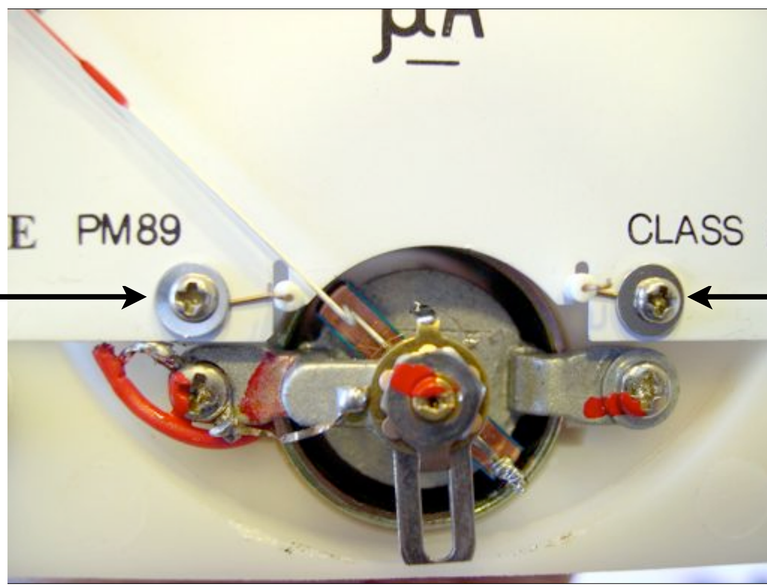
Next, cut out the "D" shape and screw holes. I find it easiest to use the tip of the X-acto knife to punch out tight corners. Others find it easier to use a small pair of scissors. It's also easier if you cut the two screw holes as slots instead. The face graphics can then slide under the faceplate screws without taking the screws off.

Remove the two screws from the front of the meter with a small Phillips screwdriver.



Gently pull off the clear plastic panel cover -- you don't want to damage the needle apparatus.

Examine the meter and notice that the existing faceplate is a piece of painted sheet metal held into the meter by two screws. Those screws also hold a pair of wire bumpers which prevent the needle from slamming too far left or right. Later, you will slide your artwork under the needle and the faceplate screws.

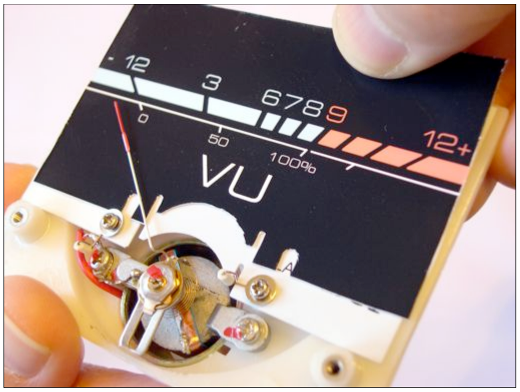


Faceplate Screw → ← Faceplate Screw

Loosen each of the two faceplate screws about two turns. Rotate the wire bumpers down so they won't be in the way of the artwork when you slide it in.

Using a glue stick, put some glue on the metal faceplate. Be careful of the fragile needle...

Slide your artwork under the needle and into the gaps under the faceplate screws. The notches you cut in the artwork should slide right under the screws, and the top edge of the artwork should line up with the top edge of the metal faceplate. While you're doing this, make sure that the faceplate screws and washers are on top of your artwork. Tweezers can be a big help here.



Press your artwork against the metal faceplate. It's important to get the artwork as flat as possible -- if the artwork is not flat, the needle may bind up on it.

Gently retighten the mounting screws. You can leave the bumpers hanging down below the face. They'll be out of view once you replace the plastic panel cover.

Replace the plastic panel cover. It will snap into place with a bit of squeezing.

Take a look at the edges of the meter, to see if your artwork is flat against the face. If it isn't, it may touch and restrict the needle. Take the cover off and press the artwork against the faceplate or loosen the faceplate screws and move the artwork around a bit (if the glue hasn't set yet).

Replace and gently tighten the panel cover screws.

Meter Mounting

There are innumerable ways to mount your meters. Mount yours on the wall, in a houseplant, in a tin box or cigar box, on steel diamond-plate or frosted plexiglass, dangle it from wires... It's up to your taste and personality.

The simplest approach is to mount the meters into a 8x10 picture frame. We'll briefly describe how that's done.

On the ShareBrained site (www.sharebrained.com/chronulator), we provide a set of spacing templates you can use to cut holes that match the meter spacings possible with the circuit board. To keep things simple, you should design your mount to use one of those spacing templates. When you print out a spacing template, make sure Adobe Reader does not scale the document. You should double-check by measuring the printout with a ruler.

Attach the template to your mounting surface. For picture frames, we use sturdy cardboard and glue the template sheet to the back side with a glue stick. Then we use an X-acto knife to cut out the large circles and screw holes for each meter. We decorate the mounting surface by gluing objects, gift wrap, collage bits, or photos to the front. From the back side, we cut the meter and screw holes through the decoration.

To mount the meters, remove the two smaller nuts and washers located at the sides of the meter. Insert the meter through the large hole and the two screw holes. Put the washers and nuts back on and tighten them as much as you can with your fingers. (Using a wrench is overkill and might break the meter.)

Circuit Board Mounting

Unscrew the nuts from the two large terminals on the back of each meter.

Remove one of the two washers from each of the terminals.

The meters mount on the side of the circuit board opposite the "Chronulator PM2V" label.

If you used one of our spacing templates, the circuit board should fit right on to the terminals on both meters. The template you used should mention which pair of circuit board holes you should use. (H1, H2, H3, H4, H5 or H6 for you "hours" meter and M1 or M2 for your "minutes" meter.)

Put one washer on each meter terminal.

Put one nut on each terminal and tighten gently. Finger-tightening should be sufficient.

Now you can connect the battery! The meters should move to the center of the meter within ten seconds of connecting power. Now you're ready to calibrate your new Chronulator!

Calibration

Required Tools: two fingers, flat-head jeweler's screwdriver for “low calibration”.

There are two buttons on the clock. The top and bottom buttons are directly behind the meters they adjust – the top button increments the hour and the bottom button increments the minute.

The calibration mode is set when both buttons are pressed at the same time. Each time you press both buttons, the next calibration mode is entered. There are two calibration modes -- “low” and “high”.

To calibrate the clock, press both buttons. The clock enters “low calibration” mode. Both meters move all the way to the left side. Turn the black screw on the front of each meter until the needle is exactly in front of the left-most tick on the meter's scale.

Press both buttons again to enter the “high calibration” mode. Both meters will swing to the far right side. Adjust the knob behind each meter to move the needle until it's exactly in front of the right-most tick on the meter's scale.

Press both buttons again and the clock will return to clock mode. That's all there is to it! You may need to re-calibrate every six months or so – as the batteries get weaker, the needles may not be dead-on any more.

Operation

This clock works like most others when it comes to setting the time. Press the button behind the hour meter to increment the hour, and press the button behind the minute meter to increment the minute.

If you want to make the clock accurate to the second, here's a trick. The clock's second counter is reset whenever you let go of the minute button. So when you're setting the minute, hold down the minute button when you press it for the last time. Then, when your master clock changes to the next minute, release the minute button. The meter clock will begin counting the minute from the instant you let go of the button.

Troubleshooting

We’ve worked hard to make this kit easy to assemble. But sometimes it just doesn’t work out. If you’re having problems, please post to our forums (www.sharebrained.com/forums) or e-mail info@sharebrained.com. We’ll do our best to help. If you want, you can also send us digital photos of your project to help us see the problem you’re having.

What Next?

Visit the ShareBrained forums (www.sharebrained.com/forums) to post pictures of your product and see what others are doing. You can also post pictures to Flickr, using the tag "chronulator".

Try designing custom meter faces that reflect your favorite hobby (our Web site has templates to get you started).

If you're technically-inclined, consider hacking on the source code and wiring up your Chronulator to show something more interesting than the time. The FTDI Basic Breakout board from SparkFun (www.sparkfun.com), or a similar serial board is all the hardware you need to get to work. As for software, we recommend the Arduino project (www.arduino.cc). Look to the ShareBrained Website for posts of interesting hacks that you can build upon.

If you really love building Chronulators, consider building custom Chronulators for other people.